Bioeconomy and Biosystems

So complicated, so simple, so smart
the lego puzzle of nature

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National and Kapodistrian University of Athens

The structure of our biosystem

The blue planet, our home

The ecosystem

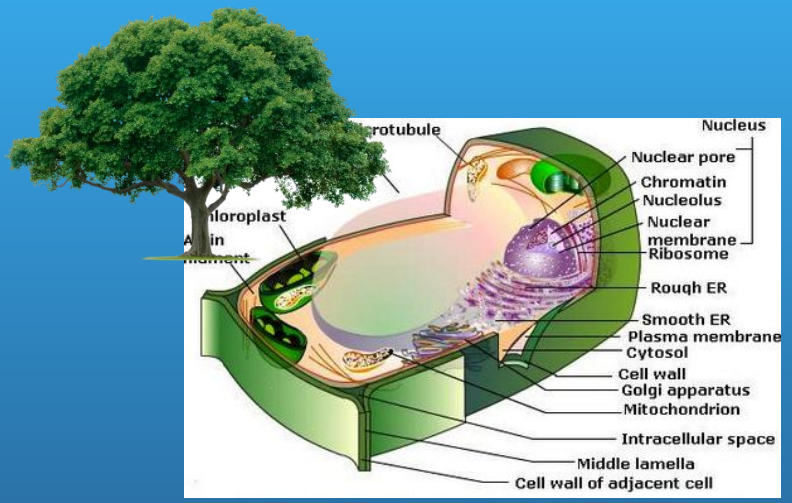
Components of our ecosystem

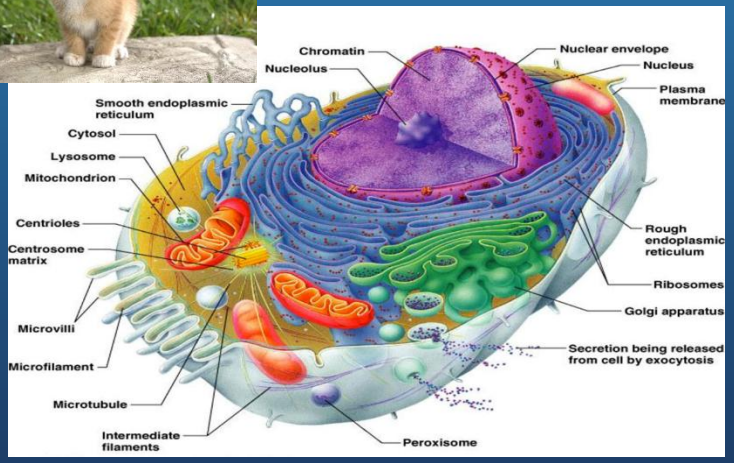


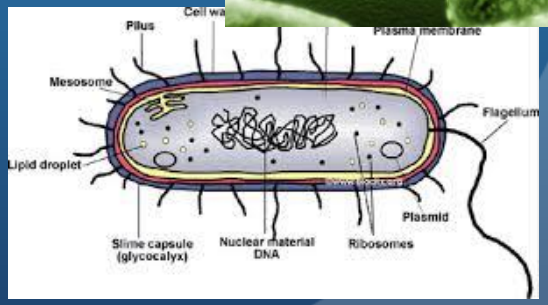



We are seeing a tiny part of what is there

Basic components of the living organisms are the cells

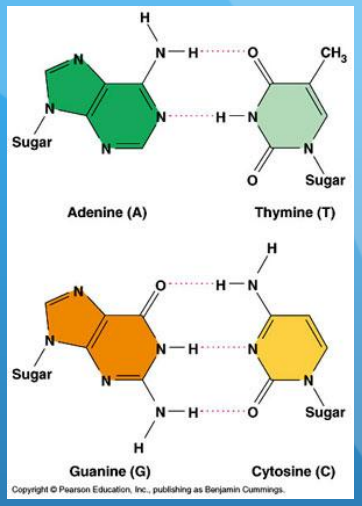






The information stockpile of our biosystem

DNA>RNA



~3 meters in humans
only 2% encodes proteins

The human genome

The book is open

To understand the entire information in the book it will take a long time

DNA: an unlimited pool of information: why?

Bacterial DNA (*10^6)

Archeobacterial DNA(*10^6)

Viral DNA(*10^4)

Eucaryotic DNA(*10^{10})

Cell free environmental DNA

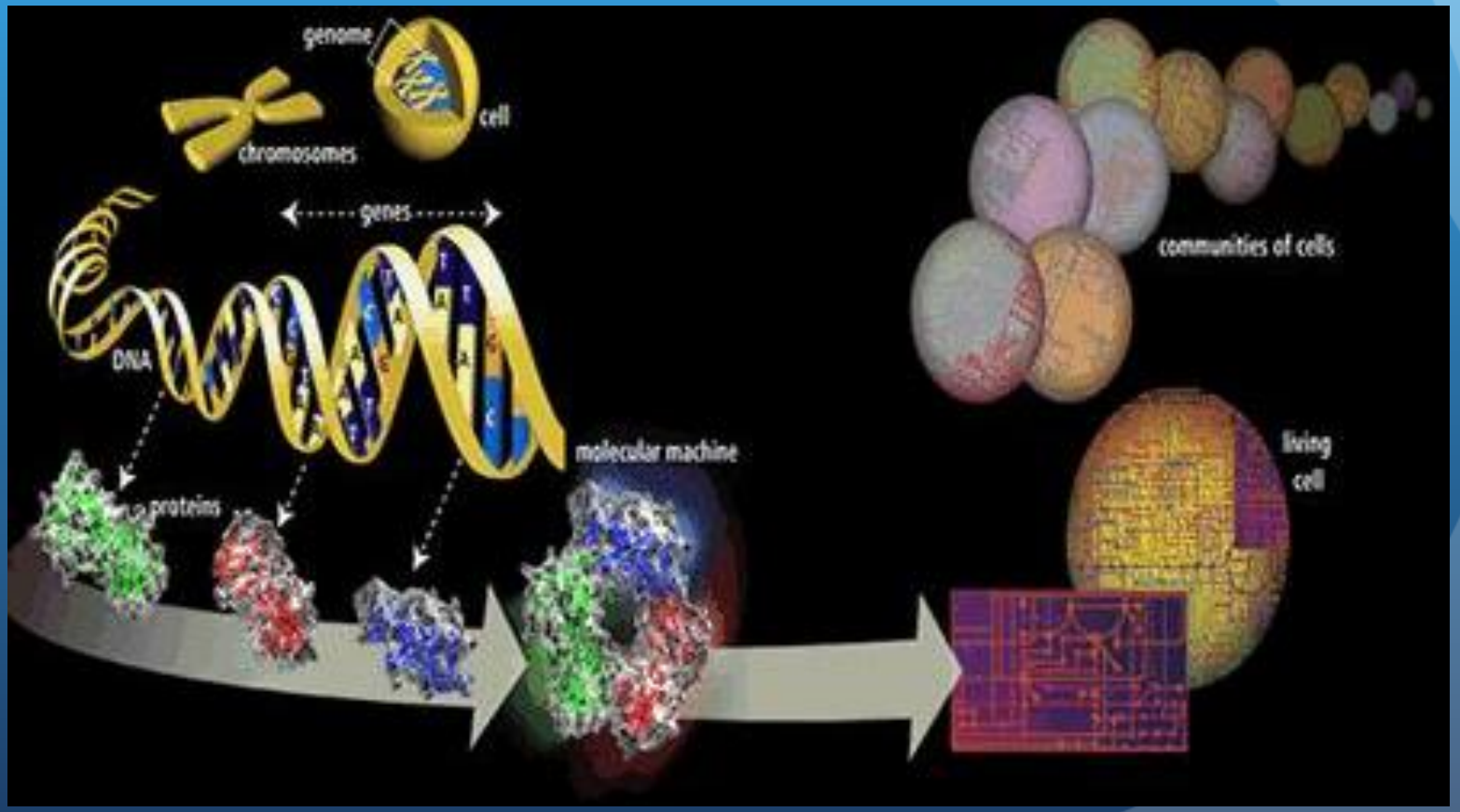
Recombinant DNA-gene technology

Shuffled DNA-directed evolution

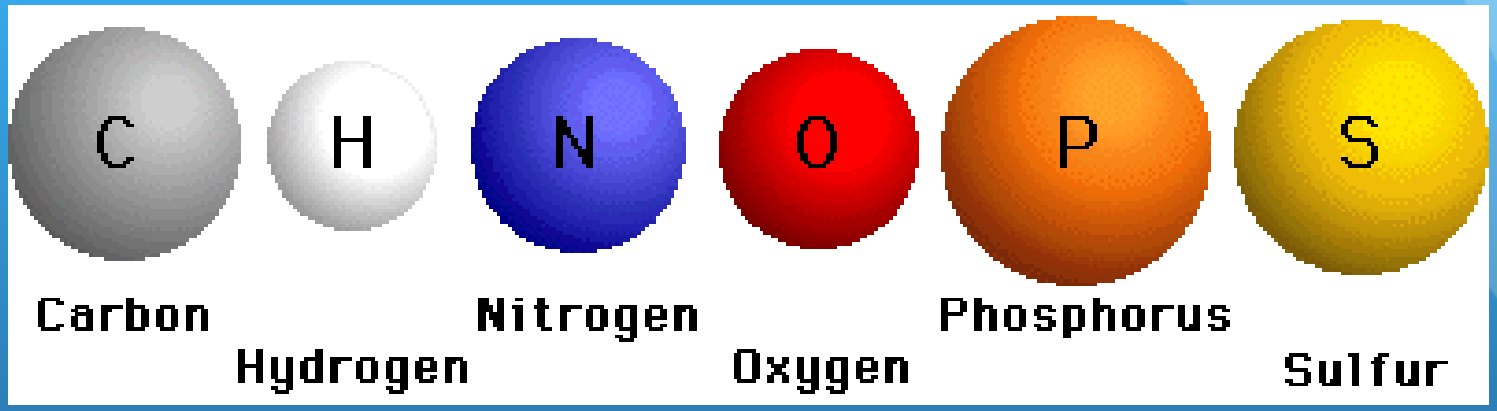
Ancestral DNA (calculated)

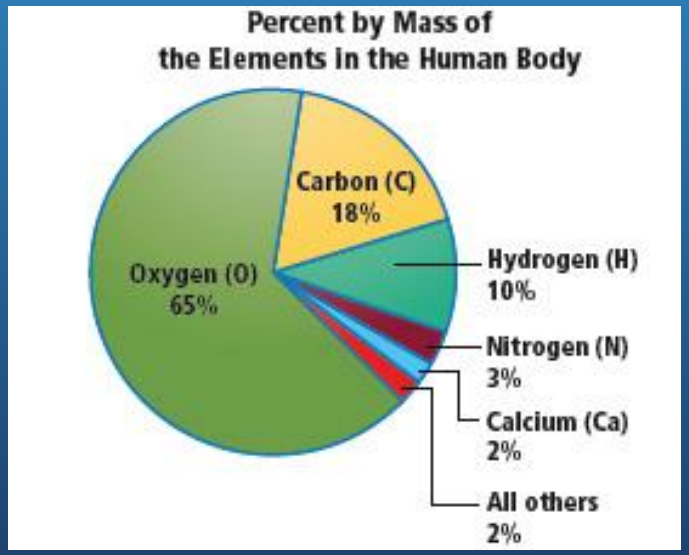
Synthetic DNA (artificial)

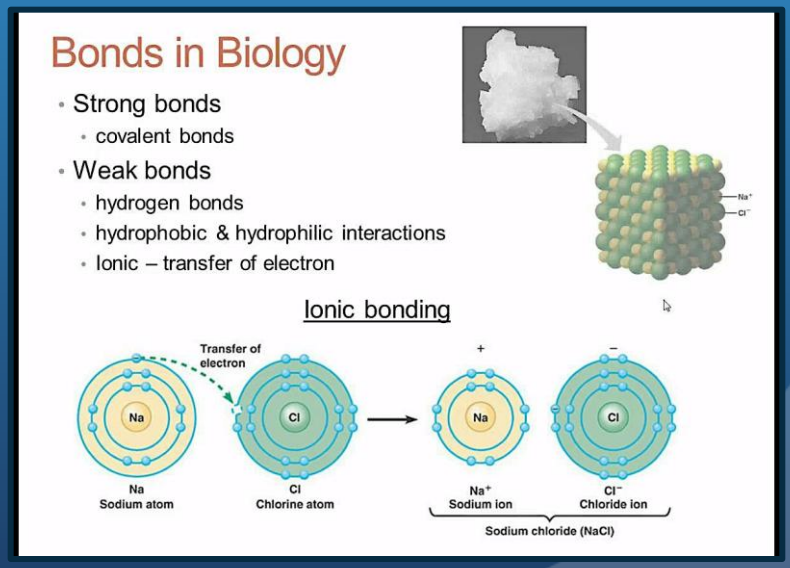
The DNA provides the essential information (genes-regulatory elements etc) to the cell machinery (proteinosynthesis) to build functional molecules: the proteins



The chemical basis of life







The physical basis of life

The Laws of Thermodynamics

0. Two bodies in thermal equilibrium are at same T
1. Energy can never be created or destroyed.

$$\Delta E = q + w$$

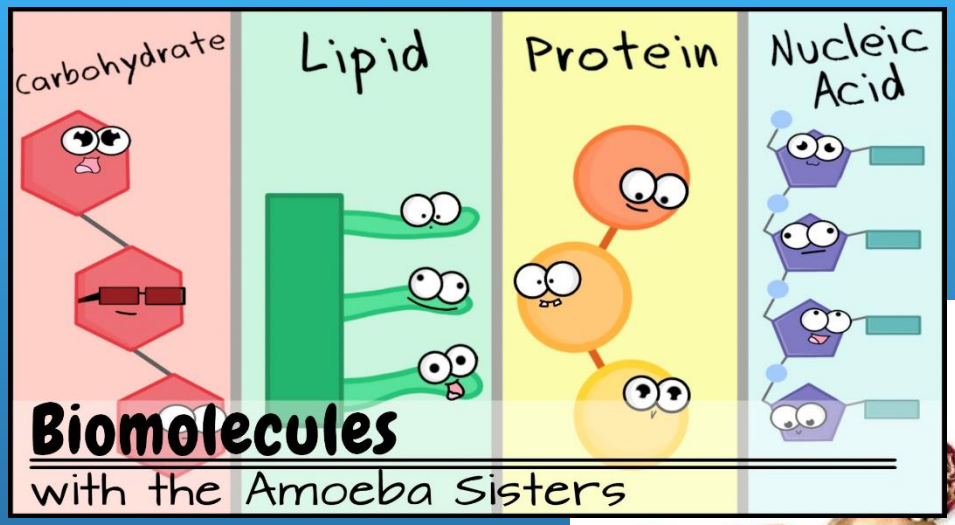
2. The total entropy of the UNIVERSE (= system plus surroundings) MUST INCREASE in every spontaneous process.

$$\Delta S_{TOTAL} = \Delta S_{system} + \Delta S_{surroundings} > 0$$

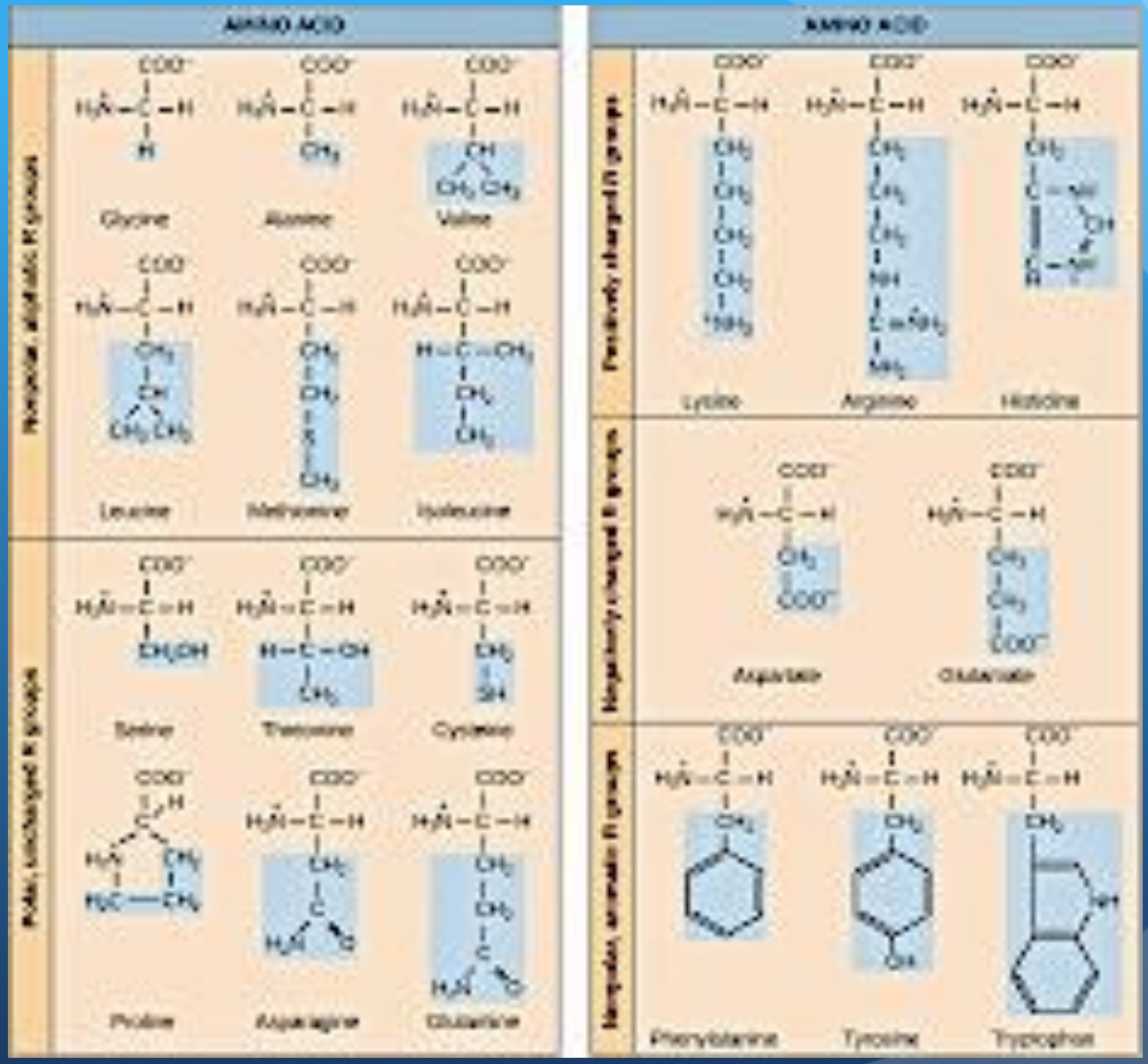
3. The entropy (S) of a pure, perfectly crystalline compound at T = 0 K is ZERO. (no disorder)

$$S_{T=0} = 0 \text{ (perfect xll)}$$

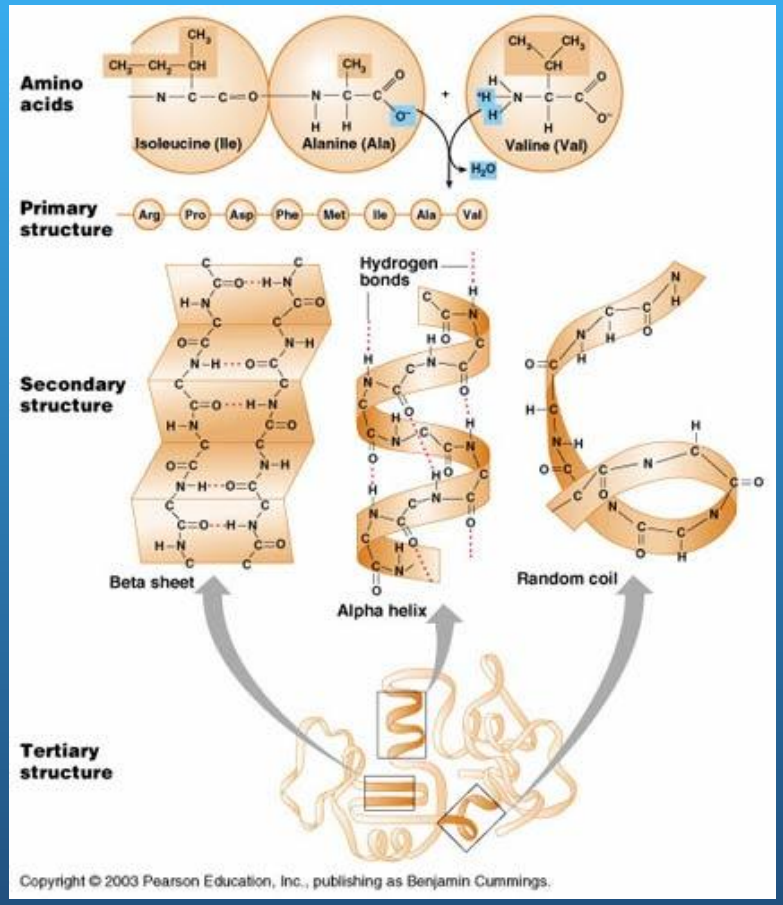
The major biomolecules



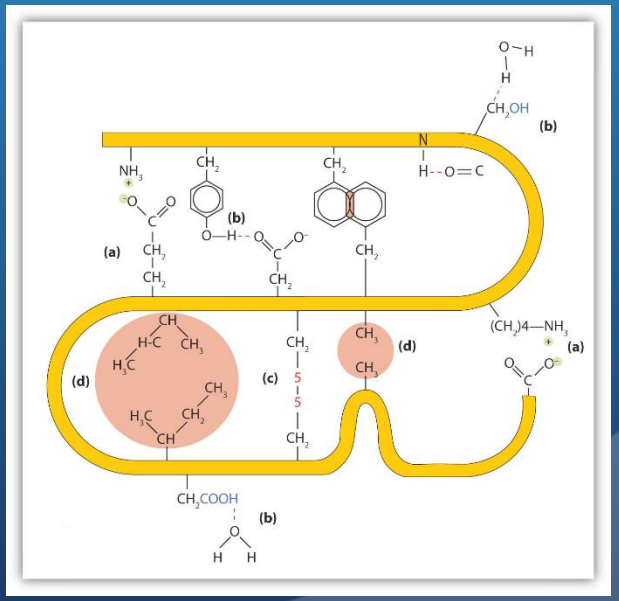
Proteins=linear chains of amino acids



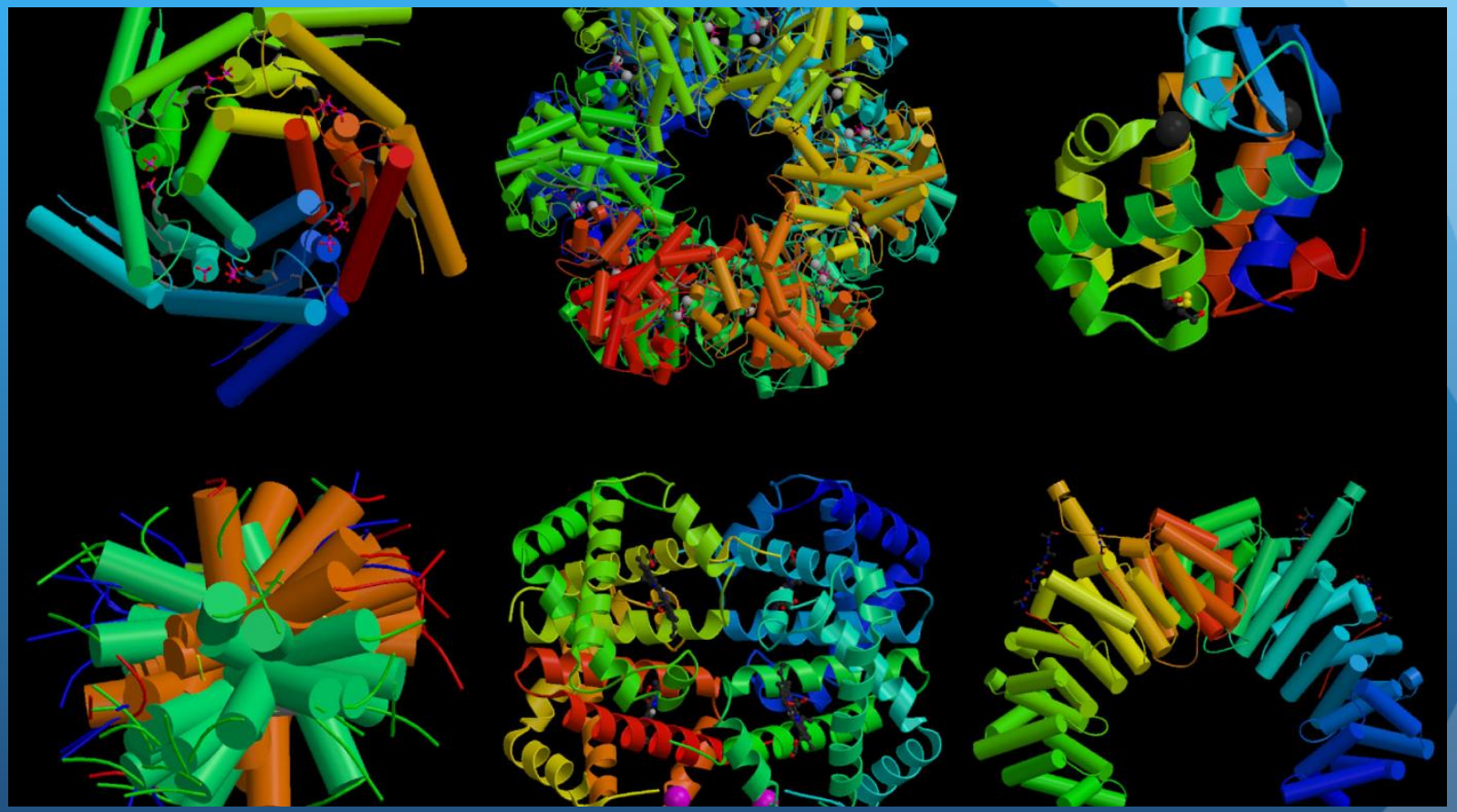
The structure of proteins



Amazing numbers: random synthesis of proteins of 300 aa length, using the 20 amino acids can create 20^{300} (~50000)

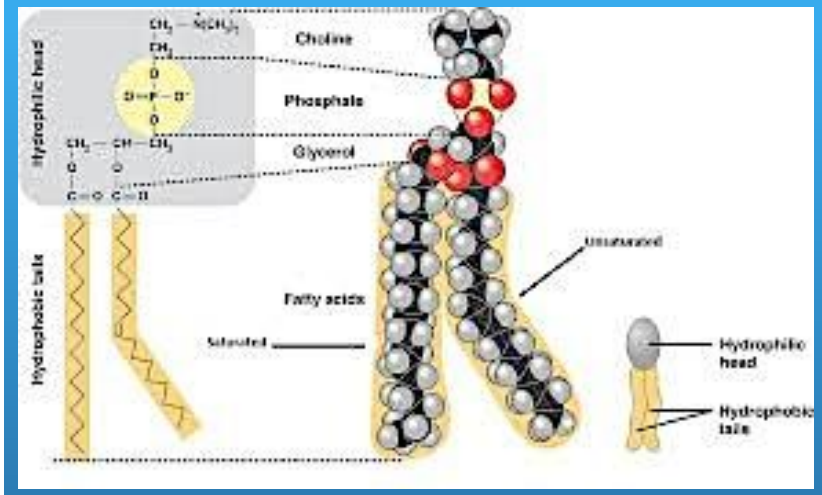


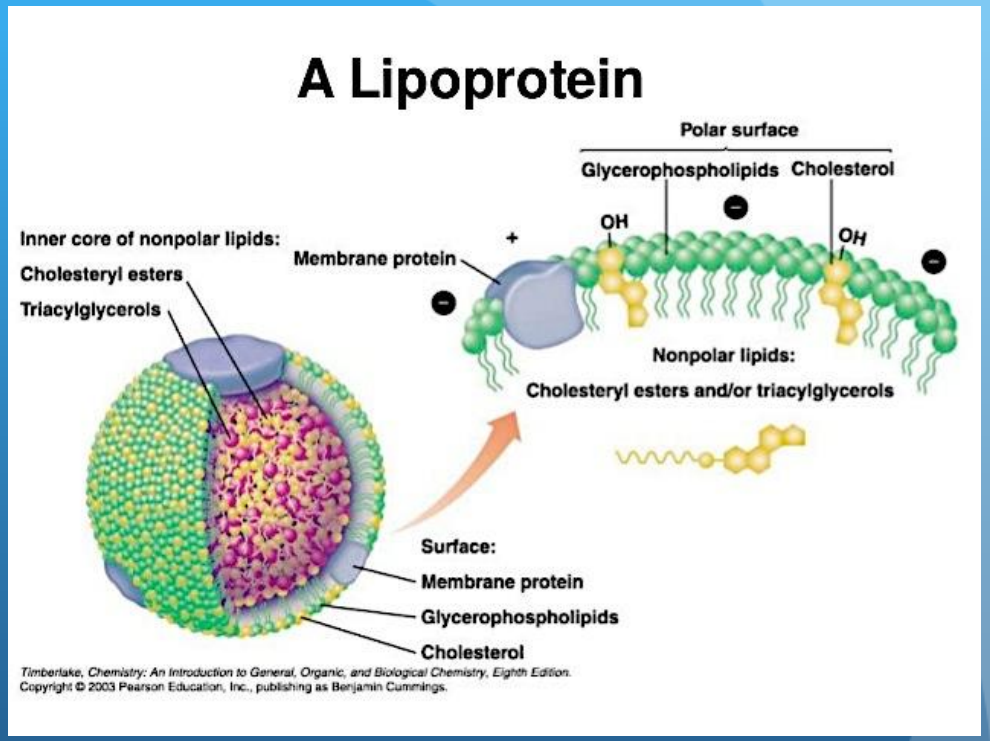
The structure of proteins

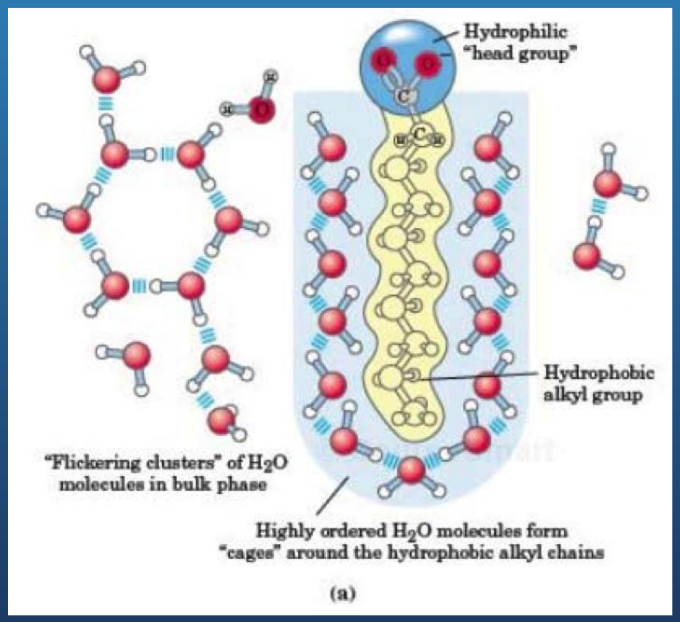


The existing proteins is a tiny fraction of the existing possibilities

The structure of lipids

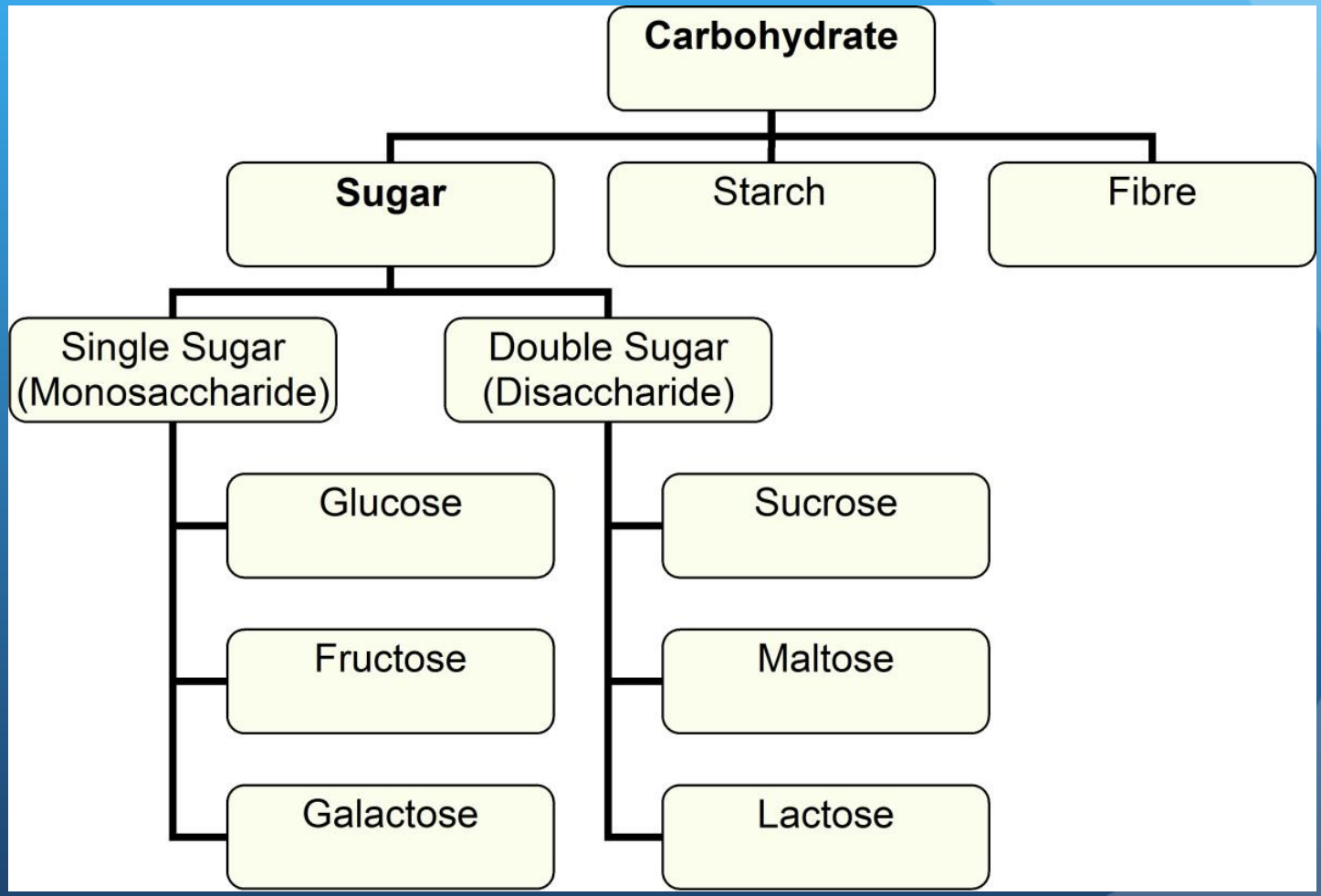




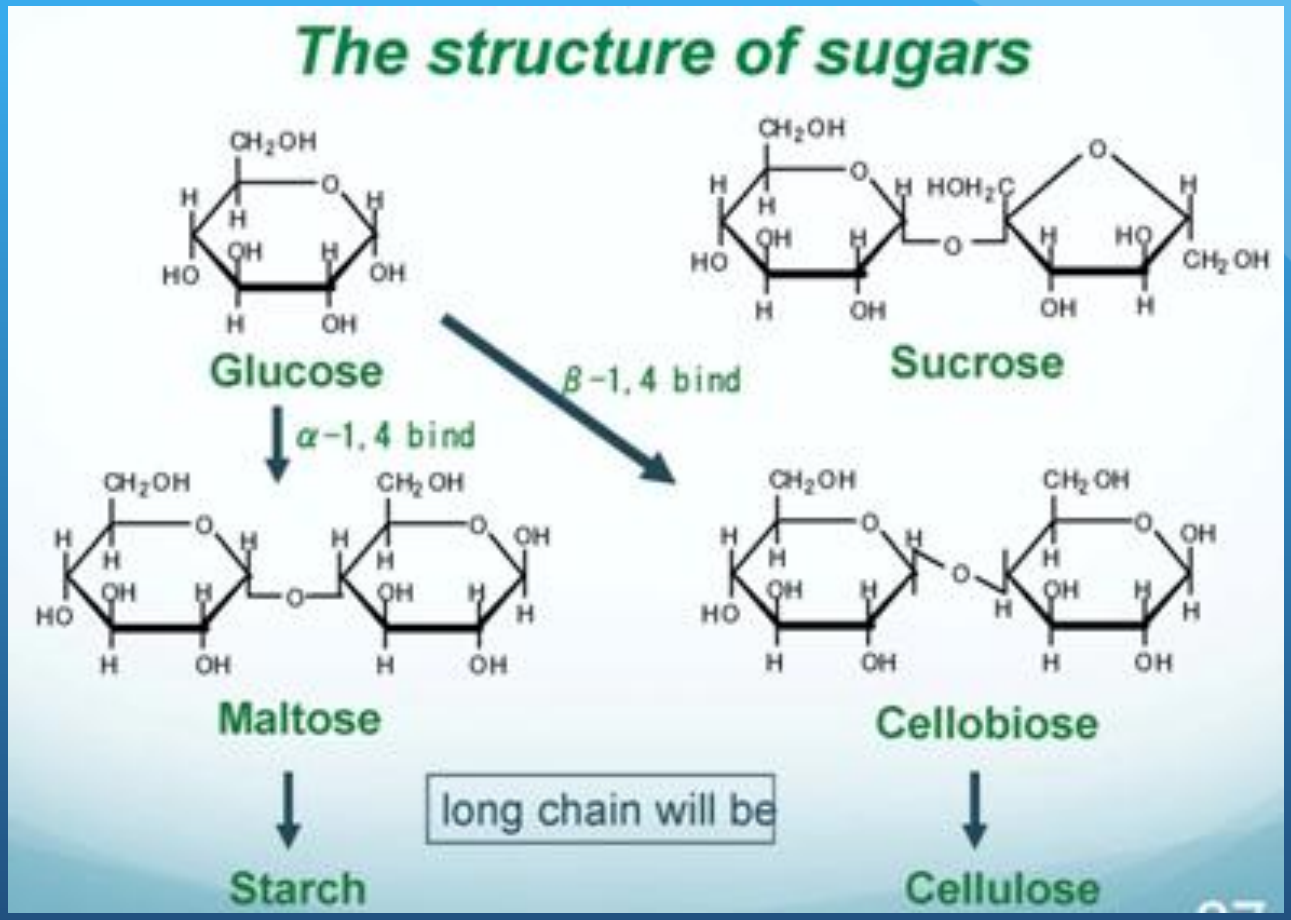


An amazing feature of lipids is their hydrophobicity, the driving force for self assembly

The structure of carbohydrates



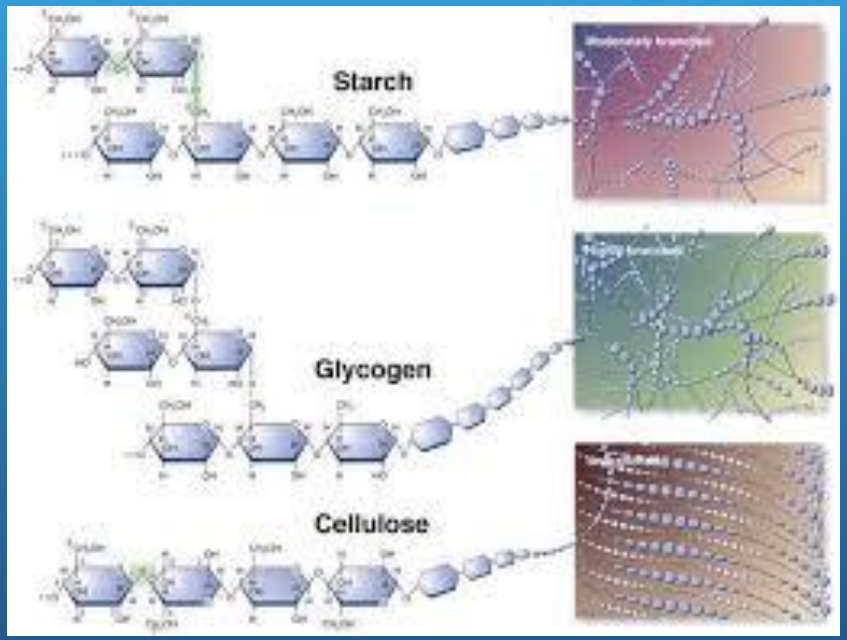
The structure of carbohydrates

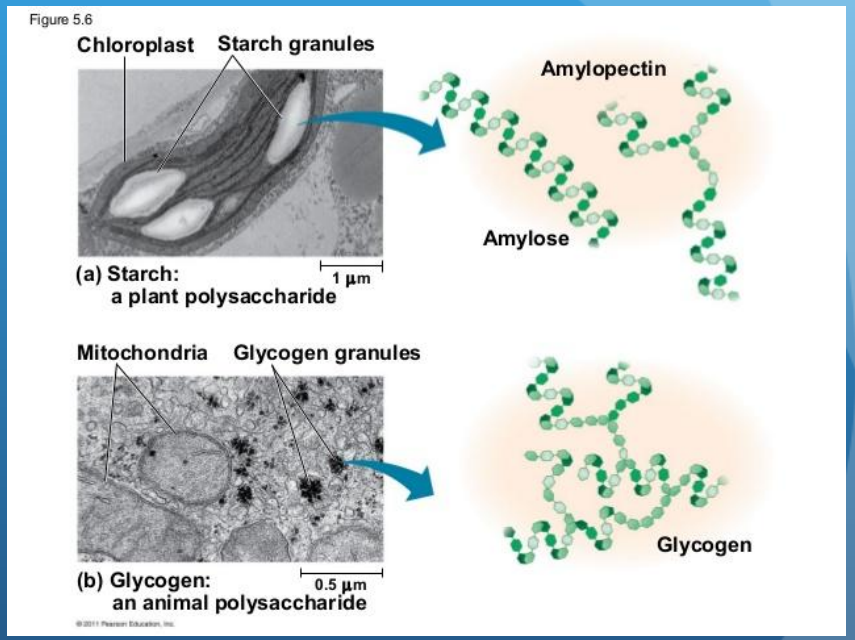


A single bond defines the structure of polysaccharides

The structure of carbohydrates

The polysaccharides are linear and branched

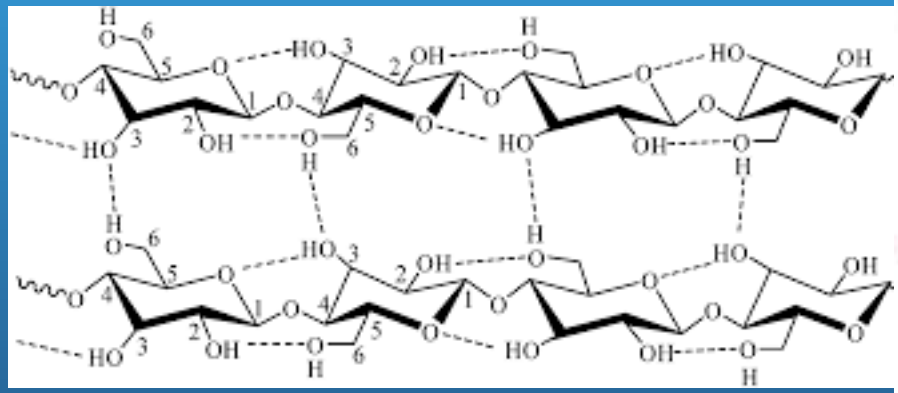


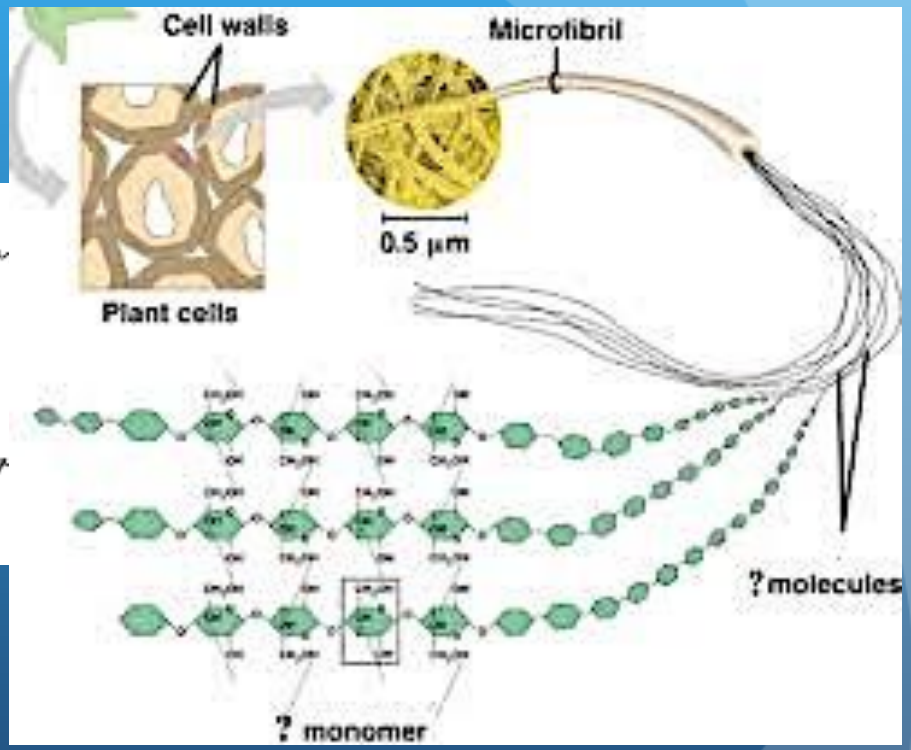


α-1,4 construct helical polysaccharides=storage

The structure of cellulose

The structural polysaccharides are linear

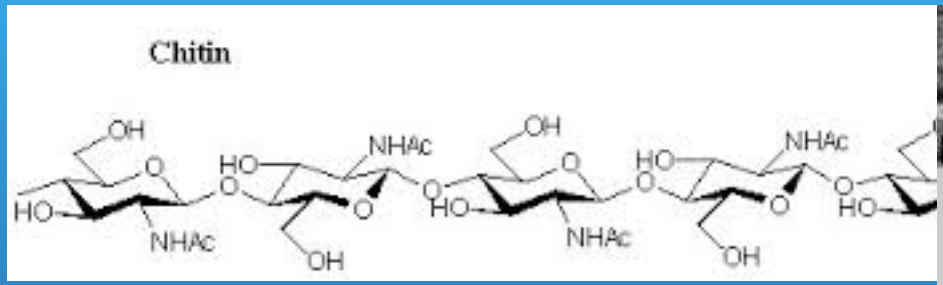


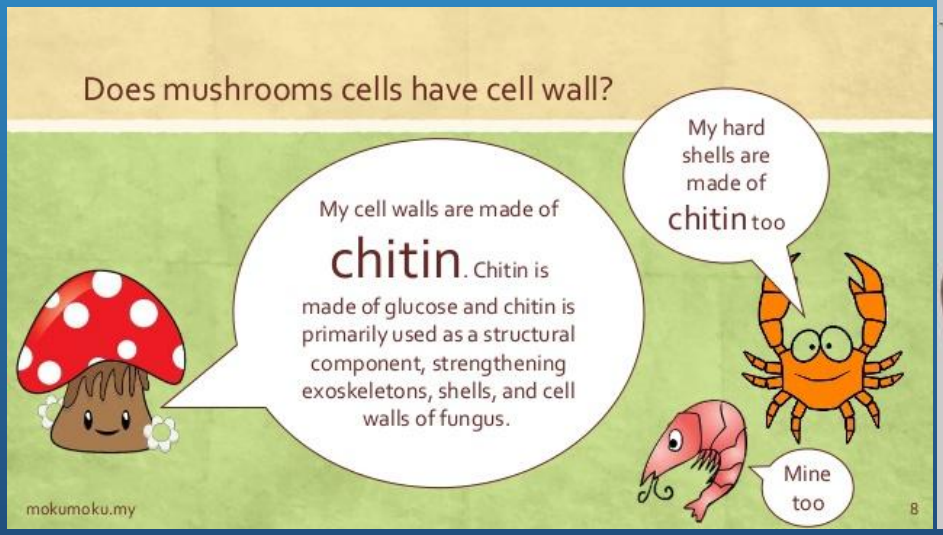


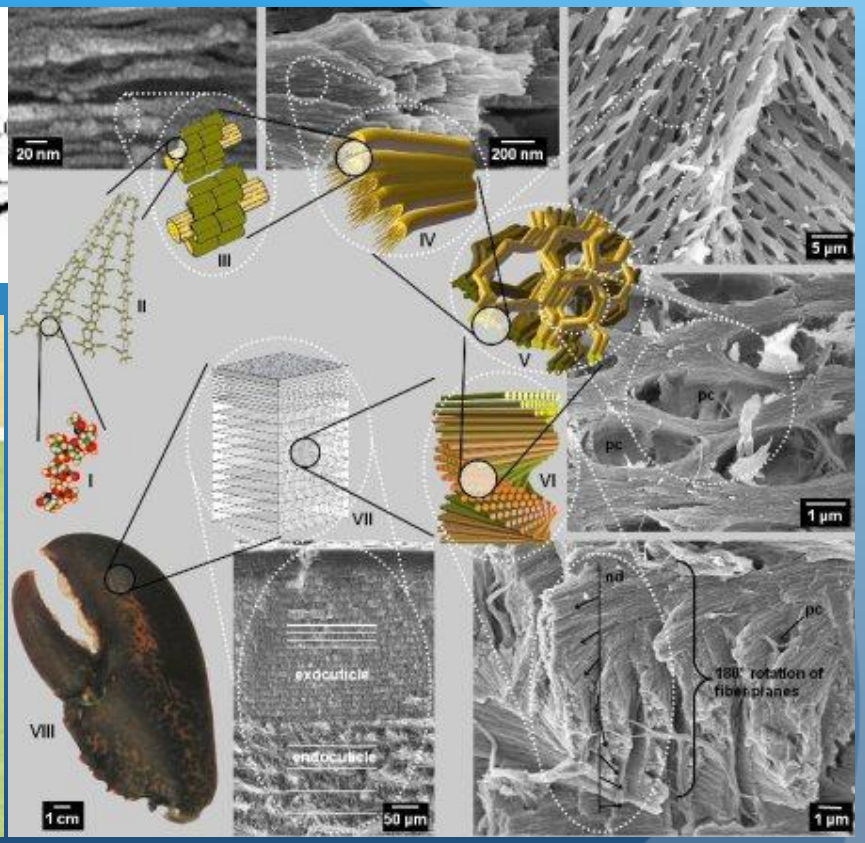
β-1,4 construct linear polysaccharides=structure

The structure of chitin

The structural polysaccharides are linear

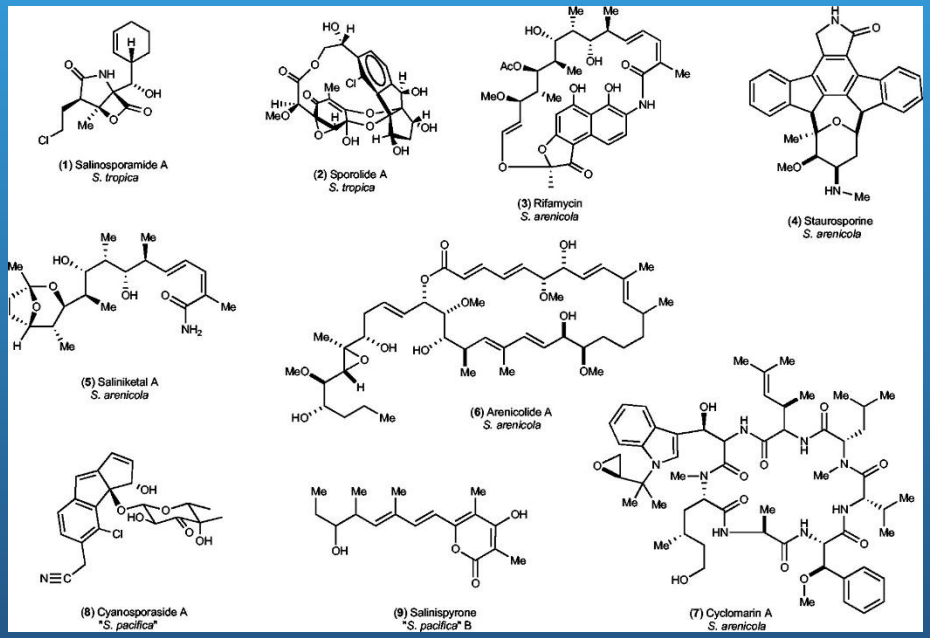


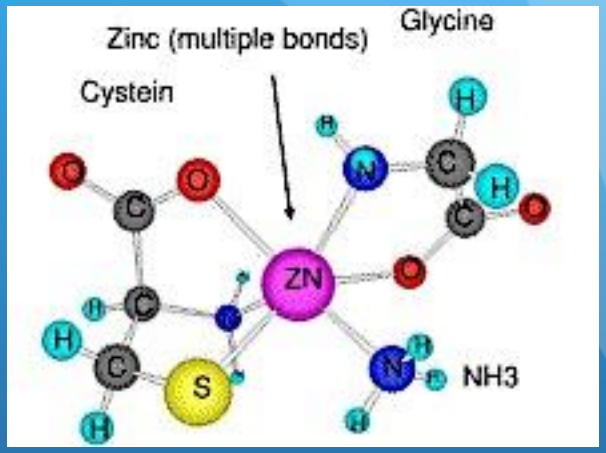


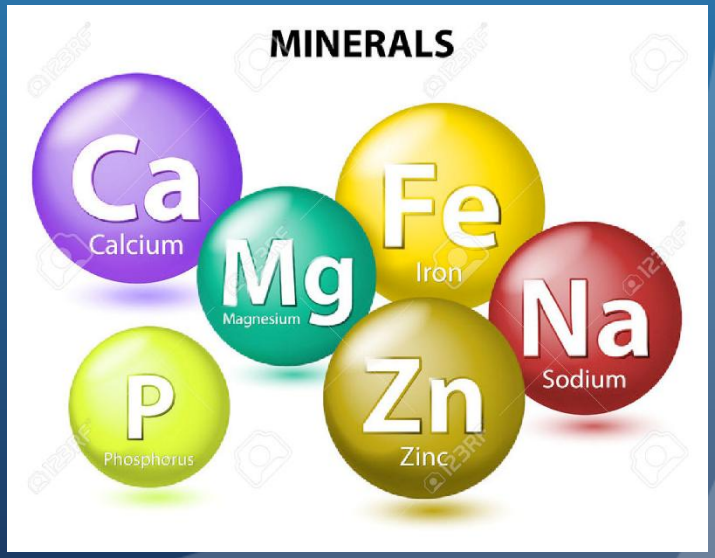


ß-1,4 construct linear polysaccharides=structure

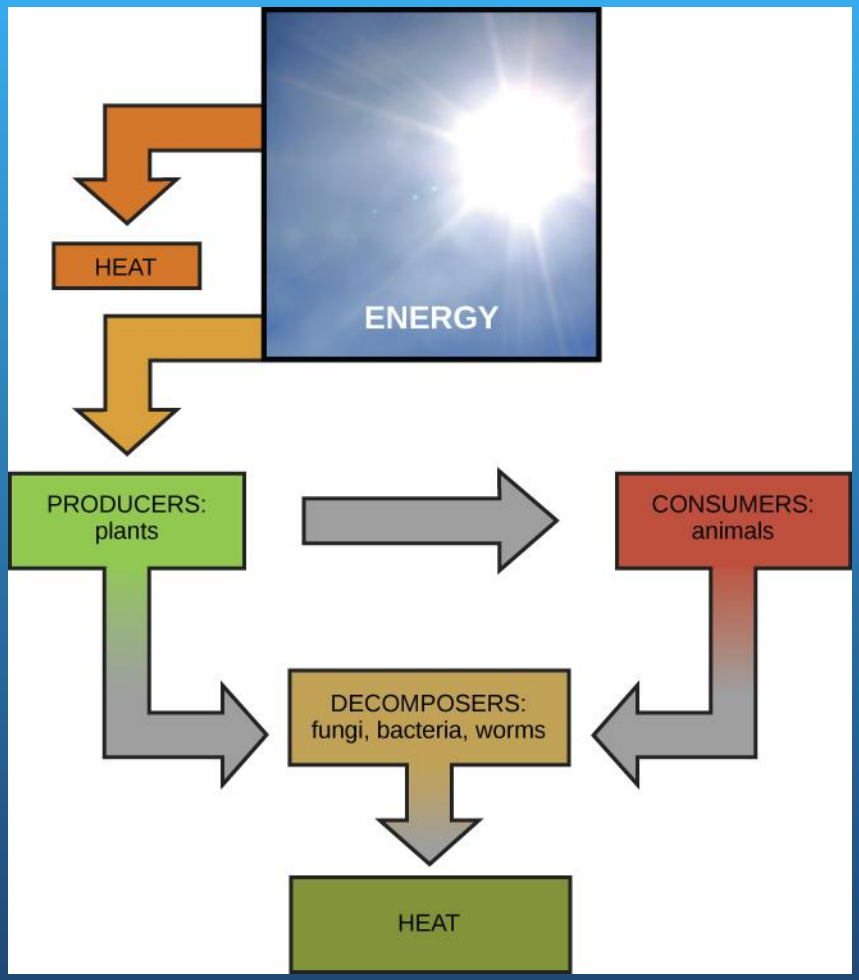
The rest: small metabolites and trace elements

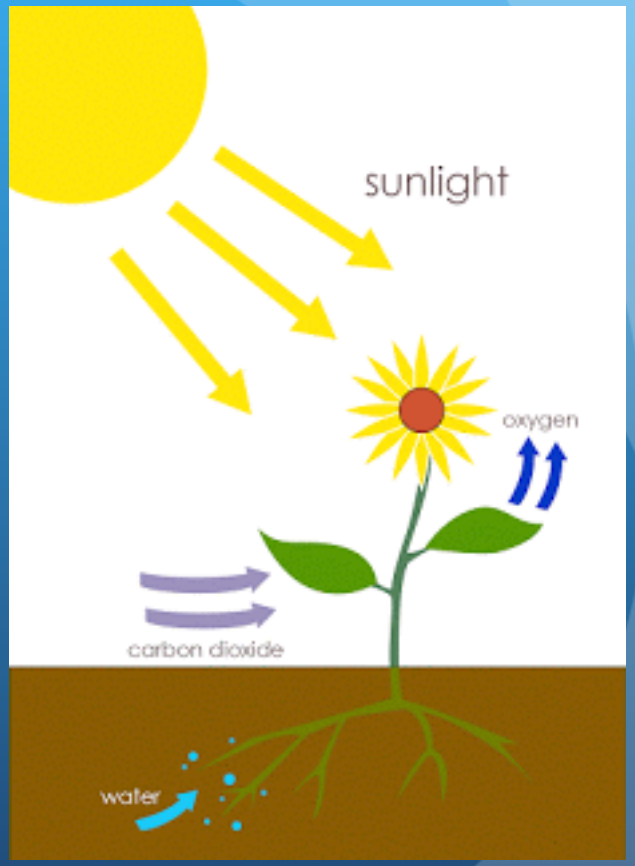




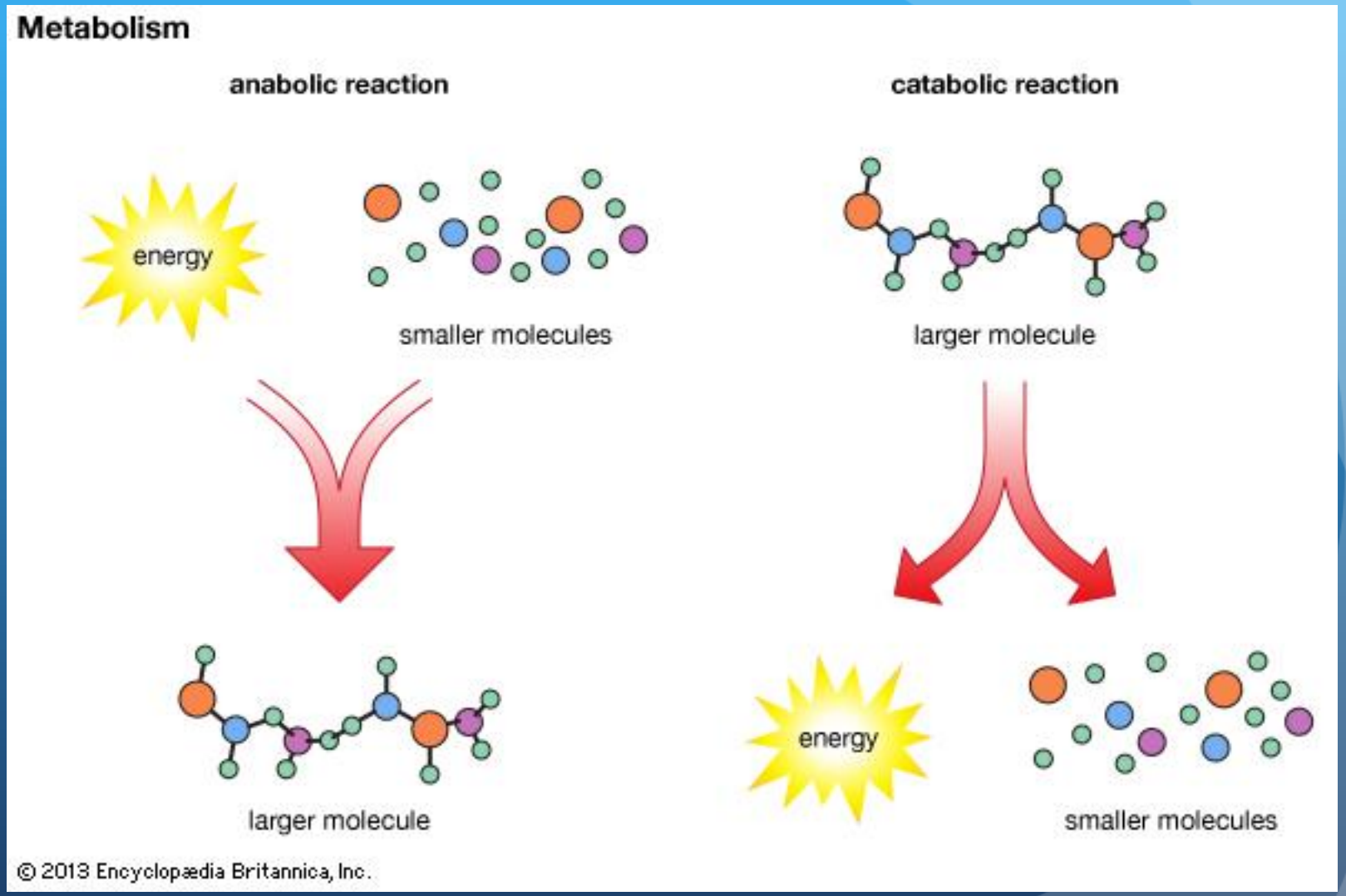


Energy in biosystems

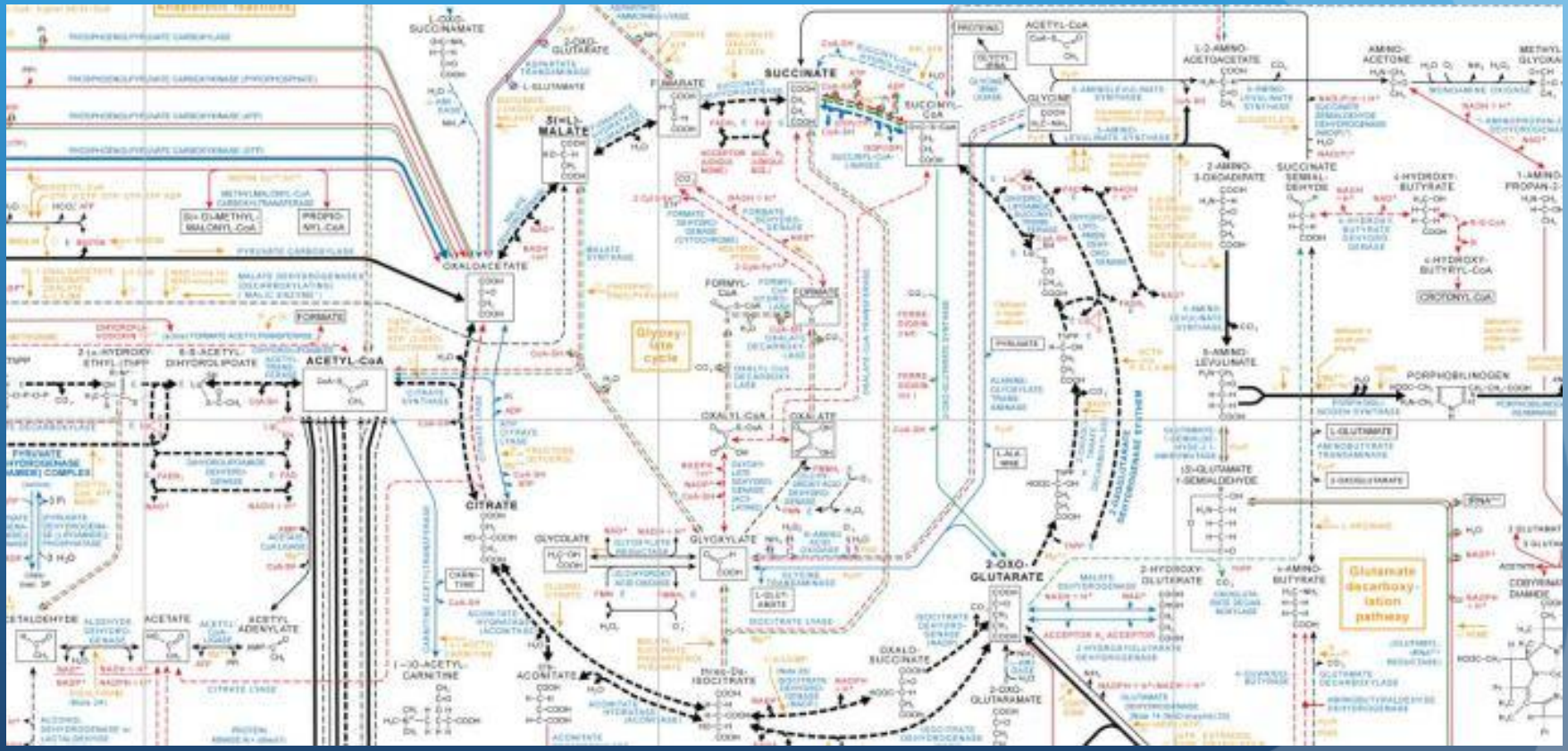




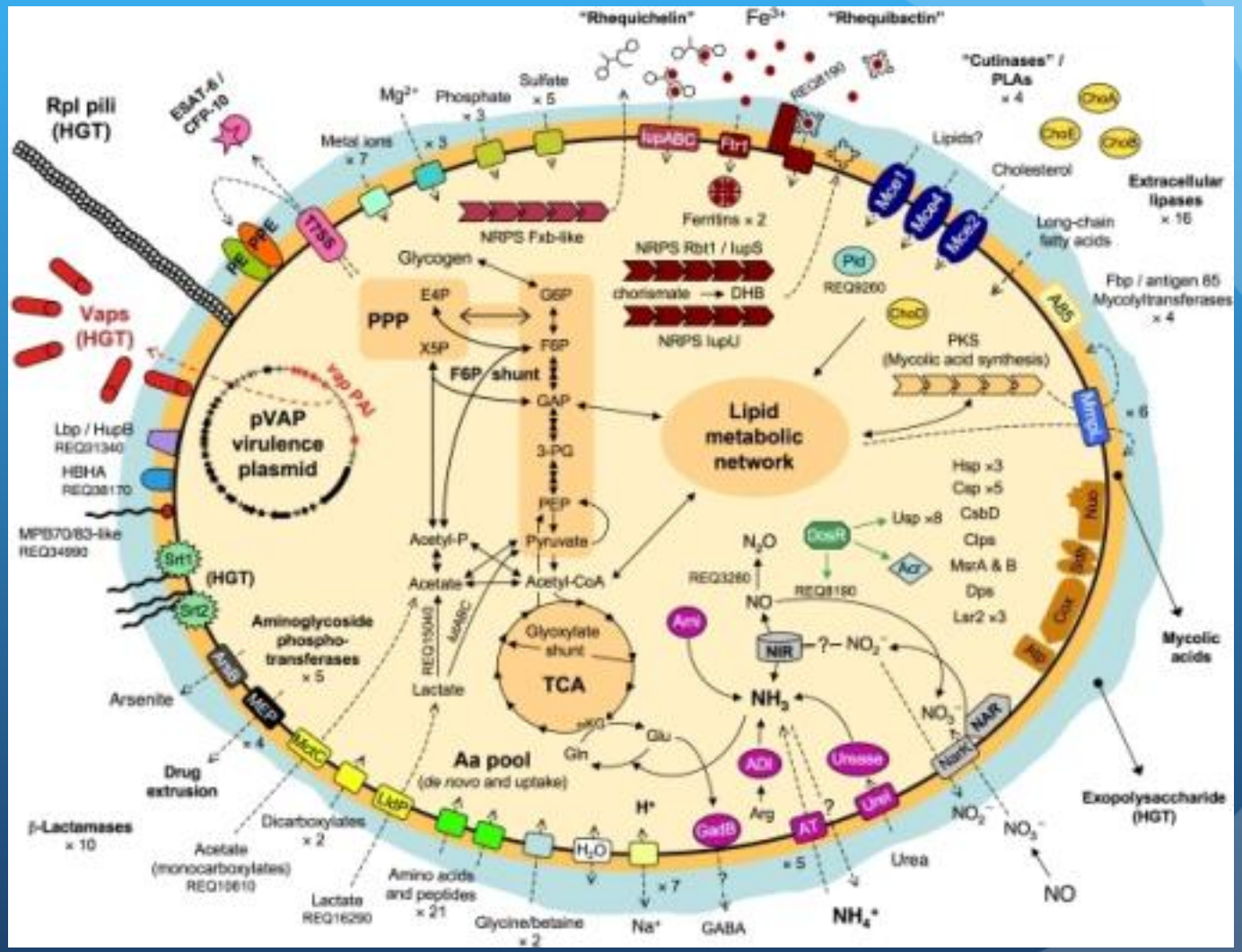
The cellular metabolism



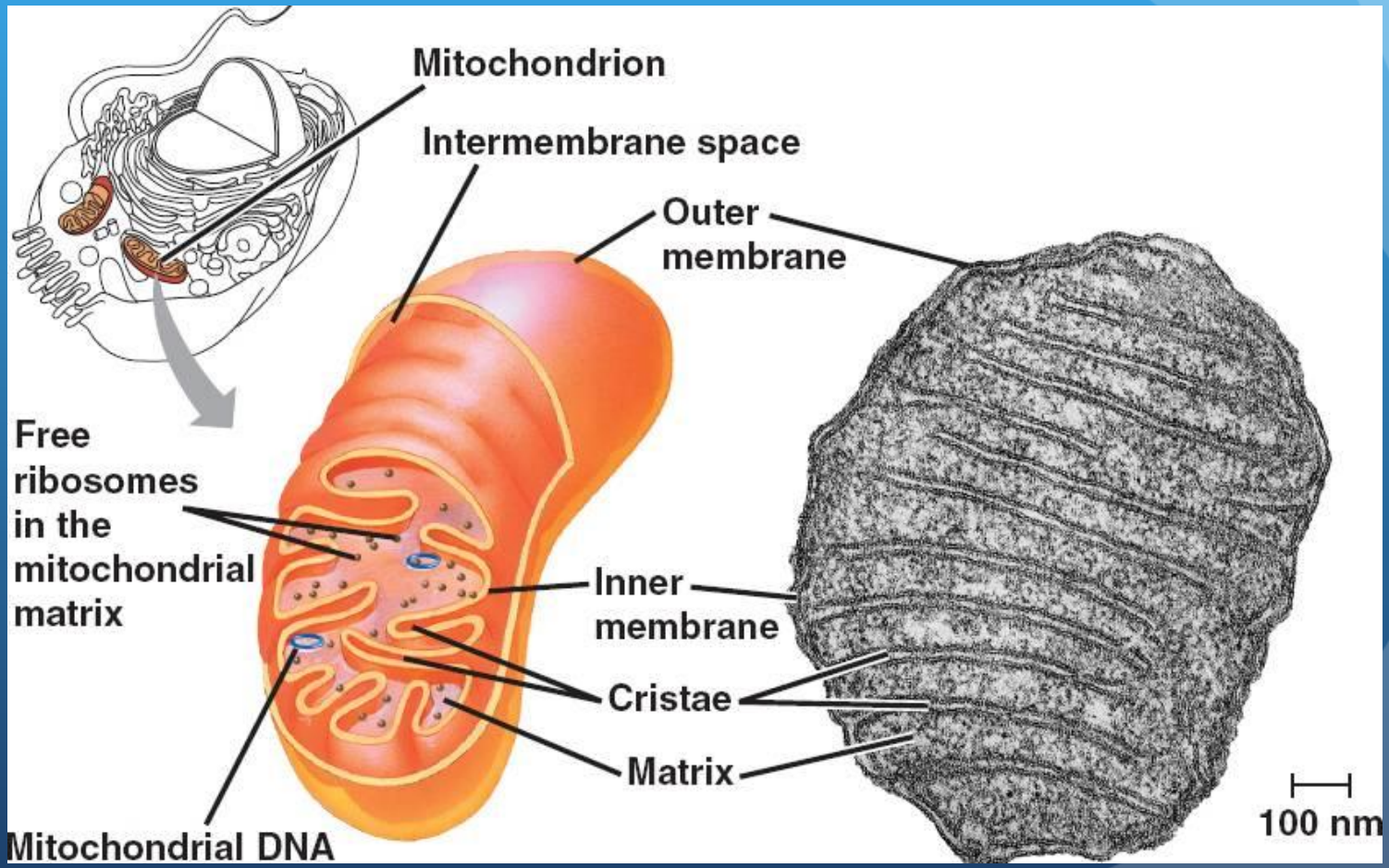
The cellular metabolism is a very complicated network of simple organic chemistry reactions, the metabolic pathways



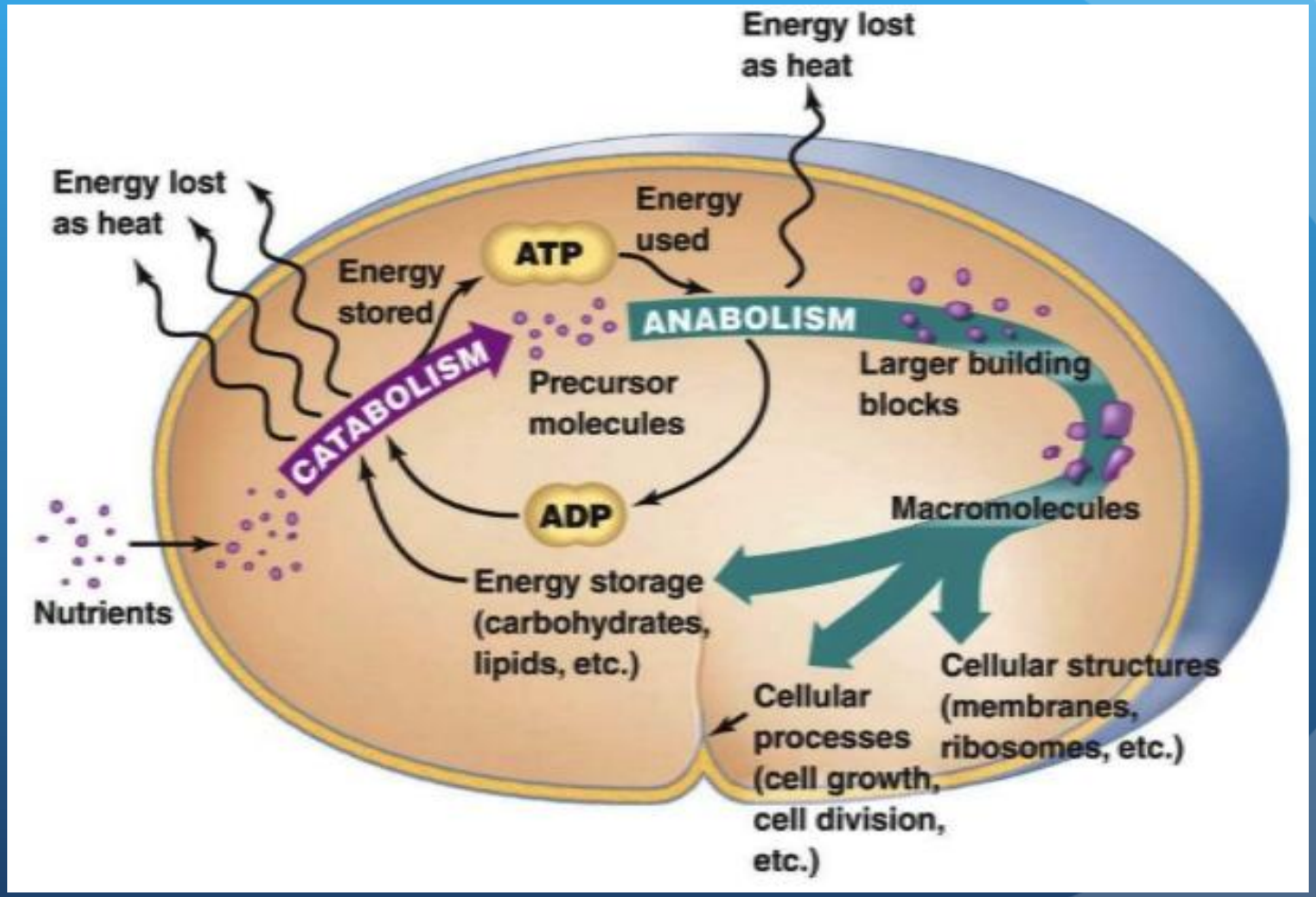
The cellular metabolism is controlled in various ways



The energy is capture either in high energy bonds (ATP) or in reduced molecules (NADPH, NADPH, $FADH_2$)



The cell factory mostly recycle the biomolecules very efficiently



Biotechnology: so young and so old

NSF Award #0501953

How Old Is Biotechnology ?

10,000 BC
Domesticating Crops

6,000 BC
Brewing Beer

Domesticating Animals
8,000-9,000 BC

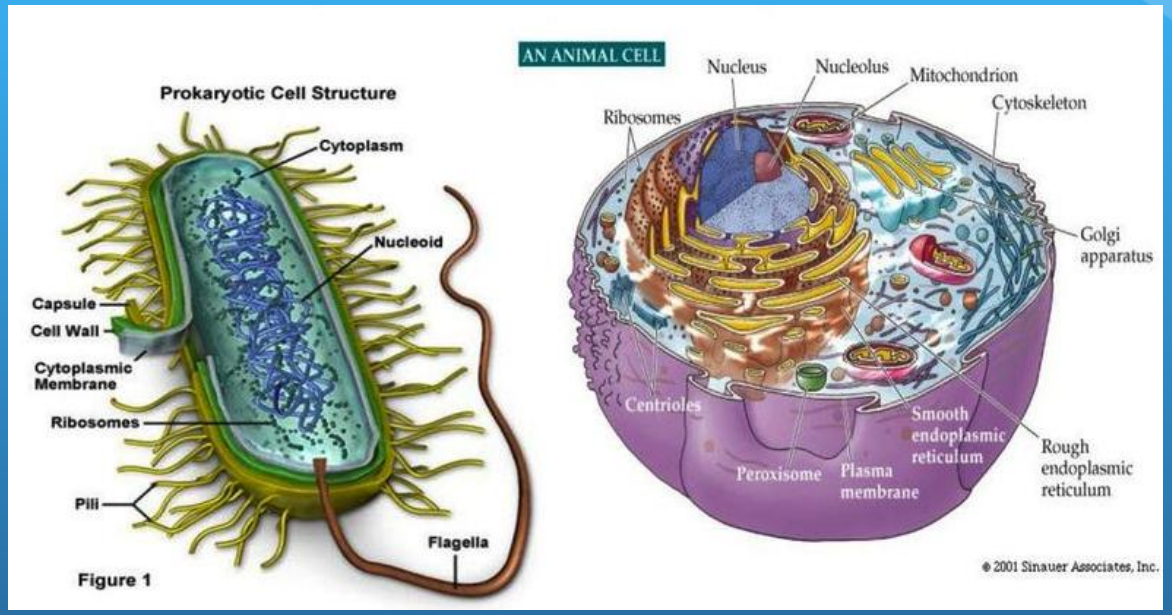
4,000 BC
Leavening Bread

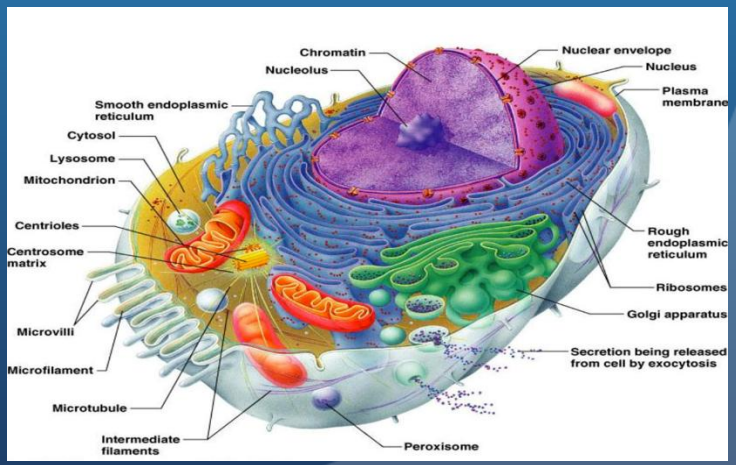
1880's
Production of Vaccines

1940's
Production of Antibiotics

1980's Use of genetically modified organisms

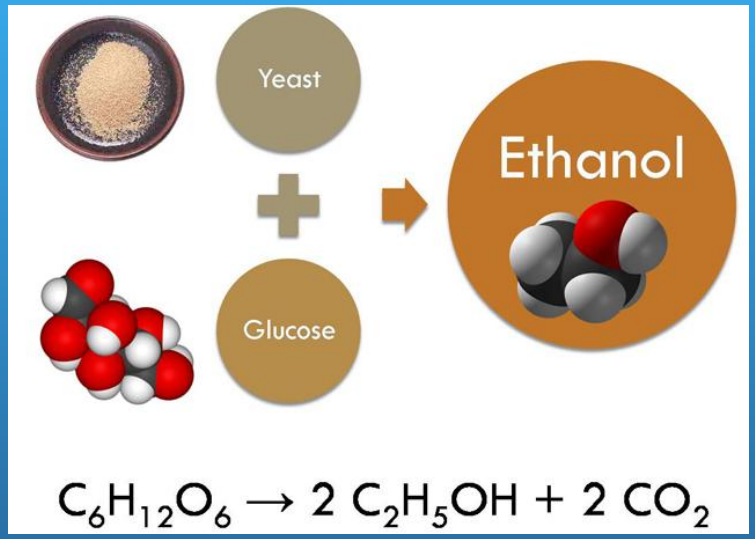
The cell factory the major tool of modern biotechnology

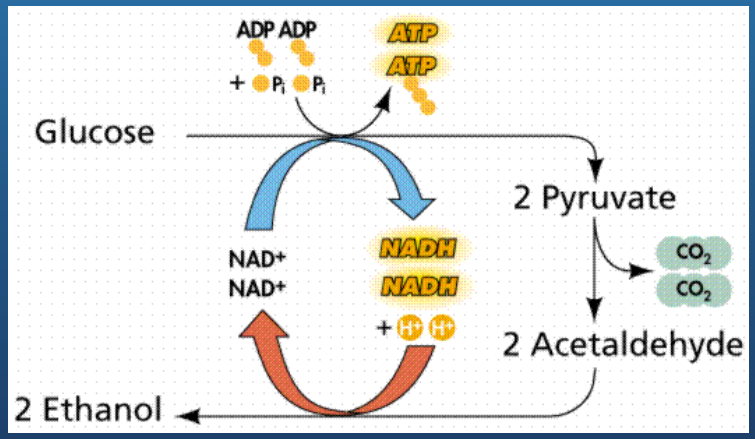




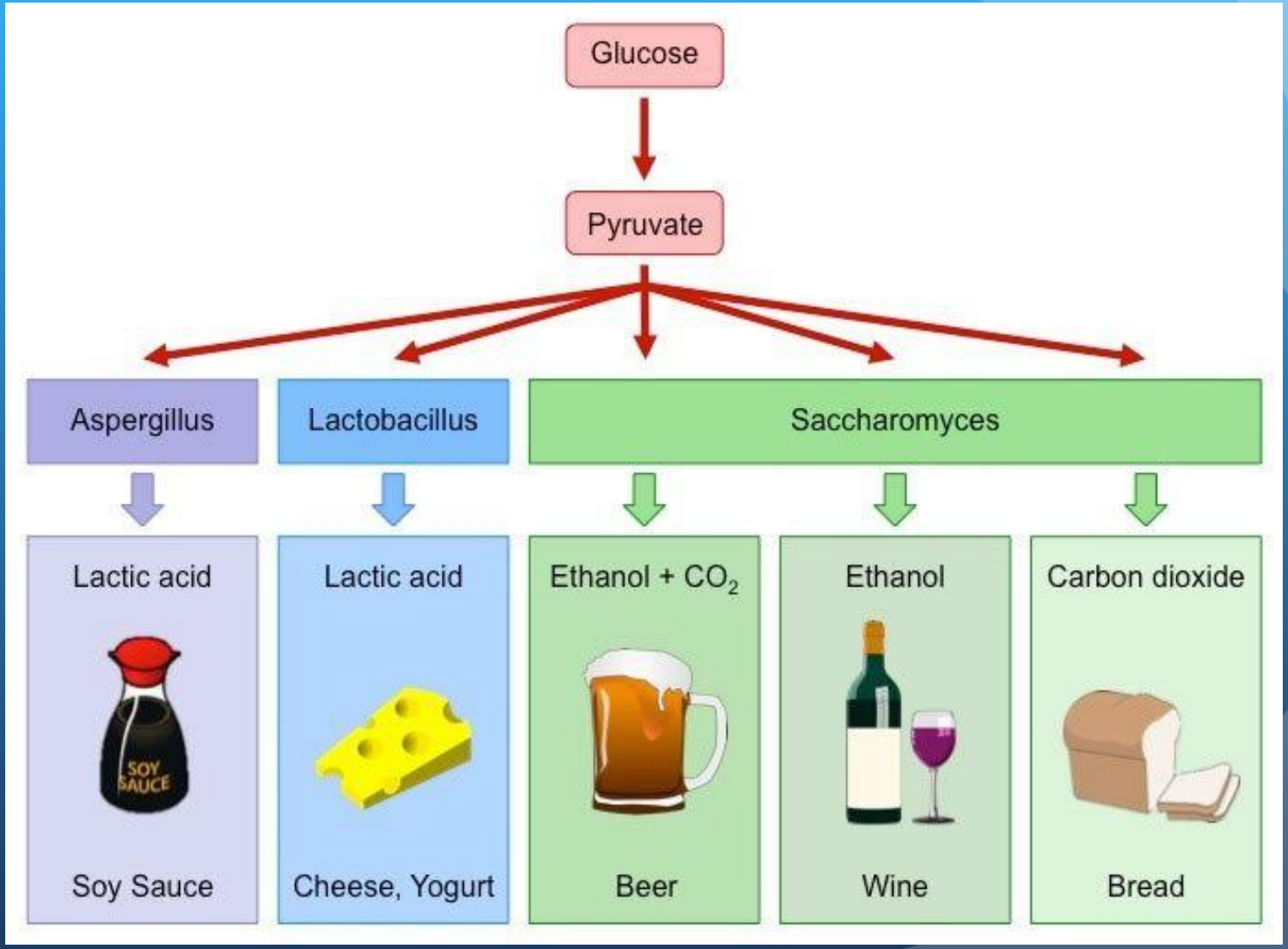
Biotechnology started empirically

The most important biotechnological application

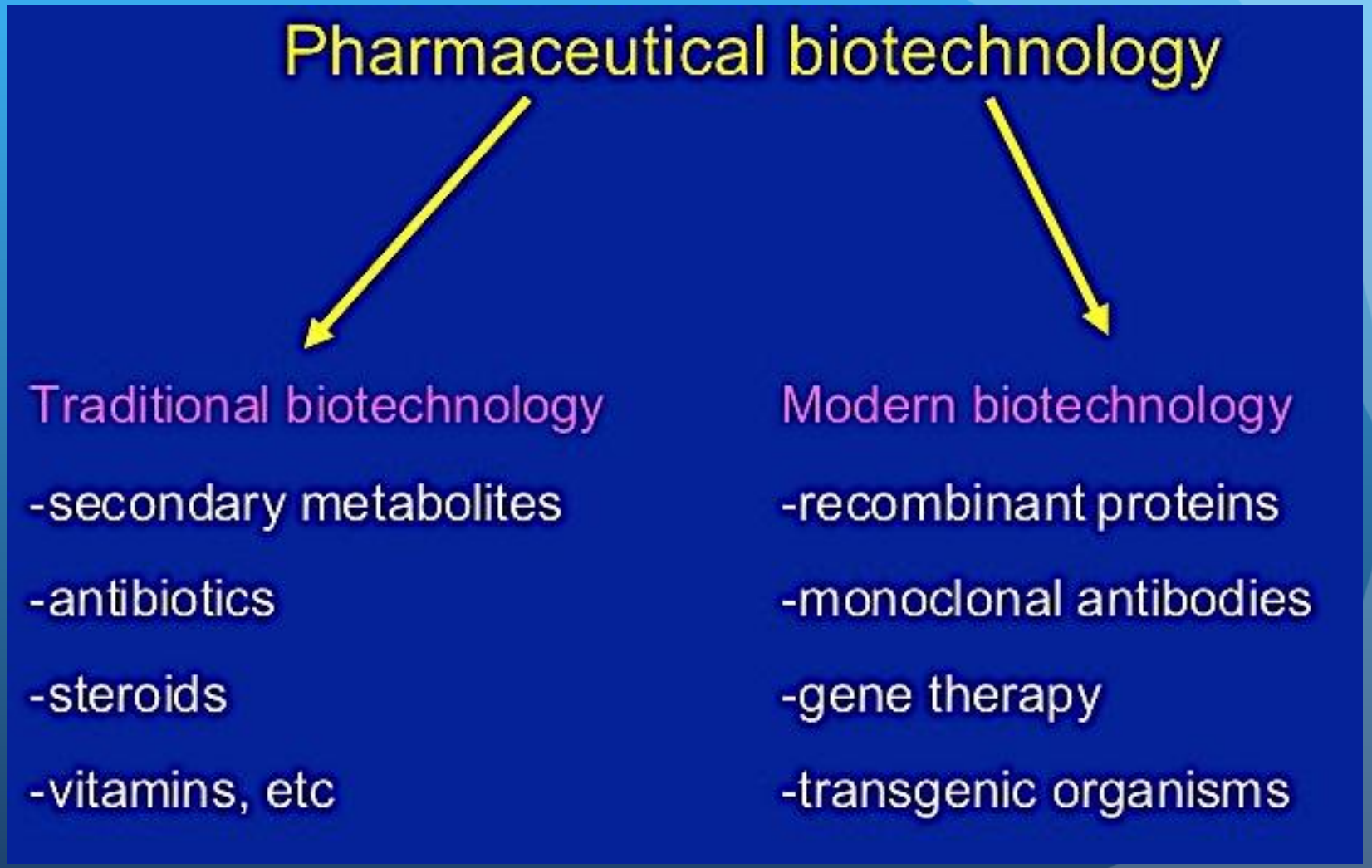




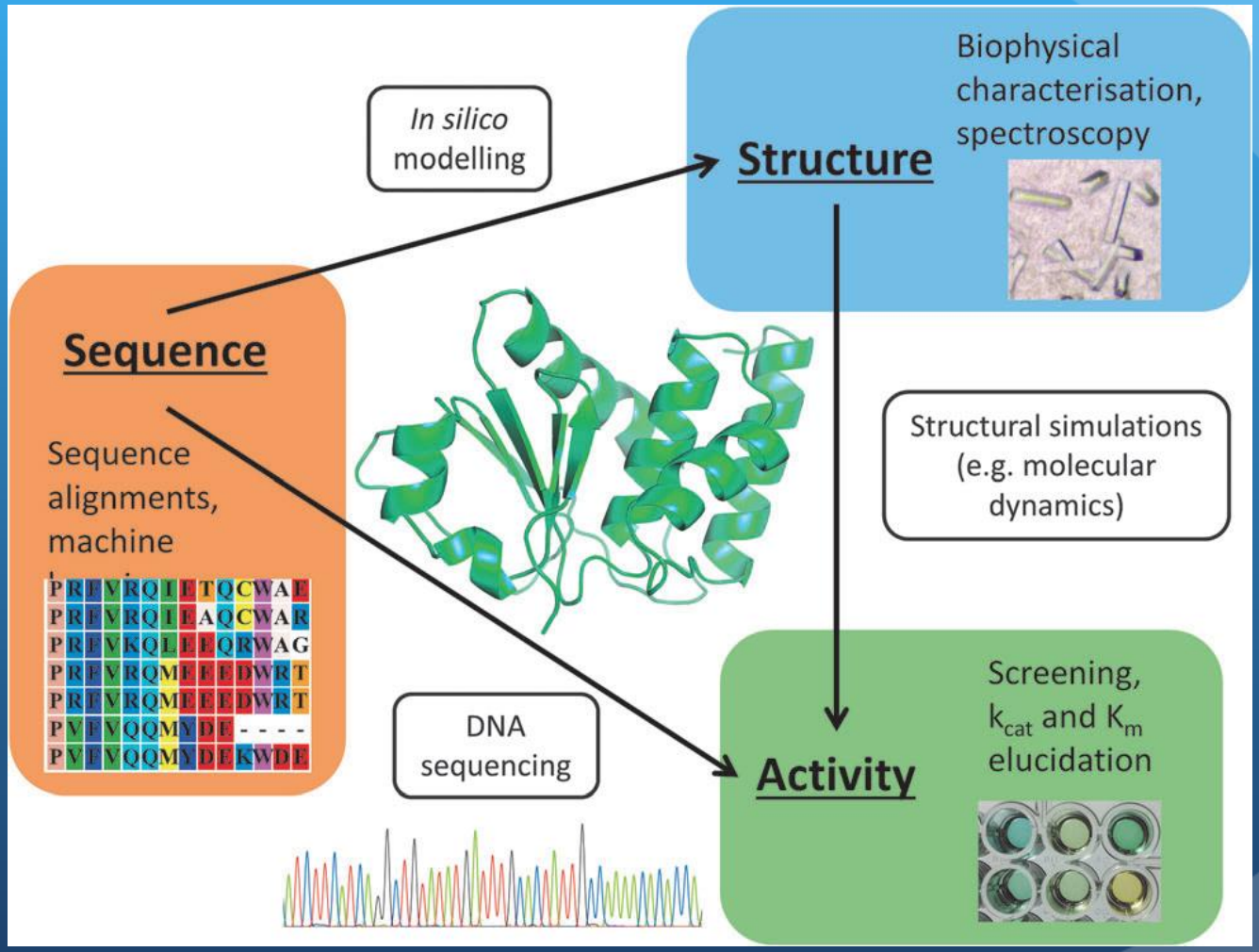
The most usual biotechnological applications



Traditional *vs* Modern Biotechnology



Synthetic biology-directed evolution
New biocatalysts



Synthetic biology-directed evolution New biocatalysts of universal interest

JACS
JOURNAL OF THE AMERICAN CHEMICAL SOCIETY

Article

pubs.acs.org/JACS

Toward Efficient Enzymes for the Generation of Universal Blood through Structure-Guided Directed Evolution

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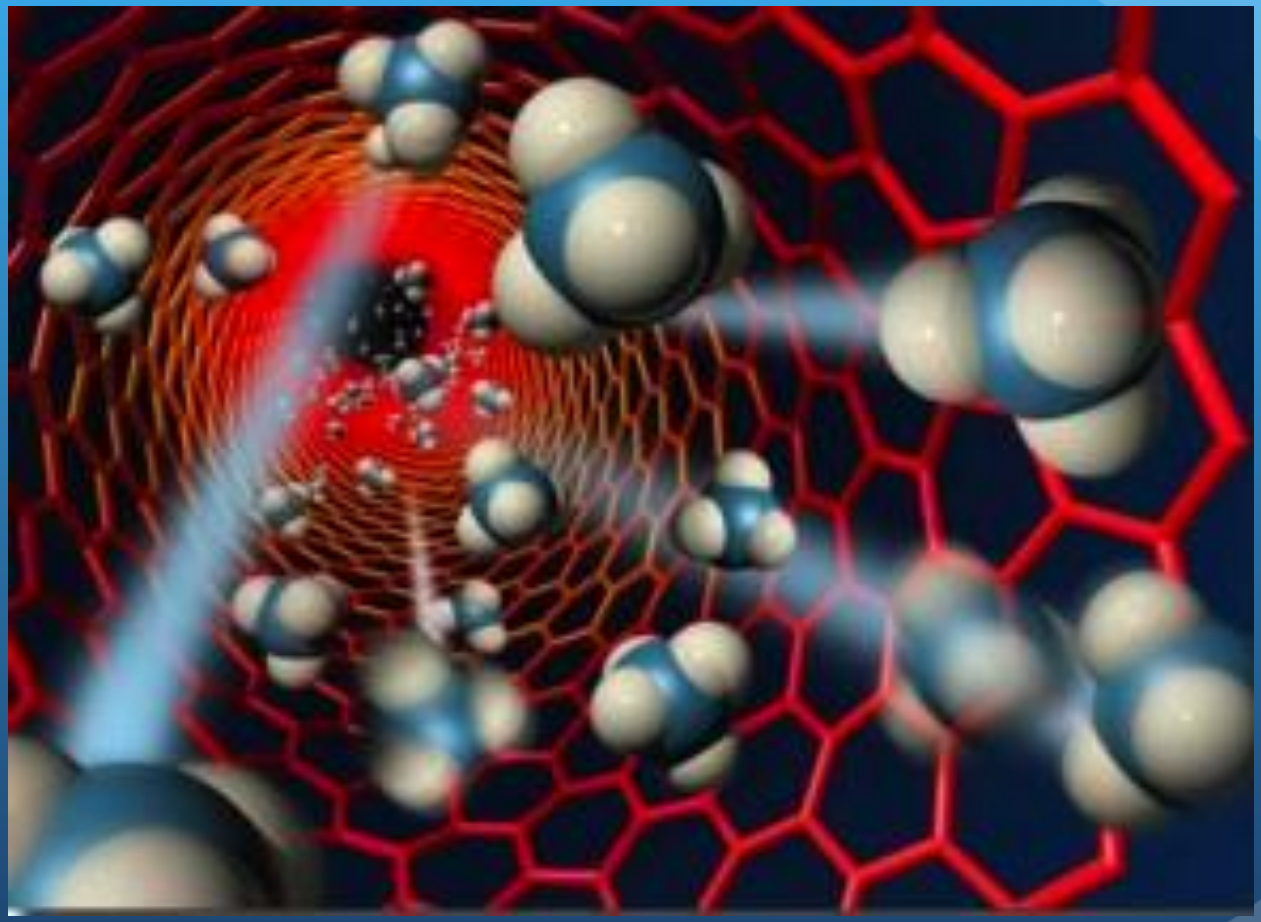
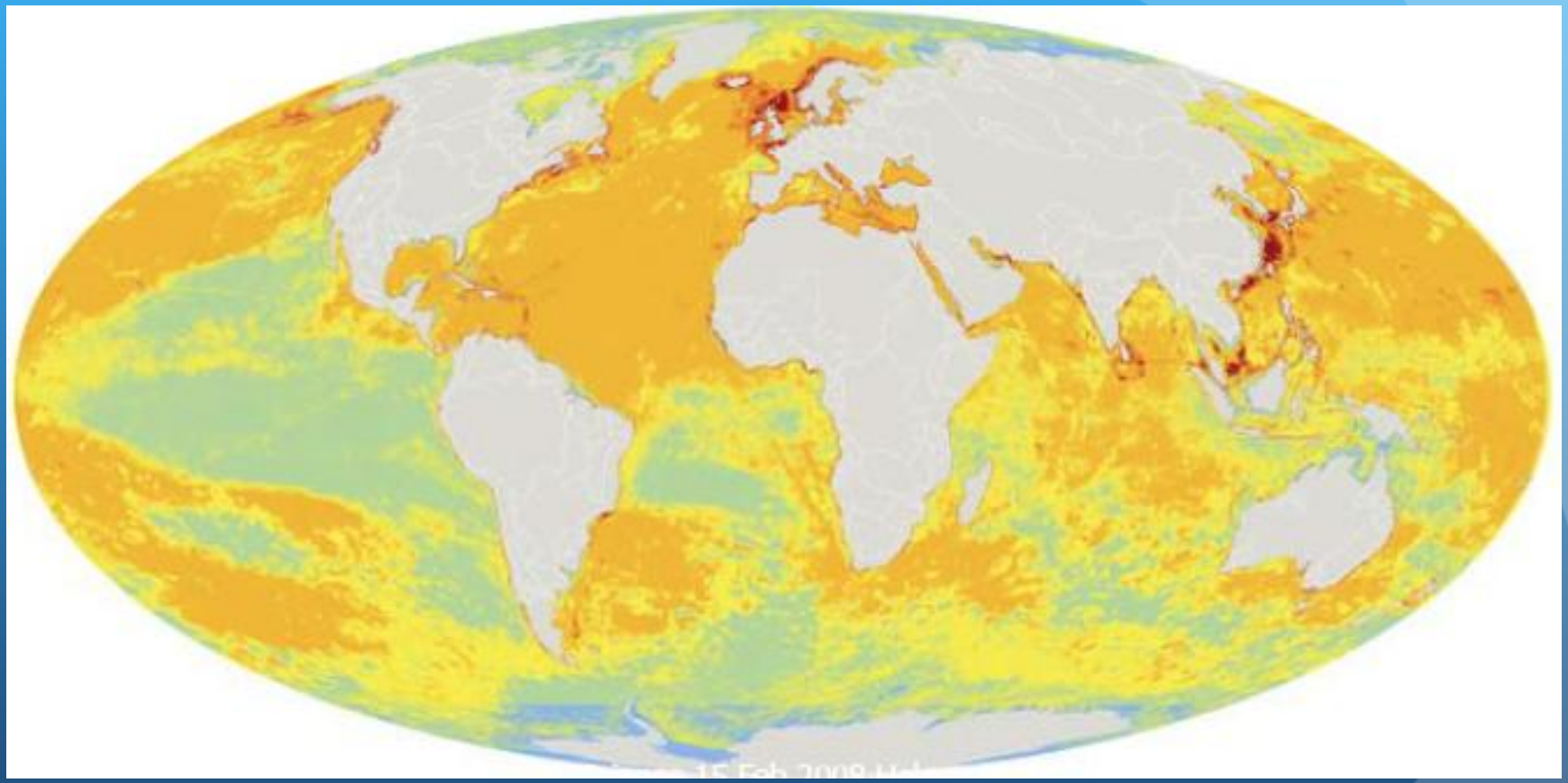
Biotechnology and Nanotechnology

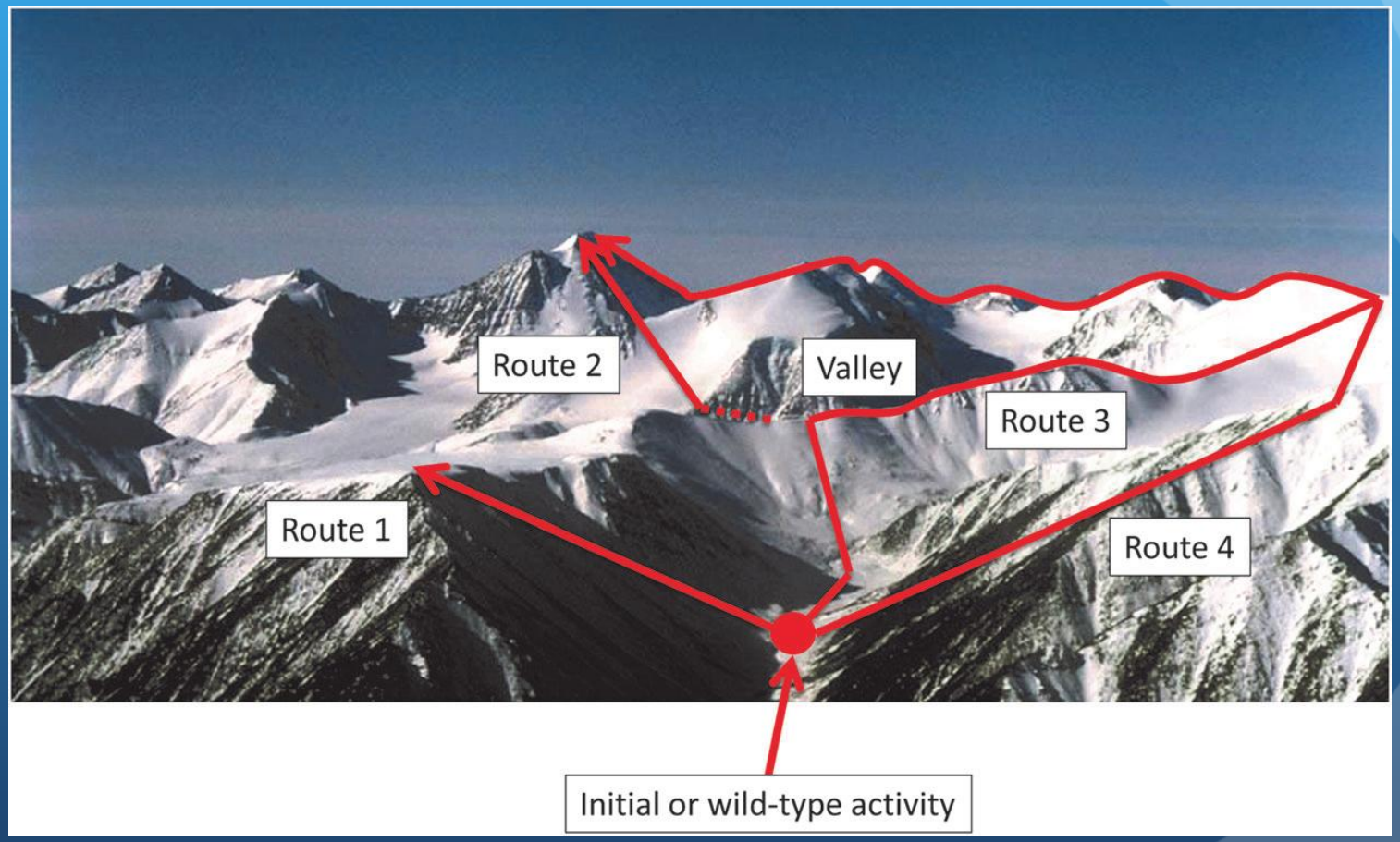


Marine environment is “the bioresource” for the future

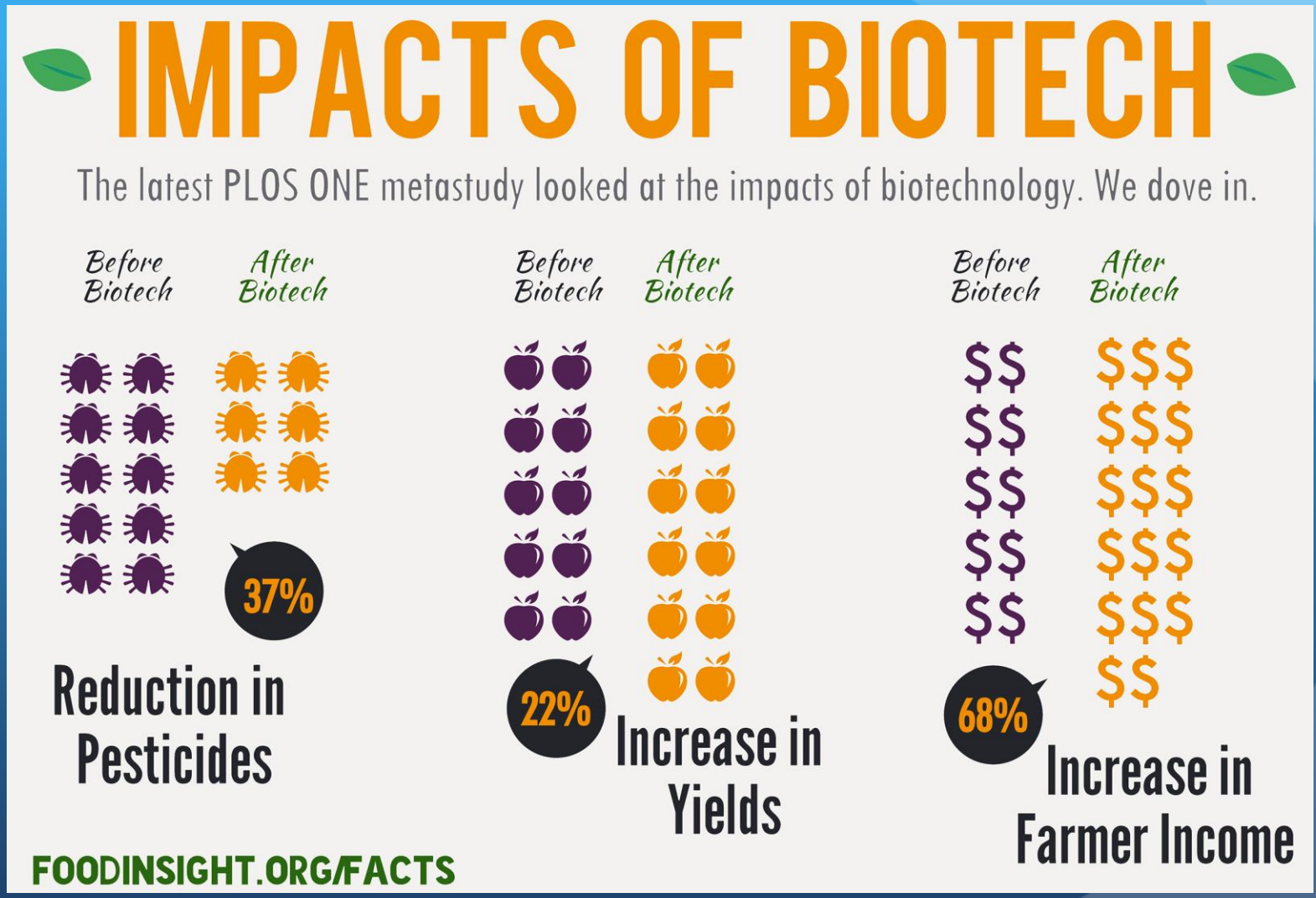


Research presented by Halpern et al in Science in Feb 2008

Synthetic biology: a “sport” similar to climbing



Biotech and Bioeconomy



The take home message

We have to think simple to solve complicated problems

Nature has the time to play its own “Lego” and find wise and sustainable solutions

We do not have the time to do so, therfore we have to learn from nature and copy

Thank you