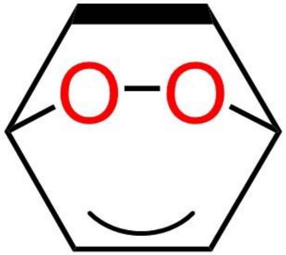
CHEM103
General Chemistry

Chapter 1: Introduction
(Matter and Measurement)

Dr. ($O_6S_4C_4Ar$) Lung Wa CHUNG(钟龙华)
(oscarchung@sustech.edu.cn)
Department of Chemistry
SUSTech



Our QQ forums: Announcement/Resource (lecture materials; left; Password: SUSTech) & Q&A (right)

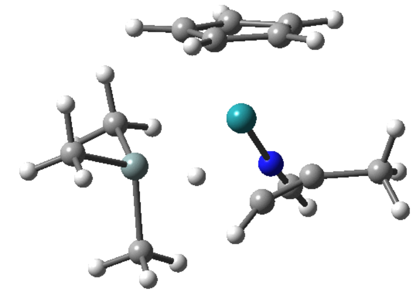
群名称:GenChem2022(通知/资料)-...
群　号:361451234

群名称:GenChem2022(Q&A)-钟龙...
群　号:910317285

My Quick Personal Profile

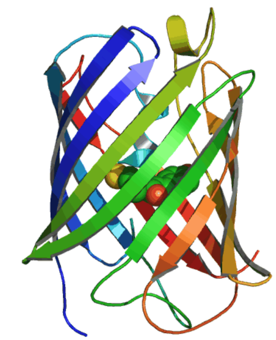
- **2000** The Hong Kong University of Science & Technology, B.Sc. (1st Hon.) & Academic Achievement Medal (GGA: A)
- **2003** The Hong Kong University of Science & Technology, M. Phil (Supervisor: Prof. Yun-Dong Wu)
- **2006** The Hong Kong University of Science & Technology, Ph.D. (Supervisor: Prof. Yun-Dong Wu)

Computational Studies of Mechanism of Metal-Catalyzed Organic Reactions



- **2006-2013** Fukui Institute for Fundamental Chemistry, Kyoto University (Advisor: Prof. Keiji Morokuma, who has 2 Nobel Winner advisors: Profs. Fukui & Karplus)

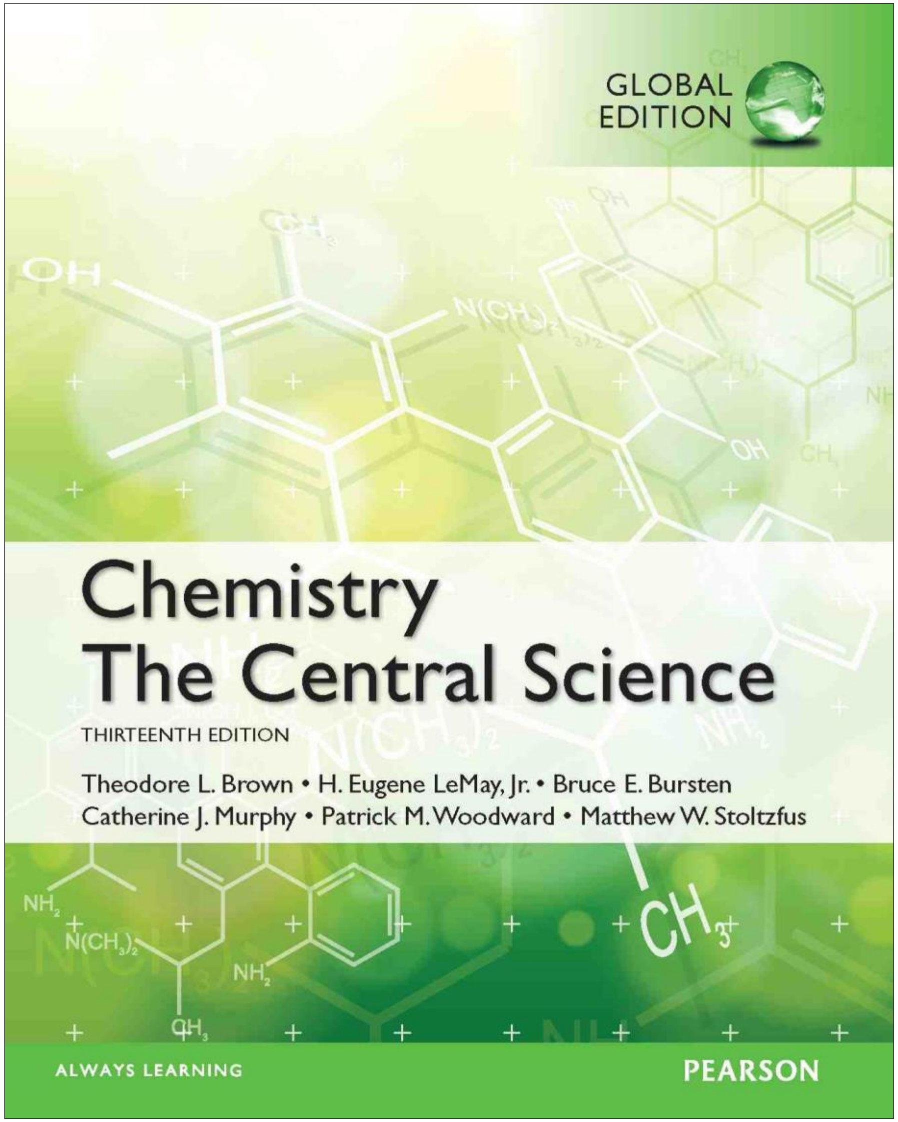
Multi-Scale **Simulations** of Complex Systems



- **2013(Oct)-present** SUSTech

Multi-Scale **Simulations** of Complex Chemical, Biochemical & Biophysical Systems

Computational & Theoretical Chemistry (Virtual Chemical Reactions)



Course Introduction
& Outline

(c.f. syllabus(教学大纲))

What is Chemistry?

Outline of Chapter 1

Chemistry: matter, its properties and changes

Classifications of Matter:
Atoms, Elements, Compounds, Mixture; State of Matter

Properties of Matter:
Physical & Chemical; Intensive & Extensive; Separation of Mixtures

Measurement of Matter:
Units (SI, Prefix); Uncertainty (Exact vs. Inexact number; Precision and Accuracy; Significant Figures); Dimensional Analysis

Chem

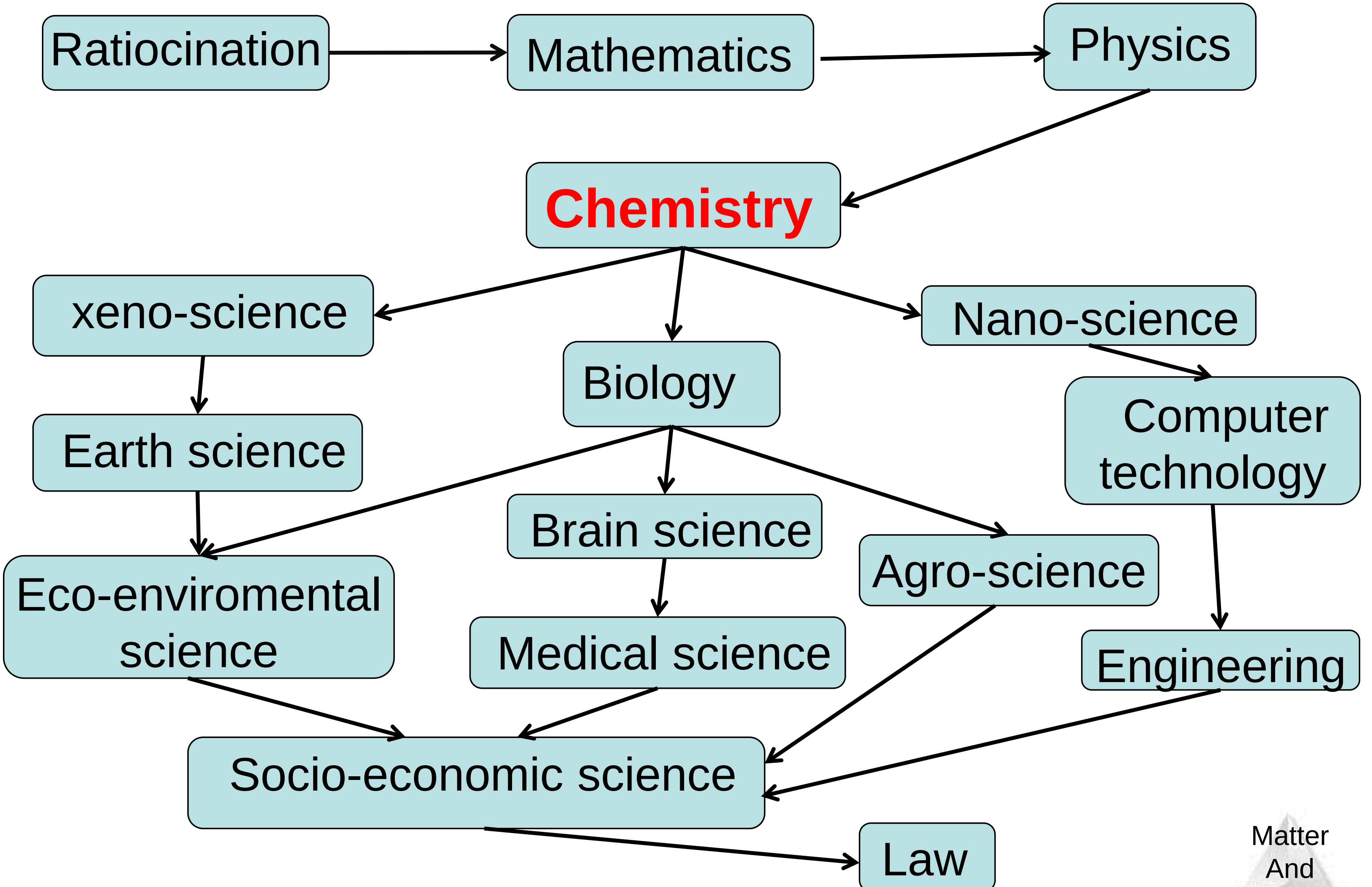
Alche
炼金

the study of ***matter (物质), its properties and changes (behaviors)****:* composition (types of atoms) and structure (arrangement of atoms).

- Synthesis of various matter with different properties
- Measure, characterize and/or isolate matter
- Explain, understand and/or predict chemical observations and principles

Chemistry: CHEM is try

Chemistry: The Central Science

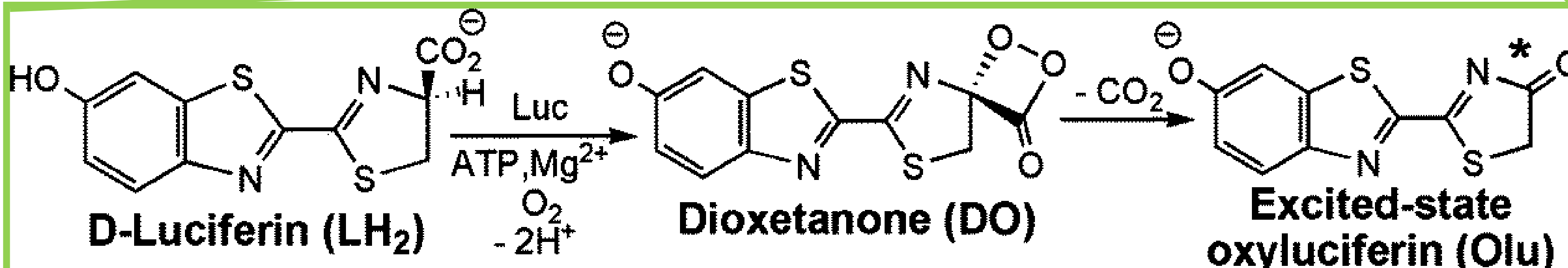


Chemistry: Useful & Important

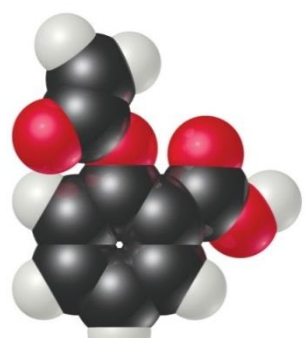
Solar panel

Painting dye

firefly

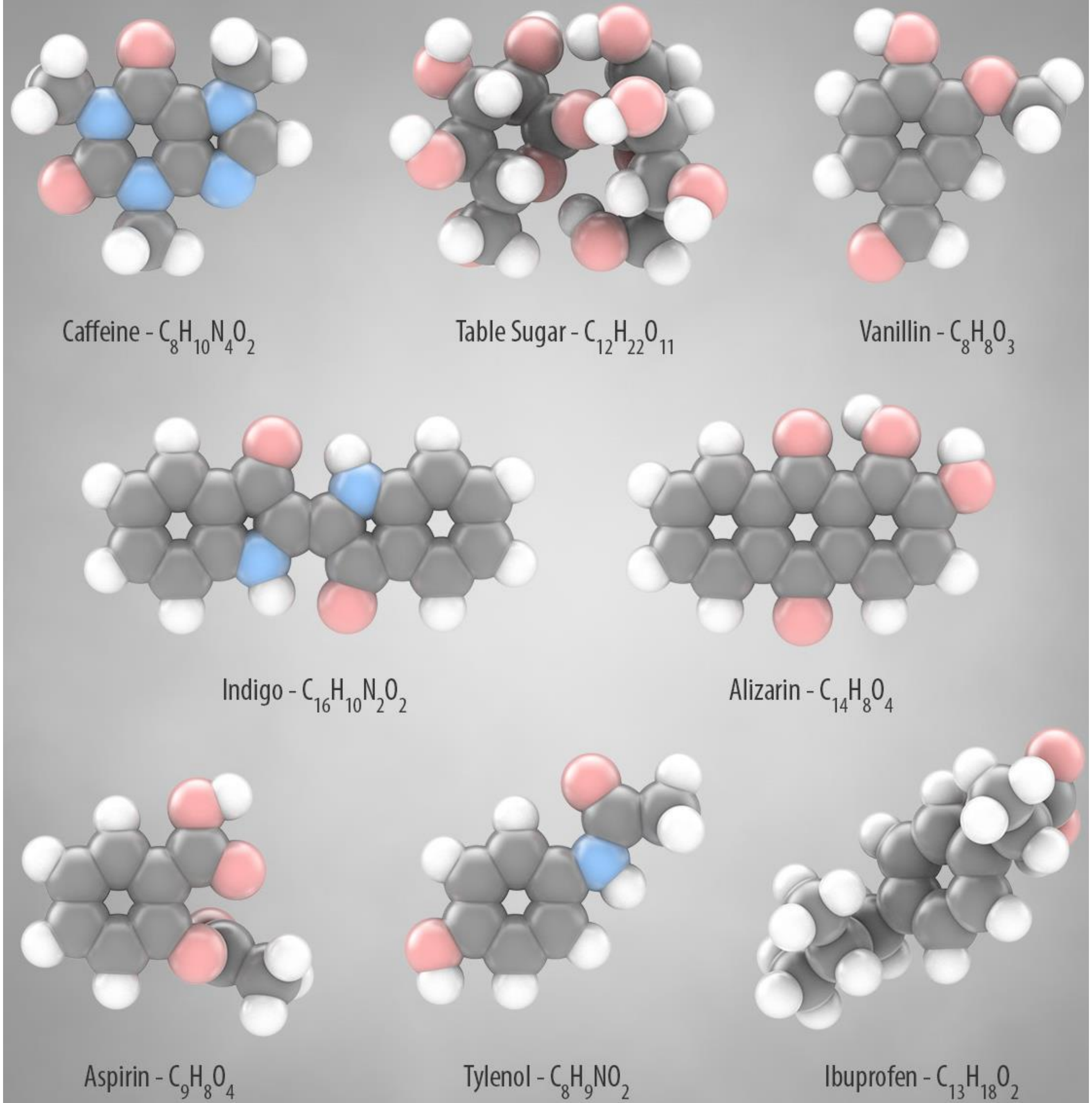


OLED



Drugs: Aspirin
（阿司匹林）

Matter
And
Measurement



Matter
And
Measurement

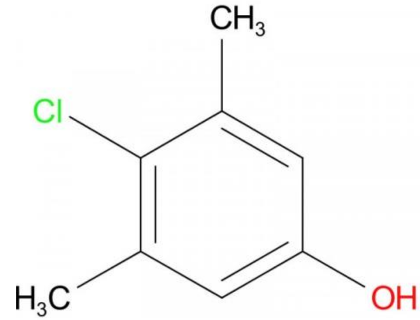
Fatty Alcohol in Our Daily Life

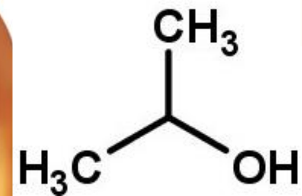
TABLE 1.1 • The Top Eight Chemicals Produced by the US Chemical Industry in 2008[a]

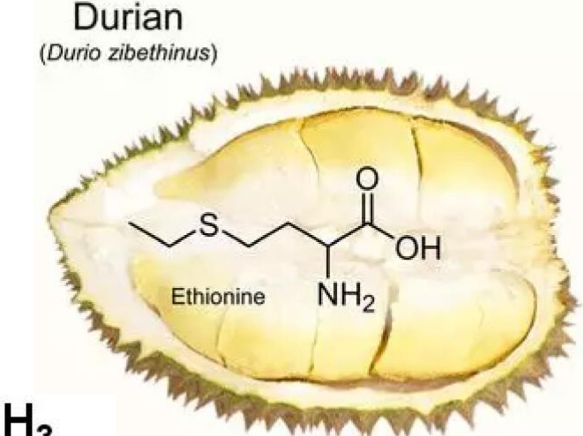
Rank	Chemical	Formula	2008 Production (Billions of Pounds)	Principal End Uses
1	Sulfuric acid	H_2SO_4	71	Fertilizers, chemical manufacturing
2	Ethylene	C_2H_4	50	Plastics, antifreeze
3	Lime	CaO	44	Paper, cement, steel
4	Propylene	C_3H_6	33	Plastics
5	Ammonia	NH_3	21	Fertilizers
6	Chlorine	Cl_2	21	Bleaches, plastics, water purification
7	Phosphoric acid	H_3PO_4	20	Fertilizers
8	Sodium hydroxide	$NaOH$	16	Aluminum production, soap

[a]Most data from *Chemical and Engineering News,* July 6, 2009, pp. 53, 56. Data on lime from U.S. Geological Survey.

012 Pearson Education, Inc.







Matter
And
Measurement

Chemistry: Beautiful

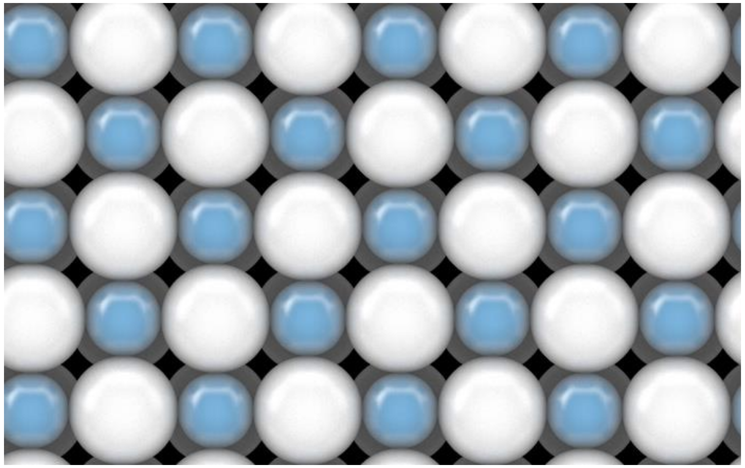
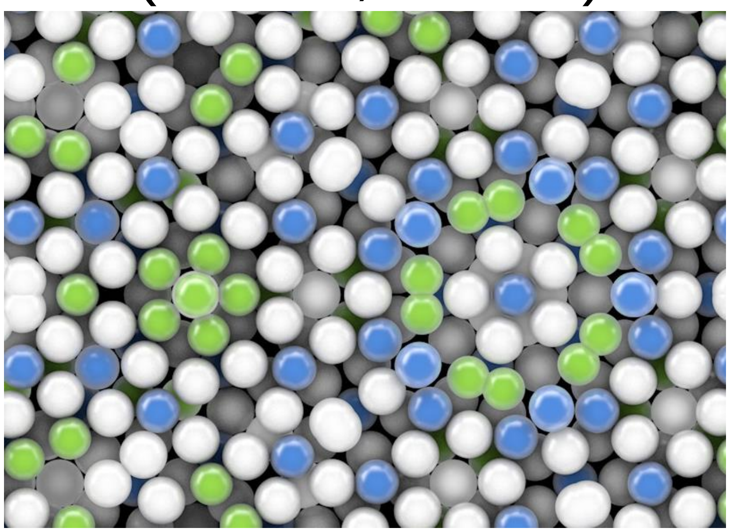
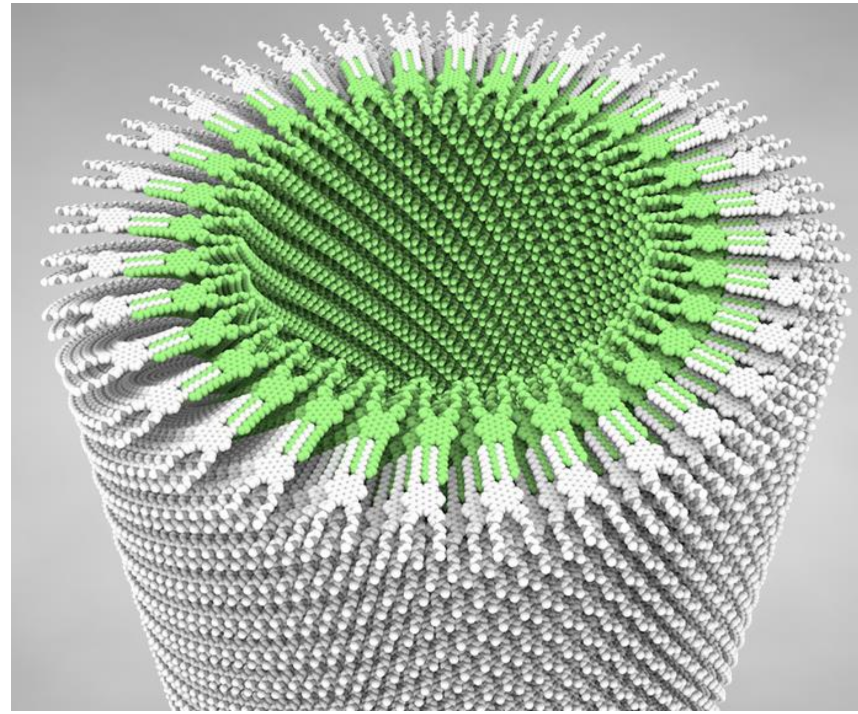


Table Salt, NaCl
(B = Na, W = Cl)



Decagonal Quasicrystal
W = Al, G = Cu, B = Rh



Supramolecular Nanotube

USTC & Tsinghua University Press
http://www.beautifulchemistry.net/

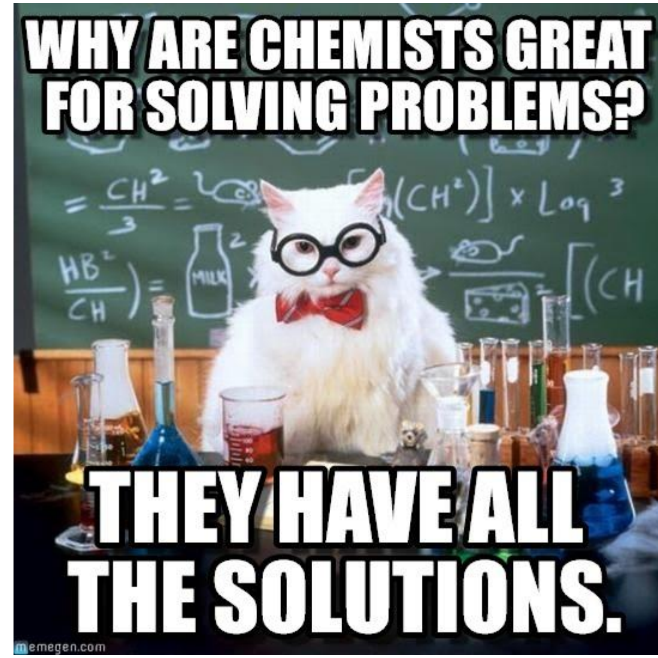
Shechtman (Quasicrystal):
Nobel Prize in CHEM (2011)

Matter
And
Measurement

Chemistry: VIPs

中科大包信和校长
USTC President

原中科院白春礼院长
Ex-Director of CAS



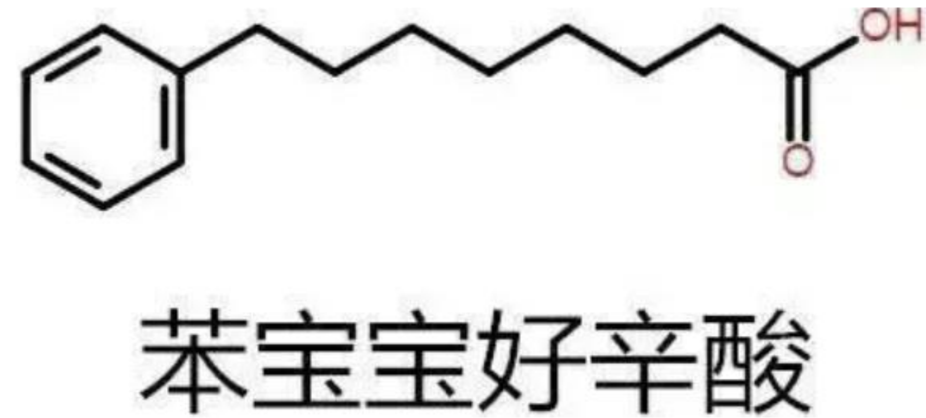
Margaret Thatcher
B.Sc. (Chem. Oxford)

Angela Merkel
Ph.D. (Phys. Chem.)

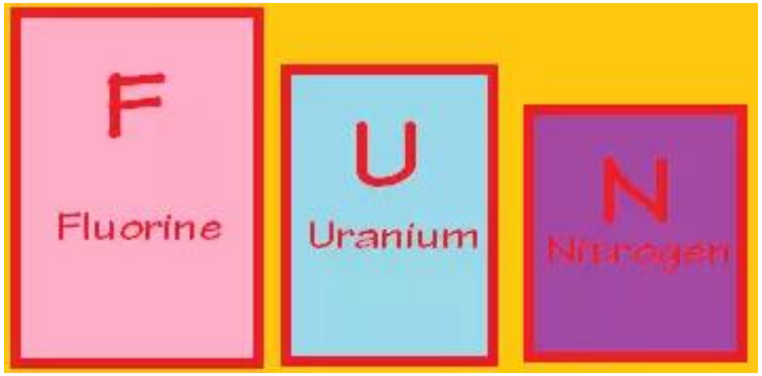
习大大
Chem (清华)

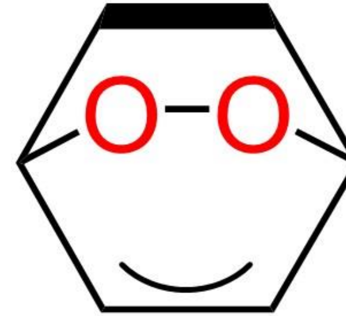
Matter
And
Measurement

Chemistry: FUN



Chemistry: F-U≡N





latter
And
surement

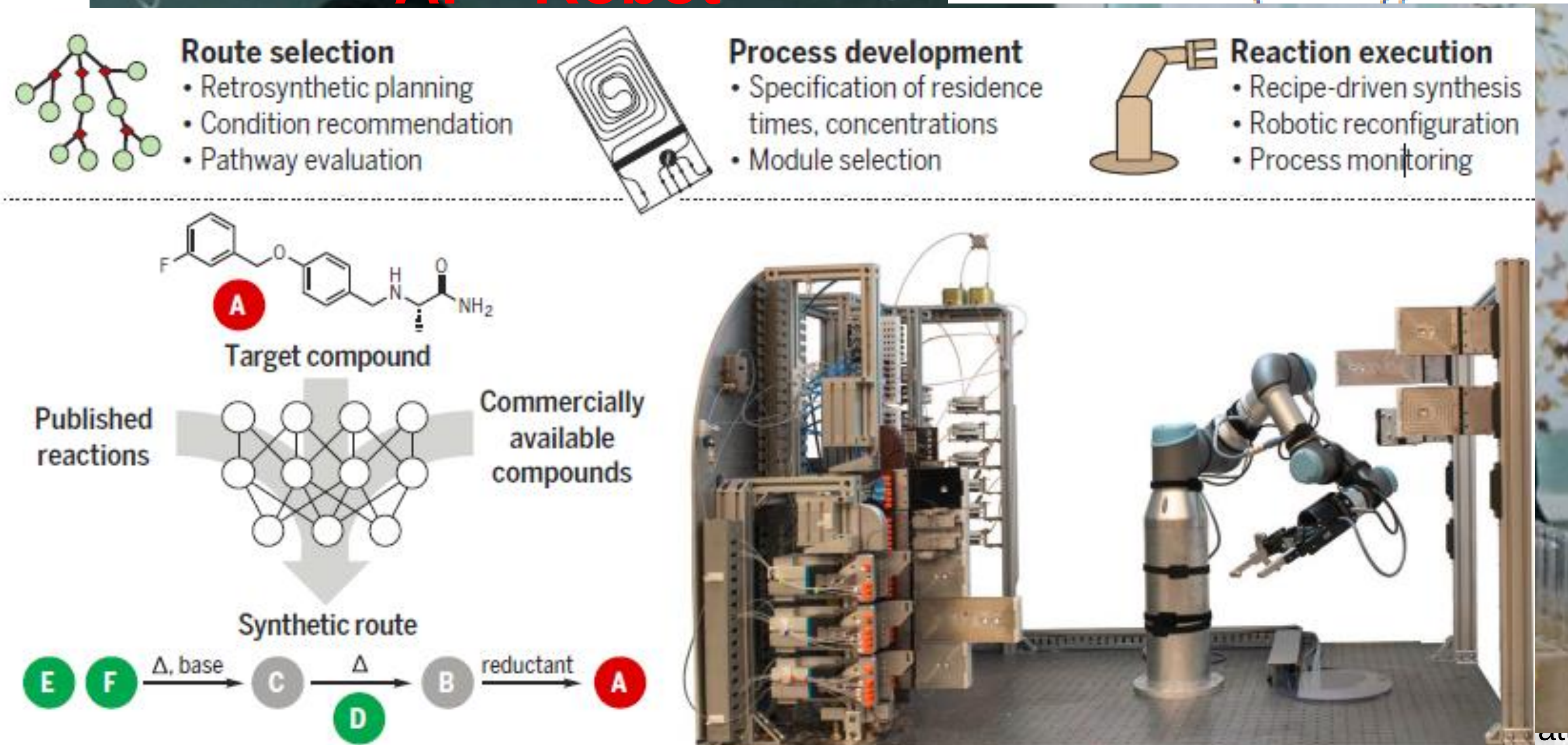
Future Chemists/Chemistry?

(Extra Info.: NOT INCLUDED IN THE EXAM)

A robotic platform for flow synthesis of organic compounds informed by AI planning

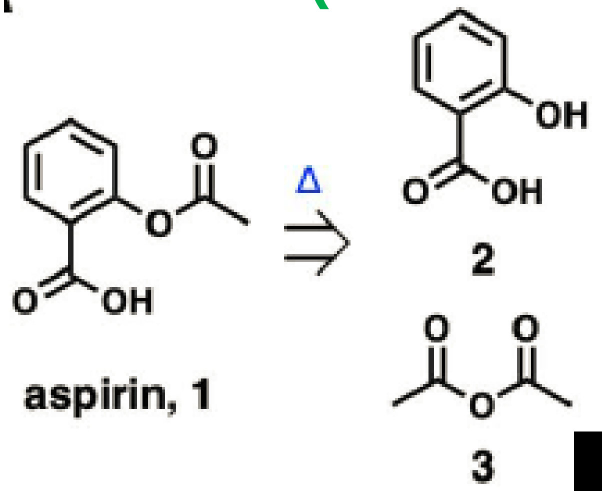
Connor W. Coley, Dale A. Thomas III, Justin A. M. Lummiss, Jonathan N. Jaworski, Christopher P. Breen, Victor Schultz, Travis Hart, Joshua S. Fishman, Luke Rogers, Hanyu Gao, Robert W. Hicklin, Pieter P. Plehiers, Joshua Byington, John S. Piotti, William H. Green, A. John Hart, Timothy F. Jamison and Klavs F. Jensen

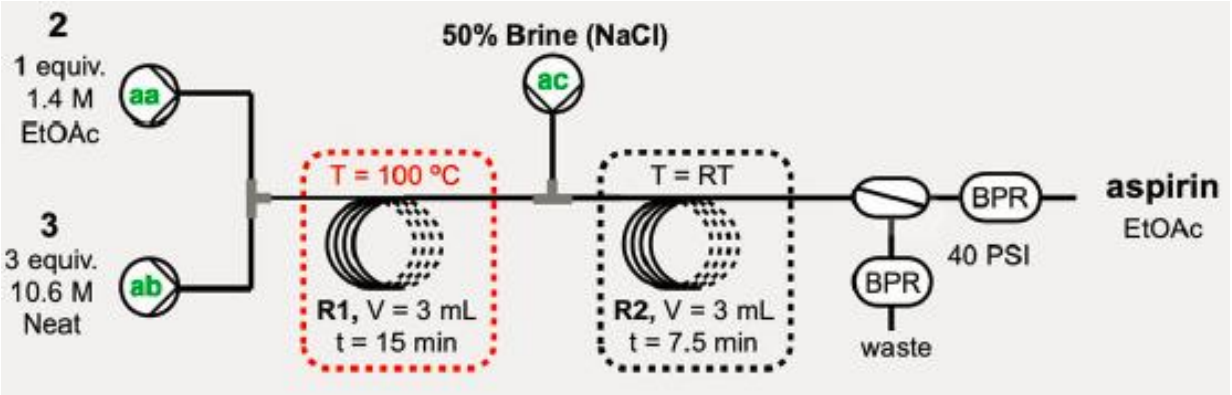
Science **365** (6453), eaax1566.



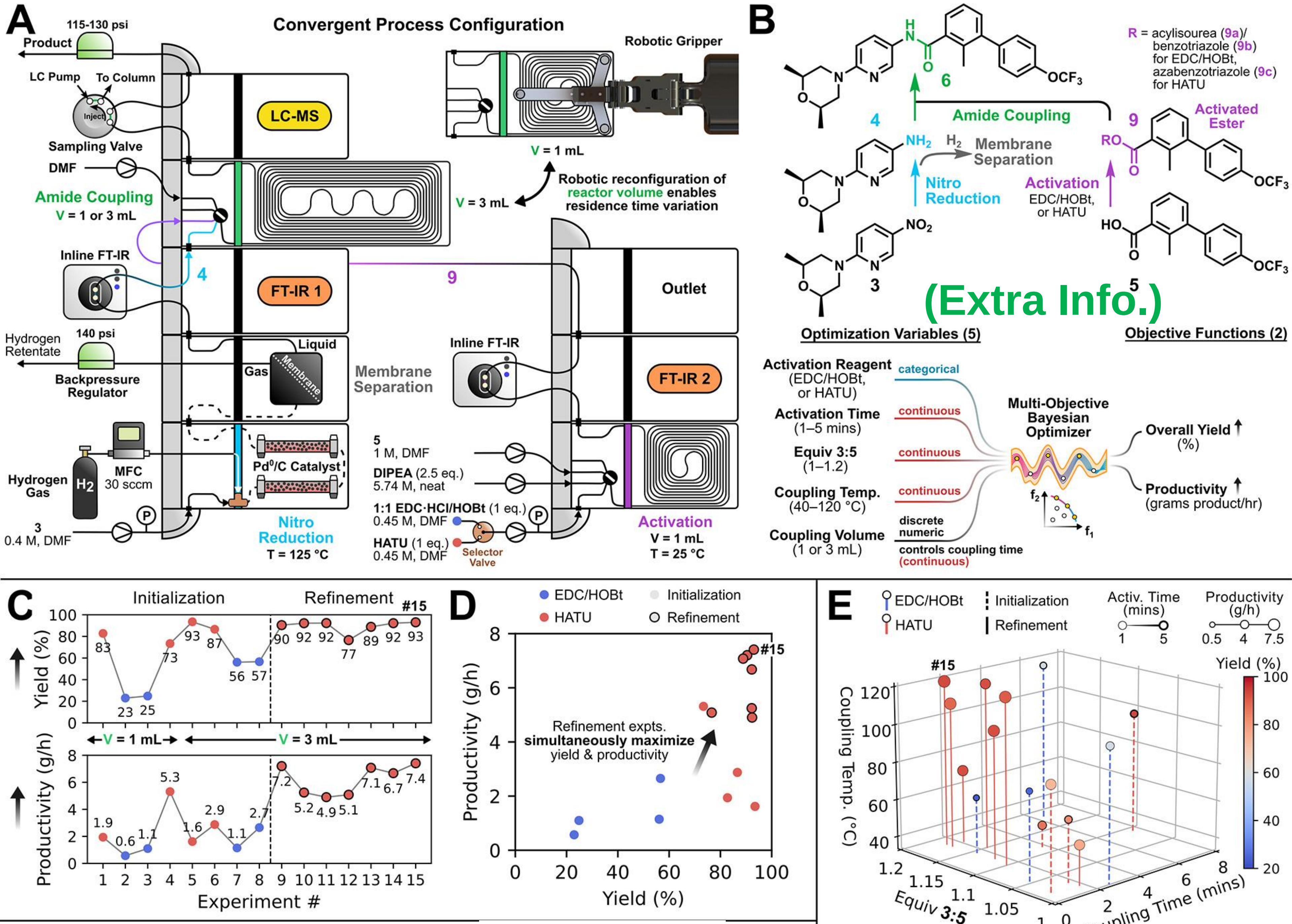
Planning and execution. A robotically reconfigurable flow chemistry platform performs multistep chemical syntheses planned in part by AI.

(Extra Info.: NOT INCLUDED IN THE EXAM)





AI + Robot



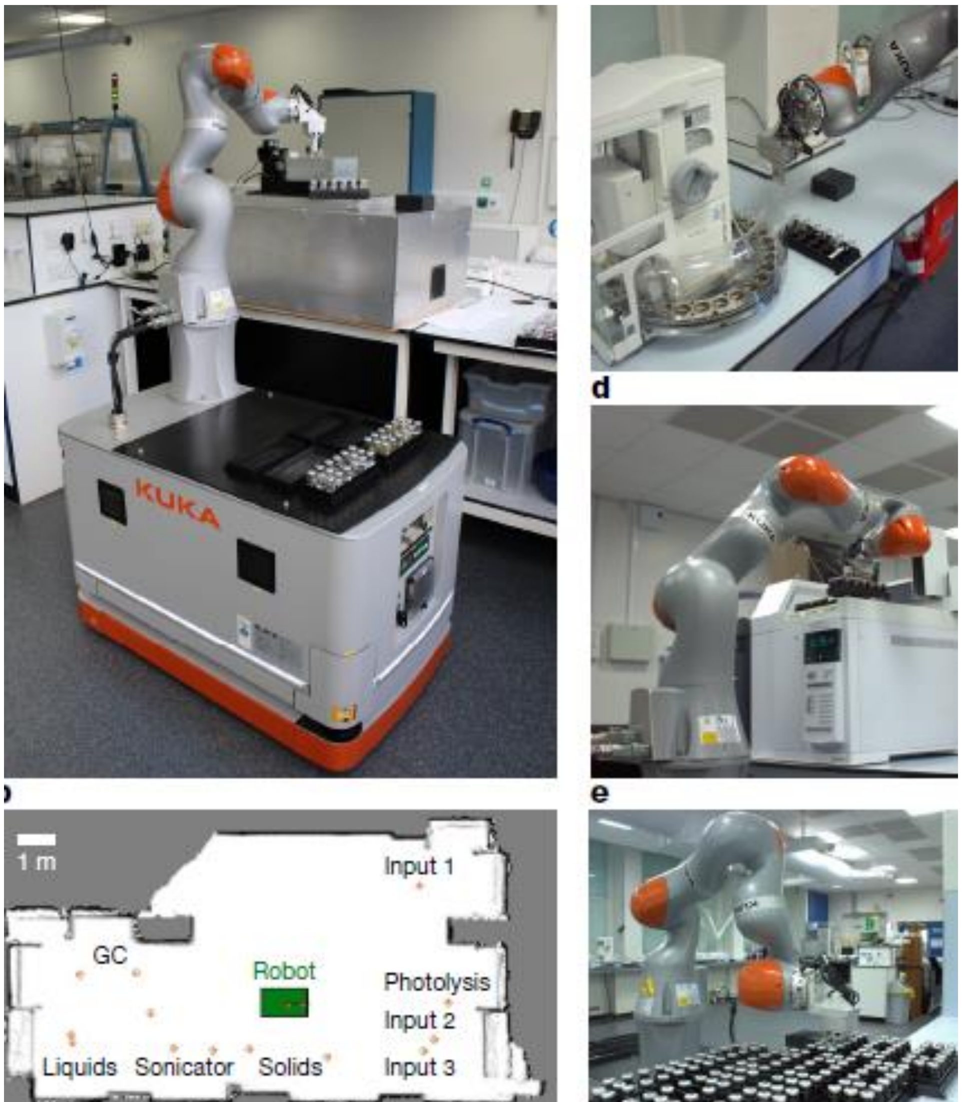
ACS Cent. Sci. 2022, 8, 825

A mobile robotic chemist

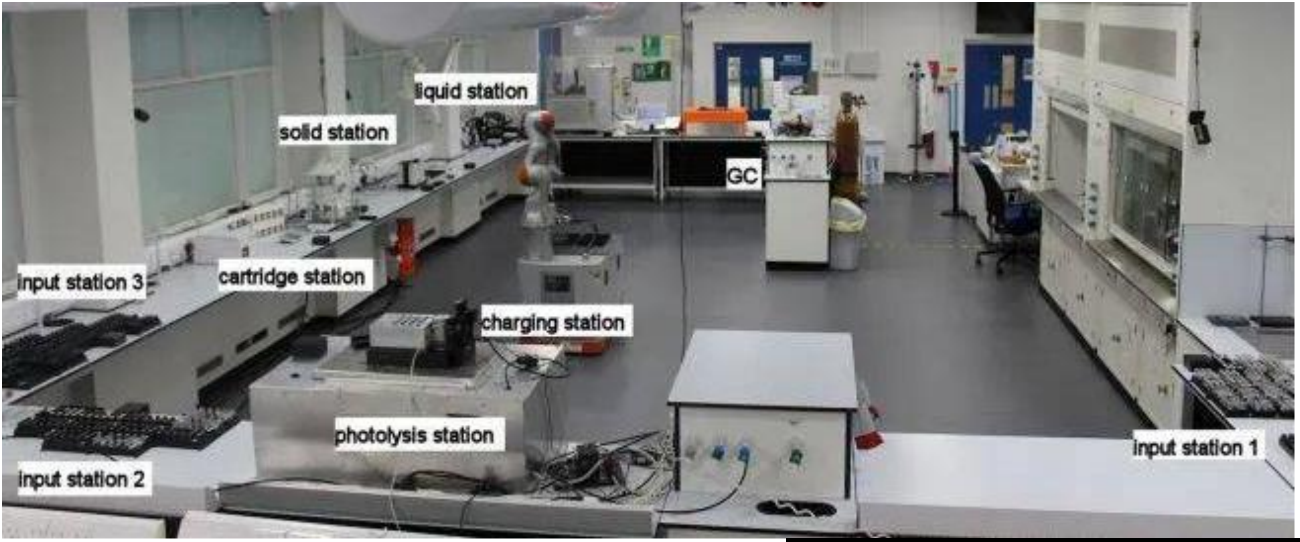
Nature | Vol 583 | 9 July 2020 | 237

Benjamin Burger[1], Phillip M. Maffettone[1], Vladimir V. Gusev[1], Catherine M. Aitchison[1], Yang Bai[1], Xiaoyan Wang[1], Xiaobo Li[1], Ben M. Alston[1], Buyi Li[1], Rob Clowes[1], Nicola Rankin[1], Brandon Harris[1], Reiner Sebastian Sprick[1] & Andrew I. Cooper[1]✉

(Extra Info.)



ent



(Extra Info.)

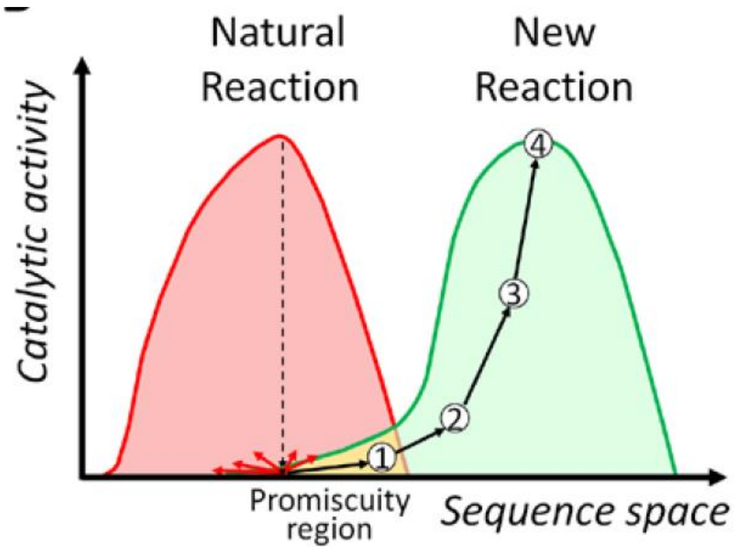
Robot + Algorithm

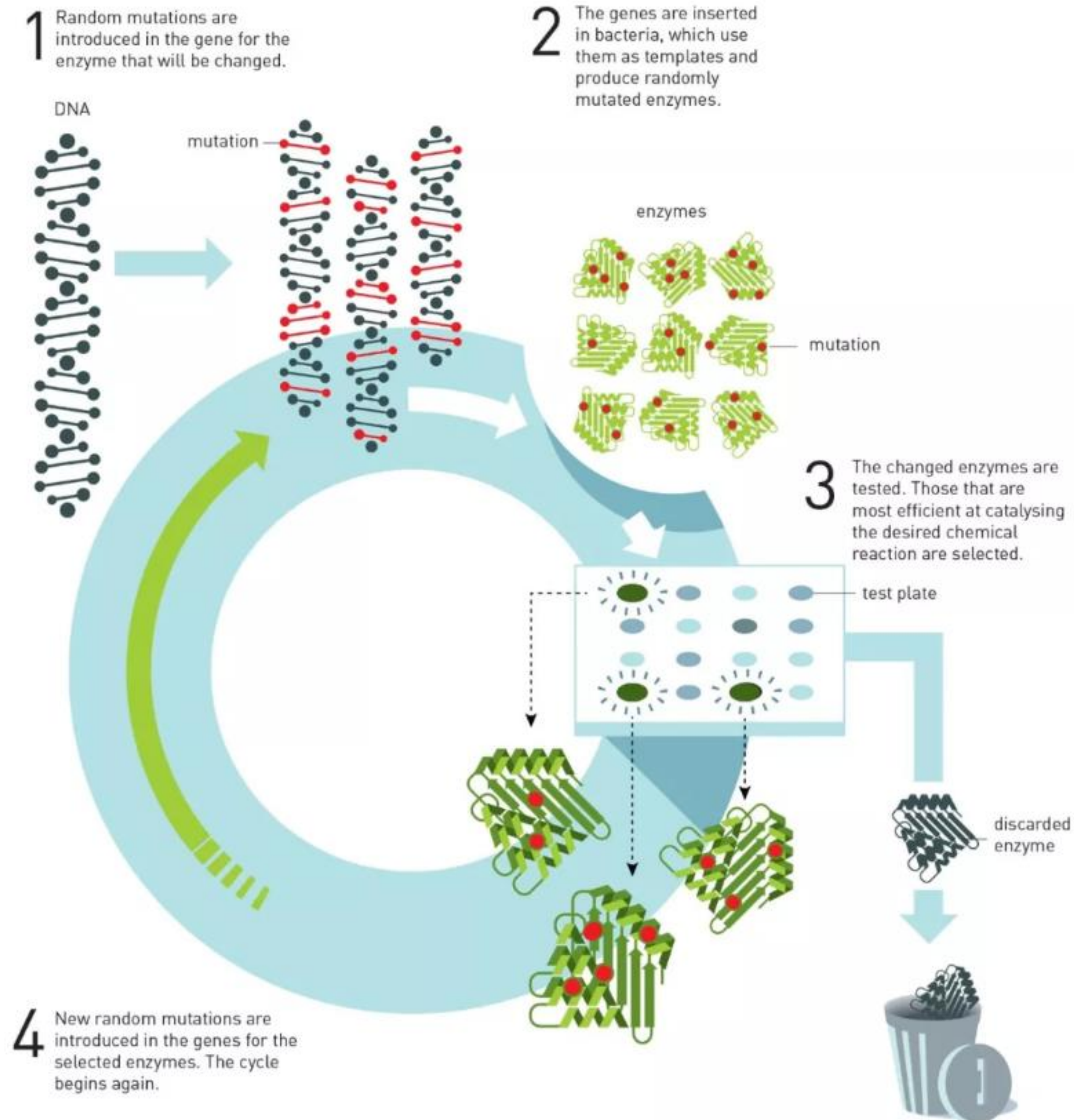
Operated autonomously over 8 days (up to 21.6 h per day), performing 688 experiments within a 10-variable experimental space.

(Extra Info.: NOT INCLUDED IN THE EXAM)

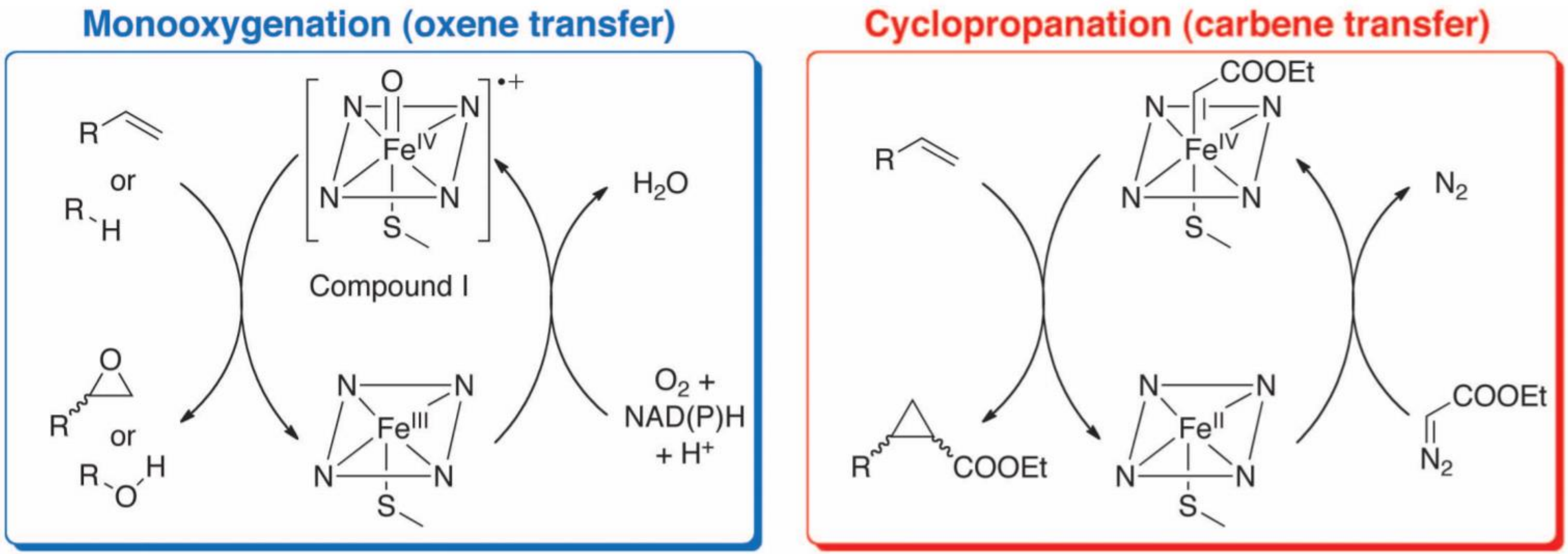
Directed Evolution of **New or Artificial Enzymes**

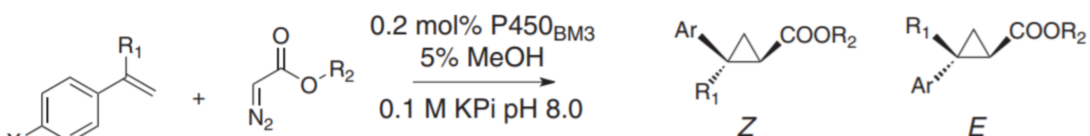
The Nobel Prize in Chemistry 2018



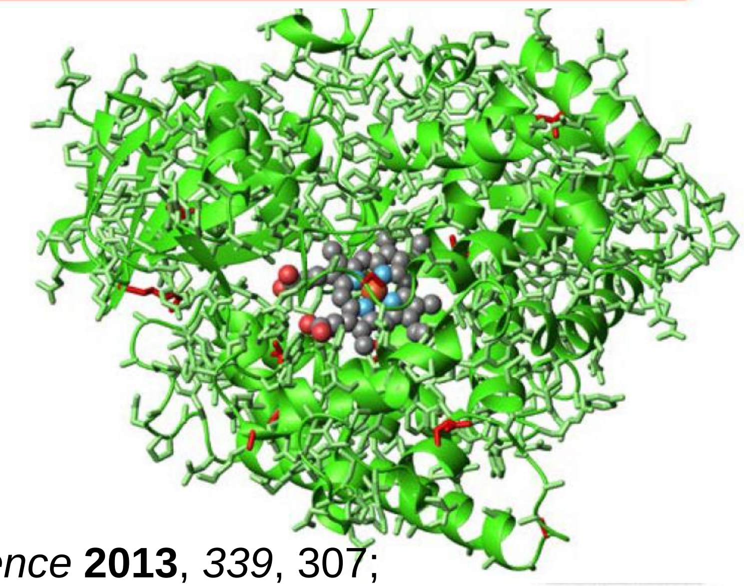


Olefin Cyclopropanation via Carbene Transfer Catalyzed by Engineered Cytochrome P450 Enzymes





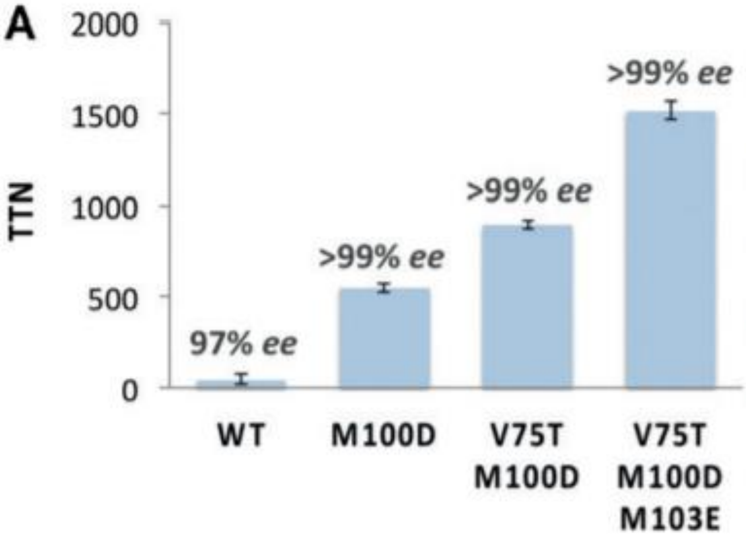
Reagents	P450 catalyst	TTN	*Z* : *E*	%*ee*$_Z$	%*ee*$_E$
R_1 = H, X= Me, R_2 = Et	BM3-CIS	228	78 : 22	-81	N/A
R_1 = H, X= OMe, R_2 = Et	H2-5-F10	364	11 : 89	38	N/A
R_1 = H, X= CF_3, R_2 = Et	7-11D	120	76 : 24	31	59
R_1 = Me, X= H, R_2 = Et	7-11D	157	41 : 49	42	N/A
R_1 = H, X= H, R_2 = *t*-Bu	H2A10	120	3 : 97	N/A	N/A

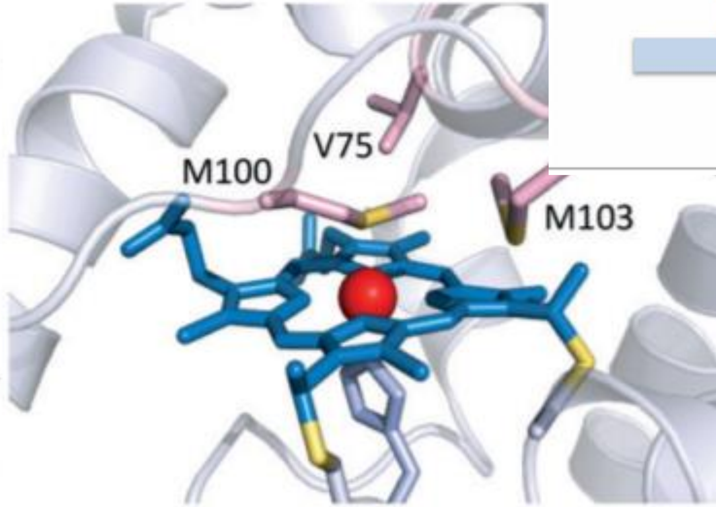


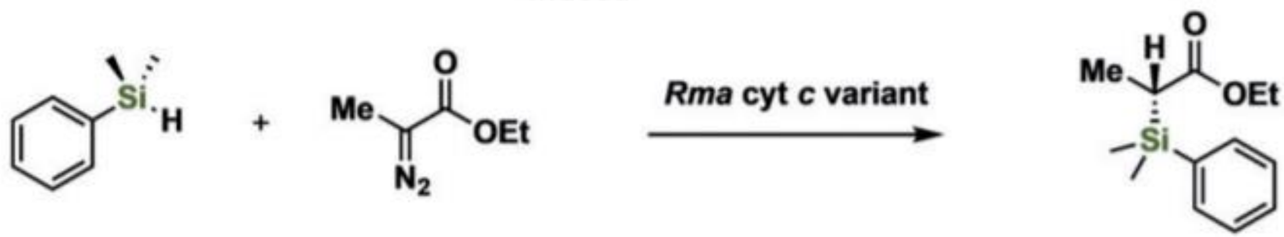
Science **2013**, *339*, 307;
Nat. Chem. Biol. **2013**, *9*, 485

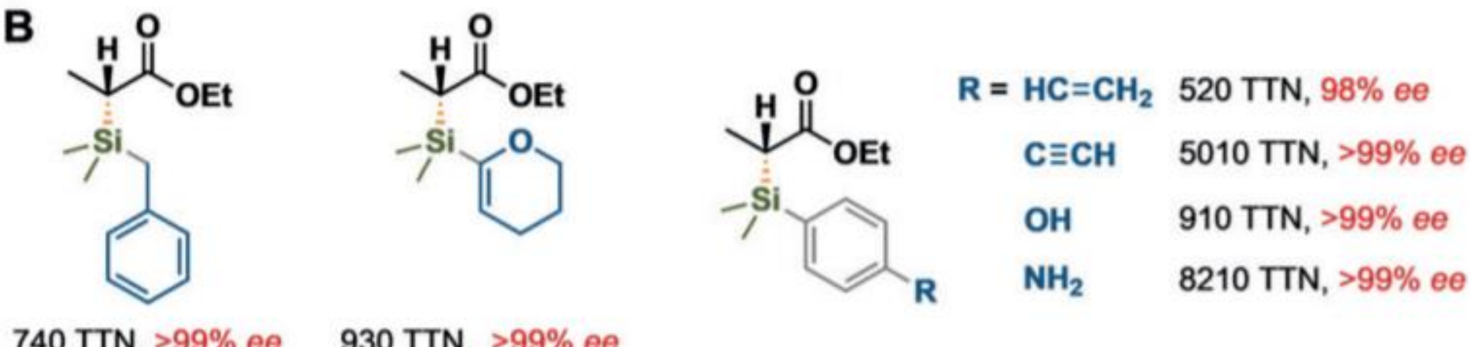
Directed evolution of cytochrome c for C–Si bond formation: Bringing silicon to life

catalyst	% ee
None	-
Hemin	0
Hemin + BSA	0
Horse heart cyt *c*	<5
Bovine heart cyt *c*	6
S. cerevisiae cyt *c*	<5
R. marinus cyt *c*	97
H. thermophilus cyt *c*	16
R. globiformis cyt *c*	<5





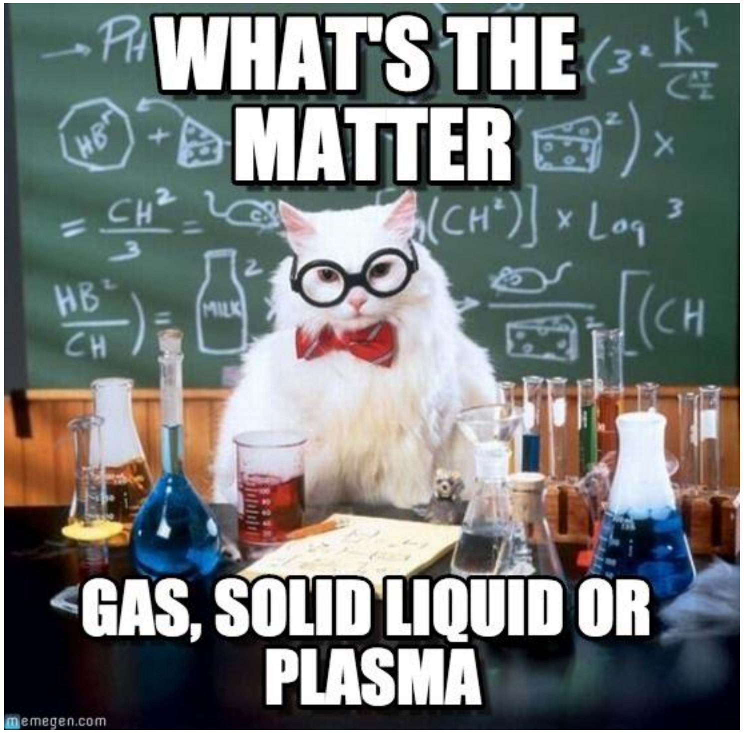




Science **2016**, *354*, 1048

Matter And Measurement

Classifications of Matter

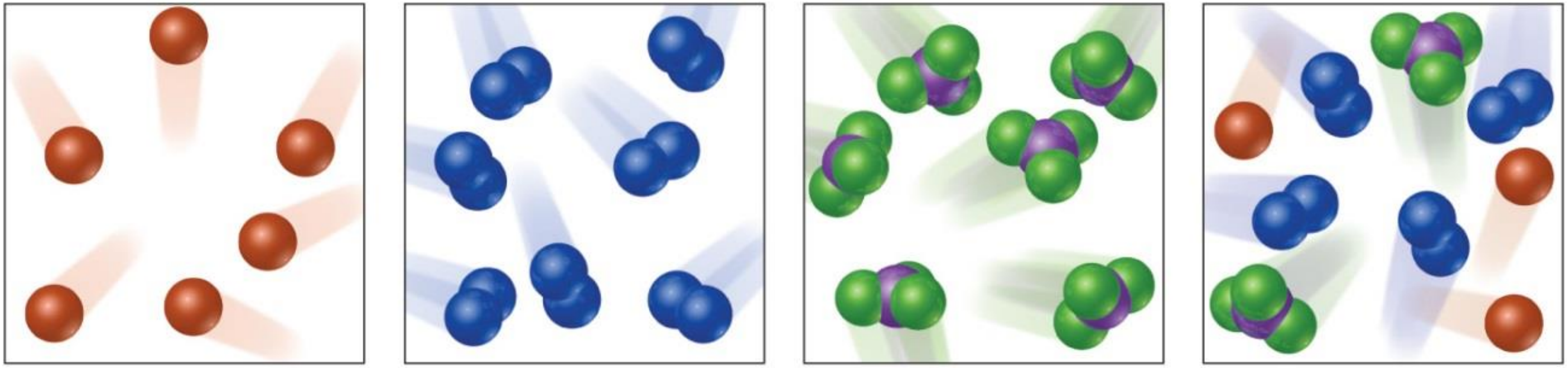


Matter

Matter: anything that has **mass** and **occupy space**.

>100 elements form all matter.

- **Atom:** the building blocks of matter.
- **Element:** only a unique kind of atom.
- **Compound:** 2 or more different kinds of elements.
- **Molecule:** 2 or more atoms are jointed together.



(a) Atoms of an element (b) Molecules of an element (c) Molecules of a compound (d) Mixture of elements and a compound

Periodic Table of the Elements

IUPAC Periodic Table of the Elements

Key: atomic number / **Symbol** / name / conventional atomic weight / standard atomic weight

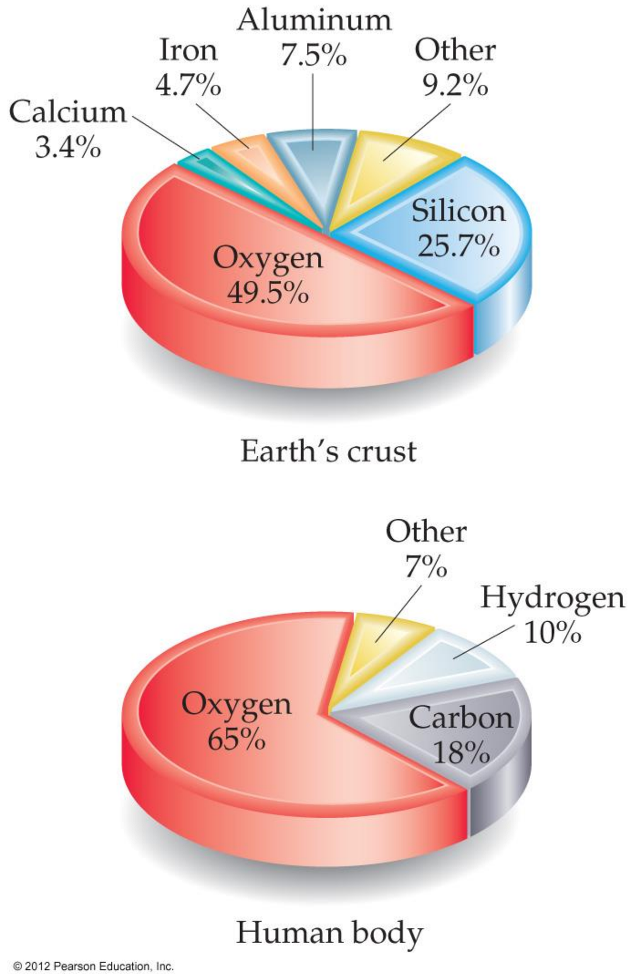
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 **H** hydrogen 1.008 [1.0078, 1.0082]																	2 **He** helium 4.0026
3 **Li** lithium 6.94 [6.938, 6.997]	4 **Be** beryllium 9.0122											5 **B** boron 10.81 [10.806, 10.821]	6 **C** carbon 12.011 [12.009, 12.012]	7 **N** nitrogen 14.007 [14.006, 14.008]	8 **O** oxygen 15.999 [15.999, 16.000]	9 **F** fluorine 18.998	10 **Ne** neon 20.180
11 **Na** sodium 22.990	12 **Mg** magnesium 24.305 [24.304, 24.307]											13 **Al** aluminium 26.982	14 **Si** silicon 28.085 [28.084, 28.086]	15 **P** phosphorus 30.974	16 **S** sulfur 32.06 [32.059, 32.076]	17 **Cl** chlorine 35.45 [35.446, 35.457]	18 **Ar** argon 39.948
19 **K** potassium 39.098	20 **Ca** calcium 40.078(4)	21 **Sc** scandium 44.956	22 **Ti** titanium 47.867	23 **V** vanadium 50.942	24 **Cr** chromium 51.996	25 **Mn** manganese 54.938	26 **Fe** iron 55.845(2)	27 **Co** cobalt 58.933	28 **Ni** nickel 58.693	29 **Cu** copper 63.546(3)	30 **Zn** zinc 65.38(2)	31 **Ga** gallium 69.723	32 **Ge** germanium 72.630(8)	33 **As** arsenic 74.922	34 **Se** selenium 78.971(8)	35 **Br** bromine 79.904 [79.901, 79.907]	36 **Kr** krypton 83.798(2)
37 **Rb** rubidium 85.468	38 **Sr** strontium 87.62	39 **Y** yttrium 88.906	40 **Zr** zirconium 91.224(2)	41 **Nb** niobium 92.906	42 **Mo** molybdenum 95.95	43 **Tc** technetium	44 **Ru** ruthenium 101.07(2)	45 **Rh** rhodium 102.91	46 **Pd** palladium 106.42	47 **Ag** silver 107.87	48 **Cd** cadmium 112.41	49 **In** indium 114.82	50 **Sn** tin 118.71	51 **Sb** antimony 121.76	52 **Te** tellurium 127.60(3)	53 **I** iodine 126.90	54 **Xe** xenon 131.29
55 **Cs** caesium 132.91	56 **Ba** barium 137.33	57-71 lanthanoids	72 **Hf** hafnium 178.49(2)	73 **Ta** tantalum 180.95	74 **W** tungsten 183.84	75 **Re** rhenium 186.21	76 **Os** osmium 190.23(3)	77 **Ir** iridium 192.22	78 **Pt** platinum 195.08	79 **Au** gold 196.97	80 **Hg** mercury 200.59	81 **Tl** thallium 204.38 [204.38, 204.39]	82 **Pb** lead 207.2	83 **Bi** bismuth 208.98	84 **Po** polonium	85 **At** astatine	86 **Rn** radon
87 **Fr** francium	88 **Ra** radium	89-103 actinoids	104 **Rf** rutherfordium	105 **Db** dubnium	106 **Sg** seaborgium	107 **Bh** bohrium	108 **Hs** hassium	109 **Mt** meitnerium	110 **Ds** darmstadtium	111 **Rg** roentgenium	112 **Cn** copernicium	113 **Nh** nihonium	114 **Fl** flerovium	115 **Mc** moscovium	116 **Lv** livermorium	117 **Ts** tennessine	118 **Og** oganesson

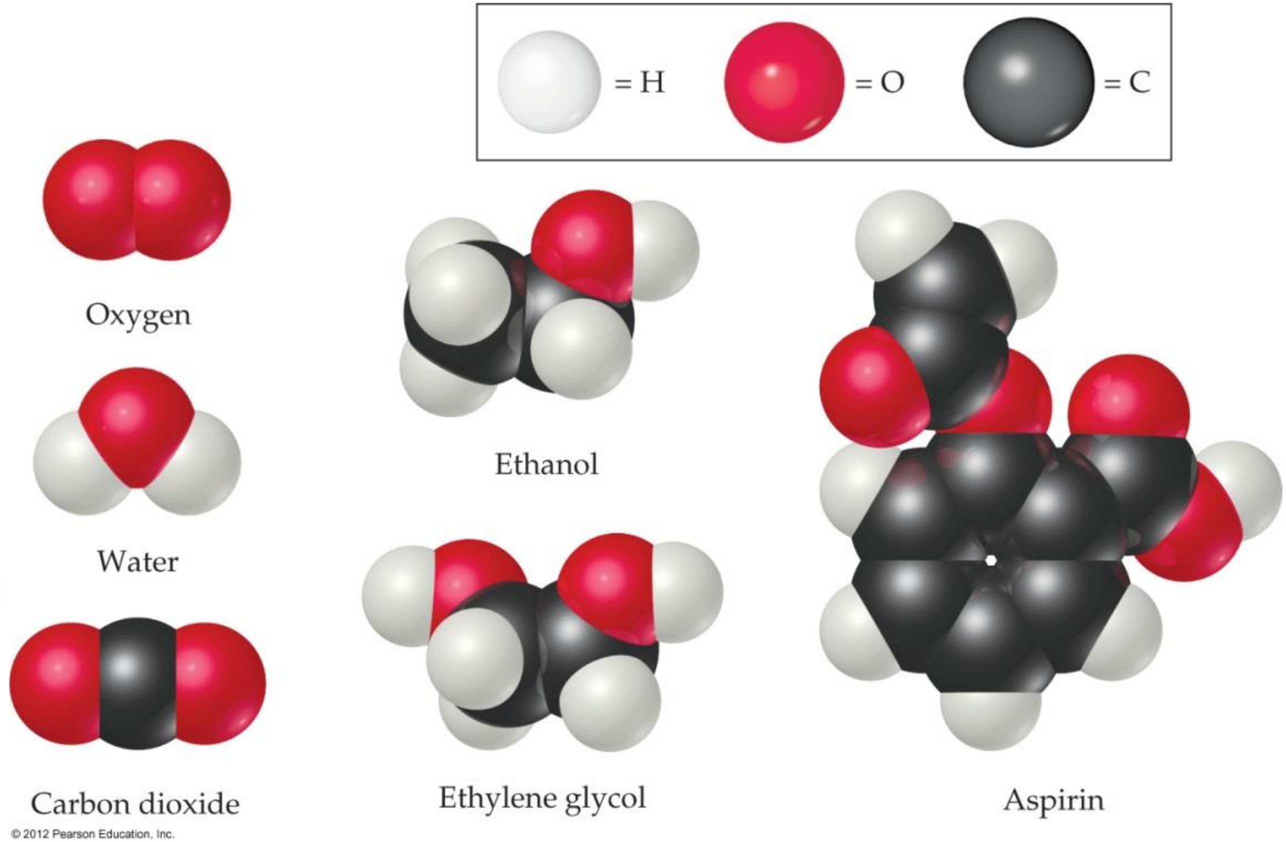
57 **La** lanthanum 138.91	58 **Ce** cerium 140.12	59 **Pr** praseodymium 140.91	60 **Nd** neodymium 144.24	61 **Pm** promethium	62 **Sm** samarium 150.36(2)	63 **Eu** europium 151.96	64 **Gd** gadolinium 157.25(3)	65 **Tb** terbium 158.93	66 **Dy** dysprosium 162.50	67 **Ho** holmium 164.93	68 **Er** erbium 167.26	69 **Tm** thulium 168.93	70 **Yb** ytterbium 173.05	71 **Lu** lutetium 174.97
89 **Ac** actinium	90 **Th** thorium 232.04	91 **Pa** protactinium 231.04	92 **U** uranium 238.03	93 **Np** neptunium	94 **Pu** plutonium	95 **Am** americium	96 **Cm** curium	97 **Bk** berkelium	98 **Cf** californium	99 **Es** einsteinium	100 **Fm** fermium	101 **Md** mendelevium	102 **No** nobelium	103 **Lr** lawrencium

ATIONAL UNION OF
ND APPLIED CHEMISTRY

For notes and updates to this table, see www.iupac.org. This version is dated 28 November 2016.

And
Measurement





Different composition of molecules ➔ Different properties


Hydrogen atom

(written H)


Oxygen atom

(written O)


Water molecule

(written H_2O)

TABLE 1.3 • Comparison of Water, Hydrogen, and Oxygen

	Water	Hydrogen	Oxygen
State[a]	Liquid	Gas	Gas
Normal boiling point	100 °C	−253 °C	−183 °C
Density[a]	1000 g/L	0.084 g/L	1.33 g/L
Flammable	No	Yes	No

[a] At room temperature and atmospheric pressure.

Law of Constant Composition

For the **same pure** compound, its elemental composition must be **SAME**

➔ same properties (at the same conditions)

Composition of my pure water (H_2O) should be same as your pure water, same as those in USA & same as those in Mars (火星).

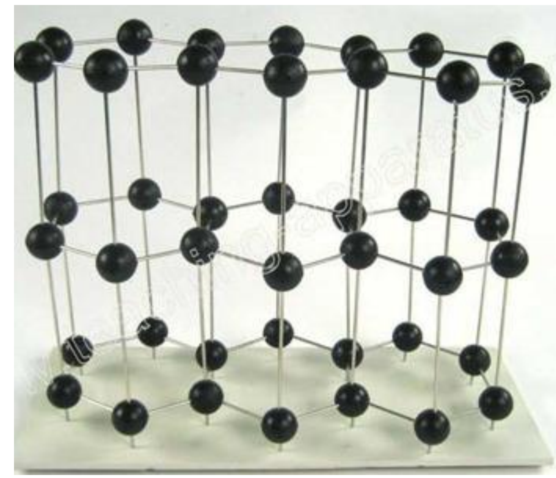
Water molecule

(written H_2O)

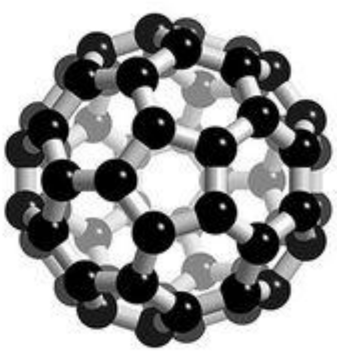
Allotropes（同素异形体）**:** Different Structures of Carbon

Diamond（金刚石）

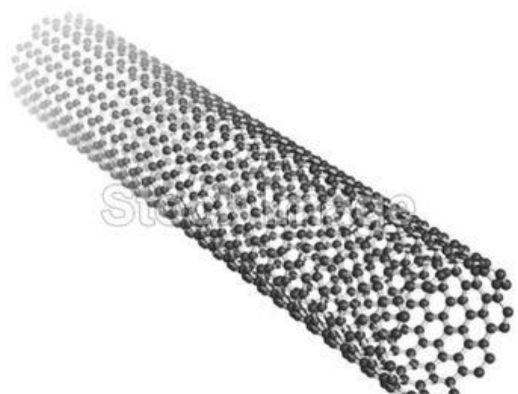
Graphite（石墨）



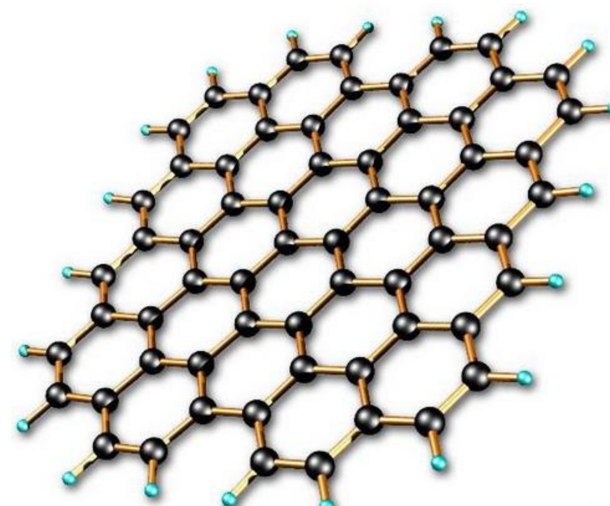
Fullerene
（富勒烯）



Carbon Nanotube
（碳纳米管）



Graphene(石墨烯)



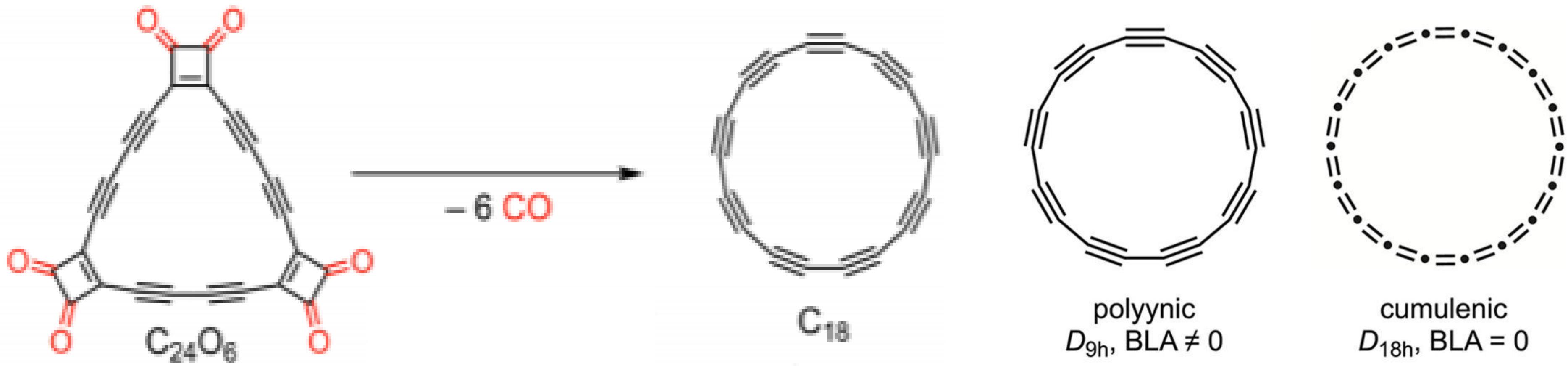
(Extra Info.)

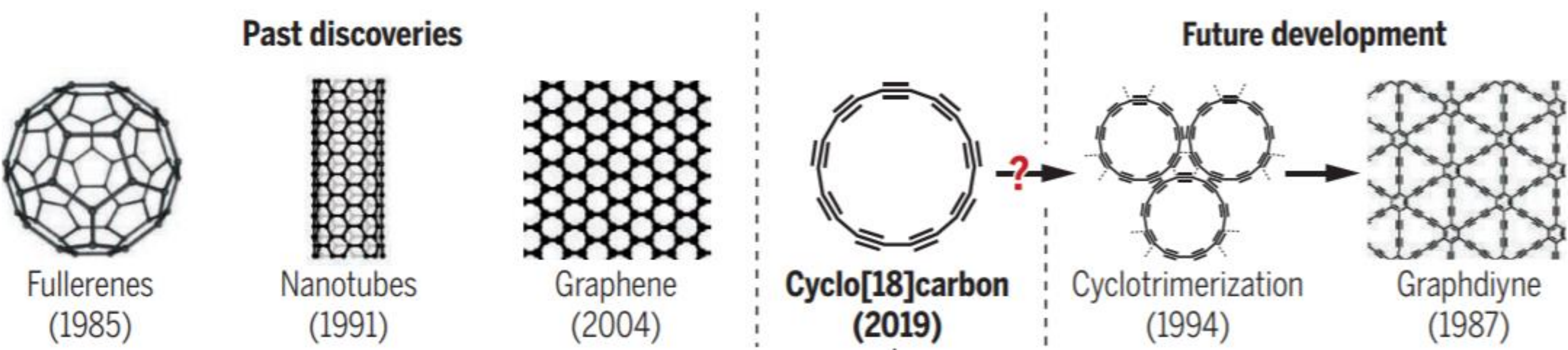
Cite as: K. Kaiser *et al.*, *Science* 10.1126/science.aay1914 (2019).

An sp-hybridized molecular carbon allotrope, cyclo[18]carbon

Katharina Kaiser[1]*, Lorel M. Scriven[2]*, Fabian Schulz[1], Przemyslaw Gawel[2]†, Leo Gross[1]†, Harry L. Anderson[2]†

[1]IBM Research–Zürich, 8803 Rüschlikon, Switzerland. [2]Department of Chemistry, Oxford University, Oxford OX1 3TA, UK.





Synthesis of a monolayer fullerene network

(Extra Info.)

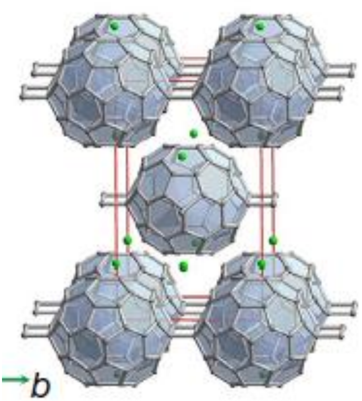
Nature | Vol 606 | 16 June 2022 | 507

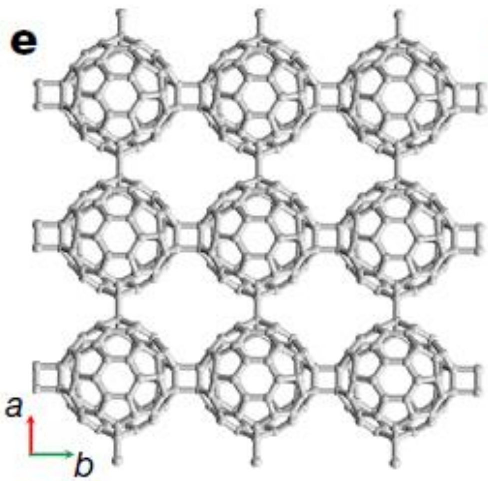
https://doi.org/10.1038/s41586-022-04771-5

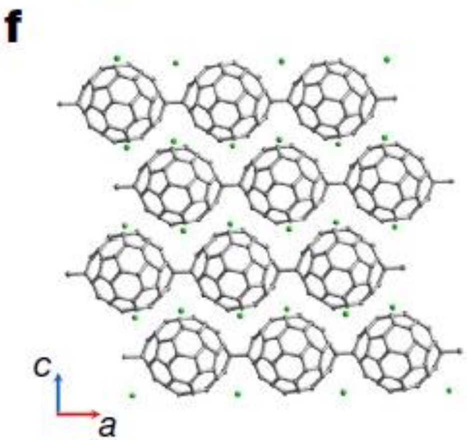
Received: 12 October 2021

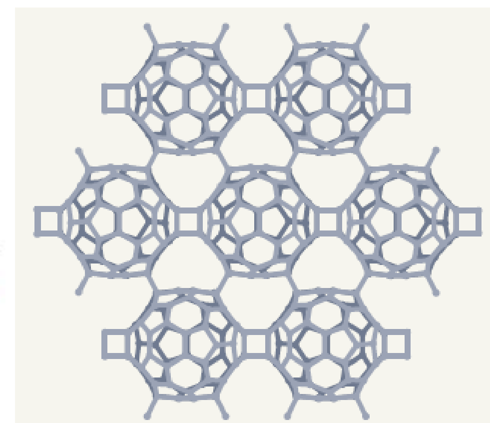
Accepted: 19 April 2022

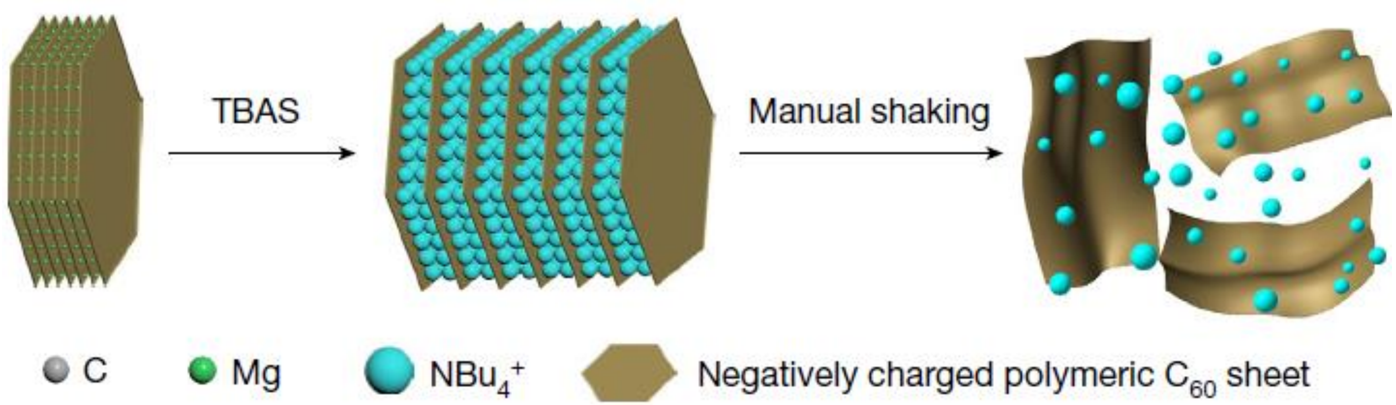
Lingxiang Hou[1,2], Xueping Cui[1], Bo Guan[1], Shaozhi Wang[1,2], Ruian Li[1], Yunqi Liu[1], Daoben Zhu[1] & Jian Zheng[1]✉





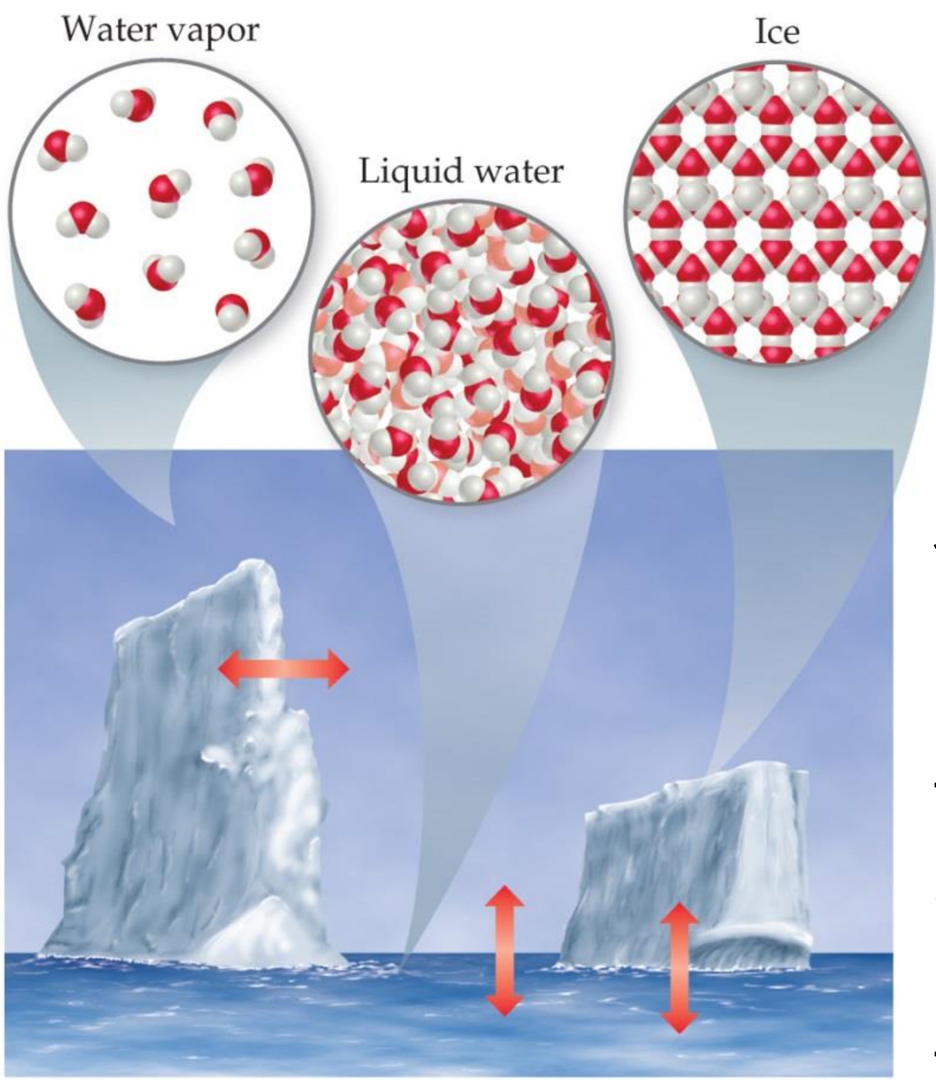






Matter
And
Measurement

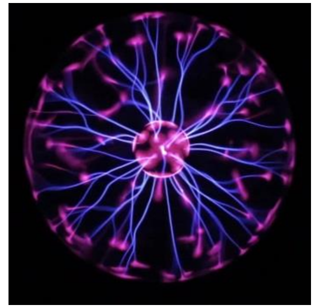
States of Matter

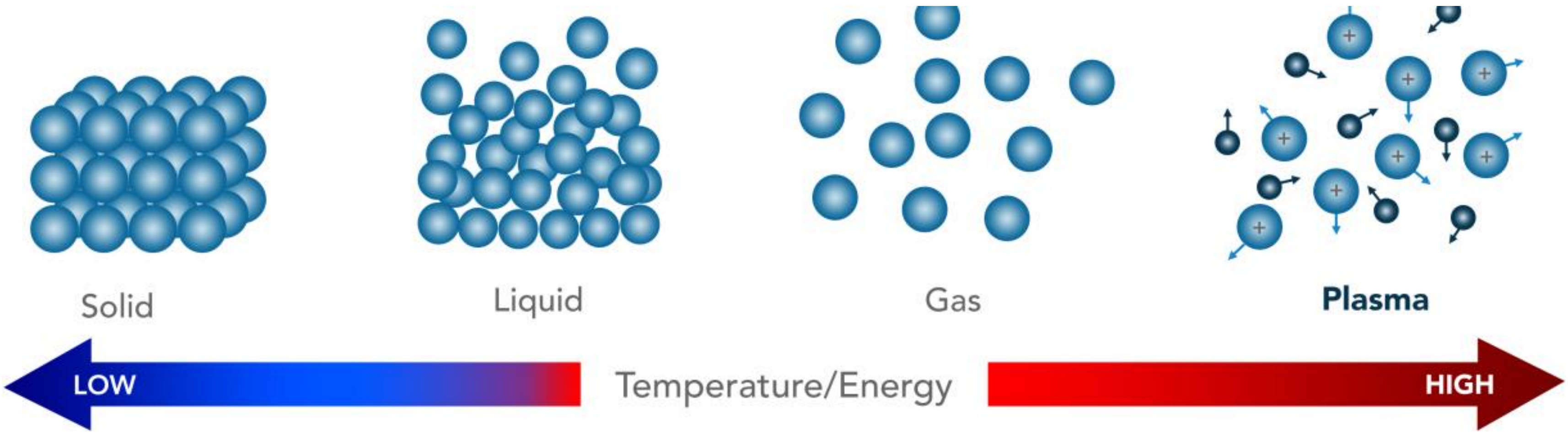


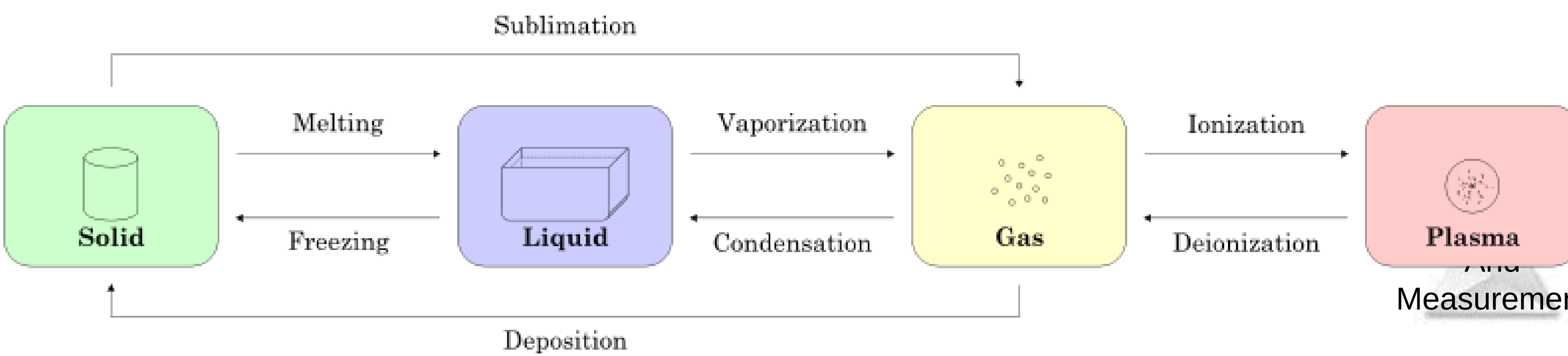
Macroscopic (observable) & submicroscopic worlds (atoms and molecules)

Gas: No fixed *volume* or *shape* (the weakest intermolecular interactions);
Liquid: has *volume*, no fixed *shape*;
Solid: has *volume* & *shape* (molecules are packed tightly).

Plasma/等离子 (Extra Info.)

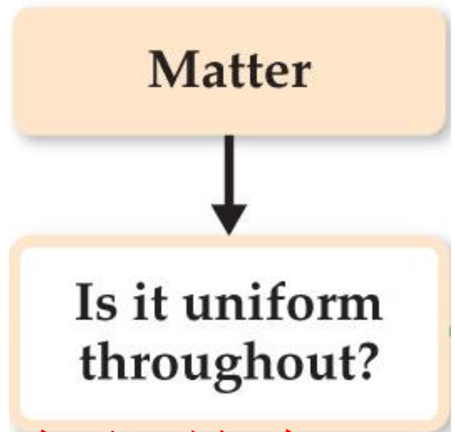






Measurement

Classification of Matter



全部均匀?

Matter

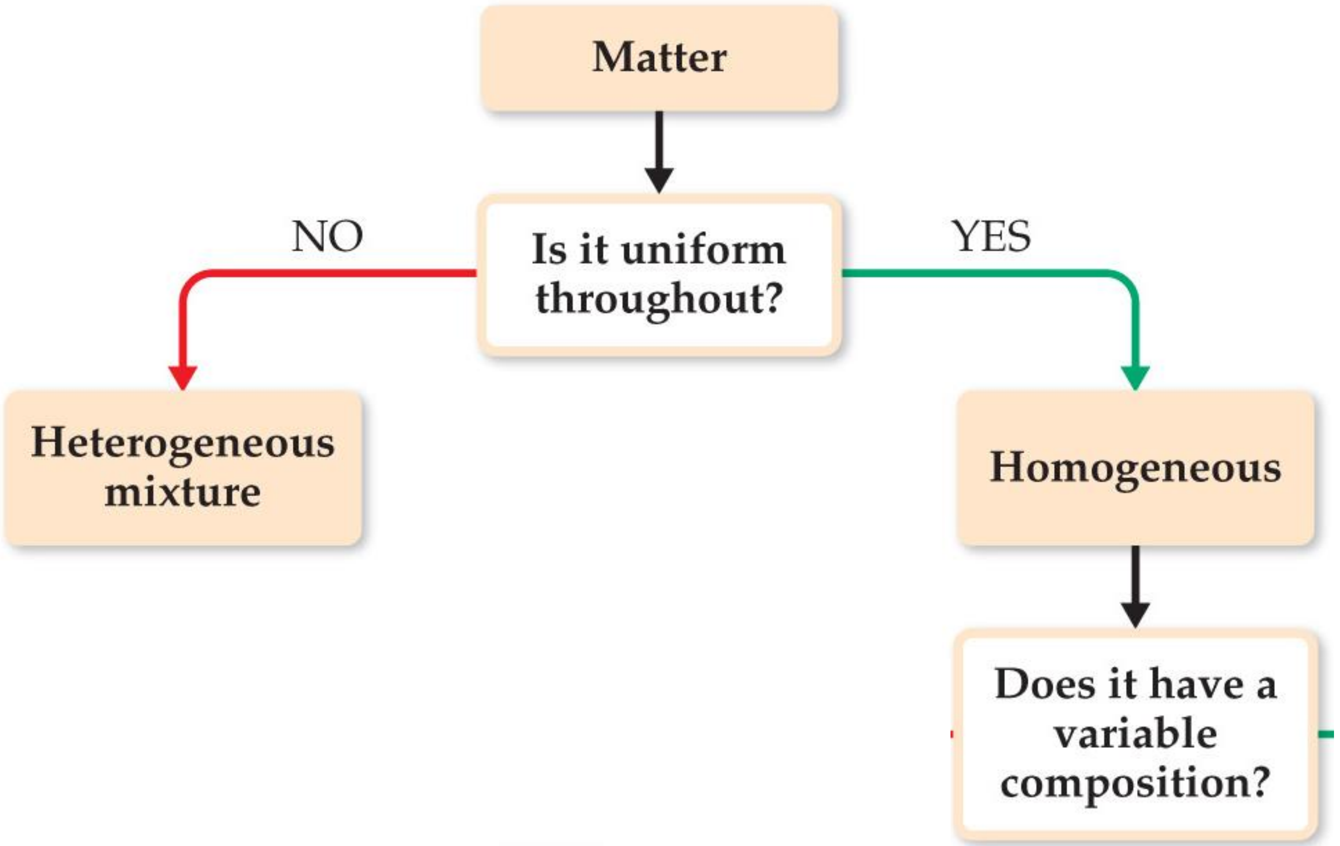
Is it uniform throughout?

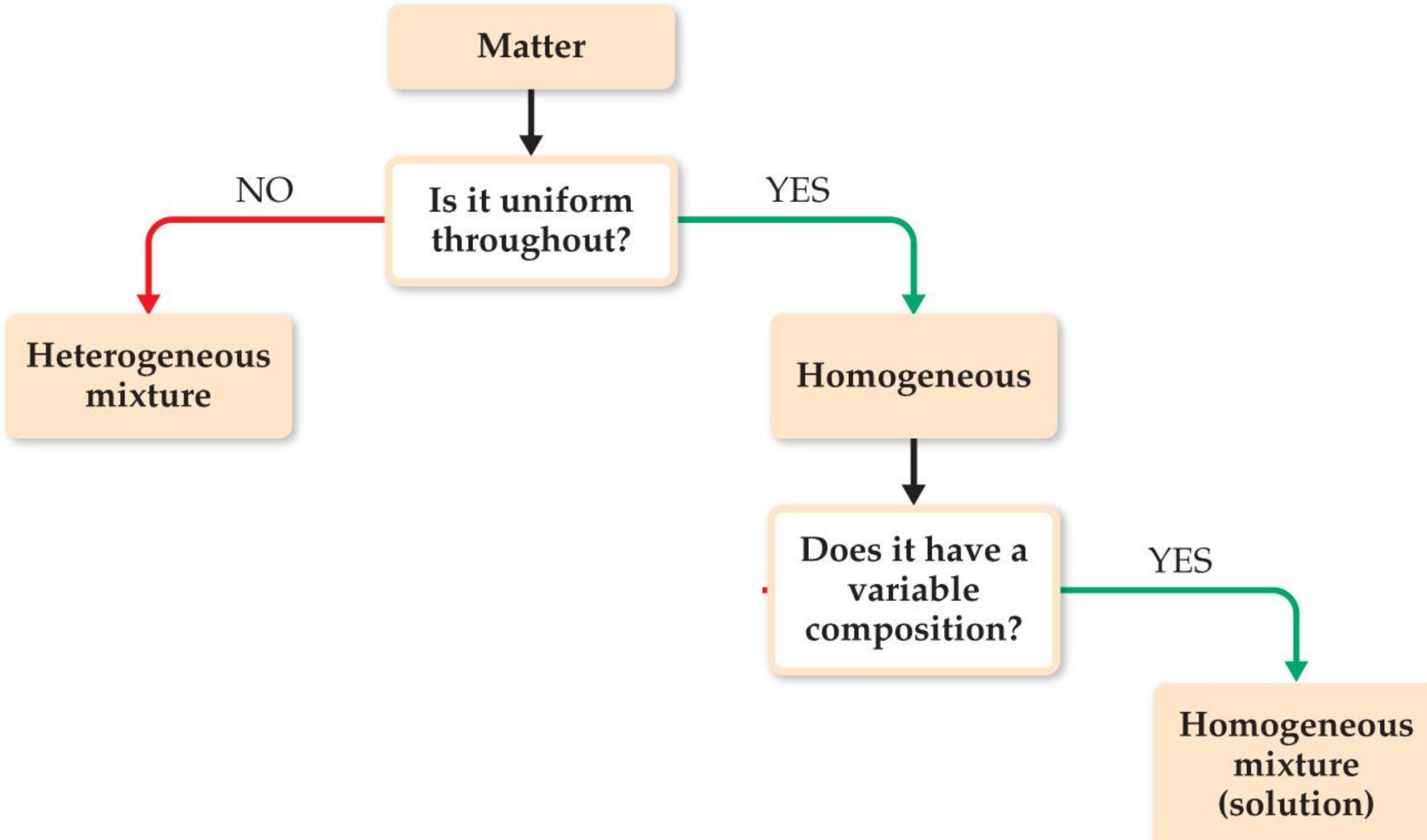
全部均匀?

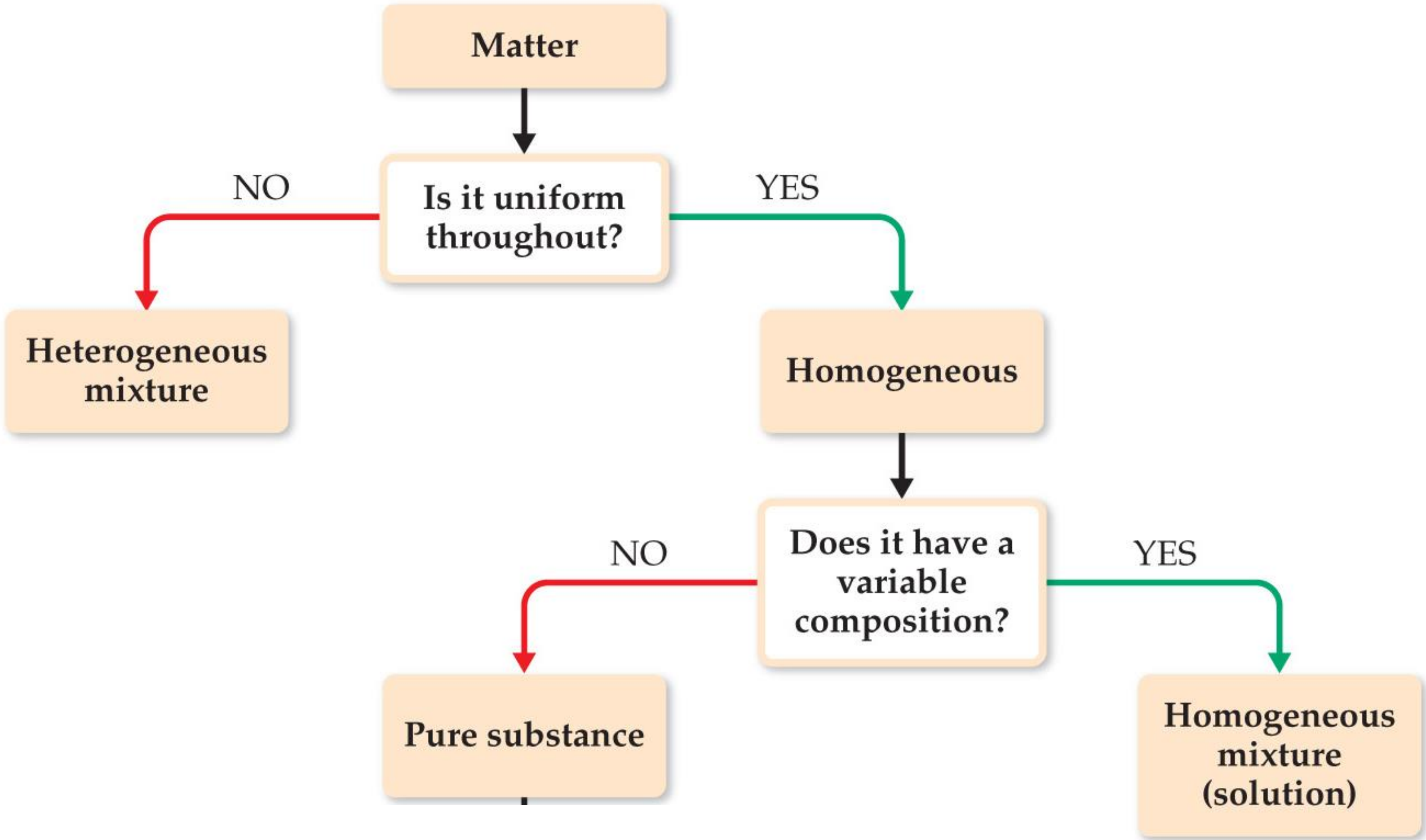
NO

Heterogeneous mixture

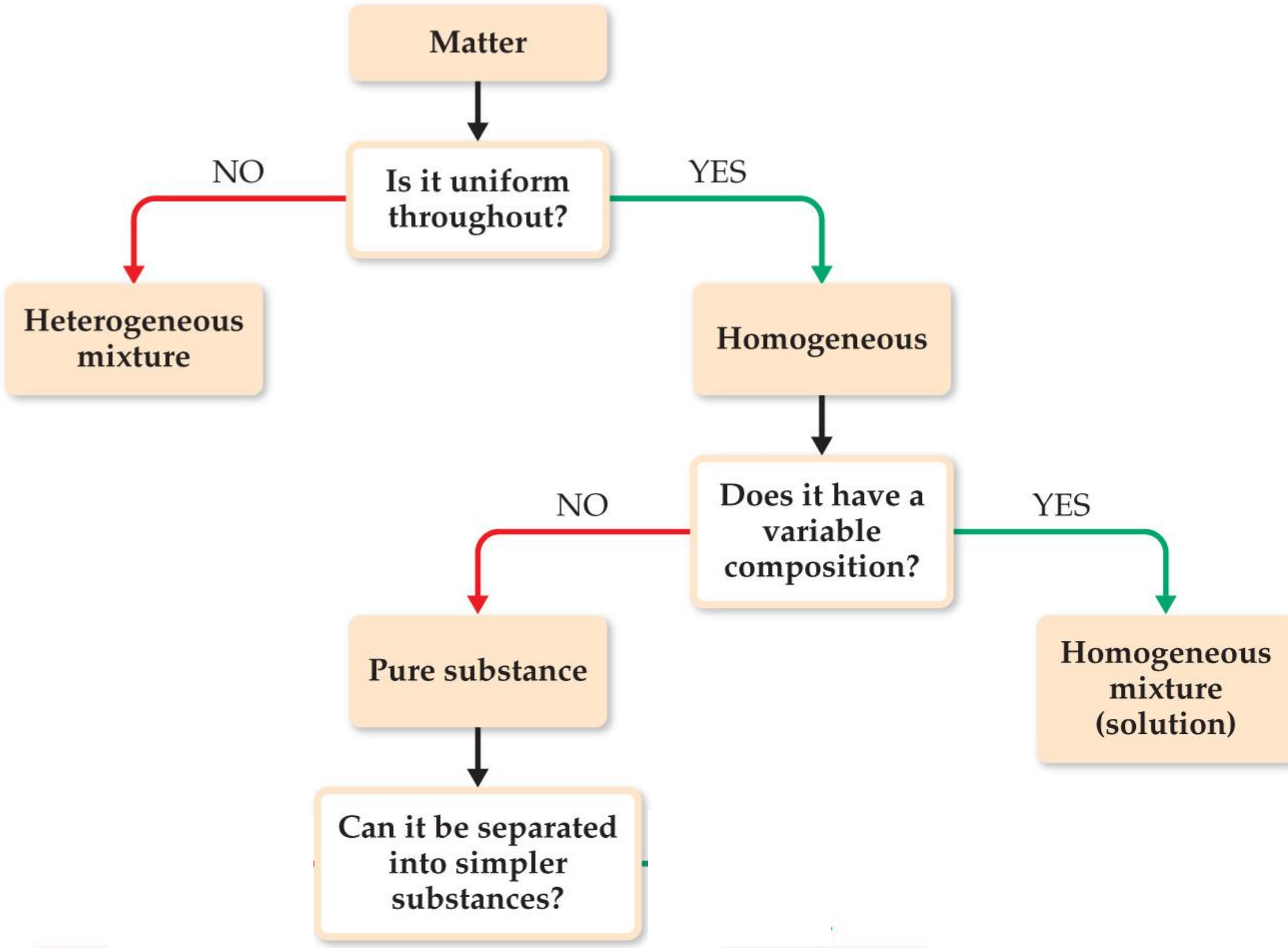

Matter
Is it uniform throughout?
NO
YES
全部均匀?
Heterogeneous mixture
Homogeneous

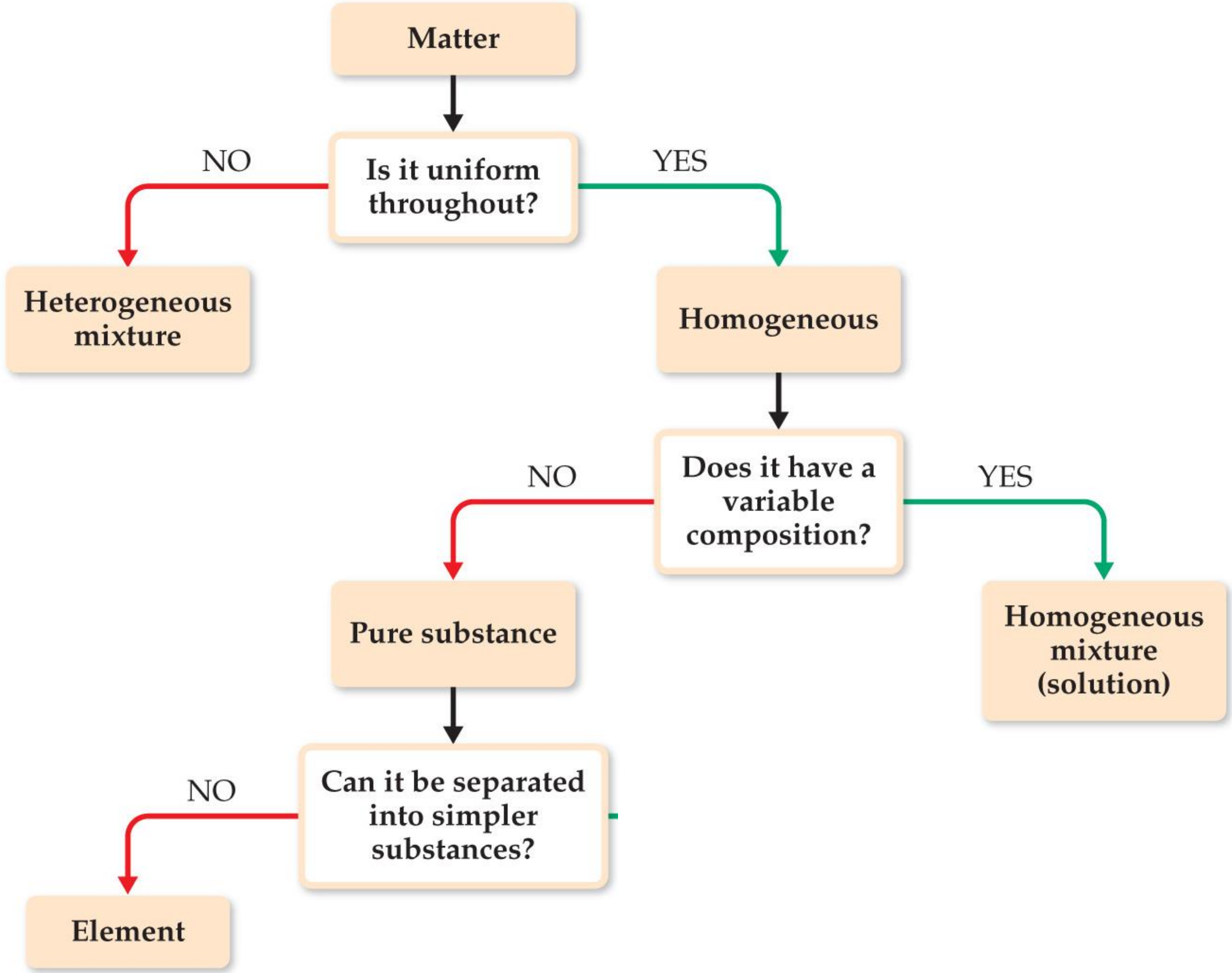

Matter
NO
Is it uniform throughout?
YES
Heterogeneous mixture
Homogeneous
Does it have a variable composition?


Matter
Is it uniform throughout?
NO
YES
Heterogeneous mixture
Homogeneous
Does it have a variable composition?
YES
Homogeneous mixture (solution)

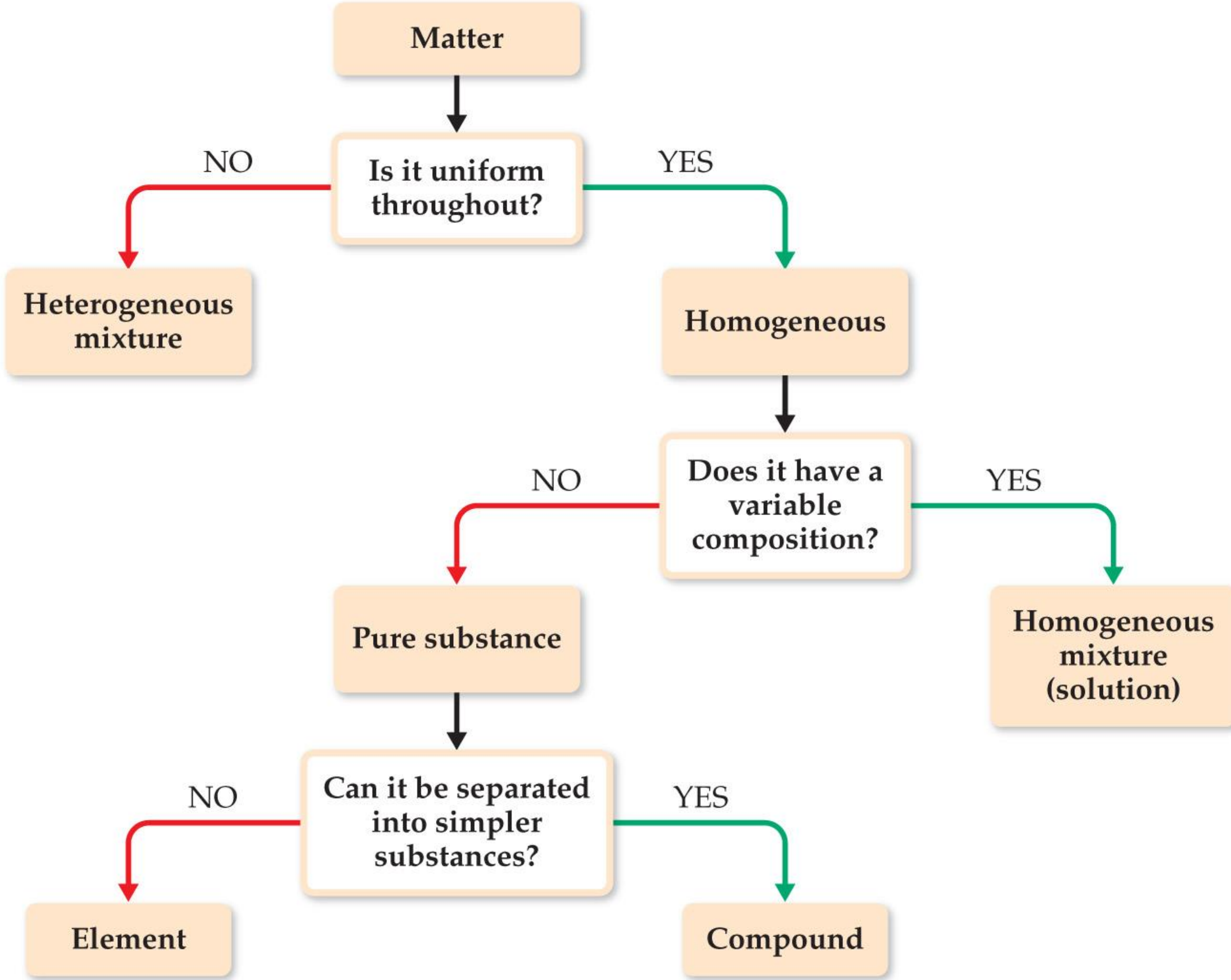


Matter
And
Measurement


Matter
Is it uniform throughout?
NO
YES
Heterogeneous mixture
Homogeneous
Does it have a variable composition?
NO
YES
Pure substance
Homogeneous mixture (solution)
Can it be separated into simpler substances?


Matter
Is it uniform throughout?
NO
YES
Heterogeneous mixture
Homogeneous
Does it have a variable composition?
NO
YES
Pure substance
Homogeneous mixture (solution)
Can it be separated into simpler substances?
NO
Element

Classification of Matter



tter
nd
rement

Which of the following is not a pure substance?

a. water
b. carbon dioxide
c. carbon
d. air

Properties of Matter

Physical & Chemical Properties

- **Physical Properties**

  No change of an identity of a substance (**A**):

  A → A

  e.g. boiling point, density, mass, volume, color, etc.

- **Chemical Properties**

  One substance is changed into another substance:

  A → B; **A → B + C**; **A + B → C**

  e.g. combustion（燃烧）, oxidation（氧化）, decomposition (分解), or reactivity with acid etc.

Intensive & Extensive Properties

- **<u>In</u>tensive Properties (强度性质)**

  <u>In</u>dependence on the **amount** of the substance present.

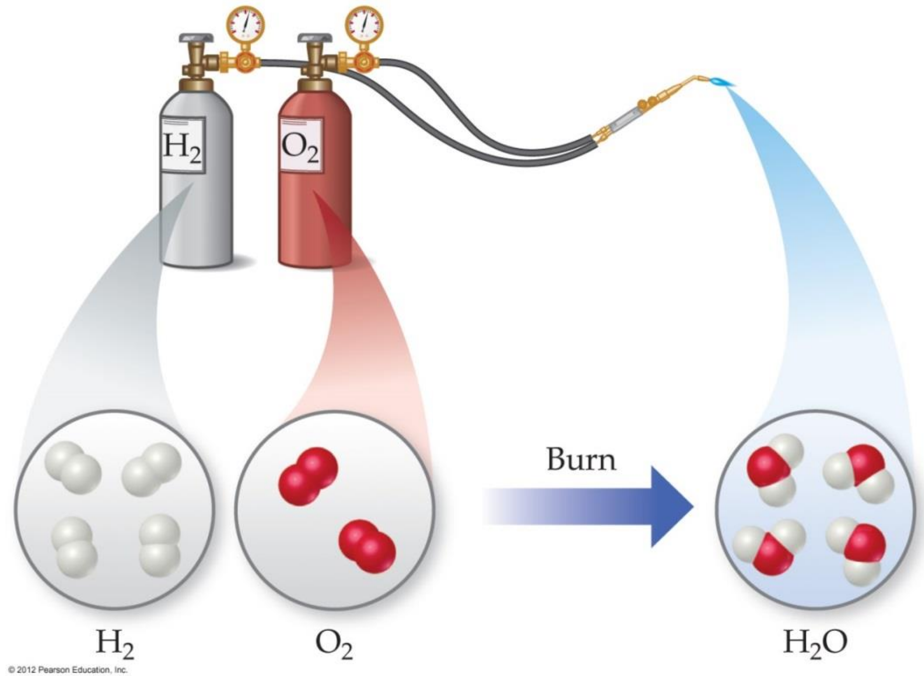
  e.g. density, boiling point, color, etc.

- **Extensive Properties (广度性质)**

  Dependence on the **amount** of the substance present.

  e.g. mass, volume, energy, etc.

Chemical Changes



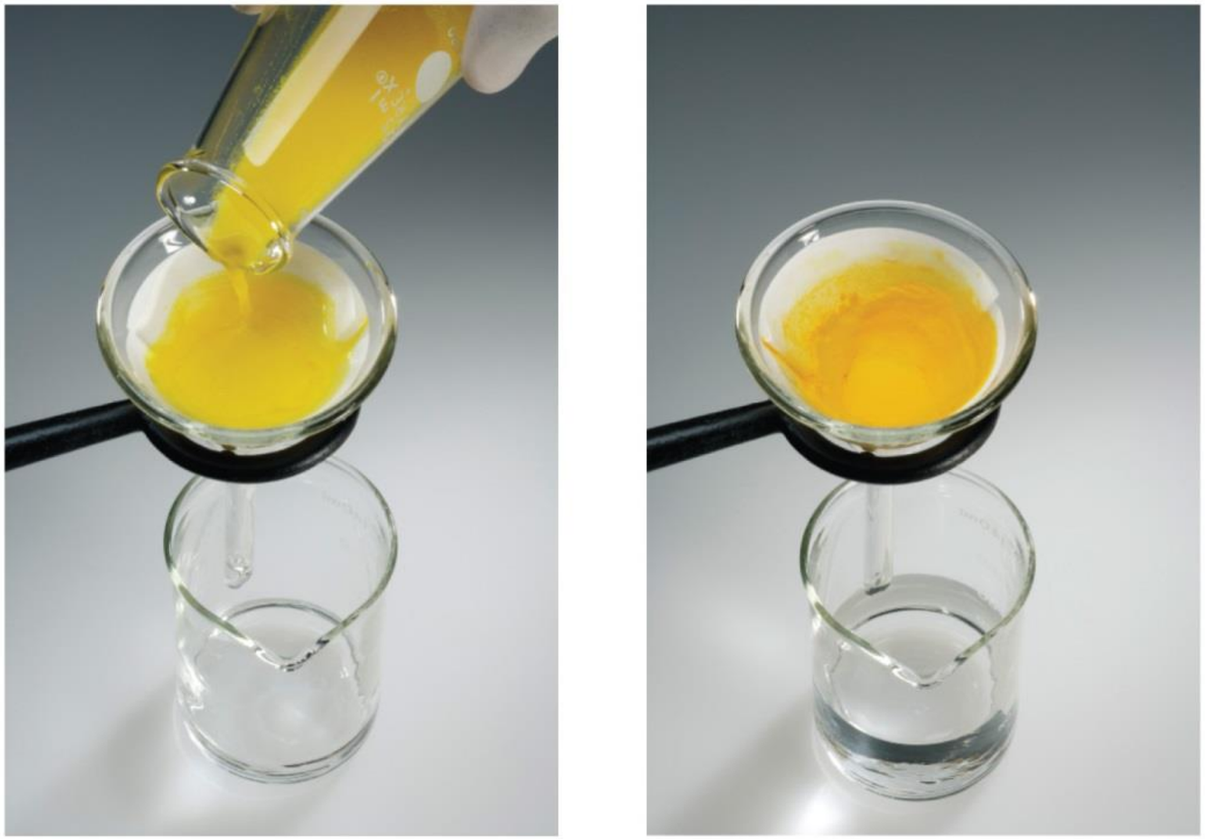
The reacting substances are converted to **new substances** after the chemical reaction/change.

- **Physical Changes:** changes in matter that do ***not* change the composition**, e.g. temperature & volume.

Matter And Measurement

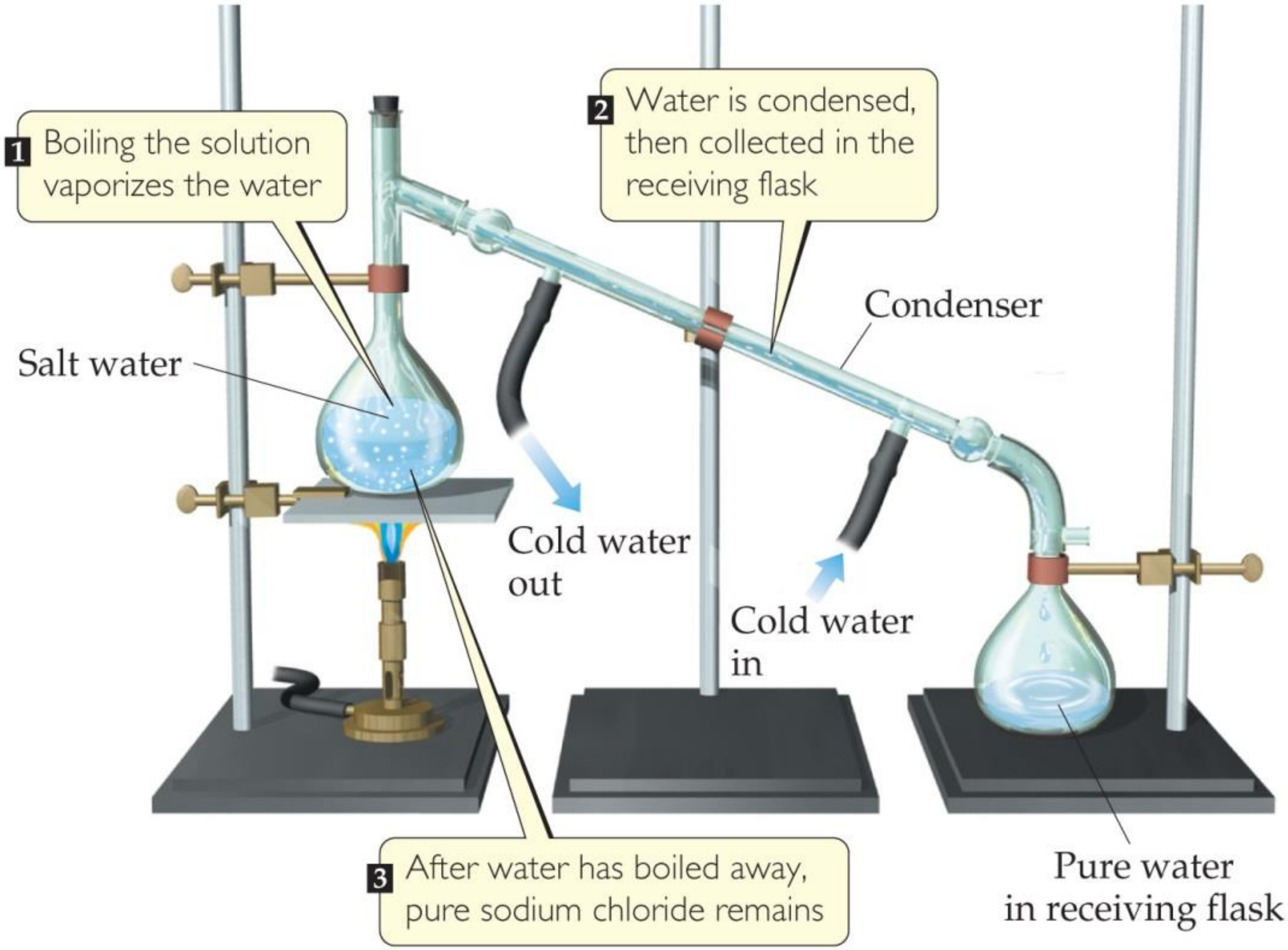
Separation of Mixtures

Filtration(过滤): Heterogeneous Mixture



Solid substances are separated from liquids & solutions.

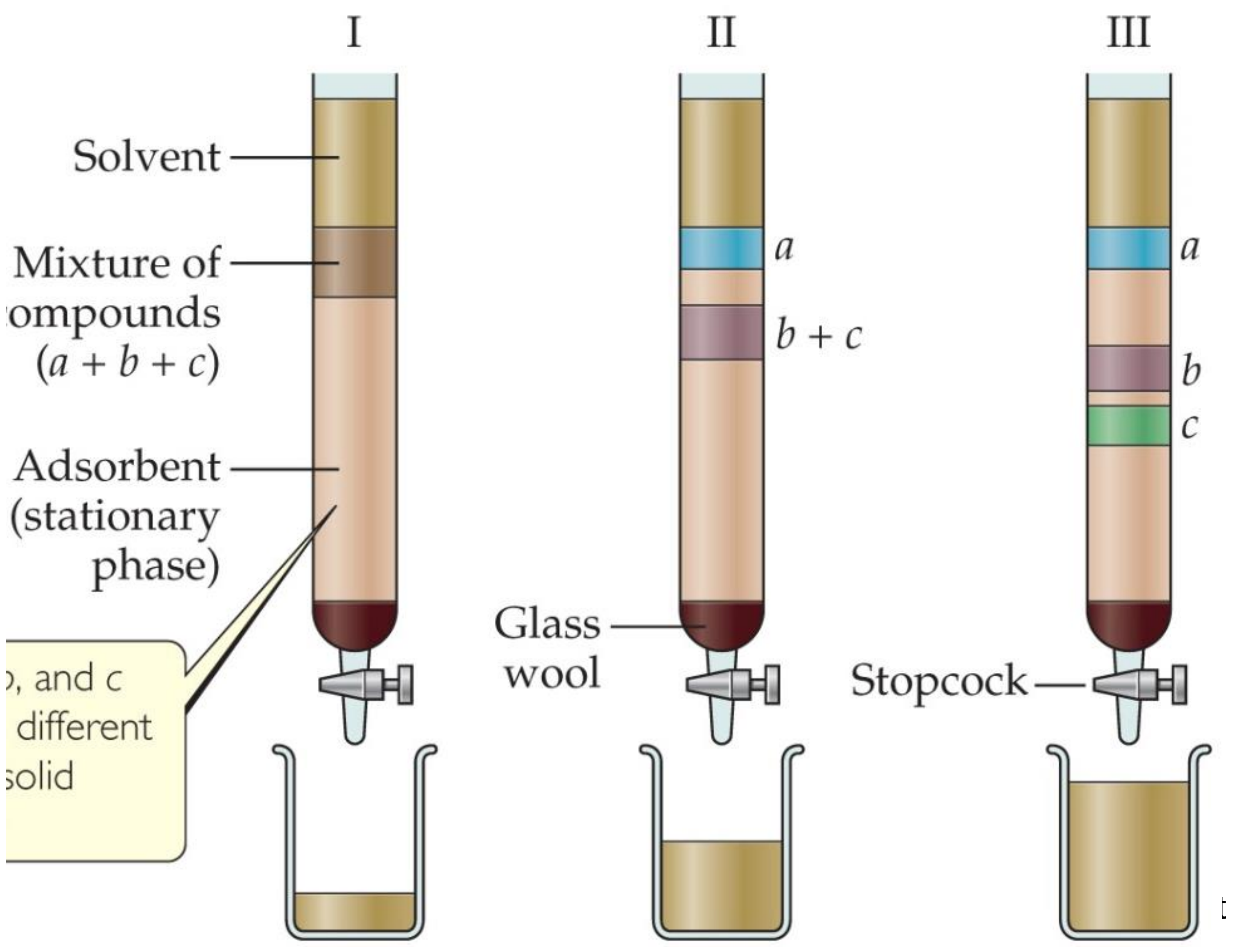
Distillation(蒸馏): Homogeneous Mixture



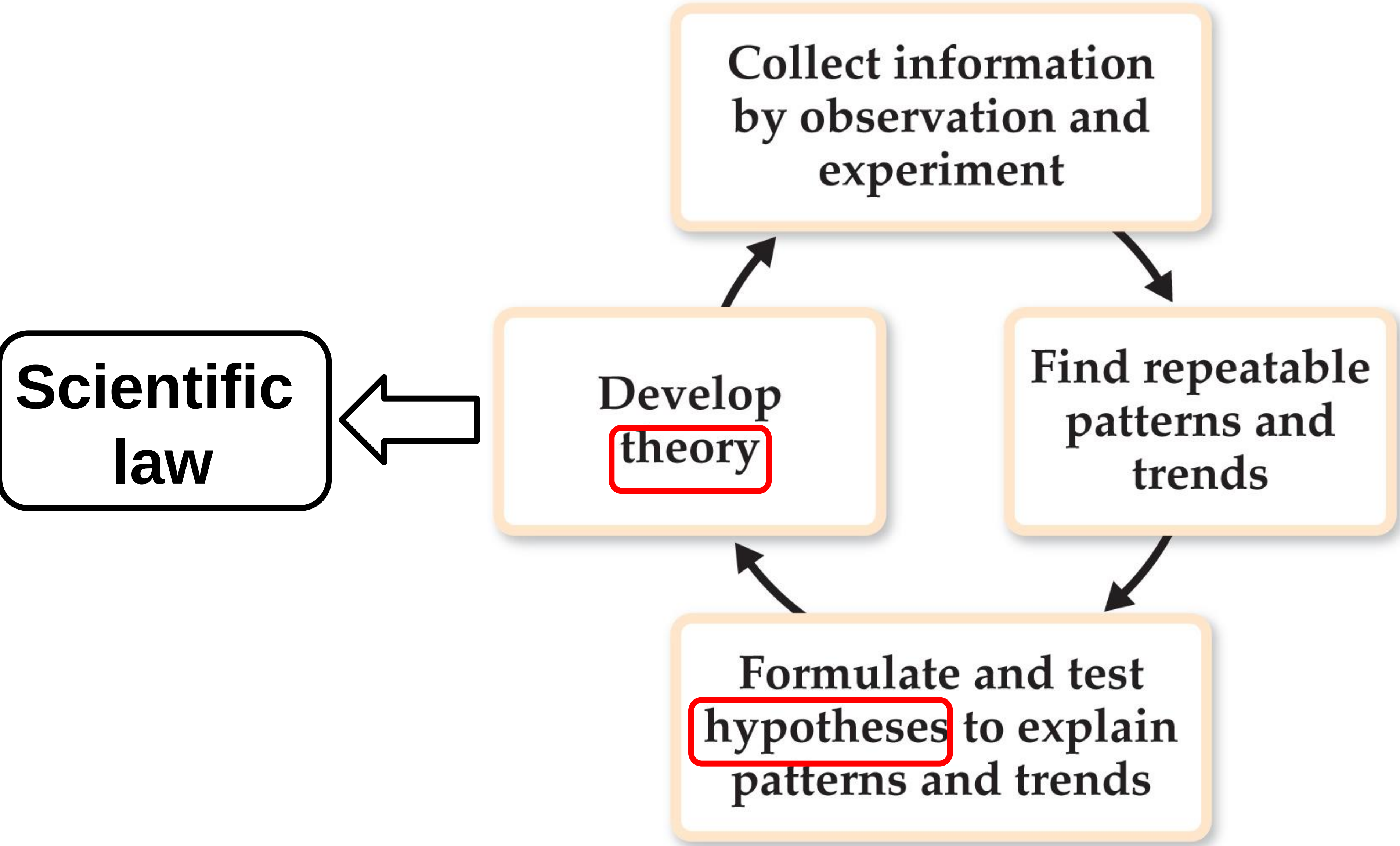
Use **differences in the boiling points** of substances to separate into its components.

Chromatography(色谱法)

Separates substances on the basis of **differences in solubility** in a solvent or **adhering ability** to the surface.



The Scientific Method



RULES OF A SCIENTIST'S LIFE

(Extra Info.)

1. SEE FAILURE AS A BEGINNING, NOT AN END.
2. NEVER STOP LEARNING.
3. ASSUME NOTHING, QUESTION EVERYTHING.
4. TEACH OTHERS WHAT YOU KNOW.
5. ANALYZE OBJECTIVELY.
6. PRACTICE HUMILITY.
7. RESPECT CONSTRUCTIVE CRITICISM.
8. GIVE CREDIT WHERE IT'S DUE.
9. TAKE INITIATIVE.
10. ASK THE TOUGH QUESTIONS EARLY.
11. LOVE WHAT YOU DO, OR LEAVE.

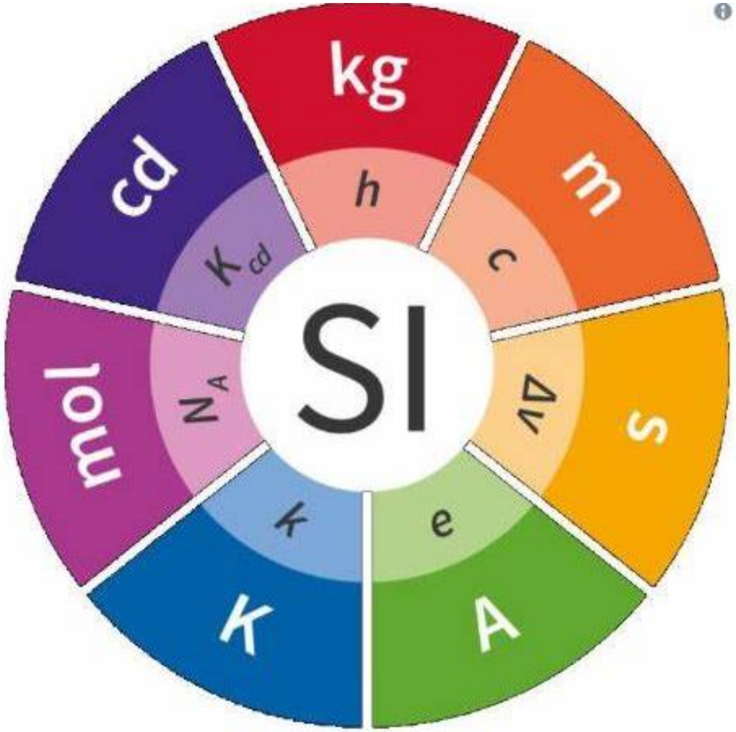
Measurement: Units

SI Units

Physical Quantity	Name of Unit	Abbreviation
Mass	Kilogram	kg
Length	Meter	m
Time	Second	s or sec
Temperature	Kelvin	K
Amount of substance	Mole	mol
Electric current	Ampere	A or amp
Luminous intensity	Candela	cd

- *Système International d'Unités* (国际单位制)
- A different base unit used for each quantity

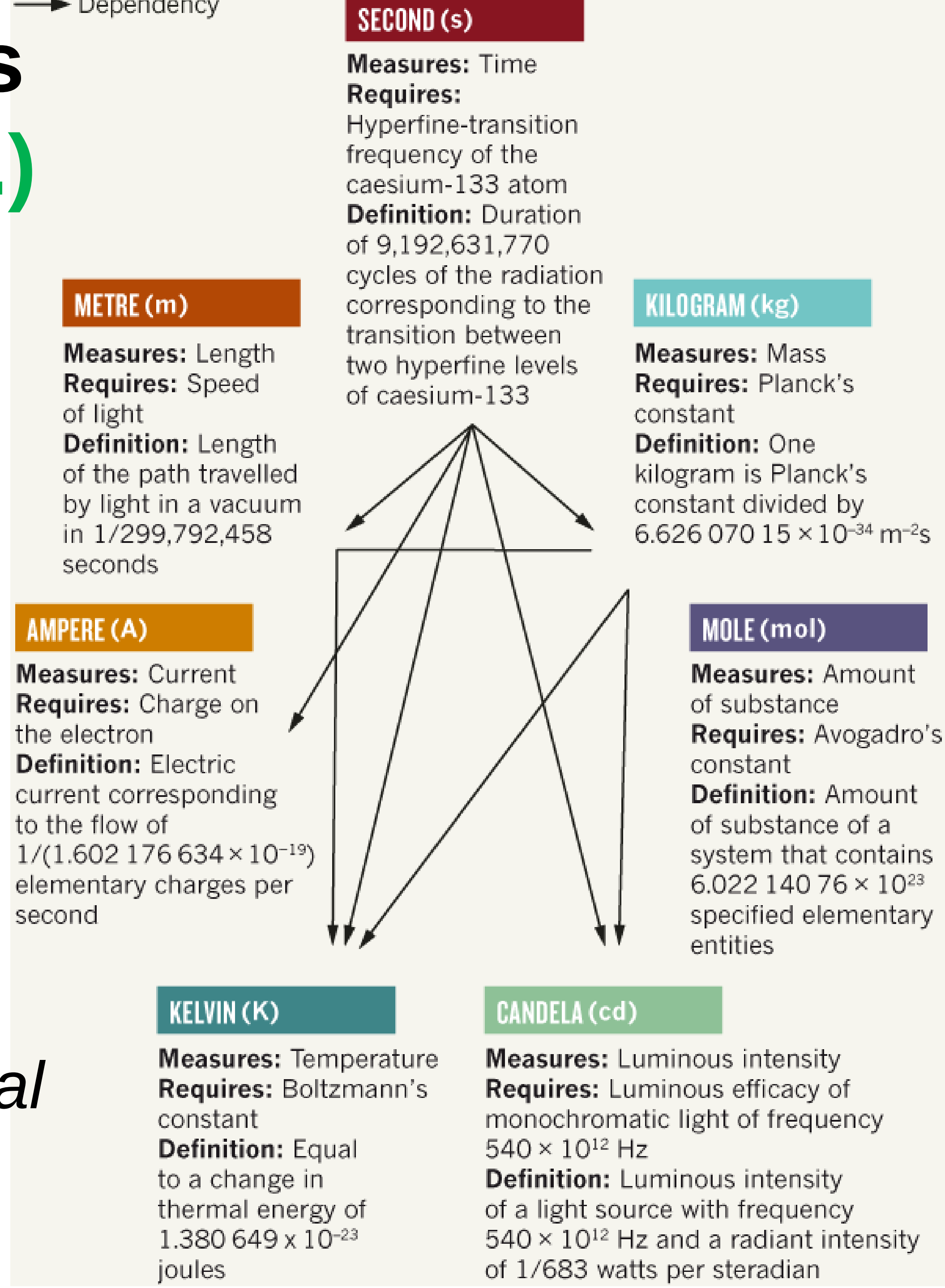
Redefined SI Units in 2018 (Extra Info.)



Old Units (Outer)

New Units (Inner):

Defined based on physical constants with fixed numerical values



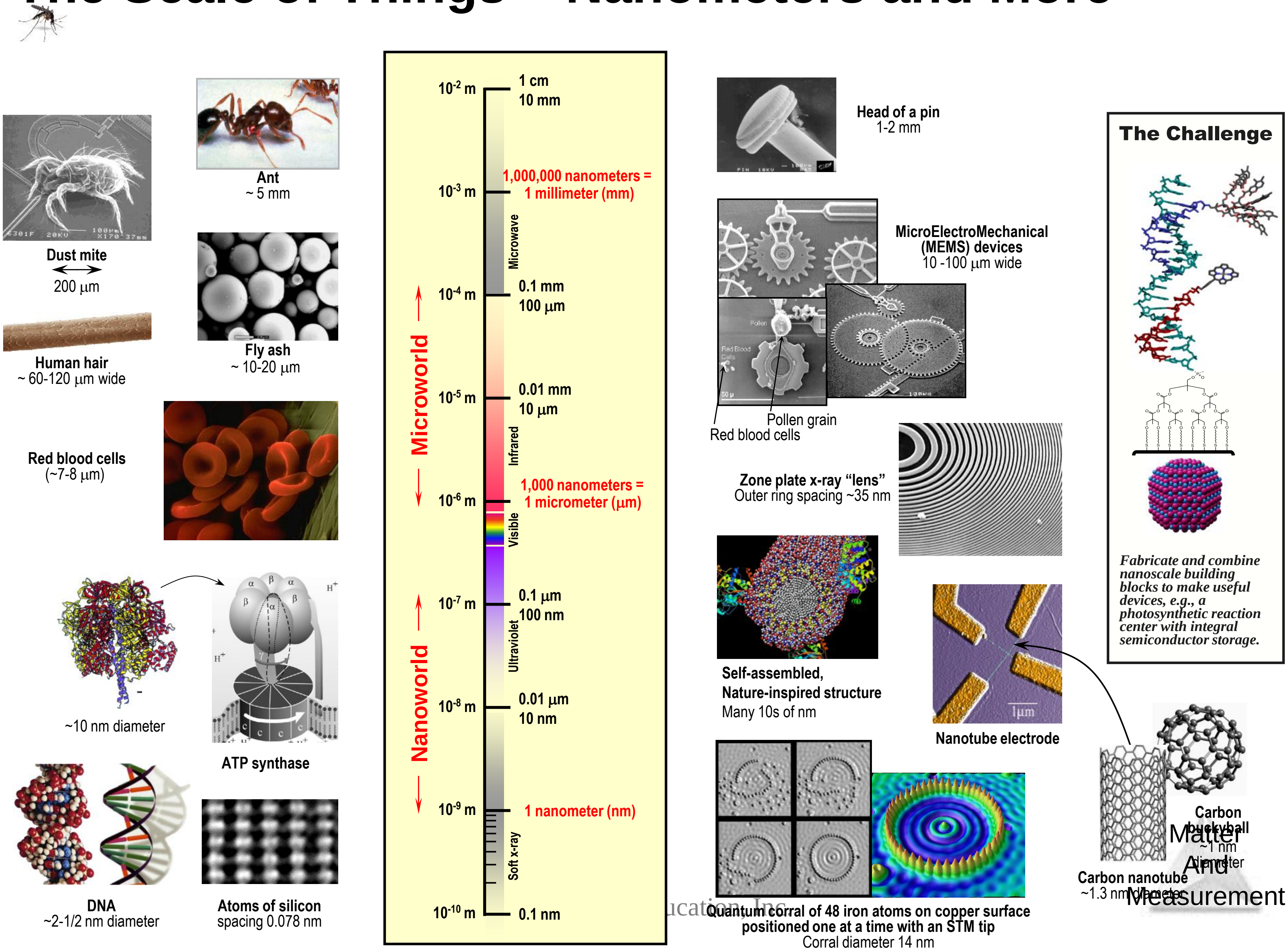
Metric (度量) System

TABLE 1.5 • Prefixes Used in the Metric System and with SI Units

Prefix	Abbreviation	Meaning	Example
Peta	P	10^{15}	1 petawatt (PW) $= 1 \times 10^{15}$ watts[a]
Tera	T	10^{12}	1 terawatt (TW) $= 1 \times 10^{12}$ watts
Giga	G	10^{9}	1 gigawatt (GW) $= 1 \times 10^{9}$ watts
Mega	M	10^{6}	1 megawatt (MW) $= 1 \times 10^{6}$ watts
Kilo	k	10^{3}	1 kilowatt (kW) $= 1 \times 10^{3}$ watts
Deci	d	10^{-1}	1 deciwatt (dW) $= 1 \times 10^{-1}$ watt
Centi	c	10^{-2}	1 centiwatt (cW) $= 1 \times 10^{-2}$ watt
Milli	m	10^{-3}	1 milliwatt (mW) $= 1 \times 10^{-3}$ watt
Micro	μ[b]	10^{-6}	1 microwatt (μW) $= 1 \times 10^{-6}$ watt
Nano	n	10^{-9}	1 nanowatt (nW) $= 1 \times 10^{-9}$ watt
Pico	p	10^{-12}	1 picowatt (pW) $= 1 \times 10^{-12}$ watt
Femto	f	10^{-15}	1 femtowatt (fW) $= 1 \times 10^{-15}$ watt
Atto	a	10^{-18}	1 attowatt (aW) $= 1 \times 10^{-18}$ watt
Zepto	z	10^{-21}	1 zeptowatt (zW) $= 1 \times 10^{-21}$ watt

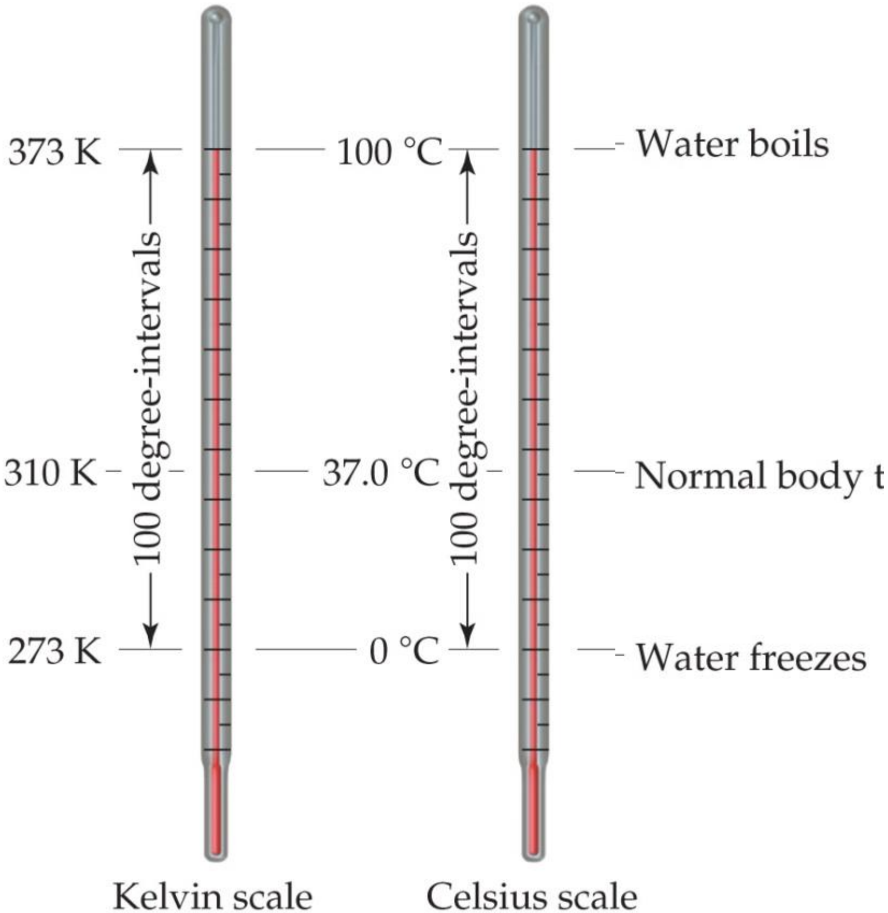
UPPER & lower cases: P vs. p & M vs. m!

The Scale of Things – Nanometers and More



Matter
And
Measurement

Temperature



- Average kinetic energy of the particles; determines the direction of heat flow.
- Celsius and Kelvin scales are most used.
- **Celsius scale**: (0 °C: freezing point; 100 °C: boiling point of water).
- **Kelvin scale** (SI unit): no negative temperatures.

  (**K = °C + 273.15**)

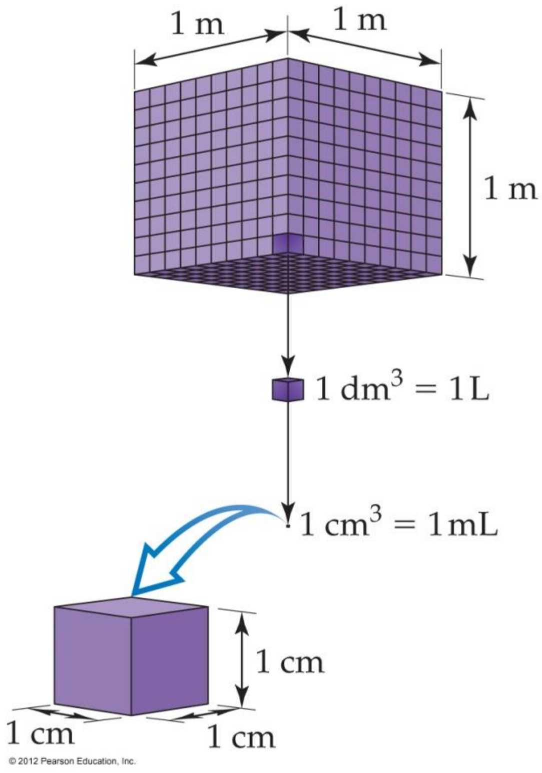
Derived SI Units

Volume

Common units: liter (L) & milliliter (mL).

e.g. 1 L = 1 dm^3

1 mL = $1*10^{-3}$ L = 1 cm^3

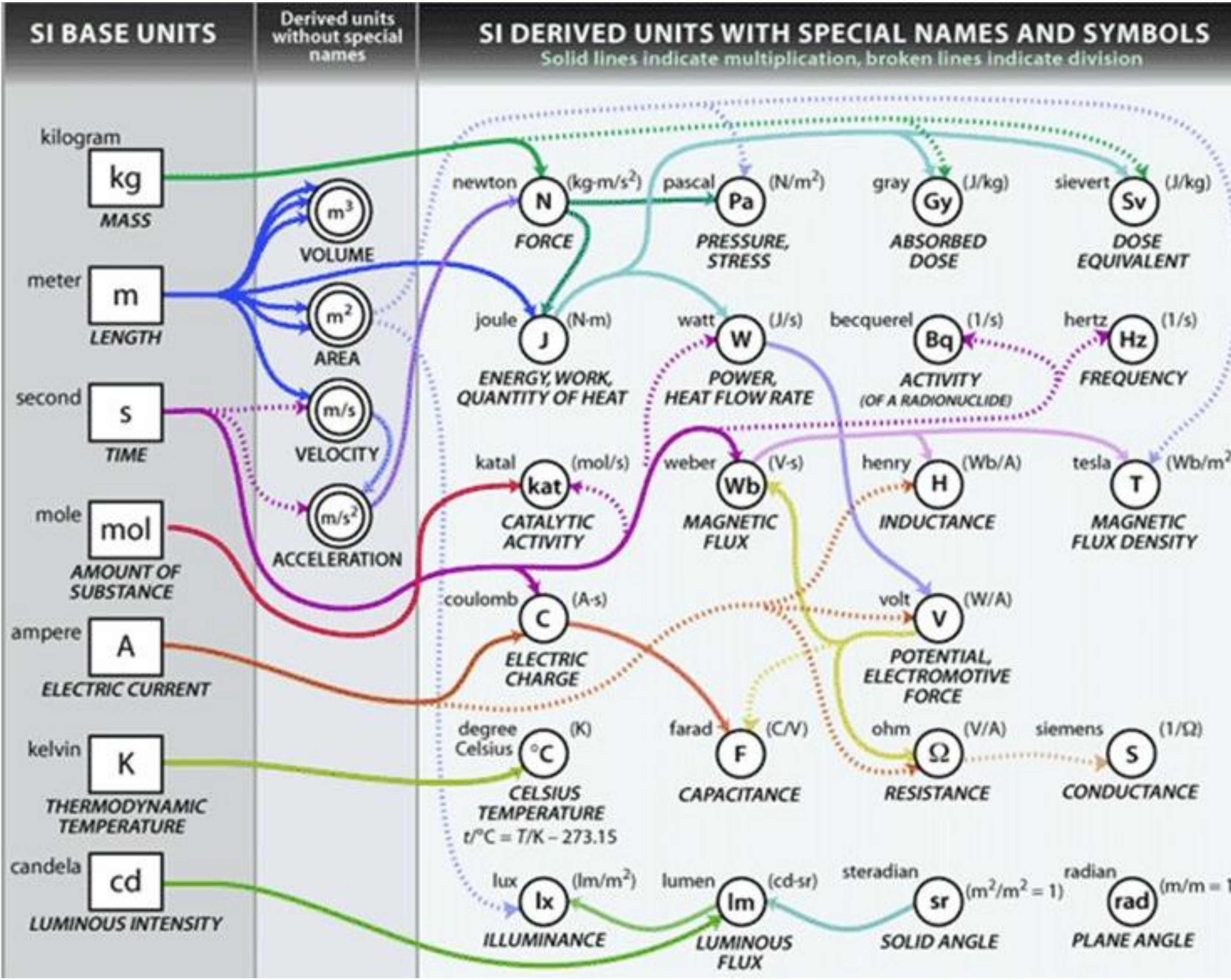


Density

Units: e.g. *g/mL*

$$d = m/V$$

(Extra Info.)



Matter And Measurement

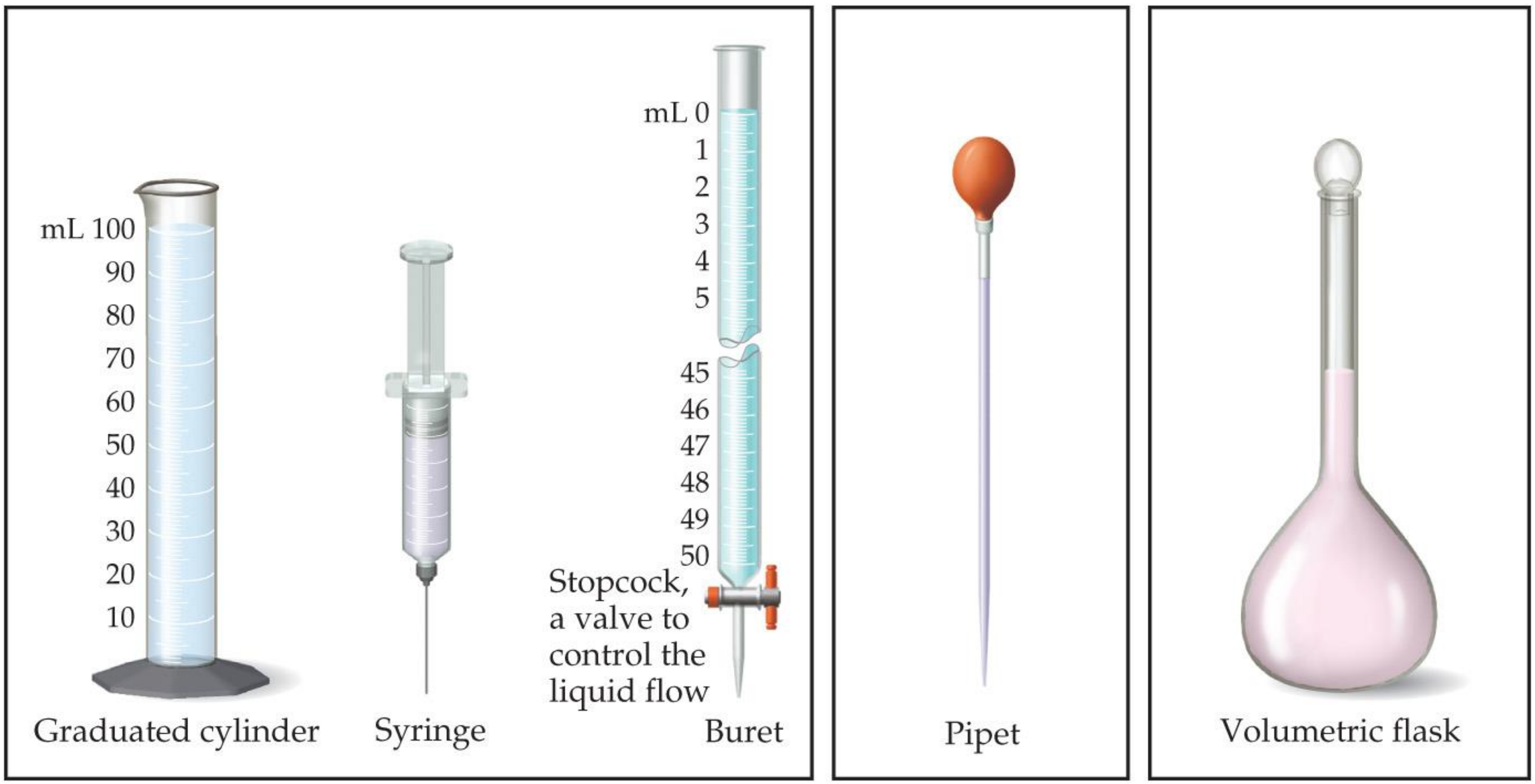
Measurement: Uncertainty

(不确定度)

Exact numbers (counting or defined; e.g. persons)

vs. ***Inexact numbers*** (measured; e.g. how tall?)

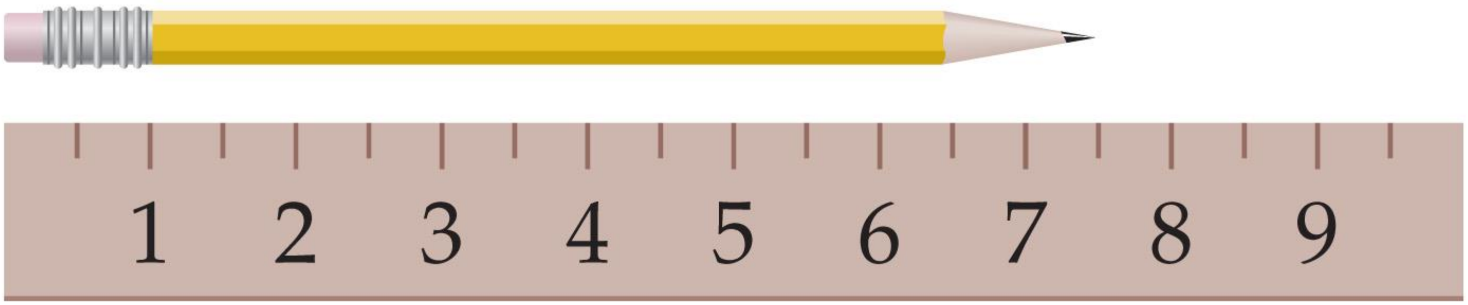
Different measuring devices: different levels of accuracy



These deliver **variable** volumes

Pipet **delivers** a **specific** volume

Volumetric flask **contains** a specific volume


1 2 3 4 5 6 7 8 9


0
20
40
60
80
100
120
140
160
180
200
220
240
km/h
0
20
40
60
80
100
120
140
160
mph

Accuracy (准确度) vs. Precision (精密度)

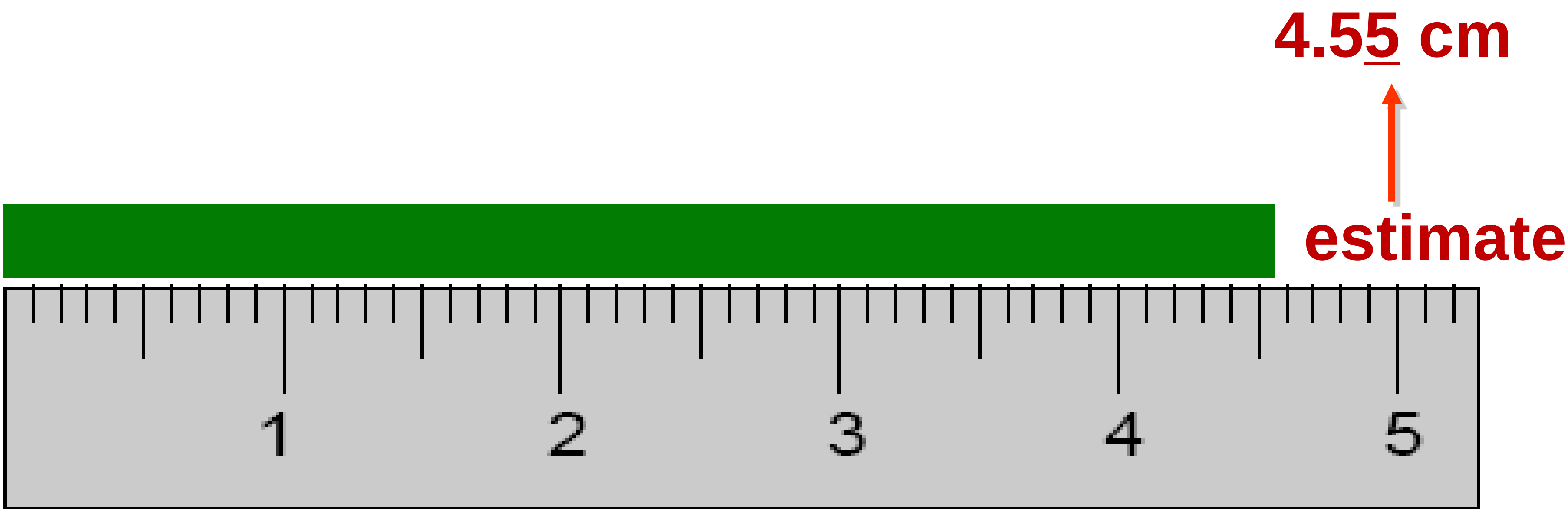
- **Accuracy:** how close is a measurement to the **true value**
- **Precision:** how close are several **measured values**

Good precision
Poor accuracy

Good precision
Good accuracy

Poor precision
Poor accuracy

Matter
And
Measurement



Team A: 4.21, 4.25, 4.23
Team B: 4.32, 4.43, 4.63
Team C: 4.51, 4.52, 4.53

Which one has
(i) Good Precision & Good Accuracy?
(ii) Good Precision & Poor Accuracy?
(iii) Poor Precision & Poor Accuracy?

Significant Figures（有效数字）

- **Significant figures:** digits reflects ***exactness of the measurement*** (**inexact**; e.g. 1.90 g ➔ 1.90 ± 0.01 g; **3** significant figures; 2 ➔ 2 ± 1 (**1** significant figures)

Rules:

1. All nonzero digits are **significant**: e.g. **12.34 (4 SF)**
2. **Zeroes** between two significant figures are **significant**: e.g. 12**0.0**34 **(6 SF)**
3. Leading zeroes before the **first nonzero** digit are **not significant**: e.g. **0.00**2 **(1 SF!)**
4. **Zeroes** at the end of a number are **significant** if the number **has a decimal point (小数点)**, e.g. 0.**20 (2)**, 2**.0 (2)**, **300 (1 SF!), 300.0 (4 SF!), 300. or $3.00*10^2$ (3 SF!), $3.0*10^2$ (2 SF!).**

Matter And Measurement

1.03×10^4 g	(three significant figures)
1.030×10^4 g	(four significant figures)
1.0300×10^4 g	(five significant figures)

The measured quantity 0.082060 contains ______ significant figures.

a. 3
b. 4
c. 5
d. 6

Calculations

- 1. **Addition (+) or subtraction (-)**: answers are rounded (四舍五入) to the **least significant decimal place** (**最小的小数位置**). e.g.

20.1 g + 11.23 g = **31.33** g → **31.3** g

(1st, ±0.1) (2nd, ±0.01) (1st, ±0.1)

46590 g - 21400 g = **25190** g → **25200** g

(±10) (±100) (±100)

- 2. **Multiplication (*) or division (/)**: answers are rounded to the number of digits that corresponds to the ***least* number of significant figures** (**最小SF数**) in any of the numbers used in the calculation. e.g.

6.221 cm * **5.2** cm = **32**.3492 cm^2 → **32** cm^2 **(2)**

6.03 g/**7.1** mL = **0.84**9257 g/mL → **0.85** g/mL **(2)**

Matter And Measurement

6.03 g + 7.1 g = ______ g.

a. 13
b. 13.1
c. 13.13
d. 13.130

7.1 m x 6.03 m = ______ m^2.

a. 43
b. 42.8
c. 42.81
d. 42.813

Significant Figures （有效数字）

What is the number of significant figures of the below values?

a) 601; b) 0.054; c) 6.3050; d) 0.0105; e) $7.0500*10^{-3}$

Answers:

Express answers with the correct number of significant figures:

f) 14.3505 + 2.65; g) 952.7 – 140.7389;

h) $(3.29*10^{4})(0.2501)$; i) 0.0588/0.677; j) 1234.5 - 1230.123

Answers:

Significant figures: reflects **exactness/error** of the **measured (inexact)** values.

1230	* 10	=	10000
(measured)	(measured)		(round-off)
(3 SF)	**(1 SF)**		**(1 SF)**
1234.56	+ 10.0	=	1244.6
(measured)	(measured)		(round-off)
(2^{nd})	**(1^{st} point)**		**(1^{st} point)**

1230	* 10	=	12300
(measured)	(**counted**)		
(3 SF)	**(exact)**		**(3 SF)**
1234.56	+ 10	=	1244.56
(measured)	(**counted**)		
(2^{nd})	**(exact)**		**(2^{nd})**

Matter
And
Measurement

Dimensional Analysis(量纲分析)

- convert one quantity to another in different units.
- Most commonly, utilizes **conversion factors** (e.g. 1 in. = 2.54 cm), analogous to currency rate ($)

The conversion factor: puts the **desired unit in the numerator (分子)**:

$$\cancel{\text{Given unit}} \times \frac{\text{desired unit}}{\cancel{\text{given unit}}} = \text{desired unit}$$

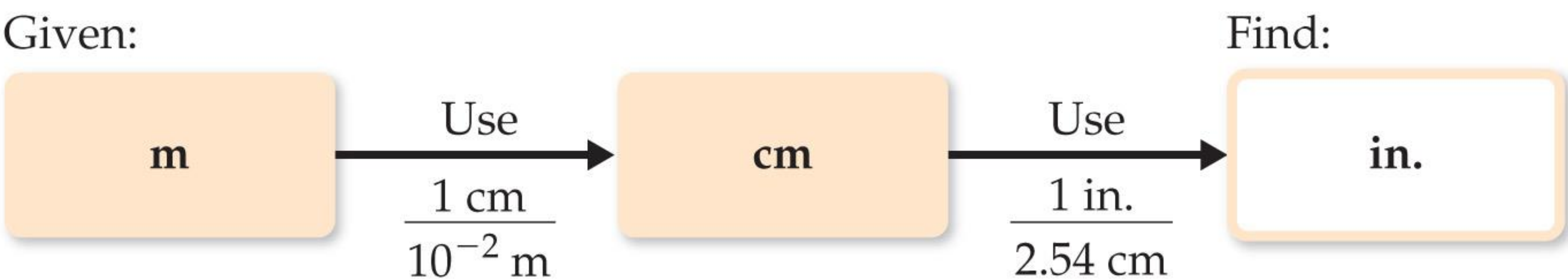
Conversion factor

$$\frac{1\ \textbf{in.}}{2.54\ \text{cm}} \quad \text{or} \quad \frac{2.54\ \textbf{cm}}{1\ \text{in.}}$$

Matter
And
Measurement

- e.g. 8.00 m to inches,

$$8.00\ \cancel{\text{m}} \times \frac{100\ \cancel{\text{cm}}}{1\ \cancel{\text{m}}} \quad \frac{1\text{ in.}}{2.54\ \cancel{\text{cm}}} = 315\text{ in.}$$



Key Summary

Chemistry: study matter, its properties and changes

Classifications of Matter:
Atoms, Elements, Compounds, Mixture; State of Matter

Properties of Matter:
Physical & Chemical; Intensive & Extensive;
Separation of Mixtures

Measurement of Matter:
Units (SI, Prefix); Uncertainty (Exact vs. Inexact number); Precision and Accuracy; Significant Figures);
Dimensional Analysis

Thank You for Your Attention!
Any Questions?