Department of
Food Science and Technology

TRANSITION TO LIFE LESSONS FROM ENZYMES

Maggy Thenawidjaja Suhartono
Departmen Ilmu dan Teknologi Pangan
Fakultas Teknologi Pertanian IPB University

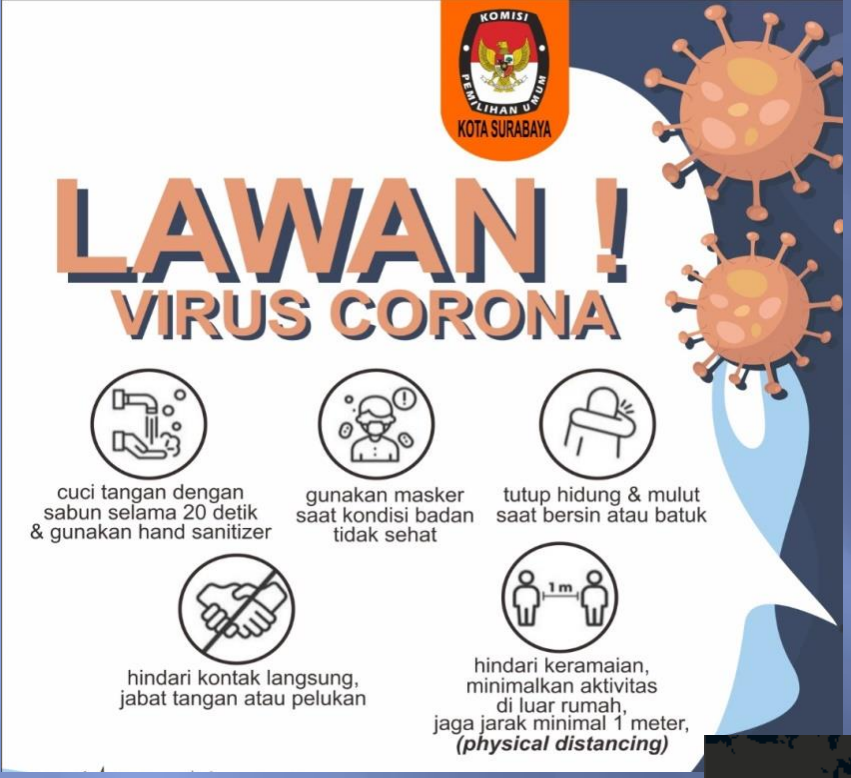
PANDEMI COVID 19

Limitless, worldwide , no stopping

Pandemi Covid, Life will never be the same

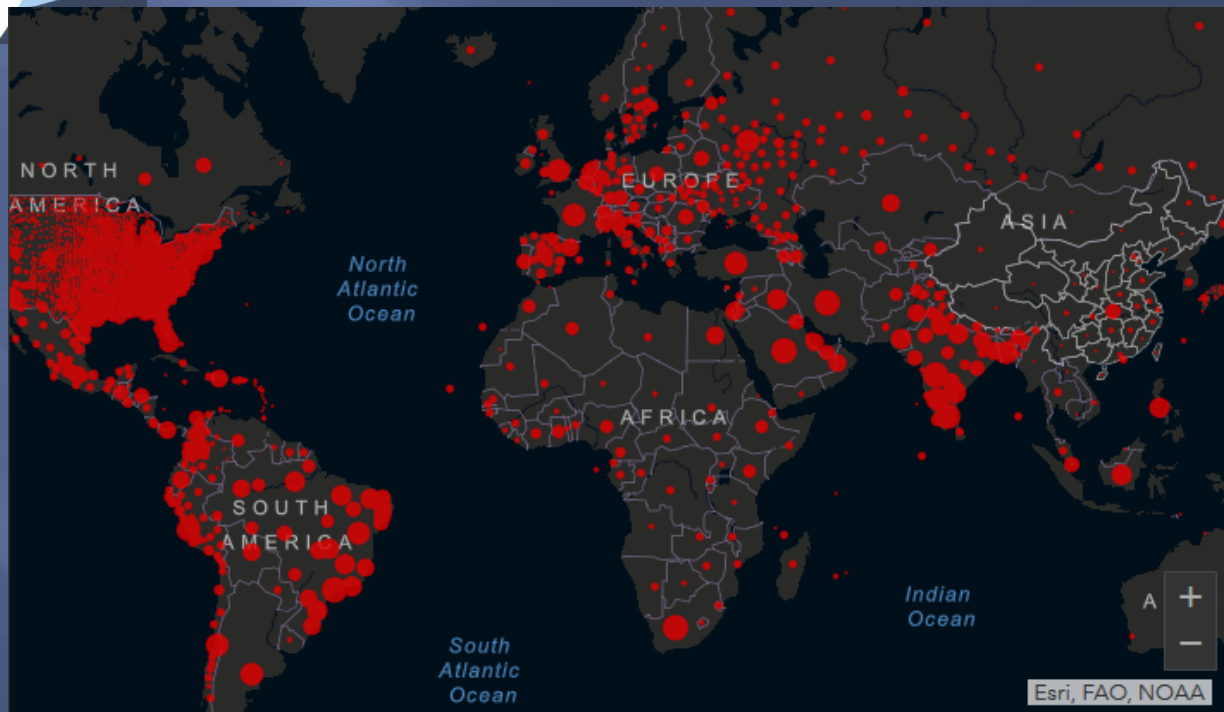
- Lockdown result in clean air, less polution
- Overcoming covid require discipline, observe rule and regulation

VS

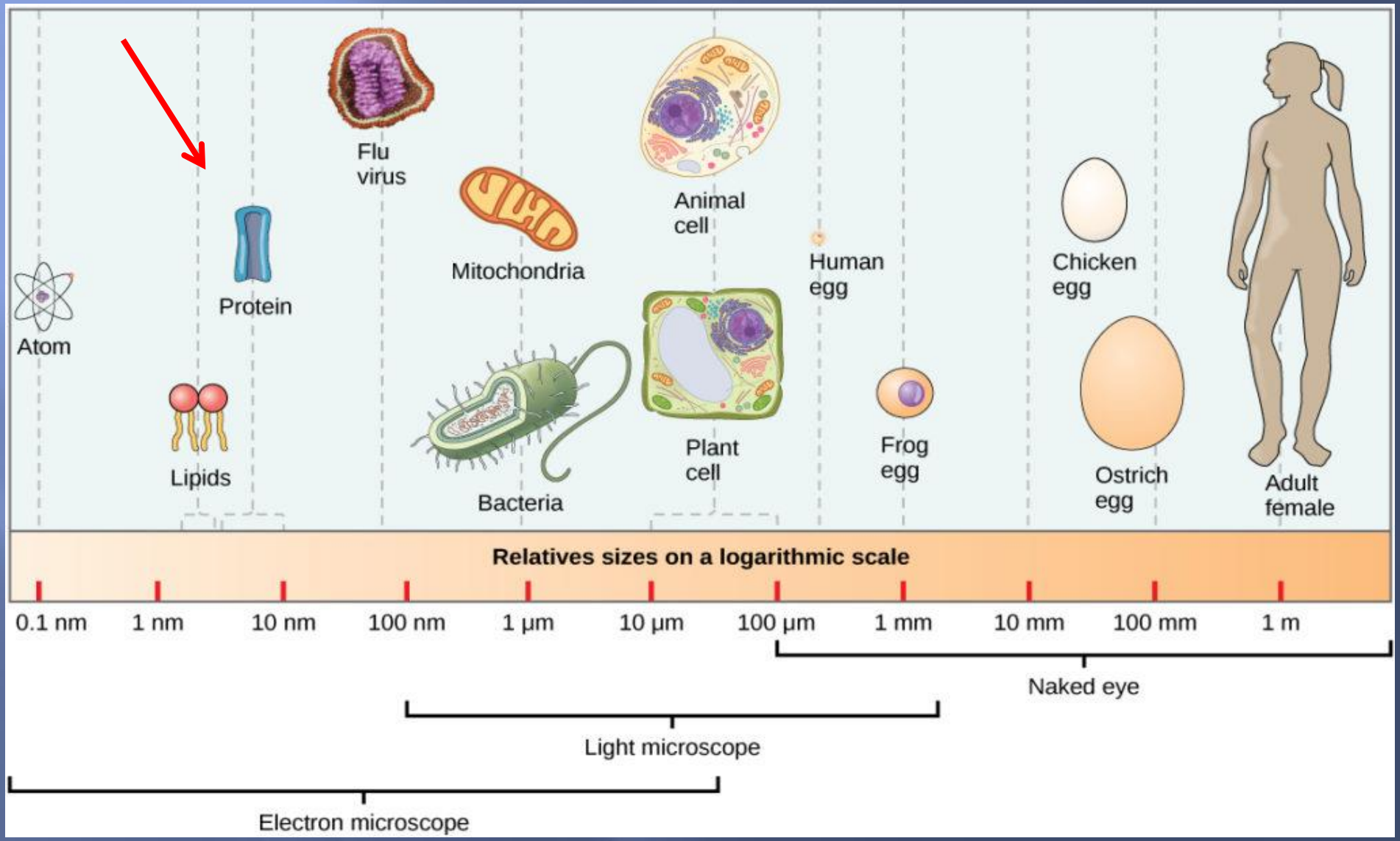


Discipline and follow comand

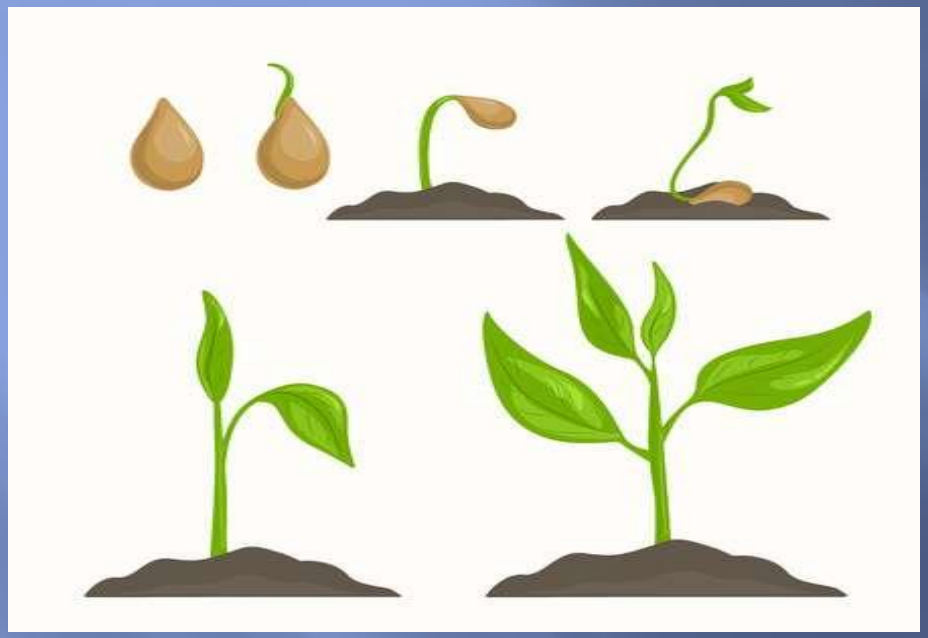
Work together be connected to achieve mutual goal



WHAT SUSTAIN LIFE IN A TINY ENVIRONMENT:
A wonder in management system, efficiency & productivity



From Seed to plant



The tiny package contain nutrient. loaded with enzymes, programmed with intricate pathways to produce energy for growth

What are important enzyme characters

- Biocatalyst, Required Only in Small Amount
- Agents in Quantum Biology
- Small With A Big Heart
- Work Harmoniously With Others
- Unselfish, Work For a Bigger Goal
- Dicipline And Follows Order, Rule And Regulation
- Clean, Efficient, Objective
- Responsive To Signals

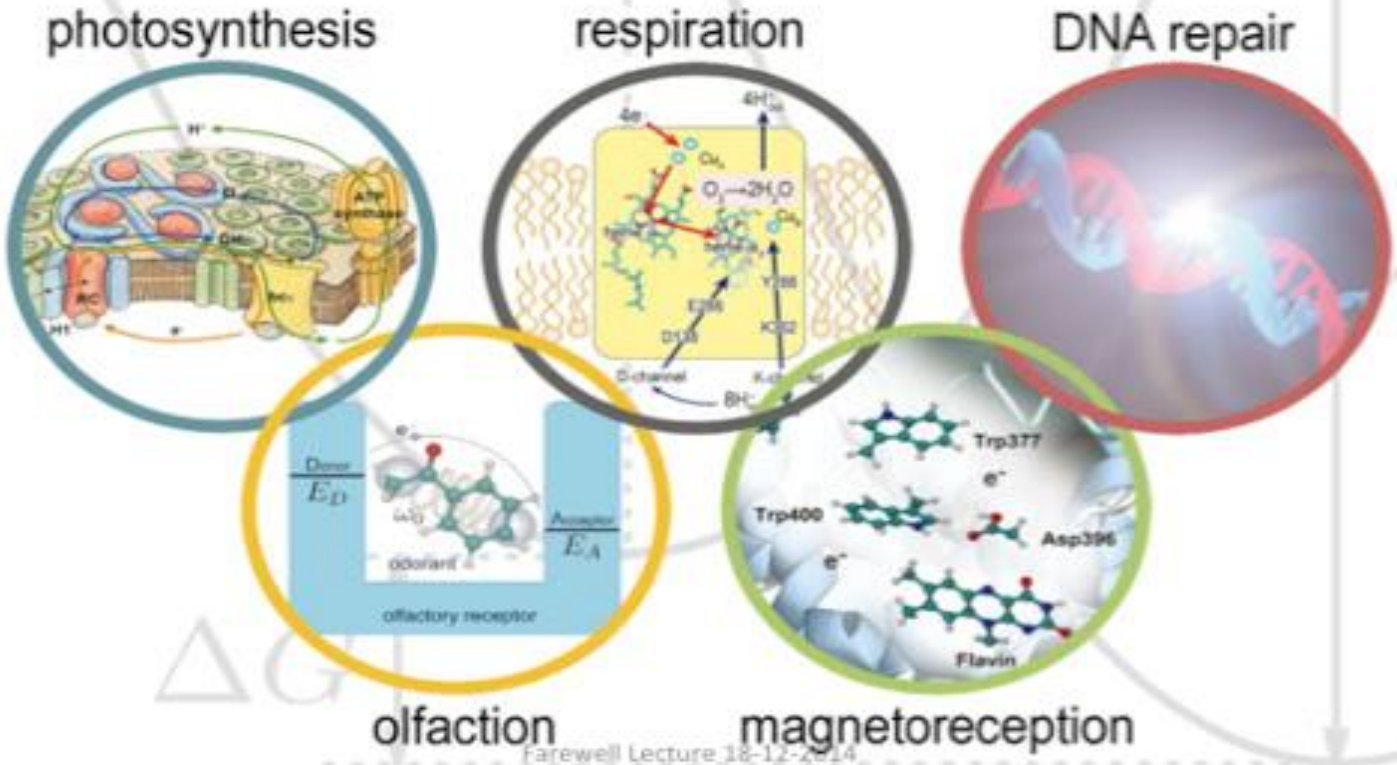
- Quantum Biology : applications of quantum mechanics and theoretical chemistry to biological objects and problems.

- Many biological processes involve conversion of energy into forms that are usable for chemical transformations, and are quantum mechanical in nature.

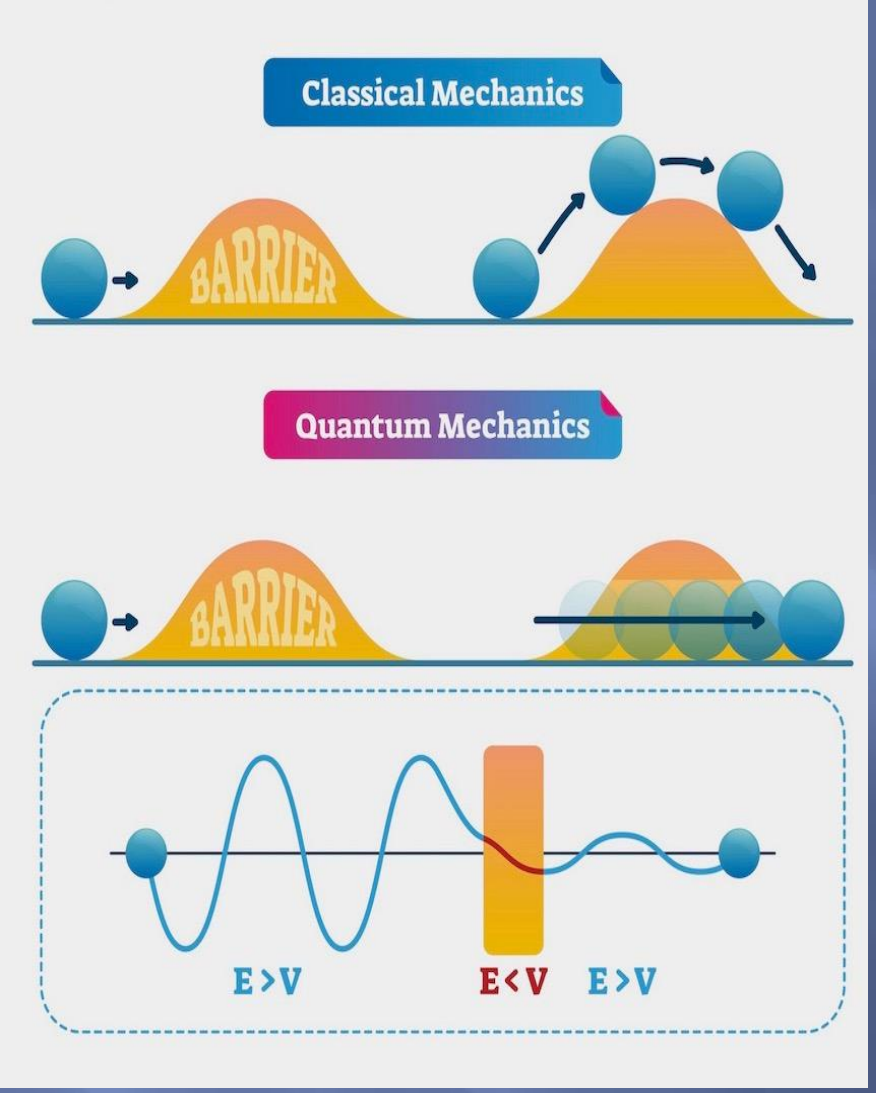
- The processes involve chemicaL reactions, light absorption formation of excited electronic states, transfer of excitation energy and the transfer of electrons and protons (hydrogen ions) in chemical processes, such as photosynthesis , olfaction and cellular respiration

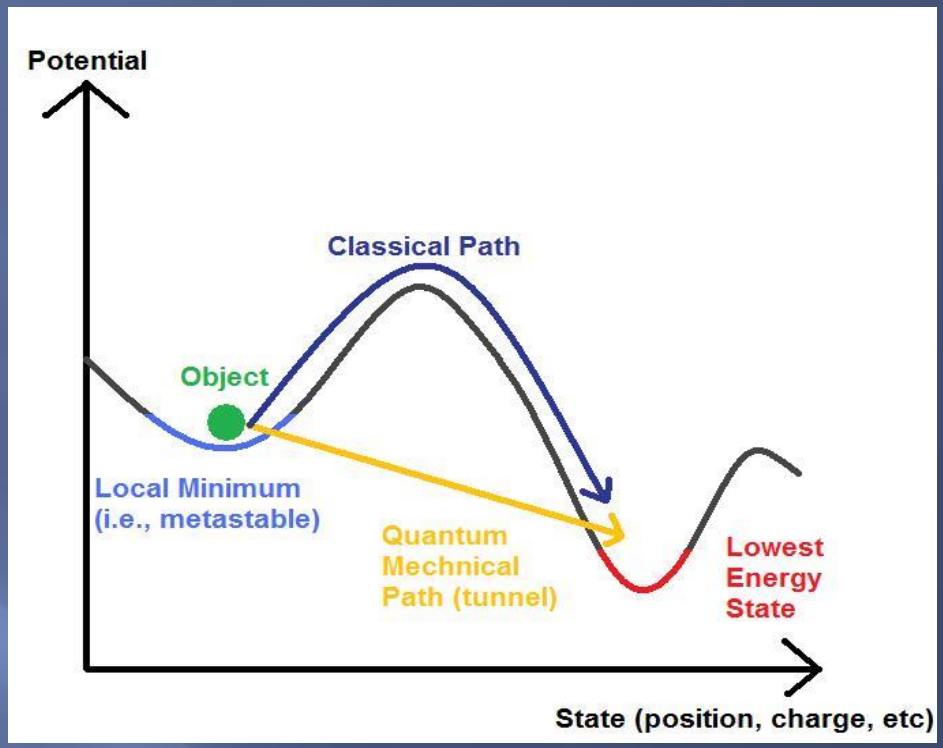
Quantum Biology

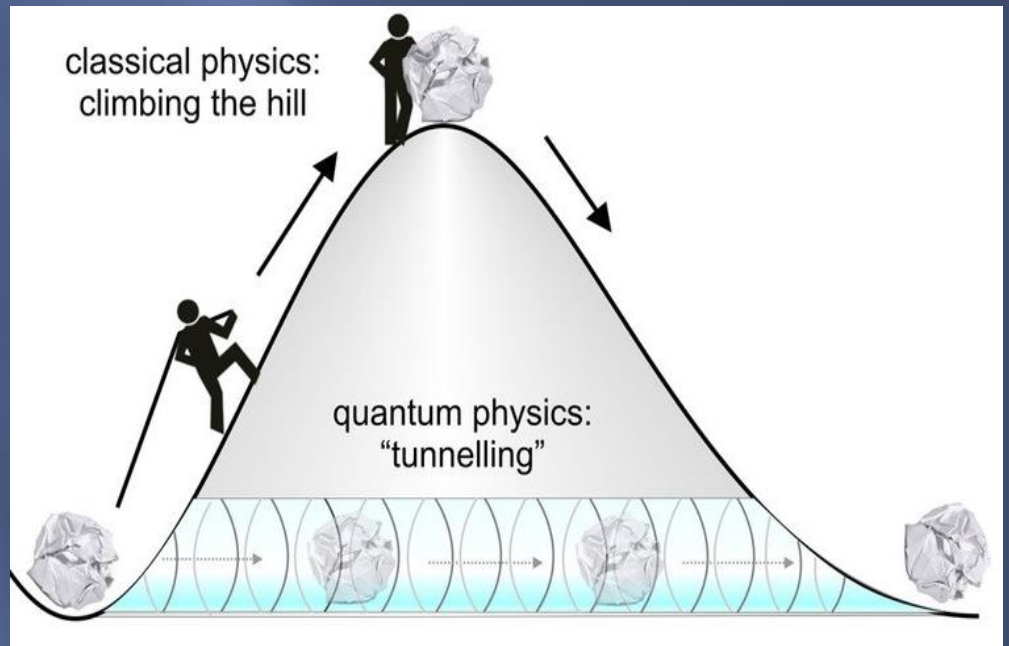
Ideas dvelop 1920 at 1990s discoveries started to appear



Most of these events are based on enzymatic reactions

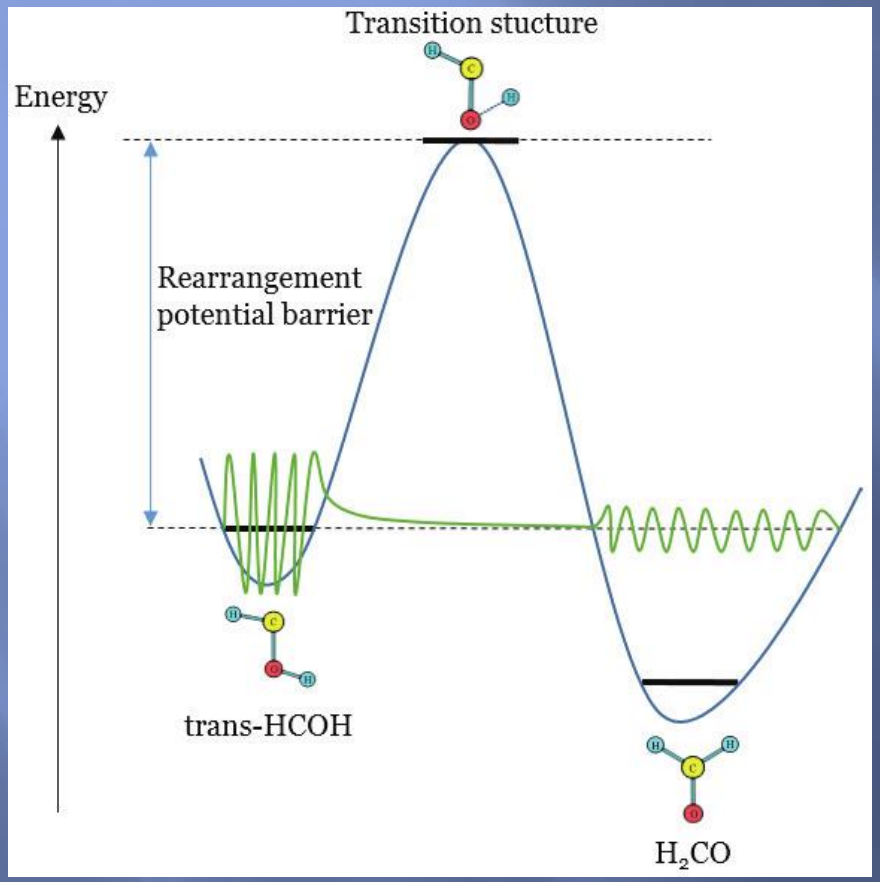




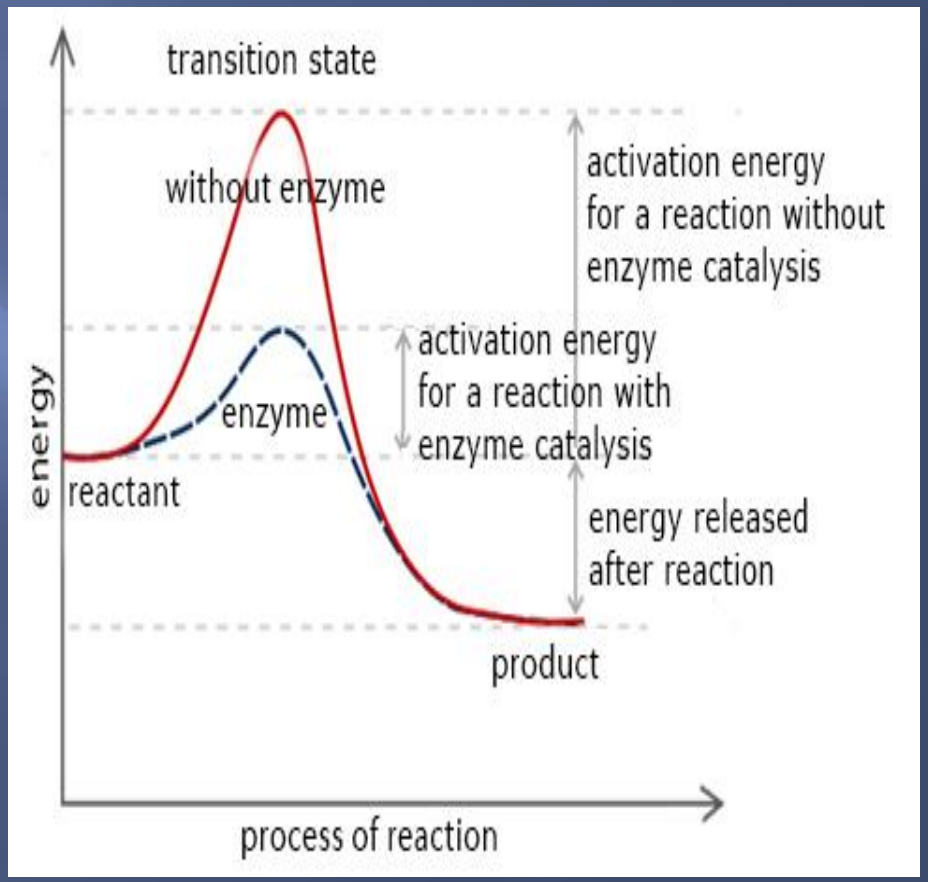


Tunneling can happen instaniously

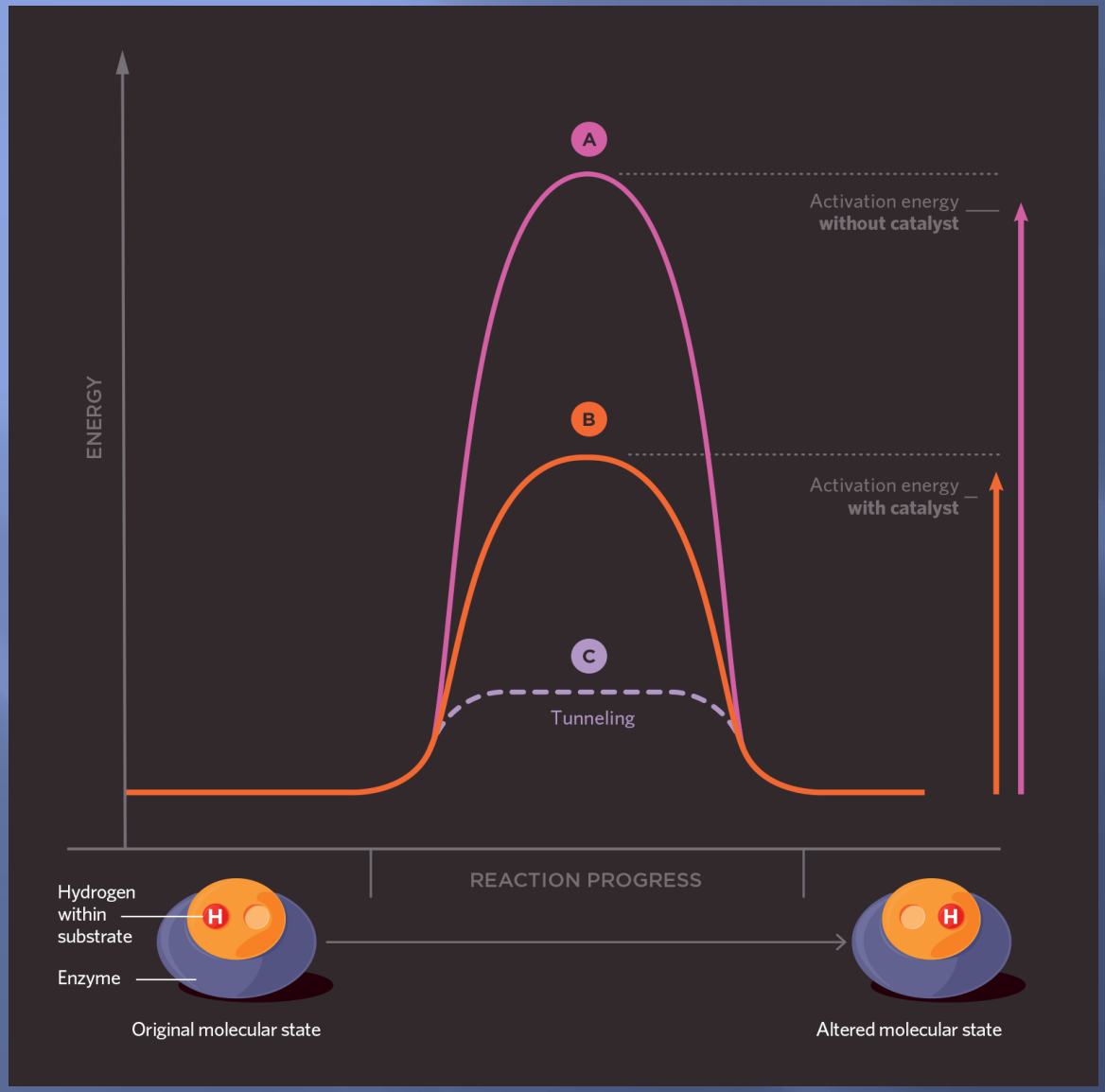
Quantum Tunneling Important Process In Biology



Enzyme reduce activation energy



- Traditional theories of enzyme : speed up reactions by lowering Ea
- A quantum trick known as tunneling also plays a role : Enzyme structure active sites might have evolved to take advantage of this phenomenon.



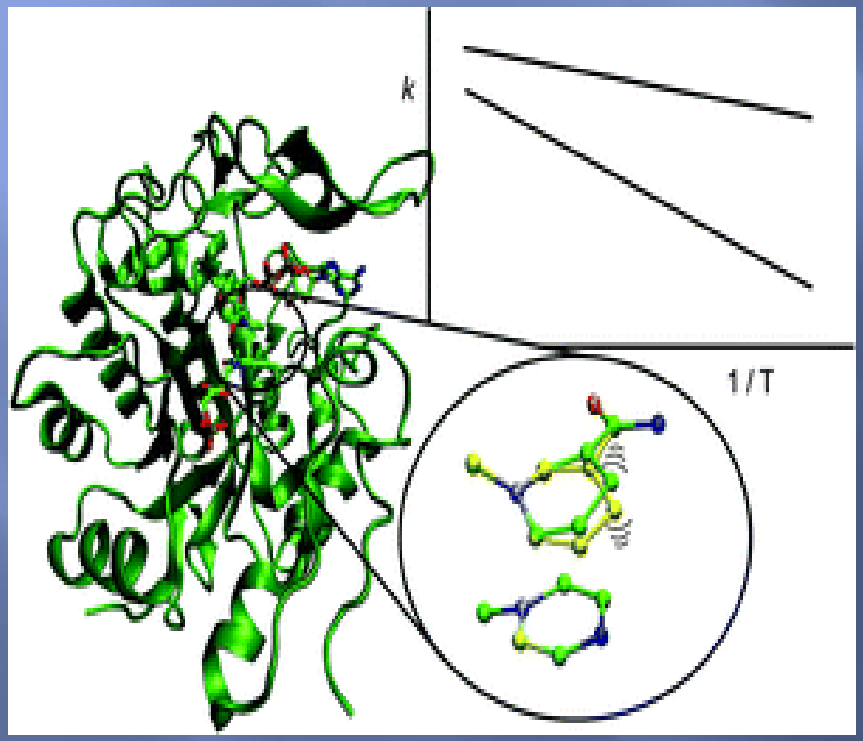
A energy barrier : activation energy.

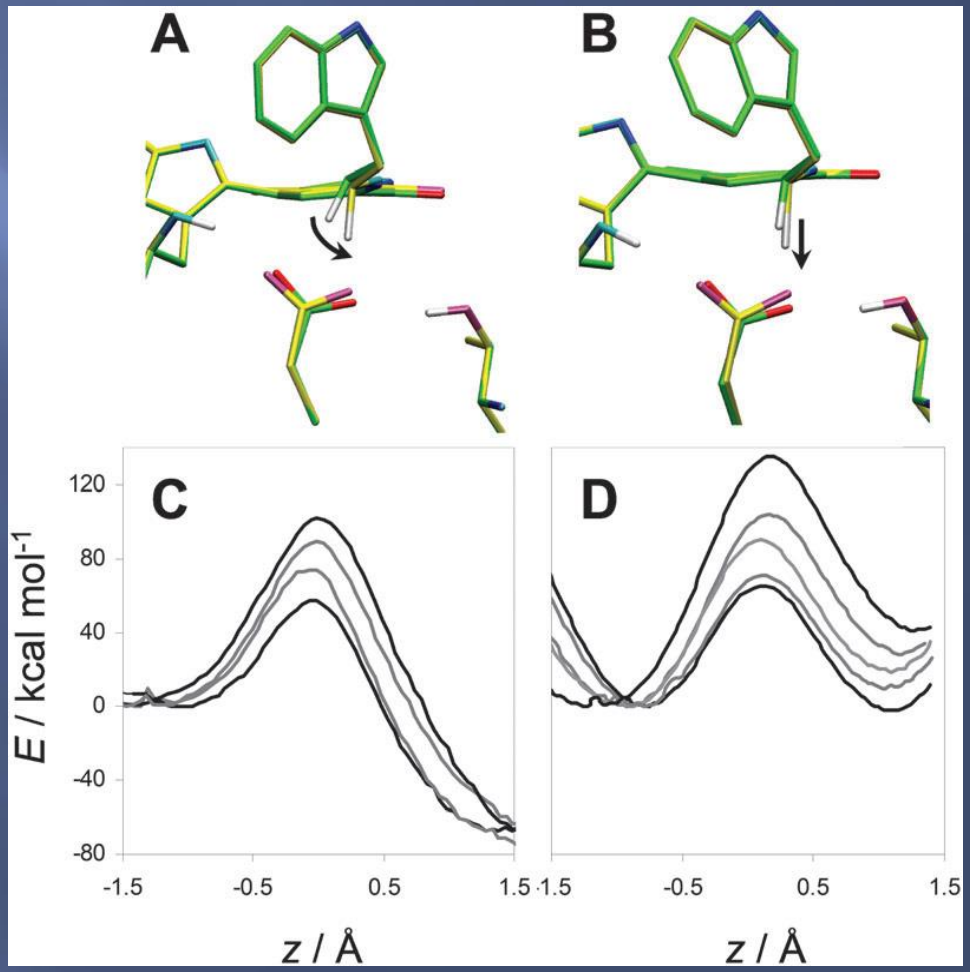
B Enzymes lower this barrier by stabilizing an intermediate, or "transition," state that allows the reaction

C The intermediate state can be bypassed if particles within the molecule are transferred via quantum tunneling, where a particle instantaneously traverses the barrier with a certain probability.

What do Enzymes do

Hydrogen bond. Hydrophobic bond, Ionic bond make the protein enzyme flexible in catalysing the reaction, tunneling atomic structures

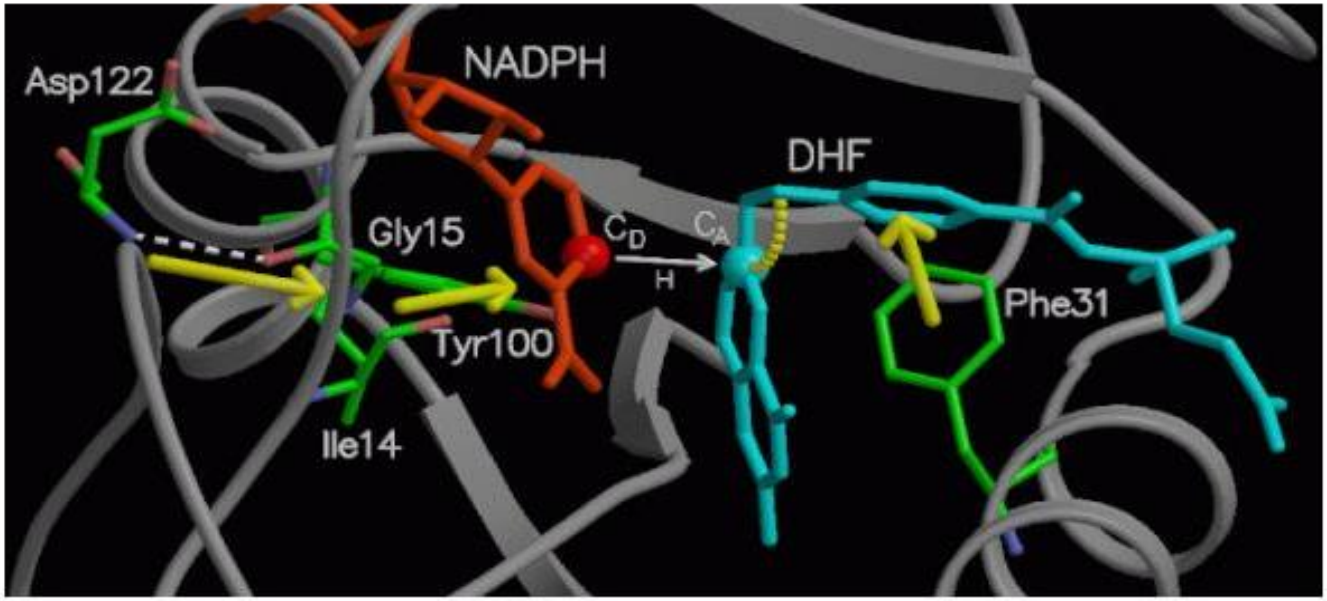




Case : Dihydrofolate Reductase

Network of Coupled Motions

- Located in active site and exterior of enzyme
- Equilibrium, thermally averaged motions
- Conformational changes along collective reaction coordinate
- Reorganization of environment to facilitate H^- transfer
- Occur on millisecond timescale of H^- transfer reaction



Case study Amido Transferase

Removal amonia from Glutamin

- Transient tunnels initiated by allosteric switch, residing in catalytic loop.
- Enzyme conformational change facilitated by dynamic interactions at the allosteric switch and adaptor-domain interface, forming a tunnel for amonia
- Allosteric hotspots modulation alter protein energy landscape, allowing enzyme to adopt transient conformations to function.

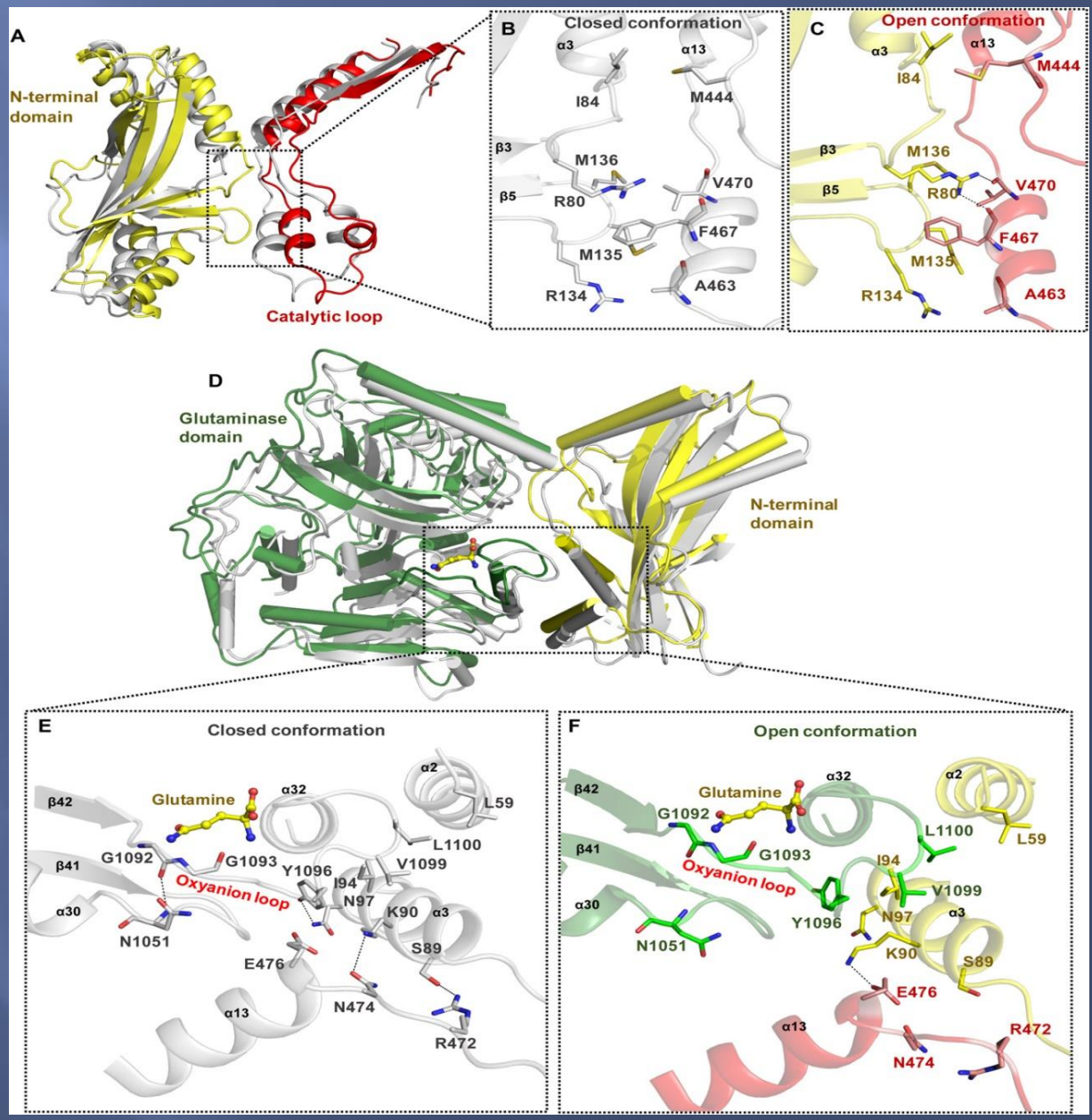
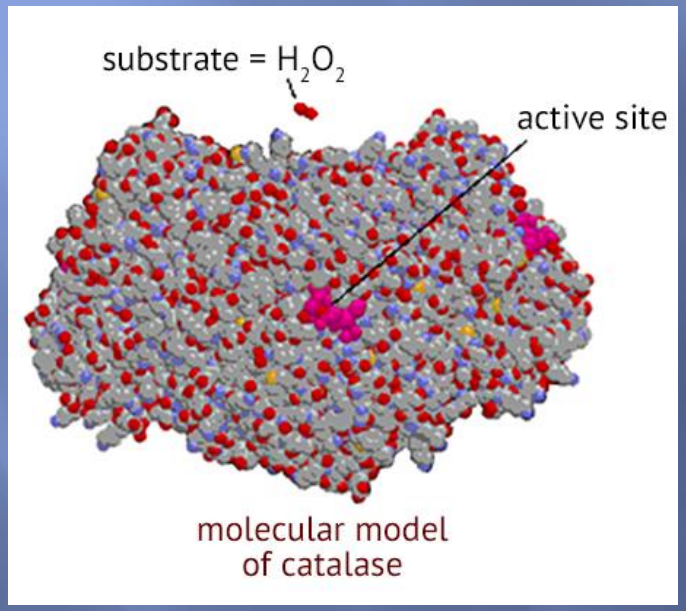


Table 8–7 Turnover numbers* (k_{cat}) of some enzymes

Enzyme	Substrate	k_{cat} (s^{-1})
Catalase	H_2O_2	40,000,000
Carbonic anhydrase	HCO_3^-	400,000
Acetylcholinesterase	Acetylcholine	14,000
β-Lactamase	Benzylpenicillin	2,000
Fumarase	Fumarate	800
RecA protein (ATPase)	ATP	0.4

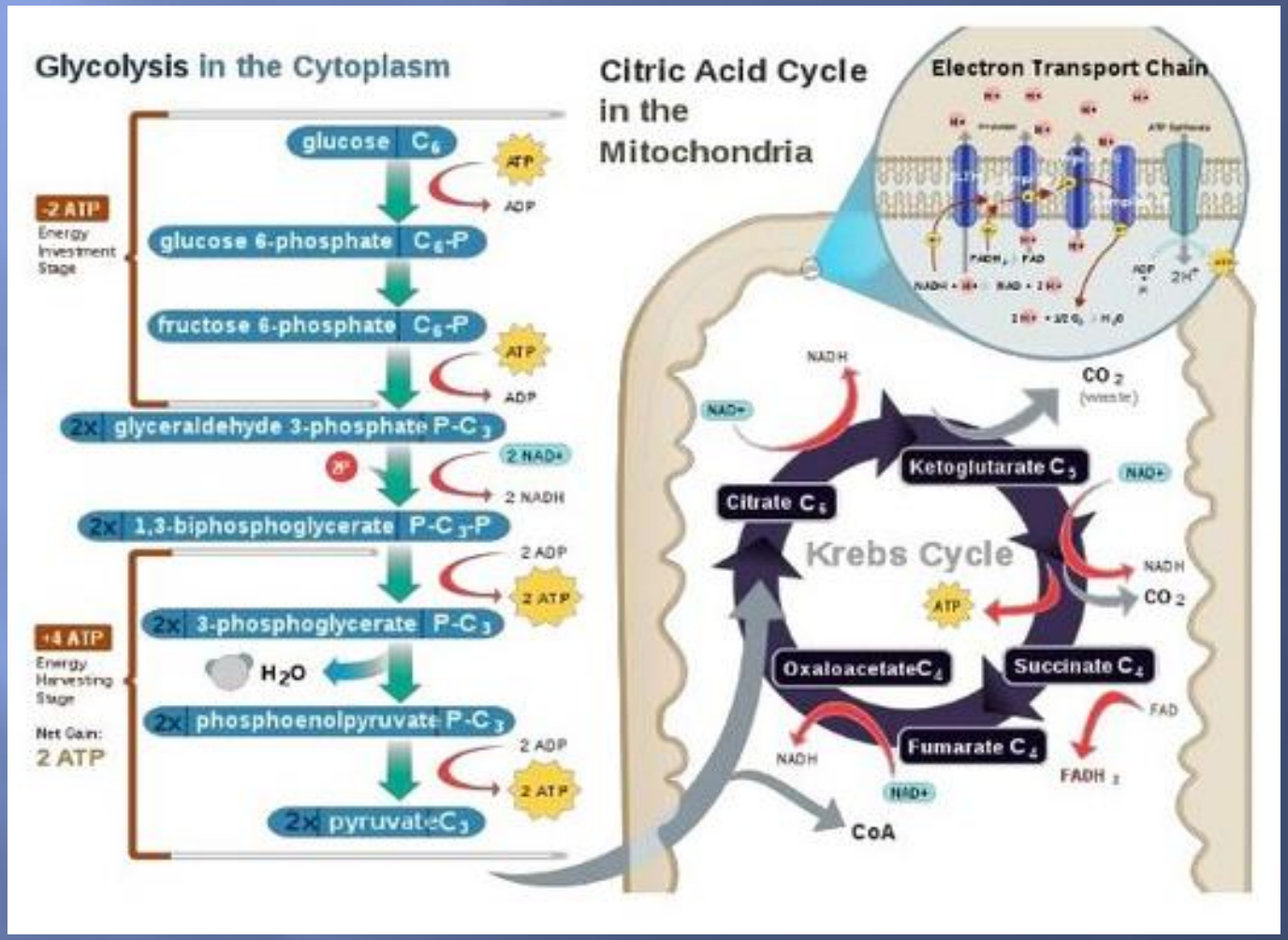
How fast can you go



Catalase
68 X 170 X
205 X
Angstroom

- Work instantly, work extremely fast
- One molecule of catalase can convert 40 00 0000 molecule H2O2 into H2O per secomd . Without enzyme, the conversion takes hours

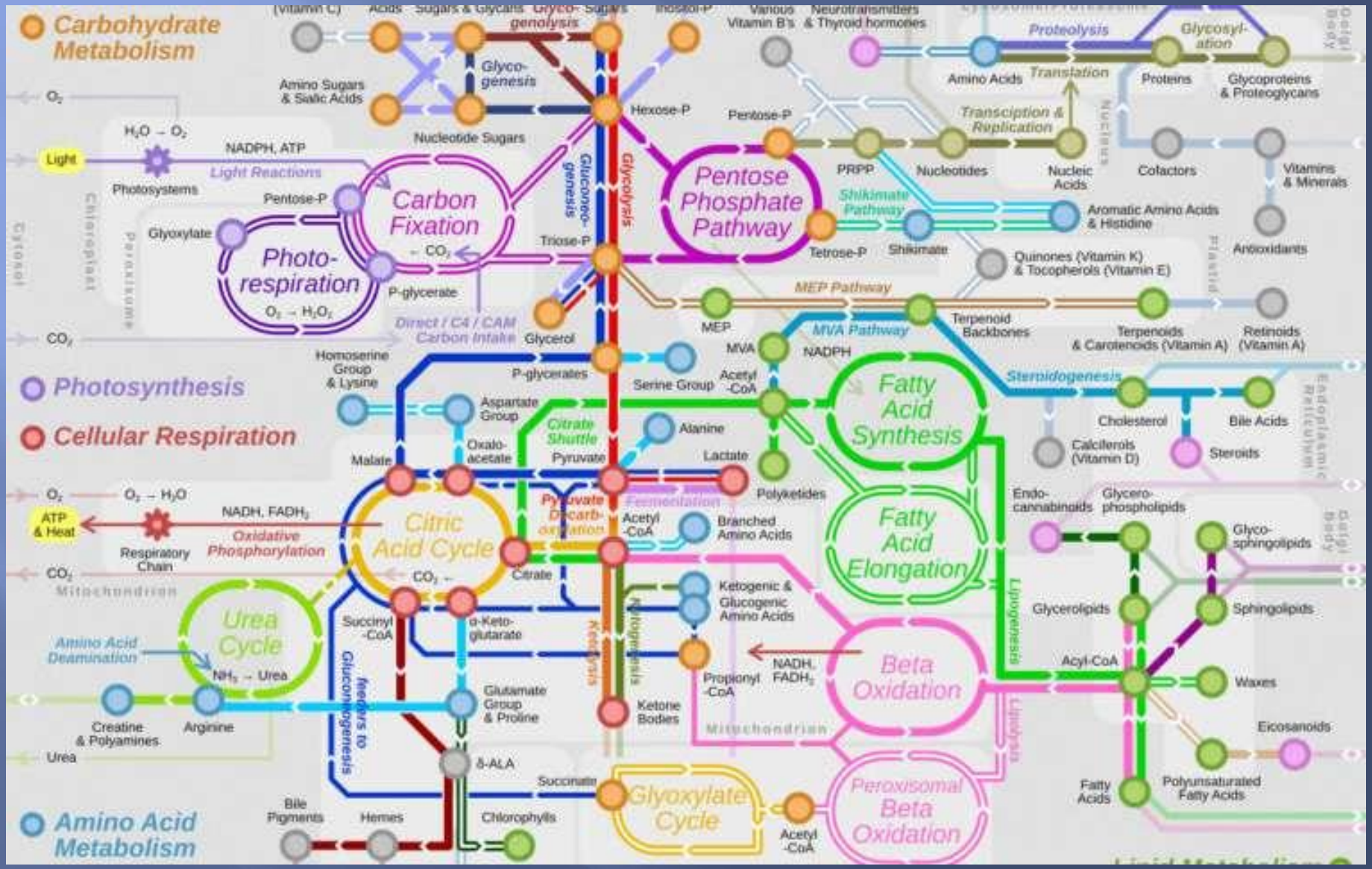
Goal : ATP (energy production)



Involved many Dehydrogenase, Oxidase, Isomerase, transferase

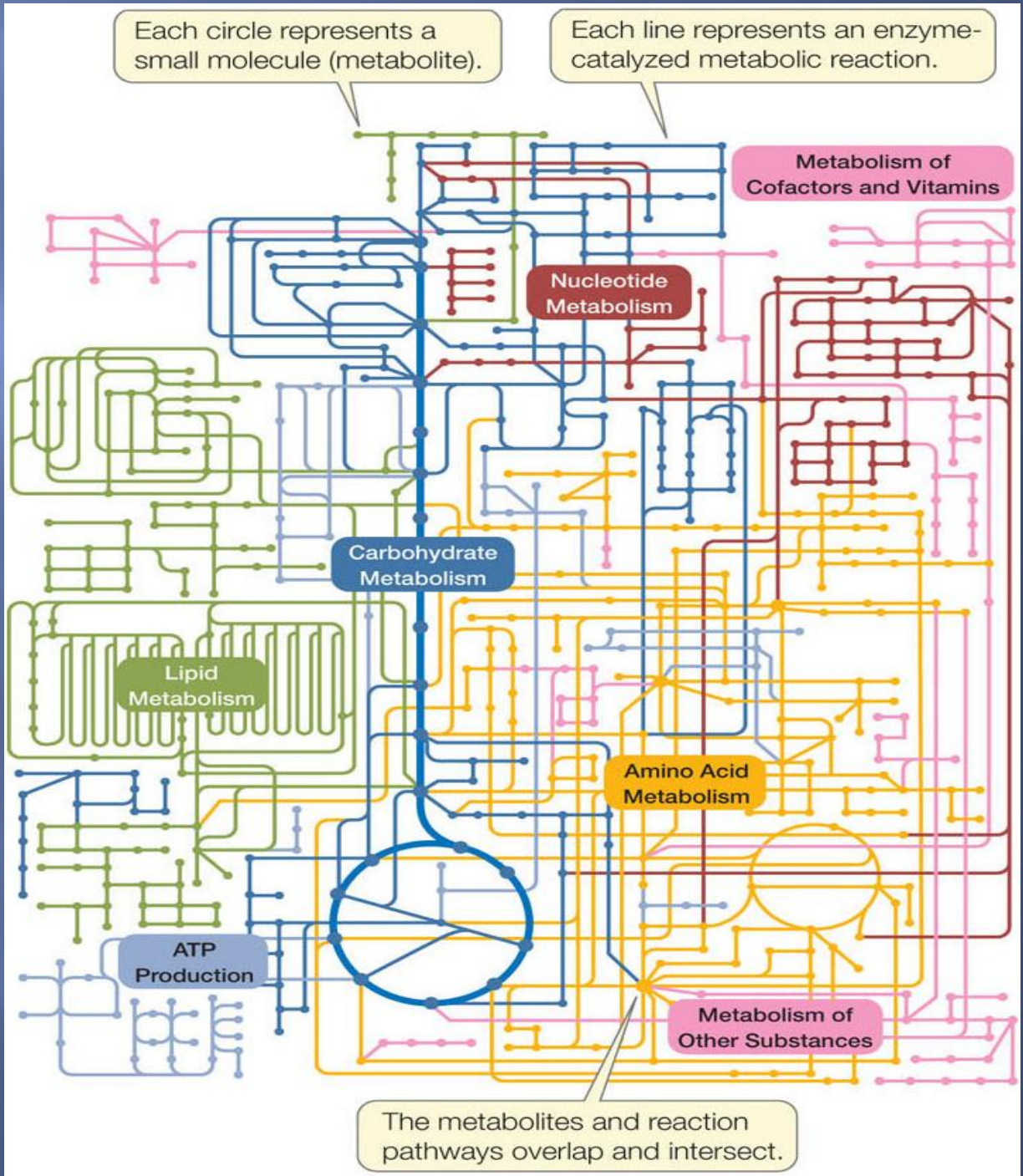
Quantum tunneling of H ion, electron and other atoms/ion

Enzyme reactions : Adopting quantum, complicated jobs in a tiny structure, highly coordinated, efficient, programmed, responsive to signals



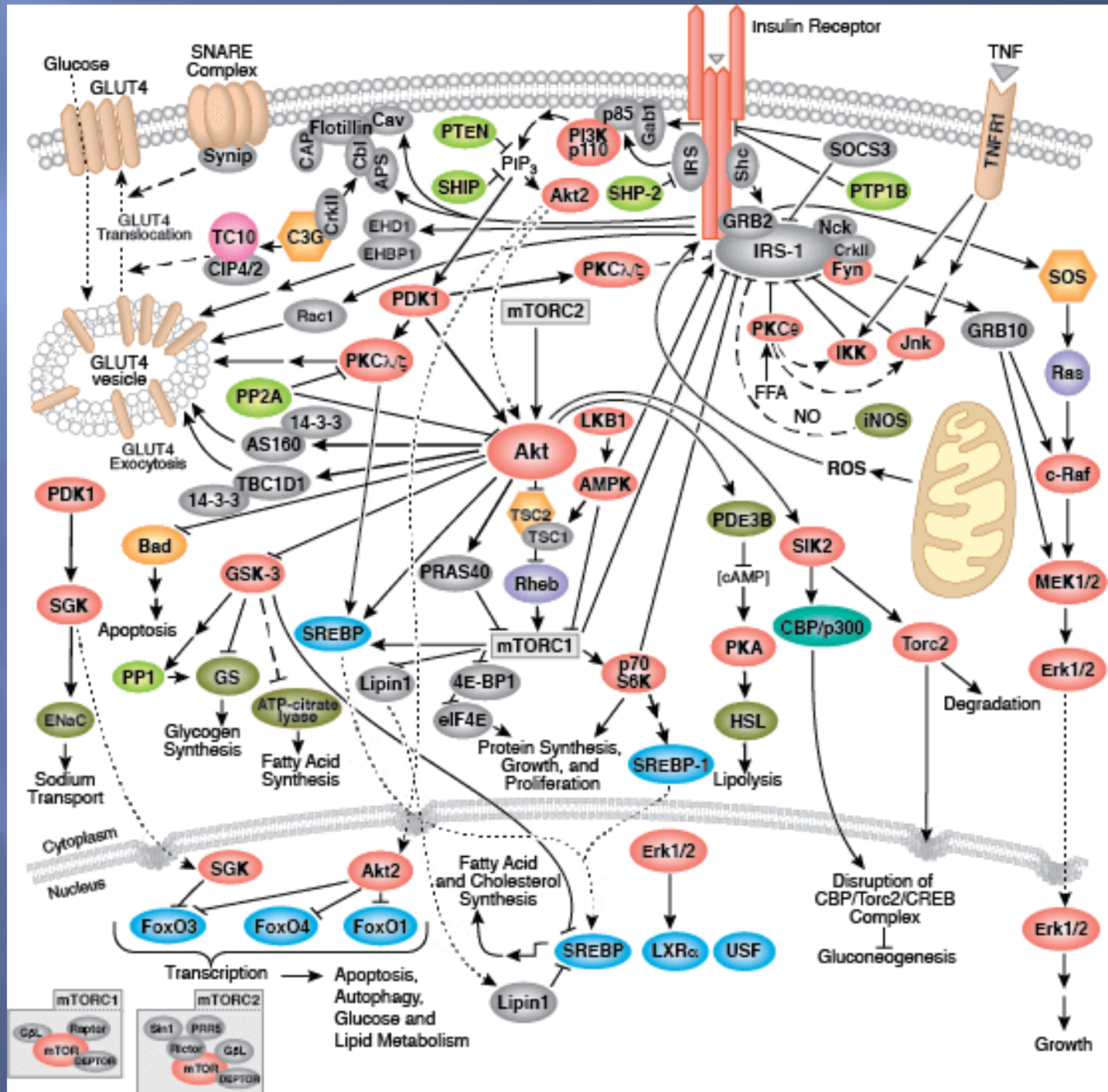
Enzymatic pathway for energy production and biosynthesis of metabolite

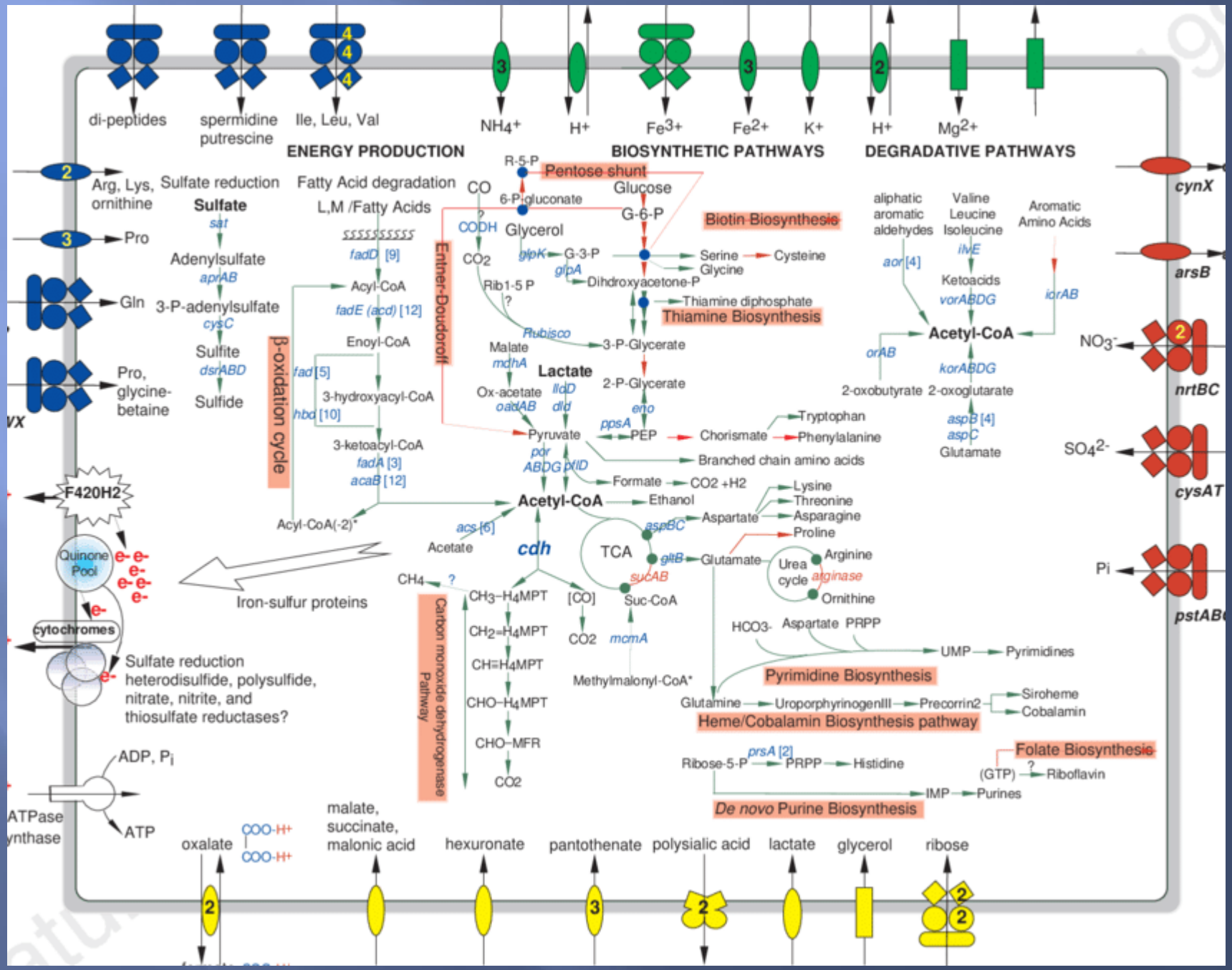
This needs to be governed well to sustain normal living

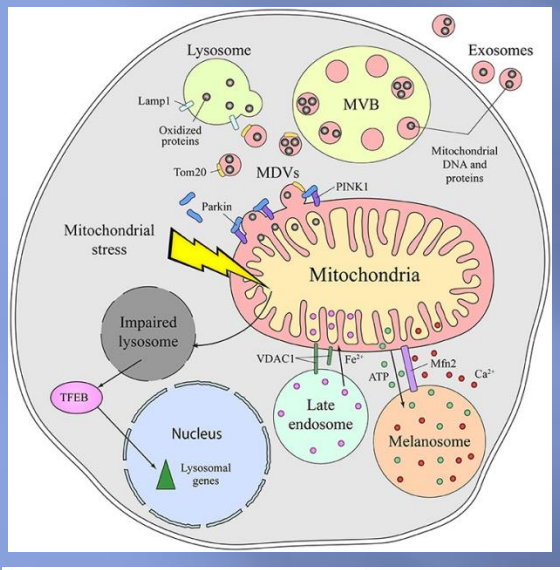


Cells need to response well to environment to live harmniously

Enzymes help sending massage to activate certain biochemical pathway

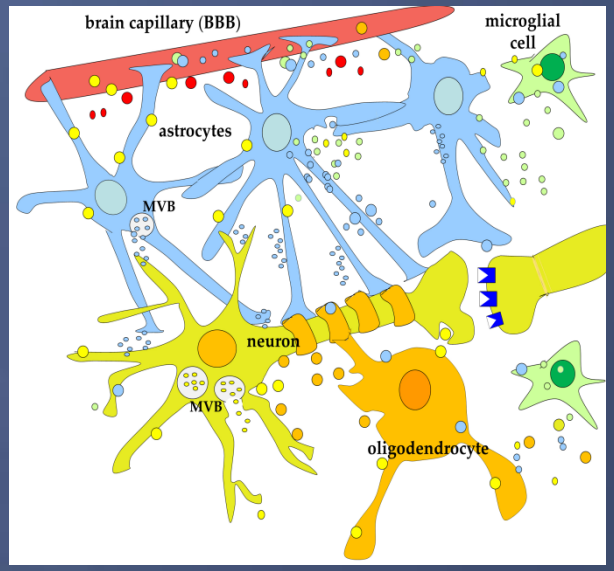


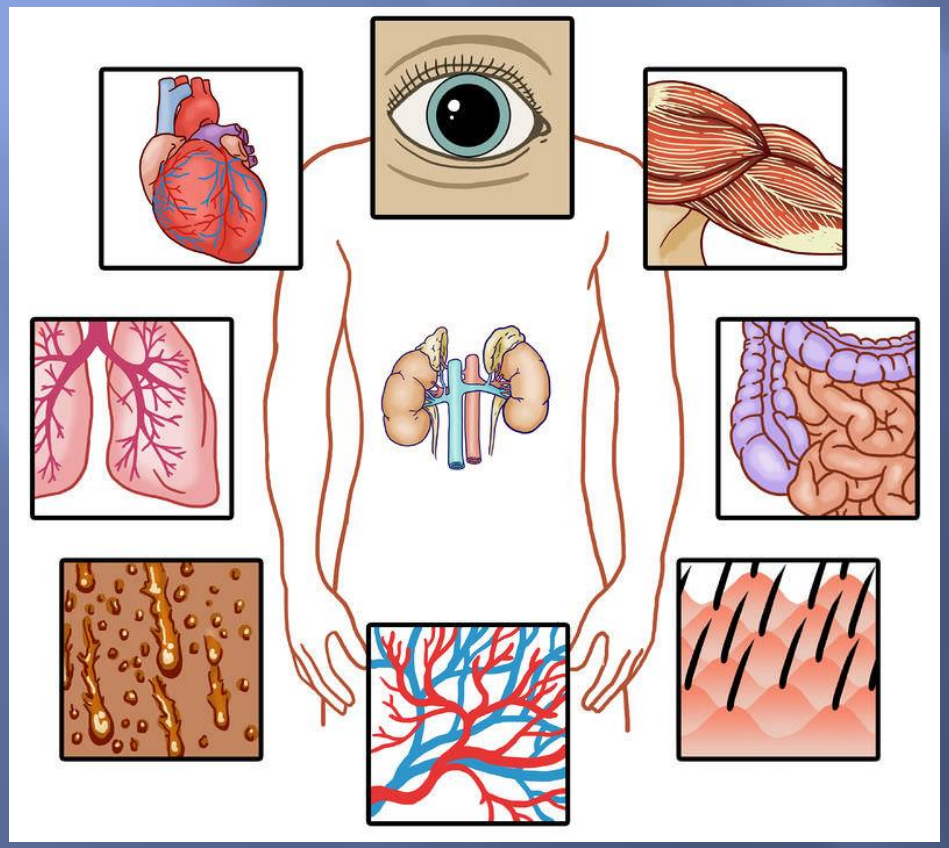

di-peptides
spermidine putrescine
Ile, Leu, Val
NH4+
H+
Fe3+
Fe2+
K+
H+
Mg2+
ENERGY PRODUCTION
BIOSYNTHETIC PATHWAYS
DEGRADATIVE PATHWAYS
Arg, Lys, ornithine
Pro
Gln
Pro, glycine-betaine
Sulfate reduction
Sulfate
sat
Adenylsulfate
aprAB
3-P-adenylsulfate
cysC
Sulfite
dsrABD
Sulfide
Fatty Acid degradation
L,M /Fatty Acids
fadD [9]
Acyl-CoA
fadE (acd) [12]
Enoyl-CoA
fad [5]
3-hydroxyacyl-CoA
hbd [10]
3-ketoacyl-CoA
fadA [3]
acaB [12]
Acyl-CoA(-2)*
β-oxidation cycle
Entner-Doudoroff
R-5-P
Pentose shunt
6-Pgluconate
Glucose
G-6-P
CO
CODH
Glycerol
CO2
glpK
G-3-P
glpA
Dihdroxyacetone-P
Rib1-5 P
Rubisco
3-P-Glycerate
Malate
mdhA
Lactate
Ox-acetate
oadAB
lldD
dld
2-P-Glycerate
eno
ppsA
Pyruvate
PEP
pdr ABDG
pflD
Formate
CO2 +H2
Acetyl-CoA
Ethanol
acs [6]
Acetate
cdh
TCA
aspBC
gltB
sucAB
Suc-CoA
Glutamate
mcmA
Methylmalonyl-CoA*
Biotin Biosynthesis
Serine
Cysteine
Glycine
Thiamine diphosphate
Thiamine Biosynthesis
Chorismate
Tryptophan
Phenylalanine
Branched chain amino acids
Lysine
Threonine
Asparagine
Aspartate
Proline
Urea cycle
Arginine
arginase
Ornithine
aliphatic aromatic aldehydes
aor [4]
Valine Leucine Isoleucine
ivlE
Aromatic Amino Acids
Ketoacids
vorABDG
icrAB
Acetyl-CoA
orAB
korABDG
2-oxobutyrate
2-oxoglutarate
aspB [4]
aspC
Glutamate
cynX
arsB
NO3-
nrtBC
SO42-
cysAT
Pi
pstABC
F420H2
Quinone Pool
cytochromes
Iron-sulfur proteins
Sulfate reduction heterodisulfide, polysulfide, nitrate, nitrite, and thiosulfate reductases?
ADP, Pi
ATP
ATPase
ynthase
CH4
CH3-H4MPT
CH2=H4MPT
CH≡H4MPT
CHO-H4MPT
CHO-MFR
CO2
[CO]
Carbon monoxide dehydrogenase Pathway
HCO3-
Aspartate
PRPP
UMP
Pyrimidines
Pyrimidine Biosynthesis
Glutamine
UroporphyrinogenIII
Precorrin2
Siroheme
Cobalamin
Heme/Cobalamin Biosynthesis pathway
Ribose-5-P
prsA [2]
PRPP
Histidine
Folate Biosynthesis
(GTP)
Riboflavin
IMP
Purines
De novo Purine Biosynthesis
oxalate
COO-H+
malate, succinate, malonic acid
hexuronate
pantothenate
polysialic acid
lactate
glycerol
ribose

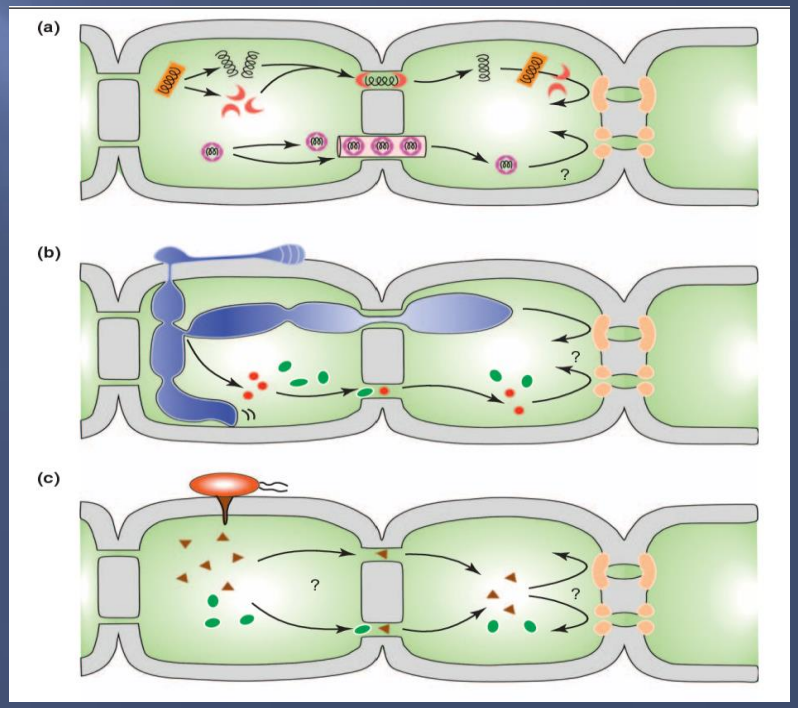


Working together and coordination

- In tiny scale and larger scale
- In war and peace







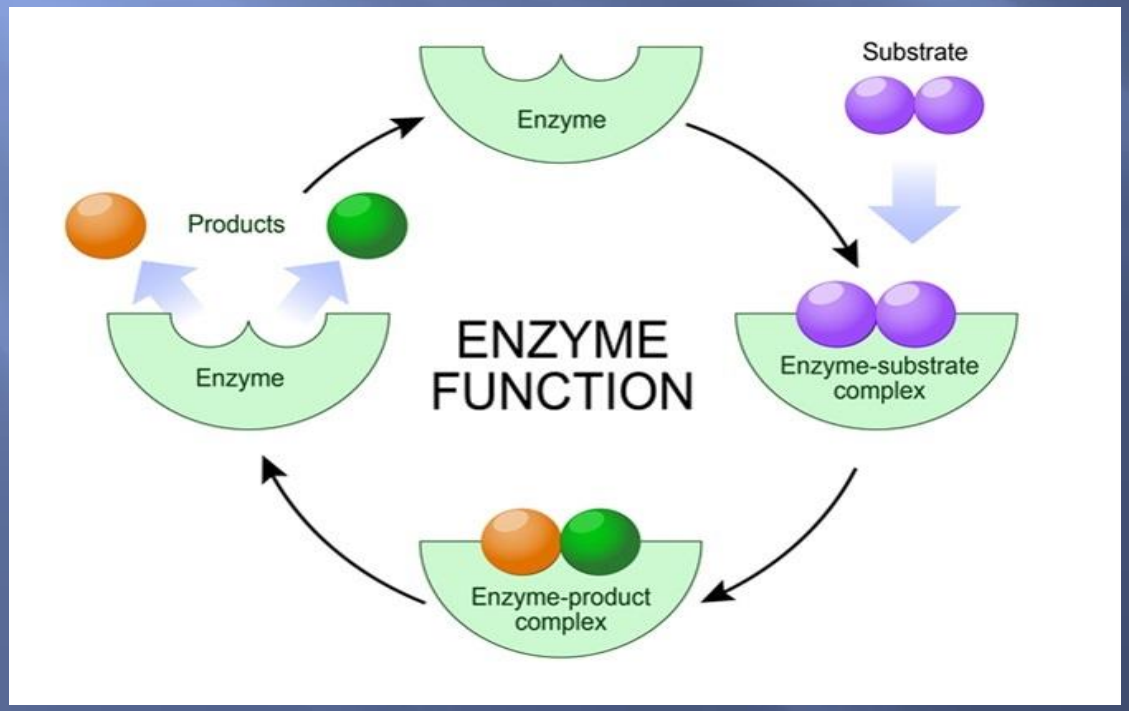
Life at that tiny space

- Diversed, yet ordered and highly coordinated, Energy efficient, quantum biology
- Clear job description and yet ready to work in groups
- Its a huge spreading task, complicated involving so many actors
- Fine tuning in managing the huge responsibilities
- Strict to rule and regulation, quick individual responses to any command brought by million messangers
- Smart in receiving and chanelling messages from outside
- Foccuss on overall target, humble enough not to push on self gain
- Almost all reactions are carried by enzymes

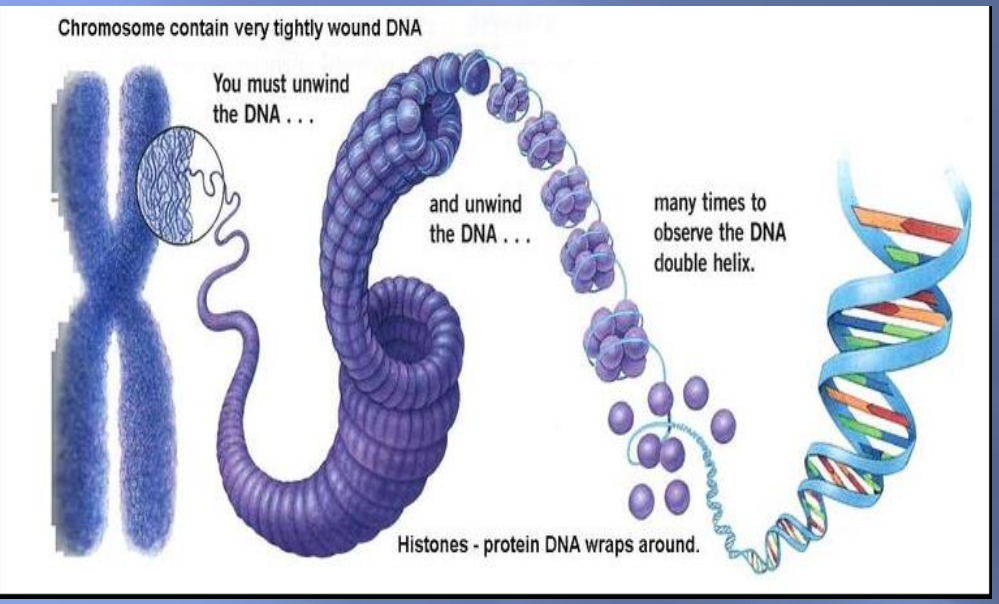
Number of enzymes per cell

A bacterium like *Escherichia coli* has about 4228 proteins of which almost 1701 of them are enzymes.

Mammals have more than 10 times the number of proteins and enzymes found in *E. coli.*

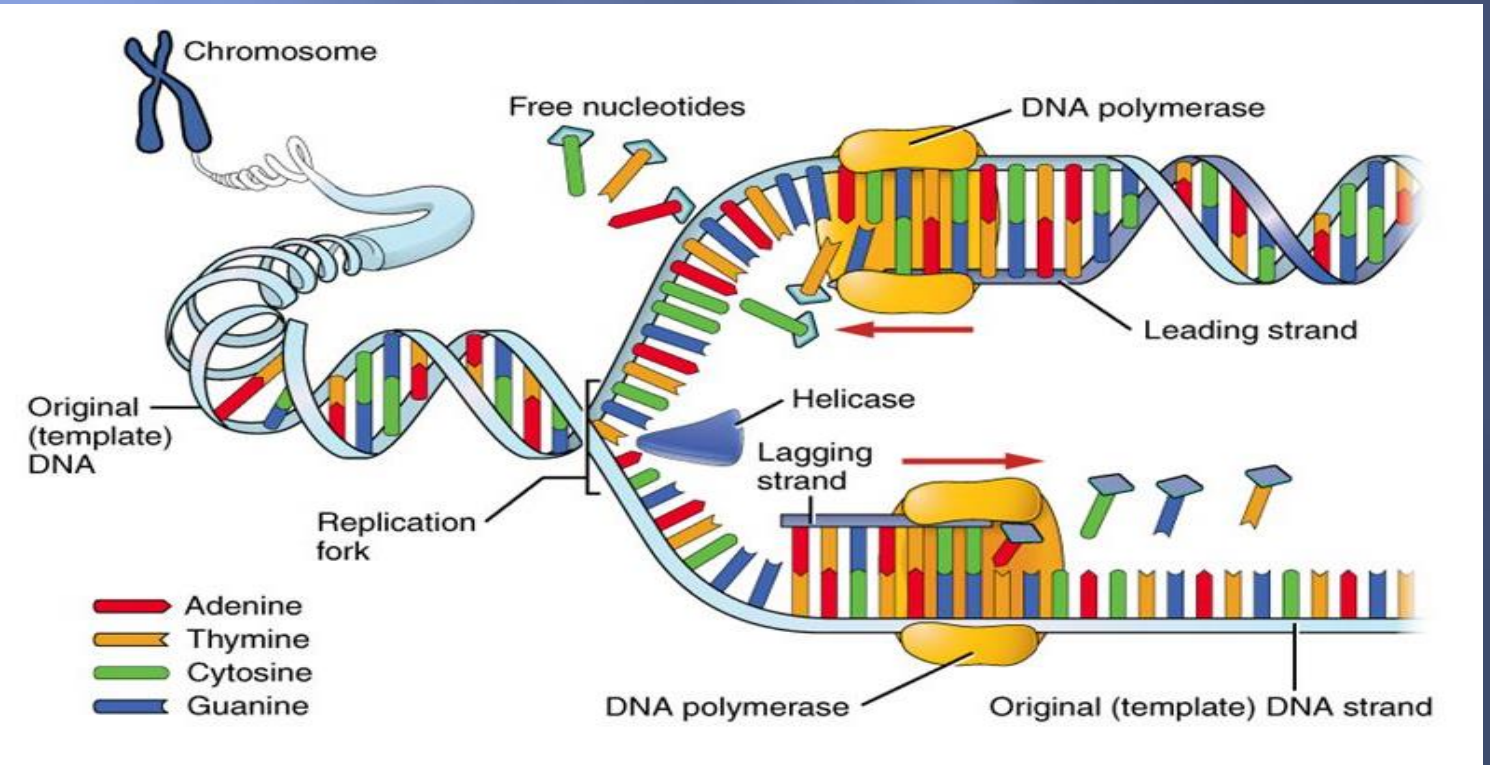


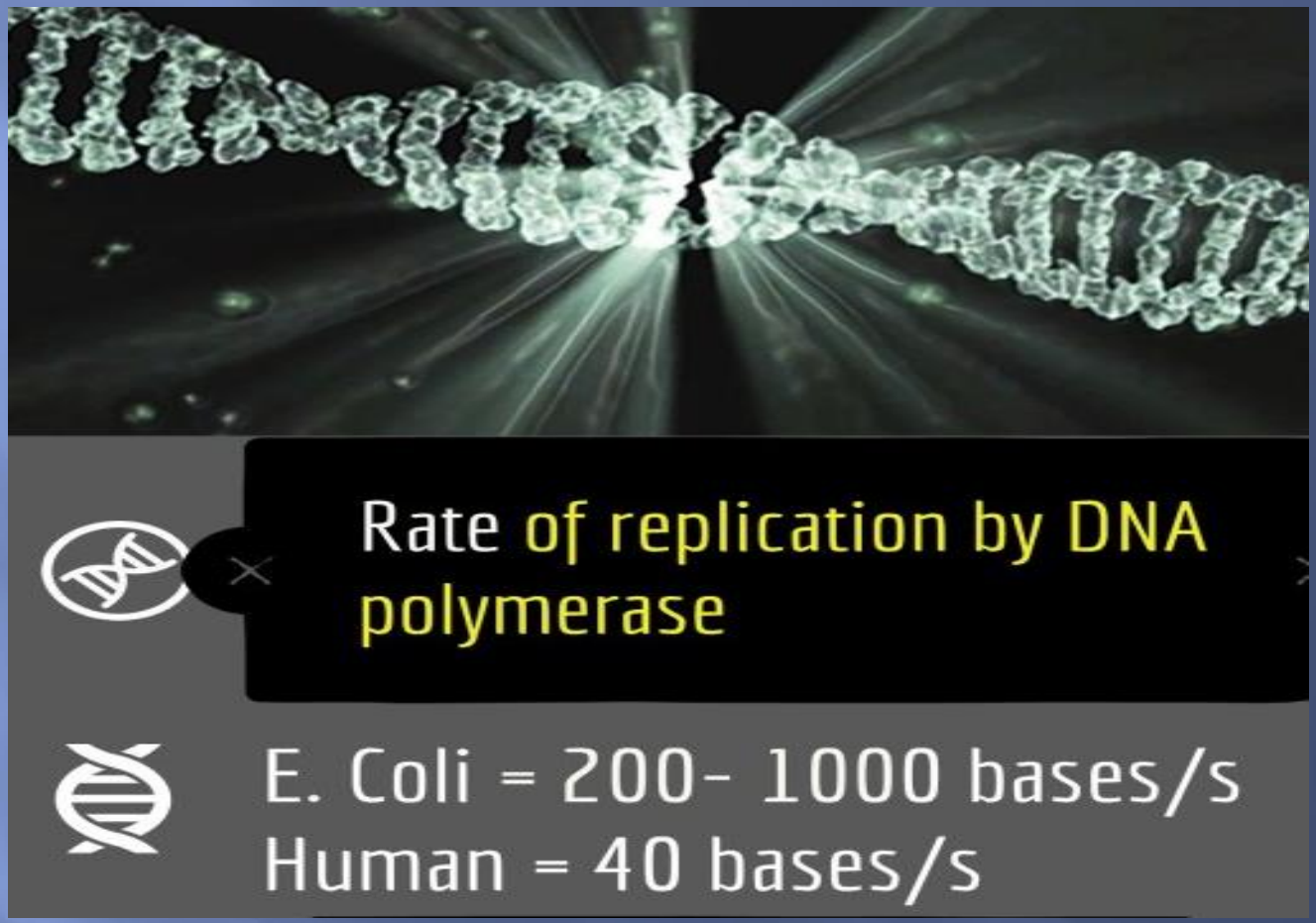
- Enzyme can be reused
- You do not need much enzyme to run a big job, to convert a large amount of substrate



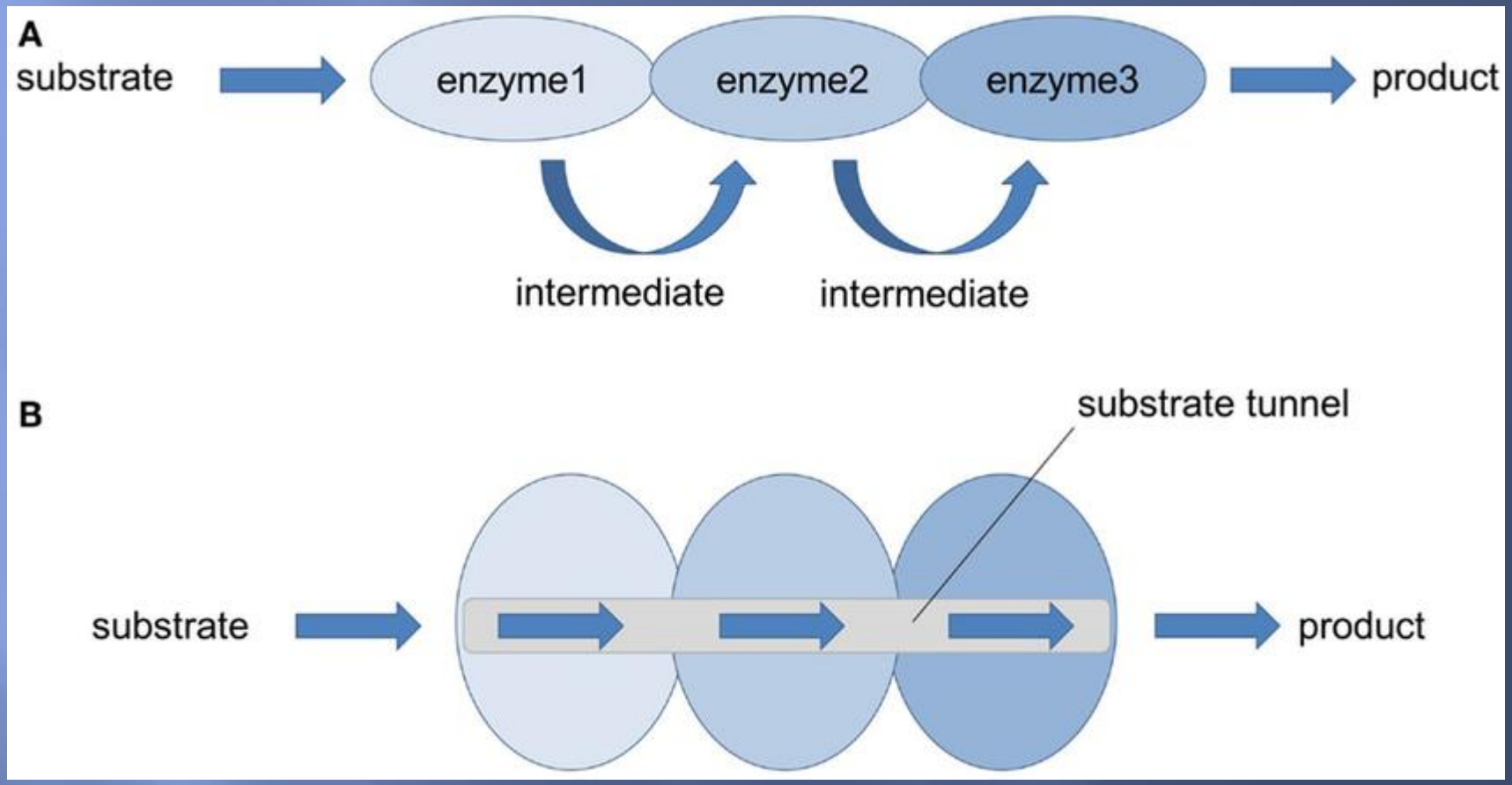
Several enzymes work together to unravel and open up a very complex structure (DNA) and making new strand with precise sequence

Unselfish, work well with others under tight coordination to meet the overall need of the cell

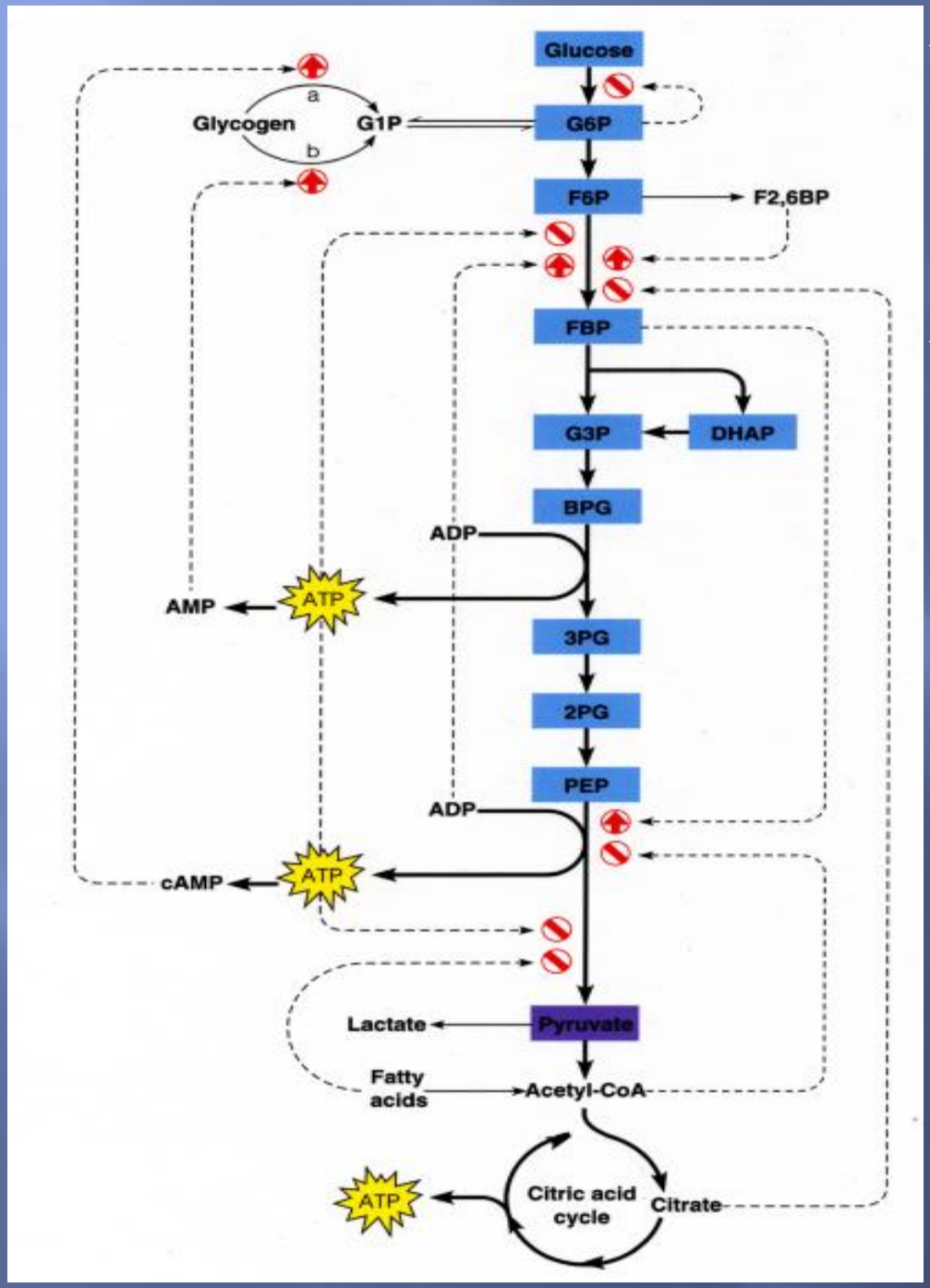




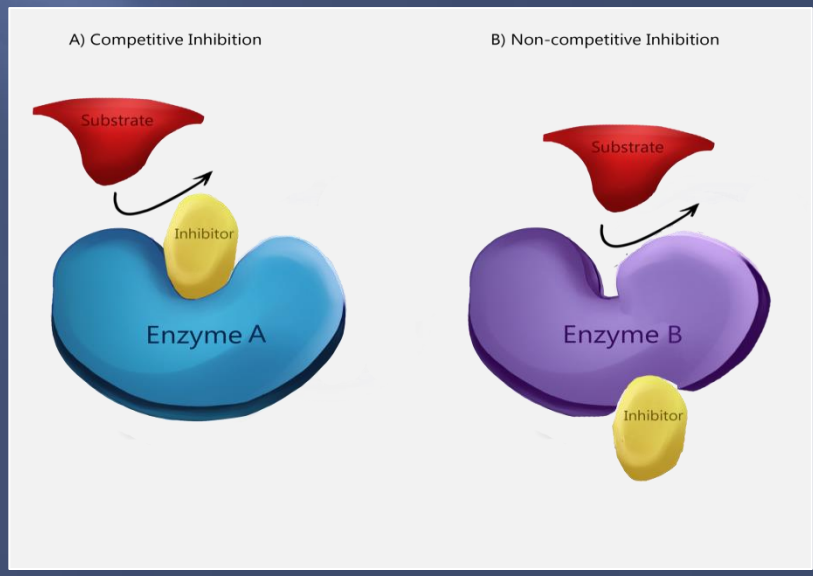
In Human, in 1 minute, DNA polimerase can add 3000 base pair to the new DNA or 40 - 50 base pair per second



- Working together, sharing energy to achieve common goal
- Who is more important, does not matter as long as the product is available at the right time and amount



- Cellular reactions would not waste energy to produce something which is already in exess
- The excess product will inhibit key enzymes in the pathway, stop the unnecessary reactions
- Why Key enzymes ? Energy saving

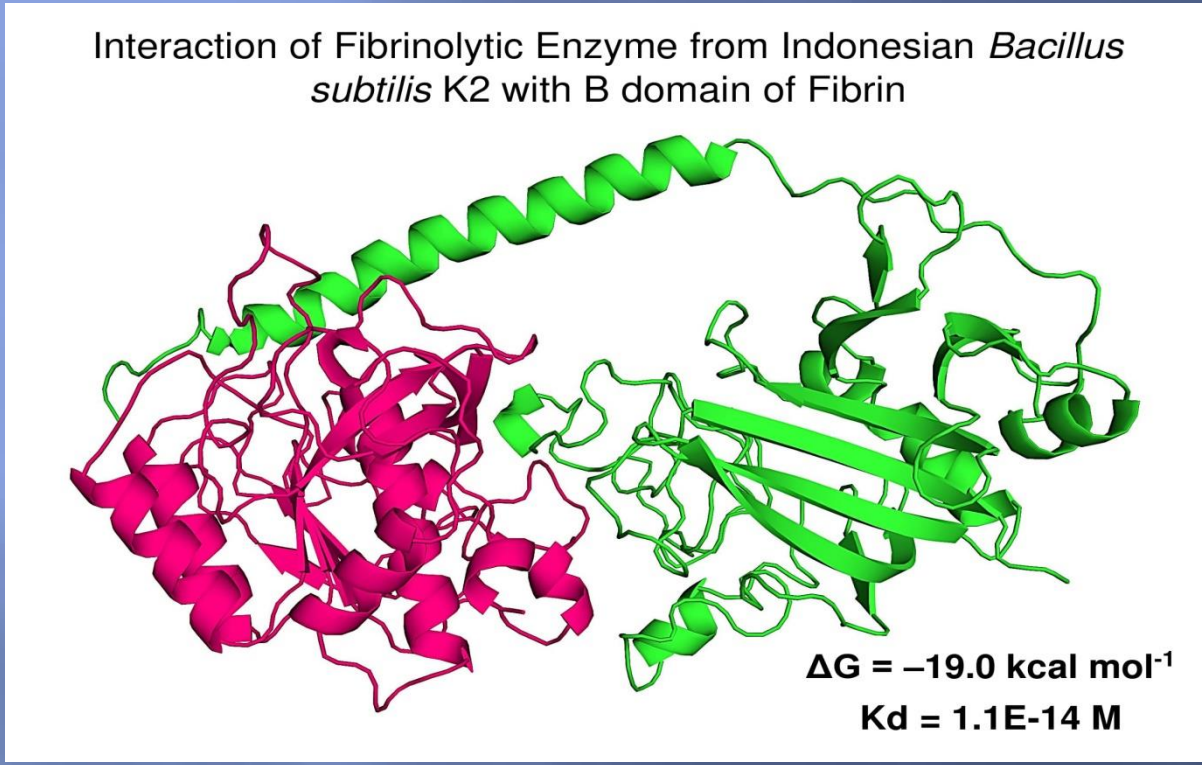


Enzymes follow command from the high hierarchi to increase or stop the reactions to safe energy / avoid unnecessary energy spending to avoid production of molecules which are already in excess amount

Enzyme make themselves available to interact with necessary agents to modify their structure and capability to interact with substrate

Working at the right time at the right speed to produce molecules at the right amount

No Life exist without Enzyme



Thank you

Enzyme is one of the Wonder given to Life
To adopt normal life they need to work in quantum mode, unselfishly, humbly, following rule and regulation, ready to repond to kind or harsh environment

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