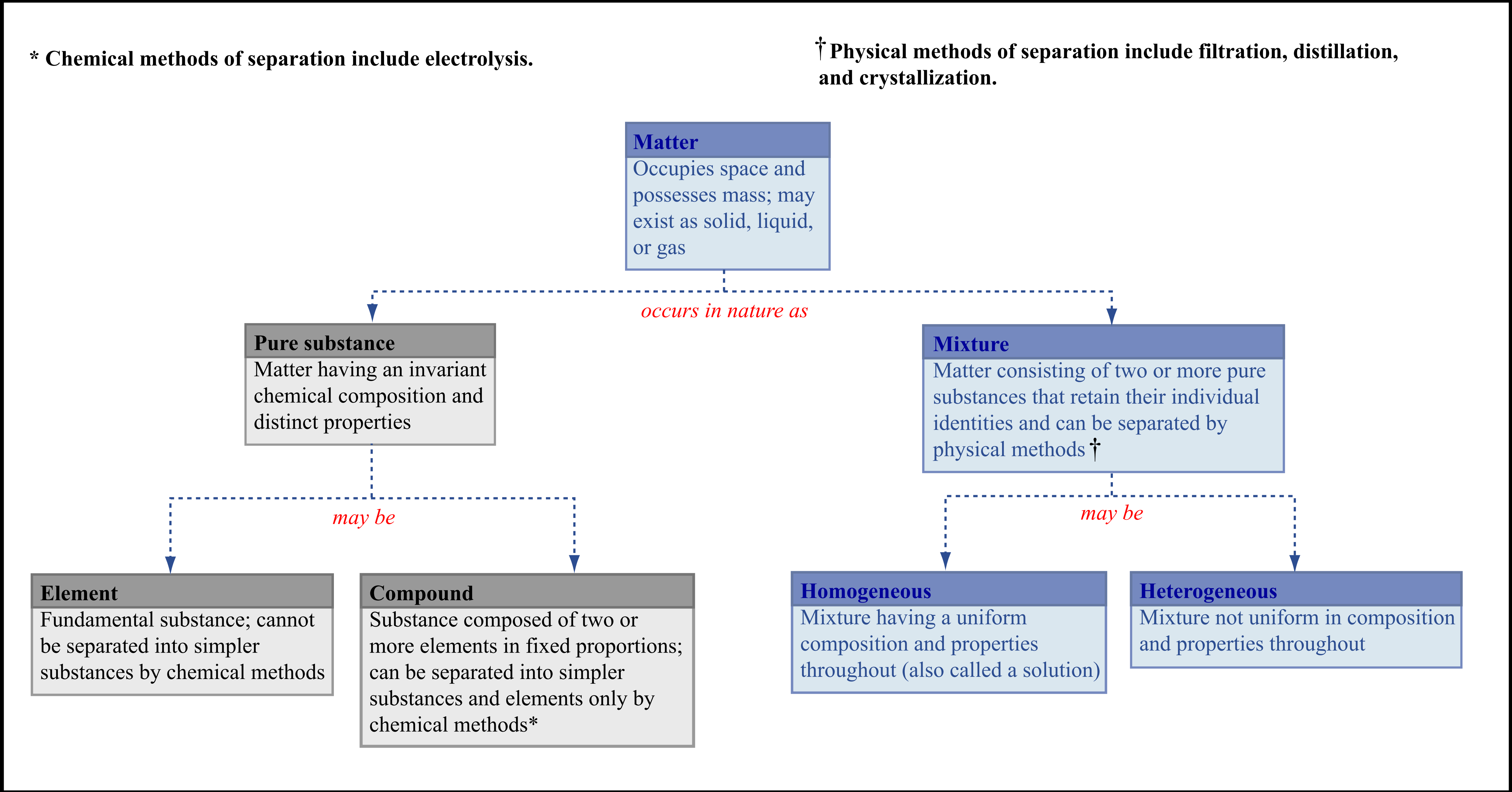
Welcome to 3.091

Lecture 25

November 9, 2009

Introduction to Aqueous Solutions

Figure 1.11



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types of solutions

solute	solvent	example
solid	liquid	brine (NaCl ☞ H_2O)
liquid	liquid	wine (EtOH ☞ H_2O)
gas	liquid	seltzer (CO_2 ☞ H_2O)
gas	gas	air (O_2, Ar, CO_2... ☞ N_2)
solid	solid	metal alloy (C ☞ Fe) doped semiconductor (B ☞ Si) stabilized ceramic (CaO ☞ ZrO_2) modified glass (Na_2O ☞ SiO_2)
liquid	solid	amalgam (Hg ☞ Ag)
gas	solid	intercalation (H_2 ☞ $LaNi_5$)

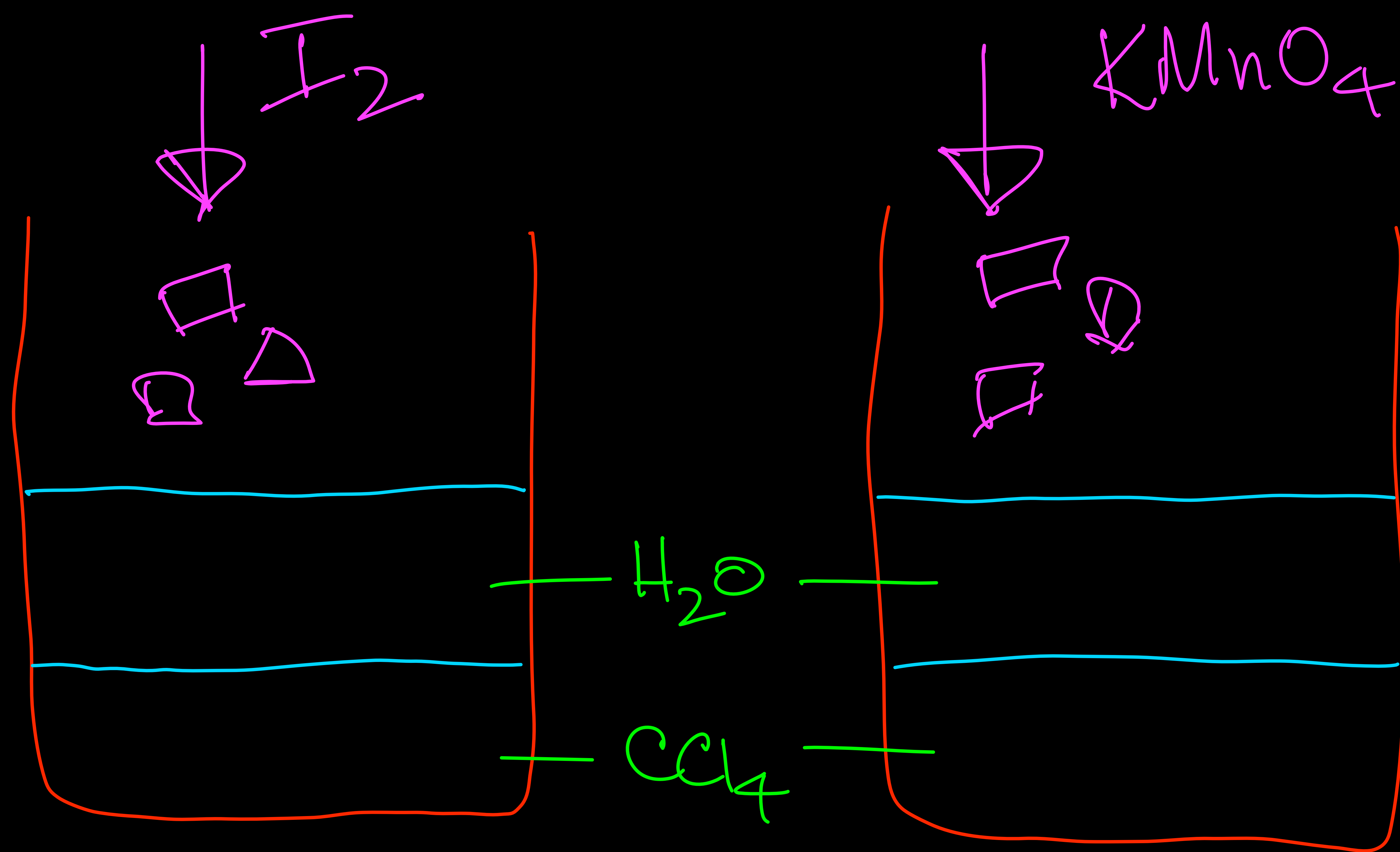
classify liquid mixtures by particle size

	ϕ (nm)	example	light	filter	settle
solution	< 2	brine	+	–	–
*colloid	2↔1000	milk	±	±	–
suspension	>1000	blood	–	+	+

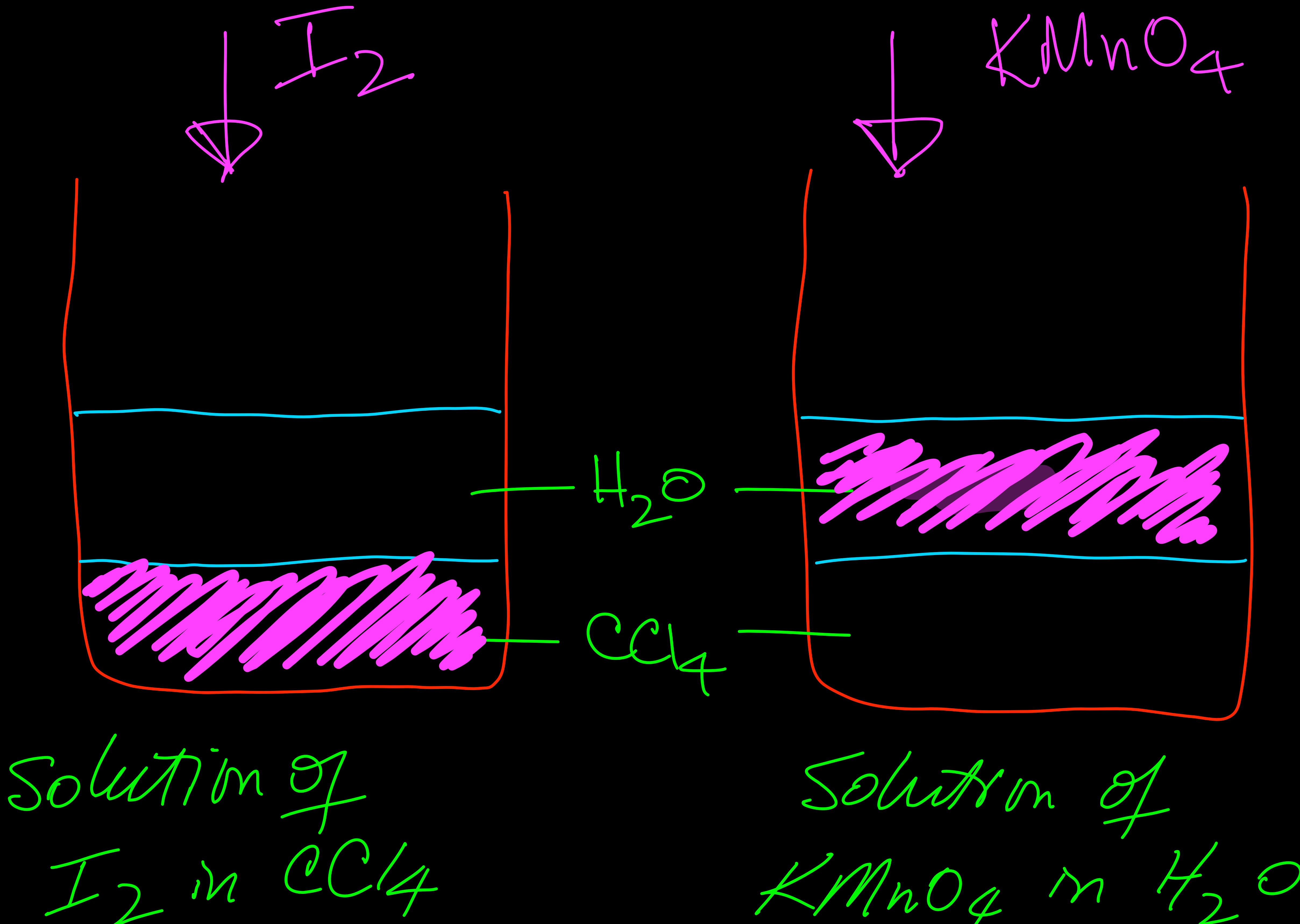
dispersion

taxonomy of colloids

dispersed phase	dispersion medium	name	example
solid	liquid	sol	jelly
liquid	liquid	emulsion	milk, mayo
gas	liquid	foam	meringue, whipped cream
solid	gas	aerosol	soot
liquid	gas	aerosol	fog, hair spray
solid	solid	solid sol	cranberry glass
liquid	solid	solid emulsion	butter
gas	solid	solid foam	pumice



I_2
$KMnO_4$
H_2O
CCl_4



I_2
$KMnO_4$
H_2O
CCl_4
Solution of I_2 in CCl_4
Solution of $KMnO_4$ in H_2O

Solubility Rules for Ionic Compounds in Water

Soluble Ionic Compounds

The Na^+ , K^+ , and NH_4^+ ions form *soluble ionic compounds*. Thus, NaCI, KNO_3, and $(NH_4)_2CO_3$ are *soluble ionic compounds.*

The nitrate ion (NO_3^-) forms *soluble ionic compounds*. Thus, $Cu(NO_3)_2$ and $Fe(NO_3)_3$ are soluble.

The chloride (Cl^-), bromide (Br^-), and iodide (I^-) ions usually form *soluble ionic compounds*. Exceptions include ionic compounds of the Pb^{2+}, Hg_2^{2+}, Ag^+, and Cu^+ ions. $CuBr_2$ is soluble, but CuBr is not.

The sulfate ion (SO_4^{2-}) usually forms *soluble ionic compounds*. Exceptions include $BaSO_4$, $SrSO_4$, and $PbSO_4$, which are insoluble, and Ag_2SO_4, $CaSO_4$, and Hg_2SO_4, which are slightly soluble.

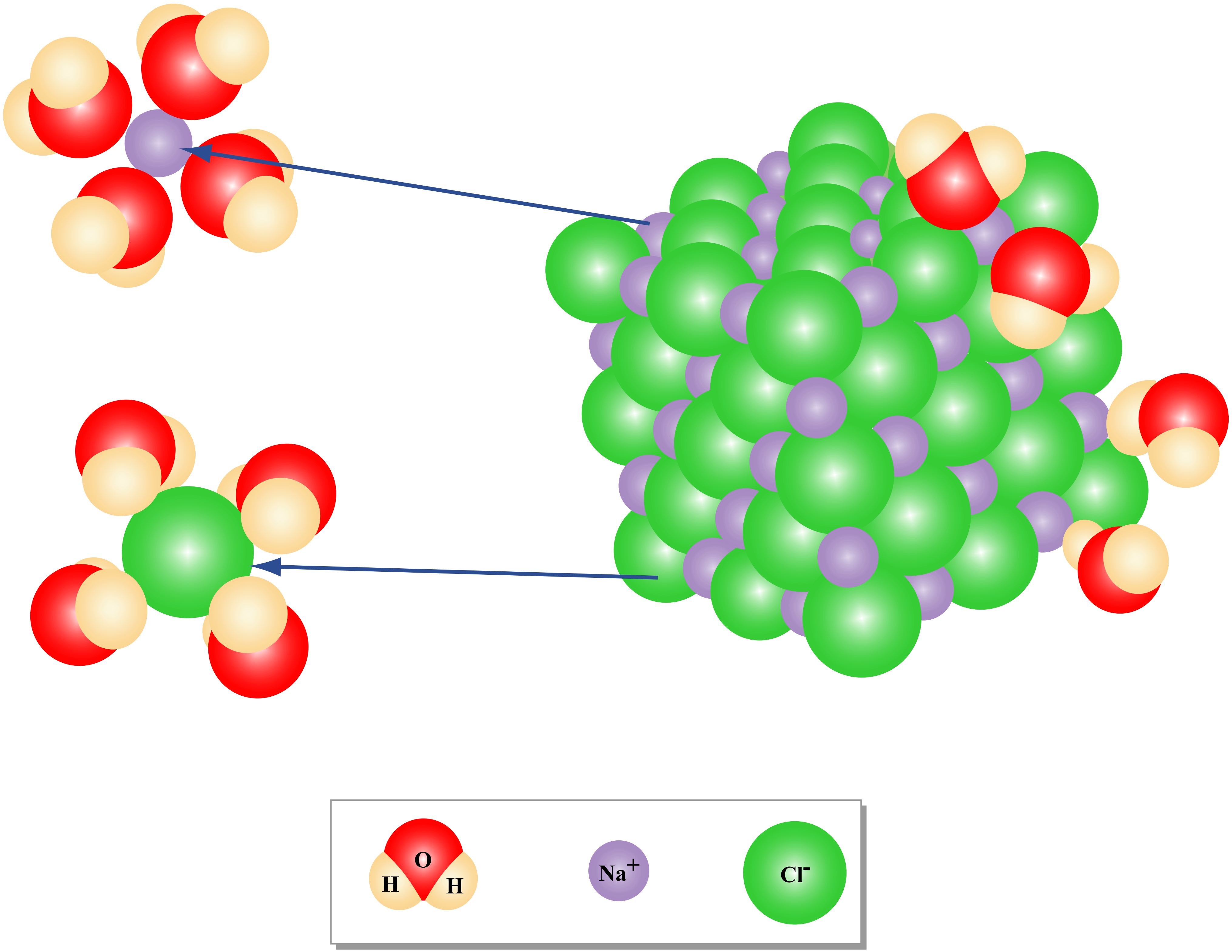
Insoluble Ionic Compounds

Sulfides (S^{2-}) are usually *insoluble*. Exceptions include Na_2S, K_2S, $(NH_4)_2S$, MgS, CaS, SrS, and BaS.

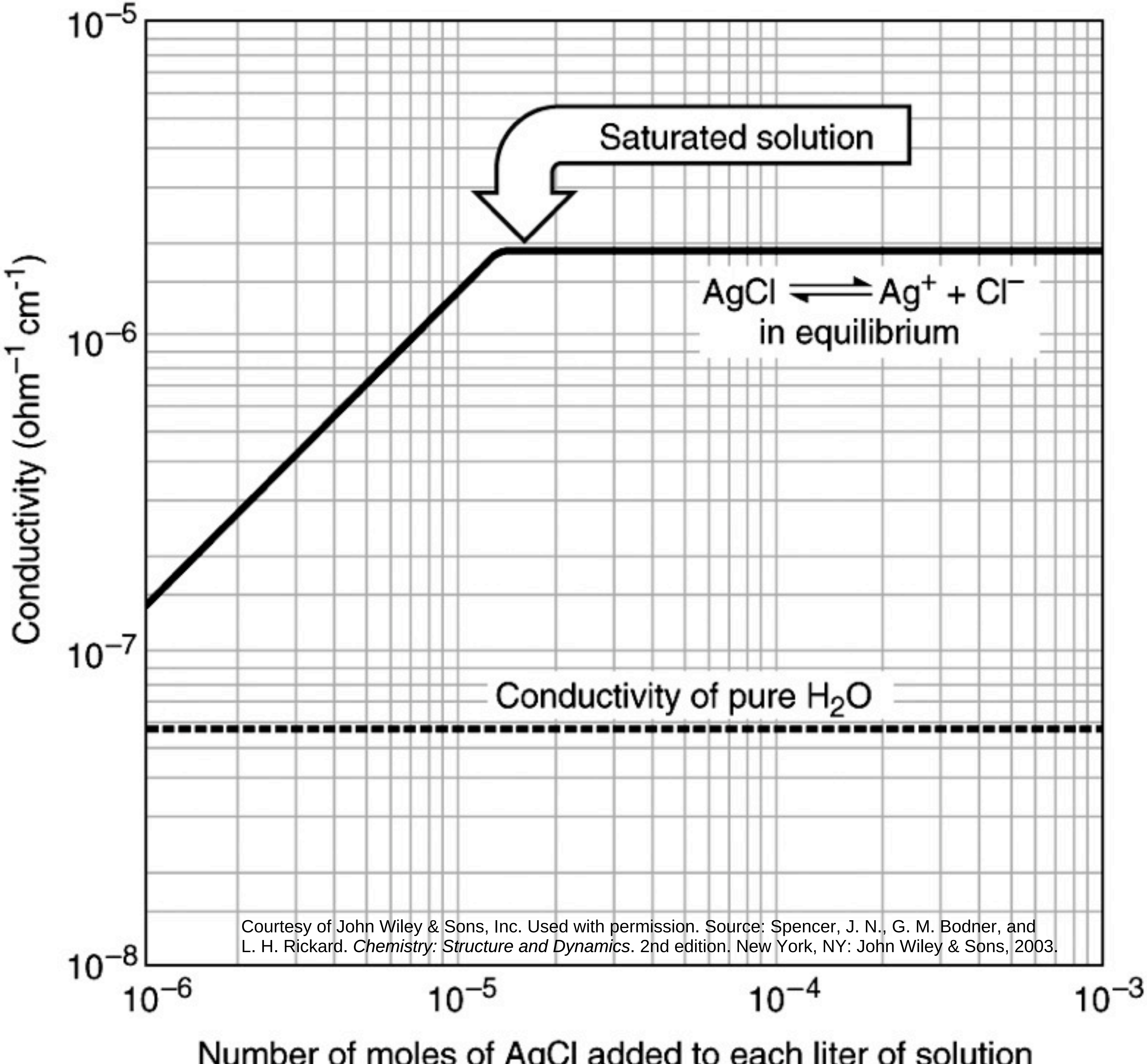
Oxides (O^{2-}) are usually *insoluble*. Exceptions include Na_2O, K_2O, SrO, and BaO, which are soluble, and CaO, which is slightly soluble.

Hydroxides (OH^-) are usually *insoluble*. Exceptions include NaOH, KOH, $Sr(OH)_2$, and $Ba(OH)_2$, which are soluble, and $Ca(OH)_2$, which is slightly soluble.

Chromates (CrO_4^{2-}), phosphates (PO_4^{3-}), and carbonates (CO_3^{2-}) are usually *insoluble.* Exceptions include ionic compounds of the Na^+, K^+, and NH_4^+ ions, such as Na_2CrO_4, K_3PO_4, and $(NH_4)_2CO_3$.



NaCl dissolving in water



Saturated solution
AgCl ⇌ Ag+ + Cl−
in equilibrium
Conductivity of pure H2O
Conductivity (ohm−1 cm−1)
10−5
10−6
10−7
10−8
10−6
10−5
10−4
10−3
Number of moles of AgCl added to each liter of solution

WORLDS IN THE MAKING

THE EVOLUTION OF THE UNIVERSE

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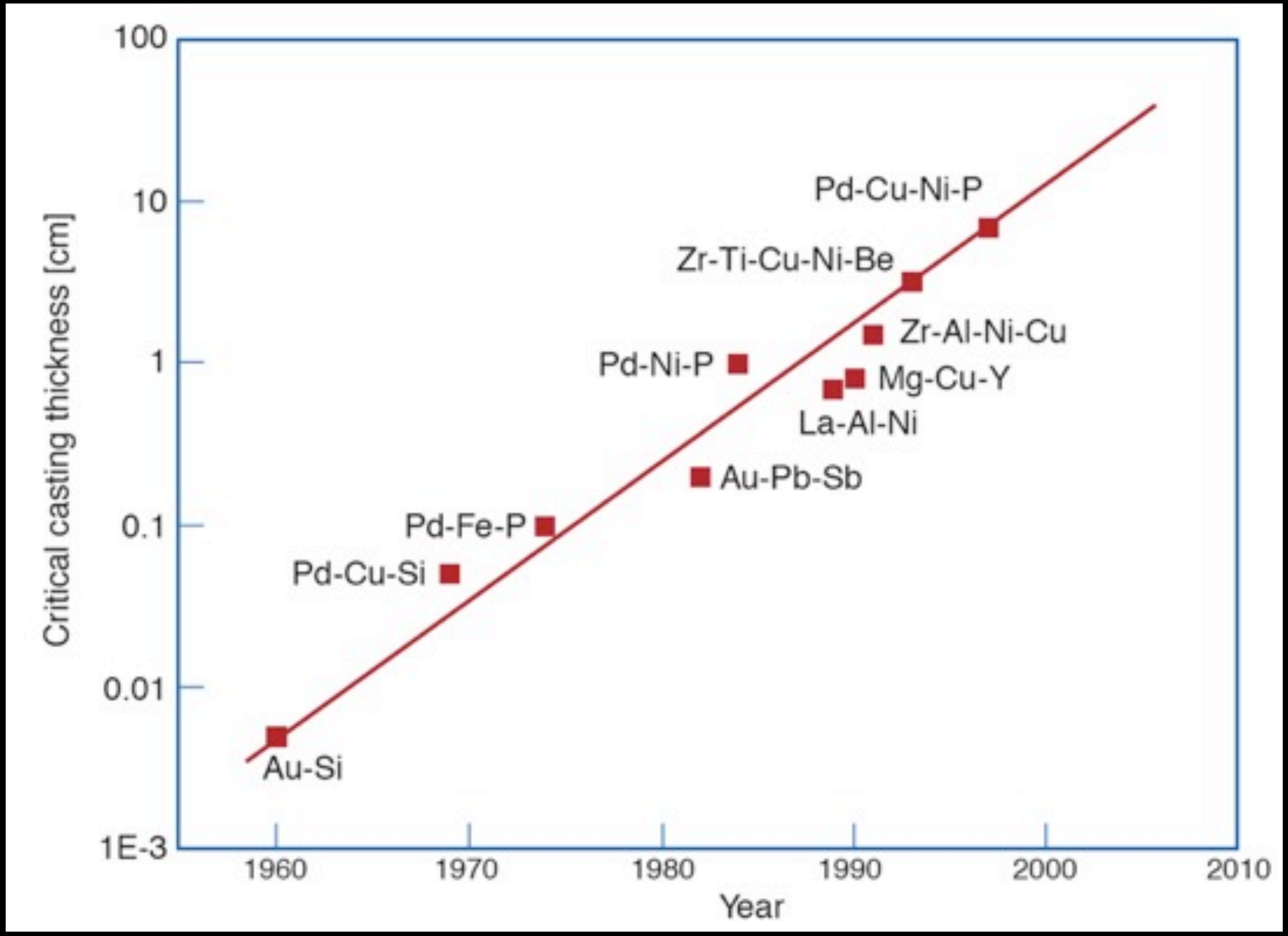
bulk metallic glasses



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bulk metallic glasses

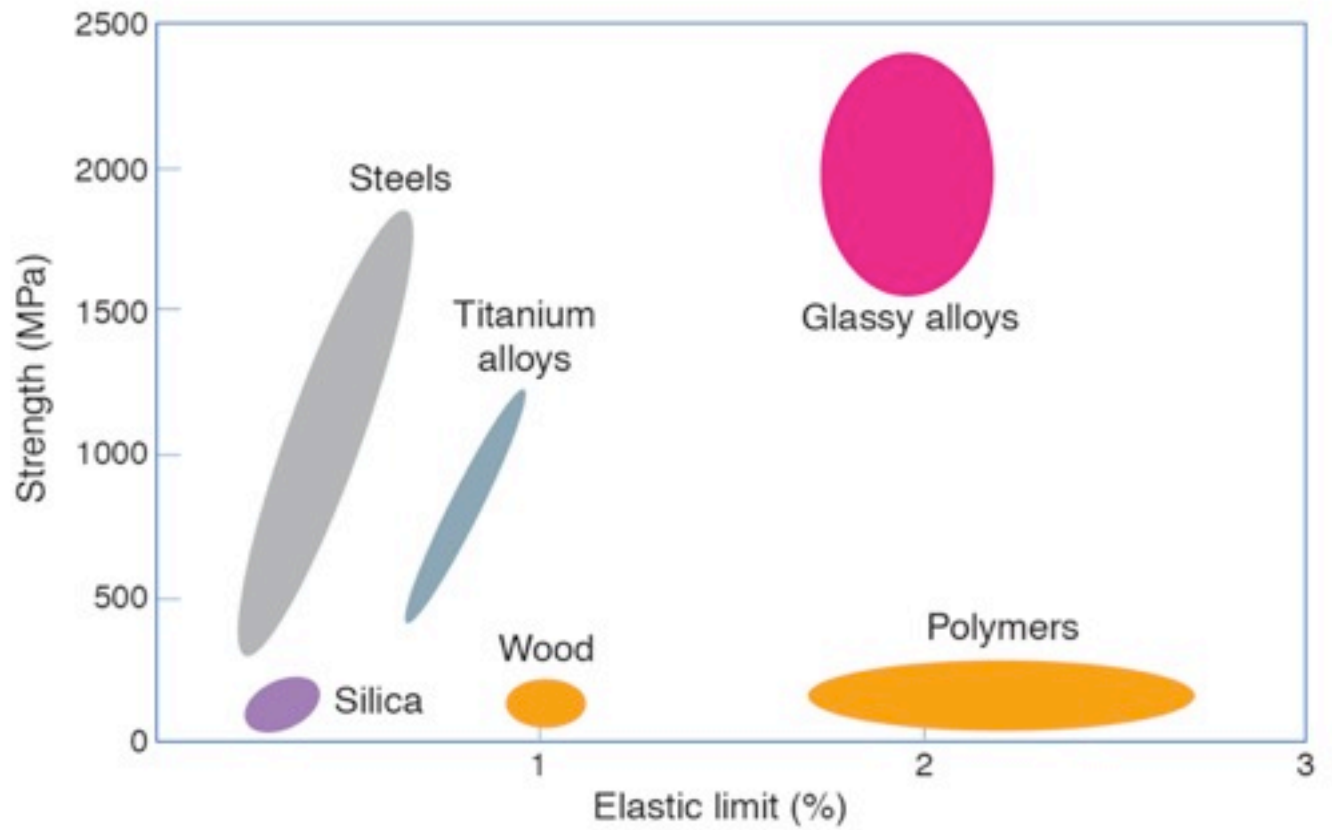


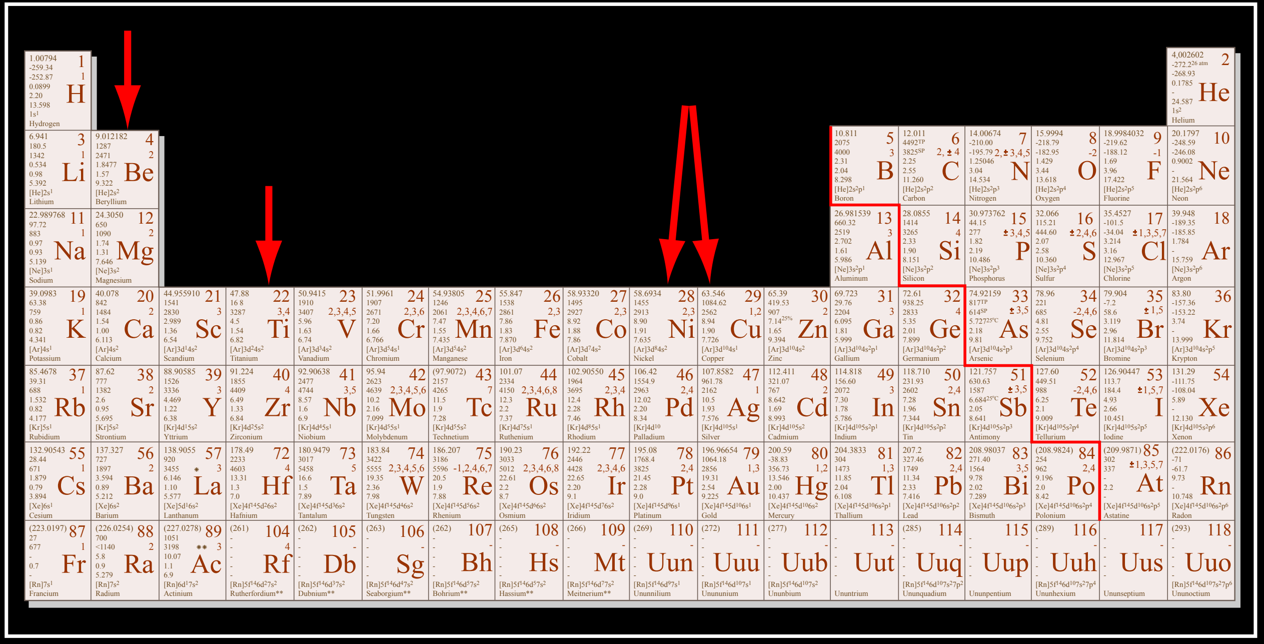
Fig. 3 Amorphous metallic alloys combine higher strength than crystalline metal alloys with the elasticity of polymers.

bulk metallic glasses (BMGs)

Vitreloy1: $Zr_{41.2}Ti_{13.8}Cu_{12.5}Ni_{10.0}Be_{22.5}$

Table 1 *Properties of Vitreloy compared to metal alloys.*

Properties	Vit1	Al alloys	Ti alloys	Steel alloys
Density (g cm^{-3})	6.1	2.6-2.9	4.3-5.1	7.8
Tensile yield strength, σ_y (GPa)	1.9	0.10-0.63	0.18-1.32	0.50-1.60
Elastic strain limit, ε_{el}	2%	~0.5%	~0.5%	~0.5%
Fracture toughness, K_{1c} (MPa $m^{1/2}$)	20-140	23-45	55-115	50-154
Specific strength (GPa g^{-1} cm^{-3})	0.32	<0.24	< 0.31	<0.21



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