

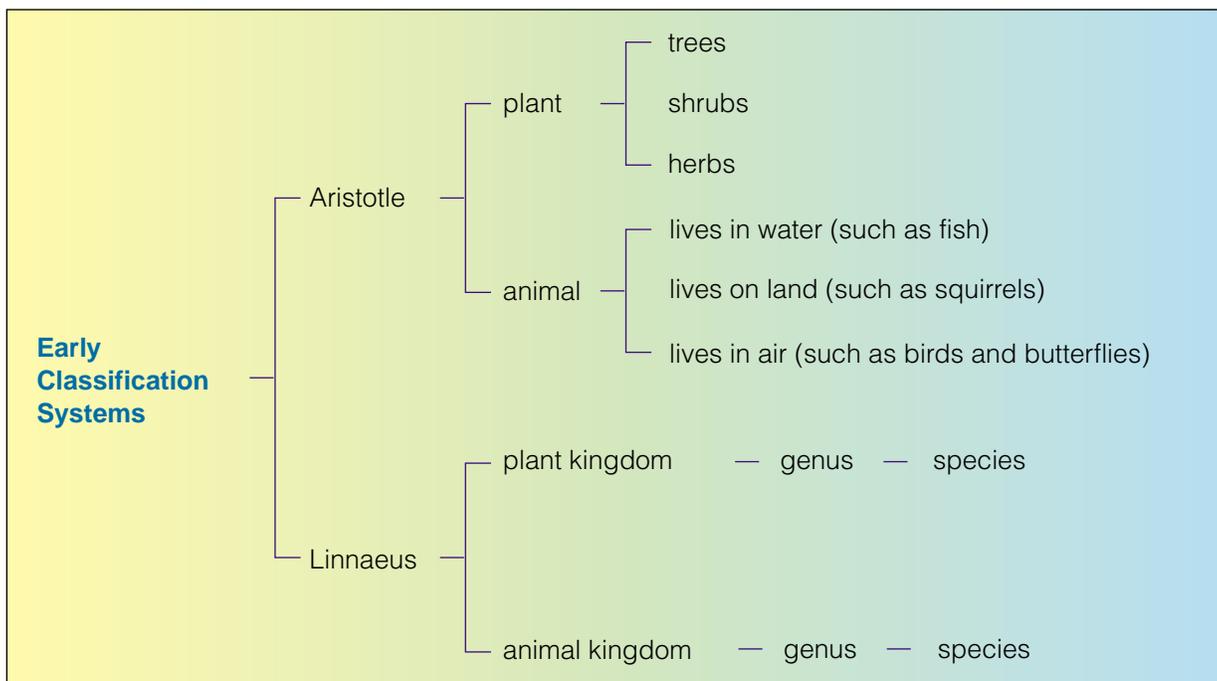
A

Classifying Living Things

Over 2000 years ago, the Greek philosopher Aristotle developed a system of classification that grouped organisms according to whether they were plant or animal. Scientists used Aristotle's system for hundreds of years, but as they discovered more and more living things, the system did not work well because it did not show probable relationships between similar organisms.

In 1735, Carolus Linnaeus produced a new system that also classified all organisms as plant or animal, but this new system was very different in other ways from Aristotle's system.

Linnaeus' system gives a two-word name to each type of organism. This system of naming organisms is still in use today. The two-word name is called the organism's scientific name, and it is given in Latin, a language that is no longer spoken. The first word of the organism's name is its genus, and the second word is its specific name. A **genus** is a group of organisms that are very similar. A **species** is the smaller, more limiting classification grouping. The Canada lynx, shown on the right, and the bobcat, shown on the left, are members of the same genus, *Lynx*, but they are considered different species. The lynx is the species *Lynx canadensis* and the bobcat is *Lynx rufus*.



In the 1900s, as knowledge about the great diversity of organisms on Earth exploded, it became clear that separating organisms into only two kingdoms, plant and animal, was inadequate. For example, bacteria are just too different from either plants or animals to be grouped with either. Likewise, fungi such as bread mould, yeast, and the many kinds of mushrooms are very different from plants and animals. Influential scientists like Robert Whittaker and Lynn Margulis supported the idea that new criteria for classifying organisms were needed. Thus, since the 1960s, a system that classifies organisms into five different kingdoms, still using Linnaeus' basic system at its roots, is largely accepted and used. The organisms and their kingdoms are shown in the table below.

Life's Five Kingdoms

	Monera	Protista	Fungi	Plant	Animal
Number of cells	One-celled	One- and many-celled	One- and many-celled	Many-celled	Many-celled
Movement	Some move	Some move	Don't move	Don't move	Move
Nutrition	Some members make their own food; others obtain it from other organisms.	Some members make their own food; others obtain it from other organisms.	All members obtain food from other organisms.	Members make their own food.	Members eat plants or other organisms.



B

PERIODIC TABLE OF THE ELEMENTS

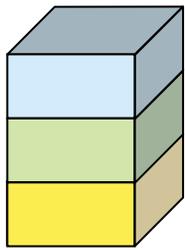
1	Hydrogen 1 H 1.008								
2	Lithium 3 Li 6.941	Beryllium 4 Be 9.012							
3	Sodium 11 Na 22.990	Magnesium 12 Mg 24.305							
4	Potassium 19 K 39.098	Calcium 20 Ca 40.078	Scandium 21 Sc 44.956	Titanium 22 Ti 47.88	Vanadium 23 V 50.942	Chromium 24 Cr 51.996	Manganese 25 Mn 54.938	Iron 26 Fe 55.847	Cobalt 27 Co 58.933
5	Rubidium 37 Rb 85.468	Strontium 38 Sr 87.62	Yttrium 39 Y 88.906	Zirconium 40 Zr 91.224	Niobium 41 Nb 92.906	Molybdenum 42 Mo 95.94	Technetium 43 Tc 97.907	Ruthenium 44 Ru 101.07	Rhodium 45 Rh 102.906
6	Cesium 55 Cs 132.905	Barium 56 Ba 137.327	Lanthanum 57 La 138.906	Hafnium 72 Hf 178.49	Tantalum 73 Ta 180.948	Tungsten 74 W 183.85	Rhenium 75 Re 186.207	Osmium 76 Os 190.2	Iridium 77 Ir 192.22
7	Francium 87 Fr 223.020	Radium 88 Ra 226.025	Actinium 89 Ac 227.028	Rutherfordium 104 Rf (261)	Dubnium 105 Db (262)	Seaborgium 106 Sg (263)	Bohrium 107 Bh (262)	Hassium 108 Hs (265)	Meitnerium 109 Mt (266)

Lanthanide Series

Cerium 58 Ce 140.115	Praseodymium 59 Pr 140.908	Neodymium 60 Nd 144.24	Promethium 61 Pm 144.913	Samarium 62 Sm 150.36	Europium 63 Eu 151.965
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Actinide Series

Thorium 90 Th 232.038	Protactinium 91 Pa 231.036	Uranium 92 U 238.029	Neptunium 93 Np 237.048	Plutonium 94 Pu 244.064	Americium 95 Am 243.061
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Metal
Metalloid
Nonmetal

- Gas
 - Liquid
 - Solid
 - Synthetic Elements
- (At room temperature and pressure)

			13	14	15	16	17	18	
			Boron 5 B 10.811	Carbon 6 C 12.011	Nitrogen 7 N 14.007	Oxygen 8 O 15.999	Fluorine 9 F 18.998	Helium 2 He 4.003	
			Aluminum 13 Al 26.982	Silicon 14 Si 28.086	Phosphorus 15 P 30.974	Sulfur 16 S 32.066	Chlorine 17 Cl 35.453	Neon 10 Ne 20.180	
10	11	12							Argon 18 Ar 39.948
Nickel 28 Ni 58.693	Copper 29 Cu 63.546	Zinc 30 Zn 65.39	Gallium 31 Ga 69.723	Germanium 32 Ge 72.61	Arsenic 33 As 74.922	Selenium 34 Se 78.96	Bromine 35 Br 79.904	Krypton 36 Kr 83.80	
Palladium 46 Pd 106.42	Silver 47 Ag 107.868	Cadmium 48 Cd 112.411	Indium 49 In 114.82	Tin 50 Sn 118.710	Antimony 51 Sb 121.757	Tellurium 52 Te 127.60	Iodine 53 I 126.904	Xenon 54 Xe 131.290	
Platinum 78 Pt 195.08	Gold 79 Au 196.967	Mercury 80 Hg 200.59	Thallium 81 Tl 204.383	Lead 82 Pb 207.2	Bismuth 83 Bi 208.980	Polonium 84 Po 208.982	Astatine 85 At 209.987	Radon 86 Rn 222.018	
(unnamed) 110 Uun	(unnamed) 111 Uuu	(unnamed) 112 Uub			(unnamed) 114 Uuq				

Gadolinium 64 Gd 157.25	Terbium 65 Tb 158.925	Dysprosium 66 Dy 162.50	Holmium 67 Ho 164.930	Erbium 68 Er 167.26	Thulium 69 Tm 168.934	Ytterbium 70 Yb 173.04	Lutetium 71 Lu 174.967
Curium 96 Cm 247.070	Berkelium 97 Bk 247.070	Californium 98 Cf 251.080	Einsteinium 99 Es 252.083	Fermium 100 Fm 257.095	Mendelevium 101 Md 258.099	Nobelium 102 No 259.101	Lawrencium 103 Lr 260.105

C

Properties of Common Substances

KEY TO SYMBOLS:

Common names of substances are enclosed in parentheses.

(*) Water solution of a pure substance

(e) Element

(c) Compound

(n) Not a pure substance

Name	Formula	Melting point (°C)	Boiling point (°C)	Density (g/cm ³ or g/mL)	
acetic acid (vinegar) (c)	CH ₃ COOH	16.6	118.1	—	
alcohol (see ethanol) (c)					
aluminum (e)	Al	659.7	2519	2.7	
aluminum oxide (alumina) (c)	Al ₂ O ₃	2015	—	—	
ammonia (c)	NH ₃	-77.8	-33.4	less dense than air	
ammonium nitrate (c)	NH ₄ NO ₃	169.6	210		
antimony (e)	Sb	631	1587	6.70	
argon (e)	Ar	-189	-185	denser than air	
arsenic (e)	As	—	—	5.727 (grey) 4.25 (black) 2.0 (yellow)	
barium (e)	Ba	727	1897	3.62	
berkelium (e)	Bk	1050	—	14.78	
beryllium (e)	Be	1280	2471	1.85	
bismuth (e)	Bi	271	1560	9.7	
boron (e)	B	2075	4000	2.37 (brown) 2.34 (yellow)	
bromine (e)	Br	-7.2	58.8	3.12	
calcium (e)	Ca	845	1484	1.55	
calcium carbonate (limestone) (c)	CaCO ₃	decomposes at 900°C	—	2.93	
calcium hydroxide (slaked lime) (c)	Ca(OH) ₂	decomposes at 522°C	—	2.24	
calcium oxide (lime) (c)	CaO	2580	2850	3.3	
carbon (diamond) (e)	C	3500	4827	3.51	
carbon (graphite) (e)	C	3652-3697	4827	2.25	
carbon dioxide (c)	CO ₂	—	—	—	
chlorine (e)	Cl ₂	-101.6	-34.6	denser than air	
chromium (e)	Cr	1907	2671	7.2	
cobalt (e)	Co	1480	2927	8.9	
copper (e)	Cu	1084	2562	8.95	
copper (II) nitrate (c)	Cu(NO ₃) ₂	—	—	—	
copper (II) sulfate (bluestone) (c)	CuSO ₄ ·5H ₂ O	decomposes at 150°C	—	2.28	
diamond (see carbon) (e)					
ethanol (ethyl alcohol) (c)	C ₂ H ₅ OH	-114.5	78.4	0.789	
ethylene (ethene) (c)	C ₂ H ₄	-169	-103.9	—	
fluorine (e)	F ₂	-270	-188	—	
gold (e)	Au	1063	2856	19.3	
glucose (c)	C ₆ H ₁₂ O ₆	146	decomposes before it boils	1.54	
graphite (see carbon) (e)					
helium (e)	He	-272.2	-268.93	—	
hematite (c)	Fe ₂ O ₃	1565	—	5.24	

DEFINITIONS:

deliquescent — able to absorb water from the air to form a concentrated solution

sublime — to form a vapour directly from a solid

Appearance (at room temperature: 20°C)	Comments
colourless liquid with pungent smell	used in the manufacture of cellulose ethanoate; vinegar is a 5–7 percent solution in water
silver-white metal	used in aircraft, cooking utensils, and electrical apparatus
white, crystalline substance	used in refining of aluminum and in cement
very soluble gas with pungent smell	used as refrigerant and in manufacture of resins, explosives, and fertilizers
white, soluble, crystalline salt	used in explosives and as a fertilizer
silver-grey solid	used in infra-red detectors
inert gas	used in electric lights
grey, black, or yellow solid	used in semiconductors and alloys; compounds are very poisonous and are used in medicine and as pesticides
silver-white solid	used in X-ray diagnosis
—	—
hard, white metal	used for corrosion-resistant alloys
brittle, white, crystalline metal with reddish tinge	used in alloys, catalysts, nuclear reactors; compounds used in medicine
brown amorphous powder or yellow crystals	used for hardening steel and for producing enamels and glasses
red-brown liquid	liquid causes severe chemical burns; vapour is harmful to lungs; used to make certain pain-relieving drugs
soft, white metal that tarnishes easily	very abundant; essential to life
white solid	main ingredient in chalk, marble
white solid	aqueous solution used to test for CO ₂
white solid	used in cement and to mark lines on playing fields
colourless, solid crystals	very hard; used for drilling through rock
grey-black solid	very soft; used in lubricants, pencil leads, electrical apparatus
colourless gas with a faint tingling smell and taste	does not support combustion and is denser than air; used in fire extinguishers and as a refrigerant at –78.5°C
green gas	poisonous; used to kill harmful organisms in water
shiny, silvery solid	very hard metal; used to make stainless steel
hard, silver-white, magnetic metal	used in alloys; compounds used to produce the colour blue in glass and ceramics
shiny, reddish solid	soft metal; good conductor of heat
blue, solid crystals	used in pesticides
colourless liquid	derived from fermentation of sugar; used as solvent or fuel; found in wine
colourless, flammable gas with a sweetish smell	made from petroleum; used in manufacture of ethanol and other organic chemicals
greenish yellow gas	similar to chlorine
shiny, yellow solid	very soft metal; highly resistant to tarnishing
white solid	simple sugar; human body converts most sugars and starches to glucose
nonflammable inert gas	used as refrigerant; provides inert atmosphere for welding; used to fill air ships and balloons
rusty red colour	found in iron ore; rusty iron

Name	Formula	Melting point (°C)	Boiling point (°C)	Density (g/cm ³ or g/mL)	
hydrochloric acid (*)	HCl	varies	varies	varies	
hydrogen (e)	H ₂	-259	-253	much less dense than air	
hydrogen peroxide (c)	H ₂ O ₂	-0.4	150.2	1.45	
iodine (e)	I	114	184	4.95	
iron (e)	Fe	1535	2861	7.86	
lead (e)	Pb	327.4	1750	11.34	
lead (II) nitrate (c)	Pb(NO ₃) ₂	—	—	—	
limestone (see calcium carbonate)					
lithium (e)	Li	179	1340	0.534	
magnesium (e)	Mg	651	1107	1.74	
magnesium chloride (c)	MgCl ₂	708	1412	2.3	
magnetite (c)	Fe ₃ O ₄	—	—	5.18	
manganese (e)	Mn	1246	2061	7.43	
mercury (e)	Hg	-38.9	356.6	13.6	
methane (c)	CH ₄	-182.5	-161.5	—	
molybdenum (e)	Mo	2623	4679	10.28	
neon (e)	Ne	-248	-246	—	
nickel (e)	Ni	1455	2913	8.90	
nitrogen (e)	N ₂	-209.9	-195.8	slightly less dense than air	
nitrogen dioxide (c)	NO ₂	—	—	—	
oxygen (e)	O ₂	-218	-183	slightly denser than air	
ozone (e)	O ₃	-192.5	-112	denser than air	
phosphorus (e)	P	44 —	280 —	1.82 (white) 2.20 (red)	
platinum (e)	Pt	1769	3824	21.41	
polyethylene (polythene) (c)	(C ₂ H ₄) _n	—	—	—	
potassium (e)	K	63.5	759	0.86	
propane (c)	C ₃ H ₈	—	-42.17	—	
selenium (e)	Se	217	684.9	4.81	
silicon (e)	Si	1410	3265	2.33	
silicon dioxide (silica) (c)	SiO ₂	1600	—	—	
silver (e)	Ag	961	2212	10.5	
sodium (e)	Na	97.5	892	0.971	
sodium chloride (table salt) (c)	NaCl	801	1465	2.16	
sodium fluoride (c)	NaF	988	1695	2.56	
steel (n)	varies	varies	varies	varies	
strontium (e)	Sr	777	1412	2.6	
sucrose (sugar) (c)	C ₁₂ H ₂₂ O ₁₁	170	decomposes at 186°C	1.59	
sulfur (brimstone) (e)	S	112.8	444.6	2.07	
technetium (e)	Tc	2157	4265	11.5	
tellurium (e)	Te	450	990	6.25	
tin (e)	Sn	231.9	2602	7.31	
titanium (e)	Ti	1666	3287	4.5	
tungsten (e)	W	3422	5555	19.25	
uranium (e)	U	1130	4131	19.05	
water (c)	H ₂ O	0	100	1.00	
xenon (e)	Xe	-111.9	-107.1	—	
zinc (e)	Zn	419	907	7.14	
zirconium (e)	Zr	1852	4400	6.51	

Appearance (at room temperature: 20°C)	Comments
colourless liquid	corrosive acid; properties vary according to concentration
colourless gas	highly flammable; liquid form is used as rocket fuel
colourless liquid	thick and syrupy when pure; an antiseptic
violet-black, solid crystals	crystals sublime readily to form poisonous violet vapour
shiny, silver solid	rusts readily; soft when pure
shiny, blue-white solid	soft metal; forms poisonous compounds
white or colourless crystals	easily decomposed by heat; soluble in water
silver-white metal (least dense solid known)	used in alloys; its salts have various medical uses
light, silvery white metal that tarnishes easily in air	used in alloys, photography; compounds used in medicine; essential to life
white, deliquescent substance	
shiny, black crystalline solid	strongly magnetic
grey-white solid	used in alloys with special magnetic properties
shiny, silvery liquid	only liquid metal; forms poisonous compounds
odourless, flammable gas formed from decaying organic matter	main constituent in natural gas
silver-white solid	used in high-strength steel alloys
colourless, odourless gas	discharge of electricity at low pressures through neon produces an intense orange-red glow
silvery white, magnetic metal that resists corrosion	used for nickel plating, coinage, in alloys, and as a catalyst
colourless gas	will not burn or support burning; makes up 80 percent of air
brown gas	causes reddish brown colour in smog
colourless gas	must be present for burning to take place; makes up 20 percent of air
bluish gas	used for purifying air and water and in bleaching; atmospheric layer blocks most of Sun's ultraviolet light
dark red powder white, waxy, luminous in the dark	highly poisonous, flammable nonpoisonous, less flammable; compounds used in fertilizers and detergents; occurs only in combined state, mainly calcium phosphate $\text{Ca}_3(\text{PO}_4)_2$; essential to life
silver-white solid	used in jewellery; alloyed with cobalt, used in pacemakers
tough, waxy, thermoplastic material	polymer of ethylene; used as insulating material; flexible and chemically resistant
silvery white, soft, highly reactive, alkali metal	essential to all life; found in all living matter; salts used in fertilizers
colourless gas	flammable; used as fuel
non-metal resembling sulfur; silvery grey, crystalline solid	used in manufacture of rubber and ruby glass; used in photoelectric cells and semiconductors
steel-grey metalloid similar to carbon in its chemical properties	used in pure form in semiconductors and alloys and in the form of silicates in glass
hard, granular powder; insoluble in water	main constituent of sand; used in clocks and watches as quartz
shiny, white solid	soft metal; best known conductor of electricity
soft, silvery-white metal; very reactive	used in preparation of organic compounds, as coolant, and in some types of nuclear reactors
white, crystalline solid	used to season or preserve foods
colorless, crystalline substance	used in water fluoridation and as an insecticide
metallic grey solid	alloys of iron with carbon and other elements; widely used as structural materials
silver-white solid	used in the manufacture of colour television tubes
white solid	made from sugar cane or sugar beets
yellow solid	used to make dyes, pesticides, and other chemicals
silver-grey solid	used in gamma ray diagnosis of bone abnormalities
silver-white solid	used in semiconductors
shiny, slightly yellow solid	soft metal; rust resistant
lustrous white solid	alloys are widely used in the aerospace industry
grey-white solid	used in light bulb filaments
metallic grey solid	used as a nuclear fuel (usually converted into plutonium)
colourless liquid	good solvent for non-greasy matter
inert gas	used in fluorescent tubes and light bulbs
hard, bluish-white metal	used in alloys such as brass and galvanized iron
silver-white solid	used in the chemical industry as anti-corrosive material