

SI

Système International d'unités
(International System of Units)

An Educational Overview for Americans



MetricPioneer.com

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Salem Oregon
United States of America

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SPEED signs near US - Canada border

Metrication in the United States

Metrication in the United States is the process of introducing the **International System of Units** to replace the outdated measurement units used in the United States. The modernized Metric System is known as *le Système International d'unités* (the International System of Units) with the international abbreviation **SI**.

The Metre Convention of 20 May 1875 is a treaty which established three international organizations to oversee the keeping of metric standards and created three main organizations:

- Conférence Générale des Poids et Mesures or **CGPM** (General Conference on Weights and Measures);
- Bureau International des Poids et Mesures or **BIPM** (International Bureau of Weights and Measures); and
- Comité International des Poids et Mesures or **CIPM** (International Committee for Weights and Measures).

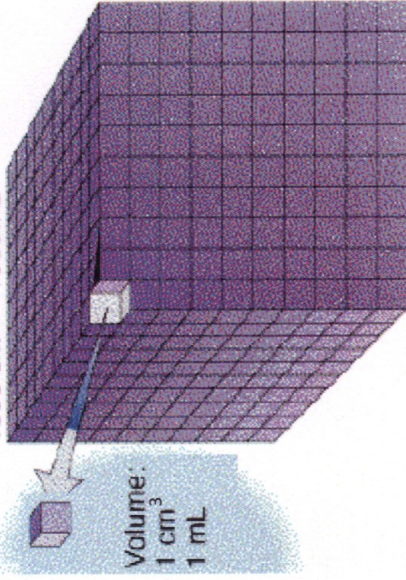


www.bipm.org

Volume: 1 cubic decimeter

"1 liter" $1\text{ L} = 1\text{ dm}^3$

$1000\text{ cm}^3 = 1000\text{ mL}$



Volume:
 1 cm^3
 1 mL



1 dm^3 = (cubic decimeter)

1 L = (liter of water)

1 kg (kilogram)



1 cm^3

(cubic centimeter)



1 mL

(milliliter of water)



1 g

(gram)

Why should the United States change?

We should change for many reasons, but international trade is the most obvious factor that should inspire Americans to adopt the same system of measurements all other people use around the world.

We could avoid costly disasters like that embarrassment in 1999. The use of two different systems was the root cause in the loss of the \$125 million Mars Climate Orbiter. NASA specified metric units in the contract. NASA and other organizations worked in metric units, but one subcontractor, Lockheed Martin, provided thruster performance data to the team in pound force seconds instead of newton seconds. The spacecraft was intended to orbit Mars at about 150 kilometers altitude, but the incorrect data meant that it probably descended instead to about 57 kilometers, burning up in the thin Martian atmosphere.

American scientists use SI because it is so much easier: A liter of water weighs one kilogram, so one cubic meter (1,000 liters) of water weighs 1,000 kilograms, which is one metric ton.

Gallons, pounds, feet, hkwe, awettha and htwa do not share such comprehensive, convenient interrelationships with each other.

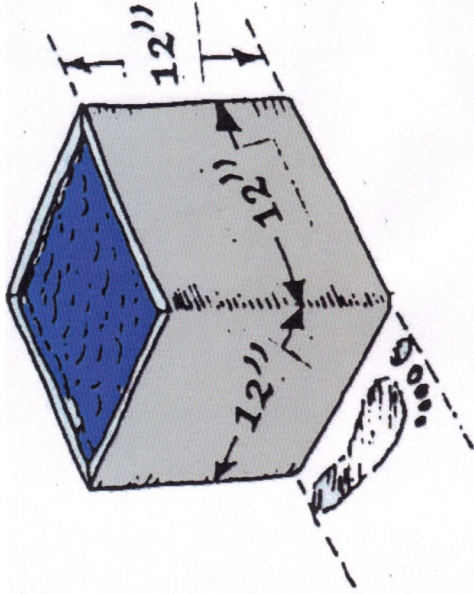
Your fingernails grow at the rate of about one nanometer per second. The diameter of our galaxy is one zettameter. It is comparatively cumbersome measuring such small and large things with outdated, obsolete measures like the Burmese Htwa and Awettha or the American inch / pound / gallon collection of random measures with absolutely no interrelationship.

Some argue that the cost-benefit ratio of adopting a United States National Metrication Policy would preclude its worthiness, but in the grand scheme of things, stubbornly clinging to a clumsy and outdated proprietary non-system is even more costly (and embarrassing).

MetricPioneer.com is dedicated to United States President Andrew Johnson and to Metric Pioneer Antoine Lavoisier (1743–1794 CE) Father of Modern Chemistry, who helps construct the Metric System during the French Revolution while working alongside Benjamin Franklin in France. The modern form of the Metric System is known as SI = *Système International d'unités* = International System of Units. The Metric System of measure was first given a legal basis in 1795 CE by the French Revolutionary government.

On 28 July, the **Metric Act of 1866** becomes law and legalizes the use of the Metric System for weights and measures in the United States. The Metric Act of 1866 was originally introduced as H.R. 596 in the 39th Congress. The House passes it on 17 May 1866 CE; the Senate passes it on 27 July 1866 CE; President Andrew Johnson signs the Metric Act the next day:

“ . . . it shall be lawful throughout the United States of America to employ the weights and measures of the metric system; and no contract or dealing, or pleading in any court, shall be deemed invalid or liable to objection because the weights or measures expressed or referred to therein are weights or measures of the metric system.”



$$1'^3 / 1 \text{ ft.}^3 =$$

$$7.4805194805 = \text{US gal.}$$

$$= 62.38 \text{ lbs.}$$

(cubic foot of water)

(US gallon)

(pound)



$$1''^3 / 1 \text{ in.}^3 =$$



$$0.554112554 = \text{US fl. oz.}$$



?

(cubic inch of water)

(fluid ounce)

The United States Congress finds that although the International System of Units (SI) has been authorized in the United States by law since **1866**, the United States of America is the only industrially developed nation lacking a National Metrication Policy.

The Metric Conversion Act of **1975** designates SI as the preferred measurement system for United States trade and commerce. The inherent simplicity of SI leads to major cost savings.

Industry in the United States is at a competitive disadvantage in the international marketplace and is often excluded when unable to deliver internationally measured goods.

The Federal Government of the United States has a responsibility to develop procedures and techniques to assist industry, especially small business, as it voluntarily converts to SI.

Thanks to a **1991** executive order signed by President Bush, federal agencies are now required to transition to SI and to report annually on their progress to the National Institute of Standards and Technology (NIST) Metric Program.

According to PISA, the Programme for International Student Assessment, The United States ranked way down at number 31 in mathematics in 2009. Even kids in Poland rank better at math than Americans!

American Exceptionalism is the belief that the United States is different from other countries in that it has a specific world mission to spread liberty and democracy. In this view, American Exceptionalism stems from its emergence from a revolution, becoming the first new nation and developing a uniquely American ideology, based on liberty, egalitarianism, individualism and populism.

Extolling the virtues of American Exceptionalism may inspire patriotism, but letting your national pride deprive you of all the benefits of using a much more logical measurement system runs counter to the American way of bettering ourselves as a nation.

Let us not lag in STEM fields (science, technology, engineering, and mathematics) but rather, let us improve our nation and adopt a National Metrication Policy so we can better compete in the global market.

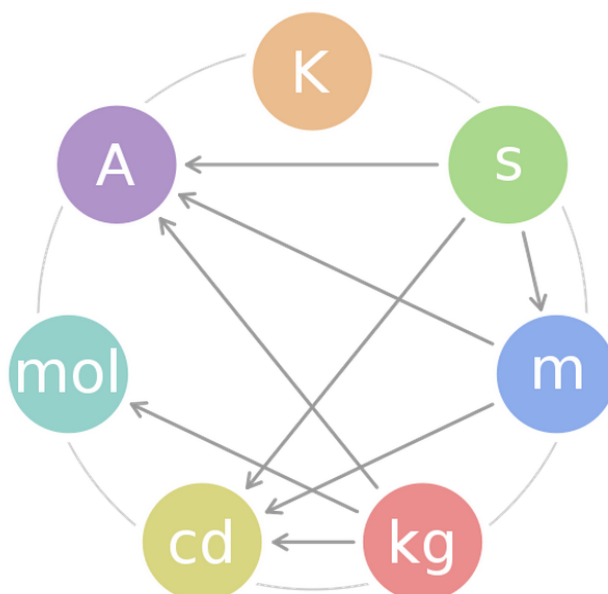
Maths			
1		Shanghai, China	600
2		Singapore	562
3		Hong Kong, China	555
4		South Korea	546
5		Taiwan	543
6		Finland	541
7		Liechtenstein	536
8		Switzerland	534
9		Japan	529
10		Canada	527
11		Netherlands	526
12		Macau, China	525
13		New Zealand	519
14		Belgium	515
15		Australia	514
16		Germany	513
17		Estonia	512
18		Iceland	507
19		Denmark	503
20		Slovenia	501
21		Norway	498
22		France	497
23		Slovakia	497
24		Austria	496
25		Poland	495
26		Sweden	494
27		Czech Republic	493
28		United Kingdom	492
29		Hungary	490
30		Luxembourg	489
31		United States	487
32		Portugal	487

Base Units

The International System of Units (SI) defines seven units of measure as a basic set from which all other SI units are derived. The SI base quantities form a set of mutually independent dimensions as required by dimensional analysis commonly employed in science and technology. However, in a given realization of these units they may well be interdependent, i.e. defined in terms of each other.

SI Base Units		
Name	Symbol	Quantity
metre or meter	m	length
kilogram	kg	mass
second	s	time
ampere	A	electric current
kelvin	K	thermodynamic temperature
candela	cd	luminous intensity
mole	mol	amount of substance

The names of SI units are written in lowercase characters (the degree Celsius meets this rule, as degree is the unit, and Celsius is a modifier). The symbols of units are written in lowercase (meter has the symbol m) except that symbols for units named after persons are written with an initial capital letter (the hertz has the uppercase symbol Hz). Many other units, such as the liter are formally not part of the SI, but are accepted for use with SI.



The seven SI base units and the interdependency of their current definitions

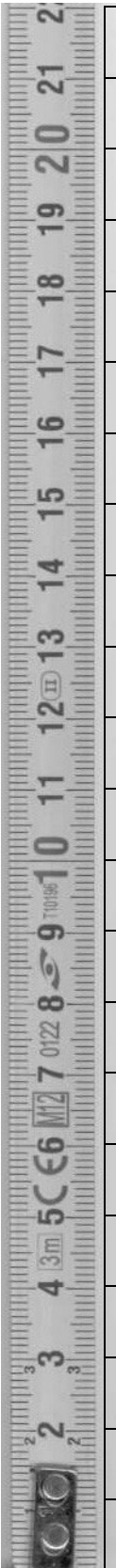
Unit Prefixes

A prefix may be added to a unit to produce a multiple of the original unit. All multiples are integer powers of ten. For example, *kilo-* denotes a multiple of a thousand and *milli-* denotes a multiple of a thousandth; hence there are one thousand millimeters to the meter and one thousand meters to the kilometer. (The prefixes are never combined: a millionth of a kilogram is a *milligram* not a *microkilogram*.) The official US spelling for deca is deka though Americans use the international spelling more often than the American one.

SI Multiples				
Symbol	Factor	Prefix	Origin	Approved
da	10^1	deka	Greek: δέκα ten	In use by 1951 but redefined in 1960 by the 11 th CGPM
h	10^2	hecto	Greek: ἑκατόν 100	
k	10^3	kilo	Greek: χίλιοι 1000	
M	10^6	mega	Greek: μέγας great	
G	10^9	giga	Greek: γίγας giant	
T	10^{12}	tera	Greek: τέρας monster	
P	10^{15}	peta	Greek: πέντε five	1975 15 th CGPM
E	10^{18}	exa	Greek: ἑξά six	1975 15 th CGPM
Z	10^{21}	zetta	Latin: sept seven	1991 19 th CGPM
Y	10^{24}	yotta	Greek: οκτώ eight	1991 19 th CGPM

SI Fractions				
Symbol	Factor	Prefix	Origin	Approved
d	10^{-1}	deci	Latin: decimus tenth	In use by 1951 but redefined in 1960 by the 11 th CGPM
c	10^{-2}	centi	Latin: centum hundred	
m	10^{-3}	milli	Latin: mille thousand	
μ	10^{-6}	micro	Greek: μικρός small	
n	10^{-9}	nano	Greek: νᾶνος dwarf	
p	10^{-12}	pico	Italian: piccolo small	
f	10^{-15}	femto	Danish: femten fifteen	1964 12 th CGPM
a	10^{-18}	atto	Danish: atten eighteen	1964 12 th CGPM
z	10^{-21}	zepto	Latin: septem seven	1991 19 th CGPM
y	10^{-24}	yocto	Greek: οκτώ eight	1991 19 th CGPM

SI Multiples and Fractions of meter



Symbol	Factor	Name	Scale
Ym	10^{24}	yottameter	Intergalactic
Zm	10^{21}	zettameter	Galactic
Em	10^{18}	exameter	Nebula
Pm	10^{15}	petameter	Interstellar
Tm	10^{12}	terameter	Outer Planetary Orbit
Gm	10^9	gigameter	Inner Planetary Orbit
Mm	10^6	megameter	Planetary Circumference
km	10^3	kilometer	Biosphere
hm	10^2	hectometer	Land Survey
dam	10^1	dekameter	Geopotential Height
m		meter	Base Unit
dm	10^{-1}	decimeter	Liter
cm	10^{-2}	centimeter	Height; Maps; CDs; DVDs
mm	10^{-3}	millimeter	Rainfall, Paper; Camera Film
μm	10^{-6}	micrometer	Genetic
nm	10^{-9}	nanometer	Nanotechnology
pm	10^{-12}	picometer	Atomic
fm	10^{-15}	femtometer	Subatomic
am	10^{-18}	attometer	Quark
zm	10^{-21}	zeptometer	High Energy Neutrino
ym	10^{-24}	yoctometer	Neutrino



Meter

The metre or meter (from the Greek μέτρον) is a unit of proper length. It is the basic unit of length in the Metric System and in the International System of Units (SI), used around the world for general and scientific purposes.

Historically, the meter was defined by the French Academy of Sciences as the length between two marks on a platinum-iridium bar, which was designed to represent $1/10,000,000$ of the distance from the equator to the North Pole through Paris.

In 1983, it was redefined by the International Bureau of Weights and Measures (BIPM) as the distance travelled by light in free space in $1/299,792,458$ of a second. The BIPM does not distinguish between quantum vacuum and free space. The speed of light is 299,792,458 meters per second.

Ten is our natural choice for measuring because ten is such an integral part of anatomy:

					
Tarsier		Orangutan		Gorilla	
1	I	一	١	א	
2	II	二	٢	ב	
3	III	三	٣	ג	
4	IV	四	٤	ד	
5	V	五	٥	ה	
6	VI	六	٦	ו	
7	VII	七	٧	ז	
8	VIII	八	٨	ח	
9	IX	九	٩	ט	
10	X	十	١٠	י	



One yottameter = 10^{24} m = 1,000,000,000,000,000,000,000,000 meters



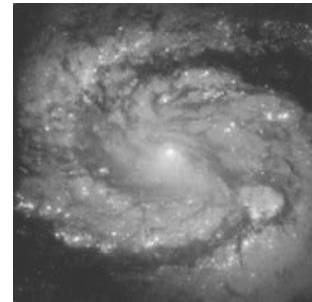
A yottameter is symbolized Ym and is 1,000,000,000,000,000,000,000,000 meters long or 10^{24} m which is easier than scrawling out 1 followed by 24 zeros.

The observable universe is estimated to be about 880 Ym in diameter.

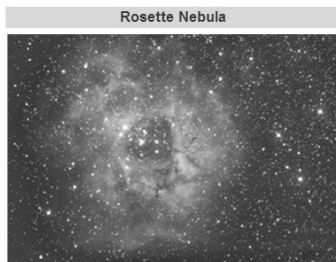
One zettameter = 10^{21} m = 1,000,000,000,000,000,000,000 meters

A zettameter is symbolized Zm and is 1,000,000,000,000,000,000,000 meters long or 10^{21} m which is easier than scrawling out 1 followed by 21 zeros.

Our galaxy is a little less than one zettameter in diameter.



One exameter = 10^{18} m = 1,000,000,000,000,000,000 meters



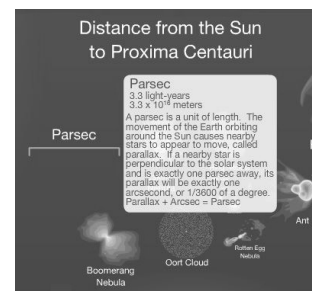
An exameter is symbolized Em and is 1,000,000,000,000,000,000 meters long or 10^{18} m which is easier than scrawling out 1 followed by 18 zeros.

Rosette Nebula is about 1.2 Em in diameter.

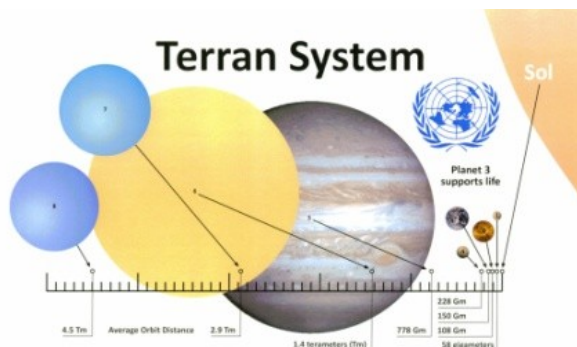
One petameter = 10^{15} m = 1,000,000,000,000,000 meters

A petameter is symbolized Pm and is 1,000,000,000,000,000 meters long or 10^{15} m which is easier than scrawling out 1 followed by 15 zeros.

A parsec is almost 31 petameters. A Julian light year is about nine and a half petameters. Proxima Centauri is 40 Pm away from us and is the nearest star to our sun.



One terameter = 10^{12} m = 1,000,000,000,000 meters



A terameter is symbolized Tm and is 1,000,000,000,000 meters long or 10^{12} m which is easier than scrawling out 1 followed by 12 zeros.

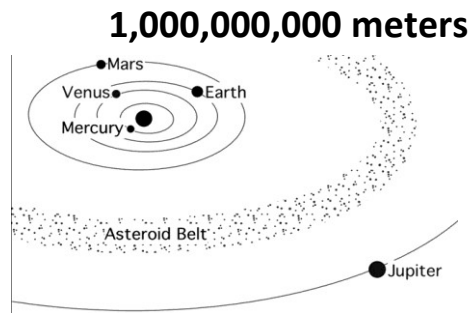
Average Orbital Distances of Saturn, Uranus and Neptune are measured in terameters.

See enlargement at MetricPioneer.com

One gigameter = 10^9 m =

A gigameter is symbolized Gm and is 1,000,000,000 meters long or 10^9 m which is easier than scrawling out 1 followed by 9 zeros.

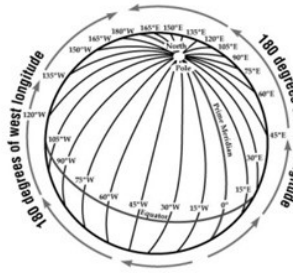
Average Orbital Distances of Mercury, Venus Earth, Mars and Jupiter are measured in gigameters. An Astronomical Unit is exactly 149.597 870 7 gigameters.



One megameter = 10^6 m =

A megameter is symbolized Mm and is 1,000,000 meters long or 10^6 m which is easier than scrawling out 1 followed by 6 zeros.

Earth circumference is 40 Mm. The approximate width of the continental United States is about four and a half megameters.



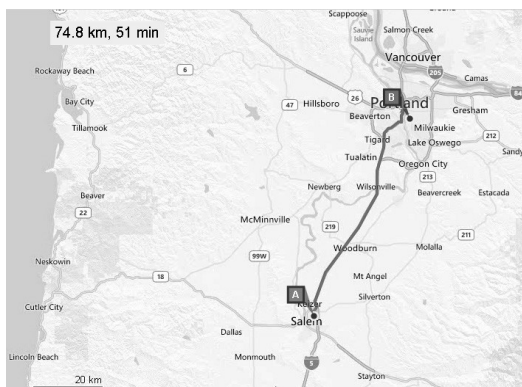
**Salem to DC
about four and
a half Mm**



One kilometer = 10^3 m =

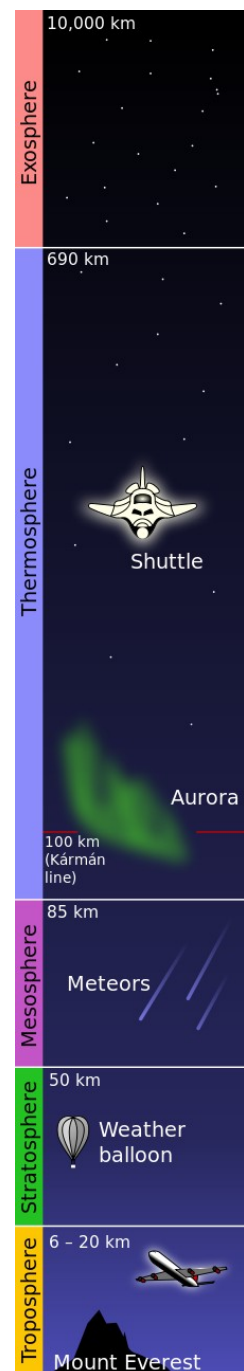
1,000 meters

A kilometer is symbolized km and is 1,000 meters long or 10^3 m.



**Salem to
Portland
75 km**

35,786 km	Geostationary Orbit	250 km	Low Earth Orbit
100 km	Atmosphere Boundary	27 km	U-2 Spy Plane
10 km	Passenger Jets	8850 m	Mount Everest
3650 m	Lhasa	1300 m	Salt Lake City
760 m	Jerusalem	277 m	Mecca
105 m	Florida's Highest Point	47 m	Salem Oregon
2 m	Tall Basketball Player	-86 m	Death Valley
-411 m	Dead Sea	-10,911 m	Mariana Trench



One hectometer = 10^2 m =

A hectometer is symbolized hm and is 100 meters long or 10^2 m.

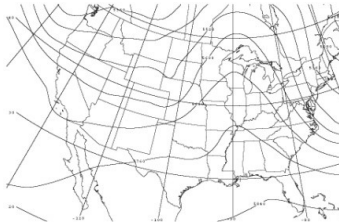
A square hectometer is a hectare, which is commonly used for measuring land area. The hectare is used in most countries around the world, especially in domains concerned with land ownership, land planning, and management, including law (land deeds), agriculture, forestry, and town planning.

100 meters



One dekameter = 10^1 m =

10 meters



A dekameter is symbolized dam and is 10 meters long or 10^1 m.

A practical use of the dekameter is for altitude of geopotential heights in meteorology. Geopotential height is a vertical coordinate referenced to Earth's mean sea level, an adjustment to geometric height (elevation above mean sea level) using the variation of gravity with latitude and elevation.

One decimeter = 10^{-1} m =

0.1 meter

A decimeter is symbolized dm and is 0.1 meter long or 10^{-1} m.

A cubic decimeter is a liter. A liter cube demonstrates the relation of length, area and volume. A cm grid on the bottom, along with capacity markings on the sides, illustrates the concept of volume as counting cubes and that volume = height x base area. The cube can be used to relate volume and mass units. Furthermore, the large top opening makes it convenient for activities measuring volume or mass of solid objects by displacement of water. Available at MetricPioneer.com



One centimeter = 10^{-2} m =

0.01 meter



A centimeter is symbolized cm and is 0.01 meter long or 10^{-2} m.

The centimeter is a practical unit of length for many everyday measurements including human height, level of snowfall, product dimensions and box sizes. CDs and DVDs are 12 cm in diameter.

In maps, centimeters are used to make conversions from map scale to real world scale (kilometers).

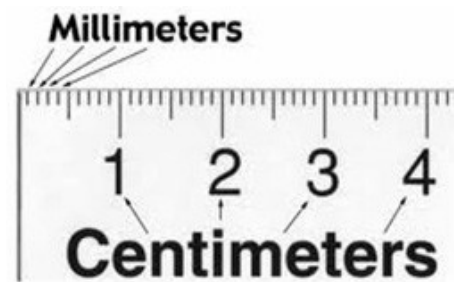


One millimeter = 10^{-3} m =

0.001 meter

A millimeter is symbolized mm and is 0.001 meter long or 10^{-3} m which is easier than scrawling out 3 digits past the decimal.

The millimeter is a practical unit of length for many everyday measurements including level of rainfall, paper and camera film. The most common paper size is A4 (297 x 210 mm); 35 mm film is common.



1 mm

Tardigrades (commonly known as waterbears or moss piglets) are small, water-dwelling, segmented animals with eight legs. They form the phylum Tardigrada, part of the superphylum Ecdysozoa. The first tardigrades were discovered by Johann August Ephraim Goeze in 1773. Since 1778, over 500 new tardigrade species have been found. Usually, Tardigrades are 1 mm when they are full grown. They are short and plump with 4 pairs of poorly articulated lobopodial limbs. Each limb has 4 to 8 claws also known as disks. Tardigrades all possess a buccopharyngeal membrane apparatus, which, along with the claws, are used to differentiate the different species. Tardigrades are covered in cuticle which contains chitin and protein.

Tardigrades were first discovered in 1773 by Johann August Ephraim Goeze, who called them kleiner Wasserbär, meaning little water bear in German. The name Tardigrada means slow walker and was given by Lazzaro Spallanzani in 1777.

The name water bear comes from the bearlike way they walk. The biggest adults may reach a body length of 1.5 mm; the smallest below 0.1 mm; freshly hatched tardigrades may be smaller than 0.05 mm.

About 1,150 species of tardigrades have been described. Tardigrades occur throughout the world from the Himalayas above **6,000 meters** to deep sea below **4,000 meters** and from polar regions to equator.

The most convenient place to find tardigrades is on lichens and mosses. Other environments are dunes, beaches, soil, and marine or freshwater sediments, where they may occur quite frequently (up to 25,000 animals per liter). Tardigrades often can be found by soaking a piece of moss in spring water.

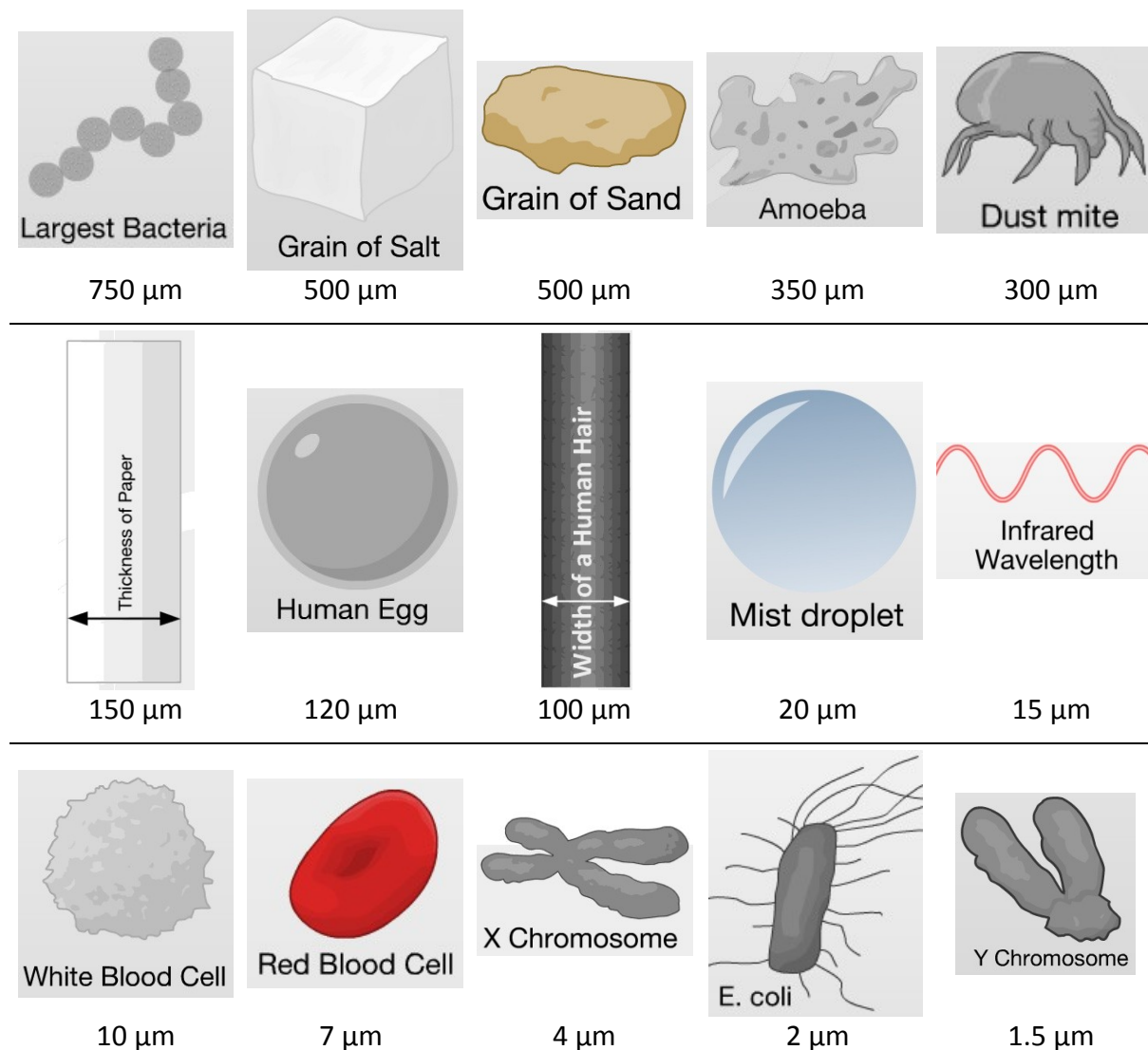
Tardigrades are able to survive in extreme environments that would kill almost any other animal. Some can survive temperatures of close to **absolute zero**, or 0 kelvin (-273 °C), temperatures as high as **151 °C**, 1,000 times more radiation than other animals, and almost a decade without water. Since 2007, tardigrades have also returned alive from studies in which they have been exposed to the vacuum of space for a few days in low Earth orbit. Tardigrades are the first known animal to **survive in space**.

One micrometer = 10^{-6} m =

0.000 001 meter

A micrometer is symbolized μm and is 0.000 001 meter long or 10^{-6} m which is easier than scrawling out 6 digits past the decimal.

A micrometer is sometimes called a micron in many English-speaking countries and is extensively used in academic science including geology, biology, physics and astronomy and in applied science and industry including machining, engineering, the semiconductor industry and plastics manufacturing. The micrometer is a common unit of measurement for wavelengths of infrared radiation. Examples of things we measure in micrometers:



Thiomargarita namibiensis is the largest known Terran bacteria and measures 750 micrometers, which is almost 1 mm in length. It lives in the ocean off the coast of Namibia. Can you imagine being in the ocean and seeing these things? They are very visible!

Amoebas are unicellular, which means only one cell. Some amoebae can grow to an amazing 700 micrometers, which is almost an entire millimeter!

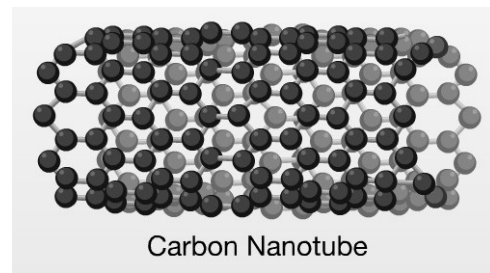
Ovum (human egg) at 120 micrometers is just about the smallest object visible to the naked human eye.

One nanometer = 10^{-9} m =

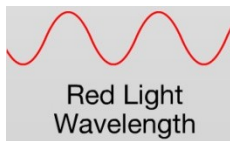
0.000 000 001 meter

A nanometer is symbolized nm and is 0.000 000 001 meter long or 10^{-9} m which is easier than scrawling out 9 digits past the decimal. The smallest thing visible to an optical microscope is 200 nm.

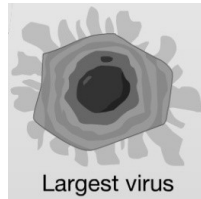
Carbon nanotubes are the strongest material yet discovered and very lightweight, which results in their high potential for use in buildings, batteries, solar panels and possibly even a space elevator.



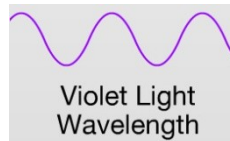
1 nm



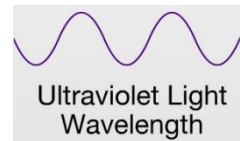
750 nm



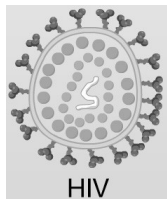
440 nm



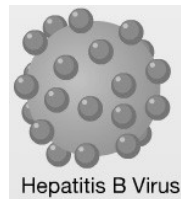
400 nm



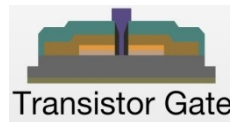
60 nm



90 nm



42 nm



25 nm



3 nm

One picometer = 10^{-12} m =

0.000 000 000 001 meter



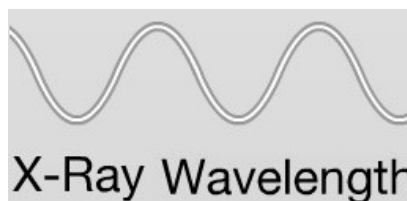
1 pm

A picometer is symbolized pm and is 0.000 000 000 001 meter long or 10^{-12} m which is easier than scrawling out 12 digits past the decimal. The smallest thing visible to an electron microscope is 50 pm. Angstrom = Å = 100 pm.

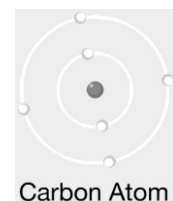
A picometer is so small that its application is almost entirely confined to particle physics and quantum physics. Atoms are between 62 and 520 pm in diameter. Gamma rays come from radioactive decay and have a very high frequency.



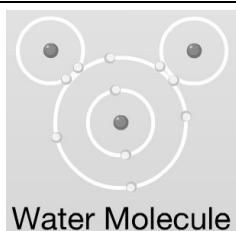
800 pm



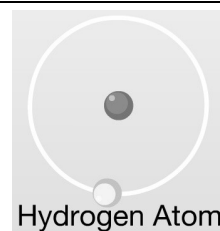
500 pm



340 pm



280 pm



31 pm

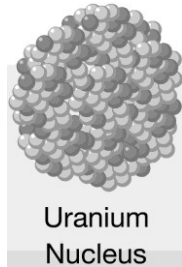


25 pm

One femtometer = 10^{-15} m =

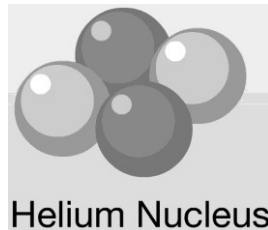
0.000 000 000 000 001 meter

A femtometer is symbolized fm and is 0.000 000 000 000 001 meter long or 10^{-15} m which is easier than scrawling out 15 digits past the decimal. A femtometer is a convenient unit of distance in nuclear physics.



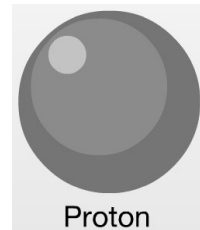
Uranium
Nucleus

15 fm



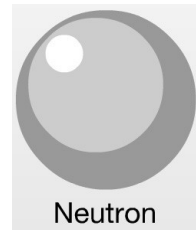
Helium Nucleus

3 fm



Proton

1 fm



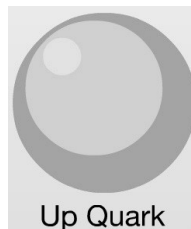
Neutron

1 fm

One attometer = 10^{-18} m =

0.000 000 000 000 000 001 meter

An attometer is symbolized am and is 0.000 000 000 000 000 001 meter long or 10^{-18} m which is easier than scrawling out 18 digits past the decimal. Lengths shorter than 100 attometers are not confirmed.



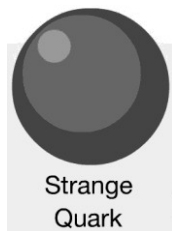
Up Quark

1 am

One zeptometer = 10^{-21} m =

0.000 000 000 000 000 000 001 meter

A zeptometer is symbolized zm and is 0.000 000 000 000 000 000 001 meter long or 10^{-21} m which is easier than scrawling out 21 digits past the decimal.



Strange
Quark

400 zm



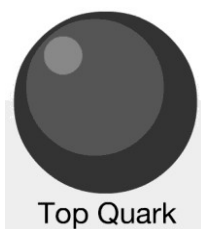
High Energy
Neutrino

15 zm

One yoctometer = 10^{-24} m =

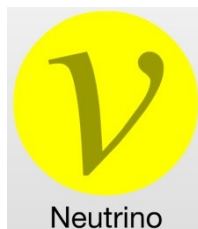
0.000 000 000 000 000 000 000 001 meter

A yoctometer is symbolized ym and is 0.000 000 000 000 000 000 000 001 meter long or 10^{-24} m which is easier than scrawling out 24 digits past the decimal.



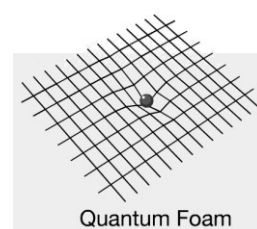
Top Quark

100 ym



Neutrino

1 ym



Quantum Foam

0.000 000 000 01 ym

Kilogram

Among the base units of the International System, the kilogram is the only one whose name and symbol, for historical reasons, include a prefix. Names and symbols for decimal multiples and submultiples of the unit of mass are formed by attaching prefix names to the unit name gram and prefix symbols to the unit symbol g (CIPM 1967).

One yottagram = 10^{21} kilograms = 10^{24} grams

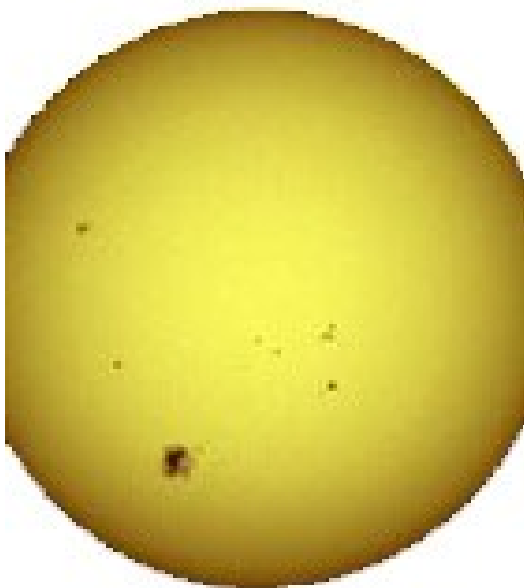


1.1 Yg

Symbol Yg means yottagram.

Dione, a satellite of Saturn, has a mass of 1.1 yottagrams.

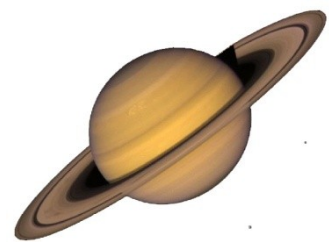
About 1.4 Yg is the total mass of the Terran hydrosphere.



Sol
1,989,100,000 Yg



Jupiter
1,899,000 Yg



Saturn
568,460 Yg



Neptune
102,430 Yg



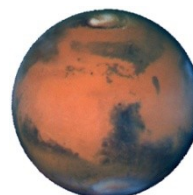
Uranus
86,832 Yg



Earth
5,974 Yg



Venus
4,869 Yg



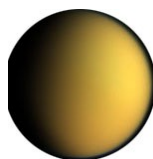
Mars
641 Yg



Mercury
330 Yg



Ganymede
148 Yg



Titan
135 Yg



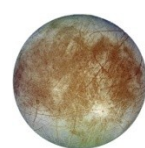
Callisto
108 Yg



Io
89 Yg



Moon
74 Yg



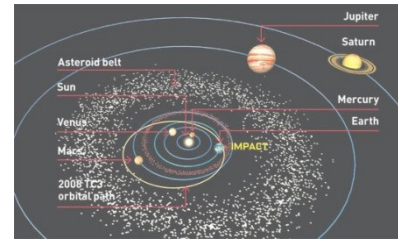
Europa
48 Yg

One zettagram = 10^{18} kilograms = 10^{21} grams

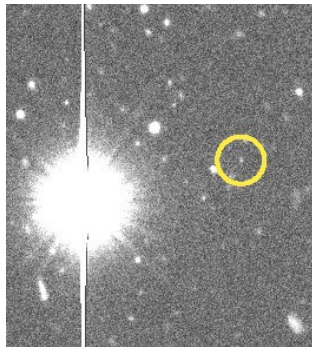
Symbol Zg means zettagram.

Some large main-belt asteroids have a mass of about 1 zettagram.

About 26 Zg is the total mass of the Terran cryosphere.



One exagram = 10^{15} kg = 10^{18} g



Margaret
6 Eg

Symbol Eg means exagram.

With a mass of nearly 6.3 Eg Margaret is considered an irregular moon of Uranus because of the eccentricity and inclination of its orbit, but it is the only such moon that travels in a prograde direction, in the same direction as the regular moons and the planet rotation about its axis. Only about 20 km in diameter and very dark, it is likely an object that was captured by gravity.

Margaret was discovered on 29 August 2003 by Scott S. Sheppard and David C. Jewitt with the Subaru 8.2-m reflector at the Mauna Kea Observatory on the island of Hawaii.

One petagram = 10^{12} kg = 10^{15} g

Symbol Pg means petagram.

Terran atmosphere contains 840 Pg of carbon.

Comet Halley has a mass of 220 petagrams.



One teragram = 10^9 kg = 10^{12} g



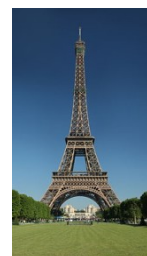
Symbol Tg means teragram.

How much would all humans on Earth weigh? Well, if the average weight of a Terran is 65 kg and if Earth supports at least seven billion of us, then we collectively weigh over 455 teragrams.

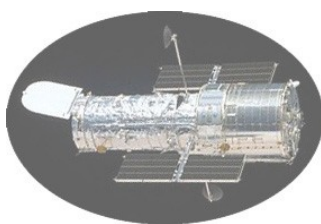
One gigagram = 1 million kilograms = 10^6 kg = 10^9 g

Symbol Gg means gigagram.

The Eiffel Tower has a mass of 10 Gg today, but weighed 11 gigagrams at its inauguration.



One megagram = 1000 kilograms = 1 t = 10^3 kg = 10^6 g



Symbol Mg means megagram.

Hubble Space Telescope has a mass of 11 megagrams.

The tonne, and its symbol t, were adopted by the CIPM in 1879. The tonne is a non-SI unit accepted for use with the International System of Units. In English-speaking countries, this unit is usually called metric ton and equals a thousand kilograms.

One kilogram = 1000 grams = 10^3 g

Symbol kg means kilogram.

A cubic decimeter is a liter and 1 kg of water precisely fills the volume of one liter. A liter cube demonstrates the relation of length, area and volume. A grid illustrates the concept that volume = height x base area. The cube can be used to relate volume and mass units. Available at MetricPioneer.com



One hectogram = 100 grams = 10^{-1} kg = 10^2 g

Symbol hg means hectogram.

About 1 hg is a typical weight of a Blue Jay.



One dekagram = 10 grams = 10^{-2} kg = 10^1 g

Symbol dag means dekagram.

American spelling is dekagram while French / British / Canadian spelling is decagram, which is often symbolized dkg in Central Europe (from local languages spelling dekagram) where it is used for usual quantities of food (mostly cheese and meat).



One gram = 10^{-3} kg

Symbol g means gram.

The gram is the most widely used unit of measurement for non-liquid ingredients in cooking and grocery shopping worldwide. A unit price is normally given per 100 g for food products that are typically sold in quantities far less than 1 kilogram. Most standards and legal requirements for nutrition labels on food products require relative contents to be stated per 100 g of the product such that the resulting figure can also be read as a percentage.

Nutritional Information		
This pack contains approx 5-6 servings		
	Per 100g serving	Per 30g serving
ENERGY	1645kJ	494kJ
	388cal	116cal
PROTEIN	10.5g	3.2g
CARBOHYDRATE	77.6g	23.3g
of which sugars	0.7g	0.2g
FAT	3.6g	1.1g
of which saturates	0.3g	0.1g
FIBRE	1.7g	0.5g
SODIUM	1.0g	0.3g
EQUIVALENT AS SALT	2.5g	0.8g

One decigram = 1 tenth of a gram = 10^{-4} kg = 10^{-1} g

Symbol dg means decigram.

A decigram is rarely used. One international carat equals two decigrams, so a diamond 5 mm wide has a mass of 1 dg and a one-carat diamond weighs two decigrams.

 0.02 Ct 1.7 mm	 0.03 Ct 2.0 mm	 0.04 Ct 2.2 mm	 0.05 Ct 2.4 mm	 0.10 Ct 3.0 mm	 0.15 Ct 3.4 mm	 0.20 Ct 3.8 mm	 0.25 Ct 4.1 mm	 0.33 Ct 4.4 mm	 0.50 Ct 5.0 mm	 0.60 Ct 5.3 mm	 0.75 Ct 5.7 mm	 0.90 Ct 6.2 mm	 1.00 Ct 6.4 mm	 1.25 Ct 6.9 mm
 1.50 Ct 7.3 mm	 1.75 Ct 7.7 mm	 2.00 Ct 8.1 mm	 2.25 Ct 8.5 mm	 2.5 Ct 8.8 mm	 2.75 Ct 9.1 mm	 3.00 Ct 9.4 mm	 3.50 Ct 10.0 mm	 4.00 Ct 10.4 mm	 4.50 Ct 10.8 mm	 5.00 Ct 11.0 mm	 5.50 Ct 11.3 mm	 6.00 Ct 11.7 mm	 7.00 Ct 12.4 mm	

One centigram = 1 hundredth of a gram = 10^{-5} kg = 10^{-2} g

Symbol cg means centigram.

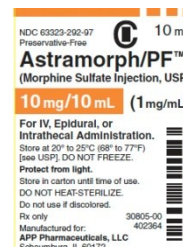
About 2 cg is a typical weight of a fly.



One milligram = 1 thousandth of a gram = 10^{-6} kg = 10^{-3} g

Symbol mg means milligram.

The pharmaceutical industry uses milligrams to weigh prescription and non-prescription medications.



One microgram = 1 millionth of a gram = 10^{-9} kg = 10^{-6} g

Symbol μ g means microgram.

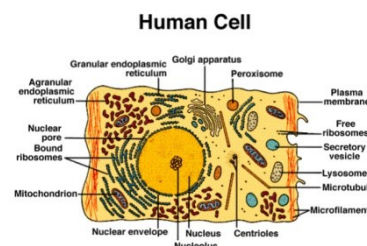
A microgram is one of the smallest units of mass (or weight) used in a macroscopic context. The symbol μ g conforms to the International System of Units and is often used in scientific literature, but the United States-based Joint Commission recommends that hospitals do not use this symbol in handwritten orders due to the risk that the symbol μ might be misread as the prefix m resulting in a thousand-fold overdose. The Joint Commission recommends the abbreviation mcg instead. The sole official abbreviation μ g remains in physical sciences academia.



One nanogram = 10^{-12} kg = 10^{-9} g

Symbol ng means nanogram.

A nanogram is obviously an extremely small amount and nanograms as units are rarely used outside of the scientific fields of microbiology, physics and chemistry. One would use nanograms to measure mass at a cellular level.

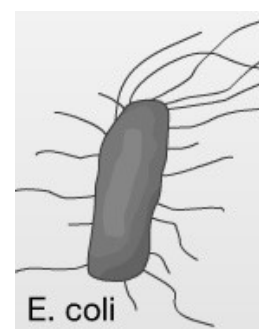


One picogram = 10^{-15} kg = 10^{-12} g

Symbol pg means picogram.

A picogram is a thousand times smaller than a nanogram. One would use picograms to measure mass at a bacterial level.

About 40 million bacterial cells typically live in a gram of soil and a million bacterial cells live in a milliliter of fresh water; about 5,000,000,000,000,000,000,000,000,000 (5×10^{30}) bacteria live on Earth forming a biomass that exceeds that of all plants and animals.

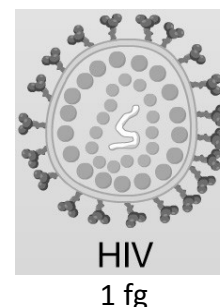


One femtogram = 10^{-18} kg = 10^{-15} g

Symbol fg means femtogram.

A femtogram is a thousand times smaller than a picogram. One would use femtograms to measure mass at a viral level.

An HIV-1 virus has a mass of about 1 fg.

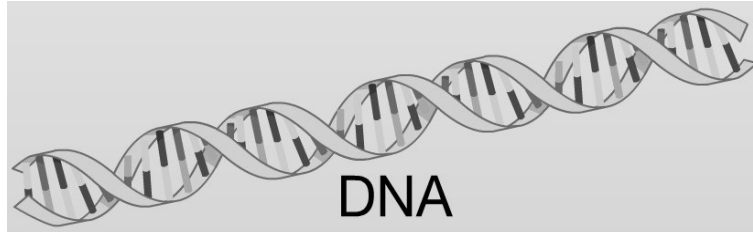


One attogram = 10^{-21} kg = 10^{-18} g

Symbol ag means attogram.

An attogram is a thousand times smaller than a femtogram. One would use attograms to measure mass at a genetic level.

A double-stranded DNA molecule consisting of 1,578 base pairs (995,000 daltons) weighs only 1.65 attograms.



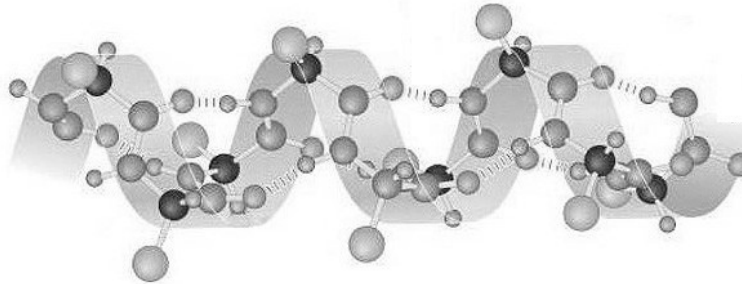
1.65 ag

One zeptogram = 10^{-24} kg = 10^{-21} g

Symbol zg means zeptogram.

A zeptogram is a thousand times smaller than an attogram. One would use zeptograms to measure mass at a molecular level.

A typical median size protein of roughly 300 amino acids weighs only 55 zeptograms.

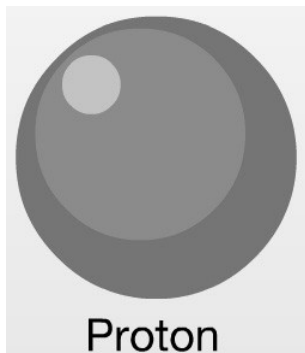


55 zg

One yoctogram = 10^{-27} kg = 10^{-24} g

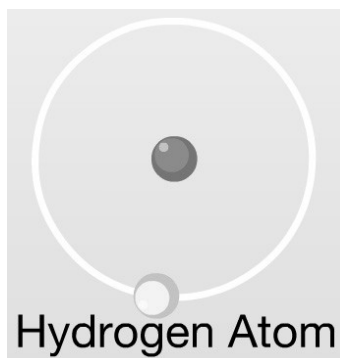
Symbol yg means yoctogram.

The smallest SI unit of mass takes us way down to what we think are fundamental particles:



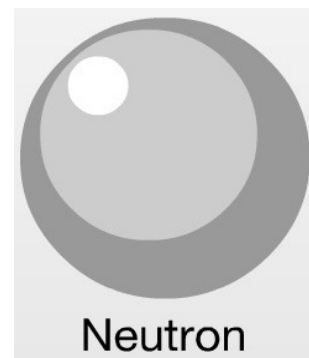
Proton

1.673 yg



Hydrogen Atom

1.674 yg



Neutron

1.675 yg

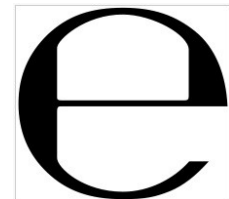
Liter

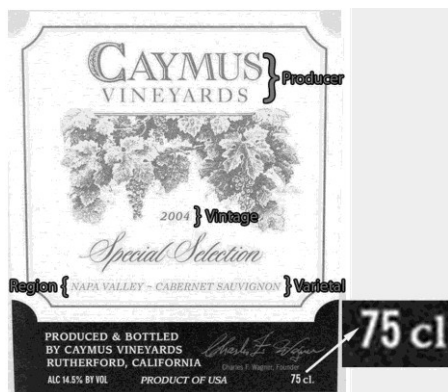
The litre or liter is a unit of volume. The liter and the symbol lower-case l were adopted by the CIPM in 1879. The alternative symbol, capital L, was adopted by the 16th CGPM in 1979 in order to avoid the risk of confusion between the letter l (el) and the numeral 1 (one). Although the liter is not an SI unit, it is accepted for use with the SI and has appeared in several versions of the Metric System. The official SI unit of volume is the cubic meter (m³). One liter is denoted as 1 cubic decimeter (dm³). The word liter is derived from an older French unit, the litron, whose name came from Greek via Latin.

One liter of water has a mass of almost exactly one kilogram when measured at its maximal density (4 °C). Similarly: 1 mL of water has about 1 g of mass because the gram was originally defined as the mass of 1 mL of water, but this definition was abandoned in 1799 because the density of water changes with temperature and, very slightly, pressure.

In many European countries, the hectoliter is the typical unit for production and export volumes of beverages (milk, beer, soft drinks, wine, et cetera) and for measuring the size of the catch and quotas for fishing boats; deciliters are common in Switzerland and Scandinavia and sometimes found in cookbooks; centiliters indicate the capacity of drinking glasses and of small bottles. In colloquial Dutch in Belgium, a vijfentwintiger and a drieëndertiger meaning twenty-fiver (25 cL) and thirty-threer (33 cL) are the common beer glasses.

The estimated sign (e) also referred to as e-mark is a mark that sometimes can be found on pre-packed goods in Europe. The e-mark indicates that the packaging is filled according to the European Directive 76/211/EEC. The scope of the directive is limited to packaging that has a predetermined nominal quantity of 5 grams to 10 kilograms or 5 milliliters to 10 liters. The e-mark indicates that the average quantity of product in a batch of packages shall not be less than the nominal quantity stated on the label et cetera.





Bottles may also be 75 cL or half size at 37.5 cL for artisanal brews or 70 cL for wines or spirits. Cans come in 25 cL and 33 cL and 50 cL also known as 0.5 L. Family size bottles as for soft drinks or drinking water use the liter (0.5 L or 1 L or 1.5 L or 2 L) as well as beer barrels (50 L or the half-sized 25 L). This unit is most common for all other household size containers of liquids from thermocans to buckets to bath tubs as well as for fuel tanks and consumption for heating or by vehicles.

For decades wine and distilled spirits have been exclusively measured in metric units in the United States; 750 mL is the most common size.

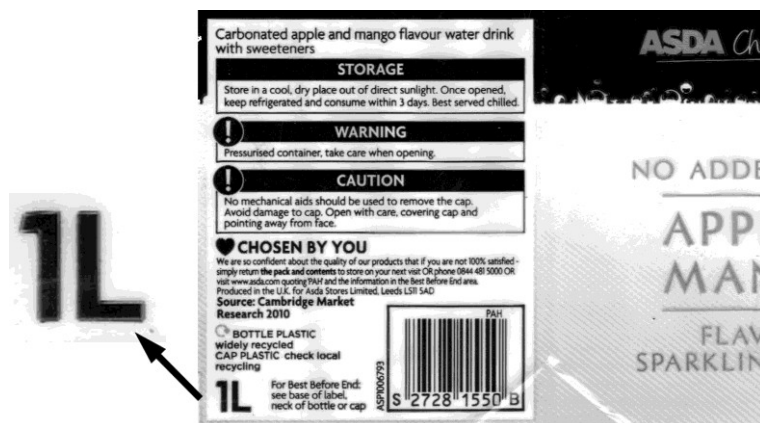
In countries where the Metric System was adopted as the official measuring system after the SI standard was established, common usage more closely follow contemporary SI conventions. For example, in Canada, where the SI is now in widespread use, consumer beverages are labeled almost exclusively using liters and milliliters.



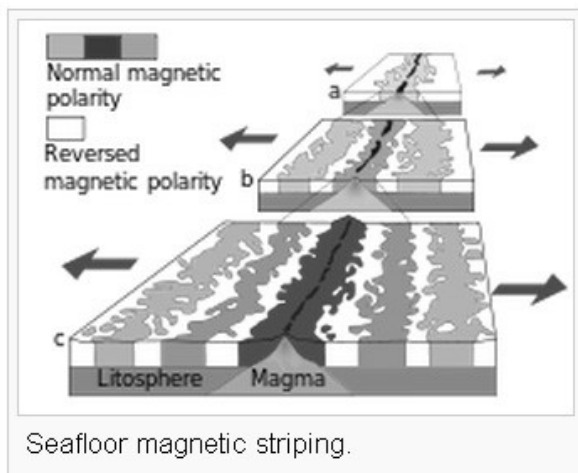
Hectoliters sometimes appear in industry, but centiliters and deciliters are rarely, if ever, used. Larger volumes are usually given in cubic meters, equivalent to 1 kL (one kiloliter), or thousands or millions of cubic meters. The situation is similar in Australia, although kiloliters, megaliters and gigaliters are commonly used for measuring water consumption, reservoir capacities and river flows.

For larger volumes of fluids, such as annual consumption of tap water, lorry (truck) tanks, or swimming pools, the cubic meter is the general unit. The cubic meter is also generally used for all volumes of a non-liquid nature.

Fluid flow rates may be measured in liters per unit time interval (second, minute, hour, et cetera).



Speed

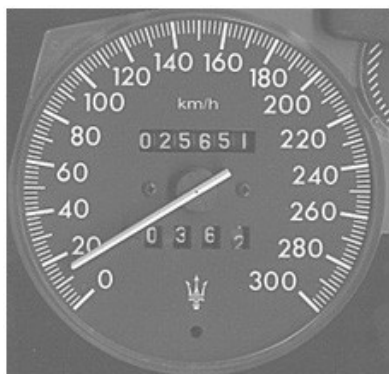


The lithosphere is broken up into tectonic plates. In the case of Earth, there are eight major and many minor plates.

The lithospheric plates ride on the asthenosphere. These plates move in relation to one another at one of three types of plate boundaries.

The lateral movement of the plates is typically at speeds of 50 to 100 mm annually, which is about 1.5 to 3 nm (nanometers) per second.

Human fingernails grow at the rate of about one nanometer per second.



A French speed limit sign says it all: Maximum speed 130 kilometers per hour when weather is nice but reduce speed to 110 kilometers per hour when weather conditions increase risk.

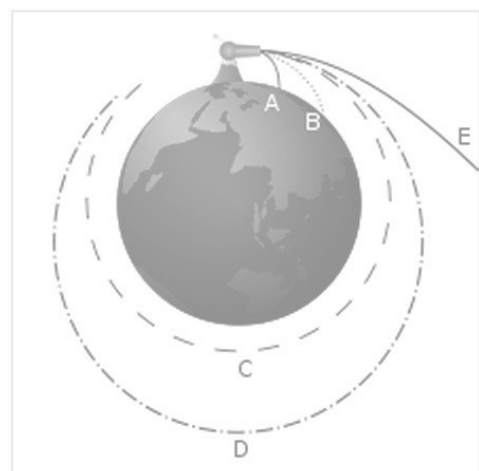
It sure would be nice to rid ourselves of dual-measurements on our speedometers! We only need kilometers.

We measure fuel efficiency by liters per 100 kilometers = L/100 km.

Escape velocity from Earth surface is about 11.2 kilometers per second, which is approximately 34 times the speed of sound (Mach 34).

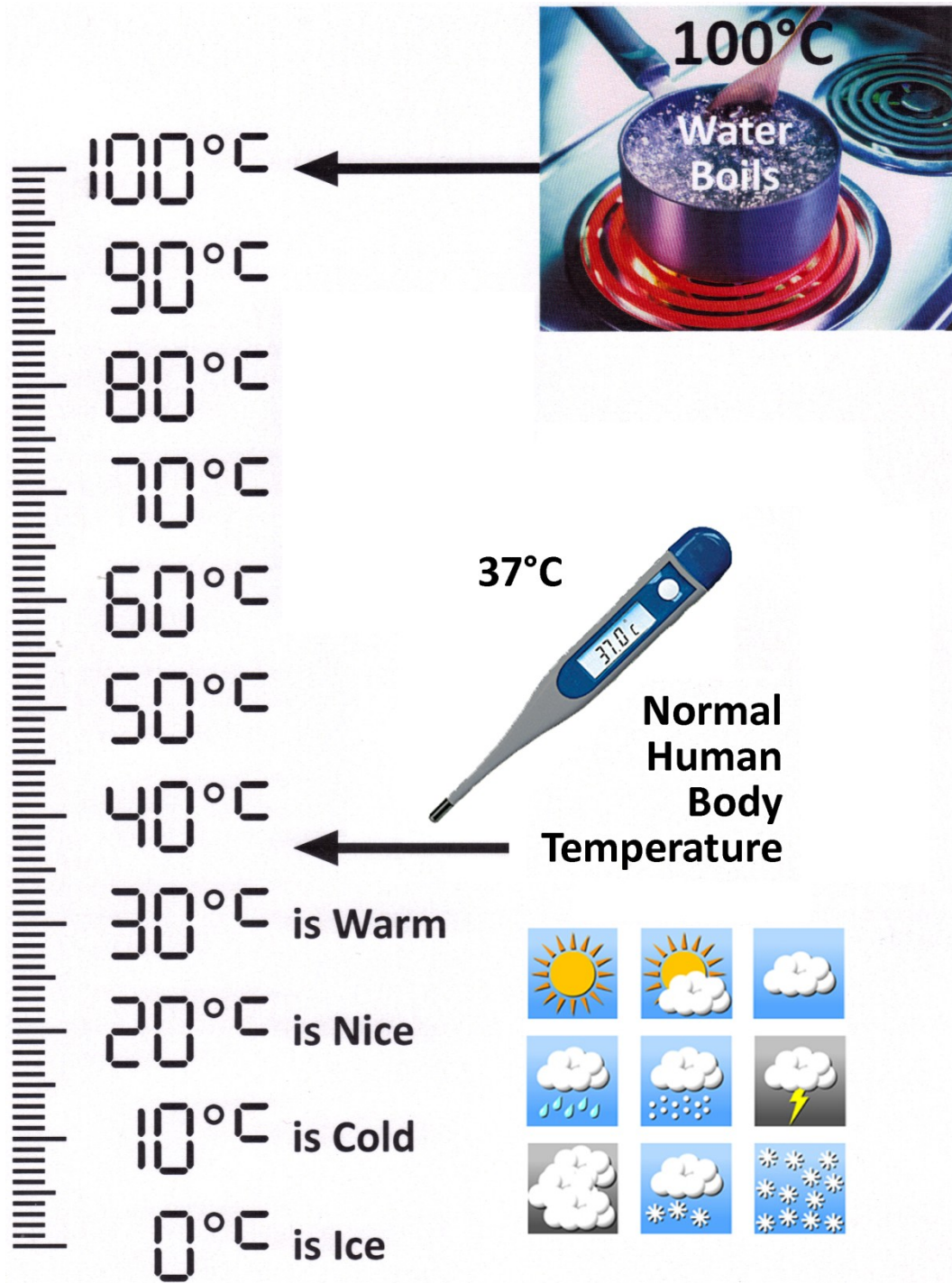
The speed of sound is the distance travelled during a unit of time by a sound wave propagating through an elastic medium. In dry air at 20 °C the speed of sound is 343.2 meters per second. This is 1,236 kilometers per hour or about one kilometer in three seconds.

In fluid dynamics, the speed of sound in a fluid medium (gas or liquid) is used as a relative measure of speed itself. The speed of an object (in distance per time) divided by the speed of sound in the fluid is called the Mach number. Objects moving at speeds greater than Mach 1 are traveling at supersonic speeds.



Celsius

Celsius (also known as centigrade) is a temperature scale that is named after the Swedish astronomer Anders Celsius (1701–1744). In everyday life, we measure temperature in degrees Celsius. For scientific measurements, or for very hot or cold things, we may use kelvin (such as for the temperature of the sun or of liquid helium). The kelvin (K) is like Celsius, but shifted so that zero is at absolute zero instead of the freezing point of water. Water freezes at 273.15 K (kelvin).




Resources

Instantly convert between units of measurement; for example, I wonder how many decigrams a carat weighs or it would be nice to know for sure how long an angstrom is.

OnlineConversion.com makes unit conversions quick and easy:

Welcome to OnlineConversion.com
All Weight and Mass Conversions

Convert what quantity? 

From:

carat [international]

carat [metric]

carat [UK]

carat [pre-1913 US]

carga [Mexico]

catti [China]

catti [Japan]

catty [China]

catty [Japan, Thailand]

cental

To:

chin [Japan]

clove

crith

dalton

dan [China]


dan [Japan]

decigram


decitonne


dekagram



dekatonne

Result:  See Also: [Common Weight Conversions](#) | [Metric Mass Conversions](#)

ConvertCenter.com makes unit conversions quick and easy:

 **CONVERT CENTER**
Instantly Convert Between Units of Measurement. Web Site Makes Unit Conversions Quick and Easy

Distance and Length Units Conversion 

Convert from **angstrom**  to **nanometer** 

Metric

angstrom (Å)

centimeter (cm)

decimeter (dm)

kilometer (km)

meter (m)

micrometer (µm)

millimeter (mm)

nanometer (nm)

British and U.S.

yard (yd)

Metric

angstrom (Å)

centimeter (cm)

decimeter (dm)

kilometer (km)

meter (m)

micrometer (µm)

millimeter (mm)

nanometer (nm)

British and U.S.

yard (yd)

Value

☒ Format result

1 angstrom = 0.1 nanometer

Direct Link

Your cell phone probably has a unit converter among the tools



Visit NIST.gov for the latest National Institute of Standards and Technology publications.



Visit Metric.org for the latest from the US Metric Association (USMA), Inc., a national non-profit organization that was founded in 1916 and advocates completing United States conversion to the SI (International System of units).



Visit unc.edu/~rowlett/units for A Dictionary of Units of Measurement.



Read the Oxford Dictionary of Weights, Measures and Units

Visit ISO.org for the latest from the International Organization for Standardization.



Visit MetricPioneer.com where you can:

- Shop for metric-only stuff like rulers, measuring tapes and this publication
- Take the Terran System Exam
- See the flags and local spelling of other nations and when they adopted SI
- Get a free Progress Checklist as you work toward becoming a Metric Pioneer
- Pledge your efforts toward undergoing personal metrication