BO1010: Introduction to Life Sciences

ourse Content:

•Relevance of Biological Principles to Engineering undergraduates
•Water and its special properties: Relevance to life
•Building blocks of life: Bio-molecules and their structure-function aspects
•Cell structure and organelles, cell membrane, cellular transport and signaling
• How does a cell sustain life? Cell metabolism and its regulation; Cell energetic: harvesting chemical & solar energy
•Cell division and cancer
•DNA structure and packing. its replication, damage and repair: Consequences of unrepaired DNA damage
•Dogma in Molecular Biology: Transfer of information from DNA to protein synthesis
•Biotechnology

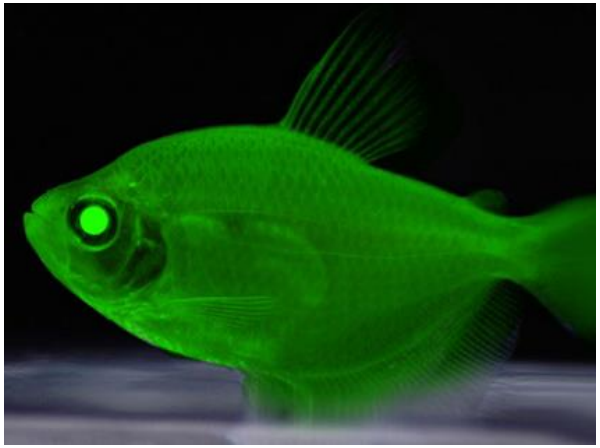
Text Book:

Biology – by N.A. Campbell and J.B. Reece, 2005. VII edition (International edition), Pearson- Benjamin-Cummings Publications, San Francisco.

Reference Book:

Molecular Biology of The Cell -by B. Alberts, 5th edition, Garland Science, New York.

Power of Biotechnology



Fish with green fluorescent protein (GFP) gene (Glowing Fish)

Tobacco plant with firefly glow gene

Pig with green fluorescent protein (GFP) gene

Completion of Human Genome Project

lgvrdlmnqvt**thequick**ababcmfxlq**brownfoxju**lrvs**mped**
overthelazyyyzplf**dog**jjiurttiy**thedoglay**hhbeld**quietly**
dreaminghwwiqldns**ofdinner**plwosiucnd

-Organ and organism cloning
-Gene Therapy
-Therapeutic protein production: Vaccine, HGH, Insulin etc
-Synthesis of small molecule for use as drugs
-Environment clean up
-Agricultural applications: Pest resistance, fortified food, Herbicide resistance, Salinity resistance

Golden Rice

Interfaces: Engineering & Life Sciences

Bioinformatics & Systems biology

Fermentation technology

Nano-biotechnology

Genomics & Proteomics

Biomedical Engineering

Biomaterials

Bio-mechanics etc..

Systems Biology and Bioinformatics

- A system is a combination of components that function together
- **Systems biology** constructs **models for the dynamic behavior** of whole biological systems: Creation of synthetic life form
- The systems approach poses questions such as:
  - How does a drug for blood pressure affect other organs?
- How does increasing CO_2 alter the biosphere? A system is a combination of components that function together
- Churn biofuels, soak up Co2 from atmosphere etc
- **Bioinformatics**

Genomics and Proteomics

Bioinformatics is an interdisciplinary field that develops **methods and software** tools for understanding biological data.

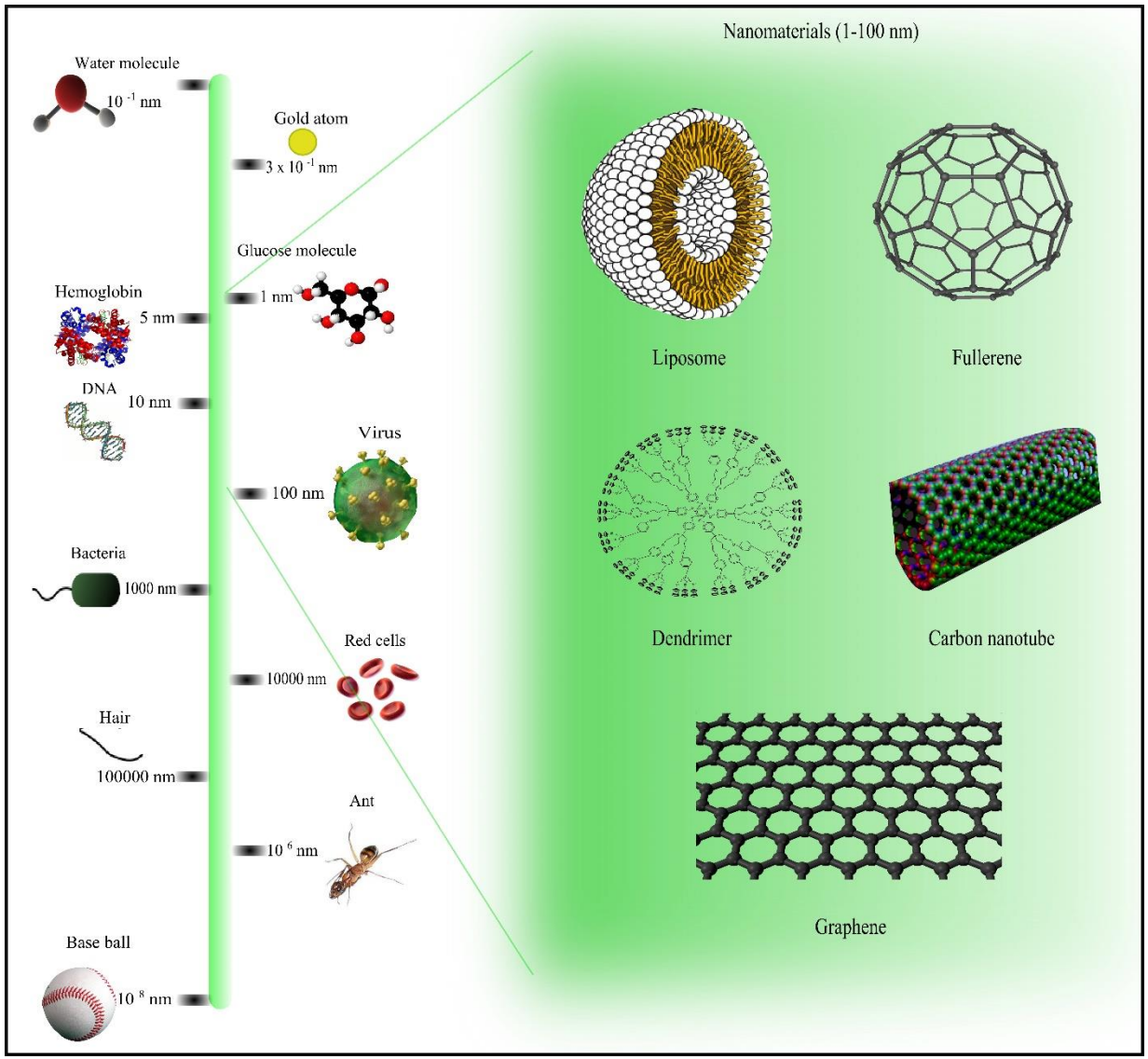
Genomics is a discipline in genetics that applies recombinant DNA, DNA sequencing methods, and bioinformatics to sequence, assemble, and analyze the function and structure of genomes. Exs: Rice genome, Mycobacterium genome, Genome of cancer patient

- **Proteomics** is the **large-scale study of proteins, particularly their structures, functions** and **interactions for given physiological process**

Nano-biotechnology

- The intersection of nanotechnology and biology.

Biologically inspired nanotechnology



-Peptide nanosheet
-Fluorescent polymers
-DNA nanotubes
-Silver nanoparticles
-Fullerenes: Nanoscale Electronics
-Bone tissue engineering
-Precise drug target

Biomedical Engineering

Biomedical Imaging

CT scan (computed tomography)
MRI (Magnetic resonance imaging)
X-ray

Machines engineered for Biotech application:

EM (Electron Microscopy)

AFM (Atomic Force Microscopy)

NMR (Nuclear Magnetic Resonance)

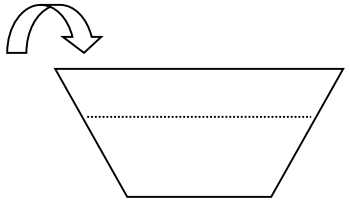
X-ray diffraction

Everyday biology

Example: Why does curd form?

How is curd made?

-Take a vessel and pour milk into it
(milk is the *medium*)
- Warm it, say upto 37^{o}C
- Add some old curd to it
(old curd is the *inoculum*)
- Close it, set it aside in a warm place
(the mixture is the *culture/broth*)
- Curd is formed in a few hours



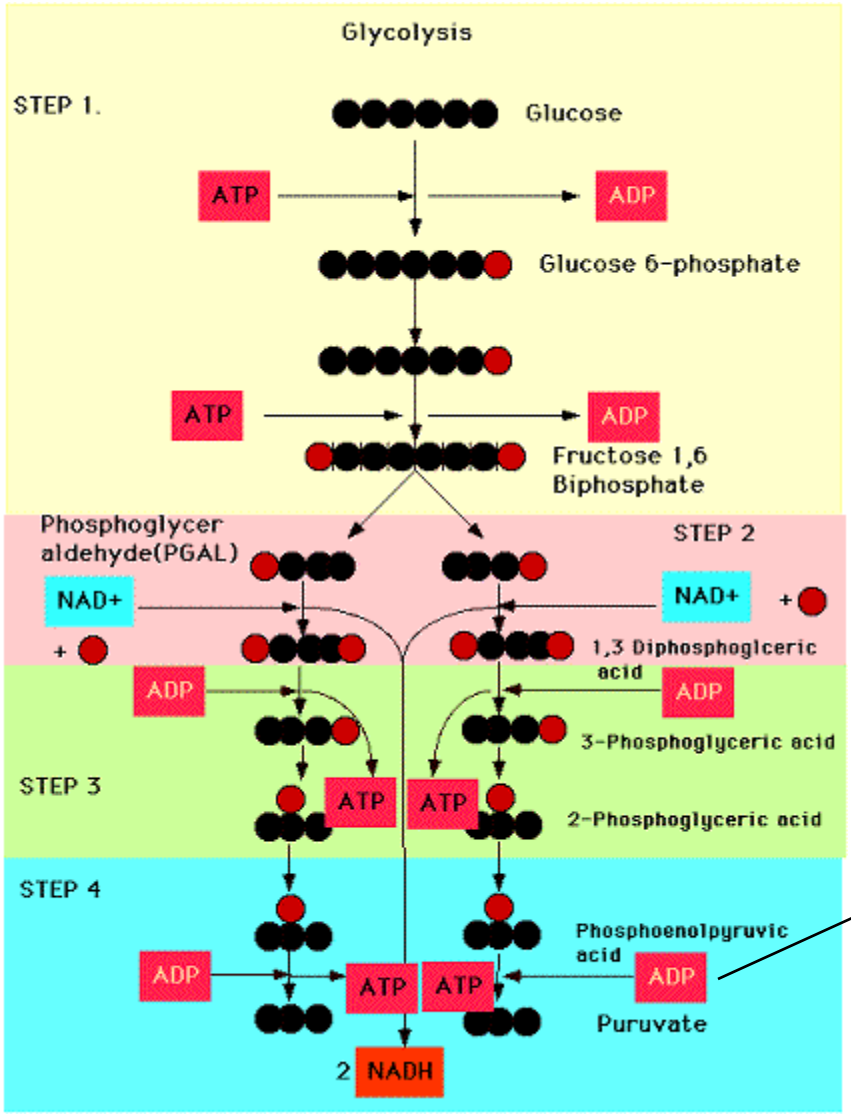
Nutrient	Cow	Buffalo	Human
Water, g	88.0	84.0	87.5
Energy, kcal	61.0	97.0	70.0
Protein, g	3.2	3.7	1.0
Fat, g	3.4	6.9	4.4
Lactose, g	4.7	5.2	6.9
Minerals, g	0.72	0.79	0.20

http://babcock.cals.wisc.edu/downloads/de/19.en.pdf

Acid formation, and consequent protein aggregation

Where does the acid come from?

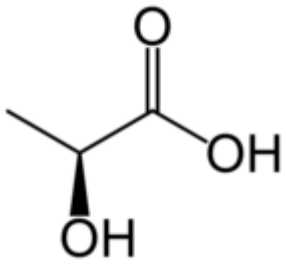
From some among the thousands of reactions that occur inside the lactic acid bacteria (*Lactococcus lactis*)

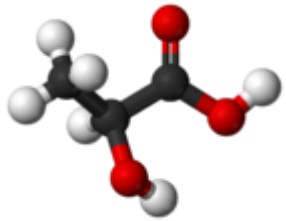


Lactic acid

www.jccc.net/~pdecell/cellresp/glycolysis.html

What kind of a molecule is lactic acid?





$C_3H_6O_3$

2-hydroxy propanoic acid

Lactic acid belongs to a class of biomolecules called

Carbohydrates

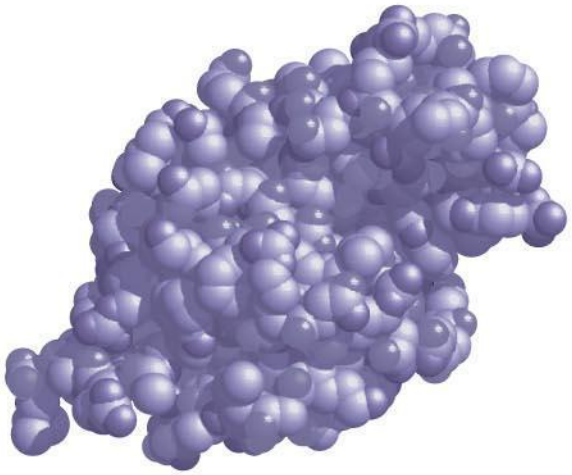
General formula: $(CH_2O)_n$ Usually n > 3

Now, let us look at the next part: curd forms due to protein aggregation

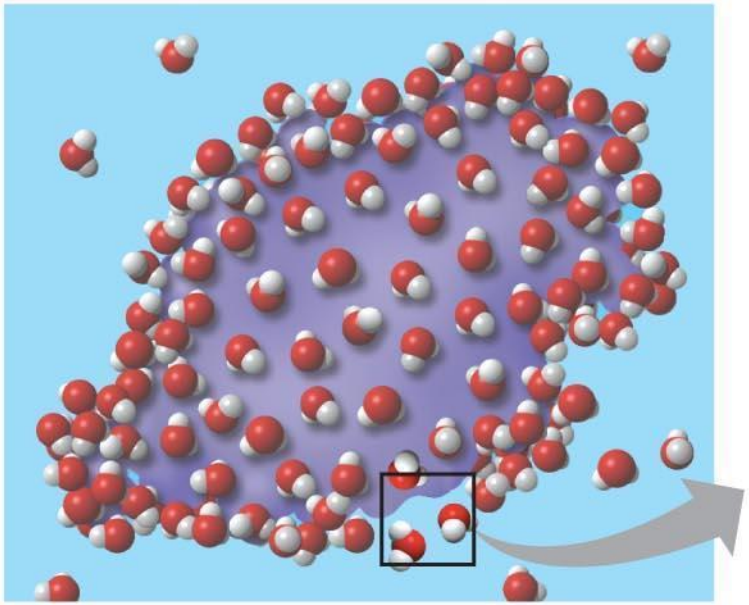
What is aggregation?

Why protein aggregates in presence of acid?

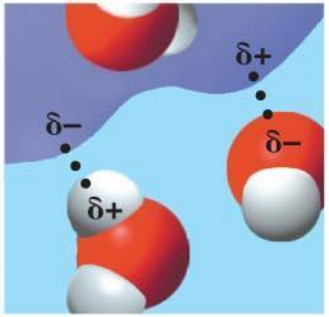
What happens at a molecular level when a substance dissolves in water?



(a) Lysozyme molecule in a nonaqueous environment



(b) Lysozyme molecule (purple) in an aqueous environment



(c) Ionic and polar regions on the protein's surface attract water molecules.

- Water can also dissolve compounds made of ionic polar molecules
- Even large polar molecules such as proteins can dissolve in water if they have ionic and polar regions
- Proteins are active/alive in our body because of cell contains >80% of water

Now, let us look at aggregation – aggregation happens when molecules fall out of solution, and are attracted to each other.

Which protein aggregates?

Mainly casein of milk

Why casein (milk protein) fall out of solution during curd formation?

From a molecular view-point, why does a protein aggregate?

From a molecular view-point, what is a protein?