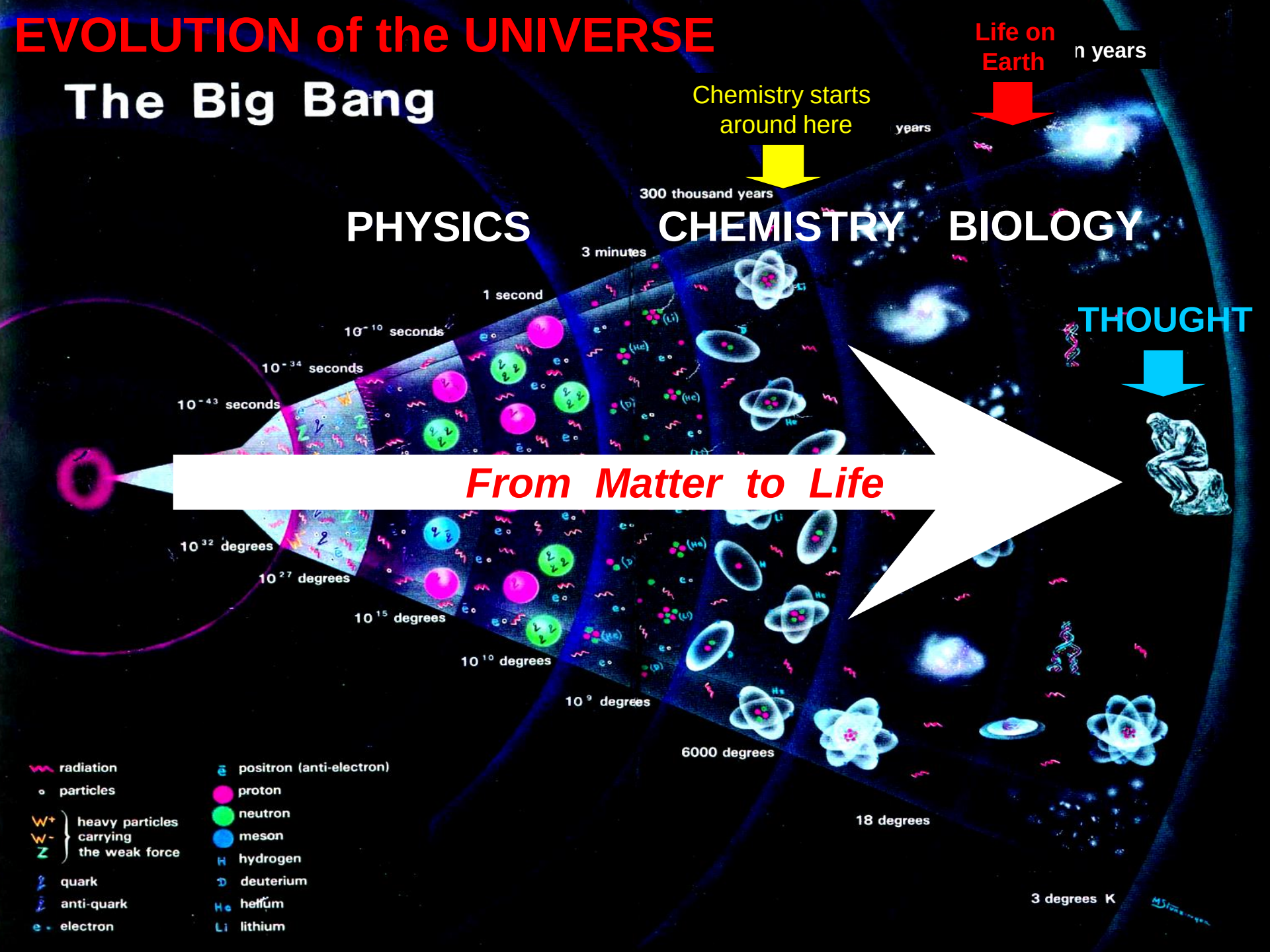
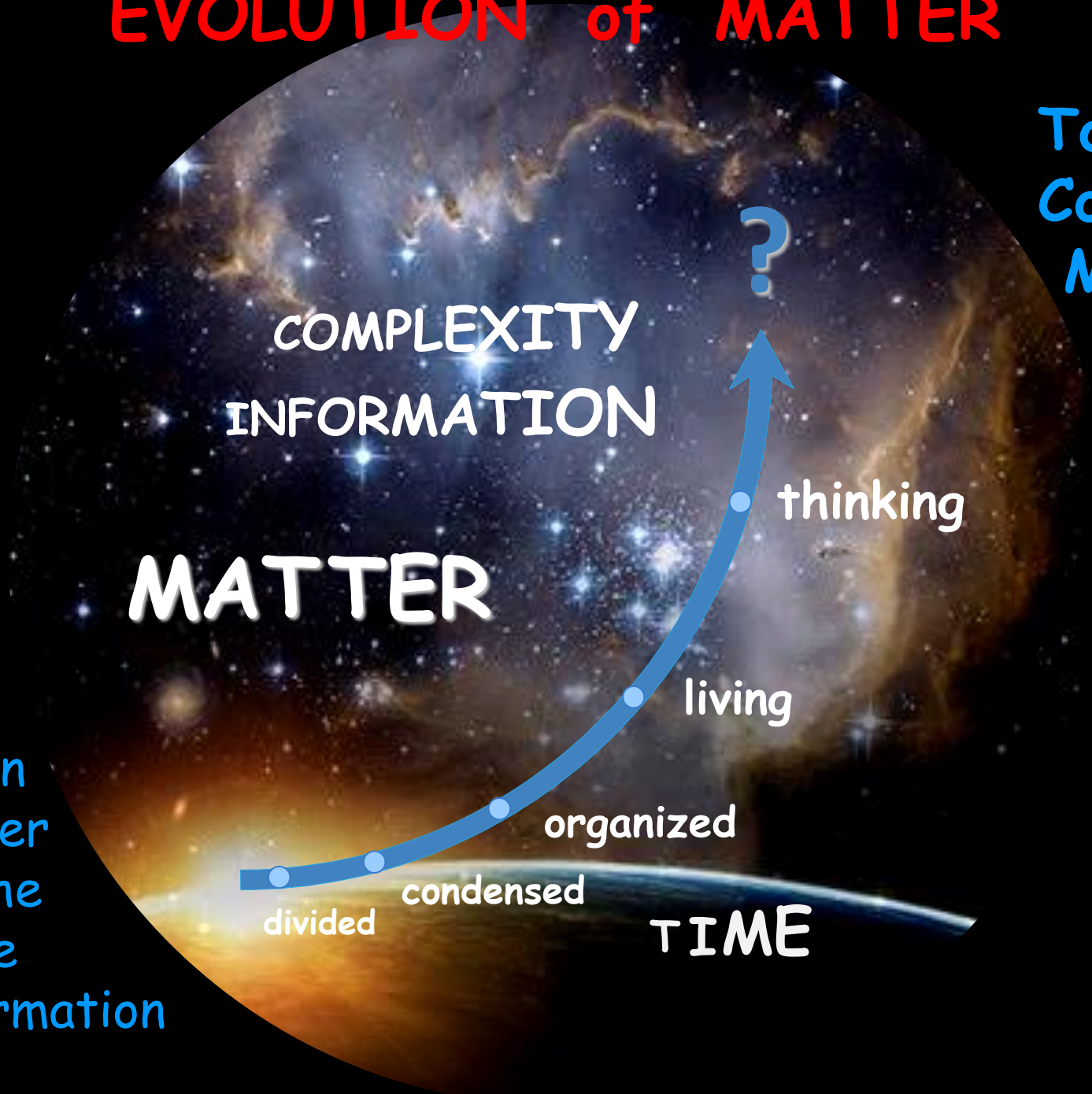

EVOLUTION of the UNIVERSE
The Big Bang
Life on Earth
n years
Chemistry starts around here
years
300 thousand years
PHYSICS
CHEMISTRY
BIOLOGY
3 minutes
1 second
10⁻¹⁰ seconds
10⁻³⁴ seconds
10⁻⁴³ seconds
THOUGHT
From Matter to Life
10³² degrees
10²⁷ degrees
10¹⁵ degrees
10¹⁰ degrees
10⁹ degrees
6000 degrees
18 degrees
3 degrees K
radiation
particles
W+ W- Z heavy particles carrying the weak force
quark
anti-quark
e- electron
positron (anti-electron)
proton
neutron
meson
H hydrogen
D deuterium
He helium
Li lithium

EVOLUTION of MATTER

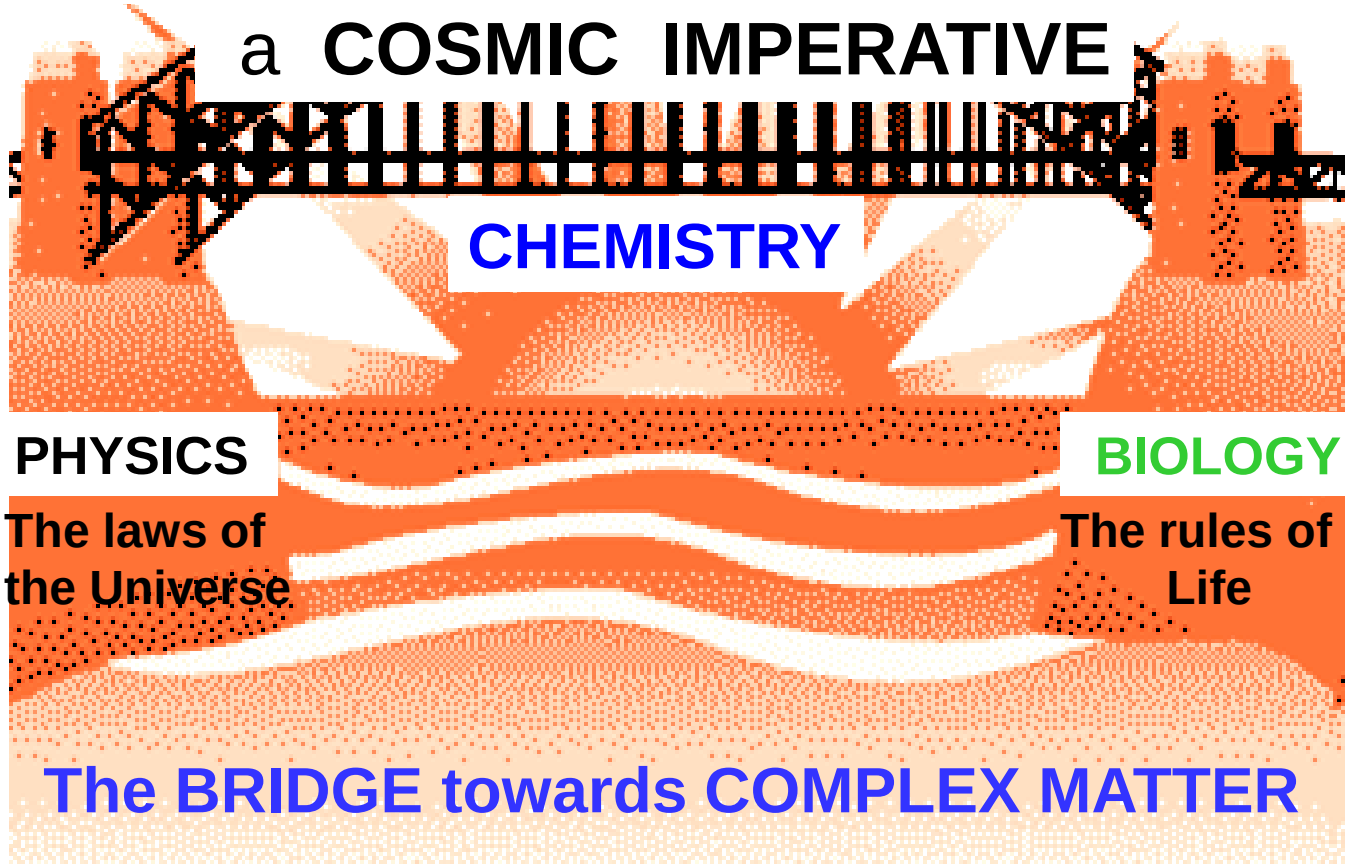


HOW DOES MATTER BECOME COMPLEX

?

By SELF-ORGANIZATION

a COSMIC IMPERATIVE



SELF-ORGANIZATION

of the UNIVERSE

through
GRAVITATIONAL
FORCES

COSMIC STRUCTURE

Structuration of the universe
by gravitational forces operating
on initial inhomogeneities in density
or in rates of expansion at very early times

of **MOLECULAR MATTER**

through
ELECTROMAGNETIC
FORCES

ORGANIZED, LIVING,
THINKING MATTER

Structuration of atomic and molecular matter
by the electromagnetic forces operating on
random structural combinations

PREBIOTIC CHEMICAL EVOLUTION

SELF-ORGANIZATION of NON-LIVING MOLECULAR MATTER

Electromagnetic forces operate selection on structural diversity leading to the progressive complexification of matter from the non-living to the living world under the pressure of information.

GENERALIZATION of DARWINIAN EVOLUTION

Chemical evolution through selection on structural diversity driven by intra and intermolecular forces implementing molecular information.

CHEMISTRY

The SCIENCE of the

STRUCTURE

and

TRANSFORMATION

of NON-LIVING
and
LIVING
MATTER

EMPEDOKLES

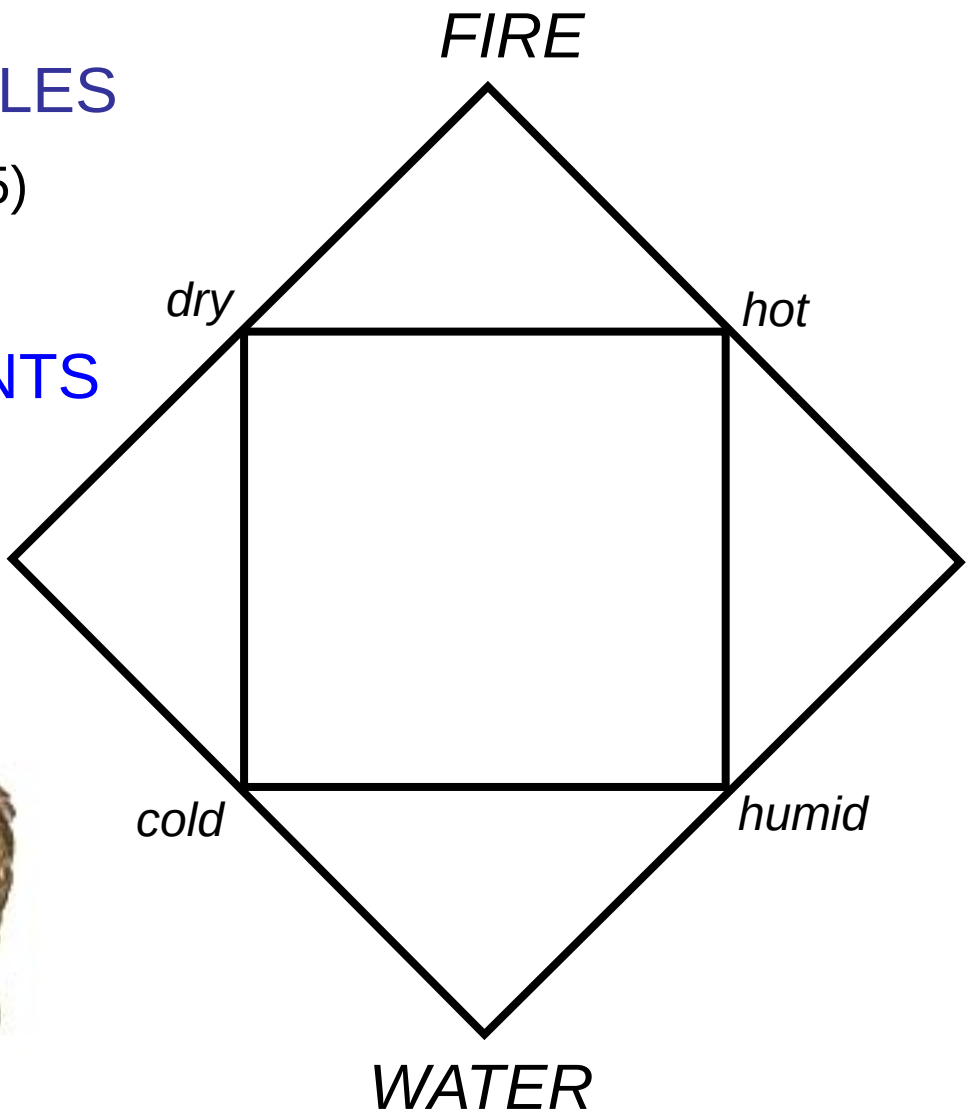
(-490, -435)

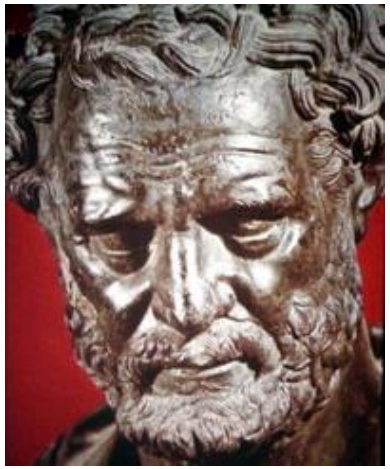
DEMOKRITOS

(-460,-370)

The ELEMENTS

The ATOMS





Bei der Vergleichung der gefundenen Zusammensetzung des Korns mit der des Mehls ergiebt sich, dass verloren gingen:

Asche	Kleber	Stärke	
0,043 Proc.	1,142 Proc.	6,459 Proc.,	zusammen 7,644 Proc.

Davon wurden verflüchtigt 3,988 Proc. Mehl, also beträgt die Differenz

On the Relationships between the Properties and the Atomic Weight of the Elements

D. Mendelejeff,

Zeitschrift für Chemie **12**, 405-6 (1869)

PERIODIC TABLE OF THE ELEMENTS

Stickstoff
Stärke
Asche

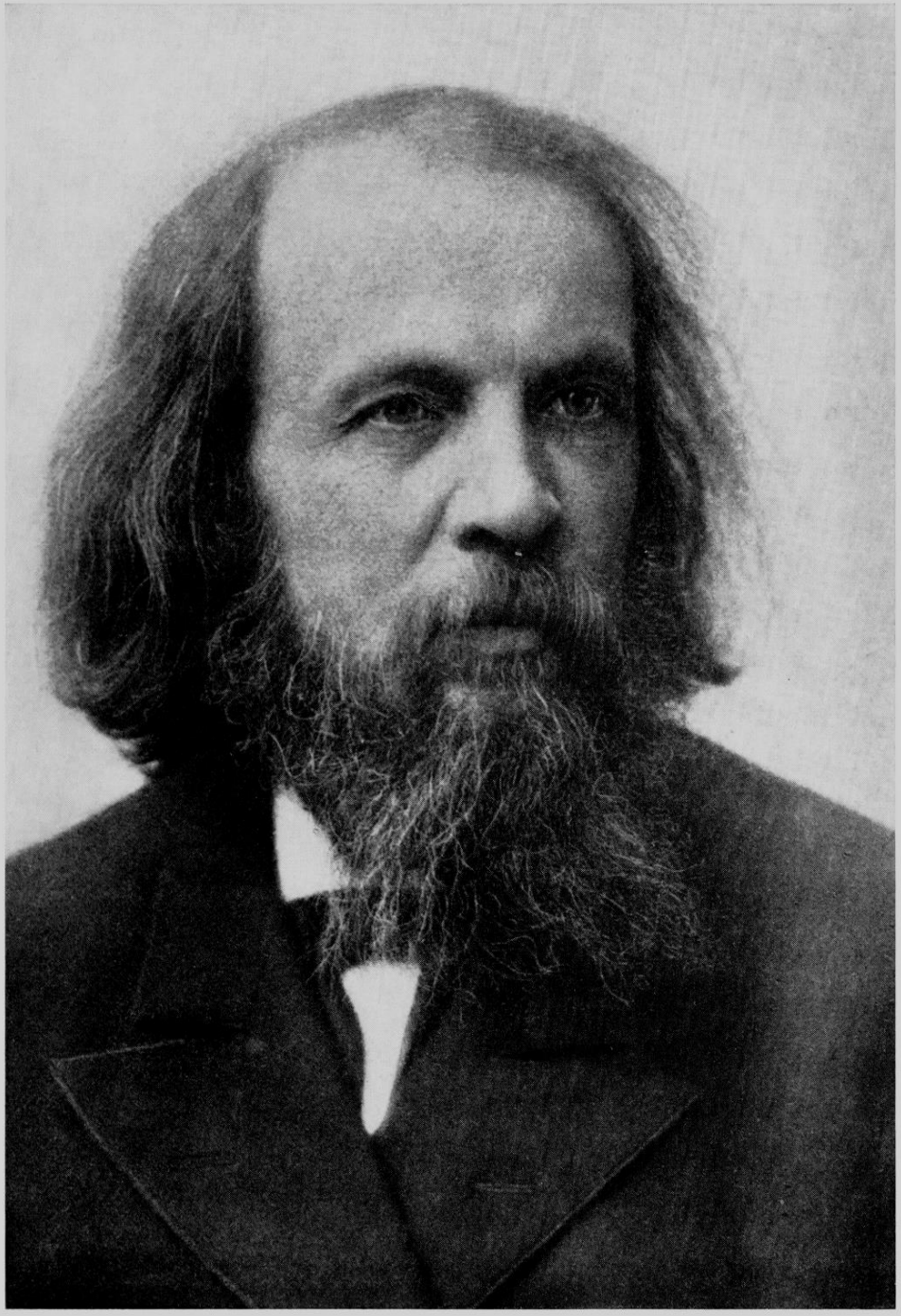
100,943.

343.)

Ueber die Beziehungen der Eigenschaften zu den Atomgewichten der Elemente. Von D. Mendelejeff. — Ordnet man Elemente nach zunehmenden Atomgewichten in verticale Reihen so, dass die Horizontalreihen analoge Elemente enthalten, wieder nach zunehmendem Atomgewicht geordnet, so erhält man folgende Zusammenstellung, aus der sich einige allgemeinere Folgerungen ableiten lassen.

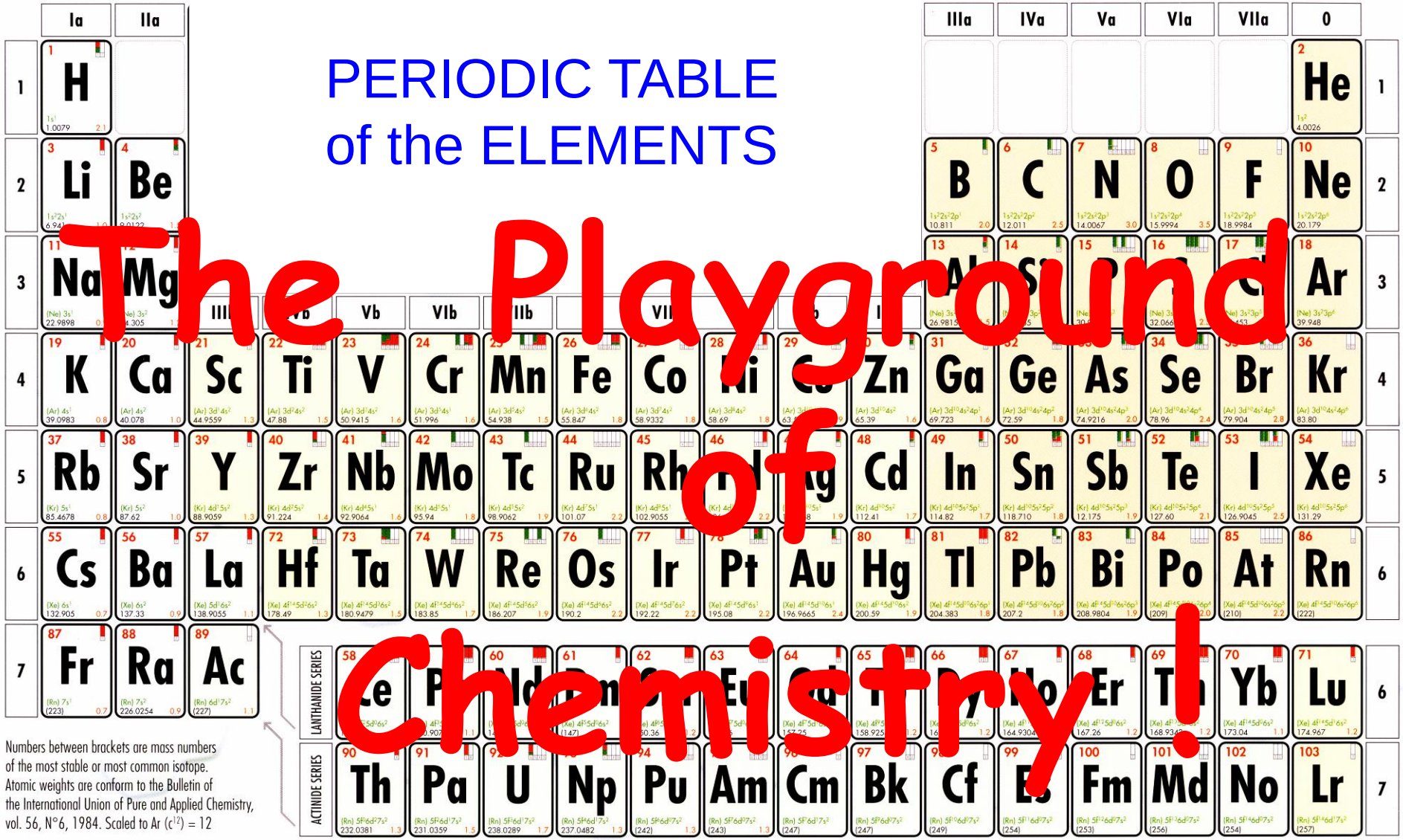
			Ti = 50	Zr = 90	? = 180	
			V = 51	Nb = 94	Ta = 182	
			Cr = 52	Mo = 96	W = 186	
			Mn = 55	Rh = 104,4	Pt = 197,4	
			Fe = 56	Ru = 104,4	Ir = 198	
		Ni =	Co = 59	Pd = 106,6	Os = 199	
H = 1			Cu = 63,4	Ag = 108	Hg = 200	
	Be = 9,4	Mg = 24	Zn = 65,2	Cd = 112		
	B = 11	Al = 27,4	? = 68	Ur = 116	Au = 197?	
	C = 12	Si = 28	? = 70	Sn = 118		
	N = 14	P = 31	As = 75	Sb = 122	Bi = 210?	
	O = 16	S = 32	Se = 79,4	Te = 128?		
	F = 19	Cl = 35,5	Br = 80	J = 127		
Li = 7	Na = 23	K = 39	Rb = 85,4	Cs = 133	Tl = 204	
		Ca = 40	Sr = 87,6	Ba = 137	Pb = 207	
		? = 45	Ce = 92			
		?Er = 56	La = 94			
		?Yt = 60	Di = 95			
		?In = 75,6	Th = 118?			

1. Die nach der Grösse des Atomgewichts geordneten Elemente zeigen eine stufenweise Abänderung in den Eigenschaften.
2. Chemisch-analoge Elemente haben entweder übereinstimmende Atomgewichte (Pt, Ir, Os), oder letztere nehmen gleichviel zu (K, Rb, Cs).
3. Das Anordnen nach den Atomgewichten entspricht der *Werthigkeit* der Elemente und bis zu einem gewissen Grade der Verschiedenheit im chemischen Verhalten, z. B. Li, Be, B, C, N, O, F.
4. Die in der Natur verbreitetsten Elemente haben *kleine* Atomgewichte



The BRICKS of MATTER

PERIODIC TABLE of the ELEMENTS



Numbers between brackets are mass numbers of the most stable or most common isotope. Atomic weights are conform to the Bulletin of the International Union of Pure and Applied Chemistry, vol. 56, N°6, 1984. Scaled to Ar (c^{12}) = 12

The Playground of Chemistry!

Antoine Laurent
LAVOISIER

(1743-1794)

CHEMICAL REACTION EQUATION

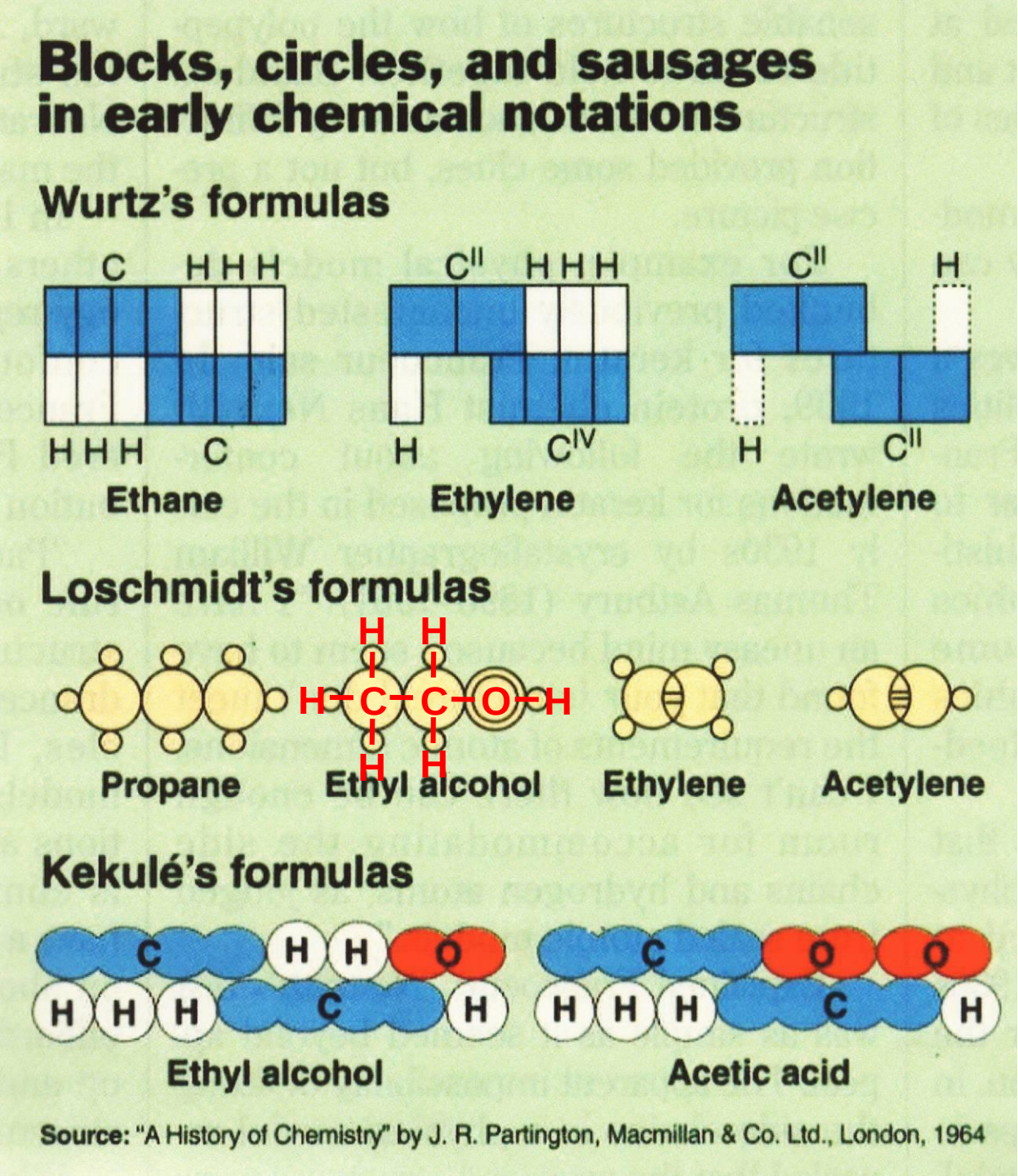
« Rien ne se perd,
rien ne se crée,
tout se transforme »

From composition to connectivity

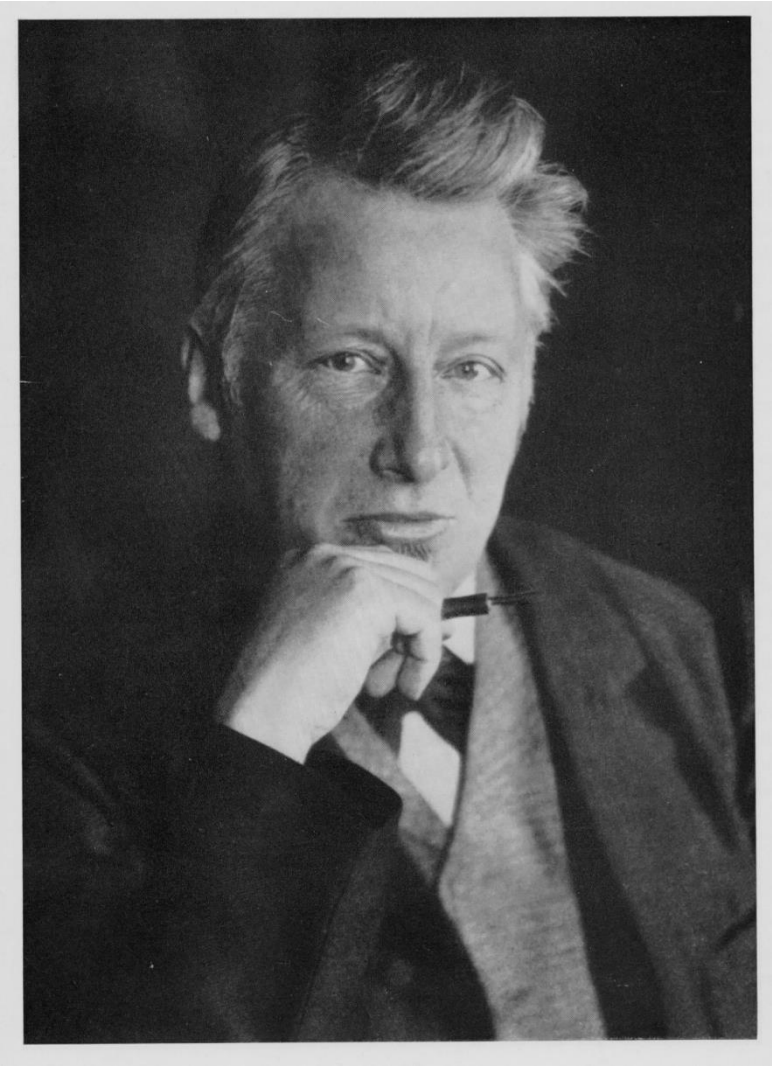
CHEMICAL STRUCTURAL FORMULAE

Around the 1860's

Attempts at representations of the connections (bonds) between the basic bricks, the elements/atoms forming the molecule



STEREOCHEMISTRY 1874 CHEMISTRY in SPACE



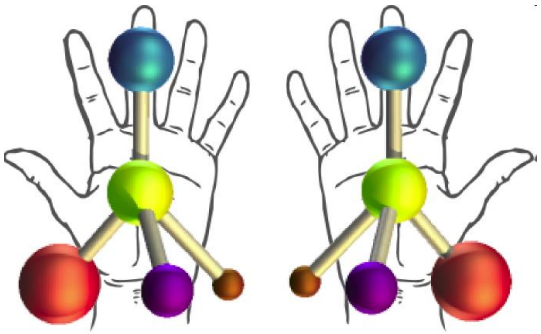
Jacobus Henricus VAN'T HOFF
(1852-1911)

Joseph-Achille LE BEL
(1847-1930)

Louis PASTEUR

(1822-1895)

MOLECULAR CHIRALITY



Mastering the Organization of Molecular Matter

Building highly complex molecules from atoms

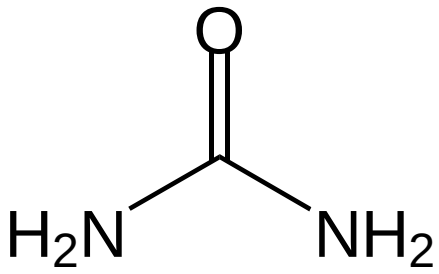
linked by **COVALENT BONDS**

MOLECULAR CHEMISTRY

From the ATOM to the MOLECULE

MILESTONES of MOLECULAR CHEMISTRY

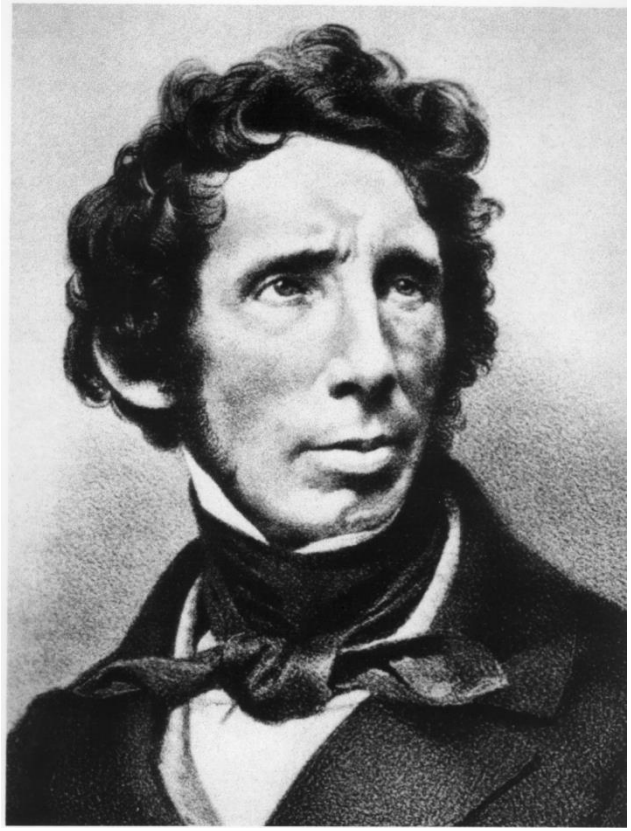
UREA



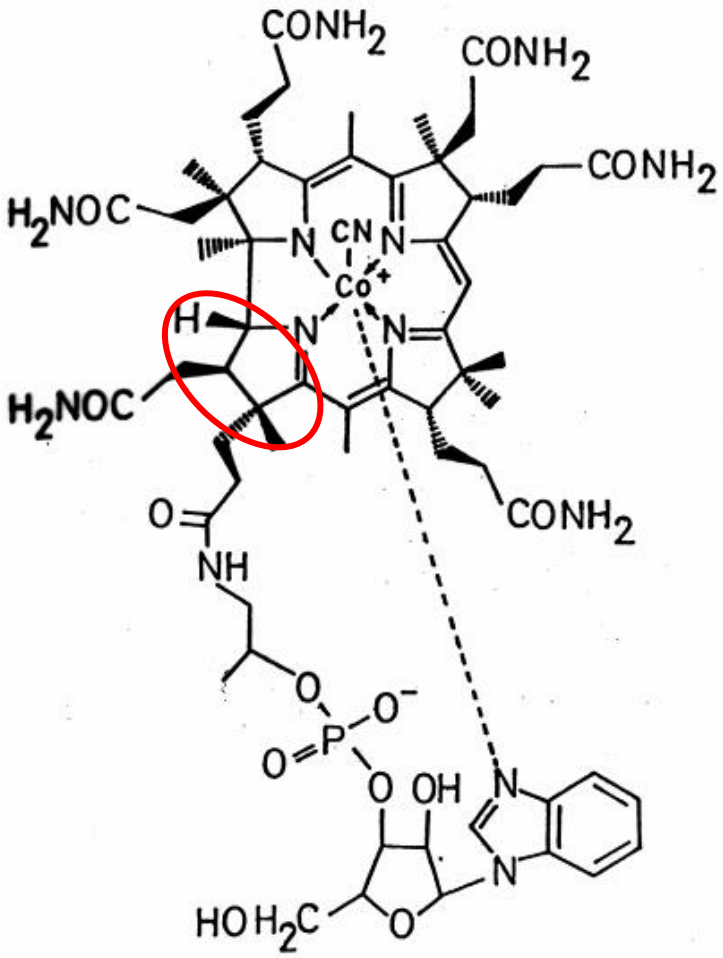
1828

Friedrich
WÖHLER

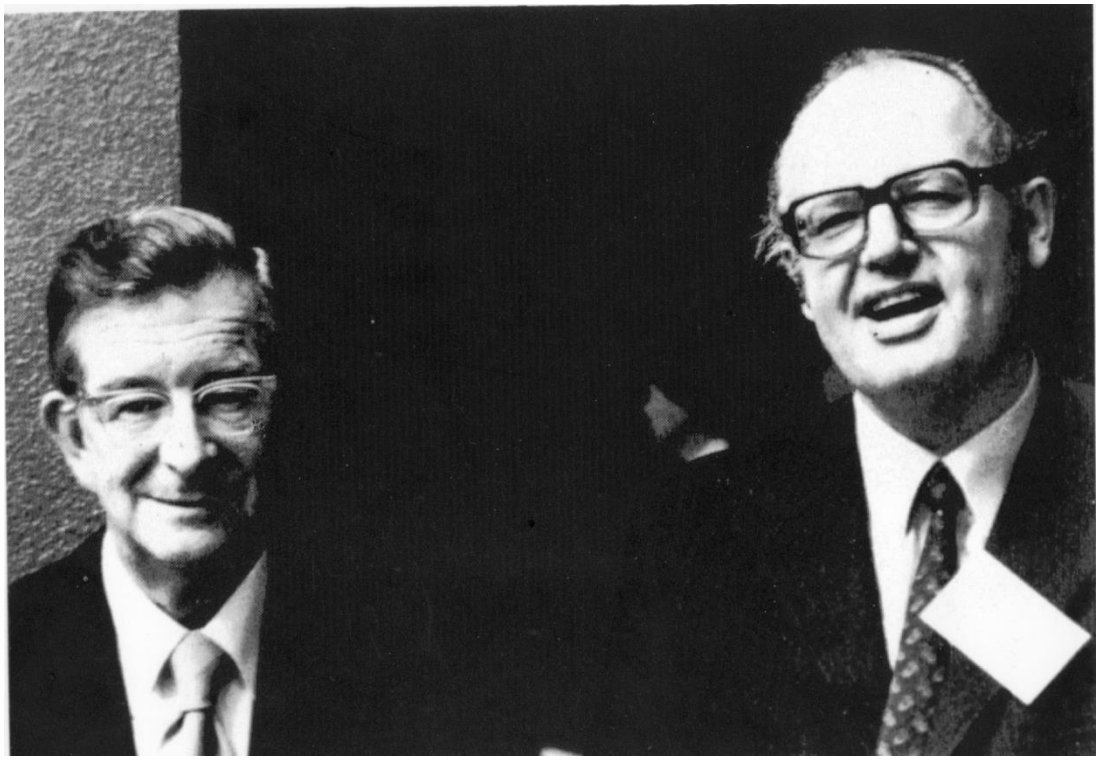
(1800-1882)



VITAMIN B_{12}



1972 (1976)



Robert Burns WOODWARD

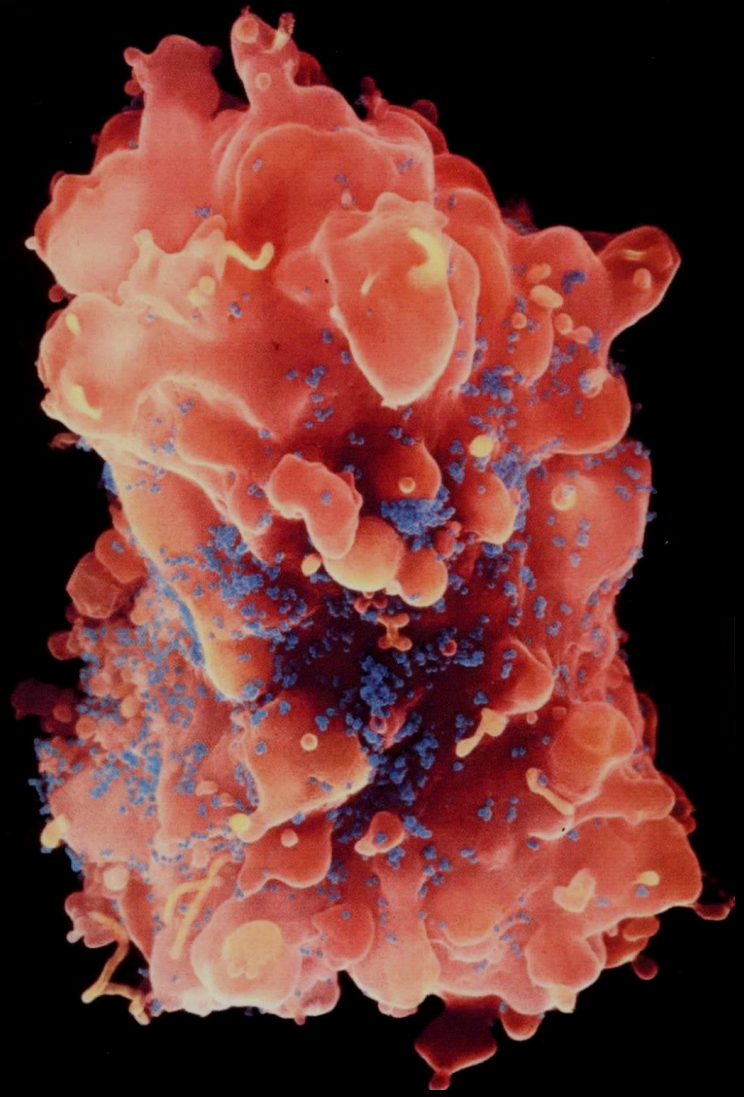
(1917-1979)

Albert ESCHENMOSER

(1925-)

A CANCER CELL and
TWO KILLER CELLS

WHITE BLOOD CELL and
PARTICLES of the HIV VIRUS



RECOGNITION, REACTIVITY and TRANSPORT

Mastering the **non-covalent bond**

Implementing non-covalent interactions between molecules

SUPRAMOLECULAR CHEMISTRY

CHEMISTRY BEYOND THE MOLECULE

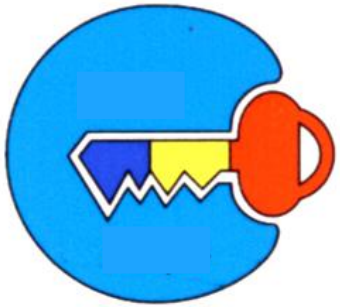
MOLECULAR CHEMISTRY

MOLECULAR RECOGNITION

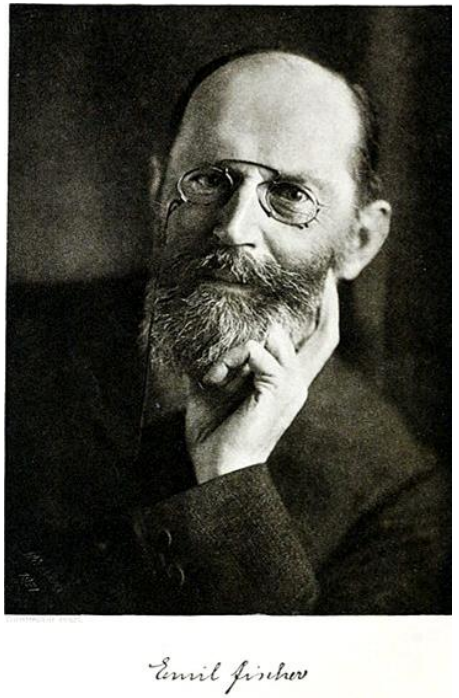
requires INTERACTIONS for BINDING

INFORMATION for SELECTING

DOUBLE COMPLEMENTARITY { geometrical / interactional



"SCHLOSS und SCHLÜSSEL"
LOCK and KEY

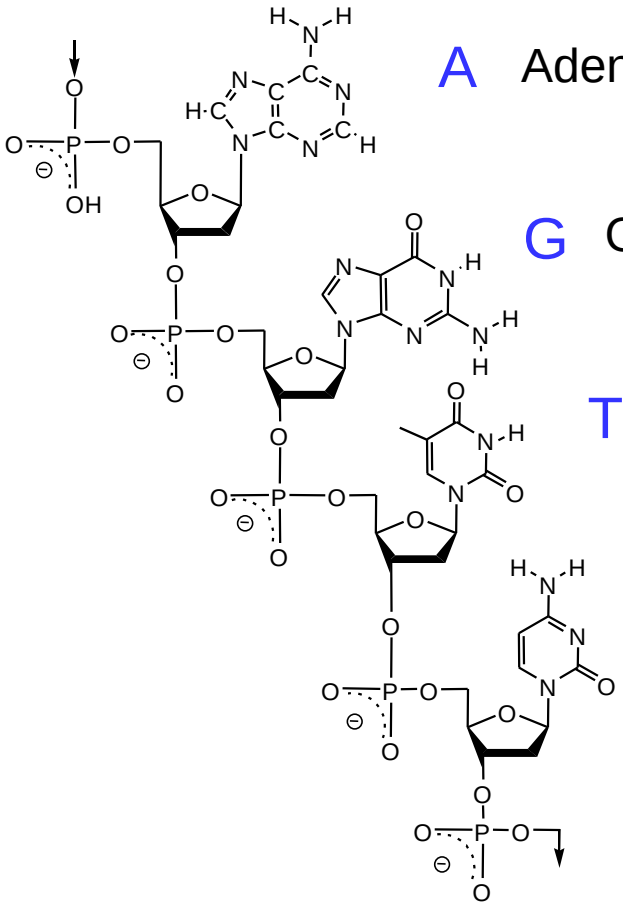


Emil FISCHER 1894

MOLECULAR STORAGE of INFORMATION

The DOUBLE HELIX of DNA

GENETIC PROGRAM written with FOUR MOLECULAR LETTERS

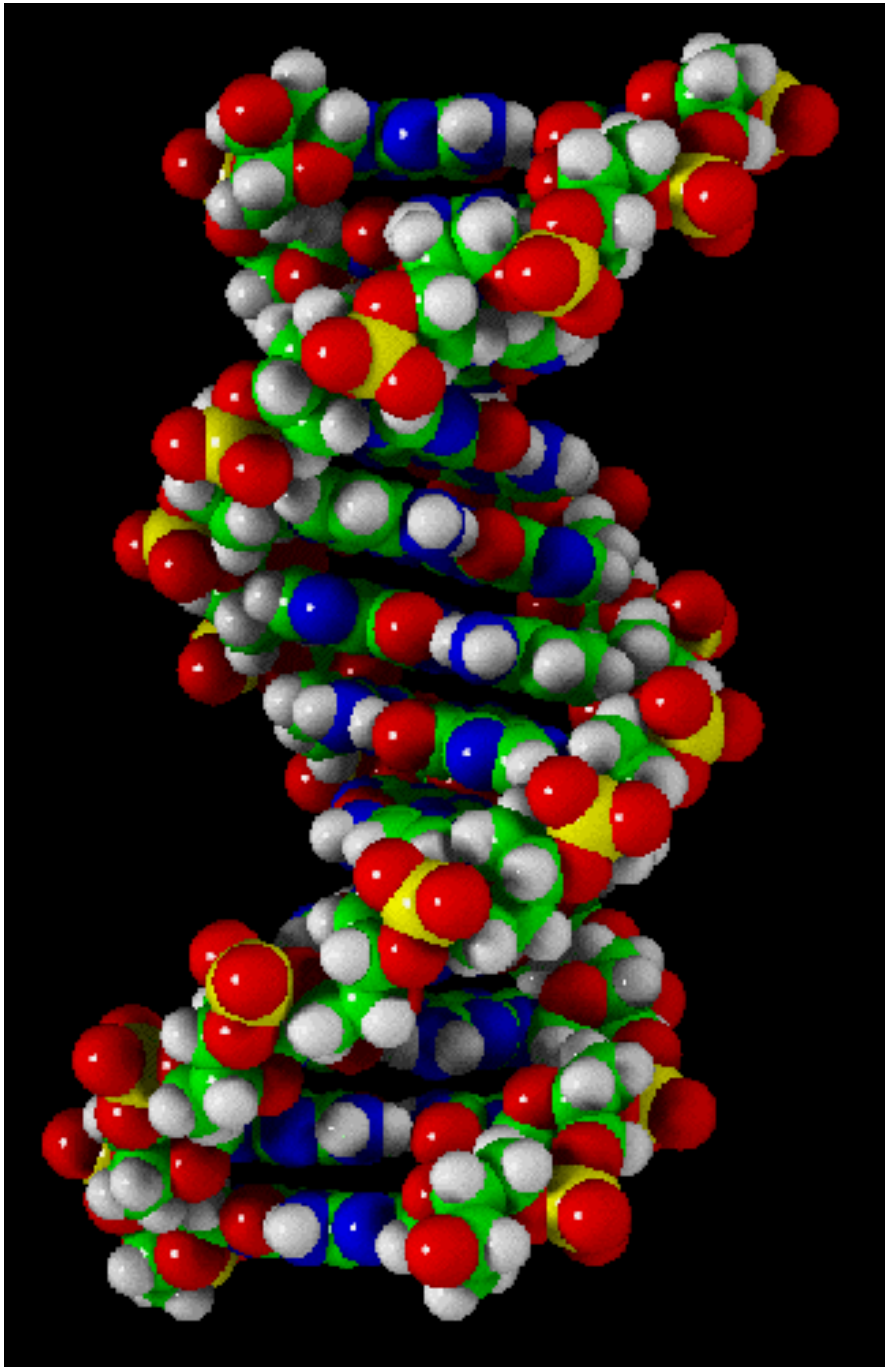


A Adenine

G Guanine

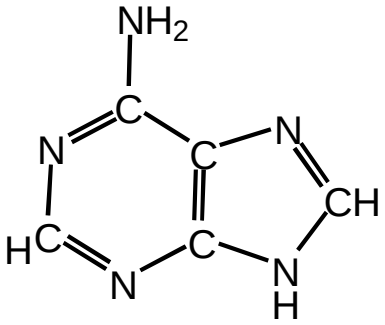
T Thymine

C Cytosine



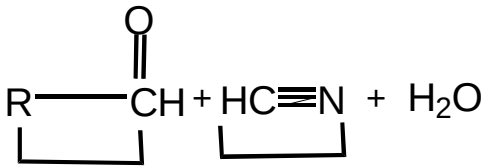
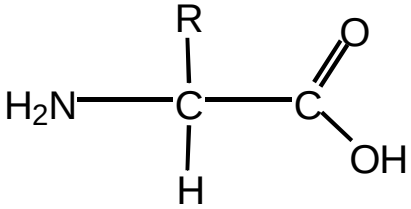
PREBIOTIC Self-Organization of Molecular Matter

Prebiotic formation of the components of the Molecules of Life

5 HCN ⋯⋯⋯►  ⋯⋯⋯► NUCLEIC ACIDS

Adenine

one of the four nucleobases

 ⋯⋯►  ⋯⋯► PROTEINS

AMINO ACIDS

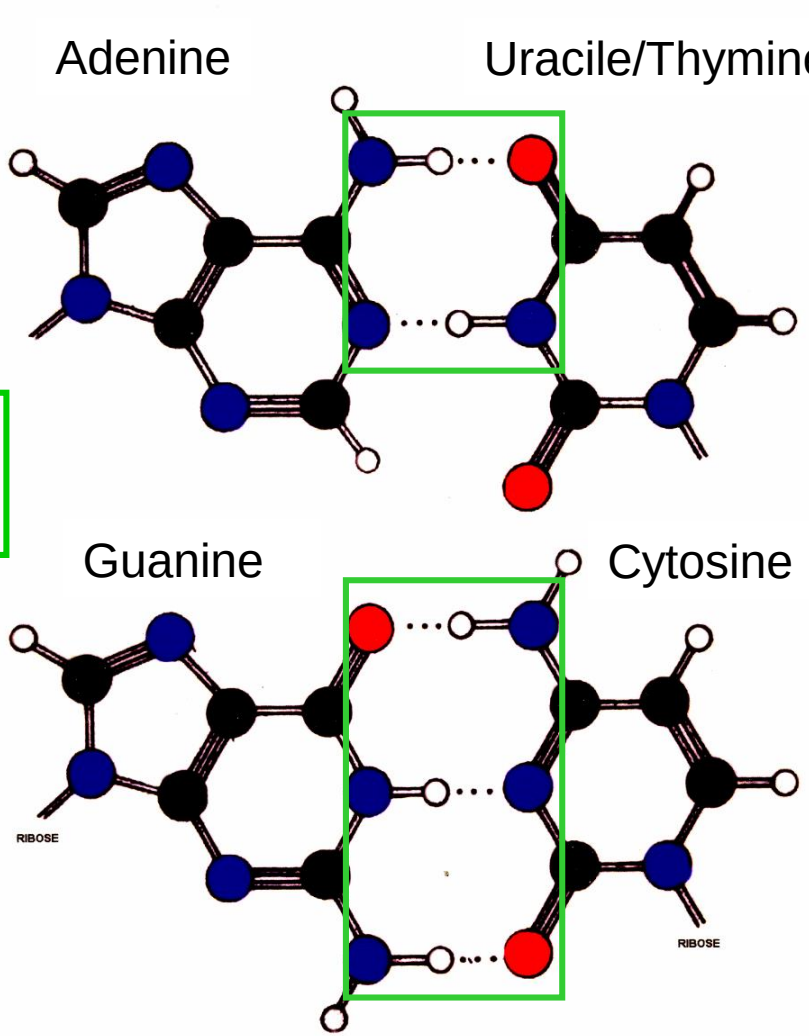
SUPRAMOLECULAR READING of the GENETIC PROGRAM

through FORMATION of NUCLEOBASE PAIRS

TWO

HYDROGEN BONDS

THREE



MOLECULAR RECOGNITION
via
COMPLEMENTARY INTERACTION PATTERNS
between
Donor and Acceptor
Hydrogen Bonding Sites

CHEMISTRY : an INFORMATION SCIENCE

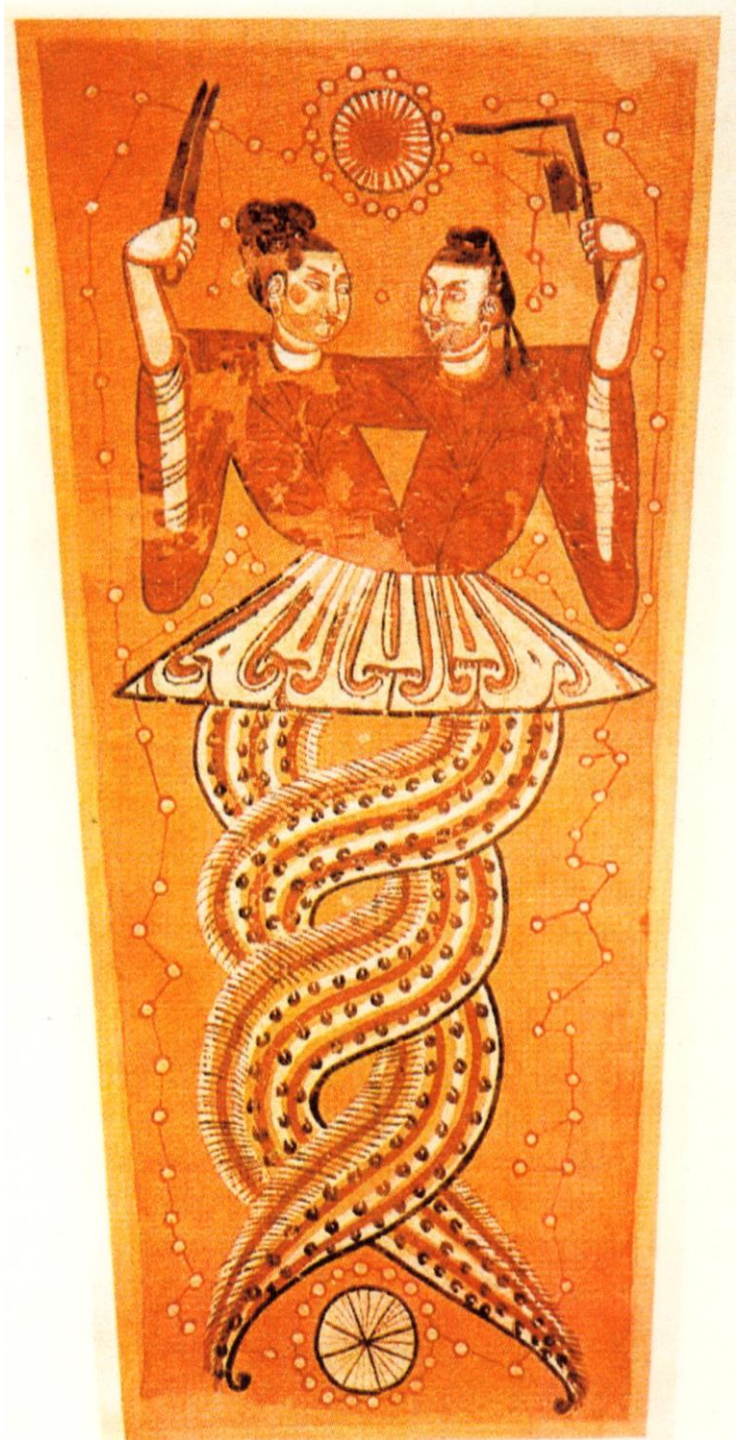
The SCIENCE of INFORMED MATTER

MOLECULAR STORAGE

SUPRAMOLECULAR PROCESSING

of INFORMATION

An early representation of the DOUBLE HELIX !

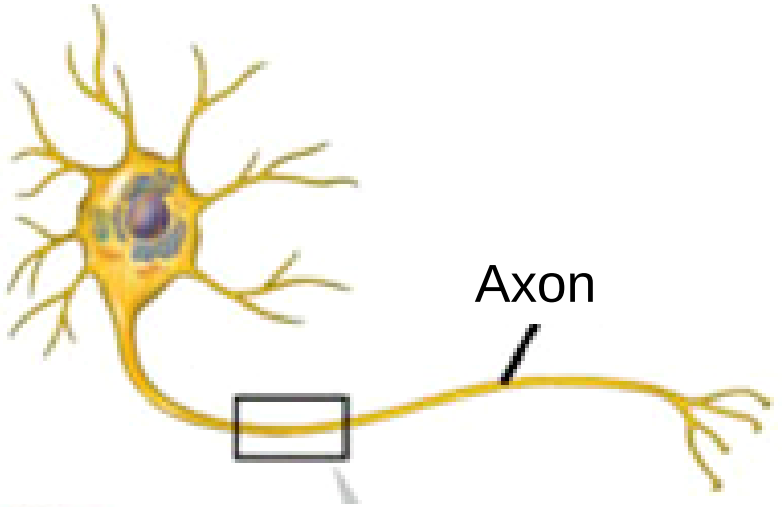


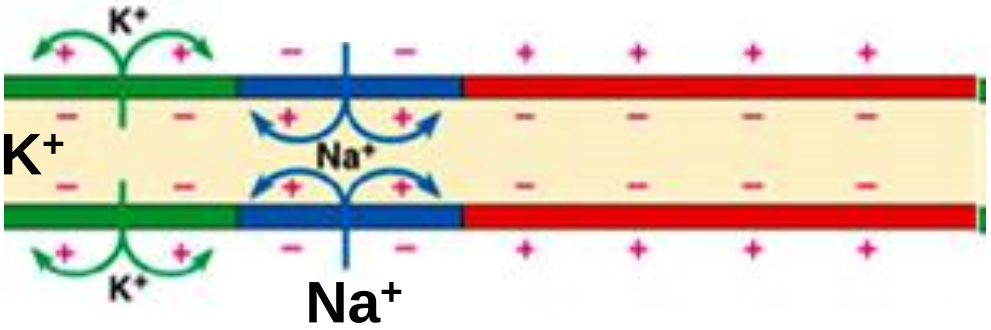
Initial Motivations.....

Propagation of the Nerve Influx

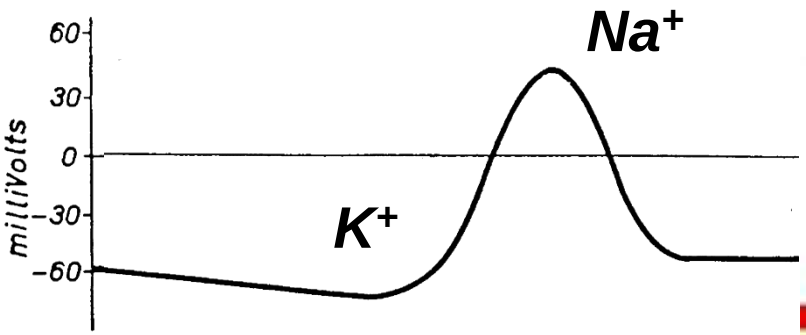
Selective Transport of Cations

Na^+ and **K^+** through the membrane of the axon

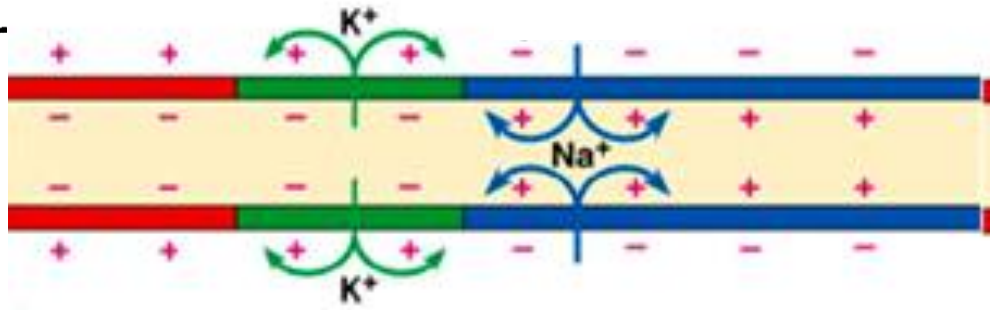




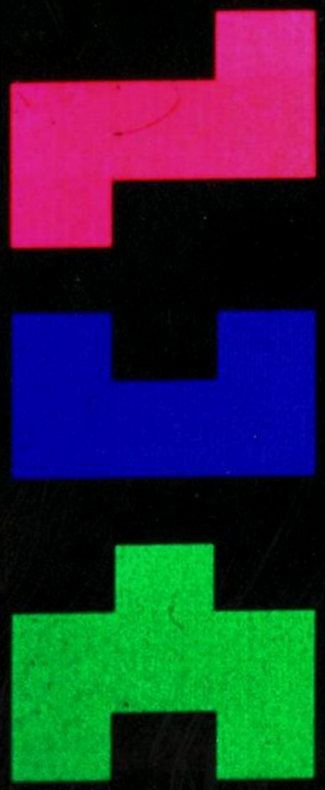
Action Potential



Direction of Propagation

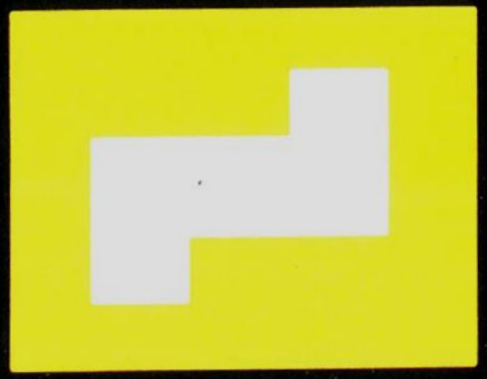


MOLECULAR RECOGNITION



Substrates

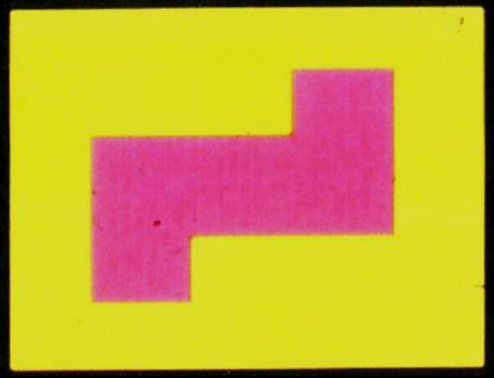
+



Molecular Receptor

Association

Selection



Supramolecular Entity

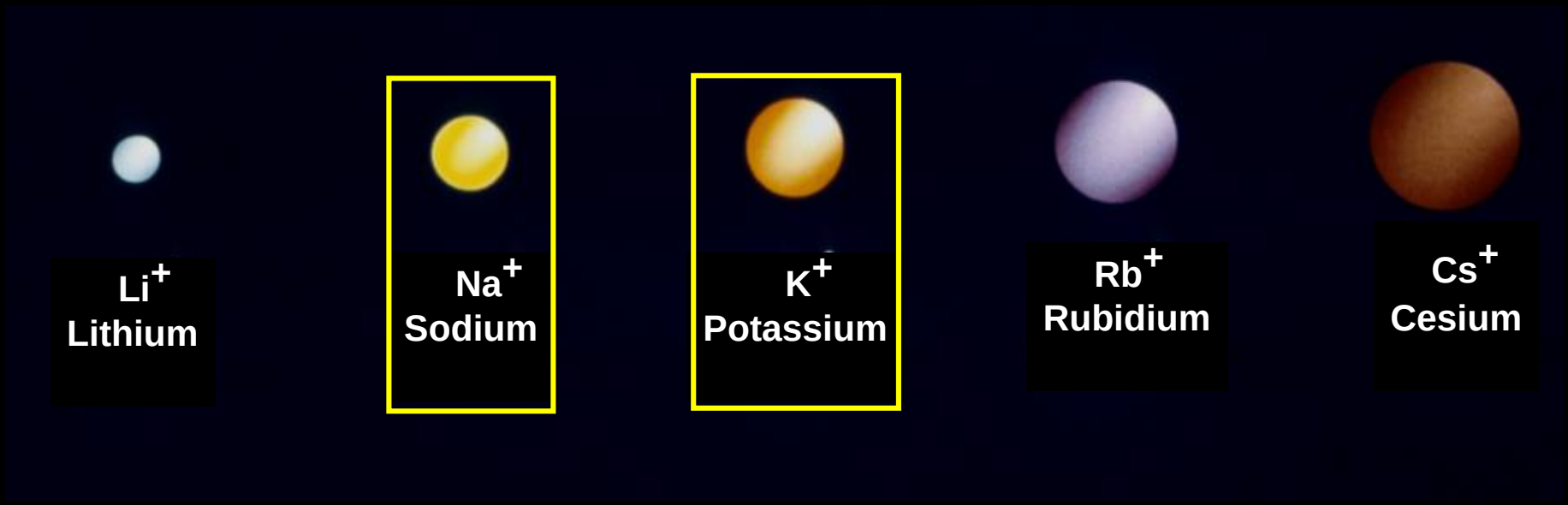
Very many studies
in numerous laboratories of
molecular recognition processes

Three KEYS and the LOCK

MOLECULAR RECOGNITION

SPHERICAL SUBSTRATES

The ALKALI METAL CATIONS

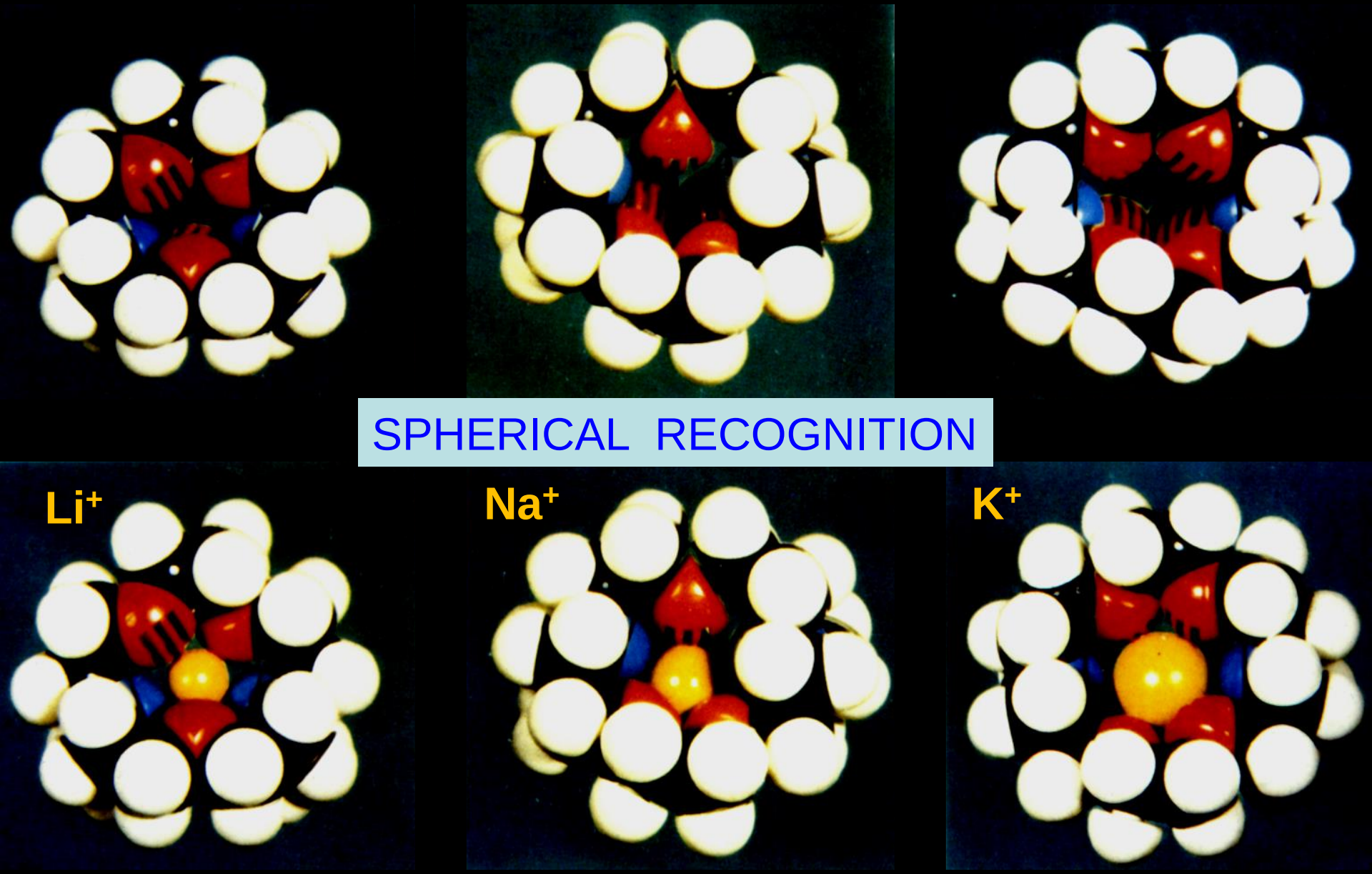


A series of spherical species of single charge and **increasing size**

Selective Binding and Transport of Spherical Cations

➡ SPHERICAL MOLECULAR RECOGNITION

CRYPTANDS and CRYPTATES



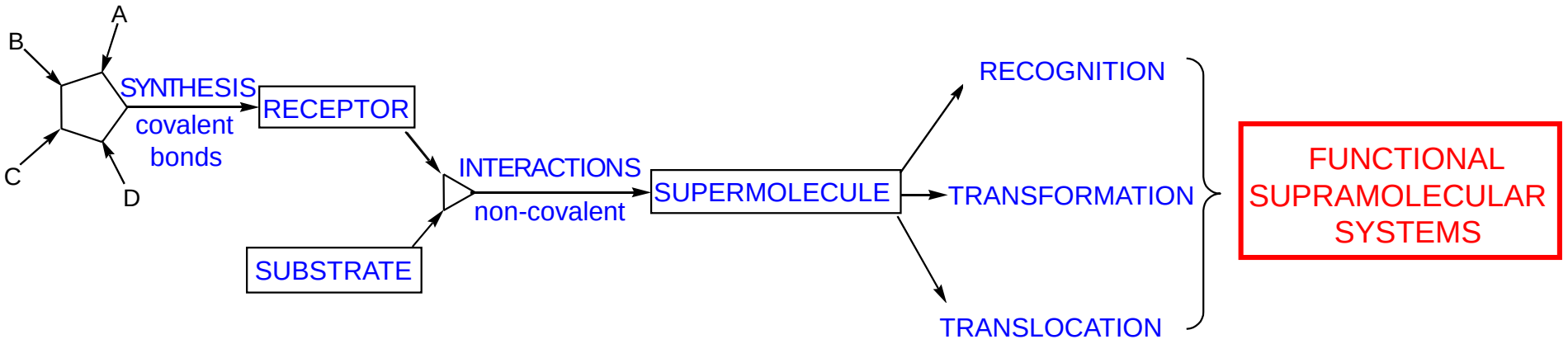
Complementarity in Size and Shape between Cavity and Cation

Béla VÍZI (1936-) University of Veszprém

CHEMISTRY

1828 → MOLECULAR

1978 → SUPRAMOLECULAR



Very many studies in numerous laboratories around the world on the three basic functions of supramolecular systems:

recognition – reaction – transport processes

APPLICATIONS in LIFE SCIENCES

- ☆ Development of biologically active substances / **DRUG DISCOVERY**
  Molecular Recognition between a synthetic molecule and a biological target

- ☆ Development of optical labels for **MEDICAL DIAGNOSTICS**

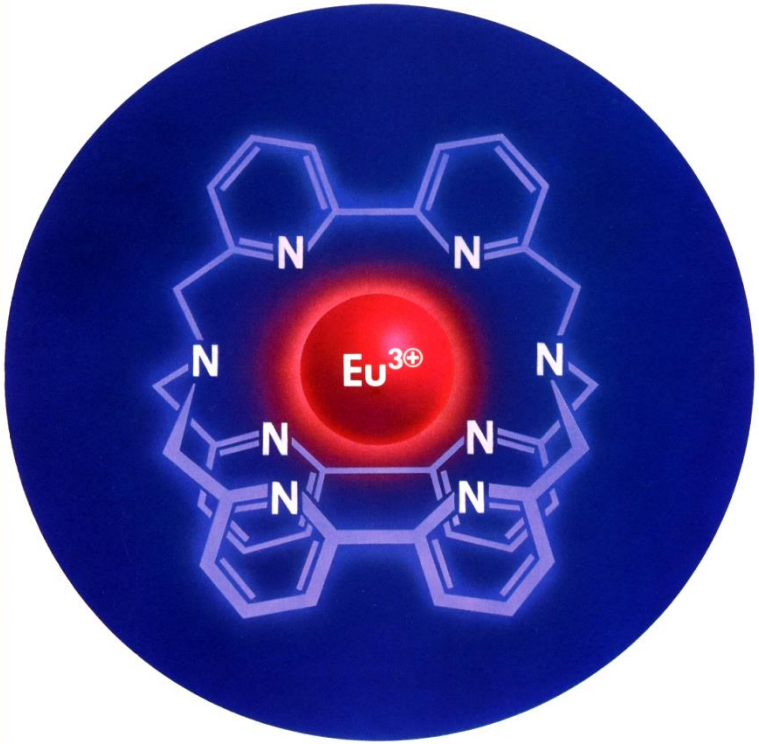
- ☆ **GENE TRANSFER**

- ☆ **BIOMATERIALS** – supramolecular polymers as biocompatible and biodegradable materials

☆ Optical Technology for MEDICAL DIAGNOSTICS

Europium Cryptate

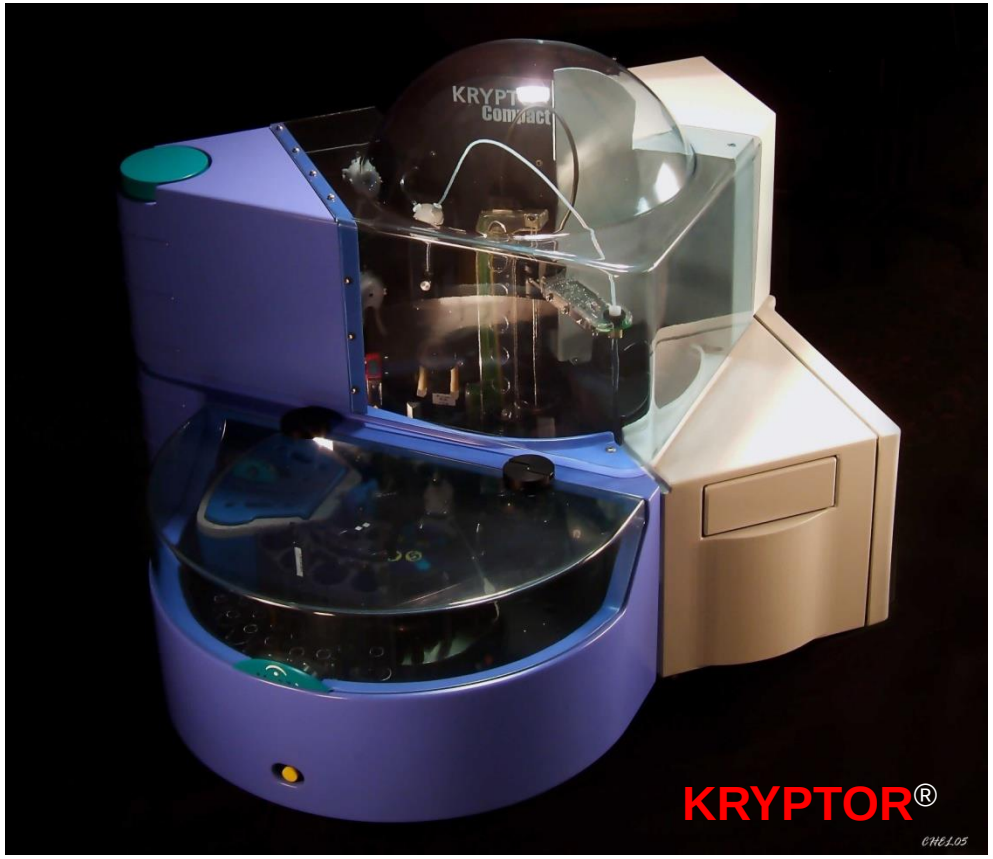
A « Nano-Bulb » for Medical Diagnostics



STRONG RED LUMINESCENCE

LABEL for MEDICAL DIAGNOSTICS

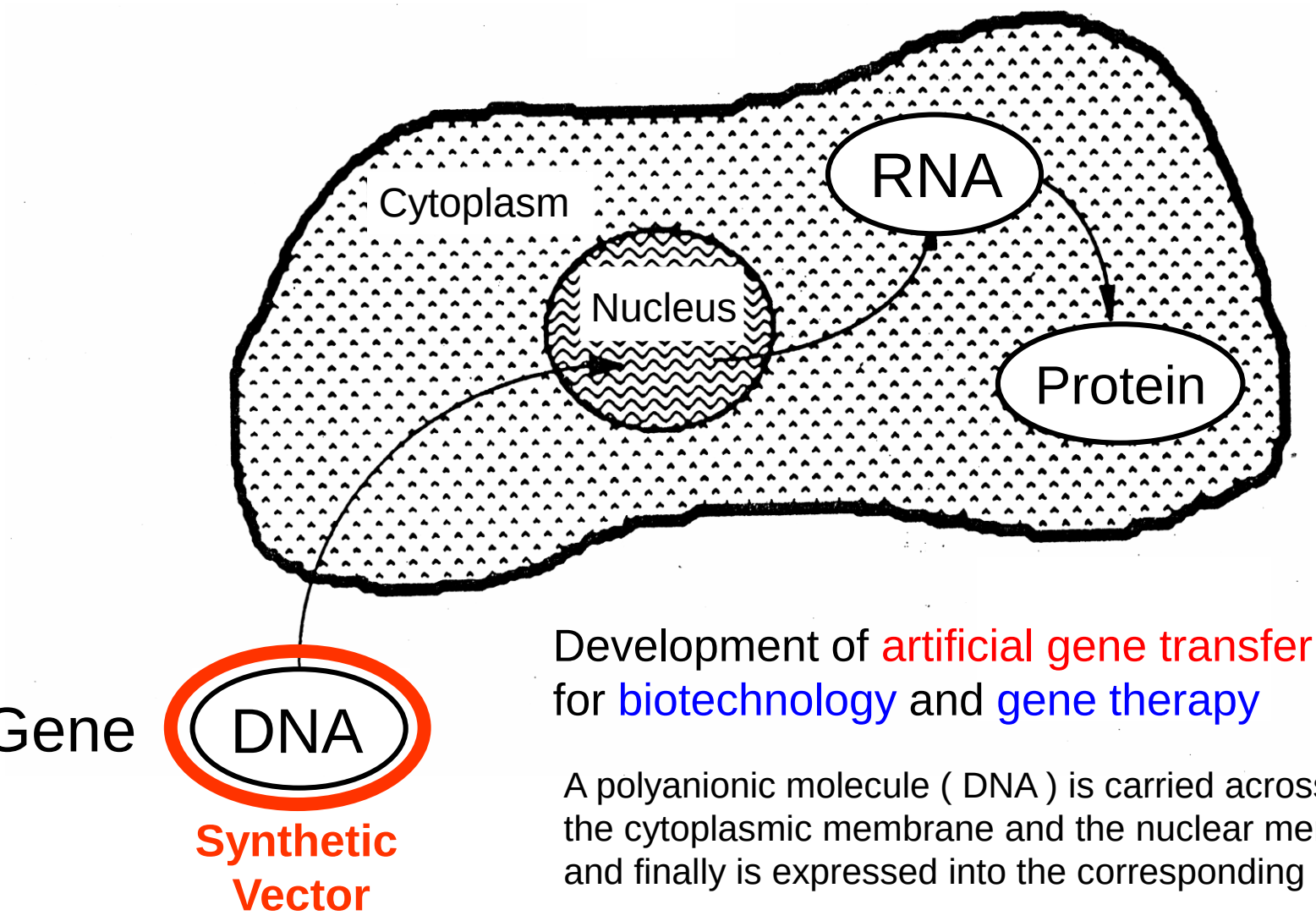
Immuno-analysis System



Cézanne Co.

Dr. Gérard Mathis CisBio International

★ GENE TRANSFER by SYNTHETIC VECTORS through the Membrane of an Eukaryotic Cell



Development of artificial gene transfer agents for biotechnology and gene therapy

A polyanionic molecule (DNA) is carried across the cytoplasmic membrane and the nuclear membrane and finally is expressed into the corresponding protein .

SUPRAMOLECULAR MATERIALS as BIOMATERIALS

SUPRAMOLECULAR POLYMERS as BIOCOMPATIBLE POLYMERS

➡ First Worldwide Application for Cardiovascular Implants

★ supramolecular polymers developed for the surgical treatment of children born with severe congenital cardiac malformation and requiring cardiac reconstruction.

Ten children successfully treated

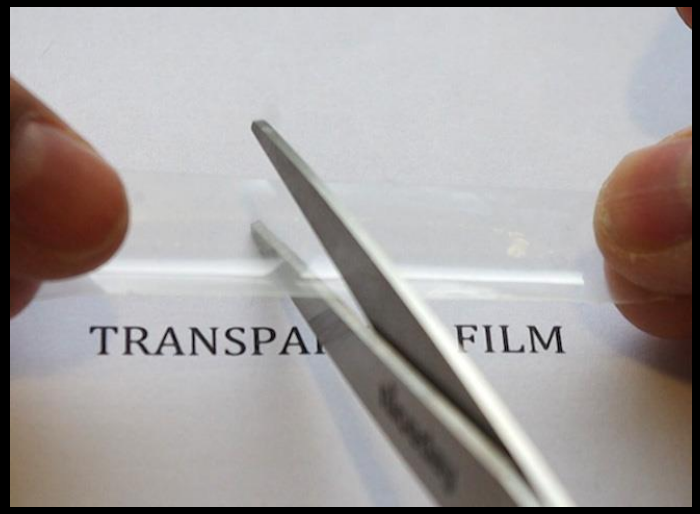
4 year old **Dominika** and Professor **Leo Bokeria**

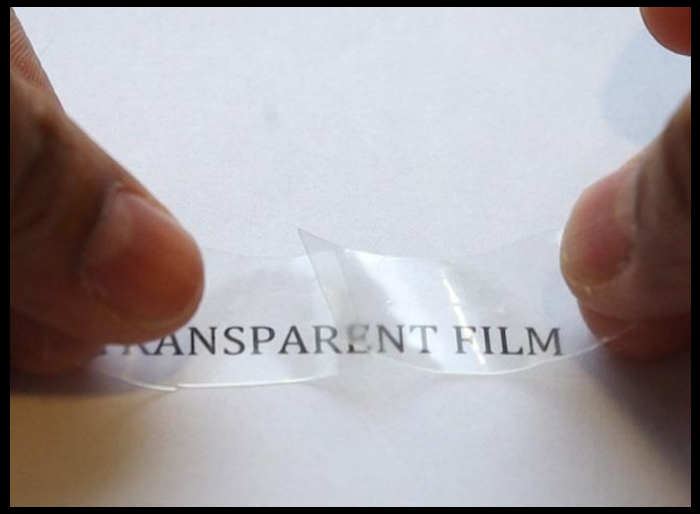
At check-up 3 months after implantation on October 23rd 2013

at the Bakulev Scientific Center for Cardiovascular Surgery in Moscow

➡ A breakthrough in surgical practice

A SELF-HEALING SUPRAMOLECULAR POLYMER FILM

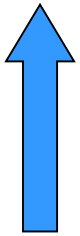




Spontaneous but information-controlled
generation of supramolecular architectures
via molecular recognition patterns

MOLECULAR RECOGNITION DIRECTED

SELF-ORGANIZATION

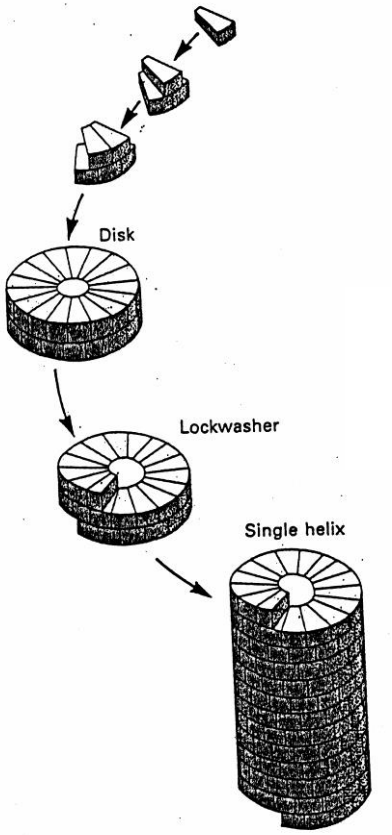


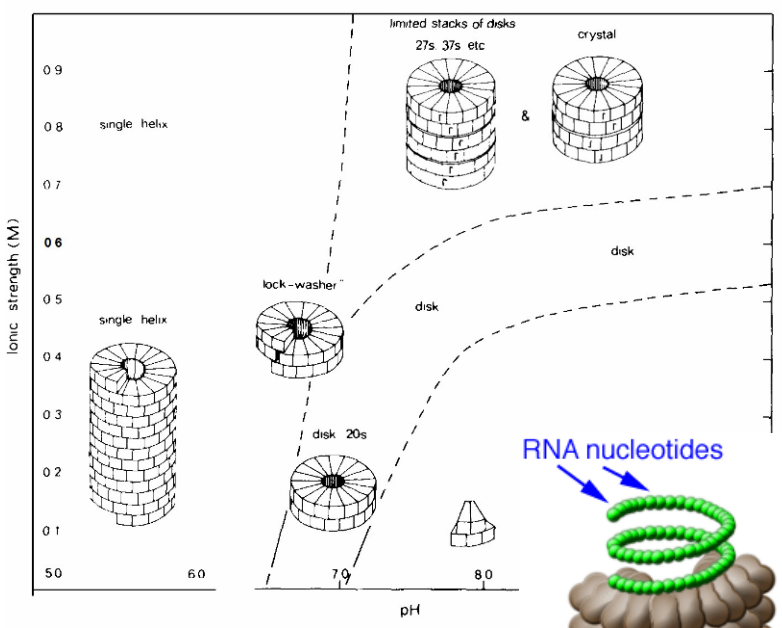
Beyond Pre-organization

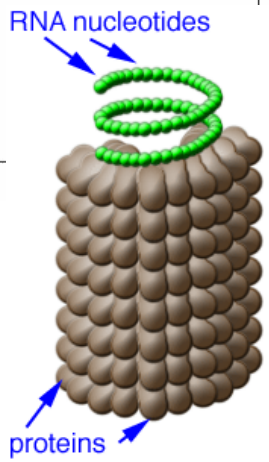
Molecular Recognition

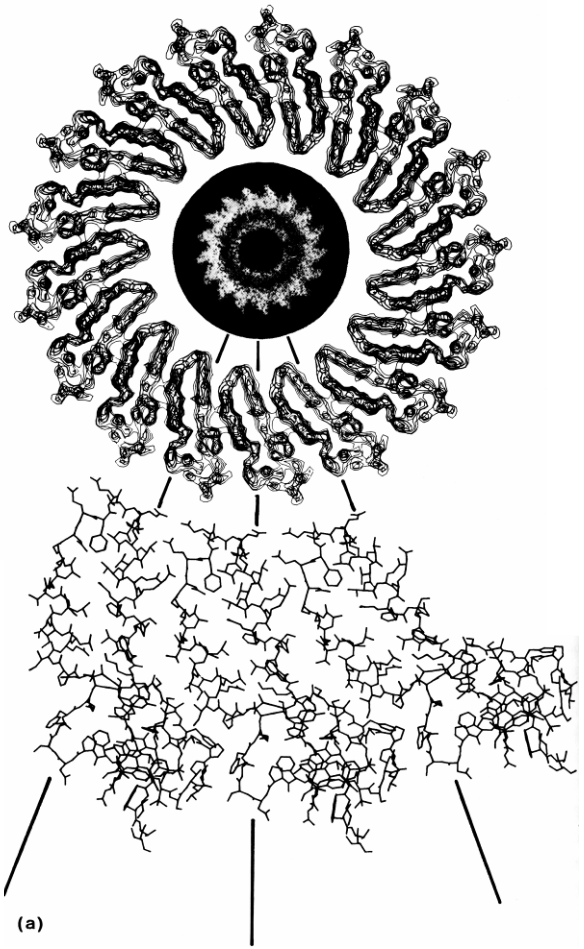
SUPRAMOLECULAR CHEMISTRY

SELF-ASSEMBLY of the TOBACCO MOSAIC VIRUS









From 2130 protein subunits + 1 molecule of viral RNA

PROGRAMMED CHEMICAL SYSTEMS

MOLECULAR PROGRAMME	⟺	SUPRAMOLECULAR OPERATION
INFORMATION stored in the COMPONENTS	⟺	PROCESSING via RECOGNITION ALGORITHM defined by the INTERACTION PATTERN

SELF-ORGANIZATION of

FUNCTIONAL SUPRAMOLECULAR ARCHITECTURES

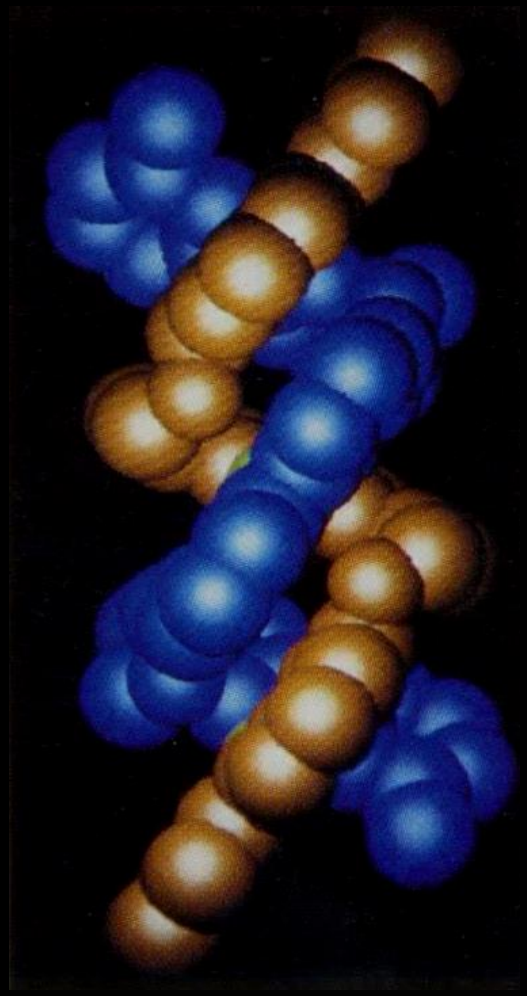
based on

- ☆ COMPONENTS / BRICKS : LIGAND MOLECULES
- ☆ CONNECTIONS / CEMENT : METAL CATIONS

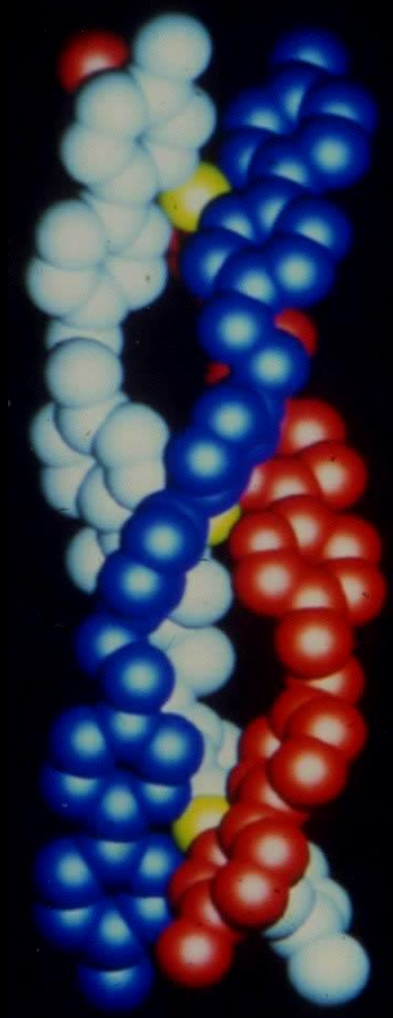
HELICATES

ARTIFICIAL HELICES

DOUBLE



TRIPLE



DNA

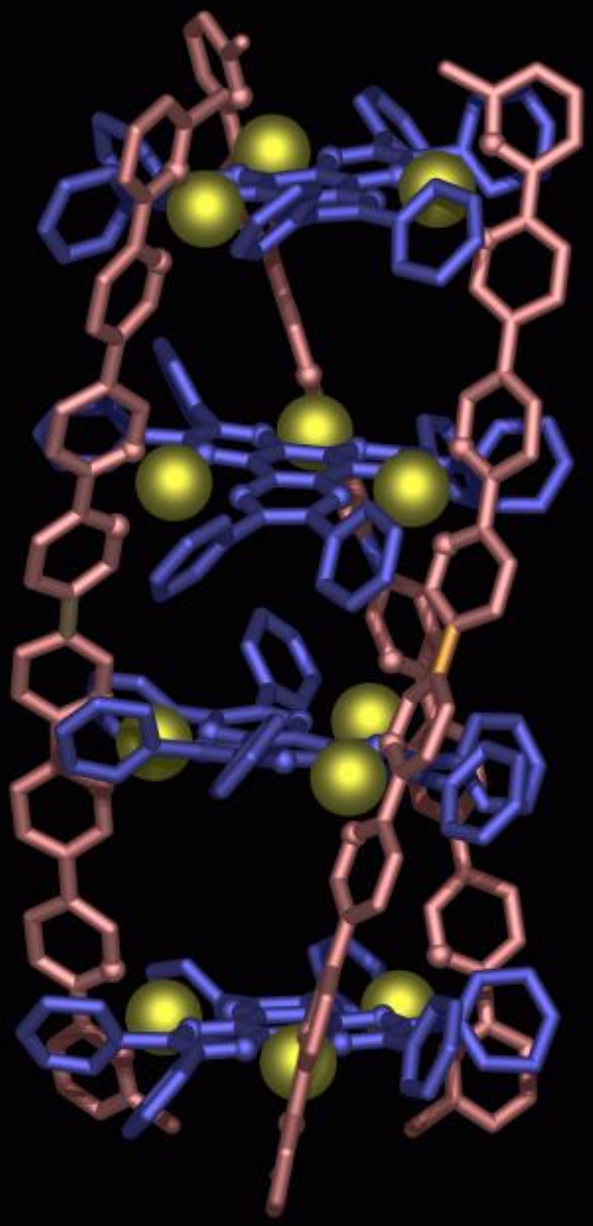
NATURAL DOUBLE HELIX

NANOCYLINDER

Cylindrical
3-Cavity
NANOCONTAINER

SELF-ORGANIZED
from
3 LINEAR LIGAND MOLECULES
4 PLANAR LIGAND MOLECULES
12 METAL CATIONS Cu(I)

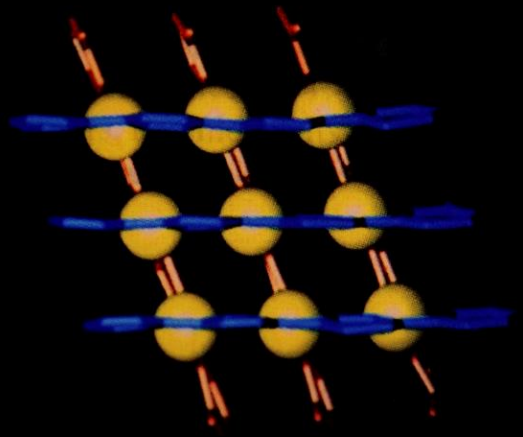
19 COMPONENTS !



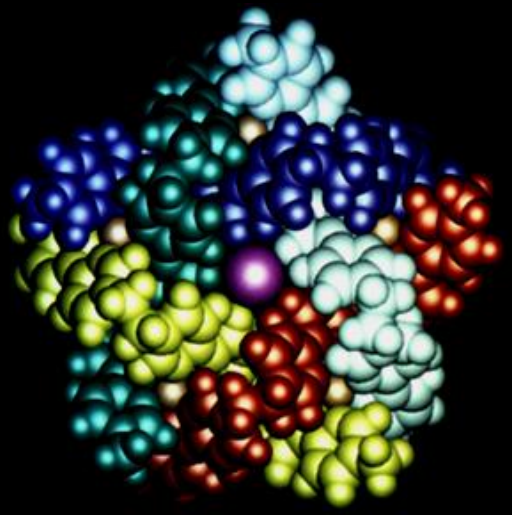
Solid State Molecular Structure

A Great Variety of Self-Organized Metallosupramolecular Architectures……

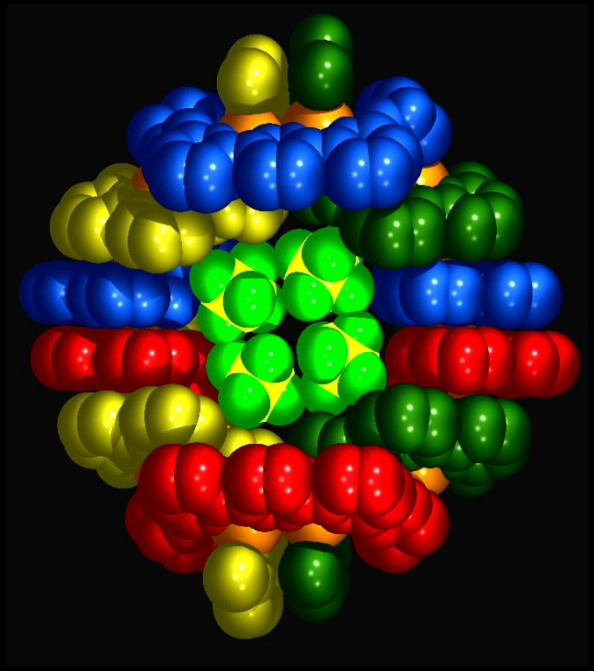
$[3x3]Ag^{+}_{9}$ **GRID**

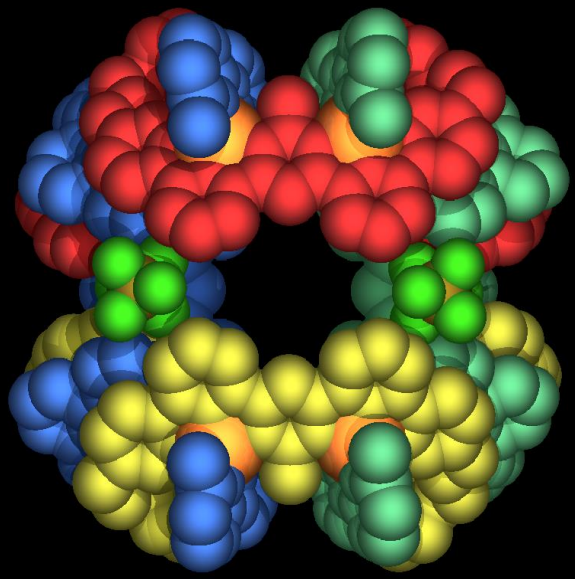


CIRCULAR ARCHITECTURES



All solid state structures





NANOSCIENCE and NANOTECHNOLOGY

Implementing PROGRAMMED SELF-ORGANIZATION

➡ Spontaneous but controlled generation of

well-defined
large
complex
organized
functional

} supramolecular architectures

➡ A powerful alternative or complement to

NANOFABRICATION and NANOMANIPULATION

➡ From FABRICATION to **SELF-FABRICATION**

The Ultimate Fabrication !

SELF-ORGANIZATION

by DESIGN

INFORMATION
PROGRAMMATION

with SELECTION

DIVERSITY
DYNAMICS

CONSTITUTIONAL
DYNAMIC CHEMISTRY

ADAPTATION

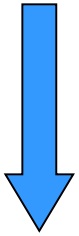
ADAPTIVE CHEMISTRY

SUPRAMOLECULAR CHEMISTRY opens towards a

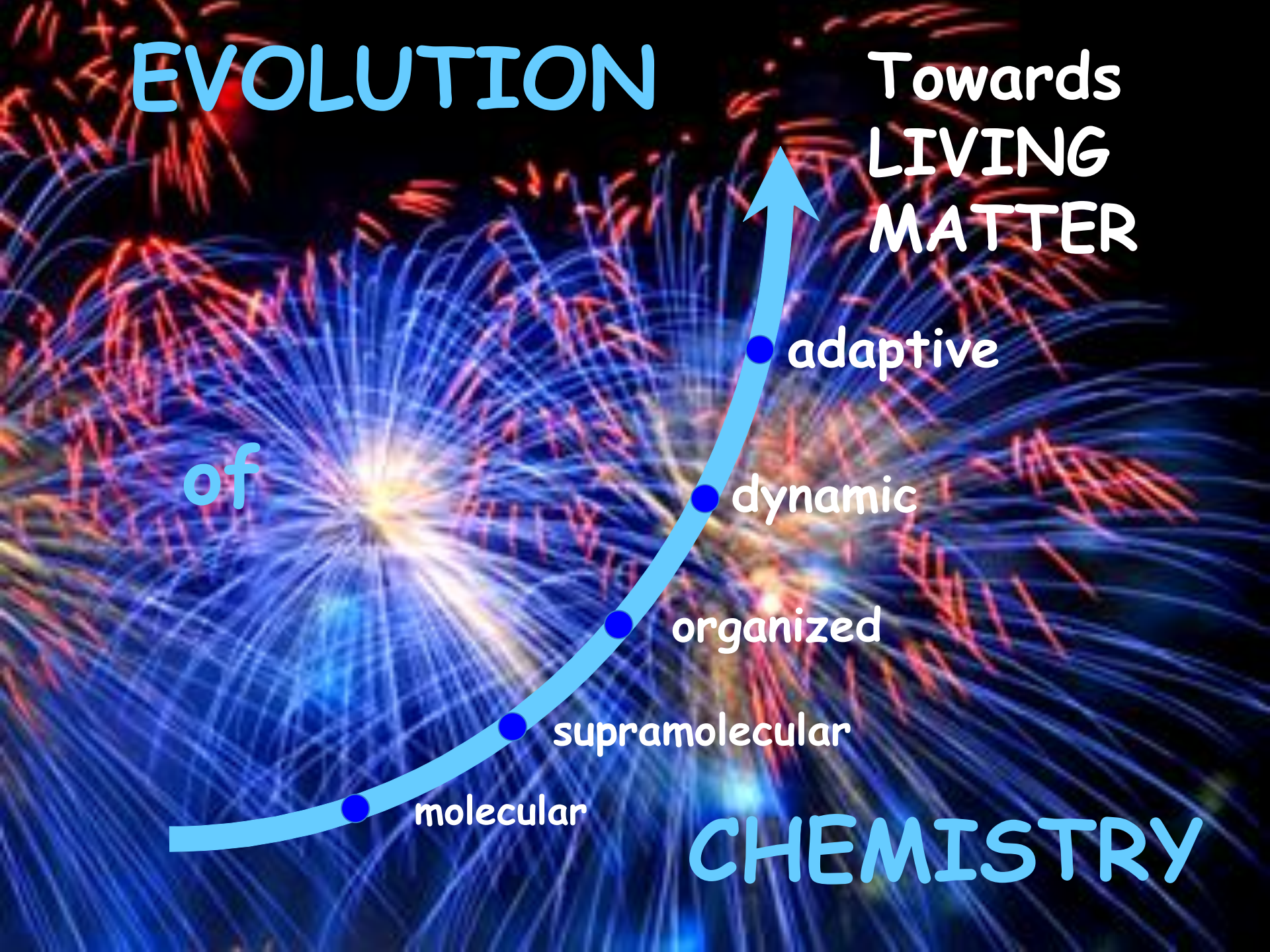
CONSTITUTIONAL DYNAMIC CHEMISTRY

able to modify the CONSTITUTION of its objects
by exchange of its components composants
due to the REVERSIBILITY of the connexions between the components

allowing for **ADAPTATION** through CONSTITUTIONAL VARIATION



⇨ search for BIOLOGICALLY ACTIVE SUBSTANCES
⇨ self-organisation of DYNAMIC NANOSTRUCTURES
⇨ development of DYNAMIC MATERIALS


EVOLUTION
Towards
LIVING
MATTER
of
adaptive
dynamic
organized
supramolecular
molecular
CHEMISTRY

The ESSENCE of CHEMISTRY

is not just to discover but to

CREATE

NOVEL EXPRESSIONS of COMPLEX MATTER

The BOOK of Chemistry is not just to be read,
it is to be WRITTEN

The SCORE of Chemistry is not just to be played,
it is to be COMPOSED

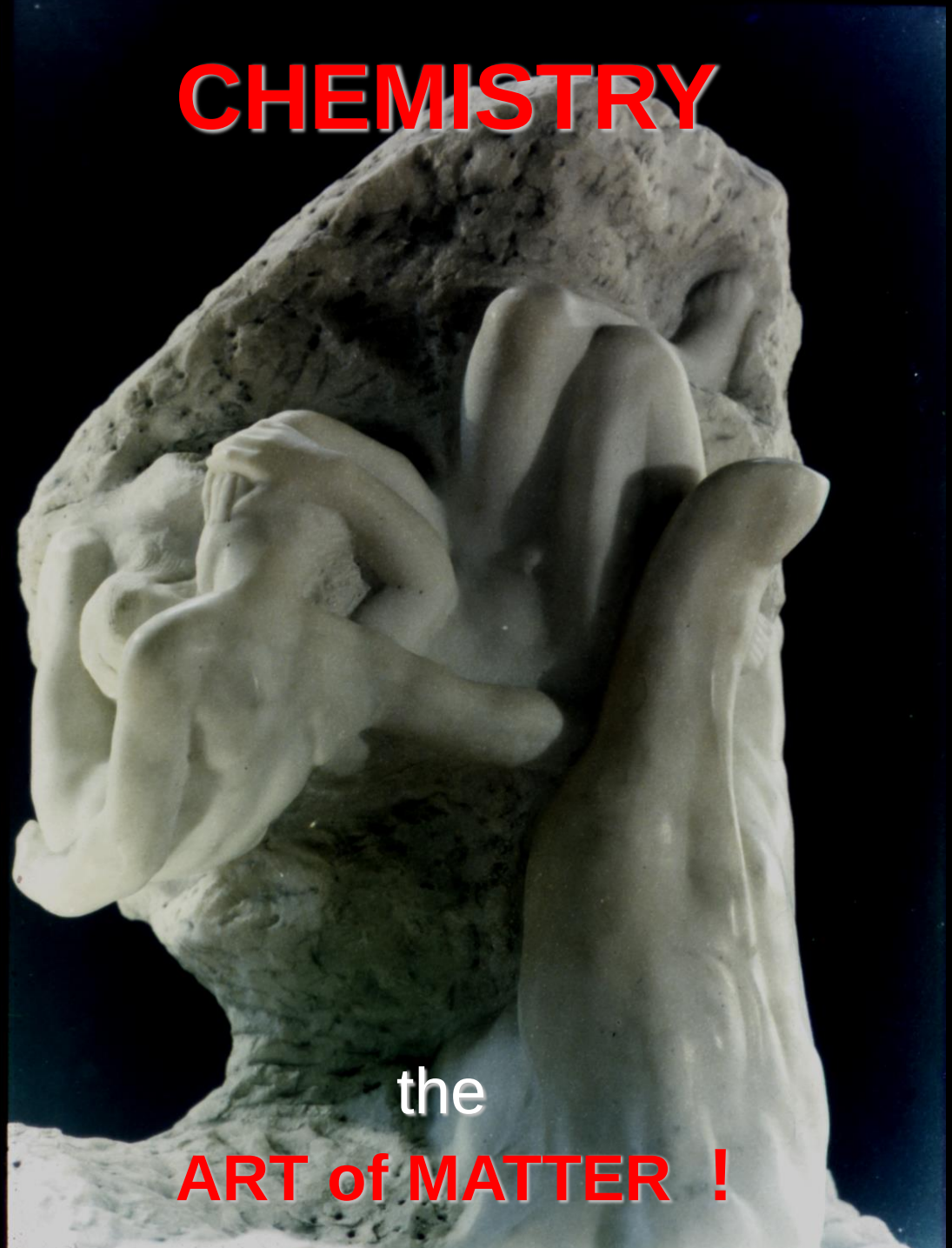
CHEMISTRY

THE CREATIVE POWER

CHEMISTRY

Auguste
RODIN

(1840-1917)



the

ART of MATTER !

(1452 - 1519)

" Là dove natura finisce di produrre le sue spezie, quivi l'uomo comincia con le cose naturali, con l'auditorio di essa natura, a creare infinite spezie. "

Leonardo da Vinci

" Where nature finishes to produce its own species, man begins, using natural things, in harmony with this very nature, to create an infinity of species. "

Leonardo da Vinci

普罗米修斯

PROMETHEUS
stole THE FIRE
of KNOWLEDGE
from the GODS
and gave it to MANKIND

We cannot give it back .

Our path leads us from
the QUEST of KNOWLEDGE to the
CONTROL OF OUR DESTINY !

普罗米修斯:
古希腊英雄，从众神处盗火给人类。象征对科学知识的渴求

坐井而观天，
曰天小者，
非天小也.

-唐.韩愈

HAN Yu (768-824)

Who sits at the bottom of a well

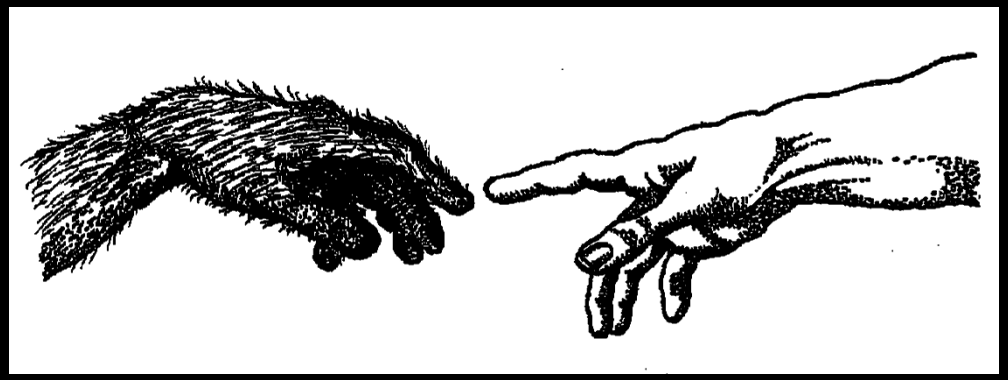
To contemplate the sky

Will find it small .

Future.....?

Present.....

Past.....



David HILBERT

(1862-1943)

WE WILL KNOW

Science shapes the future of humanity.

Participate !