BT1651-1 : Biology for Engineers

Azadi Ka Amrit Mahotsav

Why Biology for Engineers

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NITTE (Deemed to be University) | NMAM INSTITUTE OF TECHNOLOGY

WHY SHOULD ENGINEERS KNOW BIOLOGY?

- Only two socially preferred undergraduate streams for study—**engineering and medicine**

❖ **Mathematics—physics—chemistry—biology**
❖ **Mathematics—physics—chemistry—computer science**
❖ Physics—chemistry—biology

- Therefore, the students who enter **engineering undergraduate studies may or may not have studied biology after their class 10**

- The students who do not have an interest in biology or are neutral ----exposed to **uninspired teaching of biology** as a part of science at the high school (sixth to 10th standard) ----most likely **develop a hatred toward it**.

For example, class surveys done at **IIT Madras among all undergraduates who take the author's introductory course on Life Sciences** ---- > 90% of the engineering undergraduates **have not studied biology at the higher secondary stage large majority (> 98%) hate biology**.

NEED FOR BIOLOGY

- Century of biology
- Many engineers are expected to contribute to a biological aspect to fuel this revolution
- Engineering undergraduates need to be **suitably exposed atleast to the very minimum biology**, so that they would **atleast be able to consider a biological system/aspect** in which they could later **make appropriate contributions**, through their main expertise, say electrical engineering, mechanical engineering, computer science, materials engineering, or any other

Shinkansen Sonic Boom

Japan's high-speed bullet train – DESIGN OPTIMIZATION (Biomimetics)

https://www.youtube.com/watch?v=YVU6YBPaaB8

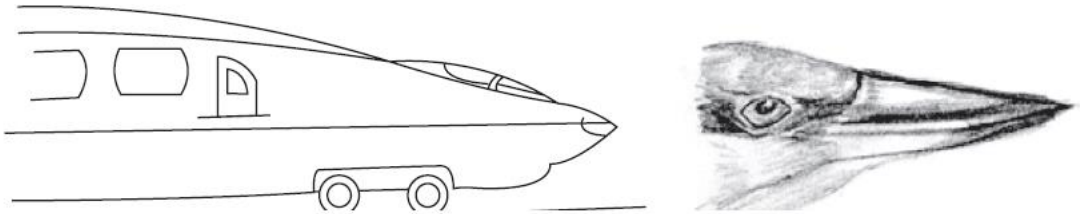


Figure 1.1 The nose of the re-designed Shinkanzen, shaped like a kingfisher's beak

- Sonic boom caused significant difficulties to the public
- To address the sonic boom problem, a team was assembled--- The team had many departments and the head of one of the departments, Eiji Nakatsu, believed in learning from nature—his hobby was bird-watching.

Kingfisher's beak ---efficiency to slice through water to catch a fish

Owl's -- Feather design

Redesigned train

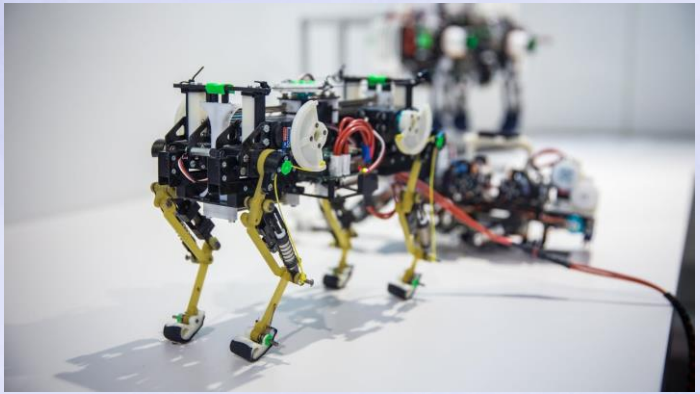
- Acceptably quieter when it exited the tunnels in dense residential areas, it was also **10 per cent faster and 15 per cent more energy-efficient**.
- **Biological features were mimicked to solve engineering problems**

Bio-robotics

- Robots that are inspired by biological entities or the use of biological components in robots

robots with human like features (e.g. the character, Data, in the hugely popular, ‘Star Trek’

Human robot



Biorobot inspired by animal movement

https://www.youtube.com/watch?v=NHnTNVmbxG0

Passive cooling in sky scrapers was inspired by observing how termite mounds are always kept around 90 degrees by opening and closing vent like structures at the bottom and top or the mounds

Belt movement of military tank was inspired by observing the way a caterpillars moves.

Hydrophobic coatings and paints were inspired by observing the superhydrophobic nature of lotus leaves due to the microscopic tips present on the surface of the leaves

Submarines design was improved by observing the ability of deep sea creatures to withstand high pressure

Inferometric modular display were designed by mimicking the way light reflects from the scales on a butterfly's wing

Recent advances:Retinal Prosthetic

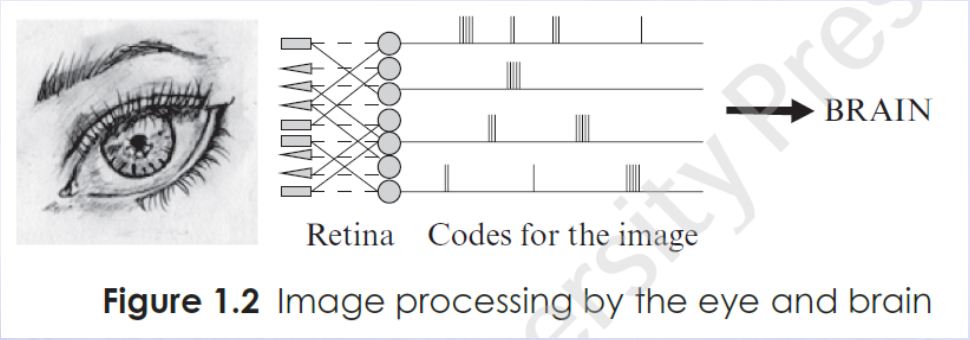
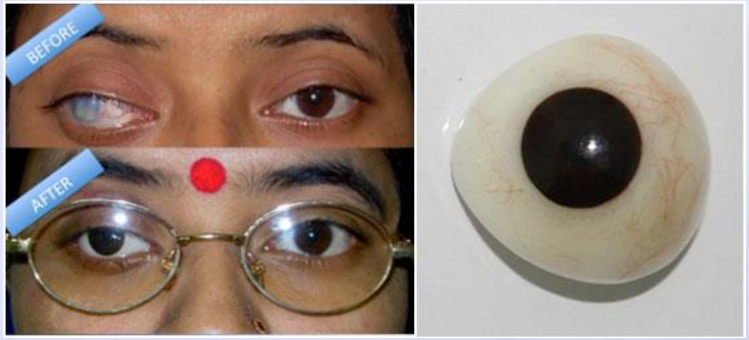


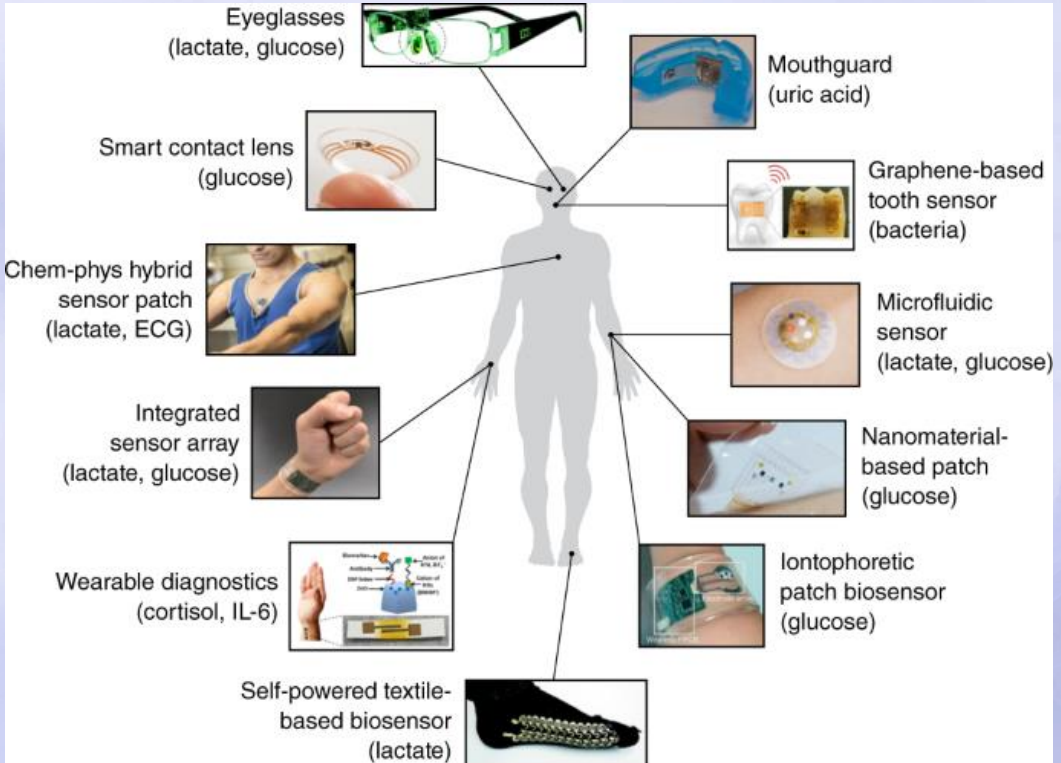
Figure 1.2 Image processing by the eye and brain



When an eye 'sees' something, its **lens projects an image onto its retina and its photoreceptor cells, where the image gets converted to appropriate codes**. The **codes, in turn, get converted to corresponding electrical signals by appropriate cells located just behind the retina** (Figure 1.2). **The electrical signals are conveyed to the brain where the image is interpreted**. **All this happens in milliseconds or less that we are able to visually perceive the happenings around us in real time**. When the **retina gets diseased, the relevant cells die and the image no longer gets converted to appropriate codes**. Scientists have developed a device, a prosthetic, that can convert optical images to codes and later to electrical signals, which can be transmitted to the brain. The prosthetic is small enough to be placed inside the eye at the retina and it is connected to the cells that transmit the signals to the brain. Thus, the person who is blind due to retinal disease can see again. Versions of this device are already **approved by the U.S. Food and Drug Administration (FDA) for use on patients.**

Recent advances: Bio-sensors

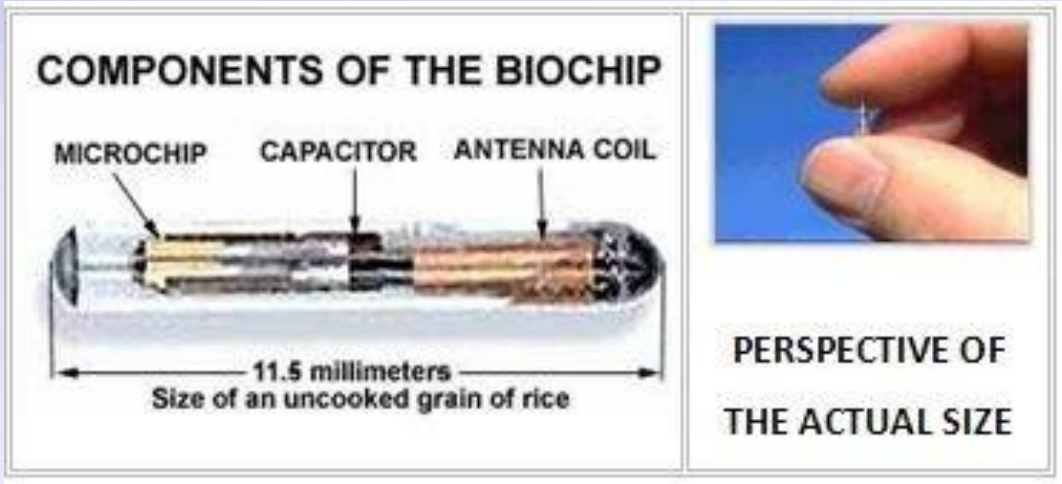
Used for diverse purposes such as analysis, toxicology, medical diagnosis (i.e., they can even be incorporated into *digital plasters* to monitor the healing progress of wound), environmental monitoring, and others



Bio-chips

A biochip is **a collection of miniaturized test sites (microarrays) arranged on a solid substrate that permits many tests to be performed at the same time in order to achieve higher throughput and speed**

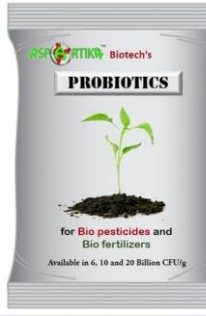
- ❖ Miniaturised laboratories in which thousands of biochemical reactions can be carried out simultaneously
- ❖ Micro-fabrication skills are necessary to design and manufacture bio-chips



Applications

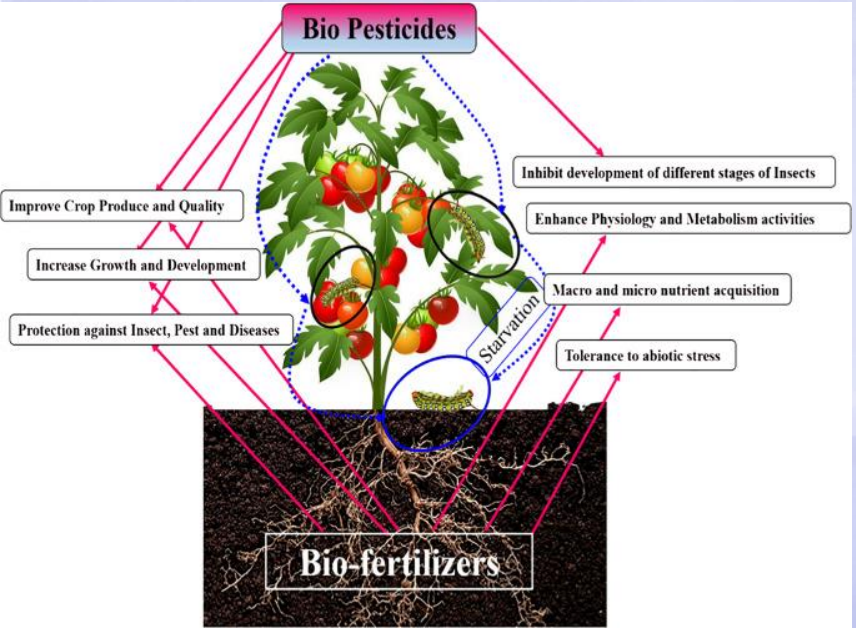
- **Pharmaceutical research**
- **Medical Diagnosis**
- **Forensics**
- **Transplantation**
- **Water and environmental testing**

Bio-pesticides & Biofertilizers



- Overcome the negative effects of chemical pesticides

- *Bio-fertilizers* are fertilizers that are composed of appropriate microorganisms
- **Biological process fixing --** N, P, and K



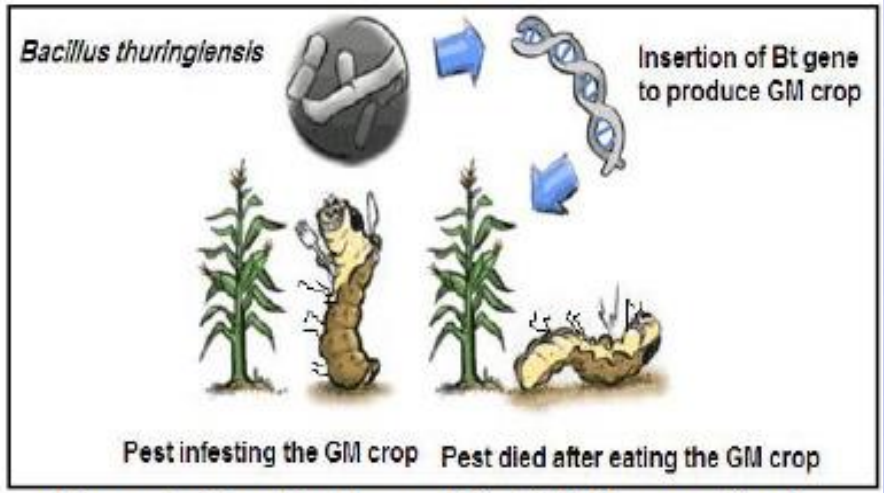


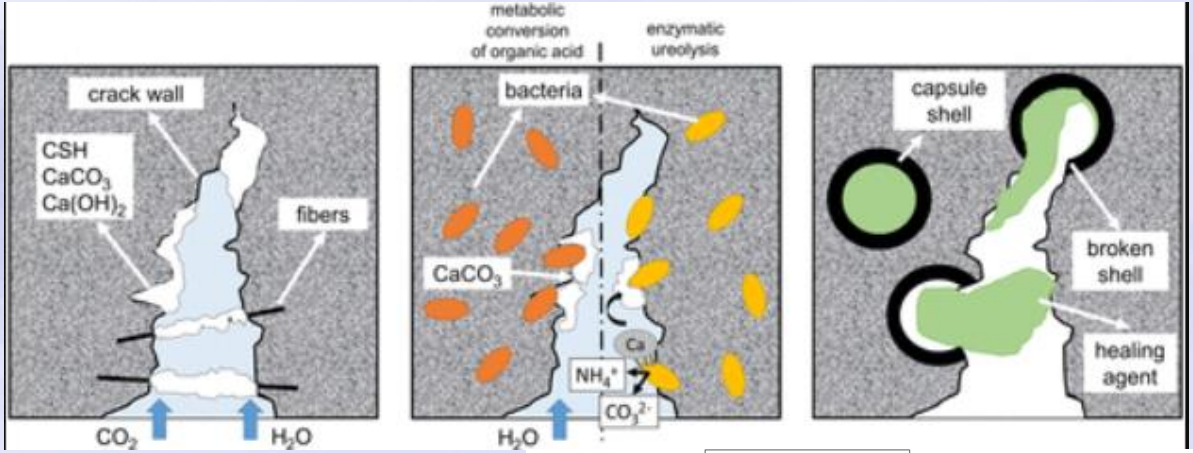
Figure 3. Genetically modified (GM) corn after the insertion of a gene from the *Bacillus thuringiensis*, corn becomes resistant to pest and kills the pest.

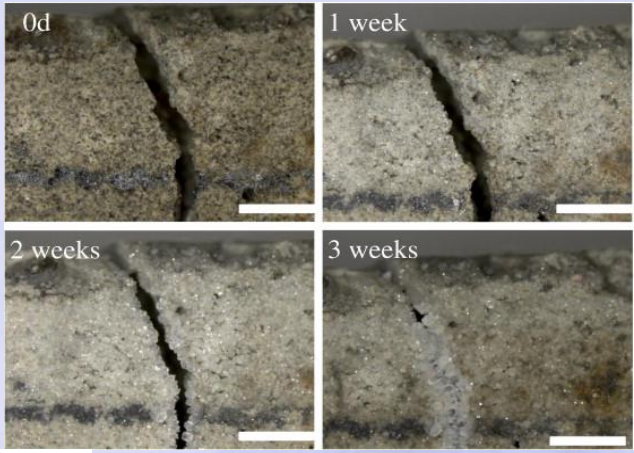
- *Bacillus thuringiensis* (Bt) – common soil borne bacterium.
- Produces proteins ("crystal proteins", Cry) that selectively kill certain groups of insects.
- Stomach toxins, must be ingested to kill.
- Protein binds to receptors in intestines and insect stops eating.
- Used in granular or liquid form > 30 years as a pesticide.
- Many (> 60) different Cry proteins and effective against different insects.

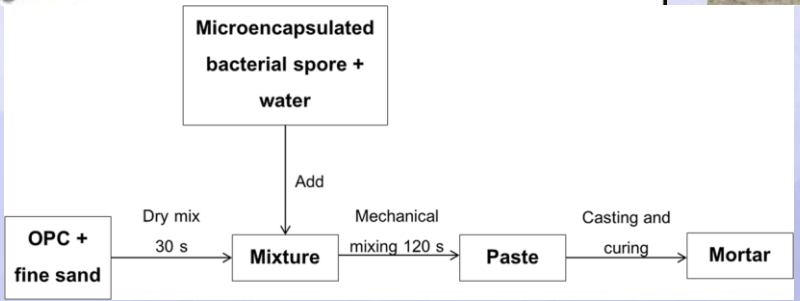
Benefits of Biofertilizers in the soil

- Increases crop yield by 20-30%
- Can replace chemical nitrogen and phosphorus by 25%
- Stimulates plant growth
- Activates the soil biologically
- Restores natural soil fertility
- Provides protection against drought and some soil borne diseases

Concrete Self-heal : Organisms can be used to make *concrete self-heal* its cracks due to wear-and-tear. For example, some bacteria can catalyse the formation of calcium carbonate in their surroundings under appropriate conditions. When this happens in cracks that are formed in the concrete, the microscopic cracks are filled with the calcium carbonate formed with the help of the bacteria, which can effectively seal the cracks, and thus effect self-healing of the concrete.

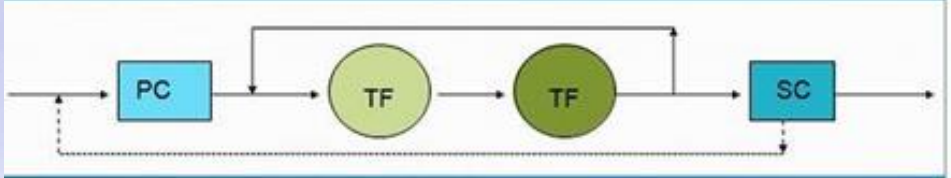


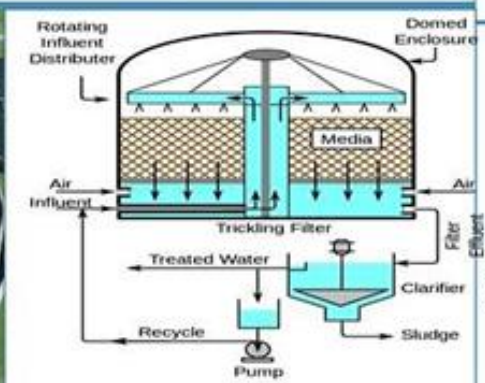


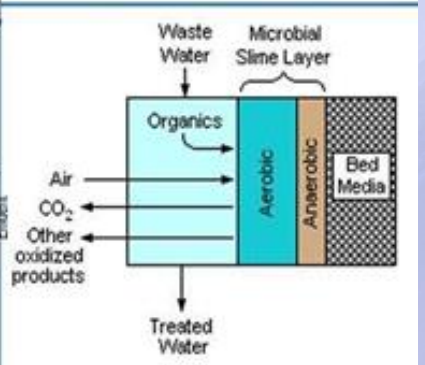


Biofilters

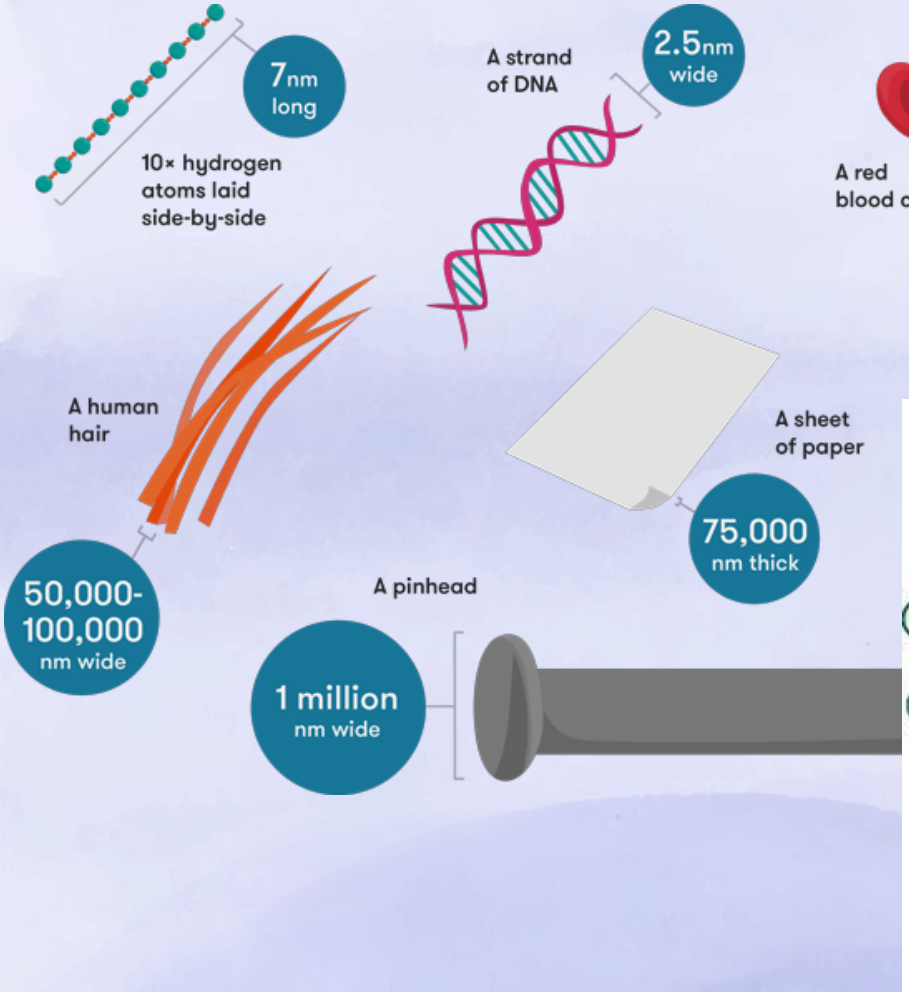
Trickling Filters (Attached Growth Process)



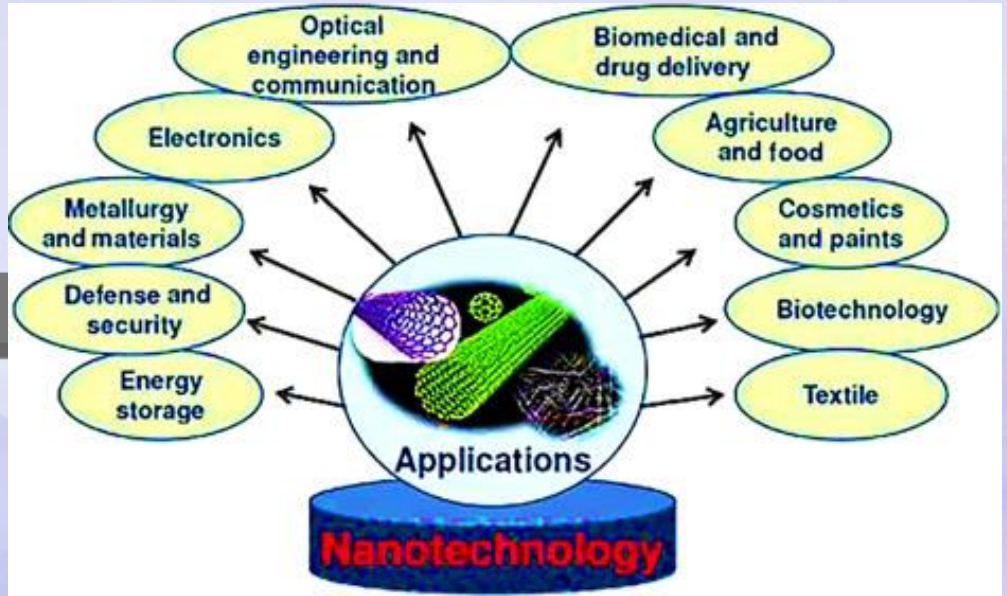




Nanoparticles and its applications

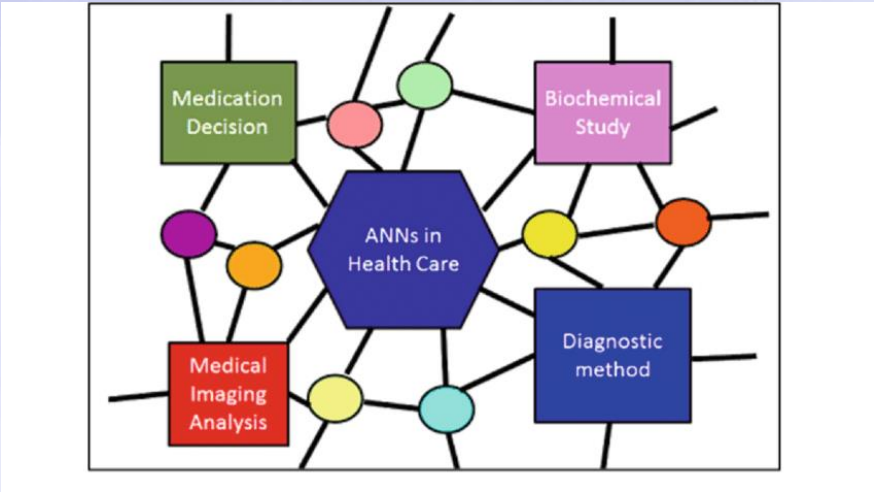


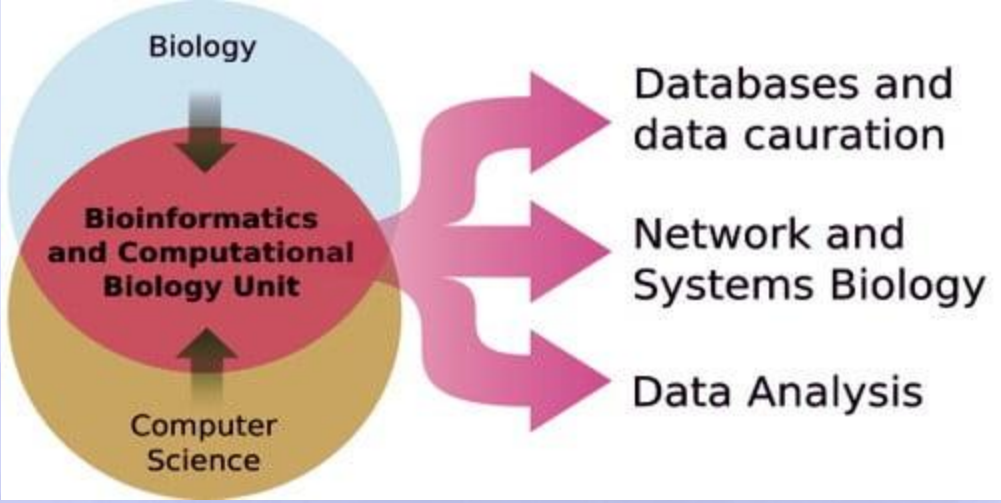
1 nm = 10^{-9} m

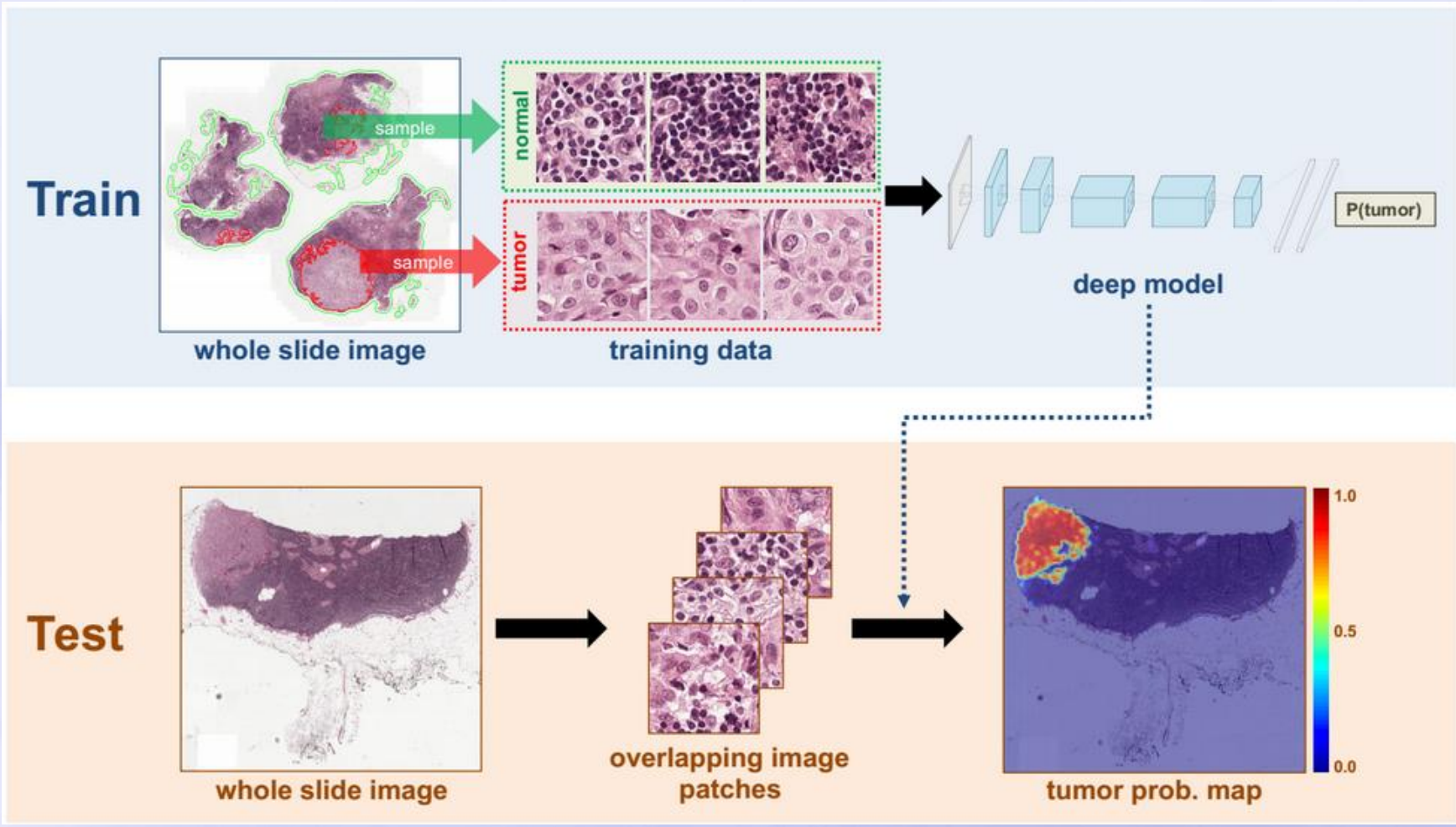


- **Artificial Neural Network :** The artificial neural network (ANN), a processing set-up, is supposedly inspired by the working of animal brains—they learn by example. ANNs are made up of a large number of interconnected elements, each of which work similar to a biological nerve cell

- **Bioinformatics, Systems Biology, and Computational Biology** These are currently popular fields of study which are highly multi-disciplinary, and engineers can significantly contribute to those fields.






Train
sample
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1.0
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tumor prob. map

THANK YOU

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Cell Properties and Types

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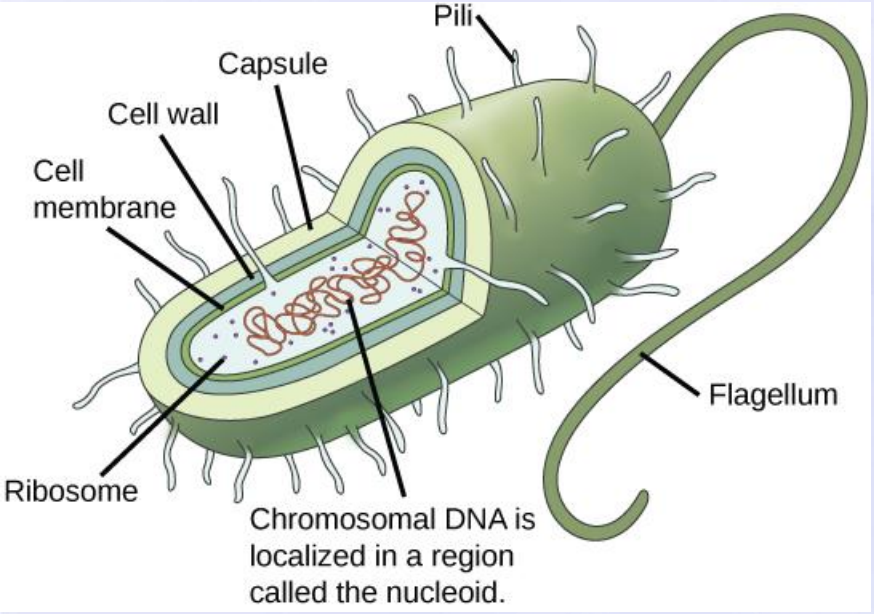
Prokaryotic cells (cell size ranges from 0.1 to 5.0 µm in diameter)

- Prokaryotic cells are the cells **that do not have a true nucleus and membrane-bound organelles**
- Prokaryotic cells are **single-celled microorganisms** known to be the earliest on earth.
- Prokaryotes include **Bacteria and Archaea**.
- The photosynthetic prokaryotes include **cyanobacteria that perform photosynthesis**.
- A prokaryotic cell **consists of a single membrane and therefore, all the reactions occur within the cytoplasm.**
- They can be **free-living or parasites**.

Characteristics of Prokaryotic Cell

- They lack a nuclear membrane.
- Mitochondria, Golgi bodies, chloroplast, and lysosomes are absent.
- The genetic material is present on a single chromosome.
- The histone proteins, the important constituents of eukaryotic chromosomes, are lacking in them.
- The cell wall is made up of carbohydrates and amino acids.
- The plasma membrane acts as the mitochondrial membrane carrying respiratory enzymes.
- They divide asexually by binary fission. The sexual mode of reproduction involves conjugation.



Capsule– It is an **outer protective covering** found in the bacterial cells, in addition to the cell wall. It helps in moisture retention, protects the cell when engulfed, and **helps in the attachment** of cells to nutrients and surfaces.

Cell Wall– It is the outermost layer of the cell which gives shape to the cell.

Cytoplasm– The cytoplasm is mainly composed of enzymes, salts, cell organelles and is a gel-like component.

Cell Membrane– This layer surrounds the cytoplasm and regulates the entry and exit of substances in the cells.

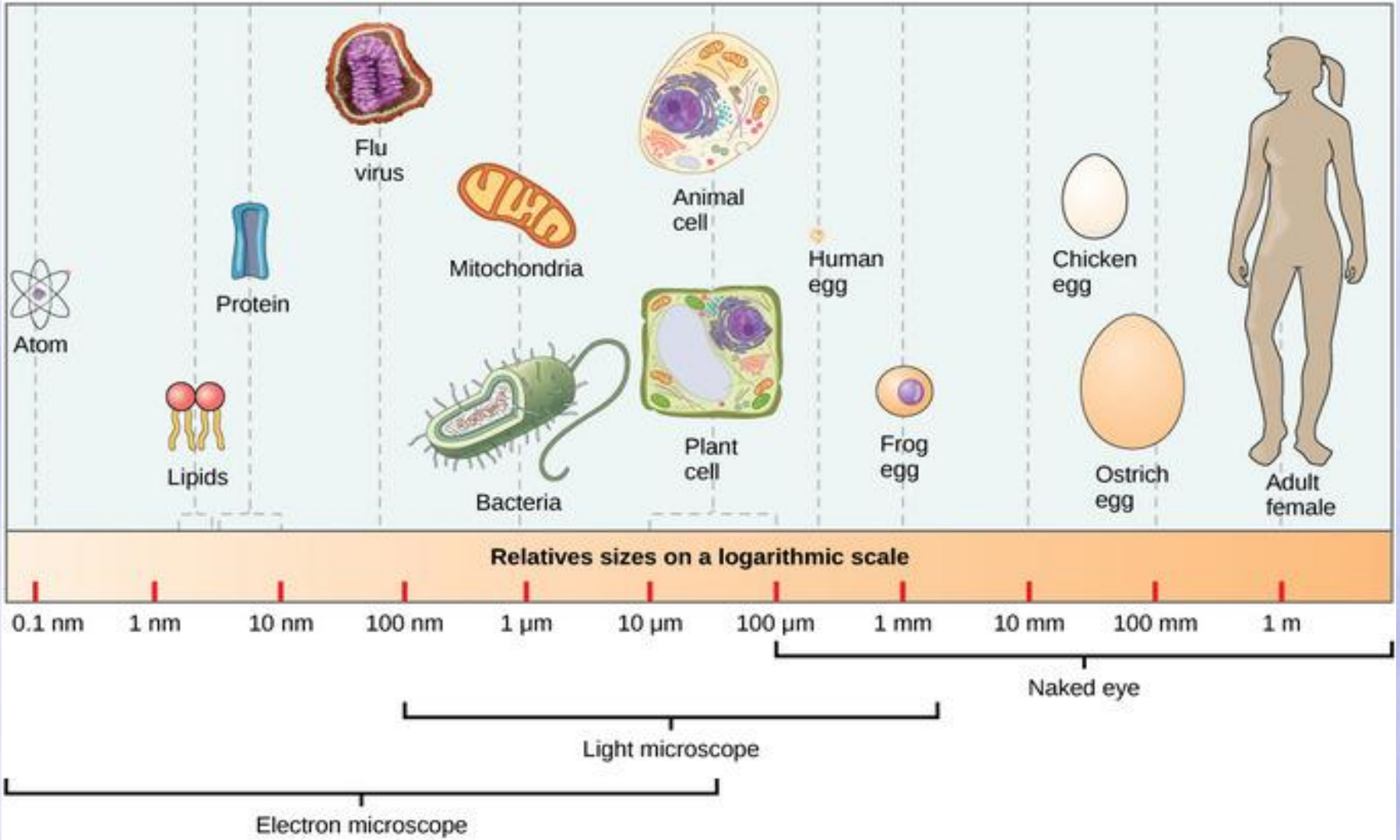
Pili– These are hair-like outgrowths that attach to the surface of other bacterial cells.

Flagella– These are long structures in the form of a whip, that help in the locomotion of a cell.

Ribosomes– These are involved in protein synthesis.

Plasmids– Plasmids are non-chromosomal DNA structures. These are not involved in reproduction.

Nucleoid Region– It is the **region in the cytoplasm where the genetic material is present**.


Flu virus
Animal cell
Mitochondria
Protein
Atom
Human egg
Chicken egg
Adult female
Plant cell
Frog egg
Ostrich egg
Lipids
Bacteria
Relatives sizes on a logarithmic scale
0.1 nm
1 nm
10 nm
100 nm
1 µm
10 µm
100 µm
1 mm
10 mm
100 mm
1 m
Naked eye
Light microscope
Electron microscope

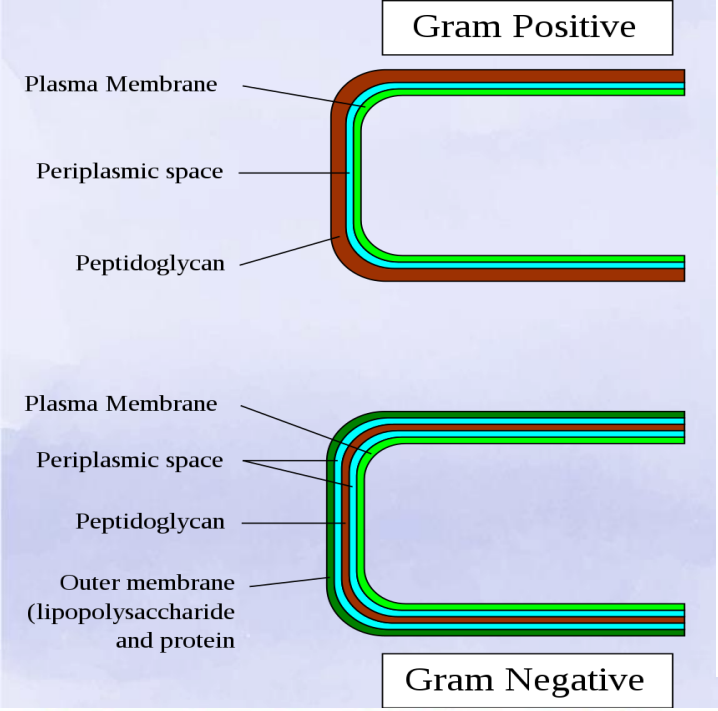
Examples of Prokaryotic Cells

Bacterial Cells

- These are **unicellular organisms** ----**from soil to the human body**.
- They have different shapes and structures.
- The **cell wall is composed of peptidoglycan**
- **Unique structures such as pili, flagella and capsule**.
- They possess **extrachromosomal DNA known as plasmids**.
- They have the **ability to form tough, dormant structures known as endospores ---**survive under unfavourable conditions ---become active when the conditions are favourable again.

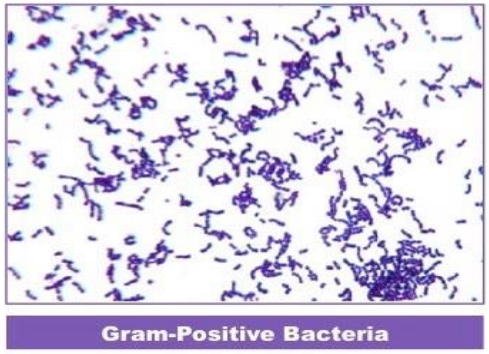
Archaeal Cells

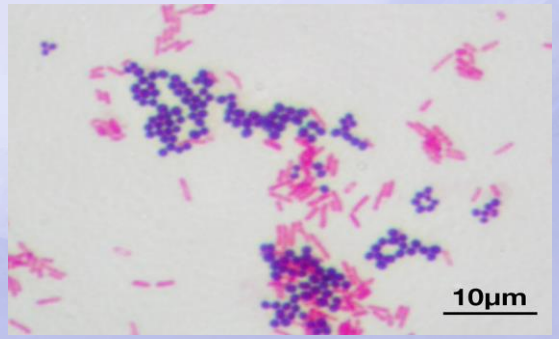
- Archaebacteria are unicellular organisms similar to bacteria in shape and size.
- They are found in **extreme environments such as hot springs** ----**soil, marshes, and even inside humans**.
- They have a **cell wall and flagella**.
- The **cell wall of archaea does not contain peptidoglycan**.
- Just like bacteria, archaea have **one circular chromosome.**
- **They also possess plasmids**.



Differences in 2 minutes
Gram positive & Gram negative bacteria

Parameter	Gram-positive bacteria	Gram-negative bacteria
Cell Wall	A single-layered, smooth cell wall	A double-layered, wavy cell-wall
Cell Wall thickness	The thickness of the cell wall is 20 to 80 nanometres	The thickness of the cell wall is 8 to 10 nanometres
Peptidoglycan Layer	It is a thick layer/ also can be multi-layered.	It is a thin layer/ often single-layered.
Teichoic acids	Teichoic acids are present.	Teichoic acids are not present.
Lipopolysaccharide	Lipopolysaccharide is not present.	Lipopolysaccharide is present.
Outer membrane	The outer membrane is not present.	The outer membrane is mostly present.
Lipid content	The Lipid content is very low.	The Lipid content is 20% to 30%.
Resistance to Antibiotic	These are very susceptible to antibiotics.	These are very resistant to antibiotics.





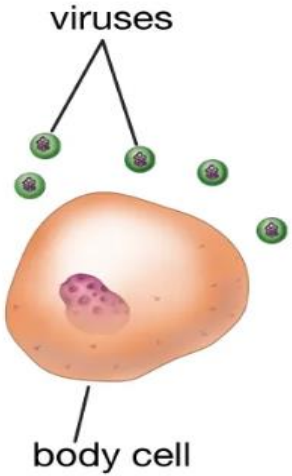
Viruses

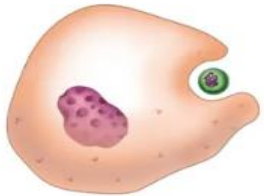
- Viruses cause **colds and flu**, as well as more serious conditions such as **HIV/AIDS, Ebola and COVID-19**
- essentially made up of **DNA or RNA that is surrounded by a protein coat**
- It needs to enter a living thing to perform its only function, which is to replicate. When a virus gets inside a human body, it can **hijack a person's cellular machinery to produce clones of itself** --- reproduce
- They also infect all life forms, from **human beings to animals to plants and even bacteria and other microorganisms**
- When the virus reproduces faster than the immune system can control it, it **begins to destroy cells and harm the body**.
- Viruses are also the **smallest germ /parasites**, making them generally the easiest to contract

❖ They're so tiny they can **spread through the air in a cough or a sneeze**.

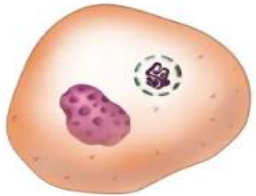
❖ Some viruses also are **spread by mosquitoes or through bodily fluid**.

How a virus invades a cell

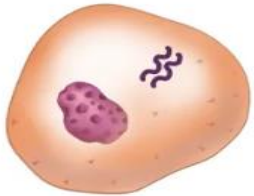




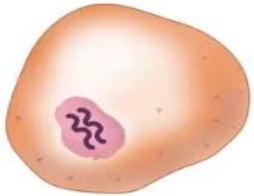
1. A virus enters a cell.



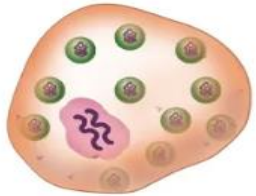
2. Substances in the cell begin to strip off the virus's outer coat of protein.



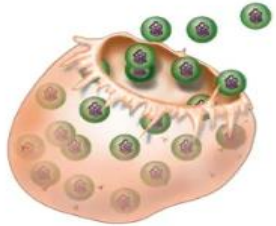
3. The nucleic acid in the center of the virus is released.



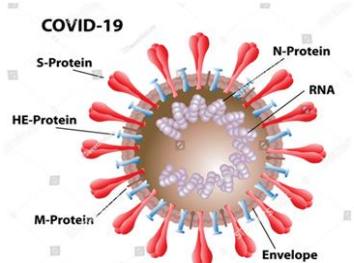
4. The nucleic acid gets into the cell's chemical manufacturing system.



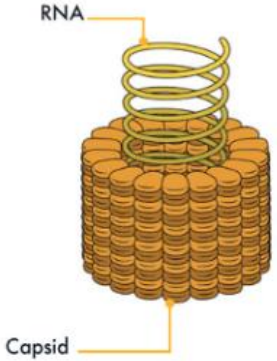
5. The cell "ignores" its own chemical needs and switches to making new viruses.

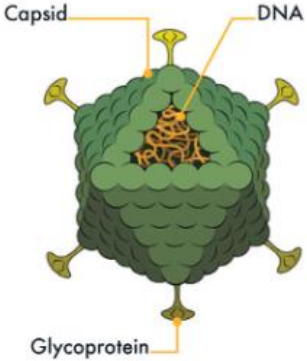


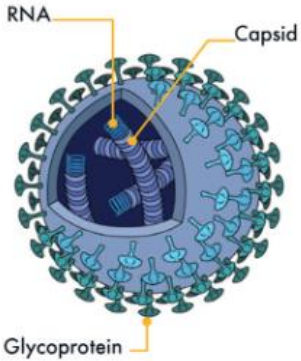
6. The cell is sometimes destroyed in the process. Many of the new viruses are released to infect other cells.

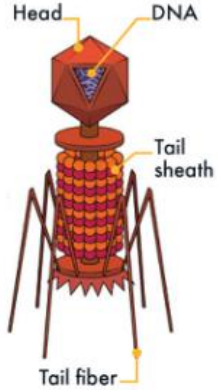


Types of Viruses







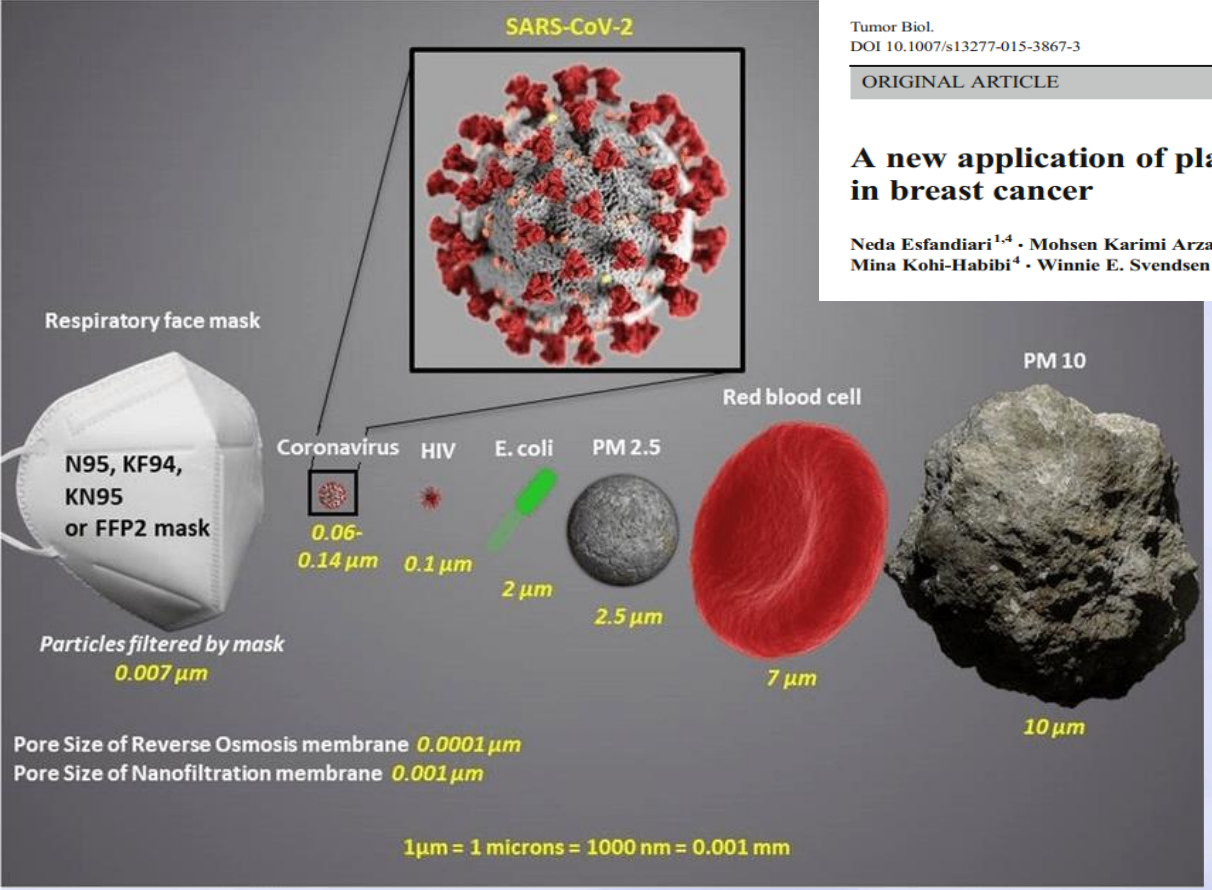


Helical viruses, like the Tobacco Mosaic Virus, which infects a number of different types of plants, have a slinky-shaped capsid that twists around and encloses its genetic material.

Polyhedral viruses, like adenoviruses, which are known to cause a range of illnesses from pink eye to pneumonia, are composed of genetic material surrounded by a many-sided capsid, usually with 20 triangular faces.

Spherical viruses, like the infamous Coronavirus, are essentially helical viruses enclosed in a membrane known as an envelope, which is spiked with sugary proteins that assist in sticking to and entering host cells.

Complex viruses, like bacteriophages, which infect and kill bacteria, resemble a lunar lander, and are composed of a polyhedral "head" and a helical body (or "tail sheath"), and legs (or "tail fibers") that attach to a cell membrane so that it can transfer its genetic material.



Tumor Biol.
DOI 10.1007/s13277-015-3867-3

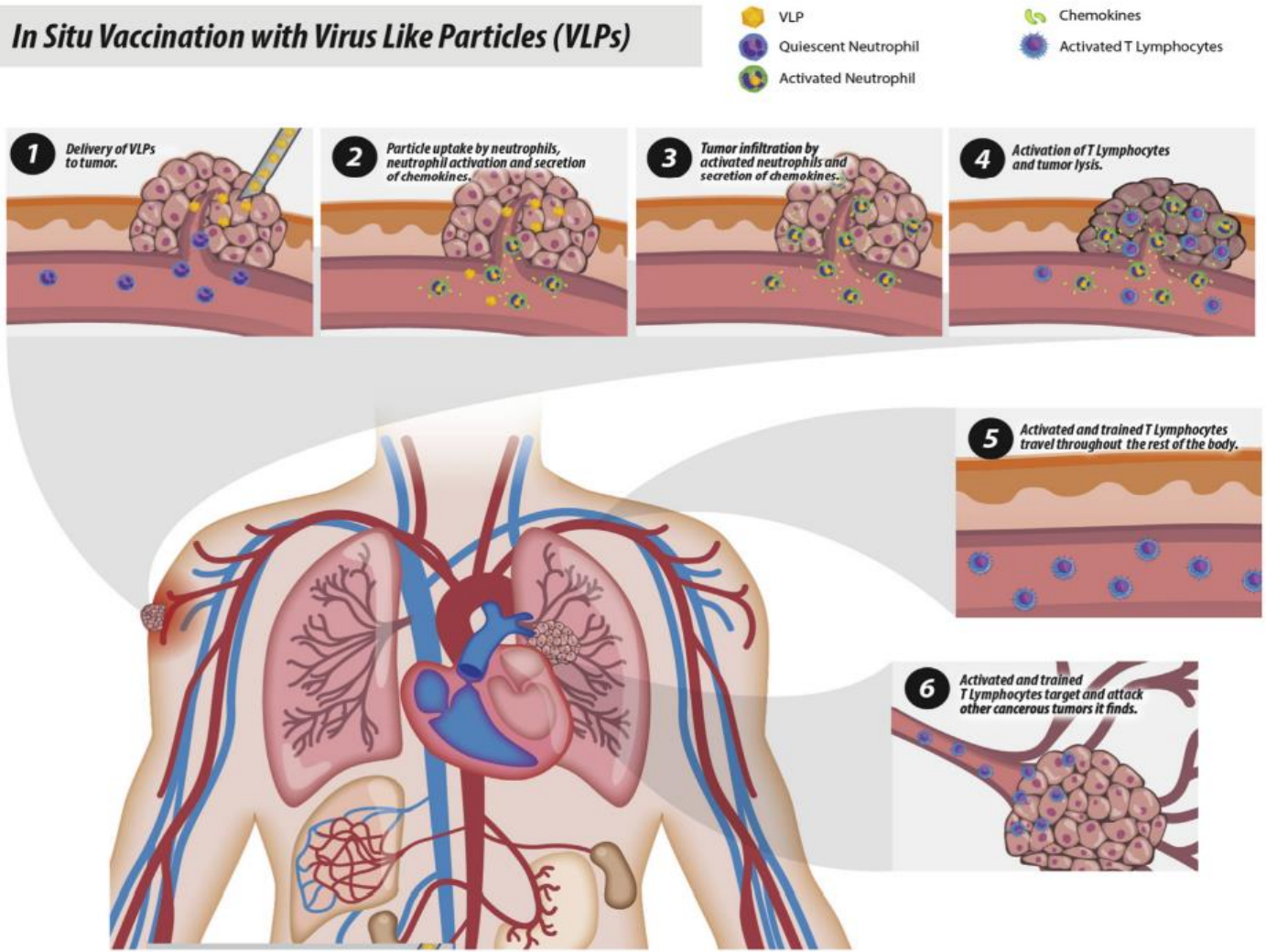
ORIGINAL ARTICLE

A new application of plant virus nanoparticles as drug delivery in breast cancer

Neda Esfandiari[1,4] · Mohsen Karimi Arzanani[2] · Masoud Soleimani[3] · Mina Kohi-Habibi[4] · Winnie E. Svendsen[1]

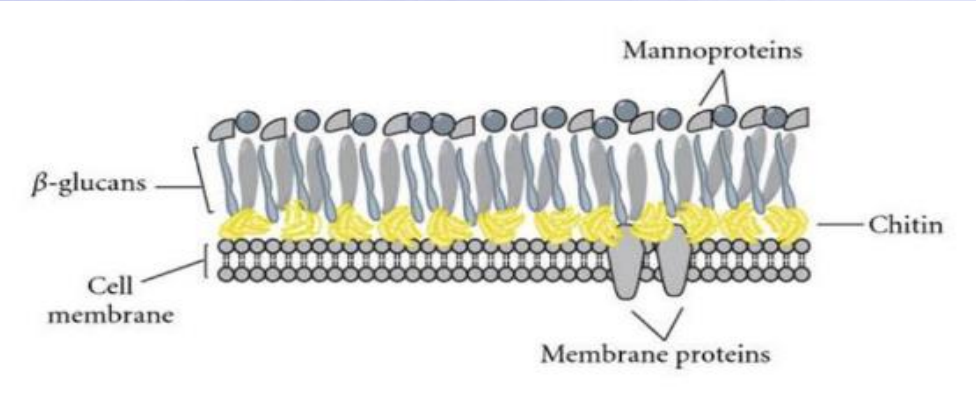
Potato virus X is presented as a carrier of the chemotherapeutic drug Herceptin that is currently used as a targeted therapy in (HER2+) breast cancer patients

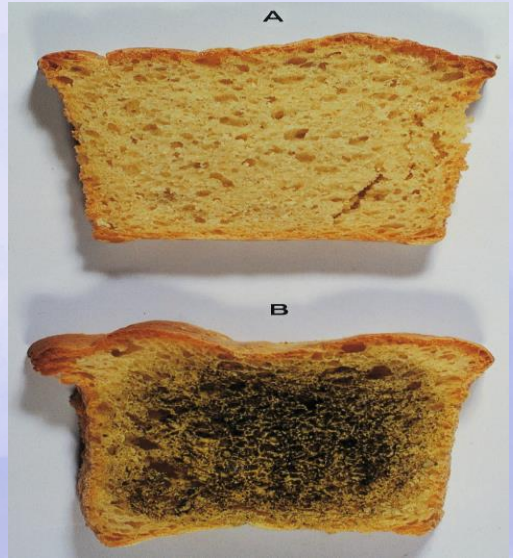
In Situ Vaccination with Virus Like Particles (VLPs)



Fungi

- Common forms: Fungi are responsible for causing conditions such as **yeast infections and meningitis**.
- They are **"eukaryotes"**
- In **collaboration with bacteria, Fungi break down organic matter and release carbon, oxygen, nitrogen, and phosphorus into the soil and environment**



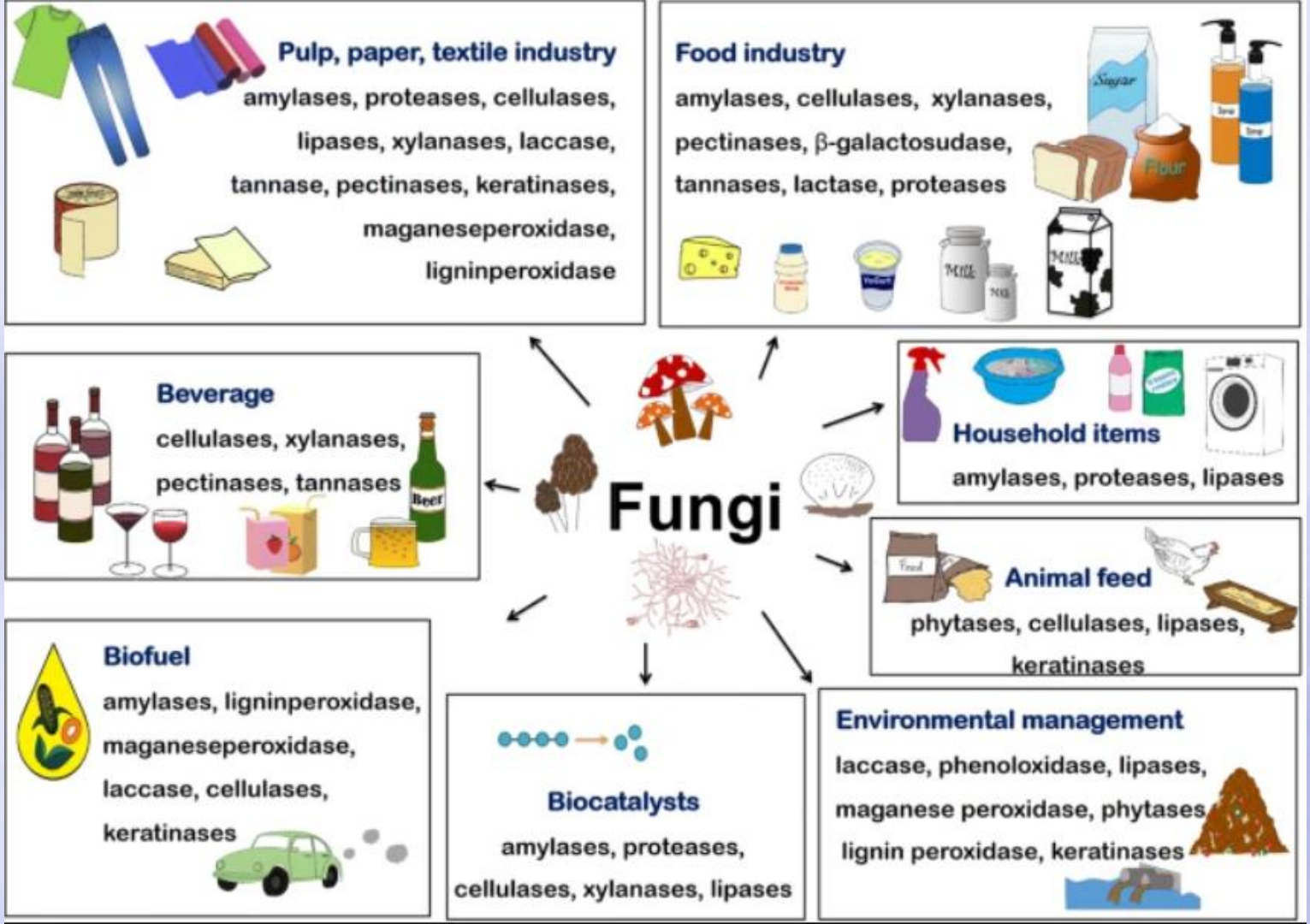


How to treat fungal infections

Antifungal medications

Benefits of Fungus

- Many domestic and commercial operations ---**production of bread, wine, beer, and some cheeses.**
- A fungus **may also be eaten**; ---mushrooms, morels, and truffles are considered an exquisite delicacy.
- **Mycoproteins (fungal proteins) generated from the mycelia** of specific fungi are used to manufacture **high-protein dishes**
- Fungi can also produce **citric acid, antibiotics, and human hormones**.
- Fungi are also **used as study models**.
- To grow, most grasses and trees need to form a mycorrhizal association with fungus.
- **Yeasts have been used to make beer, wine, and bread for thousands of years.**
- Because certain fungus prey on insects ---natural **insecticides.**


Pulp, paper, textile industry
amylases, proteases, cellulases, lipases, xylanases, laccase, tannase, pectinases, keratinases, maganeseperoxidase, ligninperoxidase
Food industry
amylases, cellulases, xylanases, pectinases, β-galactosudase, tannases, lactase, proteases
Sugar
Flour
Beverage
cellulases, xylanases, pectinases, tannases
Beer
Household items
amylases, proteases, lipases
Fungi
Animal feed
phytases, cellulases, lipases, keratinases
Biofuel
amylases, ligninperoxidase, maganeseperoxidase, laccase, cellulases, keratinases
Biocatalysts
amylases, proteases, cellulases, xylanases, lipases
Environmental management
laccase, phenoloxidase, lipases, maganese peroxidase, phytases, lignin peroxidase, keratinases

Medical Uses of Fungi:

- Fungus-derived penicillin was effectively utilized to treat a bacterial illness for the first time
- Griseofulvin, a commonly used antifungal drug, is generated from fungus
- Several fungi produce Cyclosporin A as a metabolite. It is a potent immunosuppressant in animals, and it's widely used in humans after bone marrow and organ transplants.

Agriculture:

- Fungi are being researched as possible microbial insecticides, with a few already on the market
- The mycorrhizal interaction between fungus and plant roots is critical for farmland production. 80–90% of trees and grasses would die if they didn't have a fungal companion in their root systems.

Fungi as Food

- Fungi have an important role in human nutrition. Delicacies include morels, shiitake mushrooms, chanterelles, and truffles. Agaricus campestris, or meadow mushroom, is used in various cuisines.
- Saccharomyces cerevisiae, often known as baker's yeast, is a key component of bread, which has been a necessity of human life for thousands of years.
- .Molds of the genus Penicillium ripen many pieces of cheese.

Eukaryotes – Plant And Animal Cells

Eukaryotic Cells – Charecteristics, Structure, Plant Cell And Animal Cell, Differences

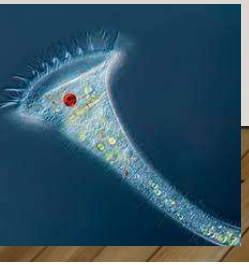
Prepared by: Dr. Louella Goveas

Asst. Professor GD III

Dept of Biotechnology Engineering

Eukaryotes

- Eukaryote – Greek eu, – meaning "well," and karyon – meaning "nut or kernel" – common scientific word – "nuclei"
- Eukaryotes – organisms made up of eukaryotic cells
- Eukaryotic Cells – are cells that contain membrane bound nucleus and organelles
- Membrane bound nucleus – consists of genetic material "DNA" arranged in the form of chromosomes.
- Various metabolic reactions – carried out – organelles
- Fungi, Protozoans, plants and animals – eukaryotic cells




Charecteristics of Eukaryotic Cells

1. Eukaryotic cells have the nucleus enclosed within the nuclear membrane.
2. The nucleus contains linear DNA, which carries all the genetic information.
3. The cell has membrane enclosed organelles – specific function –energy production, photosynthesis
4. Outermost layer – Cell Wall/Cell Membrane
5. The cells divide by a process called mitosis.
6. The eukaryotic cells contain a cytoskeletal structure.

Eukaryotic Cell – Structure

1. Cell Wall (Only Plant cells)
2. Cell/Plasma Membrane
3. Cytoplasm
4. Cytoskeleton
5. Nucleus
6. Ribosome
7. Endoplasmic Reticulum
8. Mitochondrion
9. Golgi Apparatus
10. Lysosome
11. Vacuole

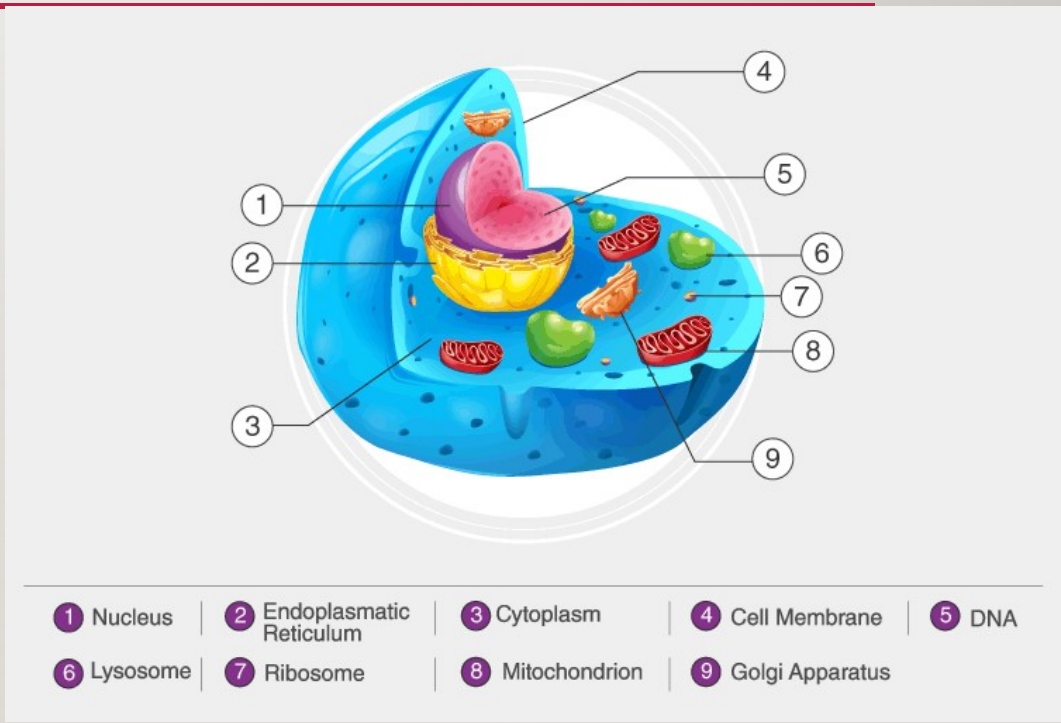


Fig: Structure of a Eukaryotic Cell

Eukaryotic Cell – Structure

1. Cell Wall

- Rigid protective structure present outside the plant cell – injury or pathogen attacks
- Provides shape to the cell and helps in cell-to-cell interaction.
- It is composed of cellulose, hemicellulose, pectin's, proteins, etc.

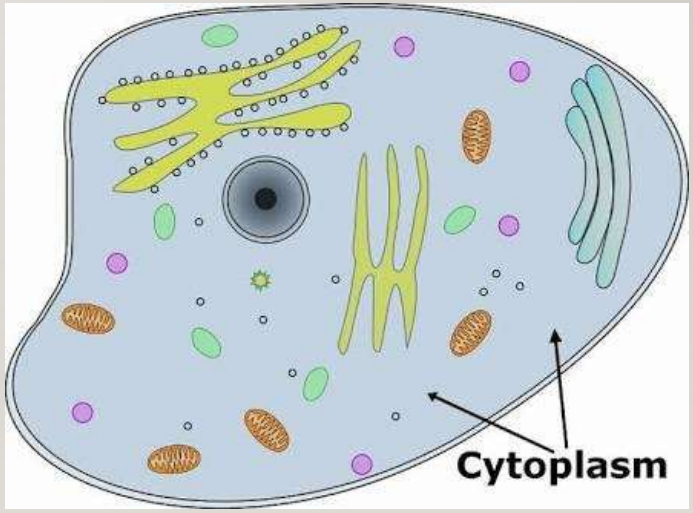
2. Cell/Plasma Membrane

- Separates the cell from the outside environment.
- Comprises of a bilayer of phospholipids
- Specific embedded proteins – exchange of substances in and out of the cell.

Eukaryotic Cell – Structure

3. Cytoplasm

- Region of cell between plasma membrane and nuclear membrane ‘
- Cytosol – water based solution.
- Nucleus and Cell organelles suspended in cytosol
- Semisolid jelly like consistency



Eukaryotic Cell – Structure

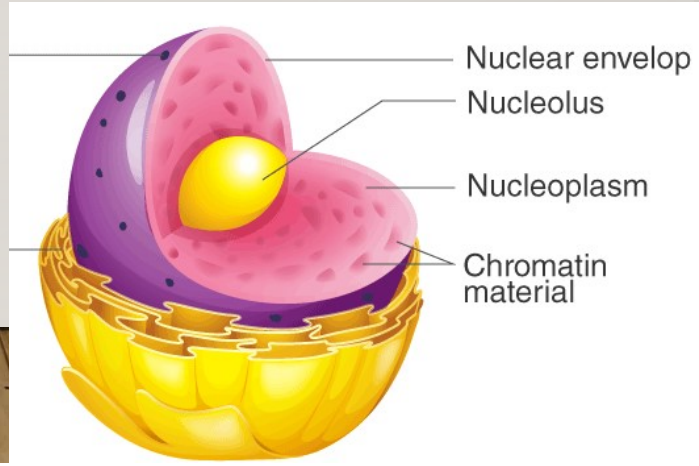
4. Cytoskeleton

- Cytoskeleton – Highly structured network of filaments
- Supports the cytoplasm, gives perfect shape to cells
- Positions the organelles and helps in movement of cell
- Microfilaments, intermediate tubules and microtubules

Eukaryotic Cell – Structure

5. Nucleus

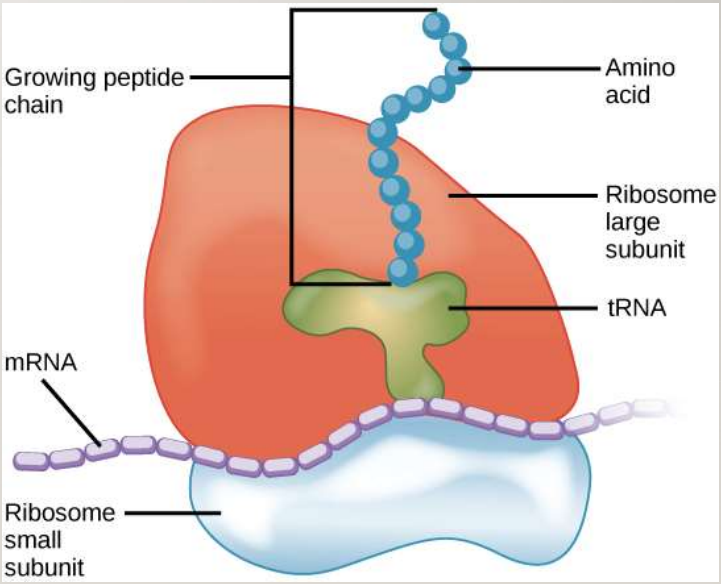
- Nuclear Envelope – two layers – outer membrane and inner membrane
- Membranes are permeable to ions, molecules, and RNA material.
- Nucleoplasm enclosed within the nucleus contains DNA and proteins.
- DNA is linear – arranged in the form of chromosomes
- Nucleolus – center of nucleus
- Function – to produce ribosomes



Eukaryotic Cell – Structure

6. Ribosomes

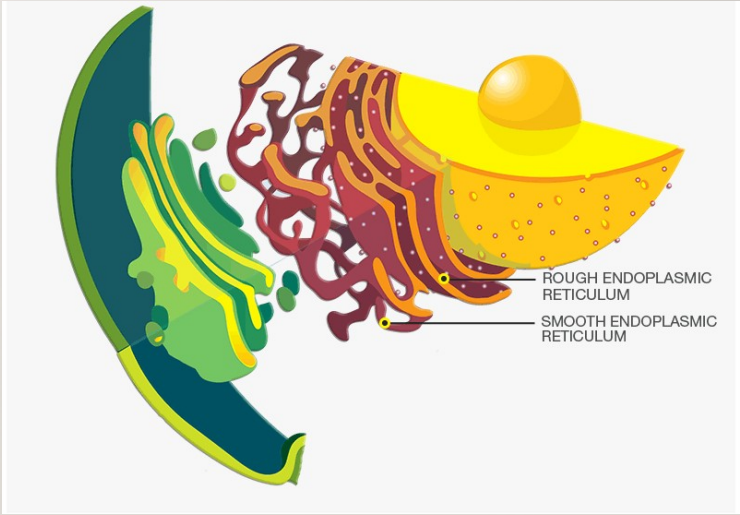
- A ribosome – two units of RNA and proteins
- The large subunit sits on top of the small subunit, with an RNA template sandwiched between the two
- Free in the cell or embedded to nucleus and rough ER
- Function – Synthesis of proteins



Eukaryotic Cell – Structure

7. Endoplasmic Reticulum (ER)

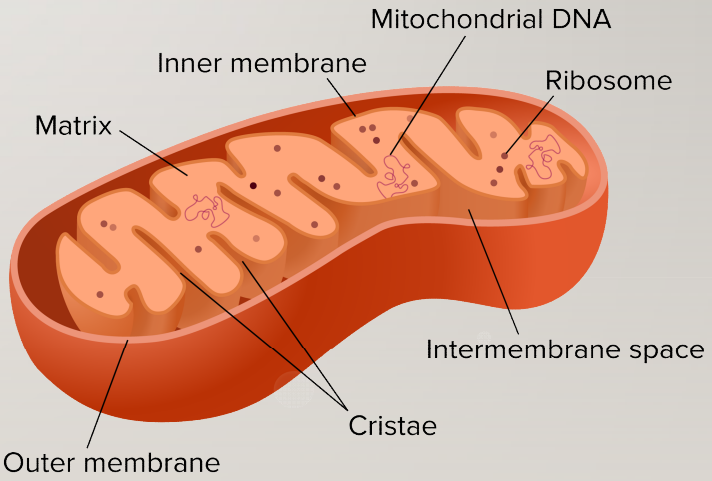
- Complex structure of tubular networks formed by membranes – joins the outer membrane of nucleus
- Two types – Rough & Smooth
- Rough ER – flattened sacs – ribosomes embedded on its surface – protein synthesis, folding & sorting
- Smooth ER – tubular form
- Multiple functions – phospholipid, cholesterol and steroid hormone synthesis, carbohydrate metabolism, stores calcium ions



Eukaryotic Cell – Structure

8. Mitochondrion

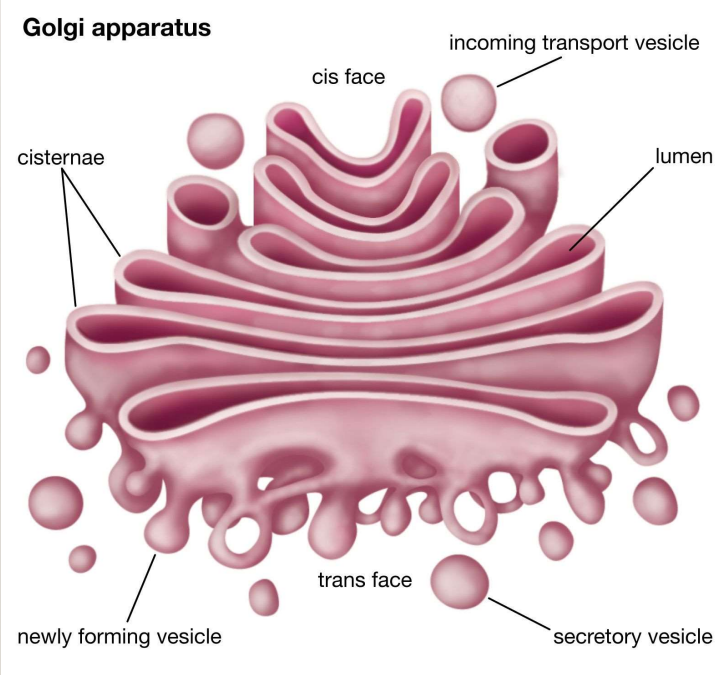
- Mitochondria are the "powerhouses" of the cell, breaking down fuel molecules and capturing energy in cellular respiration.
- Oval Shaped – two membrane – one intact
- Second inner membrane – inward protrusions – cristae
- Function – Adenosine Tri Phosphate (ATP) – energy supply
- Matrix – ribosomes and mitochondrial DNA



Eukaryotic Cell – Structure

9. Golgi Apparatus

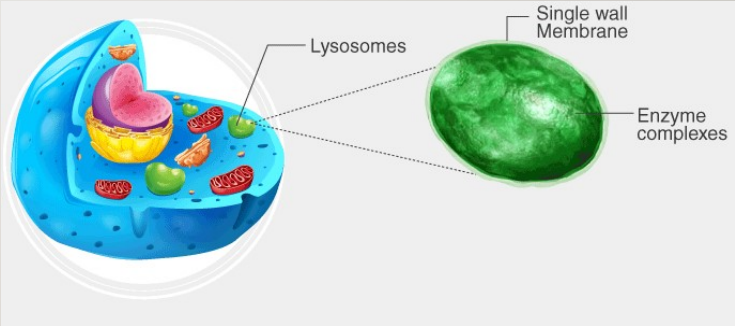
- membrane-bound organelle – series of flattened, stacked pouches called cisternae.
- 4 – 6 cisternae
- Present next to ER and near the cell nucleus
- Function – transport, modify and package proteins and lipids into vesicles for delivery to targeted destinations in the cell



Eukaryotic Cell – Structure

10. Lysosome

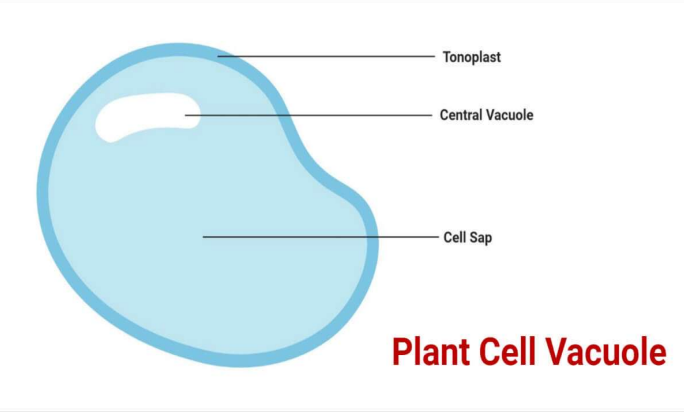
- Sphere-shaped sacs filled with hydrolytic enzymes that have the capability to break down many types of biomolecules.
- Membrane bound organelles and region within membrane is called lumen
- Function – breakdown cellular wastes and debris by engulfing them with hydrolytic enzymes
- Suicide Bags of the cells – sometimes resulting in autolysis



Eukaryotic Cell – Structure

11. Vacuole

- Membrane-bound cell organelles present in the cytoplasm and filled with a watery fluid containing various substances
- Membrane around vacuole – tonoplast.
- Components of the vacuole – cell sap
- Functions – Storage of salts, minerals, proteins and pigments
- Endocytosis and Exocytosis
- Animal cells – small and numerous, plant cell – large and single

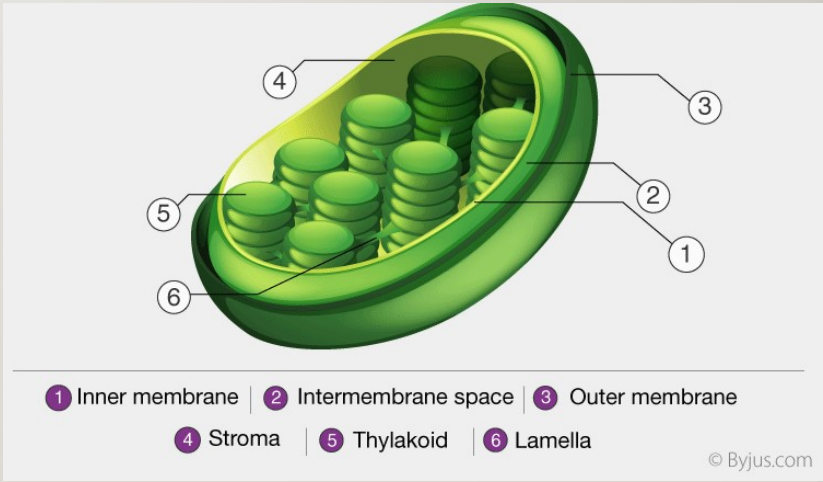


Plant Cell

- Plant Cell – Eukaryotic Cell – Basic unit of a plant
- They are cells with a nucleus and few organelles similar to that of an animal cell, although they are certain distinctions
- Shape – Rectangular
- Additional Organelles
- Plastids – Chloroplast, Leucoplast

Chloroplast

- Chloroplast – Organelle that contains Chlorophyll that captures sunlight and converts it into useful energy, thereby, releasing oxygen from water.
- Two regions – Grana and Stroma
- Stroma – matrix which contains grana
- Grana – Stacks of disc-shaped structures – thylakoids or lamellae. Grana of the chloroplast – chlorophyll pigments and are the functional units of chloroplasts.
- Function – synthesize food by capturing sunlight and CO_2 by photosynthesis

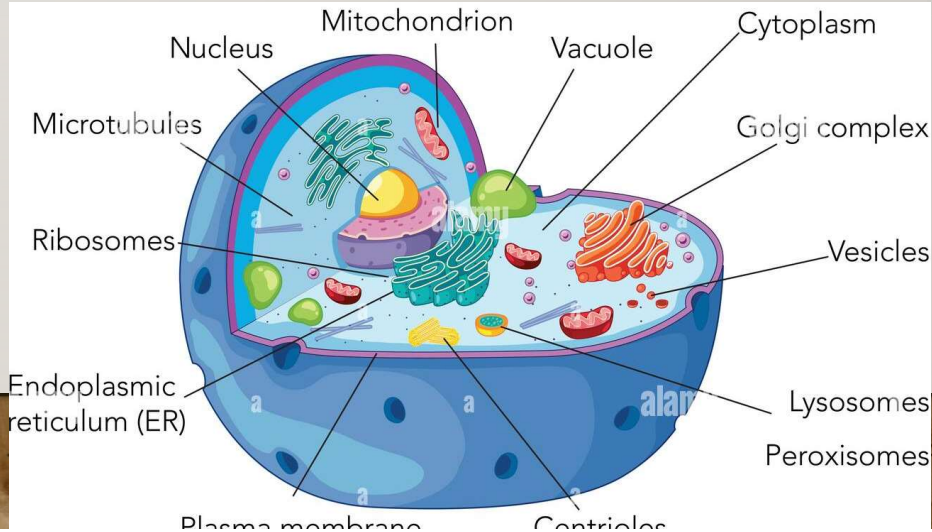


Animal Cell

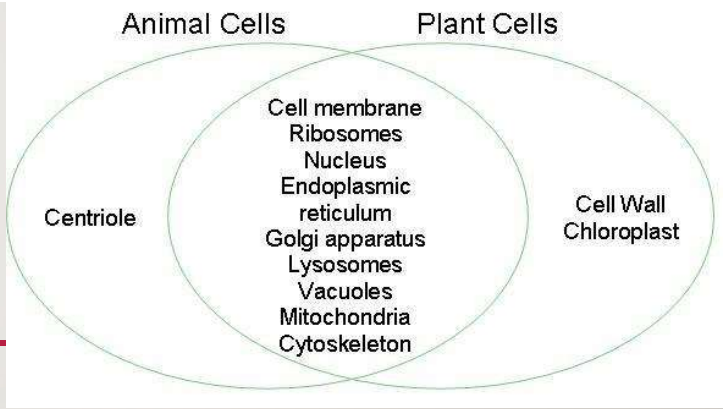
- Animal Cell – Eukaryotic Cell – Basic Unit of an Animal
- An animal cell is a type of eukaryotic cell that lacks a cell wall and has a true, membrane-bound nucleus along with other cellular organelles
- Different shapes – flat, oval, irregular or round
- Additional Organelle – Centrosome
- Centrosome/Centrioles – Thick centre with radiating

Tubules

- Center for production of microtubules



Differences Between Plant Cell And Animal Cell



PLANT CELL

1. Square or Rectangular Shape
2. Cell Wall Present
3. Nucleus lies in one side of the cell
4. Centrosomes/Centrioles Absent
5. Plastids present
6. Large vacuole centrally placed
7. Cilia absent
8. Autotrophic mode of nutrition

ANIMAL CELL

1. Round or Irregular Shape
2. Cell Wall Absent
3. Nucleus lies in the centre of the cell
4. Centrosomes/Centrioles Present
5. Plastids absent
6. Vacuole small and numerous
7. Cilia present in most of the cells
8. Heterotrophic mode of nutrition

Watch for More Understanding

- Introduction to Cells (Includes differences between plant and animal cells) - https://www.youtube.com/watch?v=8IlzKri08kk

THANK YOU

Biomolecules

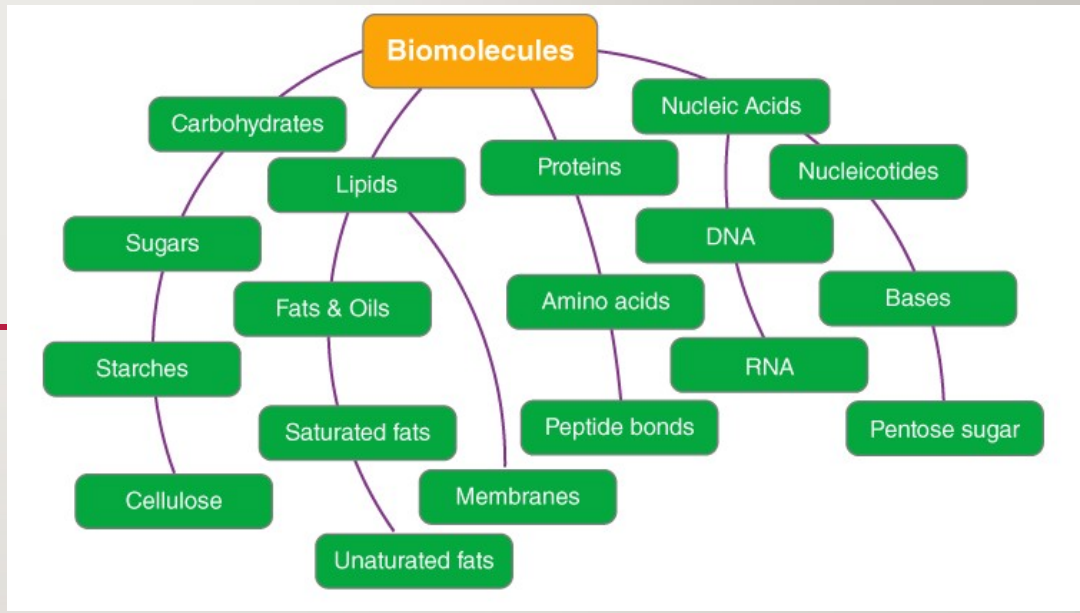
Introduction to Lipids, Carbohydrates, Proteins and Nucleic Acids, Importance in Human Body

Prepared by : Dr. Louella Goveas

Asst. Professor GD III

Dept of Biotechnology Engineering

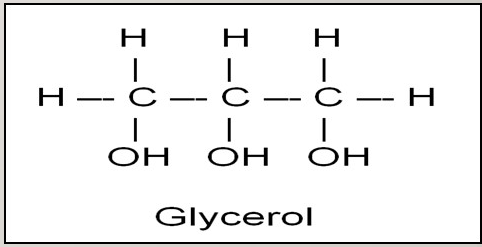
Biomolecules

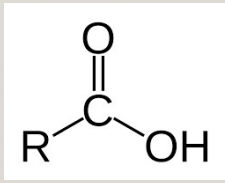


- Organisms – fundamental unit – cell.
- Cell – organic & inorganic compounds.
- Organic Compounds – Proteins, Carbohydrates, Lipids, Nucleic acids – Biomolecules.
- Biomolecules – Organic molecules present in the cell

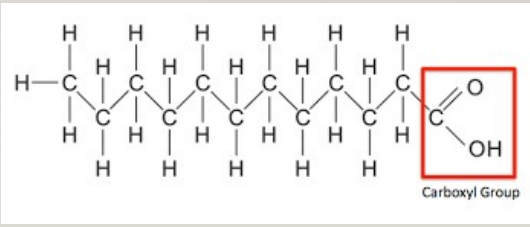
Lipids

- Lipids – class of biomolecules – insoluble or sparingly soluble in aqueous solutions and soluble in organic solvents.
- Fatty acids and glycerol – major constituents of lipids.
- Glycerol – has 3 carbon atoms attached to alcohol groups
- Fatty acids – single carboxyl group containing short/long-chain *hydrocarbon molecules.
- Fatty acid – total number of carbons
- Eg: Palmitic acid a 16-carbon fatty acid $CH3(CH_2)_{14}COOH$ – designated as C16.
- No double bonds – C16:0 – C:16:1





Carboxylic acid



Fatty Acid

*hydrocarbon – molecule made up of only C and H

Fatty Acids – Types

1. Saturated fatty acids: Fatty acids with no double bonds

- Short carbon chains – liquid at room temp
- Long carbon chains – solid at room temp

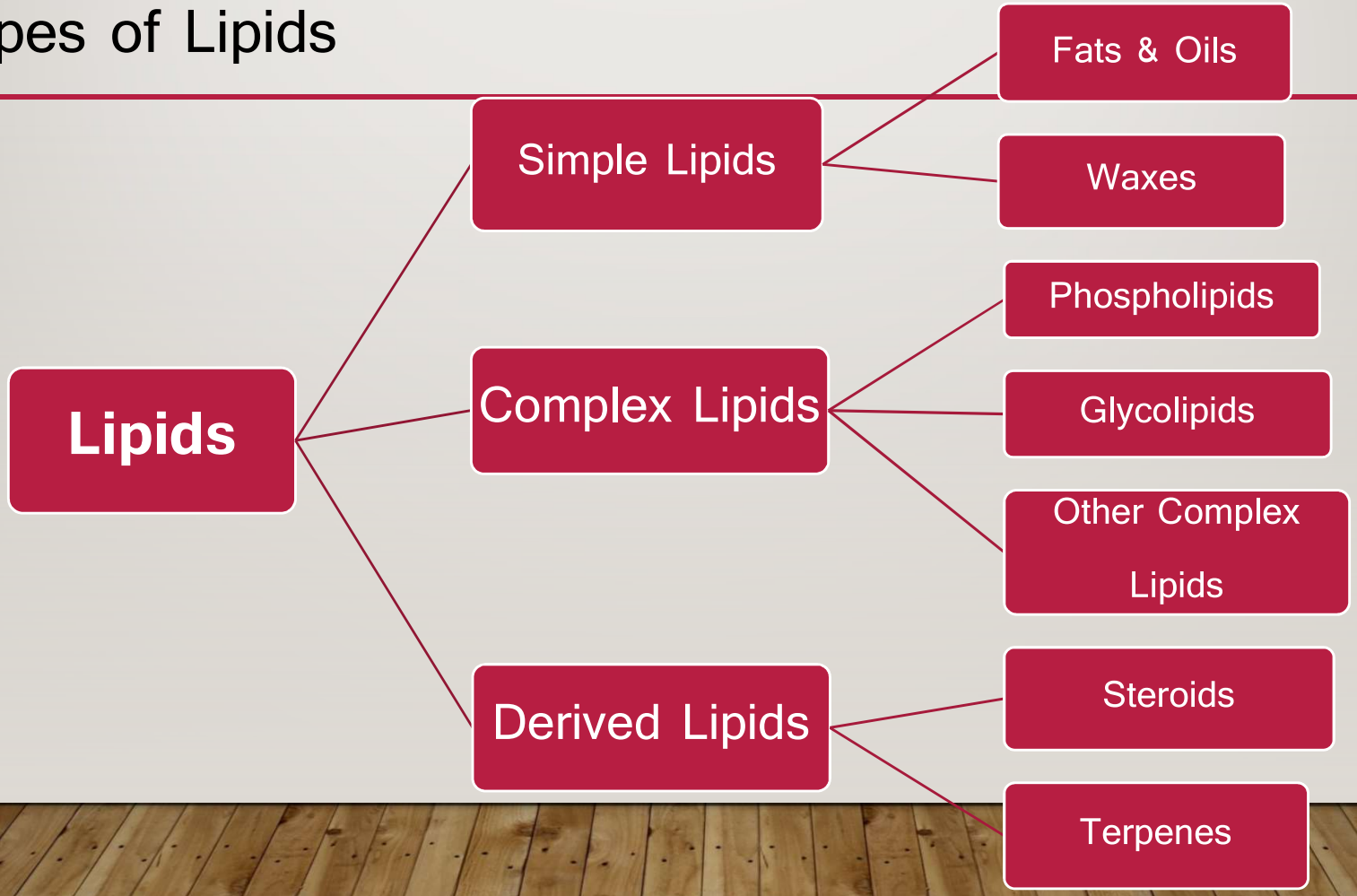
2. Unsaturated fatty acids: Fatty acids with double bonds

Representation	Common Name	Structure
4:0	Butyric acid	$CH3(CH_2)_2COOH$
6:0	Caproic acid	$CH3(CH_2)_4COOH$
10:0	Decanoic acid	$CH3(CH_2)_8COOH$
12:0	Lauric acid	$CH3(CH_2)_{10}COOH$
14:0	Myristic acid	$CH3(CH_2)_{12}COOH$
16:0	Palmitic acid	$CH3(CH_2)_{14}COOH$
18:0	Stearic acid	$CH3(CH_2)_{16}COOH$
20:0	Arachidic acid	$CH3(CH_2)_{18}COOH$

- Representations – number of carbon atoms, double bond and the place of unsaturation.
- Place of double bond– indicated by symbol (Δ) and the number of the first carbon of the double bond in superscript form.
- Eg: Oleic acid – 18-carbon fatty acid – one site of unsaturation between carbons 9 and 10 – $C18{:}1\Delta^9$.

$18{:}1\Delta^{9}$	Oleic acid	$CH_3(CH_2)_7C{=}C(CH_2)_7COOH$
$18{:}2\ \Delta^{9,12}$	Linoleic acid	$CH_3(CH_2)_4C{=}CCH_2C{=}C(CH_2)_7COOH$
$18{:}3\ \Delta^{9,12,15}$	Linolenic acid	$CH_3CH_2C{=}CCH_2C{=}CCH_2C{=}C(CH_2)_7COOH$
$20{:}4\ \Delta^{5,8,11,14}$	Arachidonic acid	$CH_3(CH_2)_3(CH_2C{=}C)_4(CH_2)_3COOH$

Types of Lipids



Simple Lipids

- Esters of fatty acids with alcohol
- 2 types.

1. Fats and Oils – Esters of fatty acids with glycerol
2. Waxes – Esters of long chain saturated fatty acids with other long chain alcohols

Examples: Bees wax, paraffin wax, ear wax etc

Complex Lipids

- Esters of fatty acids with alcohol and other groups
- 3 types.

1. Phospholipids – Lipids containing fatty acids with alcohol and a phosphate group
2. Glycolipids – Lipids containing fatty acids, alcohol and a carbohydrate
3. Other Complex Lipids – sulpholipids, aminolipids and lipoproteins

Derived Lipids

- Obtained by hydrolysis of simple and complex lipids
- 2 types.

1. Steroids – Do not contain fatty acids, but are made up of 4 fused carbon rings

Eg: Cholesterol, Vitamin D, testosterone

2. Terpenes – Component of essential oils derived by plants

Eg: Lycopene, Carotenoids etc

Importance in Human Body

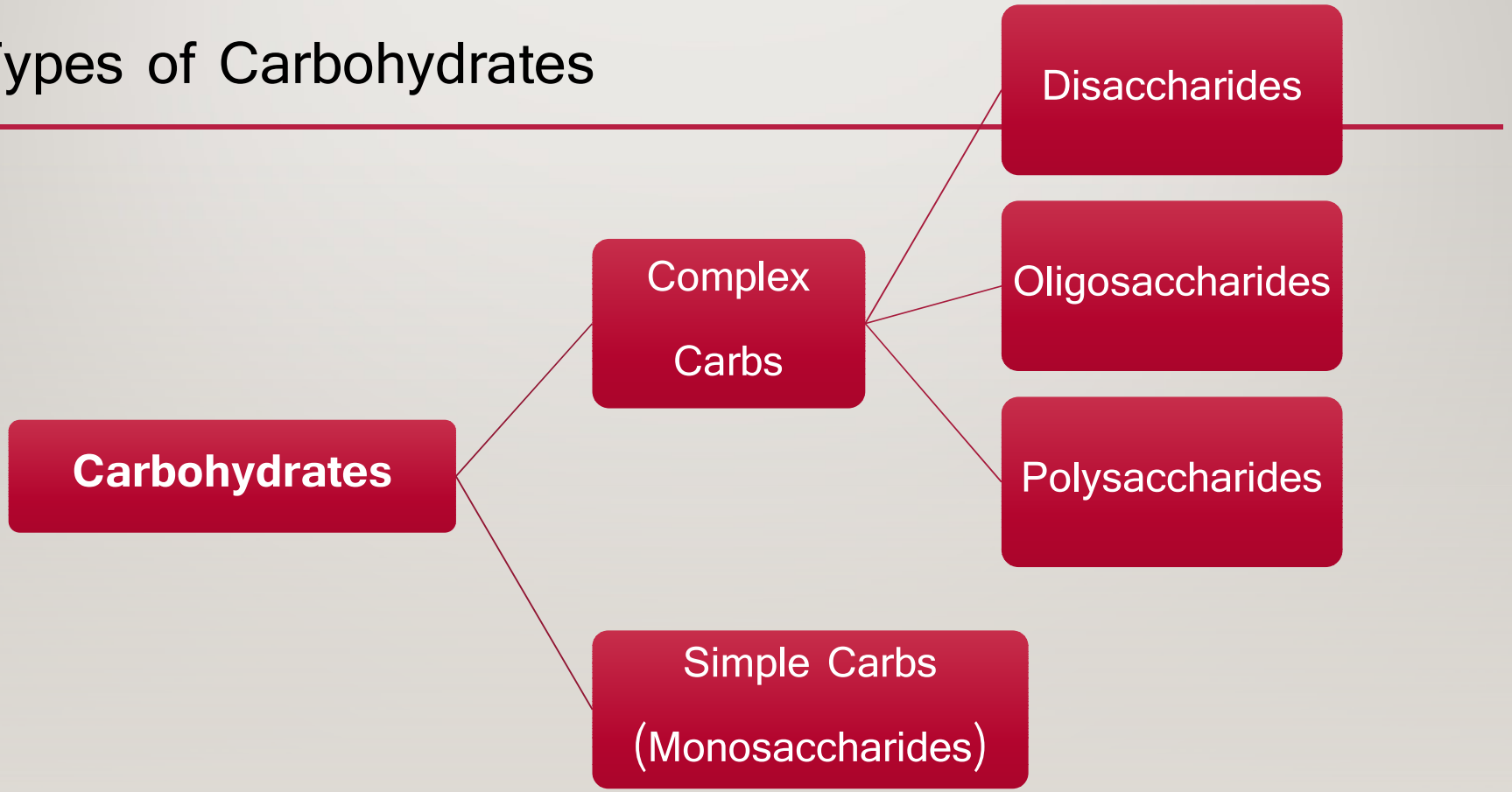
- Fats – correct amounts – proper functioning of our body.

- Some vitamins are fat-soluble – associated with fats – effectively absorbed by the body.
- Offer insulation to the body.
- Efficient way to store energy for longer periods
- Activators of some mitochondrial enzymes
- Some of lipid derivatives act as hormones Eg: testosterone
- Phospholipids – component of cell membrane
- Sphingolipids – myelin sheath of nerve fibers
- Lipoproteins – transport lipids in the blood, Examples: VLDL, LDL, HDL

Carbohydrates

- Carbohydrates are organic molecules, containing C, H and O where in H and O are in the ratio 2:1
- General formula – $C_n(H_2O)_n$
- Essential nutrients – sugars, fibers and starches. They are found in grains, vegetables, fruits and in milk and other dairy products.
- Classification – Chemical structure and degree of polymerization

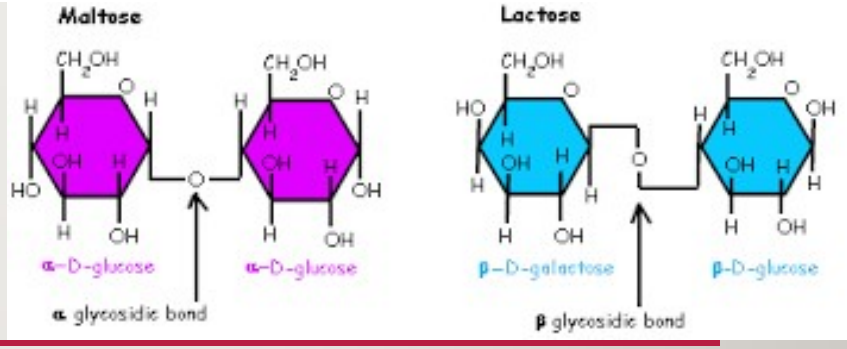
Types of Carbohydrates



Simple Carbs – Monosaccharides

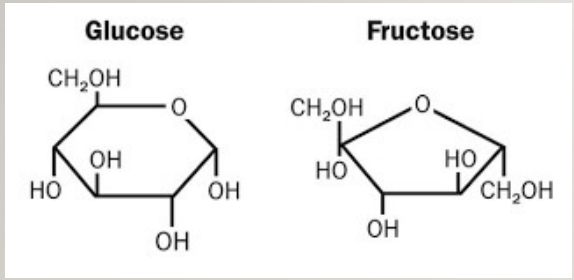
- Basic Unit of Carbohydrate – cannot be hydrolyzed further
- Based on functional groups – ketoses and aldoses
- Ketoses – Functional group – ketone (C = O) Eg: Fructose
- Aldoses – Functional group – aldehyde (– CHO) Eg: Glucose ($C_6H_{12}O_6$)
- Based on number of carbon atoms – trioses, tetroses, pentoses, hexoses, heptoses
- Pentoses – ribose, deoxy ribose
- Hexoses – glucose, fructose, galactose

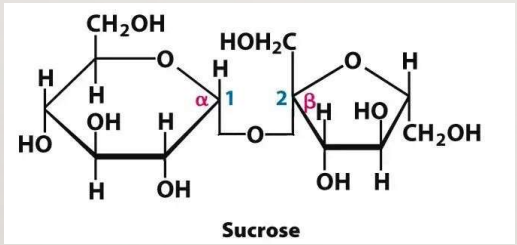
Complex Carbs

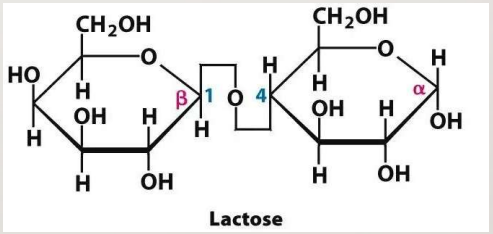


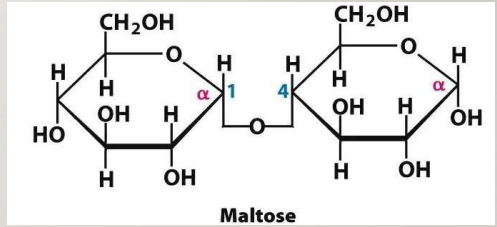
- Complex Carbohydrates – having two or more than two sugar units joined by a glycosidic bond (α or β)
- Types based on number of sugar units
- Disaccharides – two monosaccharides Eg: lactose (glucose + galactose), Sucrose (glucose + fructose), Maltose (glucose + glucose)
- Oligosaccharides – more than 2, less than 10 monosaccharides Eg: Raffinose and Stachyose
- Polysaccharides – more than 10 sugar units Eg: Starch, amylase and glycogen

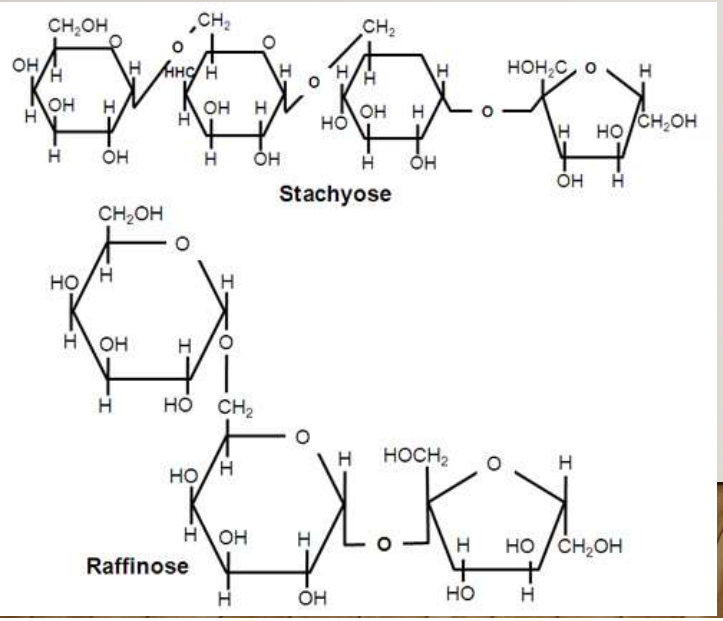
Structures of common carbohydrates

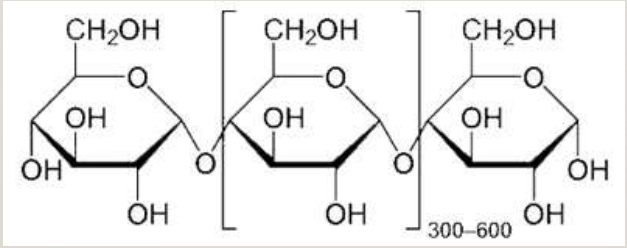




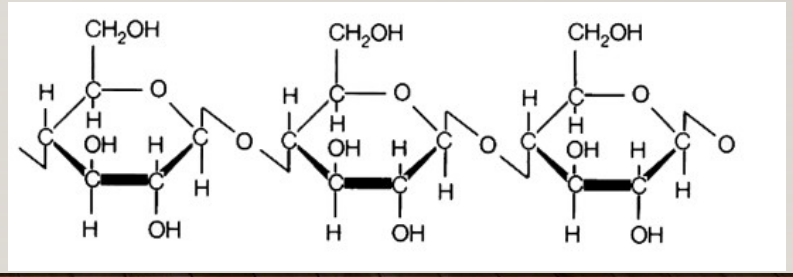








Amylose



Cellulose

Importance in Living Systems

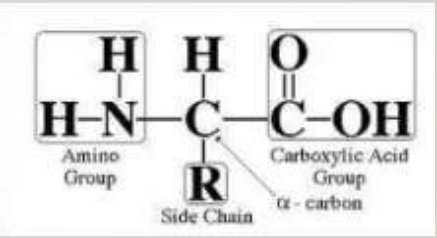
- Carbohydrates – macronutrients – main way our body obtains its energy.
- Basic food groups which play an important role in a healthy life.
- Food containing carbohydrates – glucose or blood sugar – digestion by the digestive system.
- Our body utilizes this sugar as a source of energy for the cells, organs and tissues.
- It is also involved in fat metabolism and prevents ketosis.
- Inhibits the breakdown of proteins for energy as they are the primary source of energy.
- Precursor for many organic compounds

Importance in Living Systems

- Sucrose – cane sugar, Lactose – milk, Maltose – Barley malt
- Raffinose – legumes, vegetables such as – beans, peas, soy, cabbage, brussels sprouts, and broccoli – undigestable by humans – causes flatulence
- Starch – Storage sugar in plant cells – present in tubers, like potatoes and corn seeds.
- Glycogen – storage polysaccharide in animal cells and it easily converted back to glucose to provide energy
- Cellulose/Hemicellulose – major structural polysaccharide, predominant in the cell wall of the plants

Proteins

- Proteins – pivotal roles in a wide array of cellular activities
- Constituted by amino acids, as monomeric unit or building blocks
- Made up of amino, carboxyl moieties and "R" group (also called as side chain)
- 20 amino acids – 7 groups
- Proteins are made up of multiple polypeptide chains
- Polypeptide chains – amino acids joined by peptide bonds
- Peptide bond – (–CONH–) – amine group of one amino acid and carboxyl group of second amino acid.



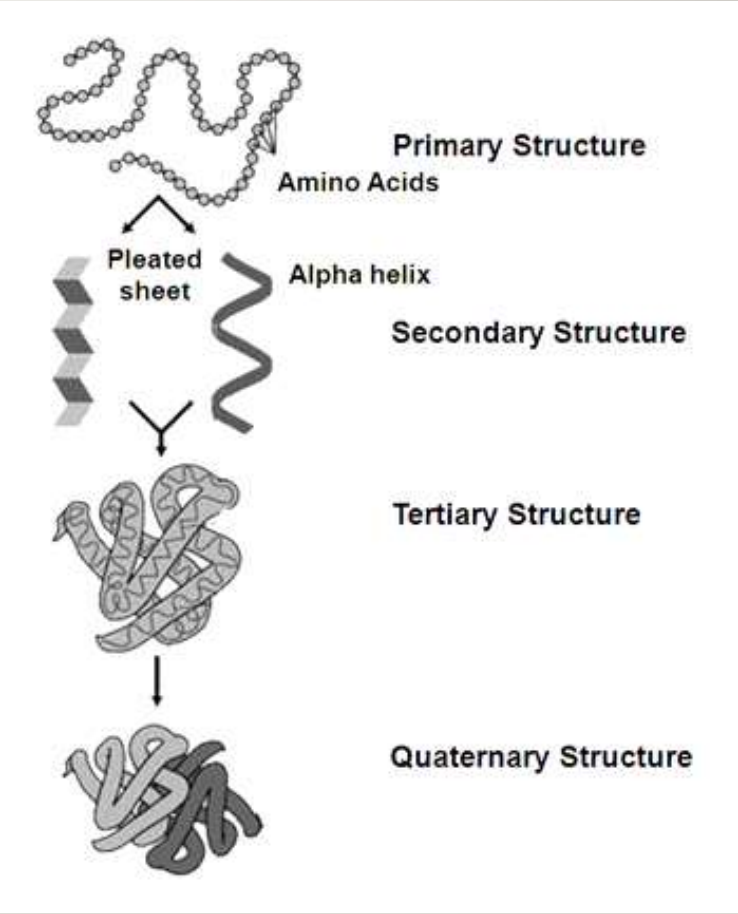
Amino Acid Groups

No.	Nature	Amino acids
1.	**NEUTRAL** : Amino acids with 1 amino and 1 carboxyl group	Glycine (Gly), Alanine (Ala), Valine (Val), Leucine (Leu), Isoleucine (Ile)
2.	**ACIDIC** : 1 extra carboxyl group	Aspartic acid (Asp), Asparagine (Asn), Glutamic acid (Glu), Glutamine (Gln)
3.	**BASIC :** 1 extra amino group	Arginine (Arg), Lysine (Lys)
4.	**S – CONTAINING :** Amino acids have sulphur	Cysteine (Cys), Methionine (Met)
5.	**ALCOHOLIC** : Amino acids having –OH group	Serine (Ser), Threonine (Thr), Tyrosine (Tyr)
6.	**AROMATIC** : Amino acids having cyclic structure	Phenylalanine (Phe), Tryptophan (try)
7.	**HETEROCYCLIC** : amino acids having N in ring structure	Histidine (His), Proline (Pro)

Structure of Proteins

- Proteins have a total of four levels of structures.

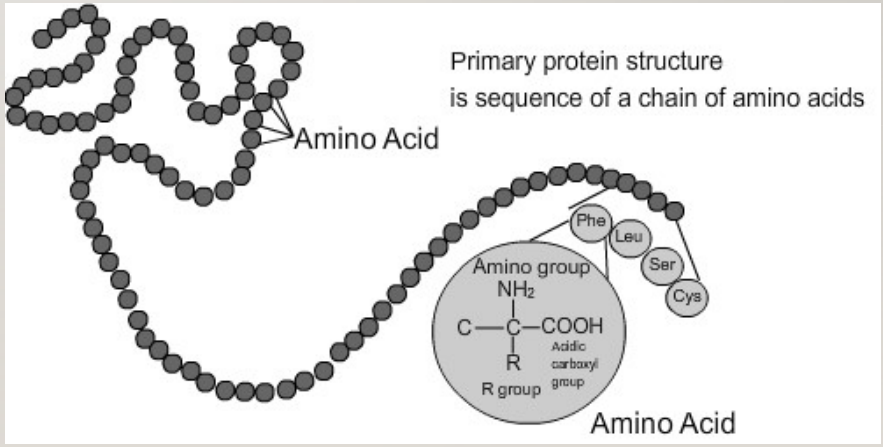
1. Primary structure.
2. Secondary structure.
3. Tertiary structure.
4. Quaternary structure.



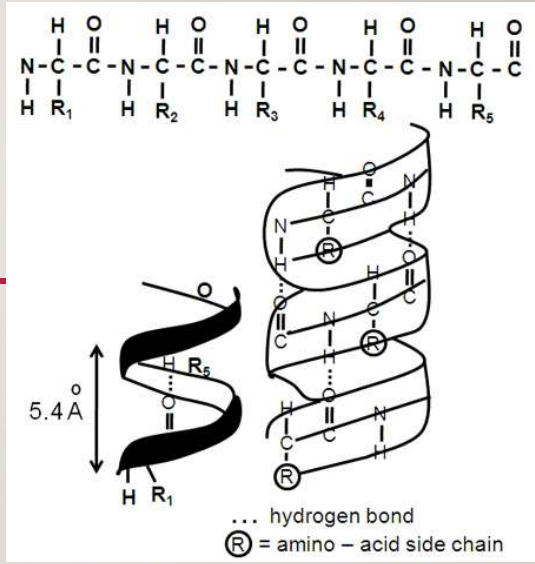
Structure of Proteins

1. Primary structure

- Simple amino acid sequence of a protein
- Arrangement of the chain – depends on sequence of amino acid residues – proper protein folding,
- Primary structure dictate 3D protein structure

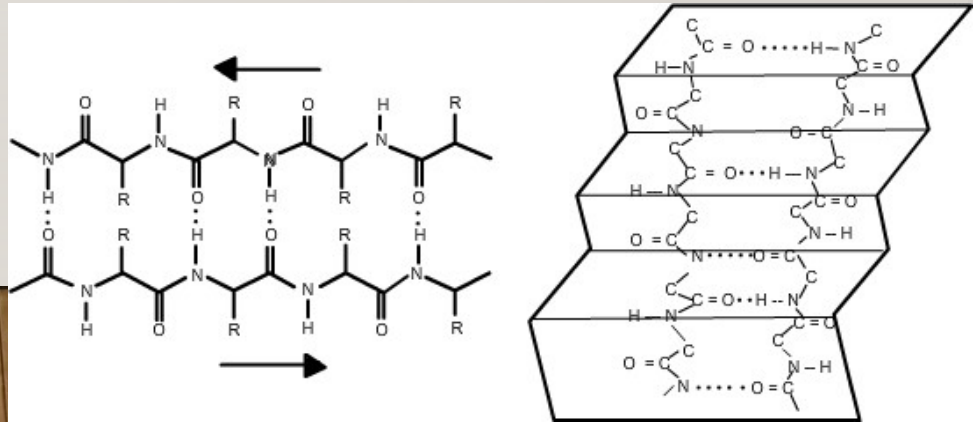


Structure of Proteins



2. Secondary structure

- Two main types – alpha helix and beta pleated sheets
- Alpha helix is a helical structure around an axis – 3.6 amino acids per turn
- Beta pleated sheet – two or more straight chains that are hydrogen bonded side by side



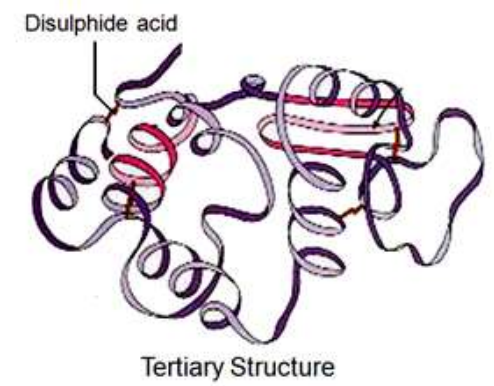
Structure of Proteins

3. Tertiary structure

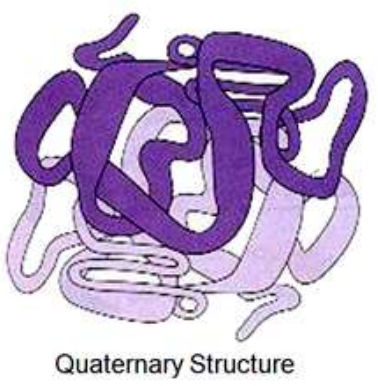
- Helical polypeptide – comprised of alpha helix and beta pleats fold upon itself
- Amino acids link with each other by polar-polar interaction, hydrophobic interaction, ionic interaction, disulfide bonds, Van der Waals forces, hydrogen bonds.

4. Quaternary structure

- Multiple polypeptide chains
- Associated with one another



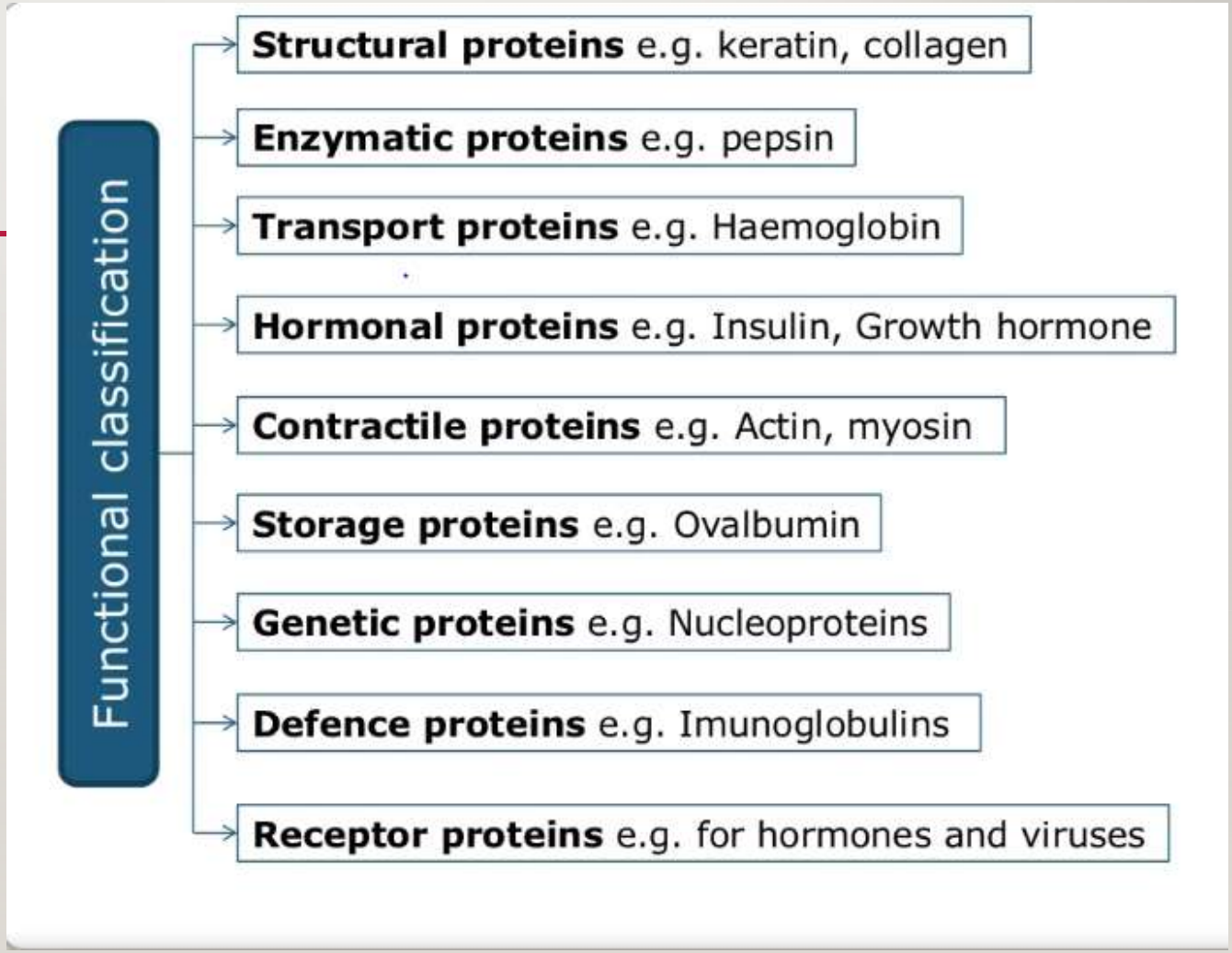
Tertiary Structure


Quaternary Structure

Importance in Living Systems

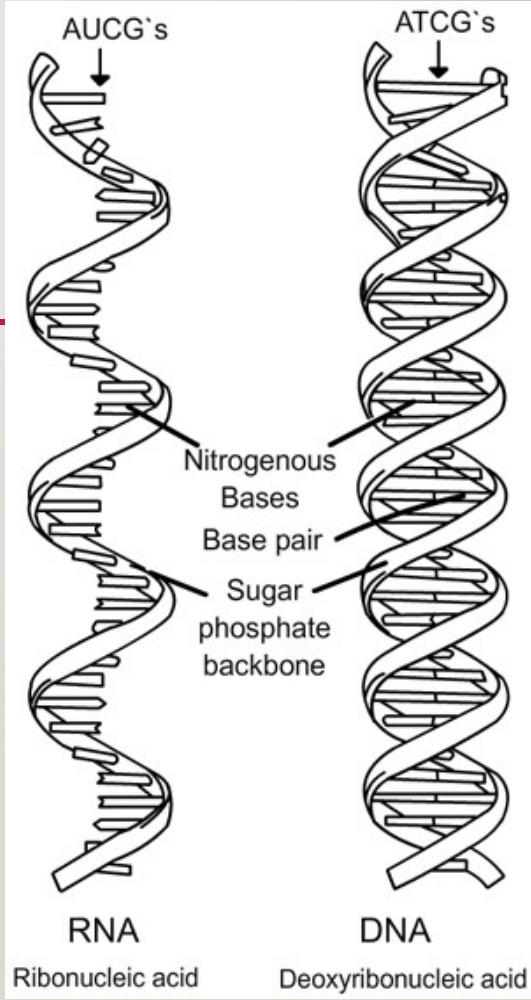
- Biocatalysis – all the biological reactions are catalyzed by the enzymes.
- Membranes and membrane receptors – lipoproteins and proteins in nature
- Transport and storage proteins – e.g. hemoglobin – transport of oxygen to tissues.
- Muscles and contraction – actin and myosin –proteins
- Mechanical support – Bones and skin are strengthened by the protein collagen.
- Antibodies of immune system are protein structures.
- Many of the hormones and growth factors such as insulin or thyroid stimulating hormone are proteins.

Protein Functions

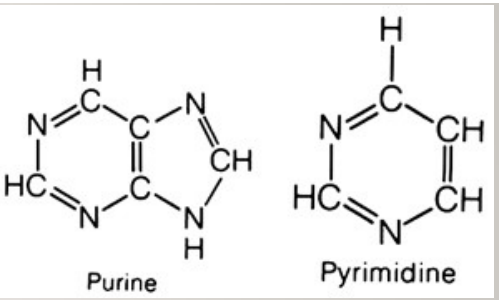


Nucleic Acids

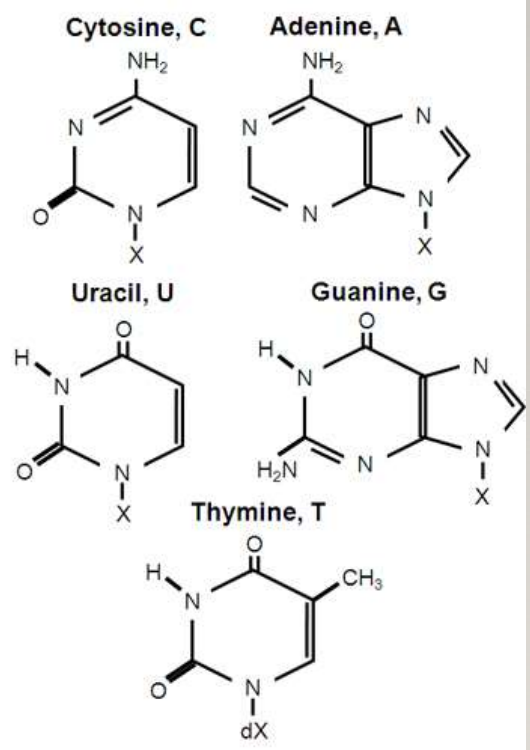
- Nucleic acids – genetic material – hereditary information from parents to progeny.
- Two types of nucleic acids namely, deoxyribonucleic acid (DNA) and ribonucleic acid (RNA).
- Main function – transfer of genetic information and synthesis of proteins by processes known as translation and transcription



Nucleic Acids (continued)

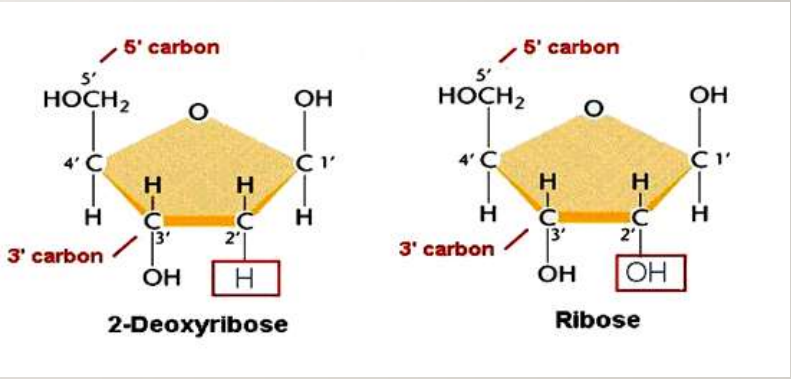


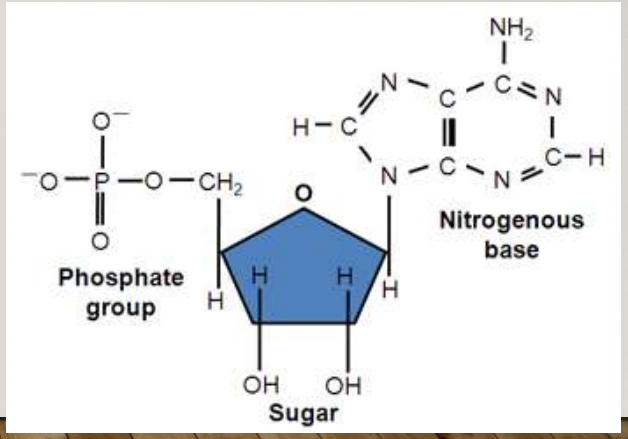
- Monomeric unit of nucleic acids – Nucleotide
- Nitrogenous base, pentose sugar, and phosphate.
- Nitrogen base attached to pentose sugar makes the nucleotide distinct.
- Nitrogen bases – Purines and pyrimidines
- Purine – adenine and guanine
- Pyrimidine – cytosine and thymine
- In RNA, thymine is replaced by uracil.



Nucleic Acids (continued)

- Sugar
- Ribose – RNA
- 2-deoxy ribose – DNA
- Furanose (closed five-membered ring) form.
- Base and the sugar – nucleoside
- Nucleoside attached to phosphate group – nucleotide
- Polynucleotide – joining of nucleotides with phosphodiester bonds



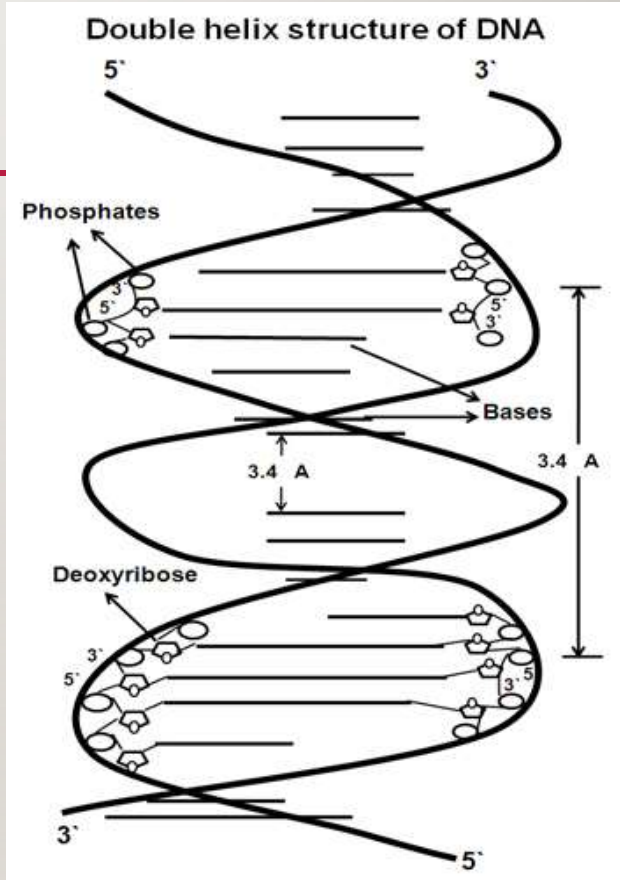


DNA Structure

- James Watson and Francis Crick – structure of DNA – 1953
- Double helical structure with two polynucleotide chains
- Chain – Sugar phosphate backbone with bases are arranged perpendicular to the chain.
- Strands – antiparallel to each other: one in 5' ---> 3' direction, other in the 3' ---> 5' direction.
- A and T ; and G and C – complementary and form base pair
- One turn of the helix is 36 A,10 base pairs are found per turn with rise of 3.6A.
- Helix is right handed along the axis.

DNA Structure

- Bases pair by hydrogen bonds
- Base-pairs of G and C – 3 H-bonds,
- Base-pairs of A and T – 2 H-bonds.
- G-C base-pairs are stronger than A-T base-pairs.
- Three variants of DNA – A, B and Z



RNA

- Three types - messenger RNA (mRNA), transfer RNA (tRNA), Ribosomal RNA (rRNA)
- mRNA - Carries the genetic information of the DNA to be used for protein synthesis.
- t-RNA - transfers amino acid for protein synthesis.
- rRNA and protein combine to form a nucleoprotein called a ribosome
- Ribosome - protein synthesis

Major Complex Biomolecules of a Cell

Biomolecule	Building Block	Major Functions
Lipids	Fatty Acids and glycerol	Storage form of energy
Carbohydrates	Monosaccharides	Source of energy
Proteins	Amino acids	Basic structure and function
DNA	Deoxyribonucleotide	Hereditary Information
RNA	Ribonucleotide	Protein Synthesis

Watch For More Information

- Biomolecules – https://www.youtube.com/watch?v=YO244P1e9QM

THANK YOU

Life Processes at Cellular Level

Photosynthesis, Respiration, Cell Division: DNA Replication and Mitosis

Photosynthesis

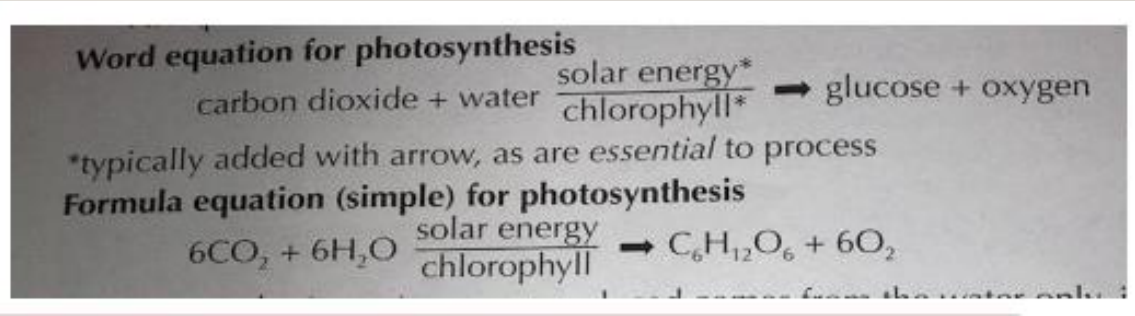
- Plants - own organic compounds - photosynthesis
- photo means ``light" and synthesis means "to make”
- Photosynthesis - chloroplasts of plant cells, mainly those of the leaf, and only in daylight hours.
- Raw materials — water and carbon dioxide — joined to produce sugar glucose
- Source of energy is solar – Chlorophyll
- Two chemical pathways in photosynthesis - enzymes

Photosynthesis

- First chemical pathway – Photolysis – light dependent reaction
- Occurs in thylakoid membranes of the grana of chloroplasts.
- ➔ Chlorophyll - thylakoid membranes capture photons of light
- Electrons 'excited' by solar energy striking them.
- High-energy electrons - carrier molecules - 'energy molecule' ATP from ADP
- Electrons are then returned to the chlorophyll.
- ➔ Water is split into its constituent elements — hydrogen, H, and oxygen, O
- Oxygen - not required - released as oxygen gas
- Hydrogen – transferred by NADP to the second chemical pathway

Photosynthesis

- Second chemical pathway – Carbon Fixation – light independent reaction
- Calvin cycle – liquid matrix of chloroplasts - stroma
- Adenosine Tri Phosphate (ATP) and NADPH - power the reactions of the Calvin cycle
- CO_2 and H enter the cycle continuously and produce the product, glucose
- ATP produced is used to run the cycle
- Photosynthesis depends on temperature, light intensity and carbon dioxide amount



Respiration

- Respiration - process by which the cell breaks down glucose to produce ATP - adenosine triphosphate and heat energy is a by-product.
- Occurs in the mitochondria of the cells in all organisms.
- ATP - nucleotide derivative.
- Purine base, a sugar and a phosphate.
- Store and release energy for chemical reactions within the cell.
- Reactions such as Active transport, synthesis of molecules and movement.
- In ATP, the bonds within the phosphate groups contain electrons in a high energy state which store a large amount of energy

Aerobic Respiration

- Oxygen - complete breakdown of glucose - carbon dioxide and water, releasing ATP and heat.
- Three chemical pathways in aerobic respiration - glycolysis, krebs cycle and electron transfer chain.
- First two - catabolic reactions decomposition of glucose
- Electron transport chain - electrons from the first two pathways - transfers through electron acceptor
- Energy released at each stepwise transfer is used to make ATP.

Aerobic Respiration

Glycolysis

- First chemical pathway- occurs in the cytoplasm of the cell.
- Glucose broken down to two pyruvate molecules
- Enter the Kreb cycle.
- Two molecules of ATP are produced

Krebs Cycle

- Second chemical pathway- occurs in the matrix of mitochondria
- Pyruvate passes around a complex cycle releasing carbon dioxide and hydrogen
- Carbon dioxide – waste, hydrogen passed to the next chemical pathway

Aerobic Respiration

Electron Transfer Chain

- final chemical pathway - occurs on the cristae of the mitochondria. -
- H atoms- ionized - high-energy electrons - acceptor molecules attached to the cristae.
- - As the electrons transferred, their energy is used to form ATP from ADP.
- - At the end of the electron transfer, electrons form H ions,
- Covert into atoms and combine with O2 to form H2O.
- Here maximum ATP is formed
- One glucose molecules – 38 ATP molecules by the end of the electron transfer chain

Anaerobic Respiration

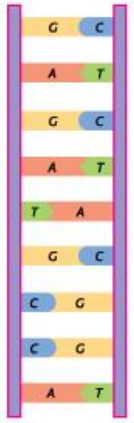
- Anaerobic respiration - absence of oxygen.
- Only glycolysis takes place - 2 ATP molecules – one glucose molecule
- Anaerobic respiration in animals – absence of oxygen – prolonged exercise
- Pyruvate formed – lactic acid
- Buildup of lactic acid causes muscle weakness
- Muscles rest – break down – built up lactic acid to carbon dioxide and water
- In yeast, the pyruvate is broken down into ethanol and carbon dioxide - fermentation.
- Small energy yield of 2 ATP molecules - sufficient for these organisms

Cell Division: DNA Replication and Mitosis

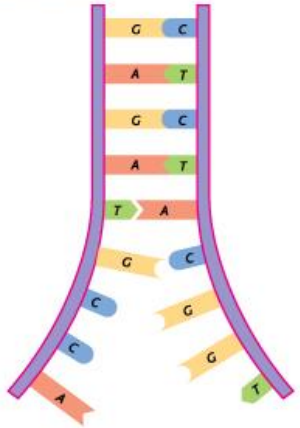
- Before cell division – DNA has to be replicated
- So that the a copy of chromosomes have to be given to each cell
- Replication - series of steps, enzyme controlled, with energy supplied from ATP.
- Eukaryotes - DNA is packaged with proteins and organized into structures called chromosomes – made up of two parts called chromatids
- DNA replication - between cell divisions.
- Two identical semi conservative molecules
- Each chromatid contains half original (parent) DNA strand and half new (daughter) DNA strand

DNA Replication - Steps

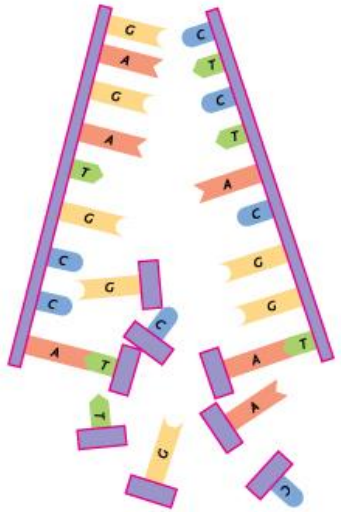
1 *A representative portion of DNA, which is about to undergo replication.*



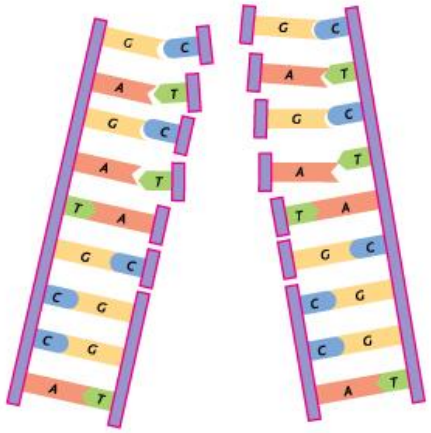
2 *The two strands of the DNA separate. The hydrogen bonds between the bases break.*



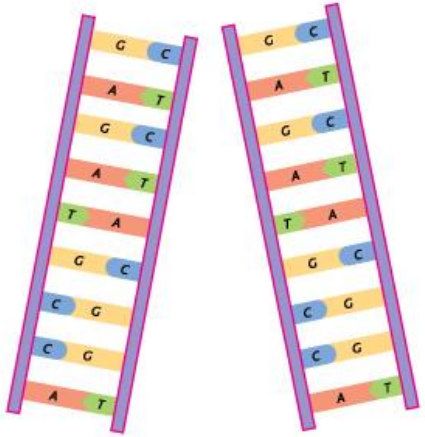
3 *Free nucleotides are attracted to their complementary bases.*



4 *Once the new nucleotides have lined up, they are joined together by the enzyme DNA polymerase.*



5 *Finally, all the nucleotides are joined to form a complete polynucleotide chain using DNA polymerase. In this way, two identical strands of DNA are formed. As each strand retains half of the original DNA material, this method of replication is called the semi-conservative method.*



Cell Cycle

- Two stages of cell cycle

1. INTERPHASE – Phase wherein cells grow and accumulate nutrients needed for mitosis and replicating its chromosomes.

- Divided into three phases:

➔ THE FIRST GAP PHASES(G1): The cell grows rapidly, while performing routine metabolic processes.

- Makes proteins needed for DNA replication and copies some of its organelles in preparation for cell division.

➔ THE SYNTHESIS PHASE(S): The chromosomes are duplicated.

➔ THE SECOND GAP PHASE (G2): The cell rapidly grows.

- The replicated chromosomes are checked for errors and any repairs required are made.
- The cell also makes additional proteins, organelles and final preparations to divide.

Cell Cycle

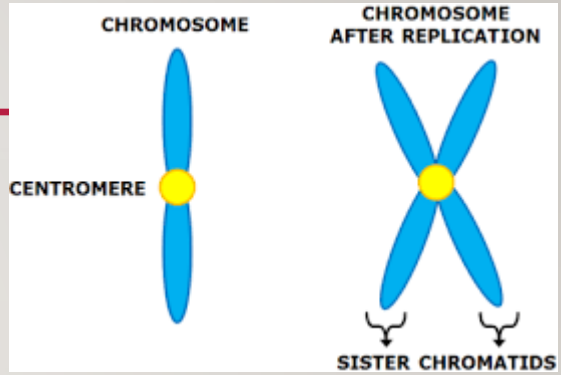
2. THE MITOSIS AND CYTOKINESIS PHASE (the M-phase):

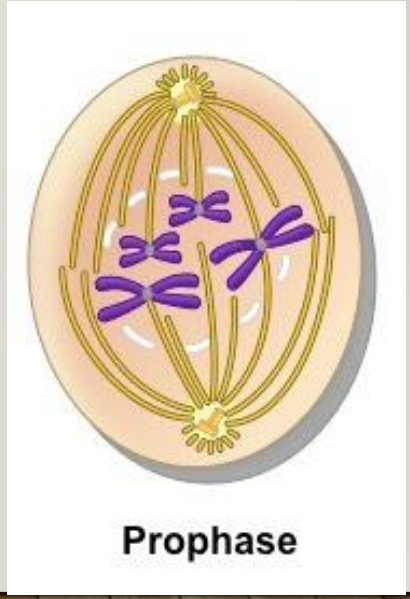
- Mitosis – Chromosomes are sorted and separated
- Each daughter cell gets one full set of chromosomes
- Cytokinesis - Cell is divided into two.
- After cell division, the cells are referred to as daughter cells.

Mitosis – Stages

1. **Prophase:**

- DNA condenses and supercoils into chromosomes.
- The nuclear membrane disappears.
- The centrosomes migrate to the poles.
- Two chromatids joined by a centromere.
- Each chromatid is a copy of the original chromosome.
- The centrioles begin to form the spindle fibers.

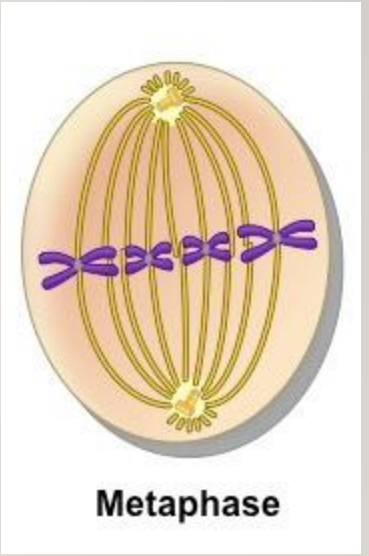




Mitosis – Stages

2. **Metaphase:**

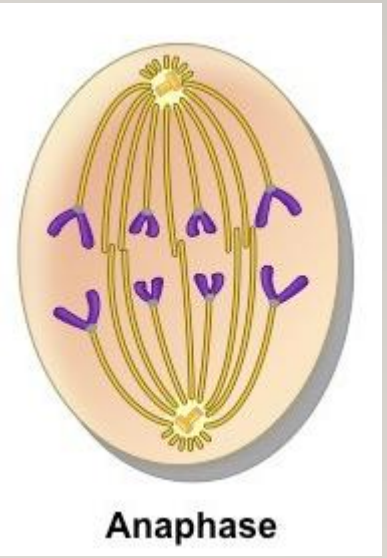
- Some spindle fibres attach to the chromosome
- Chromosomes are organized along the cell equator.
- The spindle fibres formed across the cell control the division.



Mitosis – Stages

3. **Anaphase:**

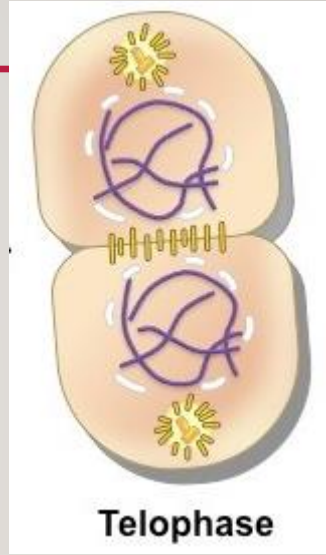
- The centromeres split
- Chromatids of each chromosome get torn apart by the spindle network
- Chromatids are moved towards the poles
- Spindle fibres elongate, pushing the poles apart and causing the cell to elongate



Mitosis – Stages

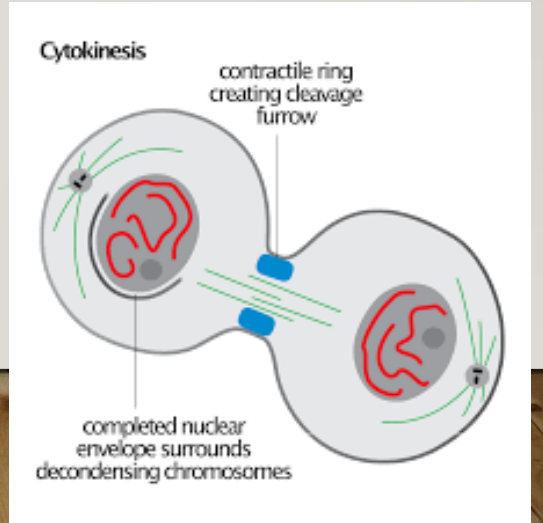
4. **Telophase:**

- The spindle fibre network retracts
- Nuclear membrane forms around each set of chromatids.
- The plasma membrane begins to construct between them.
- The chromosomes start to uncoil.



5. **Cytokinesis:**

- The cytoplasm divides between the two nuclei
- Two new daughter cells are formed.



Watch For More Information

- Photosynthesis - https://www.youtube.com/watch?v=xEF8shaU_34
- Cellular Respiration - https://www.youtube.com/watch?v=eBl3U-T5Nvk
- DNA Replication – https://www.youtube.com/watch?v=dKubyIRiN84&t=2s
- Mitosis - https://www.youtube.com/watch?v=DwAFZb8juMQ

THANK YOU

APPLICATIONS INSPIRED BY NATURE

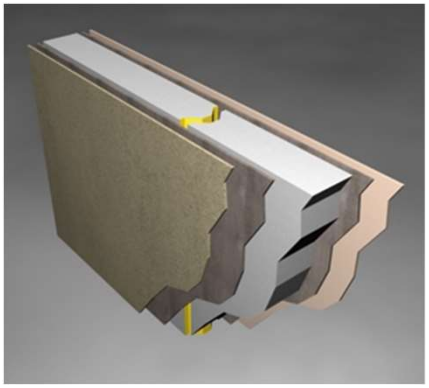
THIS CLASS INCLUDES

- Composites in Construction
- Termite Mound architecture

❖ Prepared By: Dr. Santhosh Poojary

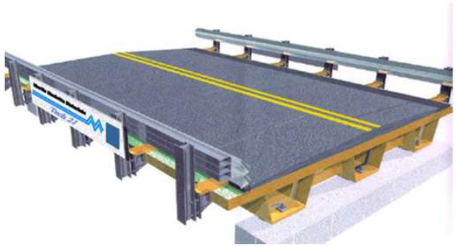
Composites

- Composites are materials produced from two or more constituent materials.
- Composite materials have played an important role throughout human history, from housing early civilizations to enabling future innovations.
- Composites offer many benefits; the key among them are corrosion resistance, design flexibility, durability, light weight and strength.
- Composites are used in constructions, medical applications, oil and gas, transportation, sports, aerospace, and many more.



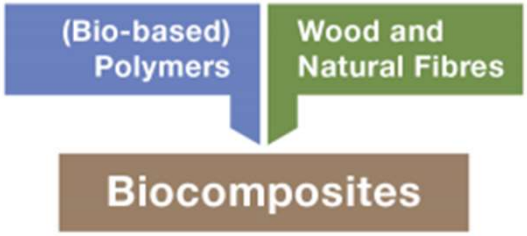
Composites in Construction

- Composite materials are used in construction due to the many benefits the provide over traditional building materials.
- Composite building material examples include concrete, reinforced plastics, cement, steel–reinforced concrete and composite wooden beams. These materials are generally durable and strong.
- Composite materials, particularly Fiber Reinforced Polymer (FRP) composites, are used in construction for a variety of reasons.
- FRP composites are created through the combination of a plastic polymer resin with strong fibers.



Bio-composites

- Bio-composites are fabricated by combining natural fibers in a matrix material.
- Wood is an example of a natural bio composite
- Naturals fibers are abundant and have low harvesting costs with adequate mechanical properties.
- Hazards of synthetic fibers with recycling issues and toxic byproducts are the main driving factors in the research and development of bio-composites.
- Bio-composites are degradable, renewable, non-abrasive, and non-toxic, with comparable properties to those of synthetic fiber composites and used in many applications in various fields



Bio-composites production

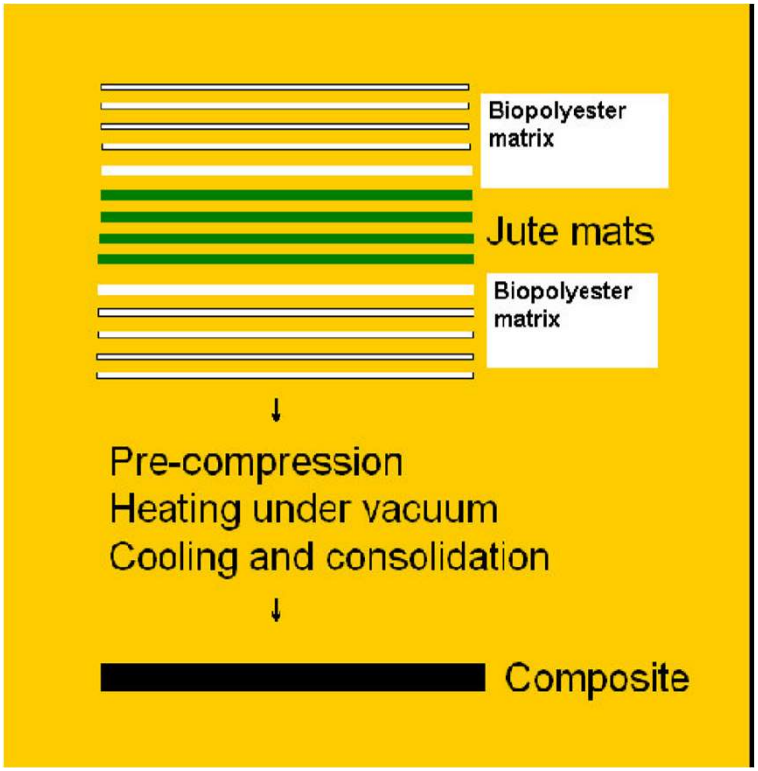
Biocomposite = **reinforcement** + **matrice**

Reinforcement/Filler

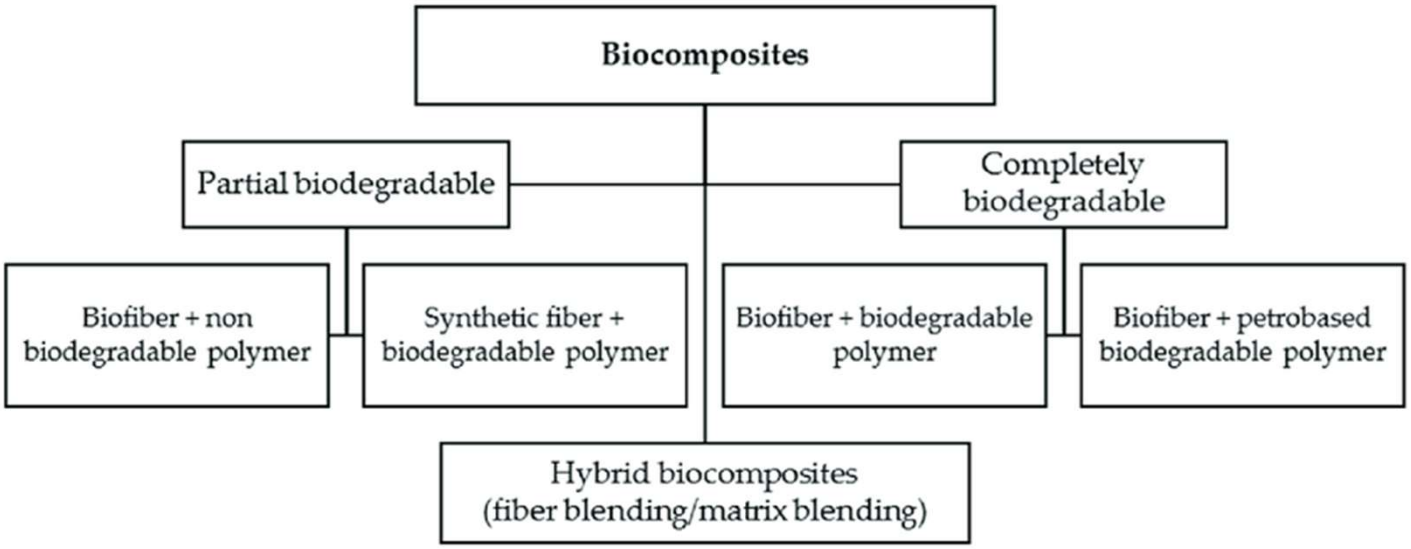
- Natural fibres (cotton, flax, hemp)
- Fibres from recycled wood or waste paper (leaf, pineapple)
- By-products from food crops

MATRICES

- Polymers derived from renewable resources (vegetable oils or starches)
- Synthetic fossil-derives polymers
- Virgin or recycled thermoplastics
- Thermosets (unsaturated polyesters, phenol formaldehyde, isocyanates, epoxies etc.)



- Hydrophobic materials (petrochemicals)
- Hydrophilic (cellulose etc.)



Bio-composites Advantages/Drawbacks

Advantages

- ✓ Light weight structures from tubed reinforcement designs
- ✓ Local production of fibers/reinforcements,
- ✓ Recyclability of products
- ✓ Green production policy is a sales argument

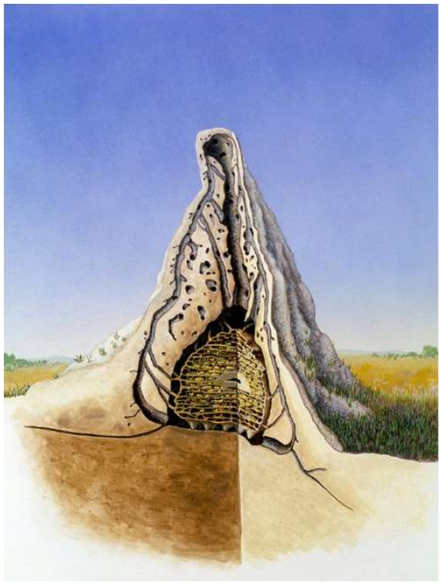
Drawbacks

- ➢ The production of resin requires still energy
- ➢ Process of solidification requires few synthetic chemicals
- ➢ Some Biocomposites from rottening and degradation at a much faster rate then synthetic fibers.

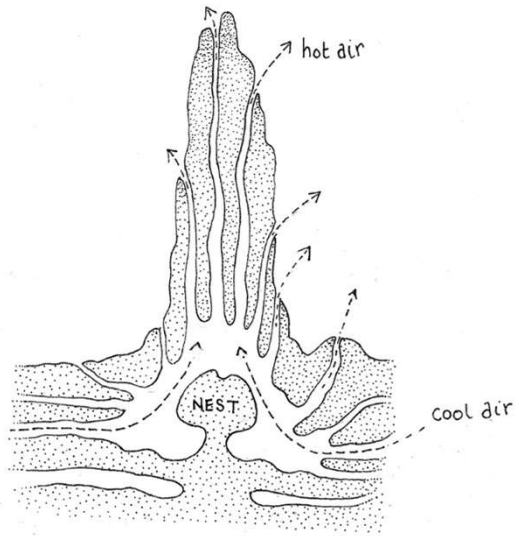
https://www.youtube.com/watch?v=0Dp9oXgE98c

Termite Mound architecture

- Mound-building termites are a group of termite species that live in mounds.
- The mounds sometimes have a diameter of 30 metres.
- The mound is constructed out of a mixture of soil, termite saliva and dung.
- Although the mound appears solid, the structure is incredibly porous.
- Its walls are filled with tiny holes that allow outside air to enter and permeate the entire structure
- When the termites abandon their gigantic mounds, they are often occupied by snakes.



- Mound termites create a system of chimneys that use sunlight to heat and cool the structure and ventilate oxygen
- The chimneys are created by digging complex tunnel systems inside the dirt mound, with smaller chimneys on the outside and a larger central chimney.
- The smaller chimneys near the outside of the mound heat up during the day, while the center chimney stays cool.
- This causes the hot air to exit the top of the mound which draws the cold air from the center which then enters the outer chimneys, and the cycle slowly repeats.
- This system allows the structure to breathe freely without any other system in use.



Termite Mounds as a Passive Design in Architecture

- Architecture has seen a push towards biomimicry in recent decades and there is no doubt that learning from natural systems can potentially help energy efficiency, structural capabilities, and even material applications.
- In the capital of Zimbabwe, a building called Eastgate Centre holds nearly 3,50,000 square-feet of office space and shops. It uses 90 percent less energy than a similar sized building next door.
- In the 1990s, Mick Pearce, the building's architect, took his inspiration from termite mounds
- The termites created their own air conditioning systems that circulated hot and cool air between the mound and the outside.

- Seeing this application in nature inspires architects to develop a "human termite mound" that will decrease energy costs and improve the efficiency.

- Architects designed buildings with this concept in mind by using porous concrete exteriors that cool hot air entering the structure.

- The potential to create a complex structure like this is there but finding material applications for it is difficult.

- One possible solution is using large 3D printers to develop a livable breathable structure.

- Biomimicry has taught architects and will continue to teach architects on new innovative ways to increase building energy efficiency

https://www.youtube.com/watch?v=620omdSZzBs

Thanks!

APPLICATIONS INSPIRED BY NATURE

THIS CLASS INCLUDES

- Counter current heat exchangers – Basics and Applications

Prepared By: Dr. Santhosh Poojary

Heat exchangers

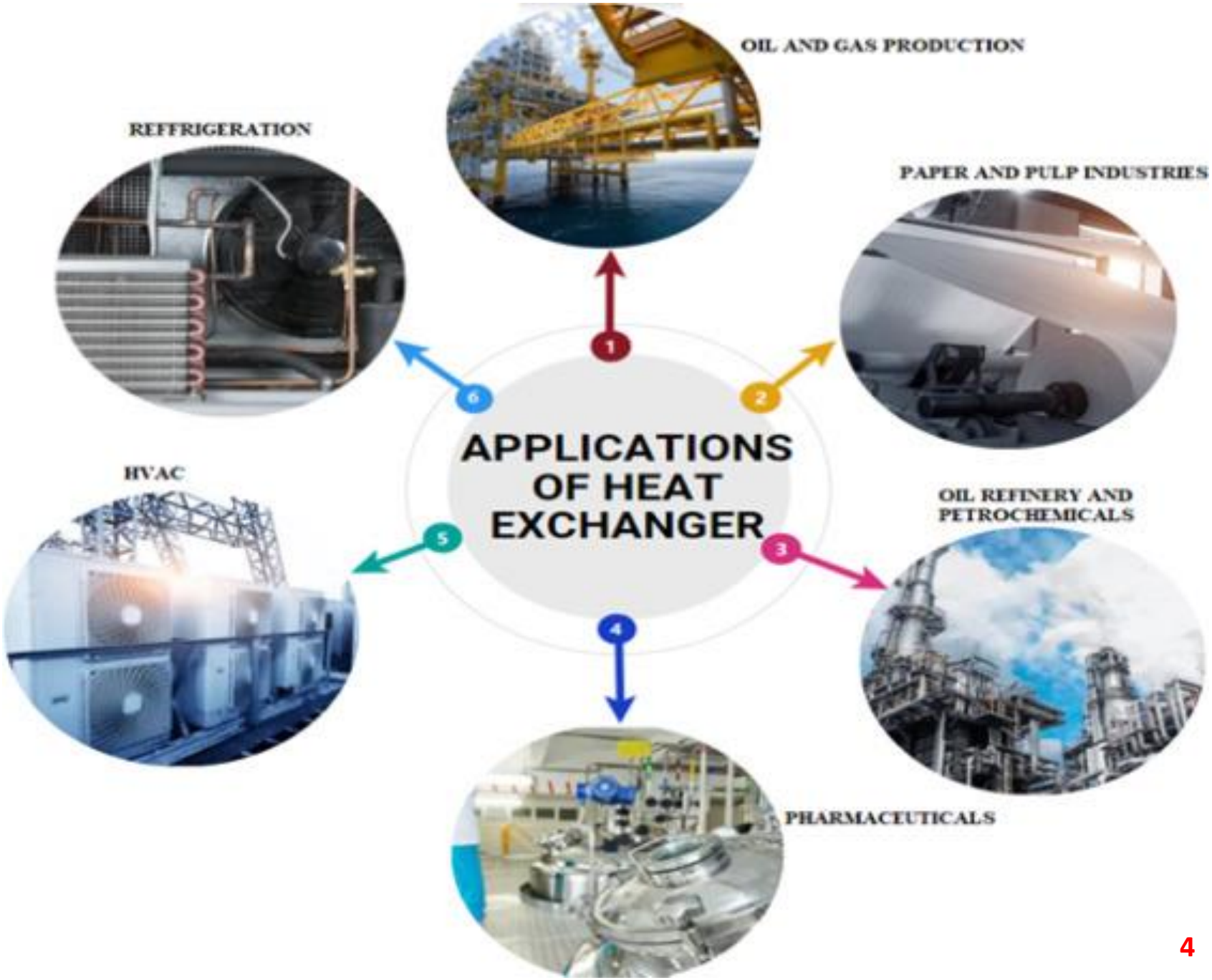
- Heat exchangers are devices designed to transfer heat between two or more fluids—i.e., liquids, vapors, or gases—of different temperatures.
- Depending on the type of heat exchanger employed, the heat transferring process can be gas-to-gas, liquid-to-gas, or liquid-to-liquid and occur through a solid separator, which prevents mixing of the fluids, or direct fluid contact.
- Other design characteristics, including construction materials and components, heat transfer mechanisms, and flow configurations, also help to classify and categorize the types of heat exchangers available.
- Finding application across a wide range of industries, a diverse selection of these heat exchanging devices are designed and manufactured for use in both heating and cooling processes.

Applications of Heat Exchangers

Heat Exchangers prevent car engine overheating and increase efficiency

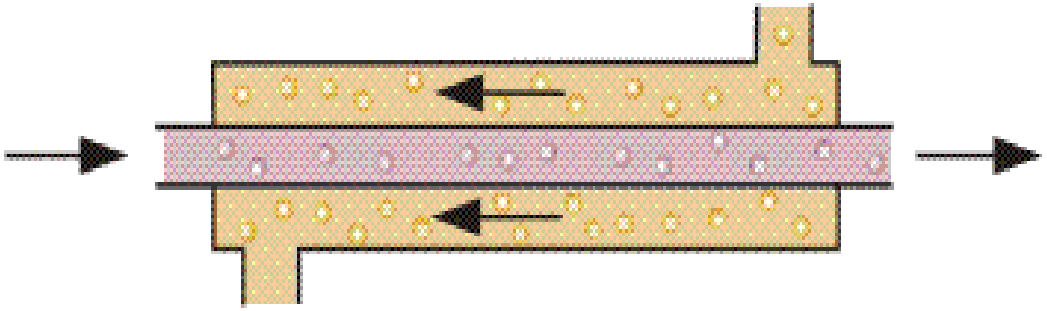
Heat exchangers are used in Industry for heat transfer

Heat exchangers are used in AC and furnaces


APPLICATIONS OF HEAT EXCHANGER
1
OIL AND GAS PRODUCTION
2
PAPER AND PULP INDUSTRIES
3
OIL REFINERY AND PETROCHEMICALS
4
PHARMACEUTICALS
5
HVAC
6
REFFRIGERATION

Countercurrent flow mechanism

- Countercurrent exchange is a mechanism occurring in nature and mimicked in industry and engineering, in which there is a crossover of some property, usually heat or some component, between two flowing bodies flowing in opposite directions to each other.
- The flowing bodies can be liquids, gases, or even solid powders, or any combination of those.
- For example, in a distillation column, the vapors bubble up through the downward flowing liquid while exchanging both heat and mass.



Counter current heat exchange in Biological systems

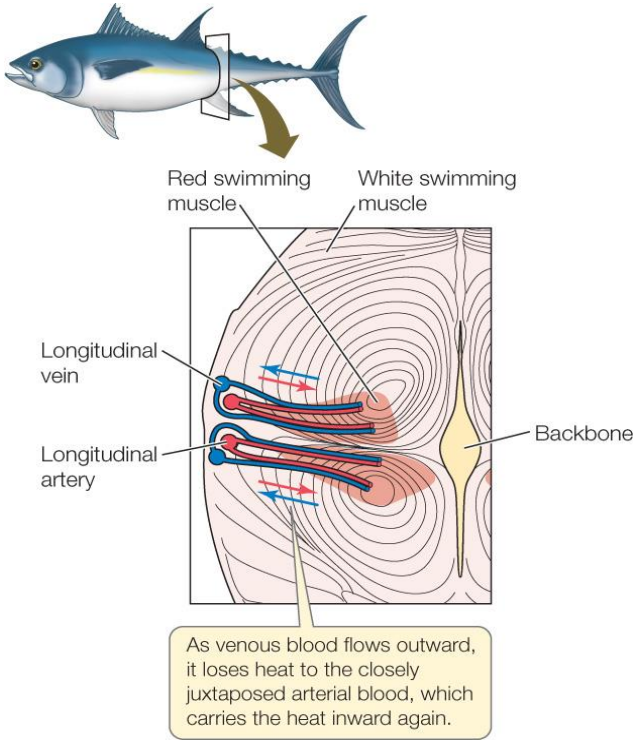
❖**Countercurrent Heat Exchange** is a common mechanism in organisms that utilizes parallel pipes (**blood vessels-arteries and veins**) of flowing fluid (blood) in **opposite directions** in order to save energy (**loss of heat into the environment**)

❖**Tuna** is a **large**, **fast swimming fish** of marine environment. It has core body temperature of **36°C** just like a **mammal**, often called as **warm blooded fish.**

❖Also while **swimming**, higher amount of heat is generated in the core of the body due to **muscle action.**

❖**Arteries** are surrounded by **veins** in the musculature of the body of this fish.

❖By transferring the heat to **incoming venous blood** it is preheated before it reaches the **core of the body**.



Counter current heat exchanger in large fish (Tuna)

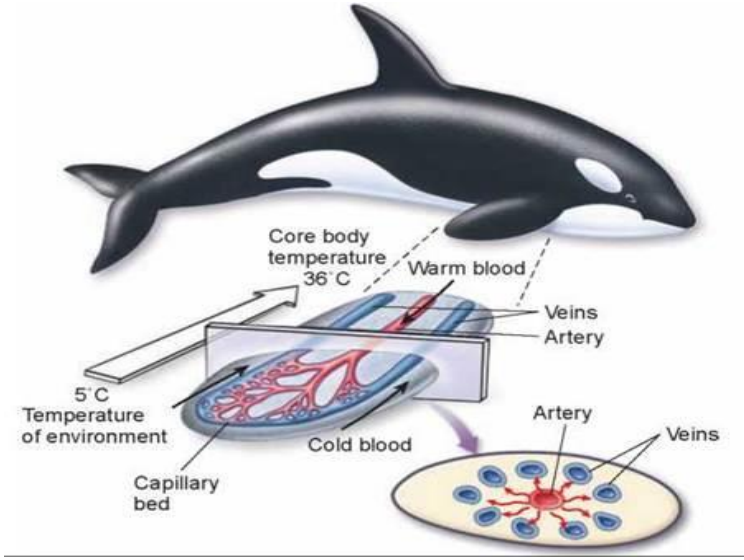
Counter current heat exchange in marine mammal

❖**Whales, dolphins, seals** and other marine mammals (**sea lions, walrus, sea cow**) can generate their **own heat** and maintain a **stable body temperature** despite fluctuating environmental conditions since they are **warm blooded**.

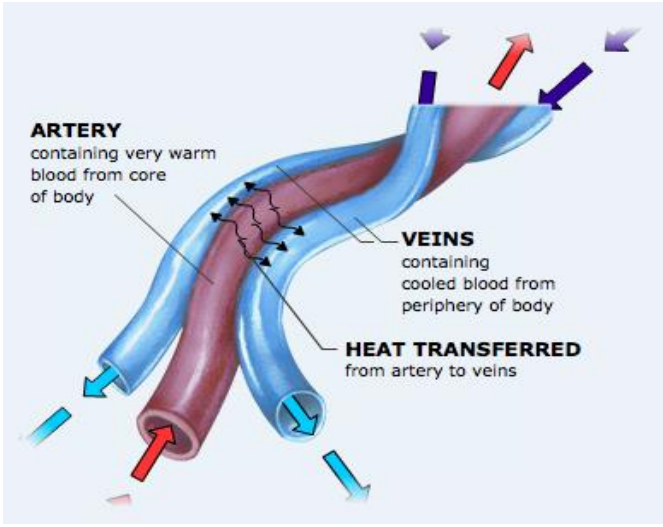
❖They maintain a **constant** body temperature in the **core of the body** by having **counter current heat exchangers** in the **flippers** and **flukes.**

❖The **warm blood** that flows in the **arteries** is pre-cooled to peripheral temperature before **it reaches the periphery** by transferring the heat to the venous blood.

❖Hence the **core body temperature** is maintained constant and the **heat is not lost to the environment .**



Counter current heat exchanger in the flipper of Dolphin



Brain cooling system in hoofed mammals

❖Many hoofed mammal pursued by a **predator** runs away from the predator and they have to run for a long distance.

❖Running is a physical exercise which **leads to generation of heat in the body** and the core body temperature may rise even up to **42^{o}C near the heart**.

❖This **hot blood** in a reaches the brain as it is, it may **lead to convulsions and instantaneous death** due to overheating of the brain.

❖To prevent this, as an **adaptation**, all these animals have developed a **counter current heat exchanger mechanism** that prevents the **hot blood** from reaching the **brain.**

Thanks!

APPLICATIONS INSPIRED BY NATURE

THIS CLASS INCLUDES

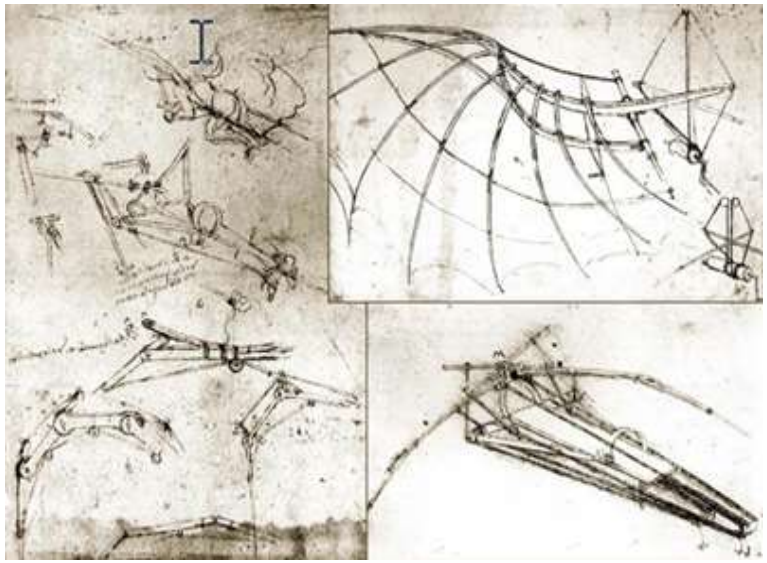
- **Emphasis on similarity between birds flight** and **Airplane design**
- **Dragon fly flight** and **Helicopter design**
- **Whale body** and **submarine design**

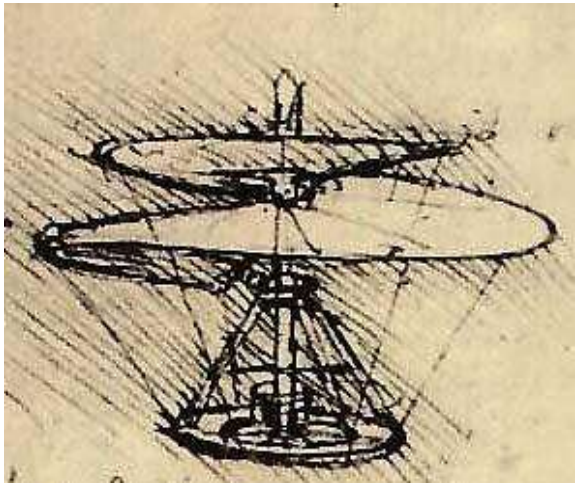
❖**Prepared By: Dr. Santhosh Poojary**

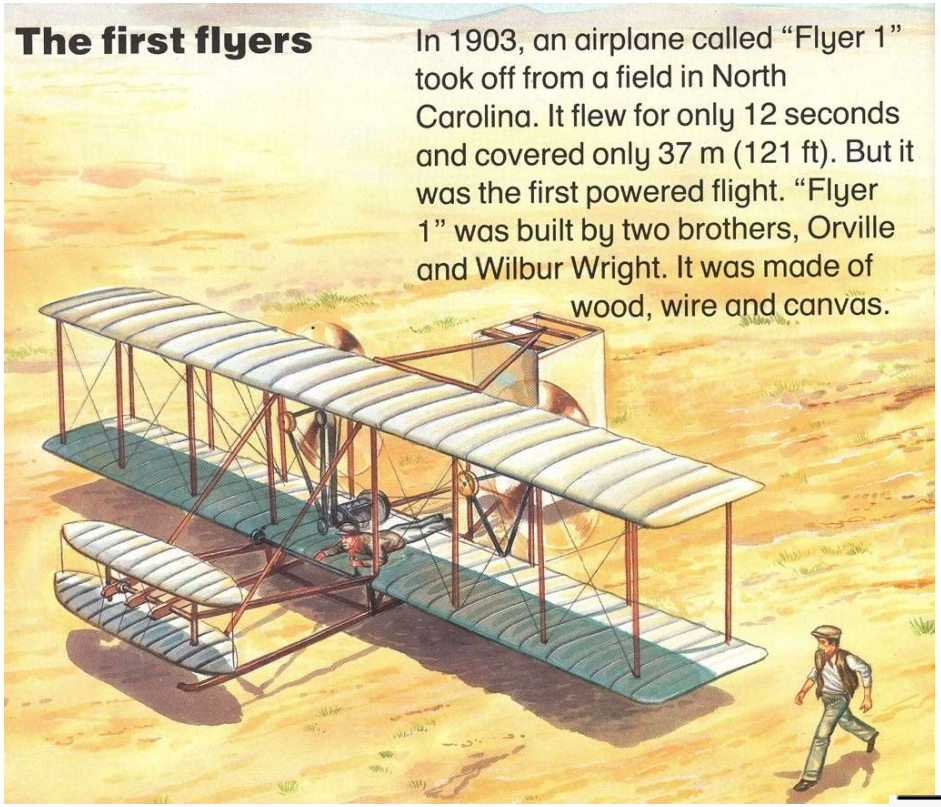
Analogy between birds flight and Airplane design

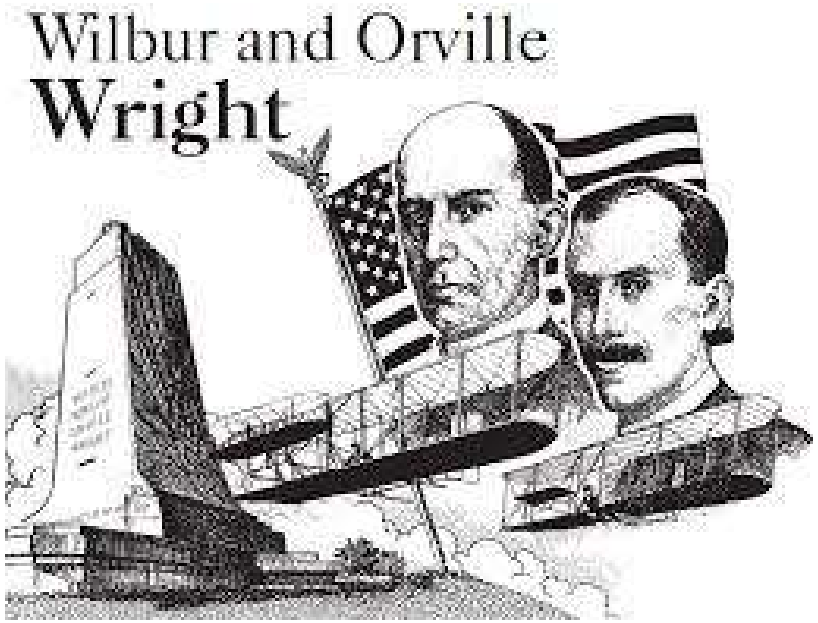
History of Aircraft

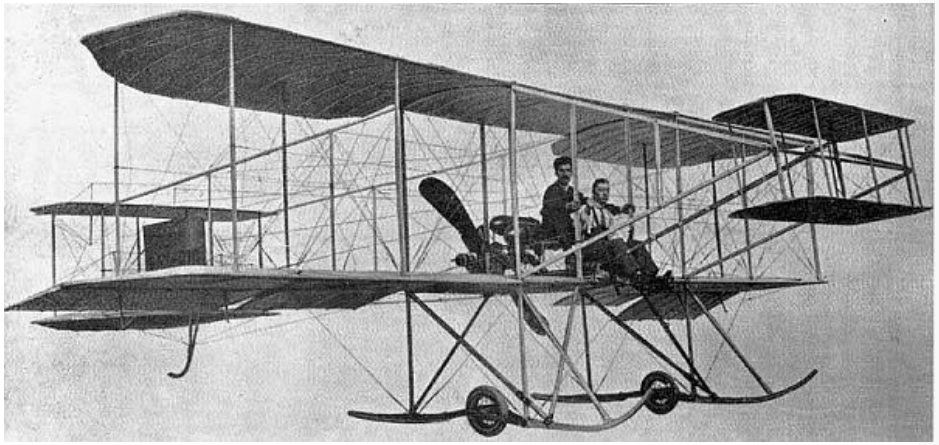
Leonardo da Vinci (1452-1519) drew the first aircraft design which he called the *'Helical air screw'*.
Though drawn with instructions on how it would operate, it was never made or tested at that time.

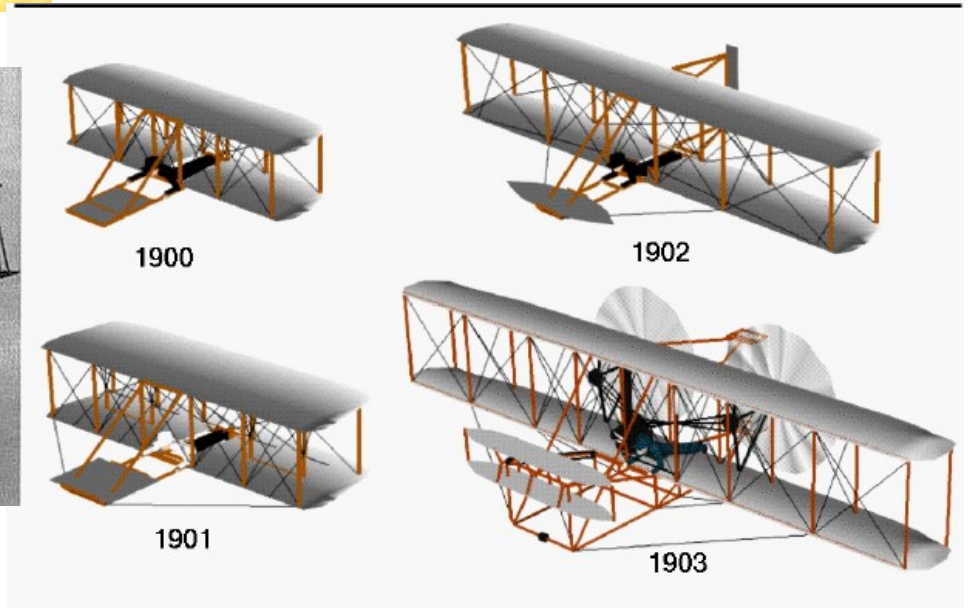





The first flyers
In 1903, an airplane called “Flyer 1” took off from a field in North Carolina. It flew for only 12 seconds and covered only 37 m (121 ft). But it was the first powered flight. “Flyer 1” was built by two brothers, Orville and Wilbur Wright. It was made of wood, wire and canvas.


Wilbur and Orville
Wright

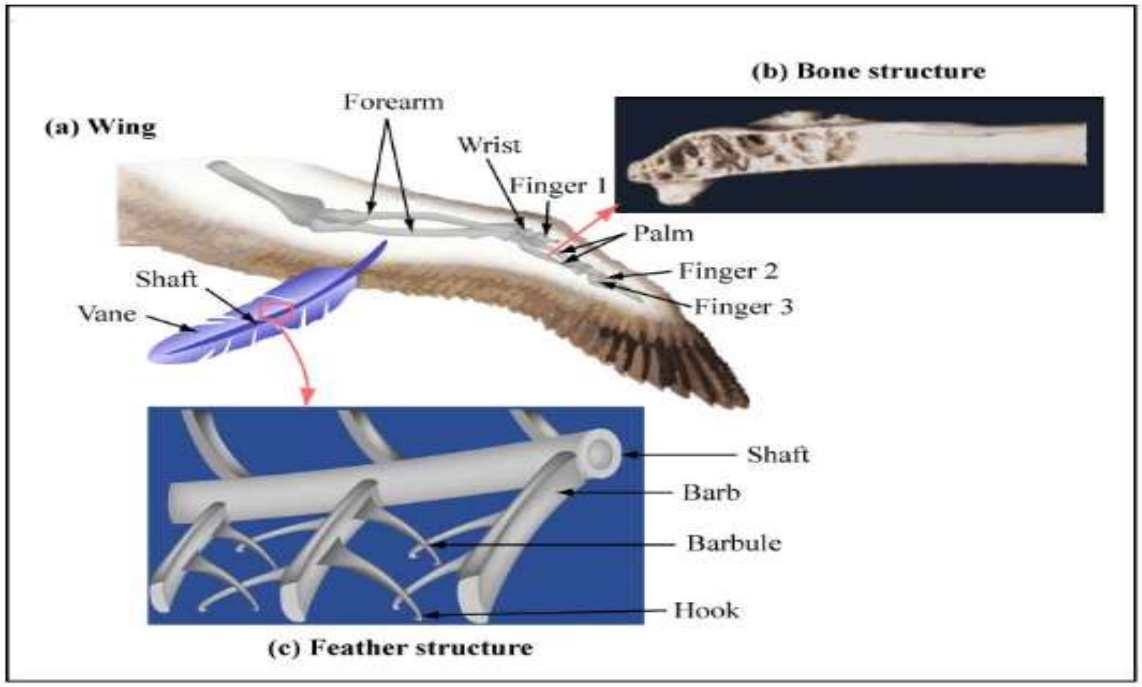



1900
1902
1901
1903

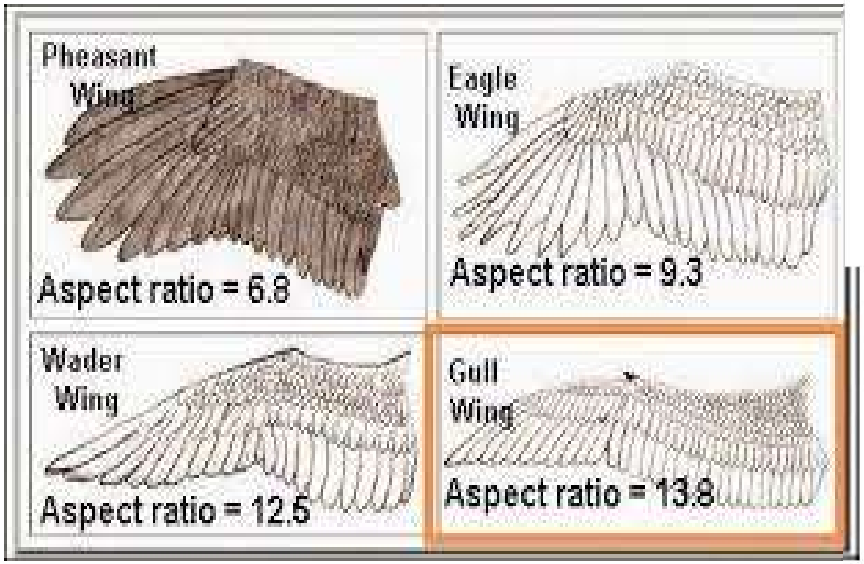
Inspiration for first flight Design!

- 1903 -Before their successful flight, **Wright brothers observed birds** to study their mechanisms of flight.
- They determined the need to adjust the angle at the end of the wings for control, **mimicking how birds bend their outer feathers.**
- From the observation of soaring birds, they believed that they could obtain **roll control** by **wing warping** (changing the shape of a portion of the wing).
- Through a series of **wires** and **pulleys** they were able to control their airplane.

Biological Design similarities in airplanes



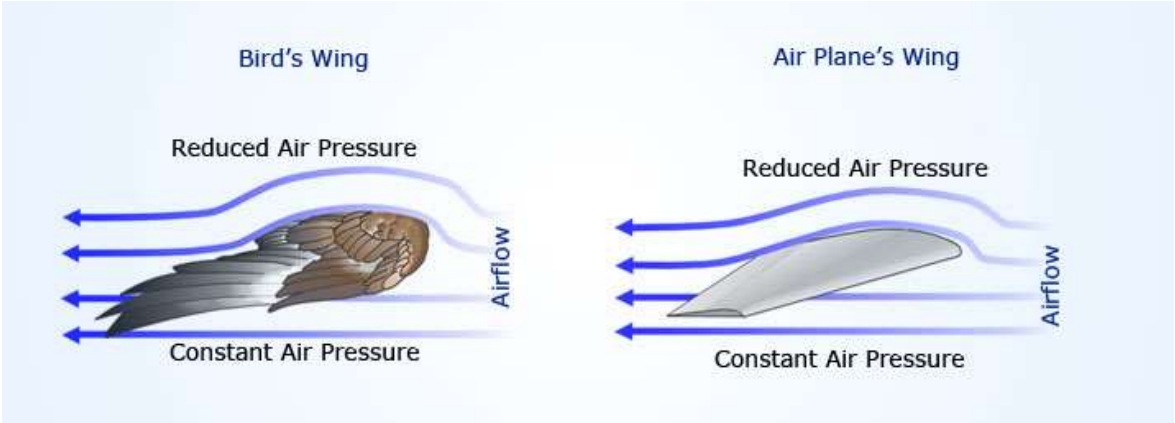
Contour of bird wing showing intricate design of arrangement of wing feathers and angular arrangement of bones to give a shape to the wing with **minimum resistance for wind**



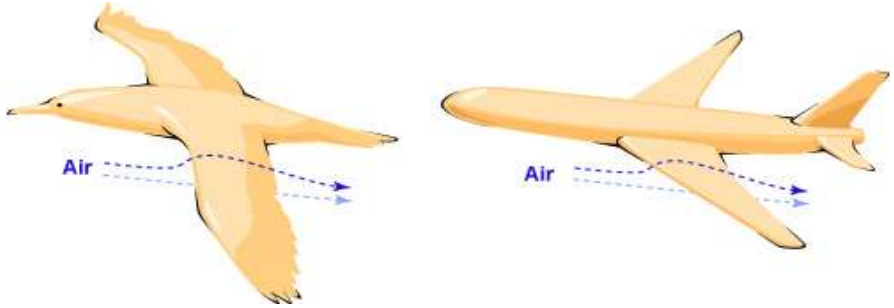
Different types of wings in relation to efficiency of adaptation to flight among different birds.

Aspect Ratio (length to width)

- vary from 1.5 to as high as about 18
- grater the **aspect ratio** better is the flight adaptability

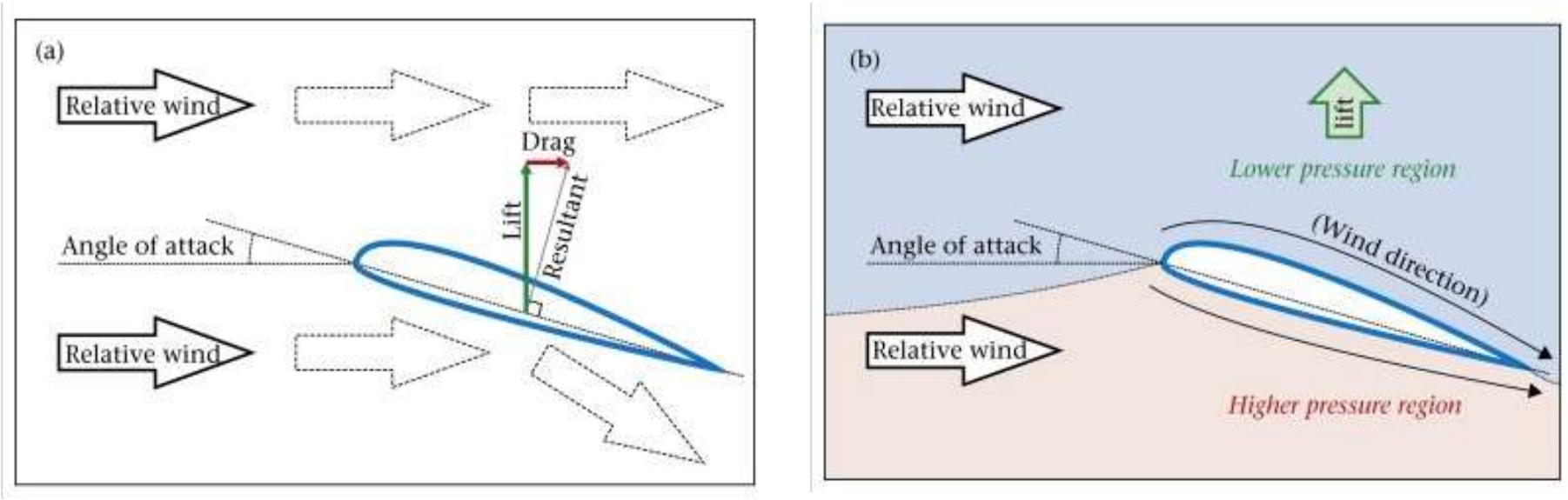


Pattern of airflow over the birds wing and airplanes wing, which is almost similar.



Air flow pattern over the birds wing and air planes wing during the flight.

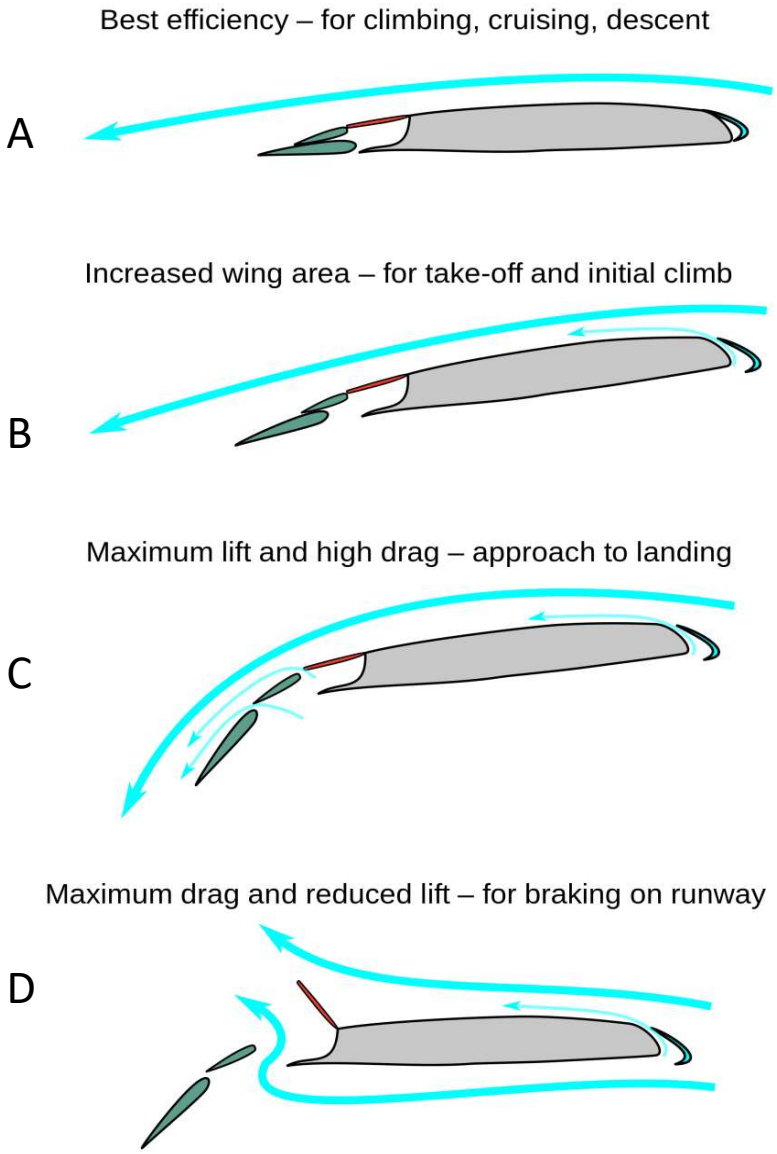
The contour of the bird's wing and air planes wing determines how much of resistance can be experienced during flight due to the airflow over the wing**. Least resistance gives smooth flight**.



Lift generation

(a) Air is deflected downward when there is a positive angle of attack, which creates **Newtonian lift**.

(b) When air moves faster over the top of the wing than the bottom, the pressure difference (lower on the top of wing) generates **Bernoulli lift.**



Birds manipulate the orientation and positioning of wing feathers and tail feathers while taking off to flight or while landing or gliding.

Similarly, the blades at the hind edge of the wings of an air plane are withdrawn while on cruise or gliding mode **(A)** and moved forward for takeoff **(B).**

Wing blades at the hind edge of the wing are extended and thrusted downward while landing **(C)**

At the same time to slowdown the speed for braking on landing, another wing blade at the hind edge of the wing is extended upward **(D).**

SIMILARITIES

- **Streamlined structure**: Helps in reduction of air pressure drag
- **Wings Design**: Produces lift
- **Feathers and flaps in birds**: Gain extra lift, and for rolling, pitching etc.

On airplanes there are high lift devices and control surfaces to do the same.

DIFFERENCES

A bird can change its **wing shape** by the **help of feathers,** But in Airplane wings, have **control surfaces, flaps spoilers etc.** that change the **air flow** altering the drag there by increasing the air flow rate

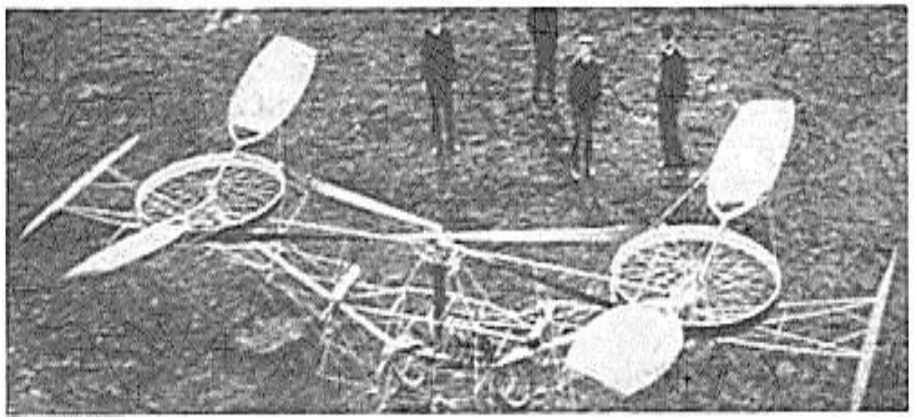
Birds can **move/flap their wings,** Airplanes **cannot.**

Analogy Between Dragonfly Flight & Helicopter Design

- **Helicopter** is an **amazing invention** of human engineering adventure
- A Helicopter is a flying machine which uses **rotating wings**
- **Nature** has inspired human kind for **hundreds of years ago,** before the vertical flight machine, **Helicopter became reality**

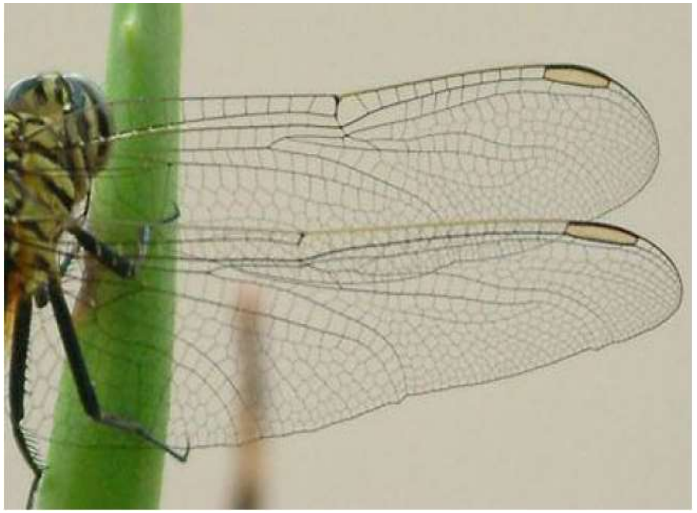
History of Helicopter

In 1906, two French brothers**, Louis-Charles** and **Jacques Breguet**, began experimenting with wing shapes for helicopters; in 1907 they successfully demonstrated the potential for rotary-winged flight with Gyroplane No 1.



It took 40 years more, for man to perfect the design of the helicopter. In 1944, **Igor Sikorsky**, a Russian born American, flew the first mass produced Helicopter, the ***Sikorsky R-4***.

- ***Dragonfly*** *is one of the only flying insects know to actually slope its body, and bank for a turn, very similar to modern Helicopter.*



Gilles Martin, a nature photographer, has done a two year study examining dragonflies, and he also concluded that these creatures have an extremely complex flight mechanism.

The eye of a dragonfly is considered the world's most complicated insect eye structure. Each eye contains about thirty thousand lenses. These eyes occupy about half the area of the head and provide the insect with a very wide visual field because of which it can almost keep an eye on its back. The wings of a dragonfly are of such a complex

How do Dragonfly fly ?

- Dragonflies have **2 sets of wings** that are almost identical.
- When it moves forward, the front set of wings gives the dragonfly its **lift** & rear wings provide **propulsion.**
- The dragonfly would rather **fly backward** only a split second after flying forward.
- This requires the **muscle that power the wings to work in reverse** so that now **back wings are provided lift**, & **the front ones propulsion.**

Helicopter flying Mechanism

- The **rotor of a helicopter creates lift** **and** **generates propulsion** **(forwards, backwards and sideways)**

- Individual rotor blades are shaped like **dragonfly wings** with a **curved upper surface.**

- Air flows **faster** over the top of the blades than beneath giving rise to an **upward suction effect**.

- The air flow below the rotor blades is **slower** resulting in high pressure, so the total effect is that the **helicopter is pushed upwards.**

- **Tail rotor** serves to stabilise the helicopter. Without it the helicopter would **rotate about its own axis.**

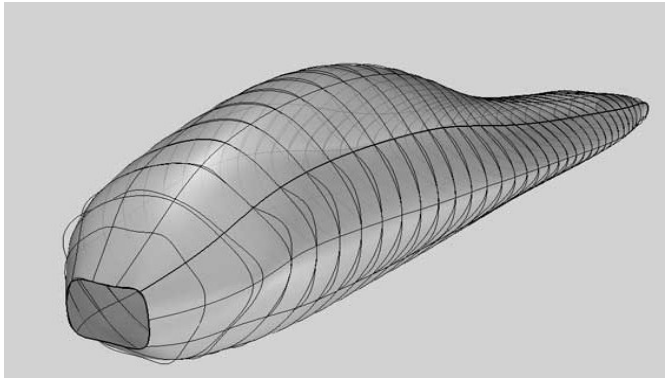
Similarities Between Dragonfly & Helicopter

- The dragonfly's wings are compositely made up of many **smaller, paper-thin wing sections.** Similarly, the blades of the helicopter are made up of **composite materials (steel)** which do not crack easily under stress.
- Like the structure of the trailing edge of the dragonfly's wings are quite bit thicker than the rest of the wing, the helicopter blades also designed similar way to prevent the wings from fluttering while flight.
- Similarly, dragonfly adjusts the angle of attack on it's wings by **transitioning its muscle to beat its wings in slightly different pattern.** Helicopter changes course by altering angle of attack at which the rotor's blades strike the air using several **mechanical levers**.

Whale body and submarine design

A whale underneath the water

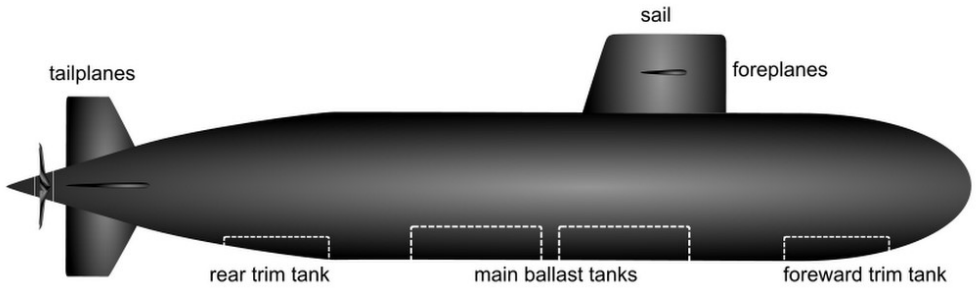
A submarine underneath the water



Body contour of a whale

Submarines

- A submarine is a watercraft that can operate underwater at pressures more than the range of regular human survivability.
- Submarines were first used in World War -1 and are used by all major Navies today (Military).
- Civilian submarines and submersibles are used for marine and freshwater research projects (Oceanography)



Thanks!

APPLICATIONS INSPIRED BY NATURE

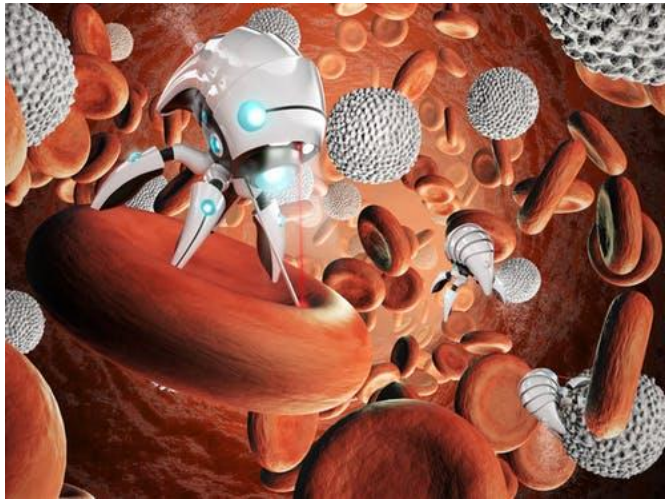
THIS CLASS INCLUDES

- **Information Theory and Biology – DNA Computing, Bioinformatics & Computational Biology**
- **SONAR – Emphasis on echolocation in bats**

❖ Prepared By: Dr. Santhosh Poojary

Information theory and biology

- Biological cells are complex nanomachines
- The **genetic information** stored is used to synthesis of **cellular components**
- Cells also process information that they receive from the environment (**membrane proteins**)
- Thereby maintaining constant temperature, pH, and concentrations of vital ions etc.

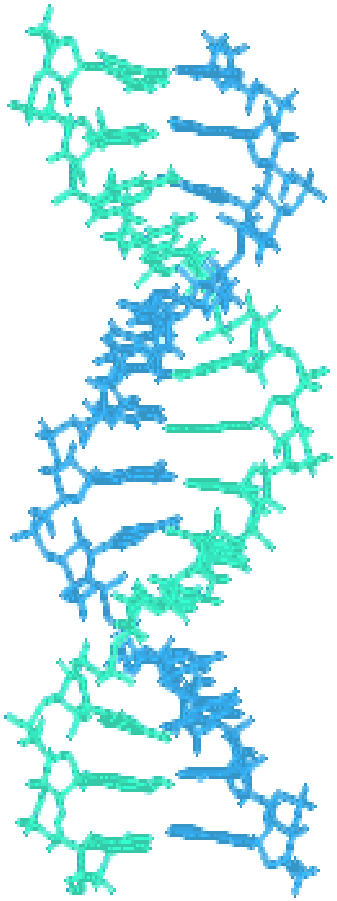


DNA?

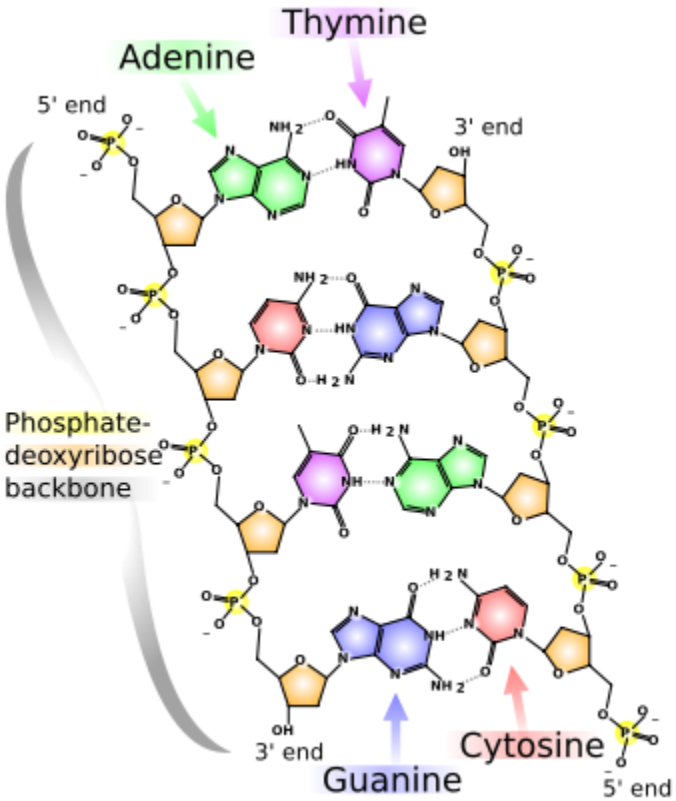
- All organisms on this planet are made of the unique type of **genetic blueprint**.
- DNA is a **double-stranded helix** of long polymers of **millions of linked nucleotides**.
- DNA carries the **genetic information of a cell**.
- This information is the **code the building block molecules** upon which life is formed.

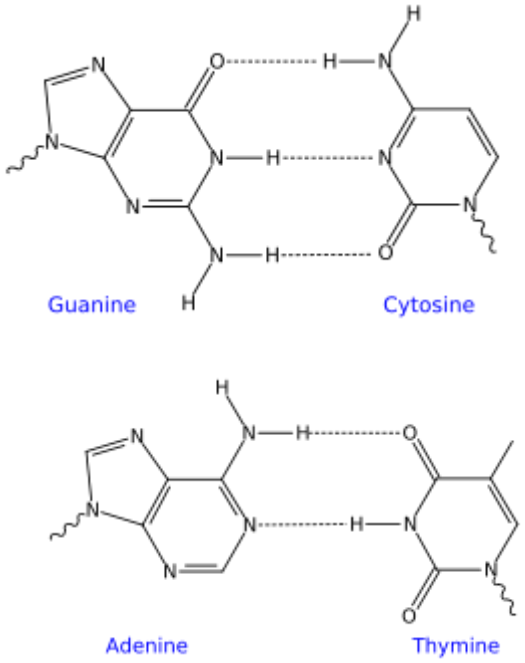
Double Helix shape of DNA

The two strands of a DNA molecule are anti parallel where each strand runs in an opposite direction.



Purines (A,G) and Pyrimidines (C,T) base pairing





GC base pair and **AT** base pair

Information theory

a subject that developed in communication industry by an American mathematician, electrical engineer **Claude Elwood Shannon** (1916 – 2001)

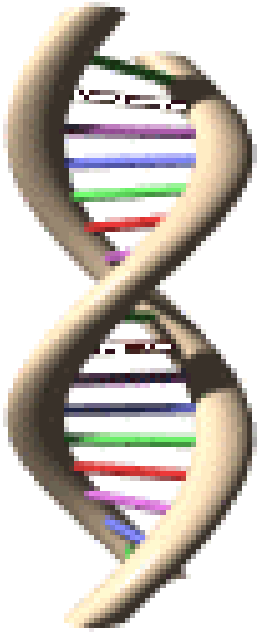
✓Main application in Electrical engineering - optimizing the information communicated per unit time or energy

✓Analysis of phenomena in other areas of inquiry also.

Eg: It gave an insight into **information storage in DNA** and the conversion of instructions embedded in a genome into **functional proteins**.

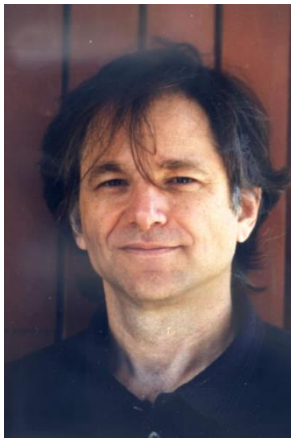
The idea of **individual molecules (or even atoms) could be used for computation** dates to 1959, when American physicist ***Richard Feynman*** presented his ideas on nanotechnology

DNA Computing



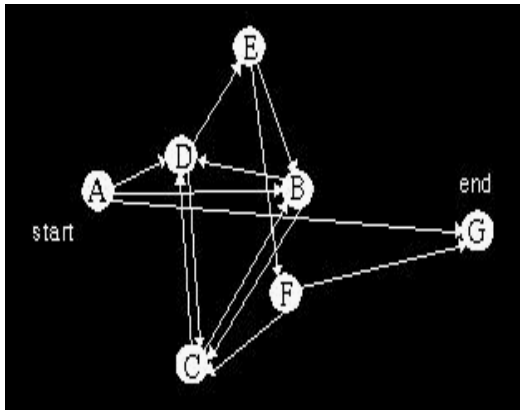
- ✓ Are there any new materials for next generation of microprocessors?
  - **DNA (including yours!).....in DNA computing.**
- ✓ Instigated in 1994 by an article written by Dr. Adleman on solving **Hamiltonian Directed Path Problem(*HDPP*)** using DNA.

I believe things like DNA computing will eventually lead the way to a "molecular revolution," which ultimately will have a very dramatic effect on the world.
LEONARD ADLEMAN

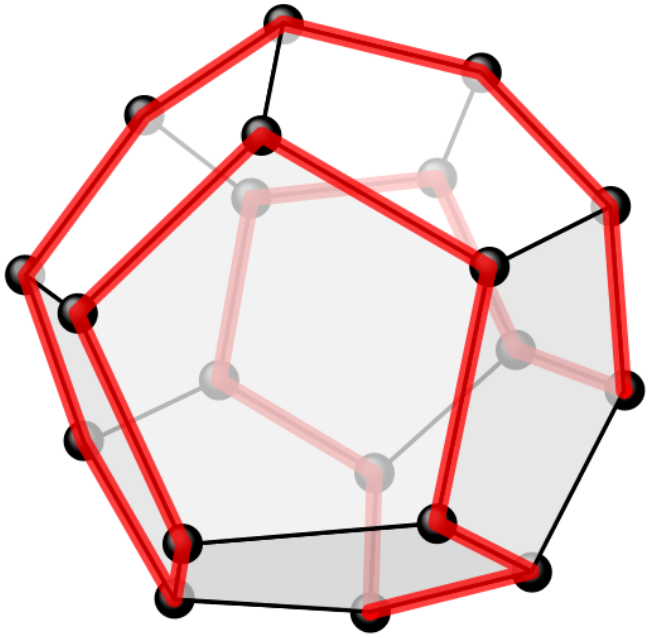


Hamiltonian Directed Path Problem(*HDPP*)

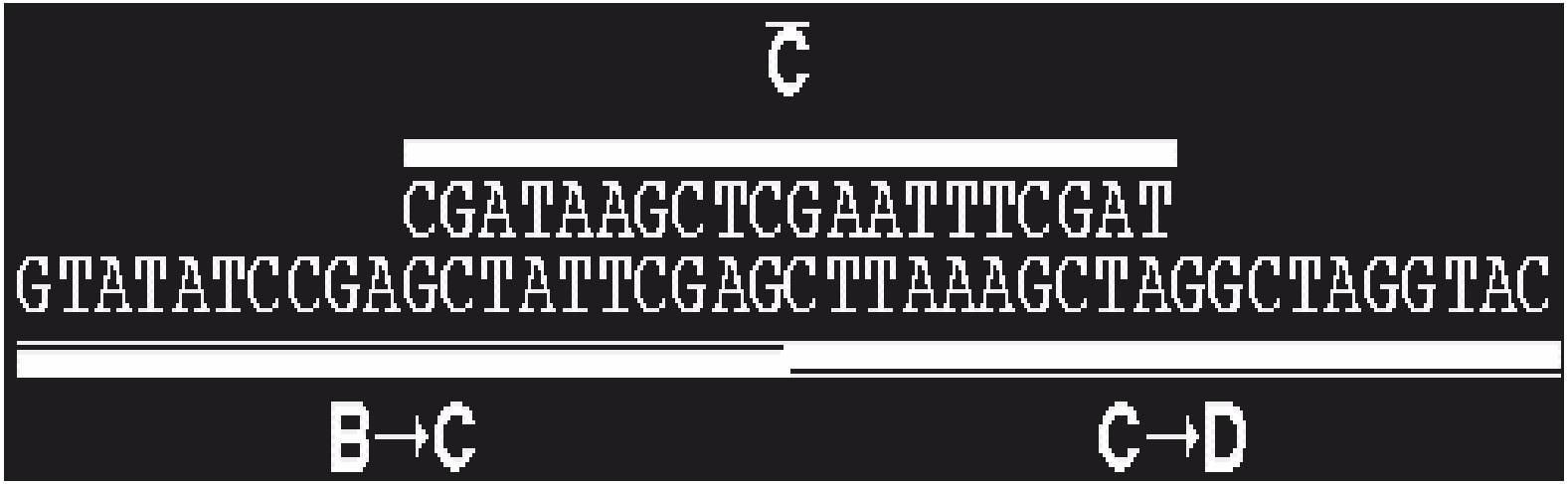
- Adleman put his theory of DNA computing to test a problem called the **Traveling Salesman Problem (TSP)** where a salesman need to visit all the cities without entering a city twice.



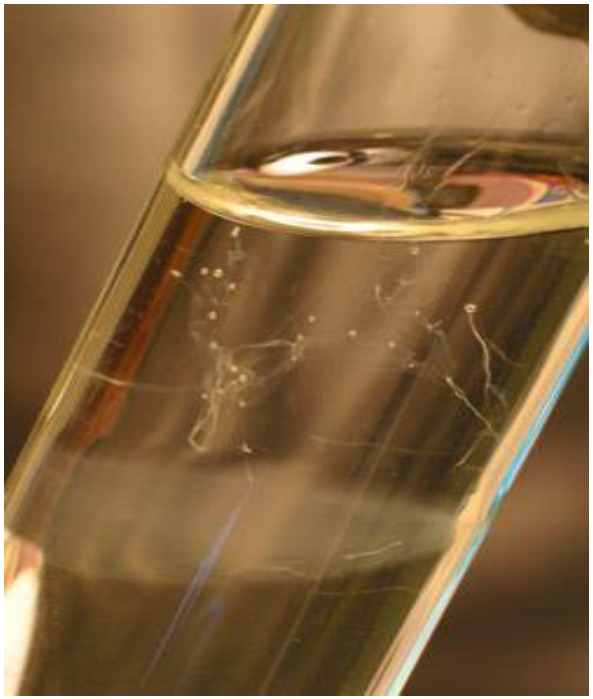
Dodecahedron



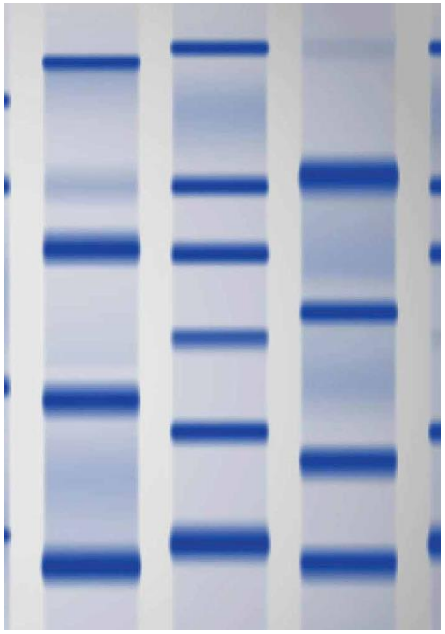
- Adleman, created randomly sequenced DNA strands 20 bases long to chemically represent each city and a complementary 20 base strand that overlaps each city's strand halfway to represent each street.



Real Lab experiments



Formation of DNA strands polymerase chain reaction [PCR]



Separation of DNA strands Gel electrophoresis

Spooling the DNA by affinity purification

Why is DNA a Unique Computational Element?

- Extremely dense information storage.

1 gram

4,000,000,000,000,000,000,000 bits

- Enormous parallel computing possibility

300,000,000,000,000

molecules at a time.

- Extraordinary energy efficiency.

1 Joule

20,000,000,000,000,000,000 Operations

- **Basic suite of operations:** AND,OR,NOT & NOR in CPU while cutting, linking, pasting, amplifying and many others in DNA.
- **Complementarity** makes DNA unique.

  Ex: in Error correction.

Limitations of DNA computers

- At Present, NOT competitive with the state-of-the-art algorithms on electronic computers
  - Time consuming laboratory procedures (High cost is **time)**.
  - There is sometime errors in the pairing of DNA strands (**Reliability**)
  - No universal method of data representation.

Hidden factors affecting complexity

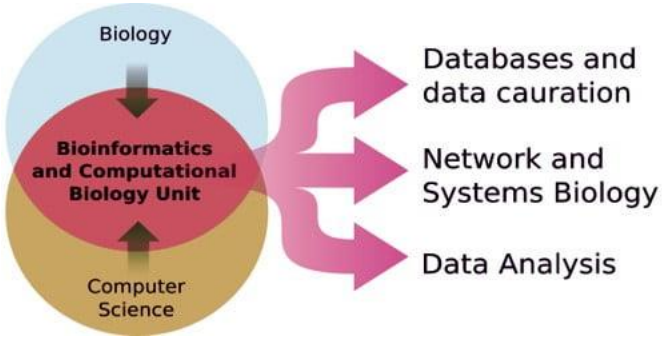
- There may be *hidden factors that affect the time and space complexity of DNA* algorithms because:
  - **Arbitrary number of test tubes** to be poured together in a single operation.
  - **Unrealistic assessment** of how reactant concentrations scale with problem size.
  - **DNA, in vitro (in the lab) decays** through time, so lab procedures should not take too long.

DNA computers- FUTURE!

- ✓ As technology becomes more refined, **more efficient algorithms may be discovered.**
- ✓ **DNA Manipulation technology** has rapidly improved in recent years, and future advances may make DNA computers more efficient.
- ✓ Scientists are experimenting with **DNA chip-based computers**.
- ✓ DNA computers are *unlikely* to feature **word processing**, **emailing** and **gaming** programs. Instead, their powerful computing power will be used for areas of **Encryption**, **Genetic programming, Language systems**. Hence better applicable in some promising areas.

Bioinformatics & Computational Biology

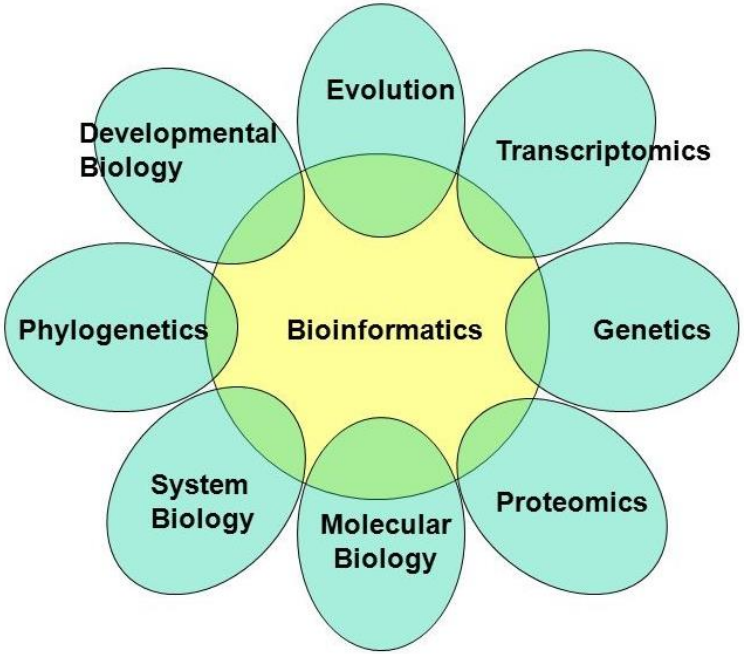
- ✓ Both **Bioinformatics** and **Computational Biology** deals with Computers and Biology.
- ✓ Biologists who specialize in use of computational tools and systems to answer problems of biology are **bioinformaticians.**
- ✓ Computer scientists, mathematicians, statisticians, and engineers who specialize in developing theories, algorithms and techniques for such tools and systems are **computational biologists.**
- ✓ The actual process of analyzing and interpreting data also referred to as computational biology.

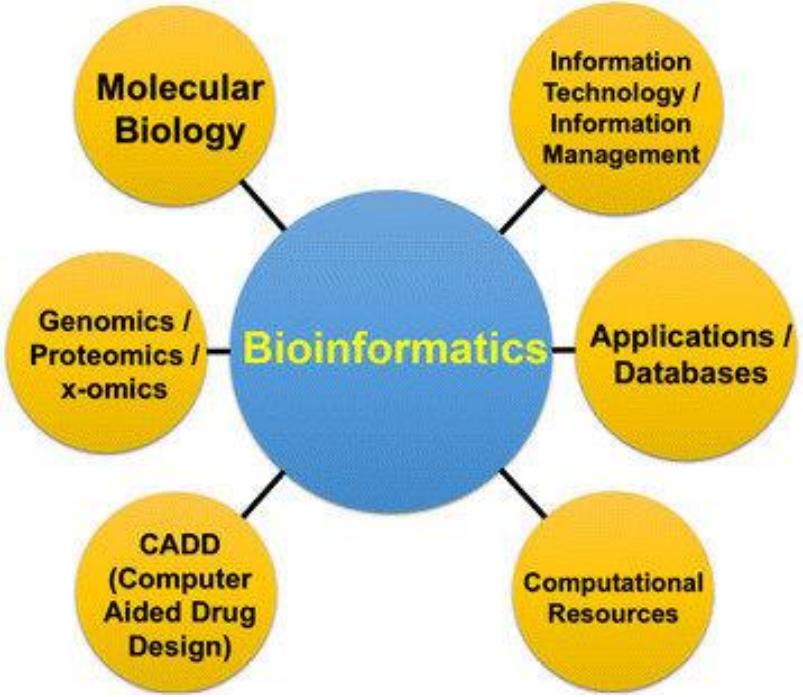


- **Bioinformatics**
  - ➢ collection and storage of biological information
  - ➢ derives knowledge from computer analysis of biological data

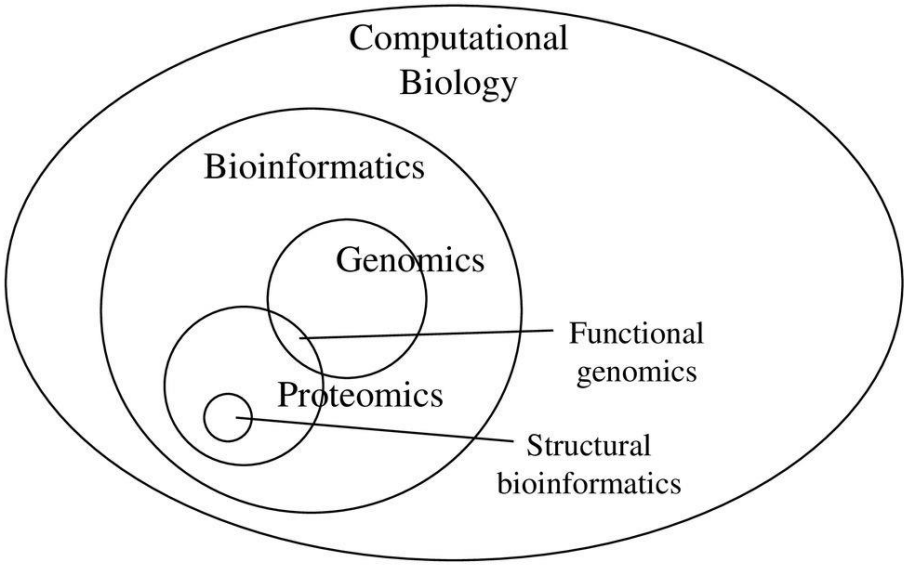
- **Computational biology**
  - ➢ development of algorithms and statistical models to analyze biological data

BT(Bio Technology) + IT(Information Technology)





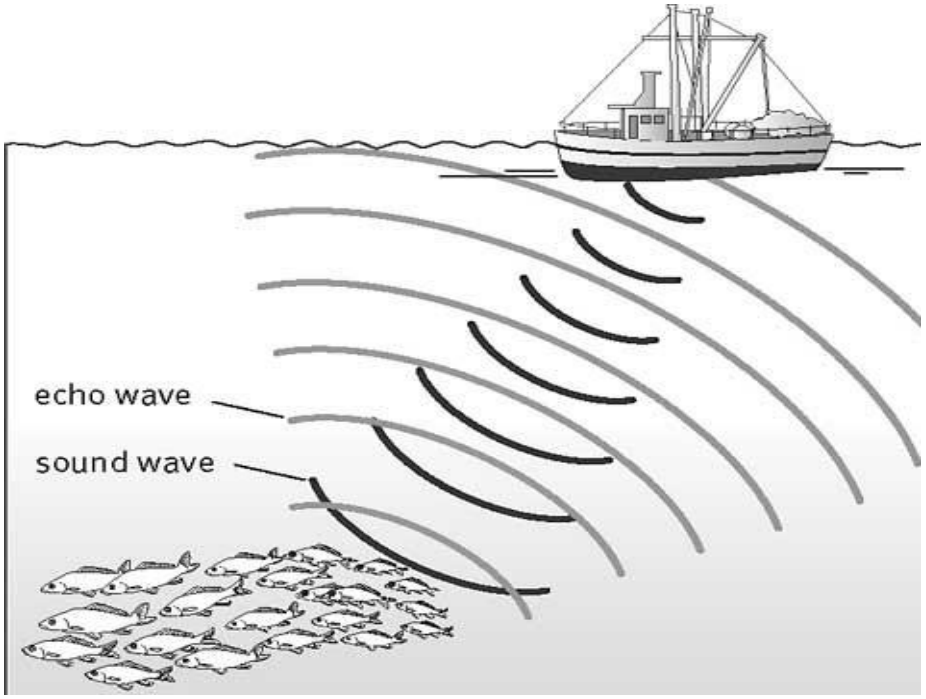
Scope of Computational Biology



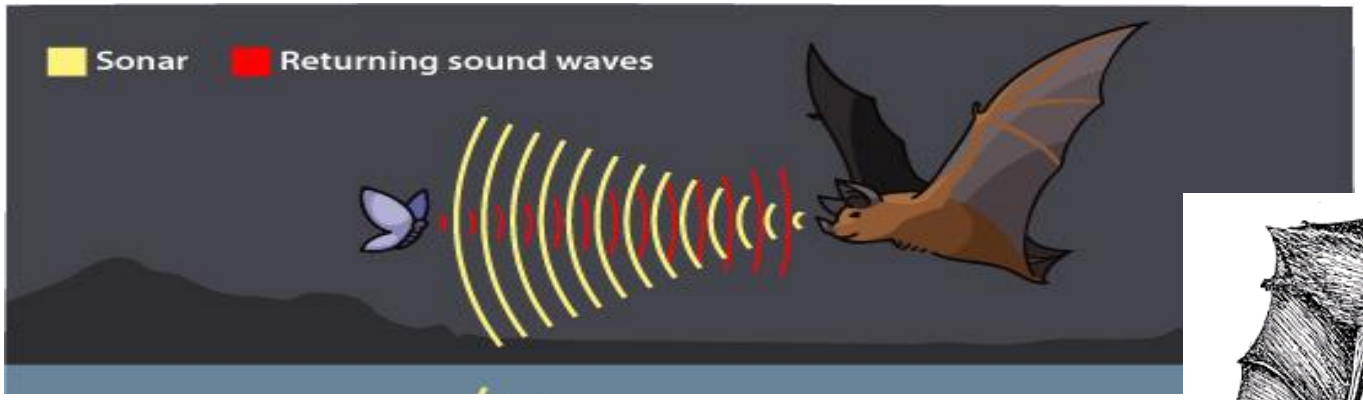
SONAR

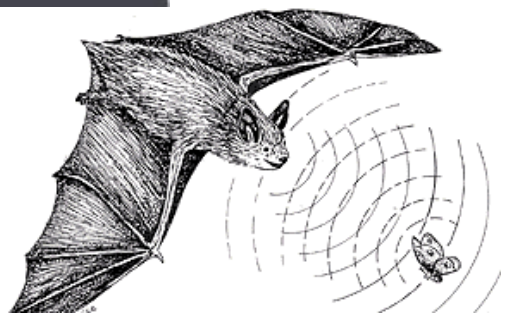
(SOund Navigation and Ranging)

- **SONAR uses the idea of sound bouncing back based in the principle of echolocation, which is widely used submarine applications**



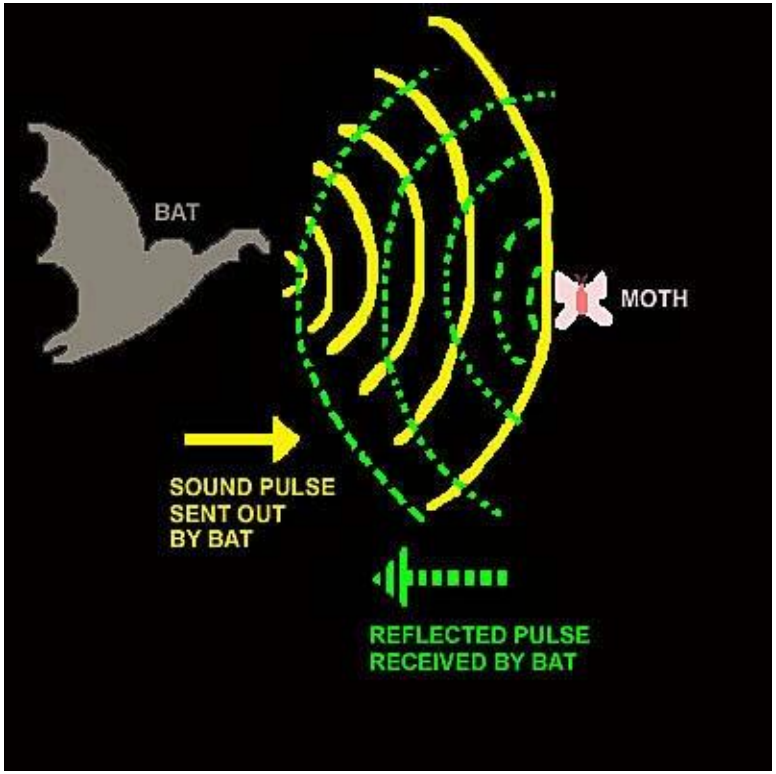
Echolocator in bats





- **Instead of relying on their sense of sight to navigate in the dark and find food, bats make rapid high-pitched squeaks called "Ultrasounds".**
- **These sounds are too high for most people to hear.**

How Echolocation helps bats?



- When the sound hits an object an echo comes back. The bat can identify an object by the sound of the echo. They can even tell the size, shape and texture of a tiny insect from its echo.

Bat-Echolocation sounds

- All bats use “ultrasonic” sounds
- CF - constant frequency
  - long tone, often with some harmonics
  - velocity
- FM -
  - frequency modulated
  - short burst of sound
  - range determined

THANKS!

APPLICATIONS INSPIRED BY NATURE

THIS CLASS INCLUDES

Medical Devices – Introduction to Artificial pacemaker, Bionic eye, Cochlear implant

❖ Prepared By: Dr. Santhosh Poojary

Artificial Pacemaker

- A pacemaker system is a device capable of generating **artificial pacing impulses** and **delivering them to the heart**.
- It consists of a **pulse generator** with appropriate **electrodes**.
- In the past few years electronic pacemaker systems have become extremely important in saving and sustaining the lives of **cardiac patients** whose normal **pacing function** of the heart have been **impaired**.

Why artificial pacemakers?

- Sometimes **heart's natural rhythm** is **interrupted** or becomes **irregular** may be because
  - The heart's natural pacemaker sends out electrical impulses too slowly due to a **diseased SA node**.
  - Or, the electrical impulses may be blocked along the pathway through the heart, -"**heart block**.“

Symptoms: dizziness, extreme fatigue, shortness of breath or fainting spells.

A pacemaker stimulates the **heart muscle** with **precisely timed discharges of electricity** that cause the heart to beat in a manner very **similar to a naturally occurring heart rhythm**

History

- First wearable pacemaker designed initiated in **1958**

1958	Earl Bakken	1st wearable transistorized pacemaker.
1958, 8th October	Dr. Ake Senning Dr. Rune Elmquist	1st implanted (trans-venous) pacemaker.
1959	W.M. Chardack Wilson Greatbatch	1st successful long term implantable pacemaker.
1970		Introduction of Li-Iodide battery technology.
1980		Introduction of rate responsive pacing.

Mechanics

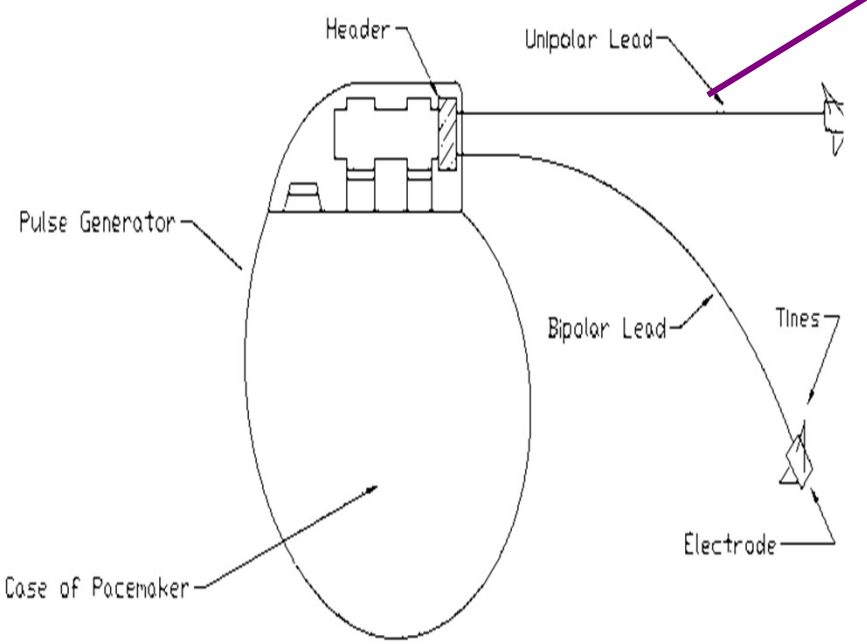
- To provide the **rhythm to the heart**
- Either **temporary or permanent** impulse generation
- Consists of **external or internal power source** and a **lead** to carry the current to the **heart muscle**
- **Batteries** provide the power source
- **Pacing lead** is a coiled wire spring encased in **silicone** to insulate it from **body fluids**

Schematic drawing of a pacemaker

Artificial Pacemaker- made up of TWO main parts

1. **Pulse Generator**
2. **Leads**

The **pulse generator** houses the **battery** and the **circuitry**, which **generates the stimulus** and **senses electrical activity of heart**.



The **lead** is an **insulated wire** that **carries the stimulus from the generator to the heart** and returns intrinsic cardiac signals **back to the generator**

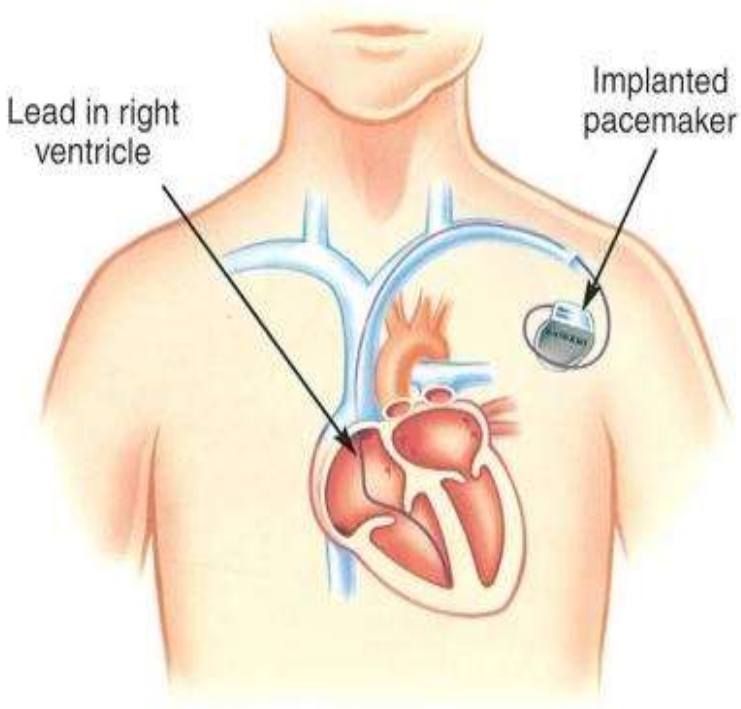
Pulse Generator

- Acts as a very **small computer**
- Sends out **sparks of electricity** that trigger the **heart to beat**
- Also **records heart's electrical activity** and **heart rhythm** so that the doctors can better adjust the pacemaker.
  - This way, each pacemaker works according to **individual needs**

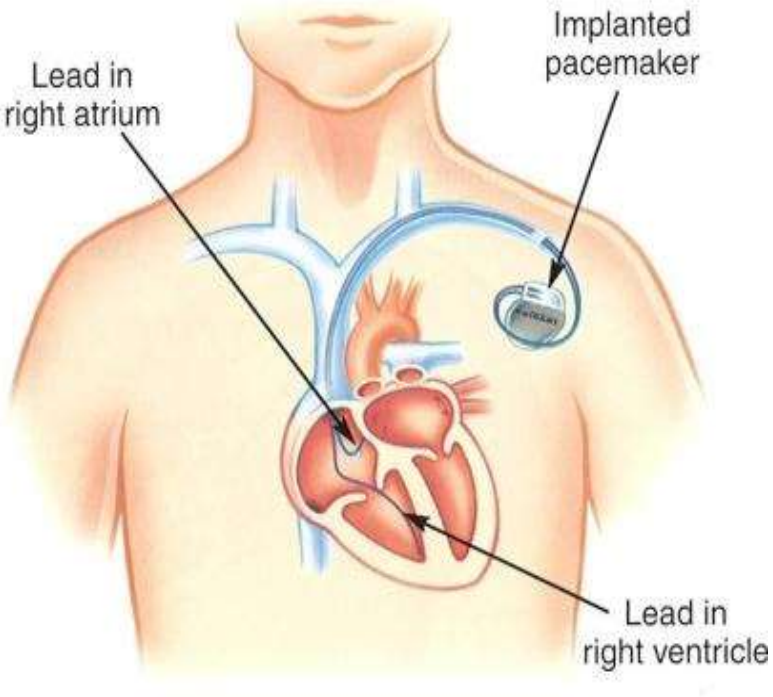
The Leads

- Wires **threaded through veins** and attached to heart muscle, carrying the impulses
- **Single Chamber**: **one lead** in ventricle **OR** atria
- **Dual Chamber**: **one** lead in **ventricle** and **one** in **atria**
- **Biventricular**: one lead in **atria** and one lead in **each ventricle**

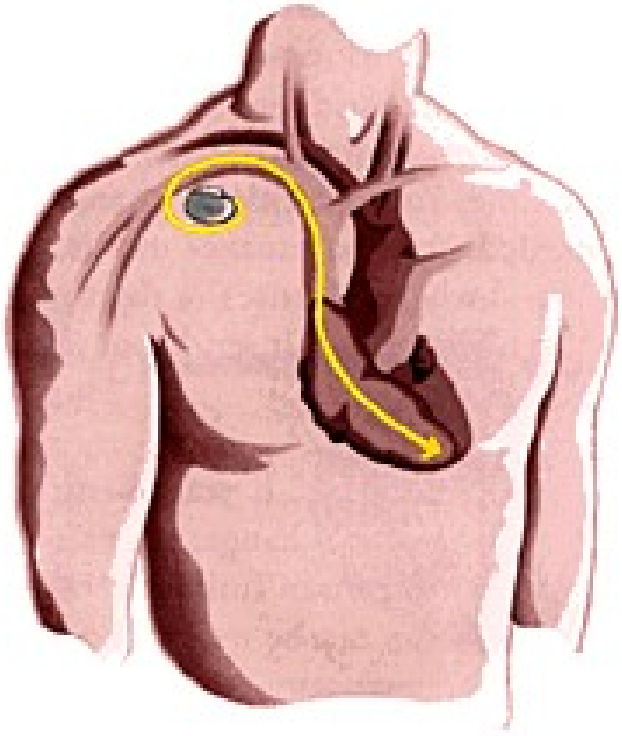
Single Chambered



Dual Chambered



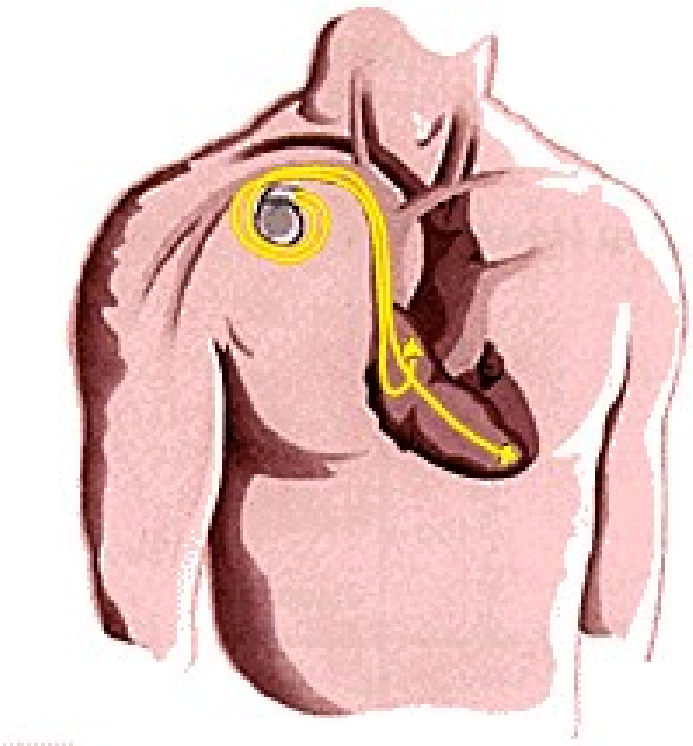
Single-chamber pacemaker



A single-chamber pacemaker placed in the right ventricle of the heart

- **Correct a slow or unsteady heartbeat**, resulted from “heart block”.
- Pacemaker lead will ensure that the heart's ventricles contract rhythmically and fully.

Dual-chamber pacemaker

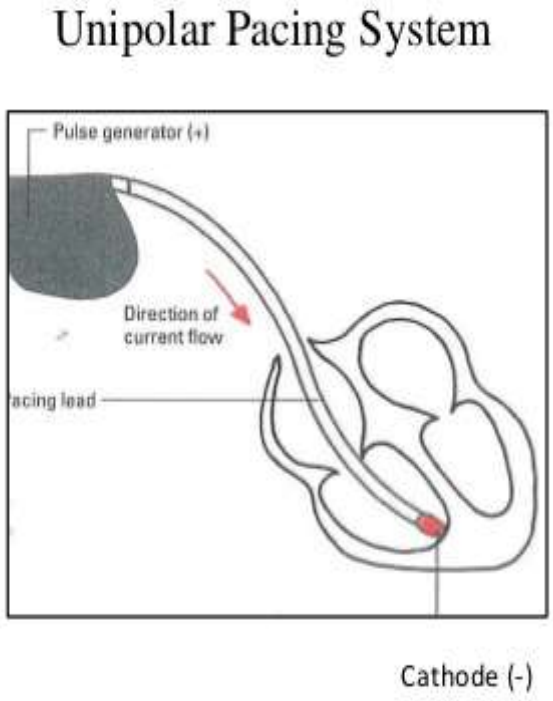


A dual-chamber pacemaker with two pacing leads

- Senses both **atrial** and **ventricular** activity to see if pacing is needed
- When pacing does occur, the contraction of the **atria** is followed closely by a contraction in the **ventricles**
- Resulting in timing that mimics the heart's natural way of working.

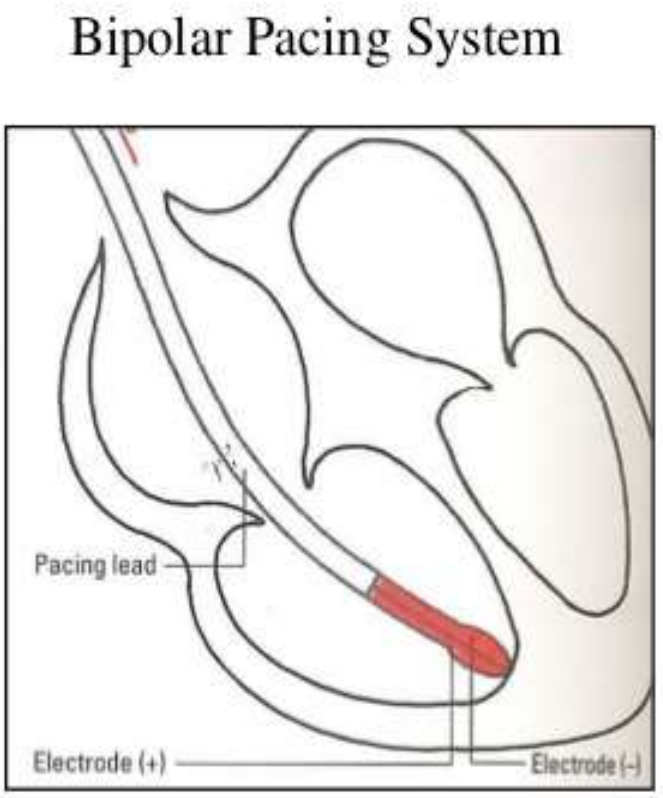
Unipolar Pacemaker

- Lead has only one electrode that contacts the **heart at its tip (-) pole**
- **The power source is the (+) pole**
- **Patient serves as the grounding** source
- Patient's **body fluids** provide the return pathway for the electrical signal
- **Electromagnetic interference** occurs more often in unipolar leads



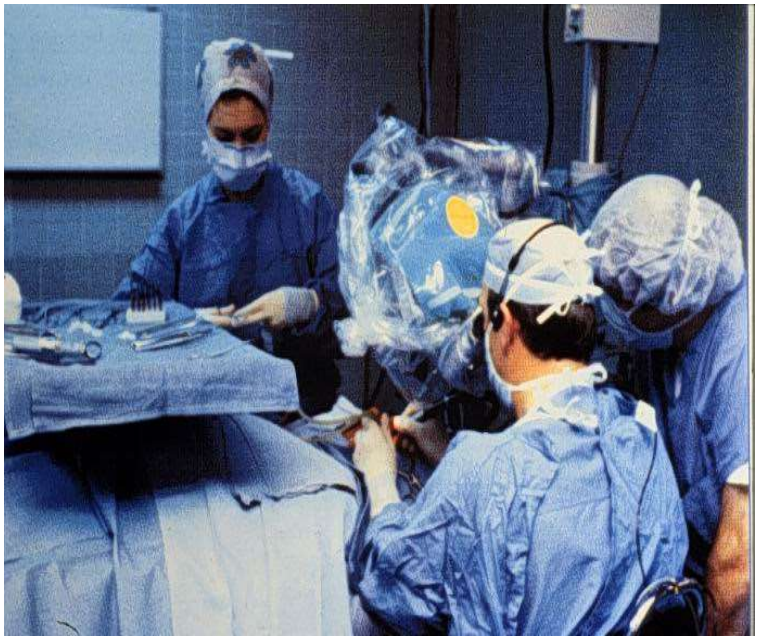
Bipolar Pacemaker

- If bipolar, there **are two wires to the heart** or **one wire with two electrodes at its tip**
- Provides a **built-in ground lead**
- Circuit is completed **within the heart**
- Provides more contact with the endocardium; needs lower current to pace
- Less chance for **Electromagnetic interference**



The Surgery Overview

- Requires **MINOR surgery**
- Takes **2-3 hours**
- Generally, NOT put to sleep
- Stay in hospital overnight
  - Return to normal activities a few days after surgery



Pacemaker Maintenance

- Pacemakers **do not last forever**
  - Battery actually last between **5-15 years** with **6-8 years being average**
  - Wires usually last a little longer
  - All depends on how active the pacemaker is
- Regular check-ups with doctor is must to make sure the battery/wires are working perfectly.

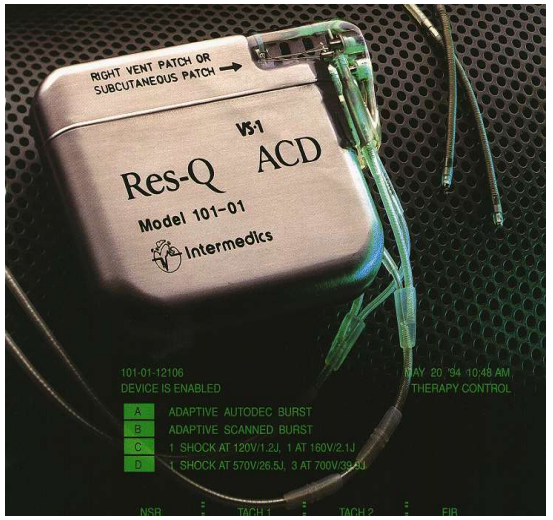
Life Post-Pacemaker

- Electrical Devices can interfere!
  - **Cell phones**
  - **Microwaves**
  - **Metal detectors**
  - **Electrical generators**
- However, only **long periods of contact really have an impact**
- Also, this danger is **lowered with newer devices**

Pacemakers Today

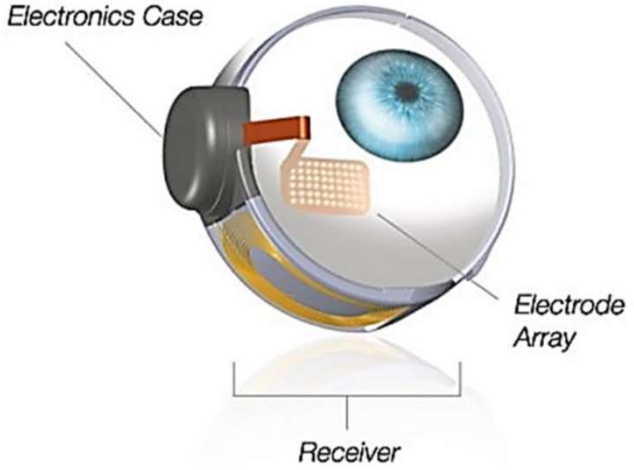
- Single or dual chamber, depending upon patient's heart condition
- **Small and lightweight** (~22-50gms)
- **Adaptive rate pacing**
- **Programmable** lead configuration

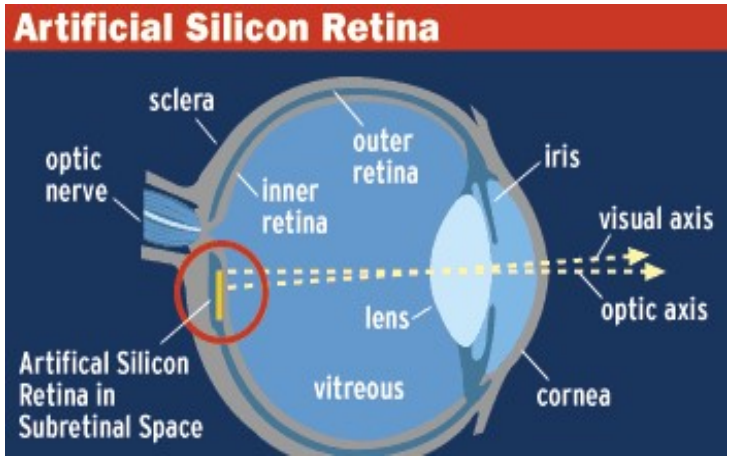
Today, advanced electronics afford dual-chamber multi-programmability, diagnostic functions, rate response, data collection, and exceptional reliability, and power sources extend longevity to upward of 10 years.



The Bionic Eye

- **Bio-electronic eye**
- Electronic device which replaces functionality of a part of the eye
- An artificial eye provokes **visual sensations in the brain** by directly stimulating different parts of the **optic nerve**.
- Many types of artificial eyes have been designed and **research is still going on.**
- Eg: **Artificial Silicon Retina**





Why Bionic Eye?

Macular Degeneration

- Age Related
- Loss of central vision and blurred peripheral vision
- Macula deteriorates over time
- Vision becomes gray
- 10% of adults over age 55 world-wide

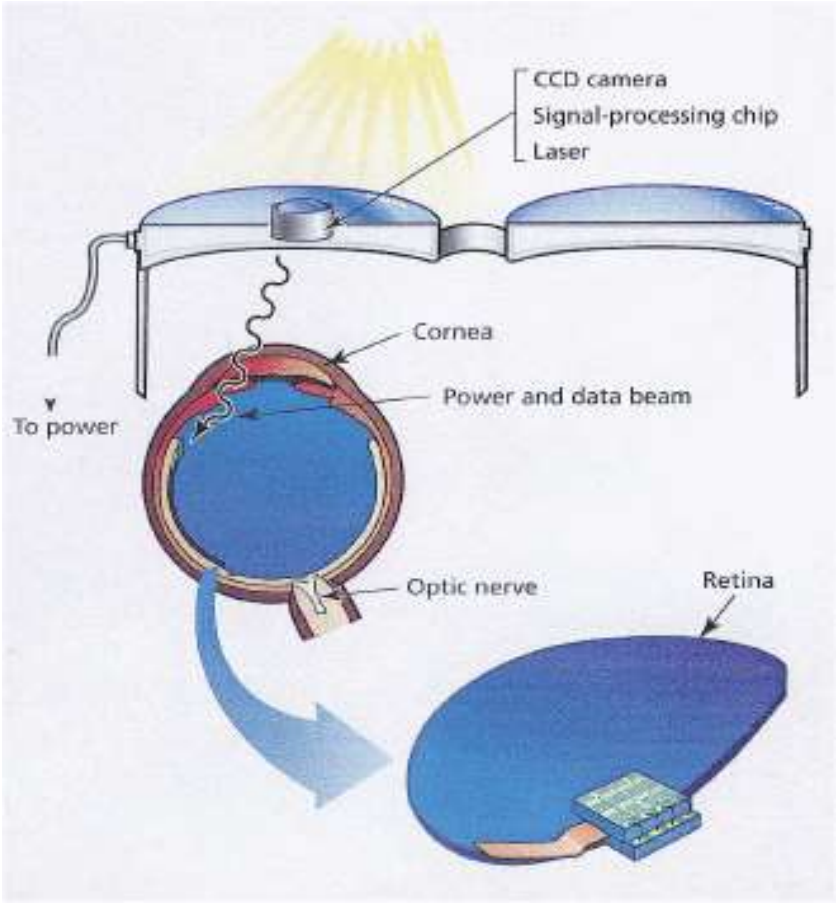
Retinitis Pigmentosa

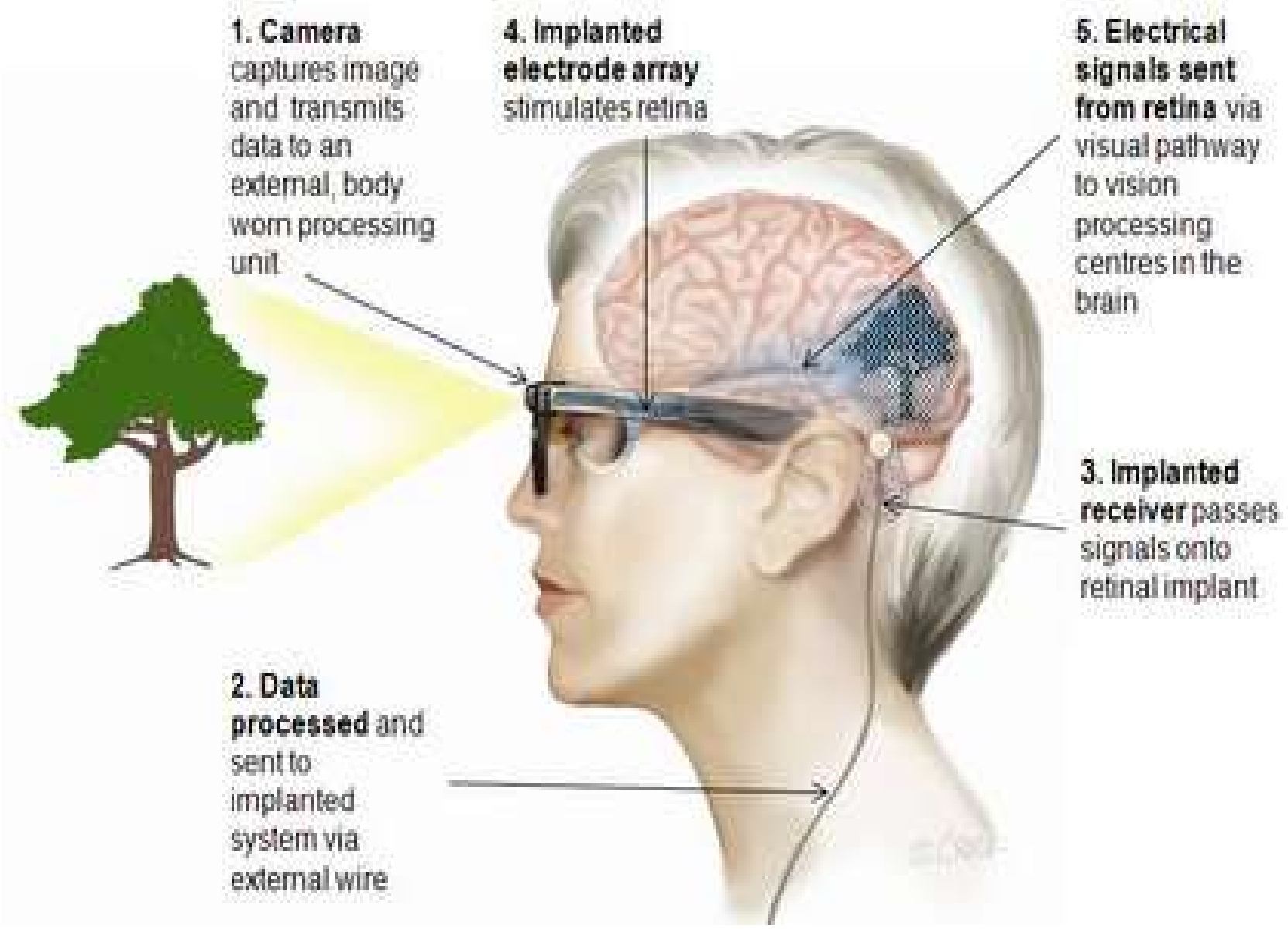
- Genetic
- Loss of peripheral vision inward
- Photoreceptors in periphery deteriorates
- 1.5 million people world-wide

Working mechanism

The bionic vision system consists of a **camera,** attached to a pair of glasses which transmits **high-frequency radio signals** to a microchip implanted in the eye

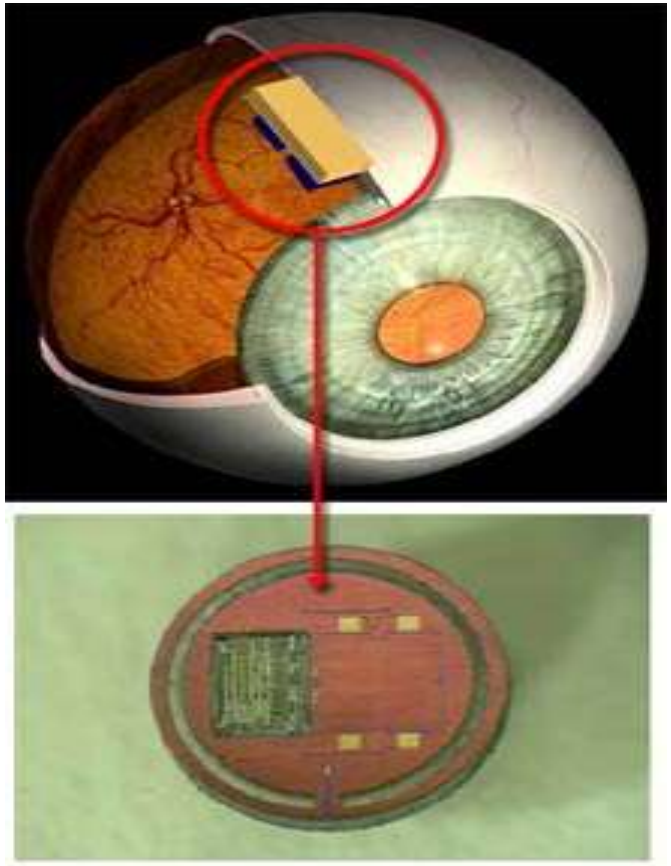
- **Electrodes on the implanted chip** convert these signals into **electrical impulses** to **stimulate cells in the retina** that connect to the optic nerve.
- These impulses are then passed down along the **optic nerve** to the vision processing centres of the brain, where they are interpreted as an image
- Patient spectacle holds the **camera** and **power source**




1. Camera captures image and transmits data to an external, body worn processing unit
4. Implanted electrode array stimulates retina
5. Electrical signals sent from retina via visual pathway to vision processing centres in the brain
3. Implanted receiver passes signals onto retinal implant
2. Data processed and sent to implanted system via external wire

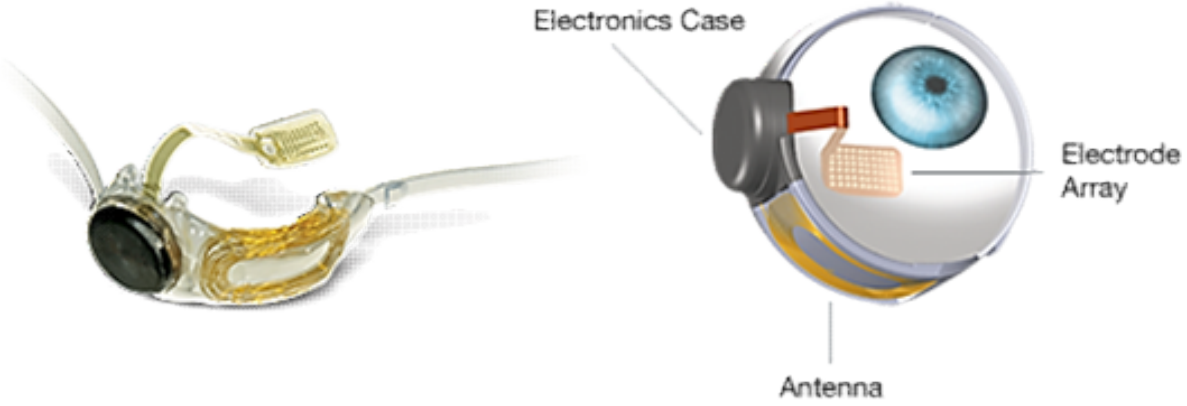
THE SURGERY!

- The microsurgery starts with **incisions** in the white part of the eye.
- Through the incisions, a **vacuuming device** will removes the **gel in the middle of the eye**.
- Then a **pinpoint opening** in the **retina** is made to create a **pocket to accommodate the chip**.
- The **retina is resealed** over the chip and **air is injected** into the middle of the eye to force the retina back over the device.



Components (The Argus®II)

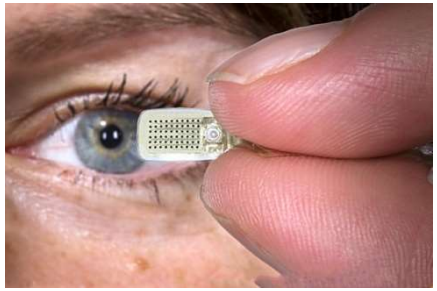
Dr. Mark S. Humayun -is the inventor of Argus series Bionic eyes.



Internal Parts

External Parts

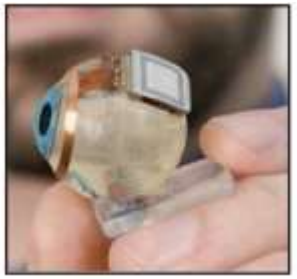
Bionic eye- Facts



Advantages

As such, the two medical conditions that this technology aims to address are **Retinitis pigmentosa** and **Age-related macular degeneration**.

- **No Batteries implanted within body (solar cells)**
- **No complicated surgical procedure**
- Power Requirement – ¼ of milliwatt



Limitations

- **Very Expensive**
- To benefit from this technology, is **patients need to have a functional visual pathway from the retina to the brain along the optic nerve, as well as some intact retinal cells.**
- The current Argus II Retinal Prosthesis System **doesn't enable users to perceive colors**

What is a cochlear implant?

A cochlear implant is an **electronic medical device** that **replaces the function of the damaged inner ear**.

Unlike **hearing aid**, which **make sounds louder**, cochlear implants **bypass the damaged hair cells** of the inner ear (cochlea) to provide sound signals to the brain.

- **Old generation**: Sound awareness only
- **New generation**: Improved communication abilities (auditory cues with **lip reading**, **open set speech**)
- Since **1972** more than 16 different cochlear implants
- **1984-** FDA approval for adults
- **1990 -**approval for children

Why cochlear implant?

The cochlear implant technology to help people who:

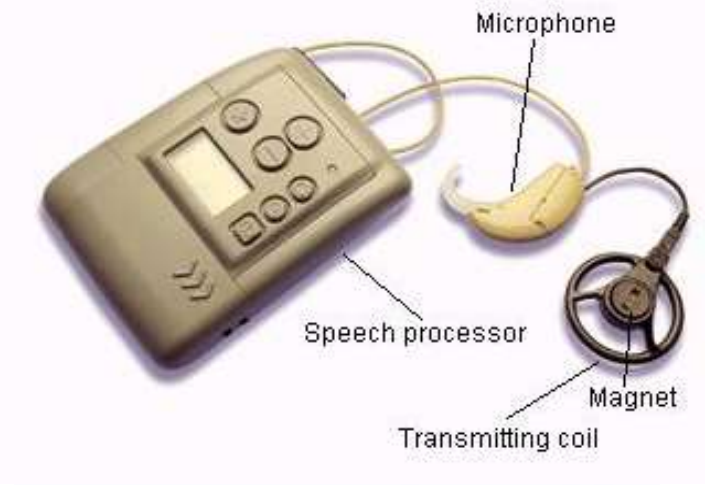
- have **moderate to profound hearing loss** in both ears
- Receive **little or no benefit** from **hearing aid**
- Score 50% or less on **sentence recognition tests** done by hearing professionals

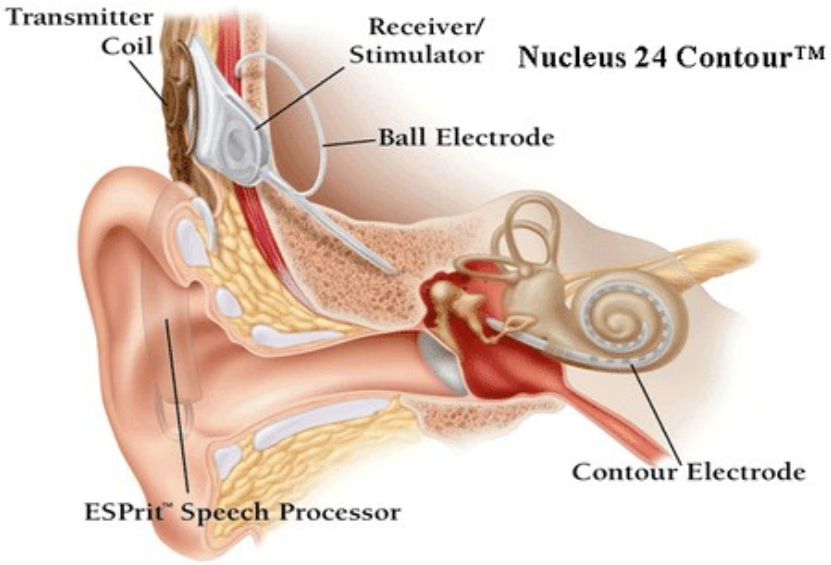
Working of a cochlear implant

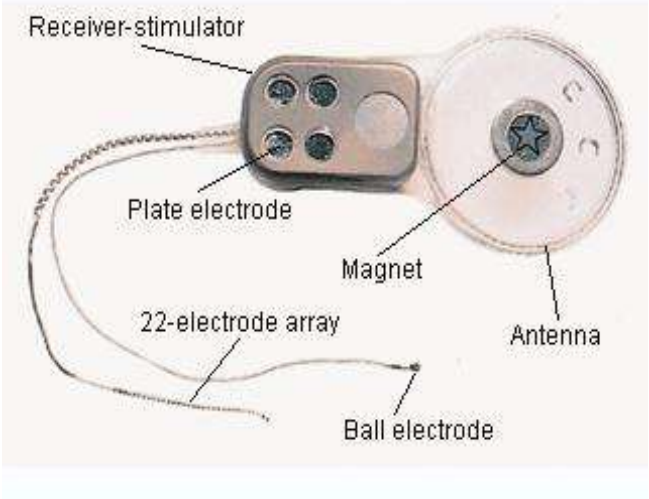
- A **sound processor** worn behind the ear or on the body, captures sound and turns it into **digital code**.
- The sound processor has a **battery** that powers the entire system.
- It **transfers digitally-coded sound** through the coil on the human head to the implant.
- The **cochlear implant** converts the **digitally-coded sound into electrical impulses** and sends them along the **electrode array** placed in the **cochlea (the inner ear).**
- The **implant's electrodes stimulate the cochlea's hearing nerve**, which then sends the **impulses to the brain** where they are interpreted as sound.

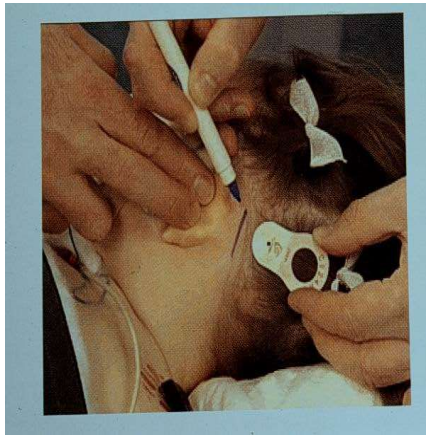
Structure of Cochlear Implant

1. External components
2. Internal components









Benefits of a cochlear implant for hearing impaired person

- **Hear better** with a cochlear implant than with a **hearing aid**.
- Can **focus better when in noisy environments**.
- Find it easier to **have conversations with people in crowded places**.
- **Reconnect with missed sounds** that they could not hear before their cochlear implant.
- **Feel safer** in the world as they can hear alarms, people calling out and approaching vehicles.

Thanks!

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BT1651-1 BIOLOGY FOR ENGINEERS

UNIT 3: REAL LIFE SCENARIOS

1. RECENT SCENARIOS IN ENVIRONMENT

Dr. Venkatesh Kamath H.
Asst. Professor, Dept. of BTE

Recent Scenarios in Environment

i) Desserto – Cactus Vegan Partially Biodegradable Leather

ii) Exhale – The Bionic Chandelier

iii) Plastic Roads

Desserto: Cactus Vegan Partially Biodegradable Leather

Desserto – Cactus Vegan Partially Biodegradable Leather

WHAT IS DESSERTO® ?

The world's first highly sustainable and environmentally friendly organic material made of ***Nopal cactus***, also known as the prickly pear.

ADRIANO DI MARTI

With the purpose of creating an alternative to animal leather, **Adrián López Velarde** and **Marte Cázarez**, both hailing from **Mexico**, developed a vegan alternative to leather made with nopal (a cactus), which they successfully showcased in October 2019 in Milan, Italy.

Desserto – Cactus Vegan Partially Biodegradable Leather

- Adriano Di Marti is a company to focus on developing Desserto®
- Desserto® is the trade name of cactus based material as an alternative to leather
- **Storyline:** Adrian and Marte had the idea after working in the furniture, automotive and fashion industries where they identified that the problem of environmental pollution was very serious. As a result, they were genuinely interested in reducing environmental impact, so they decided to leave their jobs and start Adriano Di Marti.

Desserto – Cactus Vegan Partially Biodegradable Leather

- It has competitive features compared to animal or synthetic leather, like sustainability, performance and aesthetics.
- It is distinguished by its great softness at touch while offering a great performance for a wide variety of applications and complying with the most rigorous quality and environmental standards.
- It offers cruelty free, sustainable alternatives, without any toxic chemicals, phthalates and PVC.
- It is partially biodegradable and has the technical specifications required by the fashion, leather goods, luxury packaging and furniture industries.

Desserto – Cactus Vegan Partially Biodegradable Leather

- The cactus plantation is perennial, meaning that we only plant one time and the plantation last for about 8 years, different from other C3 plantations such as corn which has to be cultivated, harvested and then cultivated again annually.
- Cactus absorbs CO_2 during night because only when the environment is fresh the plant opens it's stoma capturing CO_2, generating oxygen and absorbing water present in the atmosphere which normally comes from the morning dew.
- Cactus CO_2 sequestering capacity: Cactus is a natural carbon sink, it has a great CO_2 sequestering capacity. From our 14 acres, we are able to absorb 8,100 tons of CO_2/year while at the farm we only generate 15.30 tons of CO_2 annually.

Desserto – Cactus Vegan Partially Biodegradable Leather

- After cutting the mature leaves, we dry them under the sun for three days until achieving the exact humidity levels that we seek. So, there's no additional energy used in this drying process.
- Then we process the organic raw material to make it part of our patented formula which allows us to make Desserto®.
- No herbicides nor pesticides used
- It takes approximately 3 leaves of cactus to create one linear meter of Desserto.
- Only cut the mature leaves of the plant without damaging the plant itself, enabling repeat harvest every 6-8 months from the same plants.

- On the other hand, animal based Tanneries produce wastewaters majorly containing Chromium salts that are dangerous to environment.

Desserto – Cactus Vegan Partially Biodegradable Leather

Life Cycle Analysis: Cradle to Gate analysis (Data: per m^2 leather produced)

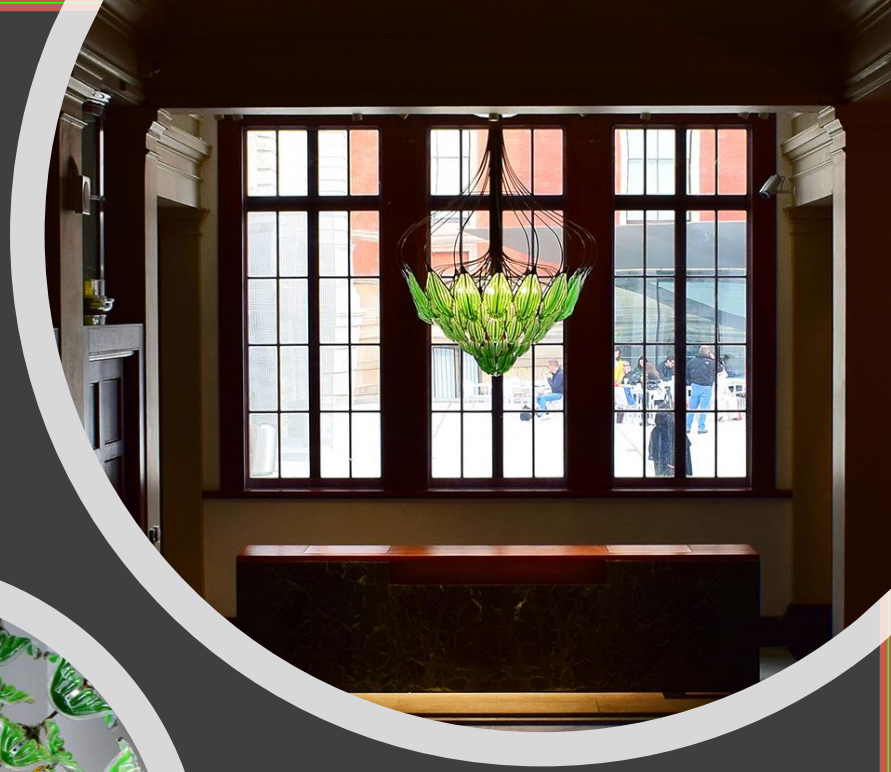
	Desserto	Animal Leather	PU Leather
CUMULATIVE ENERGY DEMAND (MJ)	34.33 ↓	335.84 ↑	92.93
GHG CARBON (kg CO_2 Eq.)	1.39 ↓	27.30 ↑	4.81
EUTROPHICATION (kg PO_4^{3-} Eq.)	0.0005 ↓	0.0030 ↑	0.0031
WATER USE (Liter)	20 ↓	32,950 ↑	2,930
CARBON NEGATIVE FARMING	Absorbs CO_2 more than production	No CO_2 absorption, only production	No CO_2 absorption, only production

PU leather = Polyurethane leather / Artificial leather

Reference: https://desserto.com.mx/home

YouTube Video: https://www.youtube.com/watch?v=x4sGOYbHoXo&t=72sa

Exhale
The Bionic Chandelier



Exhale: The Bionic Chandelier

- An air purifier, an art object, and a piece of lighting design all in one living, ‘breathing’ chandelier.
- Bionic Chandelier, a microorganism-filled light made from 70 ‘leaves’ that take carbon dioxide out of the air and turn it into oxygen.
- **Inventor** and bioengineer **Julian Melchiorri** *(Founder of Arborea Ltd., London, UK)*
- **Inspired by** the **Victoria and Albert Museum‘s Art-Nouveau and Islamic Art collections**

- The chandelier **purifies the air indoors** through photosynthesis performed by living photosynthetic microorganisms enclosed into leaf modules.

Exhale: The Bionic Chandelier

Exhale is the first living object which continuously grows while performing biologically-driven depurative functions.

How does this work?

- The light of the chandelier illuminate the space but also stimulates photosynthesis performed by tiny microalgae, this living microorganisms feed on carbon dioxide while releasing breathable oxygen into the room.
- This biological process performed by the chandelier establishes and explores a new symbiotic relationship between object and people where life-giving resources are constantly exchanged, and where each other waste enables respective metabolic processes.

Exhale: The Bionic Chandelier

Structure

- The metal structure is entirely hand-made and burned-colored.
- Each structure holds a single leaf module of 3 different sizes that repeats it-self 70 times on a radial array; similar to how nature shapes plants and shells.

- The Bionic Chandelier is connected to a life-support-unit device, developed by Arborea's engineers, which nourish and maintains the microorganism culture alive.

Exhale: The Bionic Chandelier

This piece explores how advances in biotechnology and engineering can be applied to everyday objects and architecture to improve the quality of our lives. The biological process at its core establishes a new symbiotic relationship between object and people, where life-giving resources are constantly exchanged. By harnessing one ecosystem, between microalgae and light, it essentially creates another one, with the people around it.

Reference:

Link to Inventor website: https://www.julianmelchiorri.com/Bionic-Chandelier

YouTube Video:

An interview of the Inventor: https://www.youtube.com/watch?v=Lxd43iH-CX0

Plastic Roads

Could The Roads of the Future be Bio-based?

Plastic Roads

Asphalt Roads

- **Bitumen** is a by-product of oil production and is used to bind the surfaces of paved roads.
- Concern - environmental impacts and future supply if petroleum refining slows down
- Bitumen mixed with aggregates such as crushed rock, sand and gravel to create **asphalt**.
- **Sticky bitumen binds it all together** – to build roads.
- Around 90 per cent of all paved roads are surfaced with asphalt.
- **Bitumen is a very thick liquid form of crude oil**. It does occur naturally, but the type of Bitumen used as a binder in asphalt is a by-product of oil refining.

Plastic Roads

Asphalt Roads blended with Plastic waste

- Plastic Roads are constructed from a **mixture of plastic and bitumen**.
- Most **common plastic**
  - Polyethylene terephthalate (**PET or PETE**),
  - Polypropylene (**PP**), and
  - high low density polyethene (**HDPE and LDPE**).
- Plastic waste – collected – sorted – cleaned – dried – shredded – melted (170^0C).>
- Melted plastic mixed with hot bitumen - mixed thoroughly – laid on roads

Plastic Roads

- **Asphalt Roads blended with Plastic waste**

- **Invented by Dr. Rajagopalan Vasudevan**
- Professor, Thiagarajar College of Engineering, Tamil Nadu.
- Recipient of Padma Shri award for this innovative method of road construction.

YouTube Video:

A short talk by the Inventor: https://www.youtube.com/watch?v=FjfcDnoo-I0

Plastic Roads

Biological Alternative to Bitumen

Exhibit # 1

- In the **Netherlands** there are now test roads and cycle paths that are paved with a bitumen-like product made from the **natural binder lignin**.
- Lignin is a **structural polymer in plants** and trees that is released as a waste product from a number of industrial processes.
- Testing at Wageningen University & Research
- Road used by cars and heavy trucks, some minor roads, and a cycle
- **Three sections** of roads constructed, each produced using a **different lignin-based bio-bitumen composition**.
- **Successful** demonstration up to **50% Bitumen** and **50% Lignin**

Plastic Roads

Biological Alternative to Bitumen

Exhibit # 1

- **Uses lignin from various sources**, including different types of paper pulp production and a bio-refinery that produces cellulosic ethanol from straw.
- Material appears to be **performing in a similar way** to standard bitumen, although they have a slight noise reduction.
- Normal lifetime of Asphalt road is 10-15 years. Lignin based roads requires testing
- 100% bio-based bitumen is possible in future

Plastic Roads

Biological Alternative to Bitumen

Exhibit # 2

- Research at **Aston University**, in Birmingham, UK.
- Developed a process to **breakdown the organic part of household waste** – food waste, plastic, paper and textiles – to produce a sticky, gloopy **black liquid** that is very **similar to bitumen.**
- The process is known as **Pyrolysis**
- Bio-bitumen is produced by **heating** the waste to around **500°C** in the **absence of oxygen**
- Change process parameters (temperature, processing time and product collection strategy) - improve product characteristics & quantities

Plastic Roads

Major Merits of Bio-bitumen

- Natural material and renewable
- Cost effective

Major Drawback

- Currently up to 50% blend gives good result
- Long term durability of road is concern
- Repeated servicing of roads may be required.

Thank you

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BT1651-1 BIOLOGY FOR ENGINEERS

UNIT 3: REAL LIFE SCENARIOS

2. RECENT SCENARIOS IN AGRICULTURE

Dr. Venkatesh Kamath H.
Asst. Professor, Dept. of BTE

Recent Scenarios in Agriculture

i) Solar-powered Pest Control System for Small Agricultural Fields
ii) Nanoparticle-based Bio-Degradable-Carbonoid-Metabolite (BioDCM)
iii) Crop Sensing Technology

Solar-powered Pest Control System for Small Agricultural Fields

Solar-powered Pest Control System for Small Agricultural Fields

- The semi-robotized gadget, created by Anup Behera, Hifjur Raheman, Rahul K and P.B.S. Bhadoria from the dept. of Agricultural and Food Engineering at **IIT Kharagpur**
- Address a few difficulties of automated pest control frameworks in the small farm category.
- Self propulsing boom-like sprayer, capable of being powered with solar energy while safely directing the crops in smaller fields.
- The system aims to
  - Improve the capability and standardization of the area in liquid spray
  - Reduce the pilot's daily grind
  - Renewable energy reliance for spraying in the cultivated areas.

Solar-powered Pest Control System for Small Agricultural Fields

Components & Working:

The machine involves a propelling unit mounted with a liquid storage tank and a pump powered by a DC motor to pressurize the liquid to be dispersed.

On a boom fixed towards the front of the rig, several numbers of spray nozzles are installed to reach larger widths at a point.

Solar-powered Pest Control System for Small Agricultural Fields

Components & Working:

- A collection of rechargeable solar batteries go about as the power supply of the DC engine to push the spraying module just as for operating the pump. In contrast to a backpack sprayer, the liquid storage tank is of greater limit and it is carried on a sun controlled three-wheeler trolley.
- An administrator is needed to monitor the movement of the spraying module.
- A basic package has been given to adjust the position of the spray unit or the sprayer height from the ground in order to perform showering for various statures of harvests.
- Solar panels are placed on top of the unit to give nonstop power supply during activity through the Maximum Power Point Tracker regulator and it additionally gives shade to the administrator during spraying operation.

Solar-powered Pest Control System for Small Agricultural Fields

Addresses the following Problems caused by Conventional methods:

- Avoidance of pests and sicknesses is significant to improve yield.
- For bigger plots of farmlands, sprayers mounted onto tractors are utilized, while physically worked backpack sprayer is utilized for more modest parcels.
- Proficiency of spraying relies upon the ability of the administrator prompting non-consistency in spraying.
- Requires immense labour power and activity time.
- Utilizing sprayers mounted onto tractors in more modest plots then again would make the harvests inclined to harms because of their higher turning range.
- Prompts the wastage of chemical substances because of lower control on robotized spraying notwithstanding the environmental contamination because of the smoke discharges from the tractor.

Such advancements engage every individual of the cultivating local area walking the course towards ATMANIRBHAR BHARAT

The Engineering marvels are not successful unless it reaches the end user.

Nanoparticle-based Bio-Degradable-Carbonoid-Metabolite (BioDCM)

Nanoparticle-based Bio-Degradable-Carbonoid-Metabolite (BioDCM)

- The Novel Nanoparticles can **protect** the agricultural **crops from fungal and bacterial infections**

- It can be used as an **effective organic antimicrobial agent** and carbonaceous degradable encompassing to protect crops

- **Developers:**
  - **Dr. Santosh K Misra**, and **Mr. Piyush Kumar** from the Department of Biological Sciences & Bioengineering, IIT Kanpur
  - **Dr. C. Kannan** and **Ms. Divya Mishra** from ICAR-Indian Institute of Rice Research, Hyderabad
  - **Dr. R Balamurugan** and **Ms. Mou Mandal** from the School of Chemistry, University of Hyderabad.

Nanoparticle-based Bio-Degradable-Carbonoid-Metabolite (BioDCM)

How does this work?

- The technology is a protective biological alternative that can be used to enhance crop protection against various diseases in agricultural field, especially for rice crops.
- It is a bio-degradable nanoparticle system with a metabolite – the end-product of metabolism or the process of conversion of food, extracted from the naturally occurring common soil fungi viz., Trichoderma asperellum Strain TALK1.
- The extracted metabolite can be used as an effective organic antimicrobial agent and carbonaceous degradable encompassing to provide protection against crop diseases and enrichment of soil, respectively.

Nanoparticle-based Bio-Degradable-Carbonoid-Metabolite (BioDCM)

Effectiveness against *Xanthomonas oryzae*

- Plating of *Xanthomonas oryzae* on different concentration of BioDCM-NP
- High density region (whitish) in the sector indicate no impact of the metabolite on growth of X. oryzae.
- **Pale white indicate growth inhibition by BioDCM-NP** *[Required outcome of Expt.]*

Nanoparticle-based Bio-Degradable-Carbonoid-Metabolite (BioDCM)

Some key advantages of the invention:

- Precise target action
- Can be active at low concentration
- Has similar advantages like chemical pesticides but safe and biodegradable, unlike them
- Can offer multiple actions, e.g. – bio pesticide, phyto-stimulants, etc.
- Fast in action as it is applied in bioactive forms
- The bio formulation protects the active compound from high temperature

Crop Sensing Technology

Crop Sensing Technology

- **Modernized farming:** blending conventional farming with modern tools and IoT
- **Target:** Improving crop yield, high productivity
- **Commonly used tool:** Sensors
- **Sensors to measure:**
  - Plant water potential,
  - yield quality,
  - stage of development (ripeness),
  - nutrient levels,
  - pest and disease infections
  - Morphology factors: biomass, leaf area, and distribution of plants and organs
  - Surrounding condition: weather, temperature, soil properties

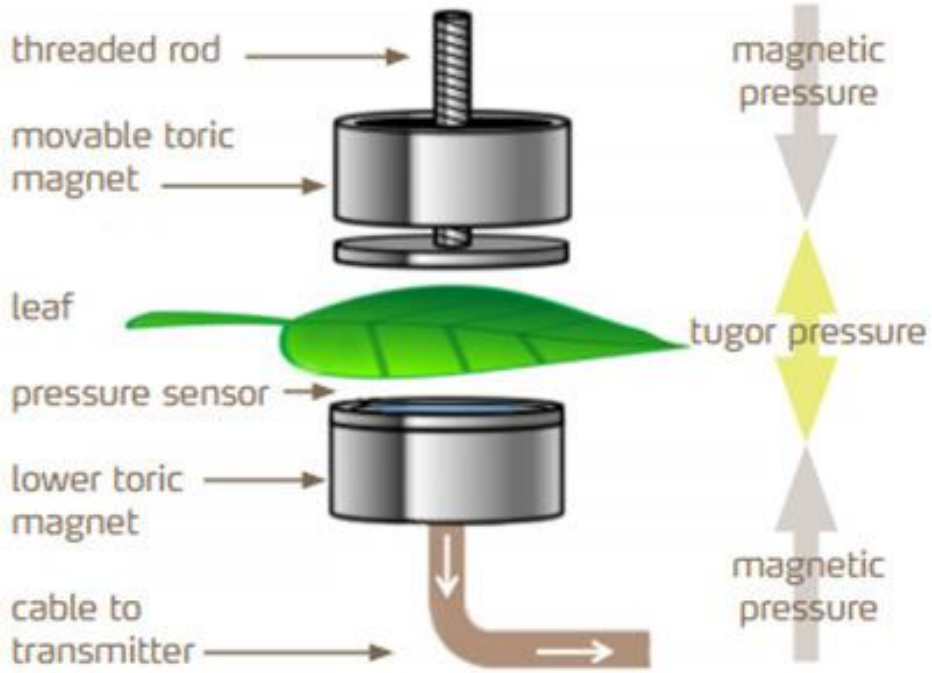
Crop sensing technology works using one of three principles of measurement:

- **Mechanical**
- **Acoustic**
- **Optical**

Mechanical Sensors

Mechanical sensors operate based on a plant contact.

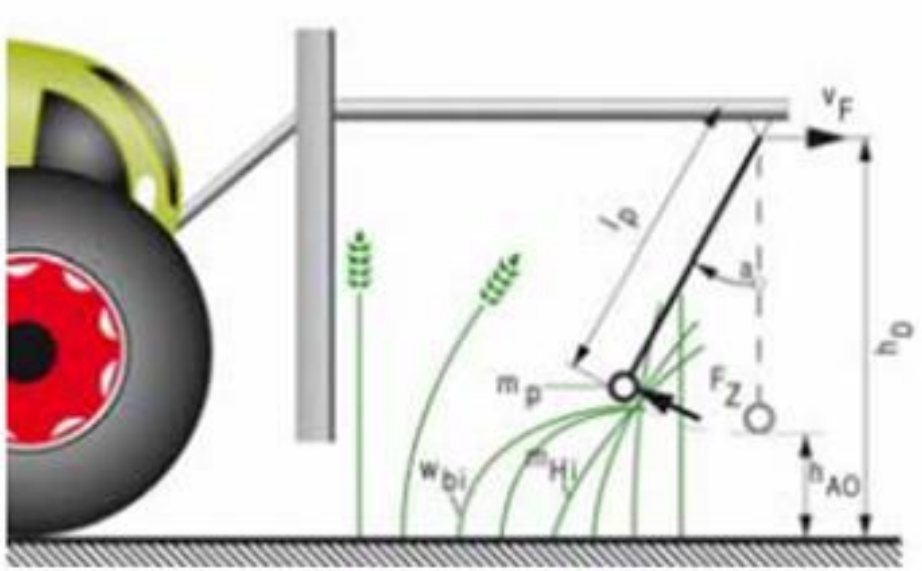
Sensors which measure crop water potential, Relative changes in the leaf's turgor pressure is measured. The leaf is placed between two magnets which measure the difference between plant turgor and magnetic pressure. Low plant turgor will increase magnetic pressure, thus indicating that the plant lacks sufficient water, making, irrigation necessary. Such sensors can measure changes in leaf turgor pressure in real time.



The work principle of water potential sensor

Mechanical Sensors

Sensors for crop biomass density measuring in which the sensor has a pendulum system which passes over the crop under a certain angle, thus detecting differences within the crop. In measuring the crop biomass, the sensor serves to be beneficial, as it regulates nitrogen applications over specific areas as well as ensures optimum plant protection.



Principle of sensor for crop biomass measurement

Acoustic Sensors

These sensors **detect the plant geometric structure by emitting an ultrasonic wave signal** to the plant. The sensor emits the signal as a **repeated sweep** under a certain frequency (usually 50-100 kHz). As a result of the application of ultrasonic energy to the plant, **several echoes occur**. Each echo contains information about the **geometric structure** of the plant, i.e. the structure of the foliage. This information can be captured by **extracting** features from the **echo signal into geometric features** related to the foliage structure (size, shape, orientation, and overall positioning of the leaves).

Optical Sensors

These sensors can be classified according to the platform. These include:

- **Satellites** – use cameras to collect images from great distances
- **Aerial (airplanes, UAV)** – use cameras to collect images from long distances
- **Ground-based** – collect reflectance data from short distances and can store it in a text file

The **ground sensors** can also be classified as **active** or **passive** based on the light source. **Active sensors** have **their own source of light**. This source can be a wide range light or a specific wavelength. Oppositely, **passive sensors** require an **external source of light**, such as the sun and are not able to work at night.

Optical Sensors

- Optical crop sensors evaluate various crop conditions by using specific wavelengths, from **monochromatic to multi-spectral (<10 wave bands) and hyperspectral (>10 wave bands)**.
- By shining light of specific wavelengths at crop leaves, sensors are able to measure **the type and intensity of the light wavelengths** reflected from the leaves back to the sensors.
- Different color light waves can be used to measure different crop conditions.

Optical Sensors

- Measuring crop reflectance, optical sensors are used to **evaluate crop conditions related to nitrogen**. They can estimate crop parameters like **LAI (Leaf Area Index), leaf chlorophyll content, soil cover, dry matter, water content, yield, nitrogen content**, and many others.

- An optical sensor, connected to a **GPS**, is able to use geographical coordinates to create maps from reflectance measurements. This map can help **identify the parts of the field** that are experiencing **more stress**, thus saving the use of inputs.

Crop Sensing Technology

Precision farming allows farmers fast and easy determination of various soil and crop factors crucial for farming. Because of this, crop sensing technology is one of the fastest growing segments in precision farming.

Optical sensor for nitrogen requirement detection

Optical sensor for weed detection

In the era of digital farm technologies and data-driven decisions, every farmer has the opportunity to make farming more efficient and easier than ever.

Thank you

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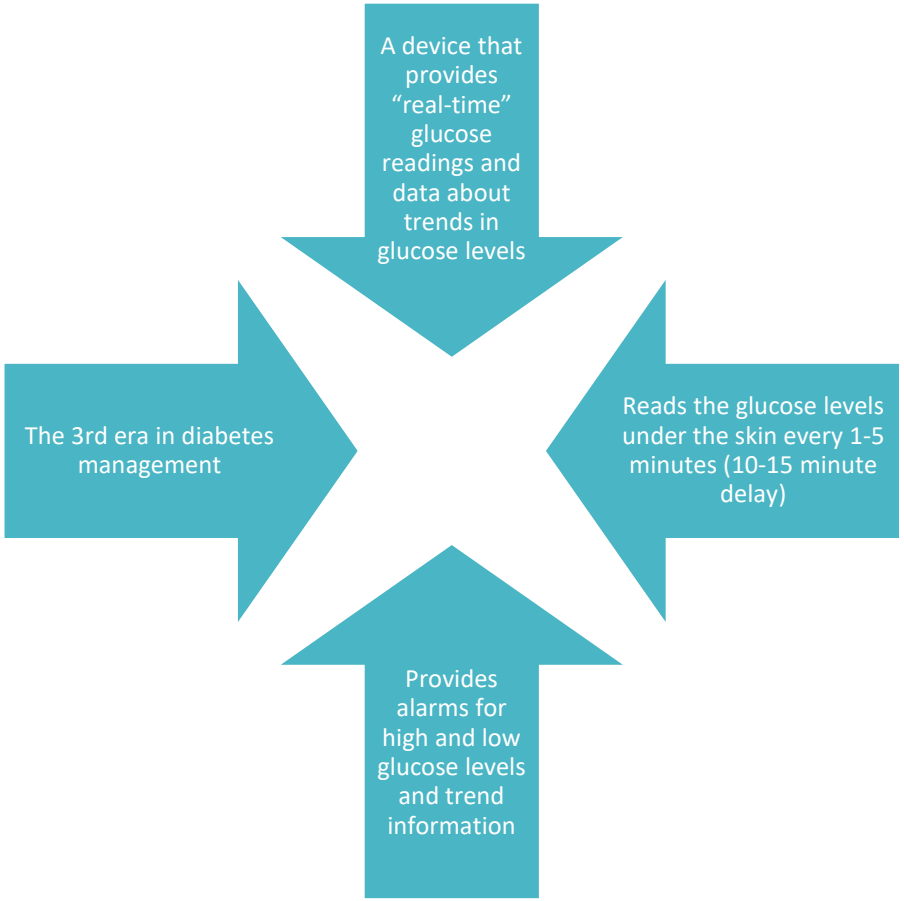
UNIT 3: REAL LIFE SCENARIOS

3. RECENT SCENARIOS IN MEDICAL TECHNOLOGY

Dr. Anil Kumar H. S.
Associate Professor, Dept. of BTE

CONTINUOUS GLUCOSE MONITORS

What is a CGM? (Continuous Glucose Monitor)



Who Should Use a CGM?

- The person and the family must both want a CGM
- A youth must be willing to wear the sensor (and carry the receiver)
- Using good diabetes care (4 BGs/day)
- Good support system
- Adequate body “real estate”
- Cost of CGM (RNs to elaborate)

Understanding Pumps and CGMs, p.100

Barbara Davis Center for Childhood Diabetes April 2010

WHY Use CGM?

Prevention of low blood sugars (alarms)

Prevention of high blood sugars (ketones)

Minimize wide glucose fluctuations

Behavior Modification

Prevention of Complications (?)

WHY Use CGM?

Prevention of low blood sugars (alarms)

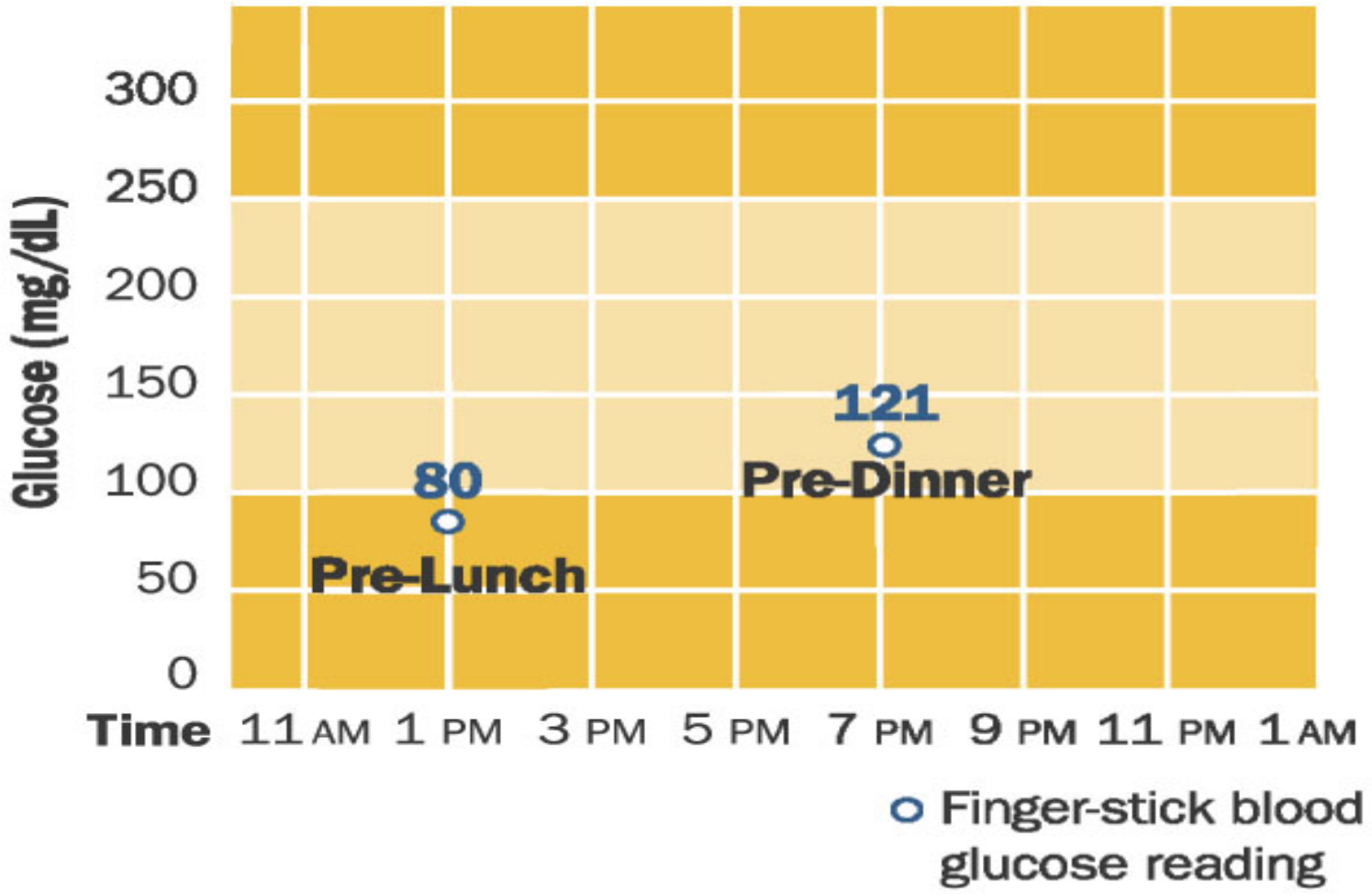
Prevention of high blood sugars (ketones)

Minimize wide glucose fluctuations

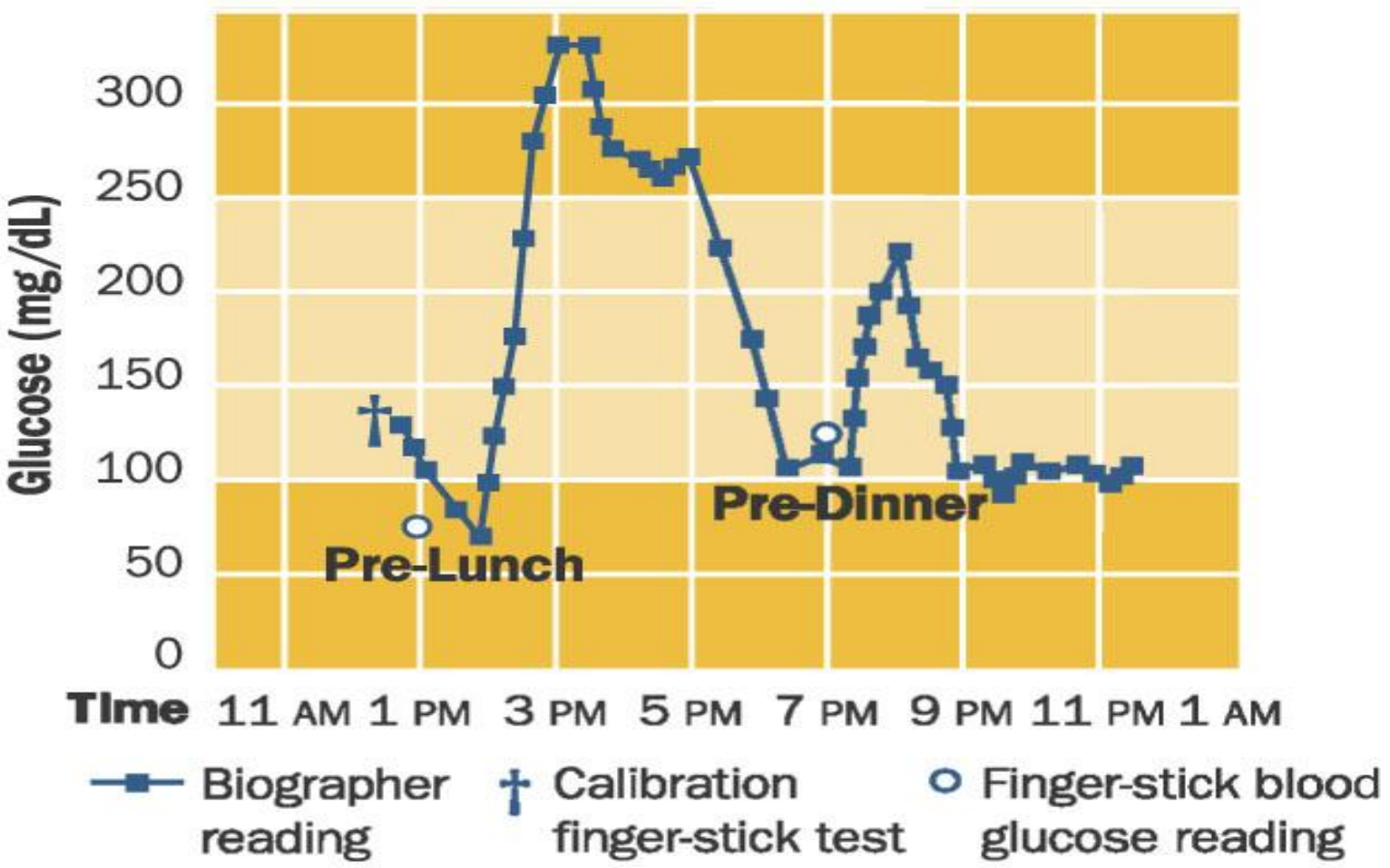
Behavior Modification

Prevention of Complications (?)

“Snapshot of BG levels”



Continuous Glucose Monitoring



WHY Use CGM?

Prevention of low blood sugars (alarms)

Prevention of high blood sugars (ketones)

Minimize wide glucose fluctuations

Behavior Modification

Prevention of Complications?

Three Parts to CGMs:

A. Sensor

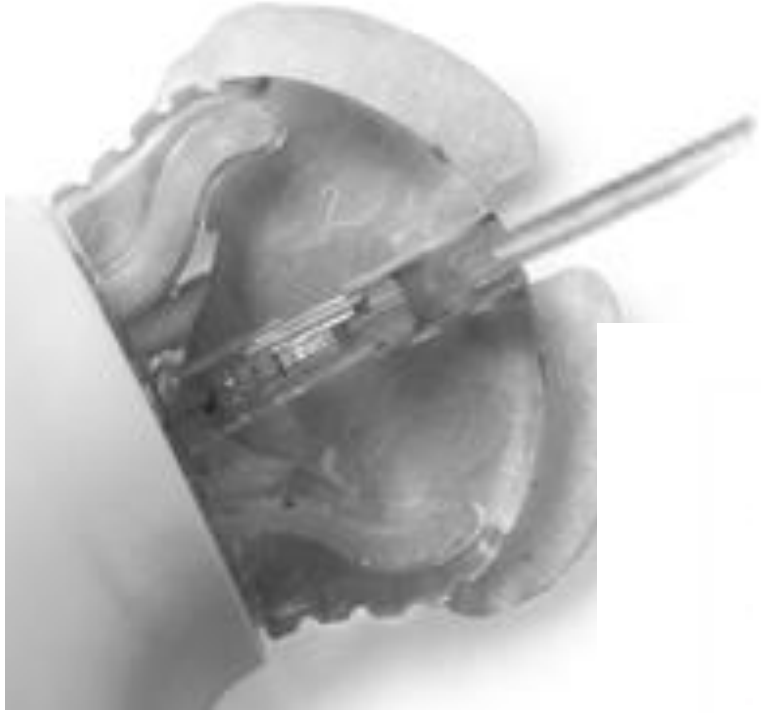
B. Transmitter

C. Receiver/Monitor

Understanding Pumps and CGMs, p.103

Barbara Davis Center for Childhood Diabetes April 2010

A) Sensor



B) Transmitter

C) Receiver or Monitor

What does “Calibration” mean and why do I need to do it?

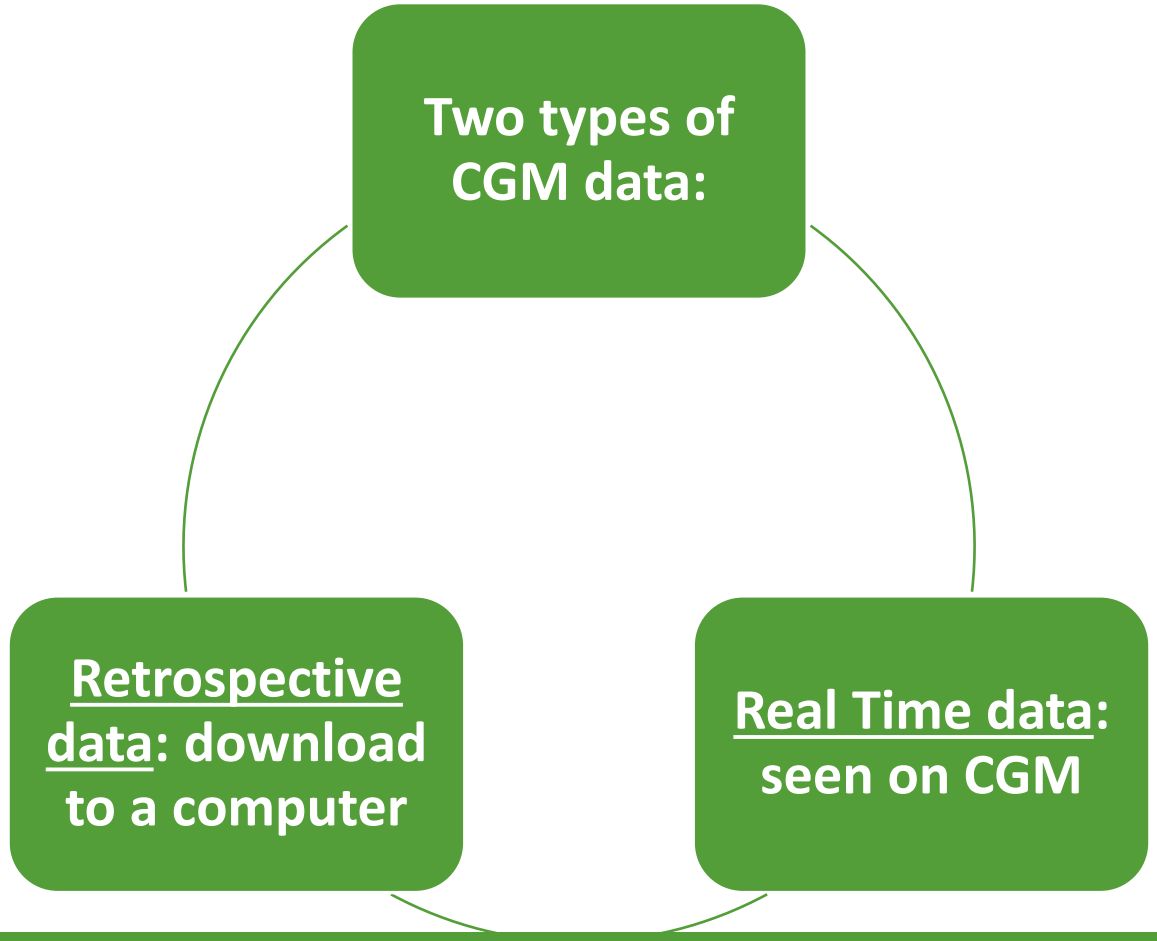
Calibration is a process that gives a fingerstick BG value to the CGM system so the values will align with each other

Number of Calibrations vary by device

Best times to calibrate are when the BG values are stable: before meals and before bed

Do not calibrate when arrows are present

What type of data will we get?



Real Time Data

Three types of Real Time Data:

A) Trend graphs

B) Alarms

C) Trend Arrows

Understanding Pumps and CGM: pages 109-113

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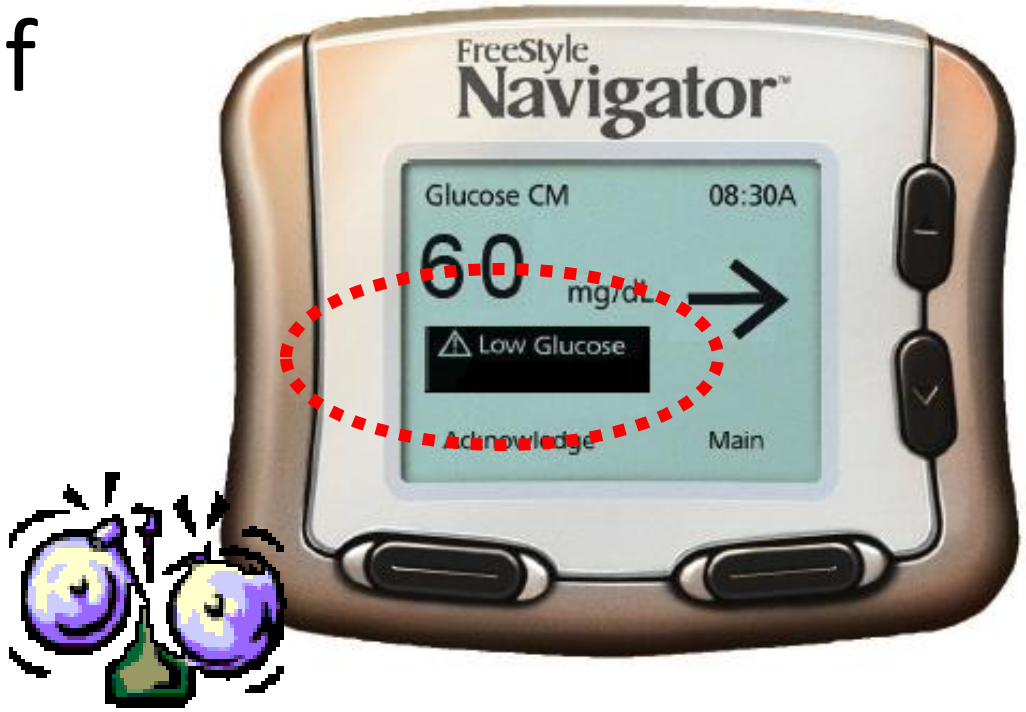
April 2010

Real Time data

ALARMS

Warn patients of current or projected high and low blood sugar



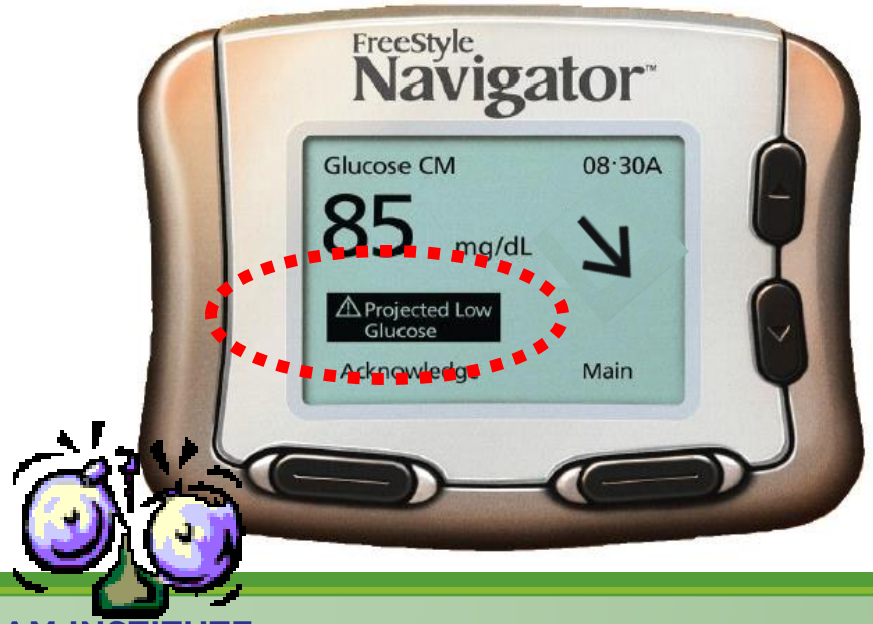
Real Time data

Threshold alarm:

Warning when glucose is

above or below a set value

--all devices have this



Projected Alarms:

10,20 or 30 minute warning of

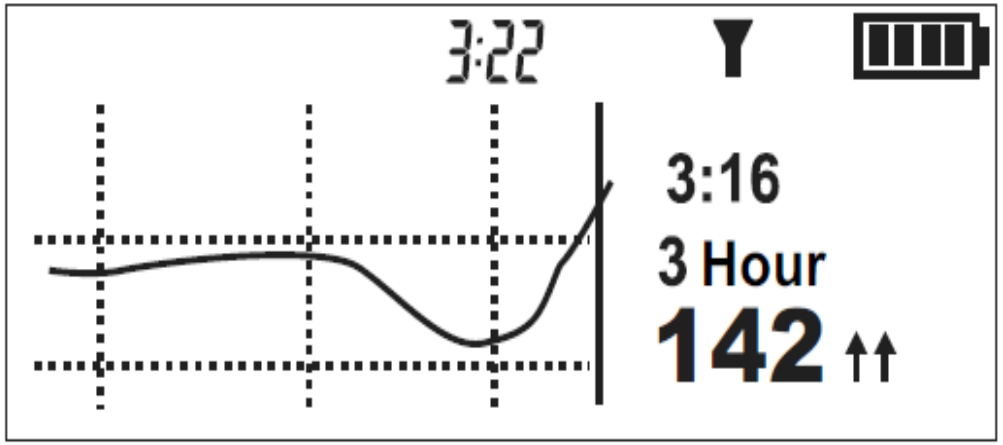
Impending hypo- or hyperglycemia

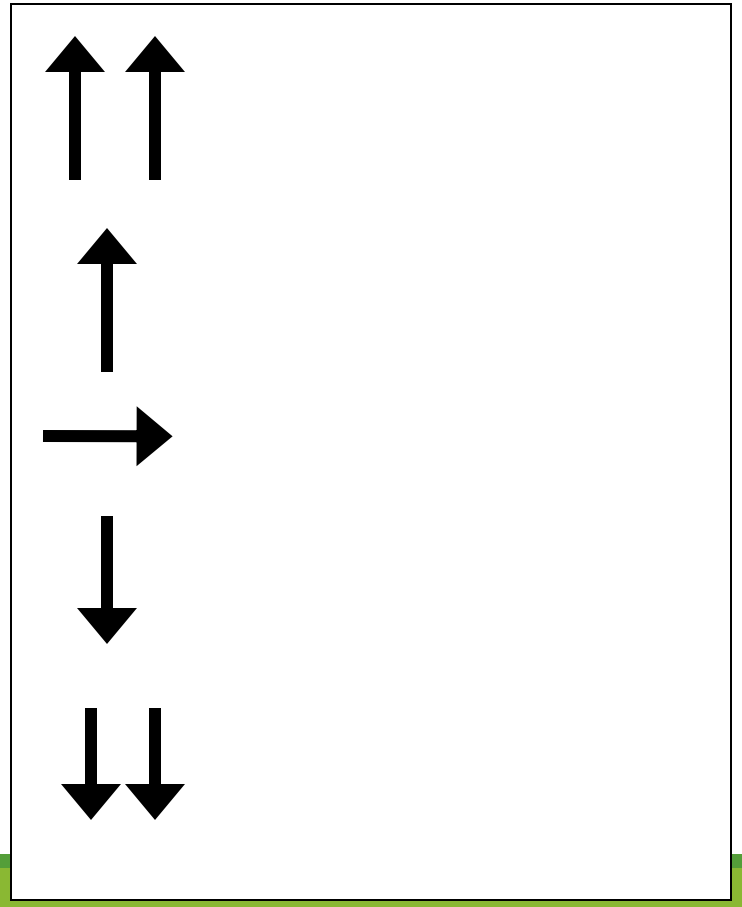
Real-Time Revel System, Guardian Real-Time and the Navigator have these

Real Time data

TREND ARROWS

Arrows that indicate the rate and direction of change





Retrospective Data

Three types of Retrospective data

(viewed on computer download)

A) Trend graphs

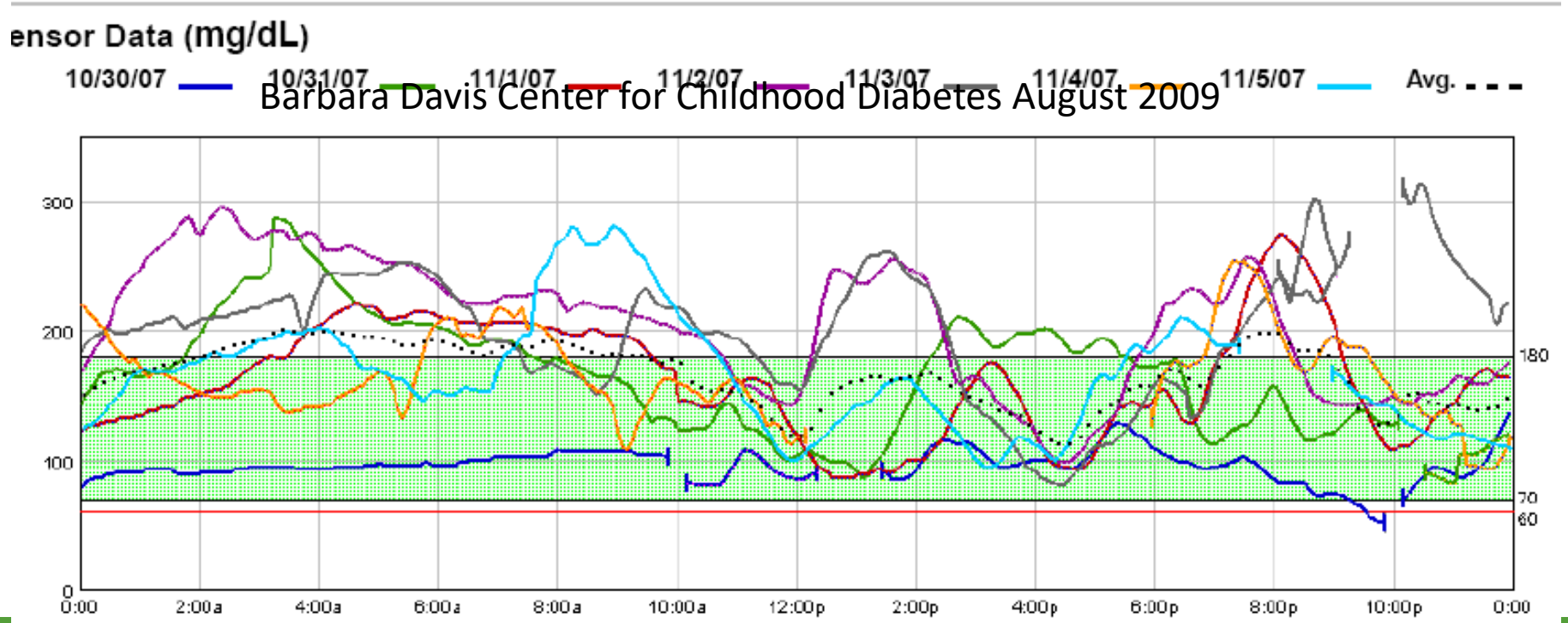
B) Pie charts

C) Data tables

Understanding Pumps and CGMs, Chapter 17

A) Trend Graphs

Reports that show one or more days of CGM data– also called sensor overlay



Barbara Davis Center for Childhood Diabetes August 2009

Barbara Davis Center for Childhood Diabetes April 2010

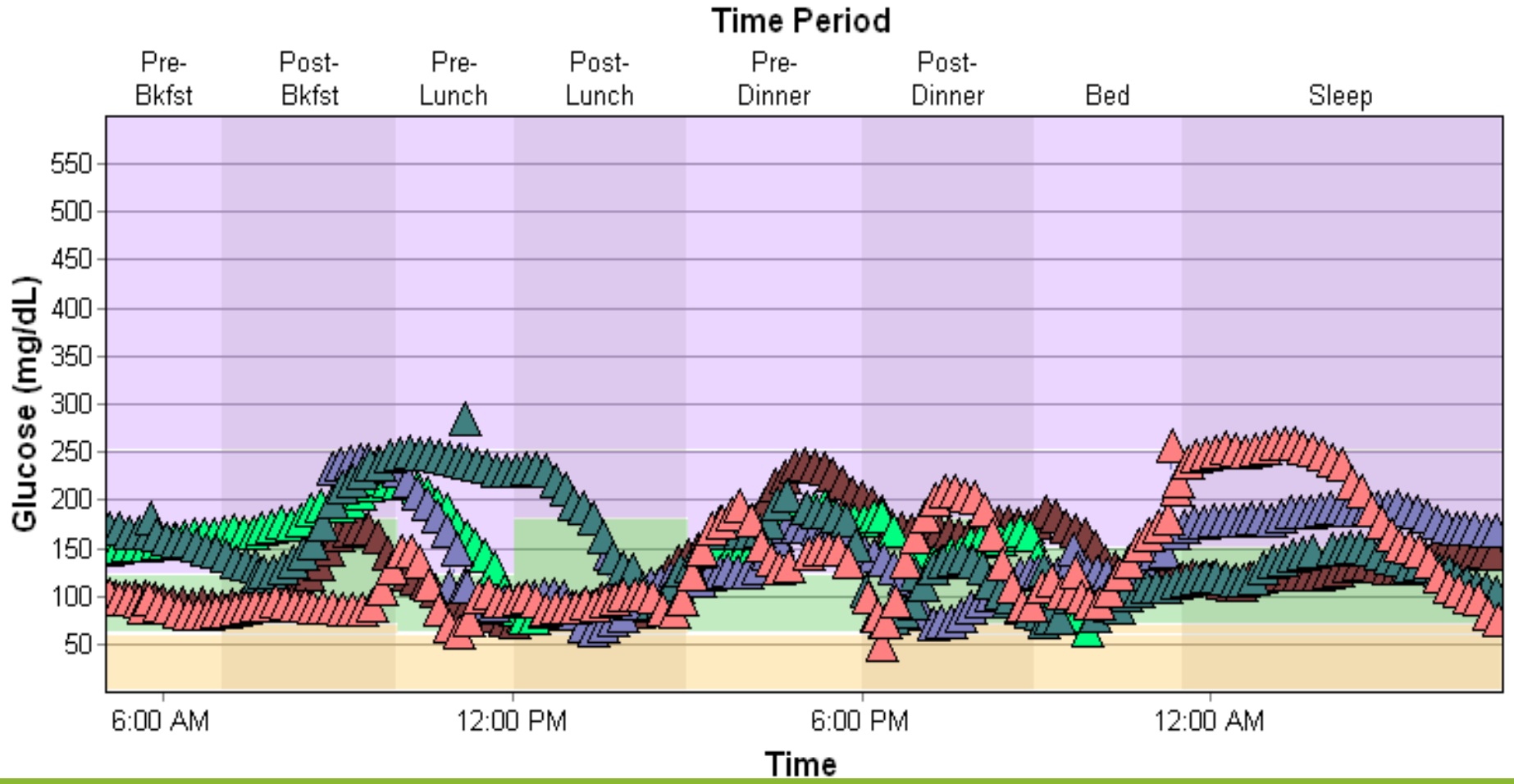
Retrospective data

Case Study: Using Trend Graphs

- **Three Trend Graphs showing change over time:**
  - Teenager with T1D for 9.5 years
  - Started Navigator: Sept. 2005
  - Starting HbA1c: 7.1%
  - Most recent HbA1c: 6.0%
  - Current number of low BGs per week (<60 mg/dL or <3.3 mmol/L): 1/week

BASELINE GLUCOSE Trend Graph #1

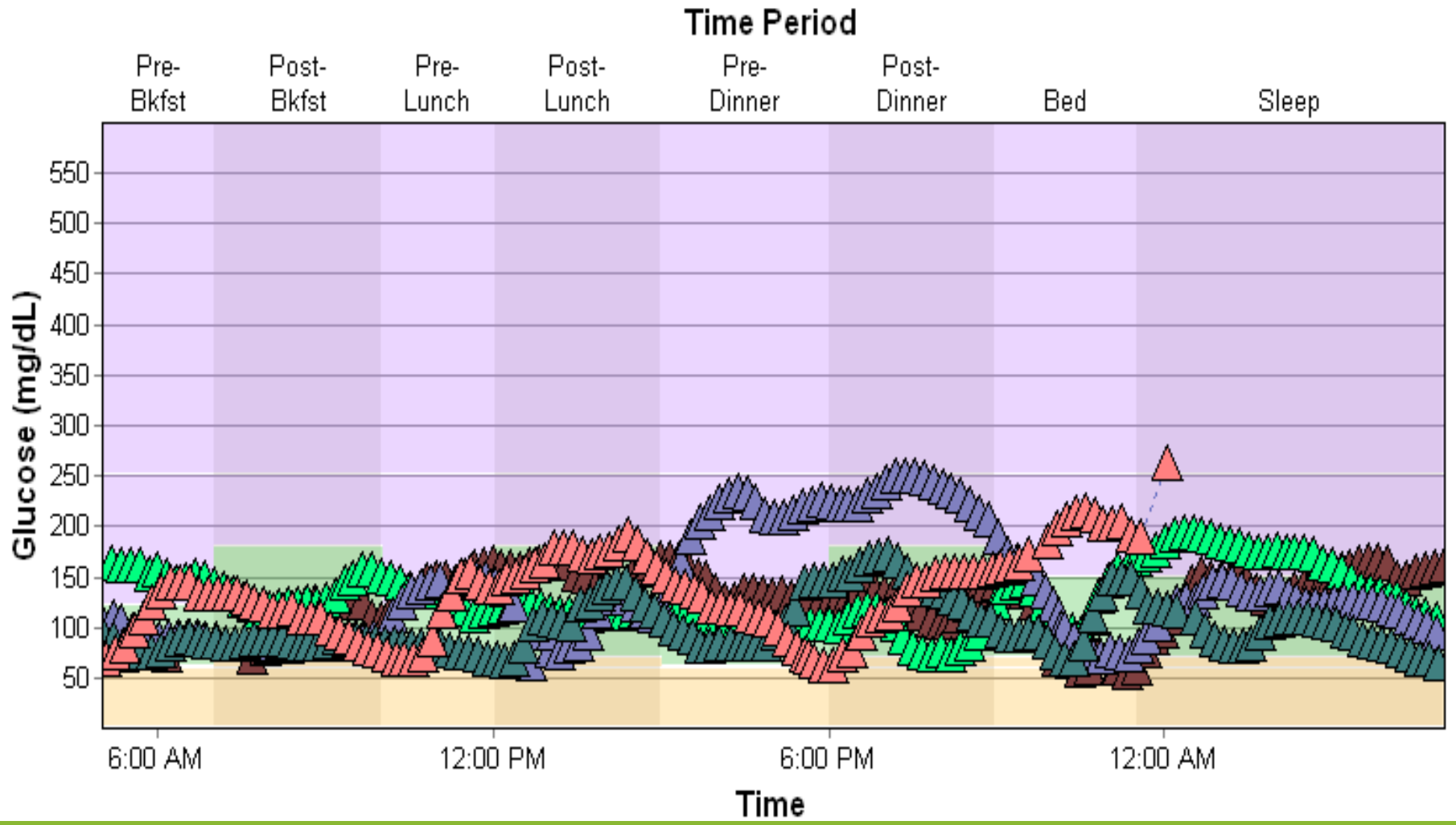
Prior to CGM Use



Retrospective data

Glucose Trend Graph #2

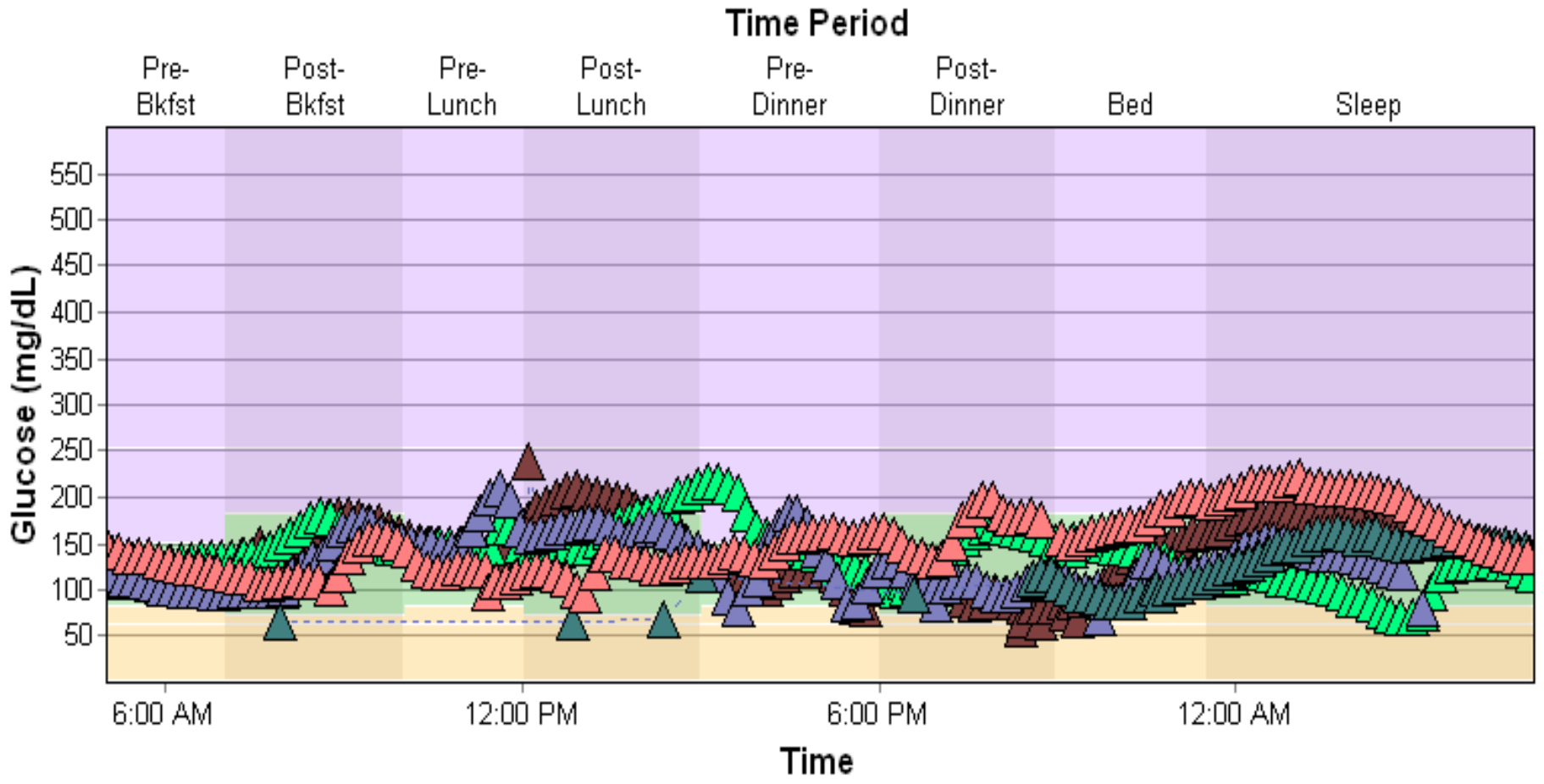
After three months of CGM use



Retrospective data

GLUCOSE Trend Graph #3

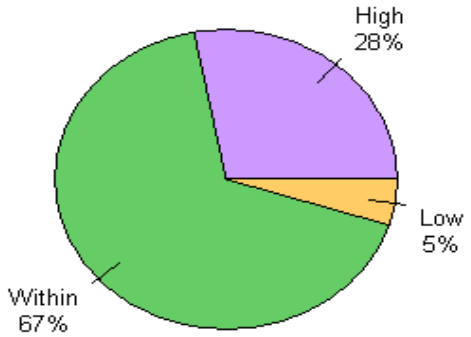
Most recent CGM report



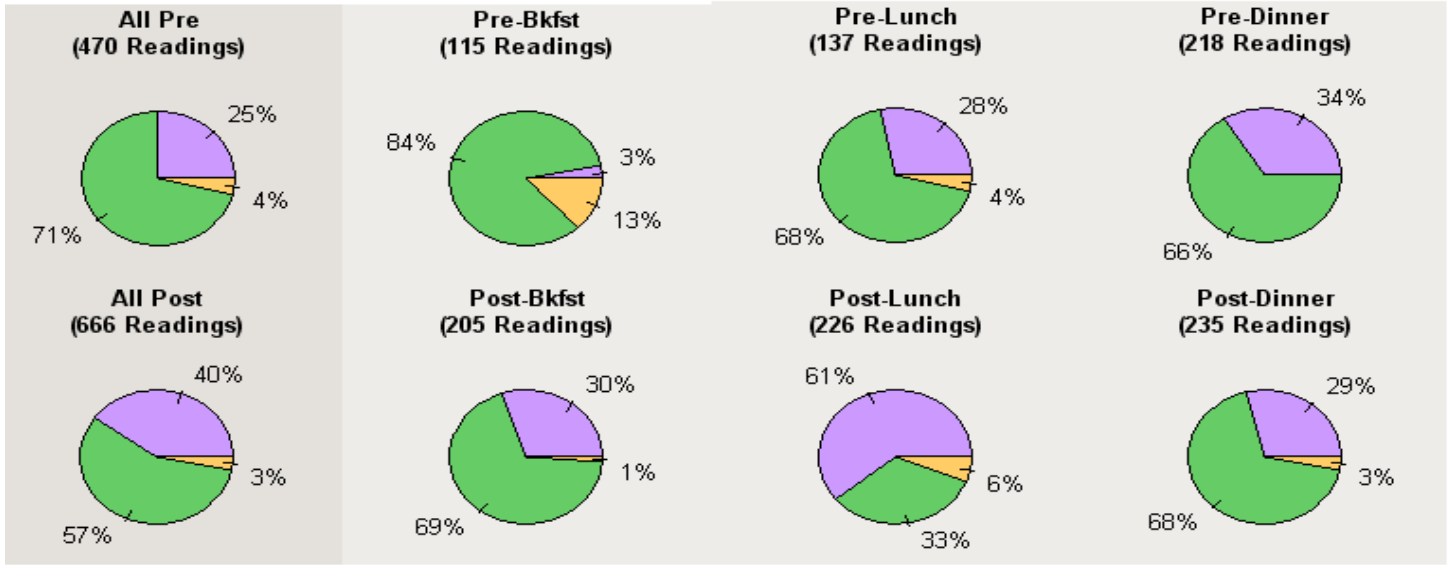
B) PIE CHARTS

Retrospective data

Show percentage of time glucose is above, below and in target range



Total
(1675 Readings)



Barbara Davis Center for Childhood Diabetes April 2010

Retrospective data

C) Data Tables

Show statistical information about different periods of the day

	Breakfast		Lunch		Dinner		Bed & Sleep	
Glucose Statistics (mg/dL)	Pre	Post	Pre	Post	Pre	Post	Bed	Sleep
# Readings	55	73	47	52	46	68	66	130
# Days w/Readings	5	4	5	3	3	4	5	5
Avg. # Readings/day	11.0	14.6	9.4	10.4	9.2	13.6	13.2	26.0
Highest	251	366	409	338	213	321	324	299
Lowest	34	92	82	57	58	50	56	75
Average	149	210	202	156	111	142	160	175
Standard Deviation	56.2	81.3	75.7	76.9	29.8	69.4	74.1	52.7
Above %	33	64	60	35	4	25	27	45
Within %	58	36	40	57	89	69	65	55
Below %	9	0	0	8	7	6	8	0

USING CGM RESULTS:

(To make insulin adjustments)

- Important not to get overwhelmed by data

  **** Make One Change At A Time**

- Look for patterns 2 out of 3 days
- A behavior modification device → Missed boluses, snacking, low BGs on CGM
- Good initial communication with HCP

CGMs available in market

Paradigm Real Time systems

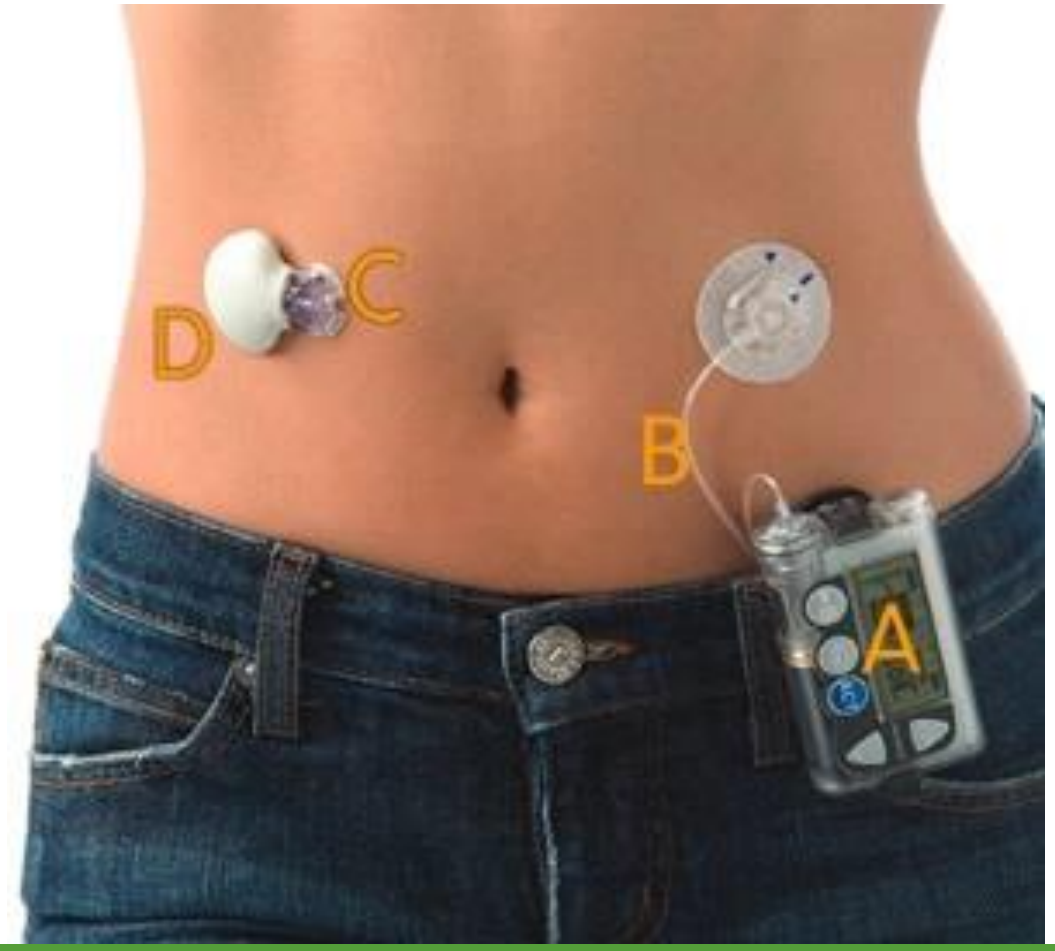
(Paradigm pump and Revel pump)

A: Insulin pump and CGM receiver

B: Infusion set

C: Sensor

D: Transmitter



Paradigm Real-Time system
(Paradigm pump and Revel pump)

Pump is not controlled by CGM readings

No extra receiver to carry

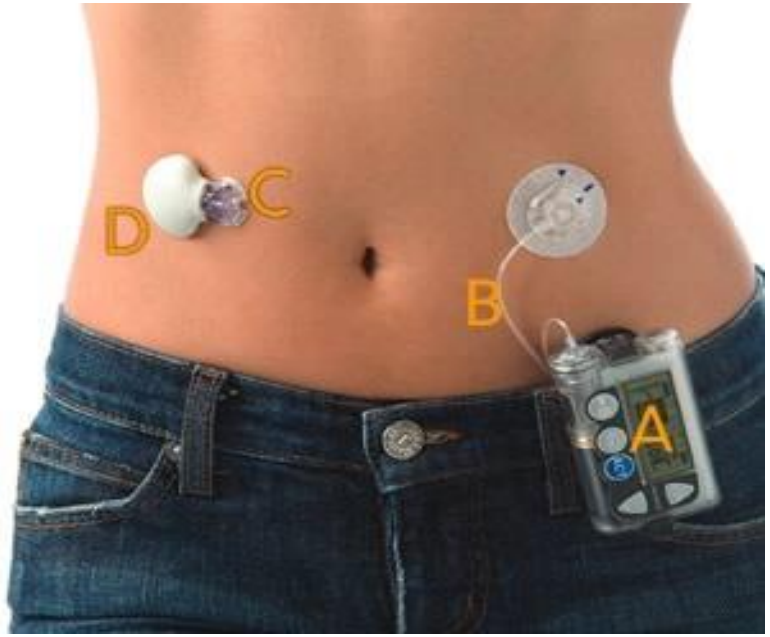
Has high and low alarms

Revel has predictive alarms

Sensors last 3 days (6 days)

Calibrations every 12 hours

Great online download



Barbara Davis Center for Childhood Diabetes April 2010

Guardian Real Time

For people not using a pump

Has high and low alarms

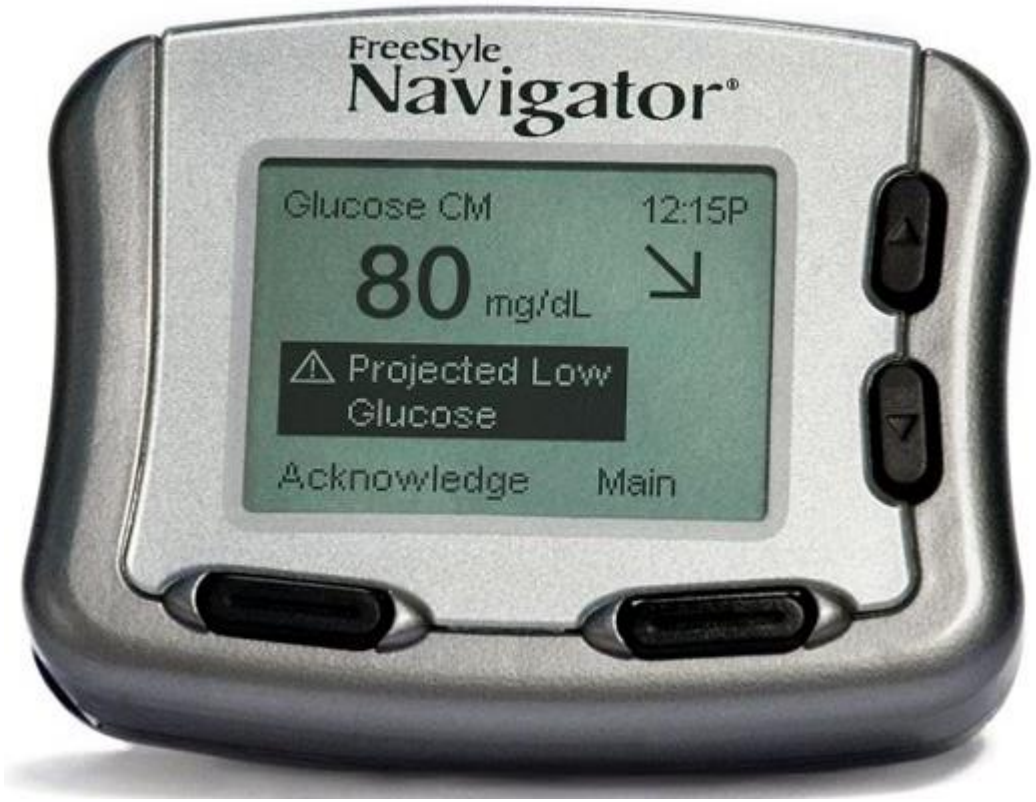
Has predictive alarms

Sensor lasts 3 days (6 days)

Calibrations every 12 hours

Why not buy a pump?

Navigator CGM



Navigator CGM

Has built in Freestyle BG meter

Larger transmitter

Has high and low alarms

Has predictive alarms

Sensors last 5 days

Calibrations at 10, 12, 24 and 72 hours

Well studied and highly accurate

DexCom 7 Plus

DexCom 7 Plus

Most simple system to use

Smallest transmitter

Has high and low alarms

Has rate of change alarms

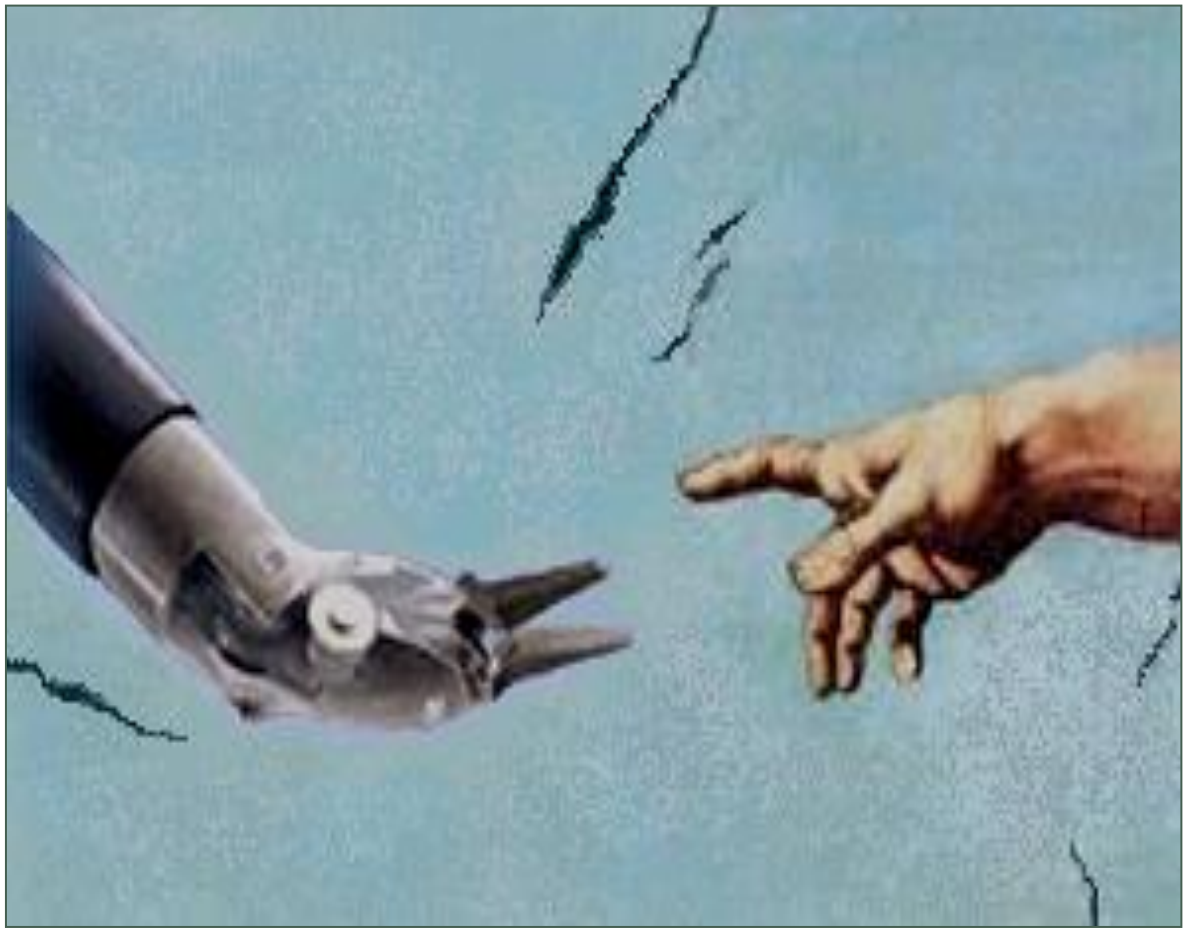
Sensor lasts 7 days

Calibrations every 12 hours

Basic download software

	MiniMed Guardian	MiniMed Paradigm 522/722	Freestyle Navigator	Dexcom Seven Plus
Sensor life	3 days		5 days	7 days
Initial calibration period	2 hours		10 hours	2 hours
Number of calibrations	2-4 per day		4 in 5 days	2-4 per day
Trend arrows	Yes		Yes	Yes
High/low alarms	Yes		Yes	Yes
Predictive high/low alarms	Yes	No-Paradigm Real-time Yes-Revel pump	Yes	Rate of change alarms
Cost	~$1300 system $35/sensor	$1000 system + 722/522 insulin pump $35/sensor	~$1000 system ~$35-50/sensor	~$400-800 system ~$60/sensor

ROBOTIC SURGERY



INTRODUCTION

- The term “Robot " was coined by the Czech playright Karel Capek in 1921 in his play Rossom's Universal Robots.
- In 1985 a ROBOT, the PUMA 560, was used to place a needle for a brain biopsy using CT guidance.
- Robots were first introduced in 1987 with the first laparoscopic surgery.

DEFINITION OF ROBOTIC SURGERY

- Robotic surgery is Microsurgery in which the surgeon performs surgery by manipulating the hands of a robot
- Any mechanica device that operates automatically with human like skill

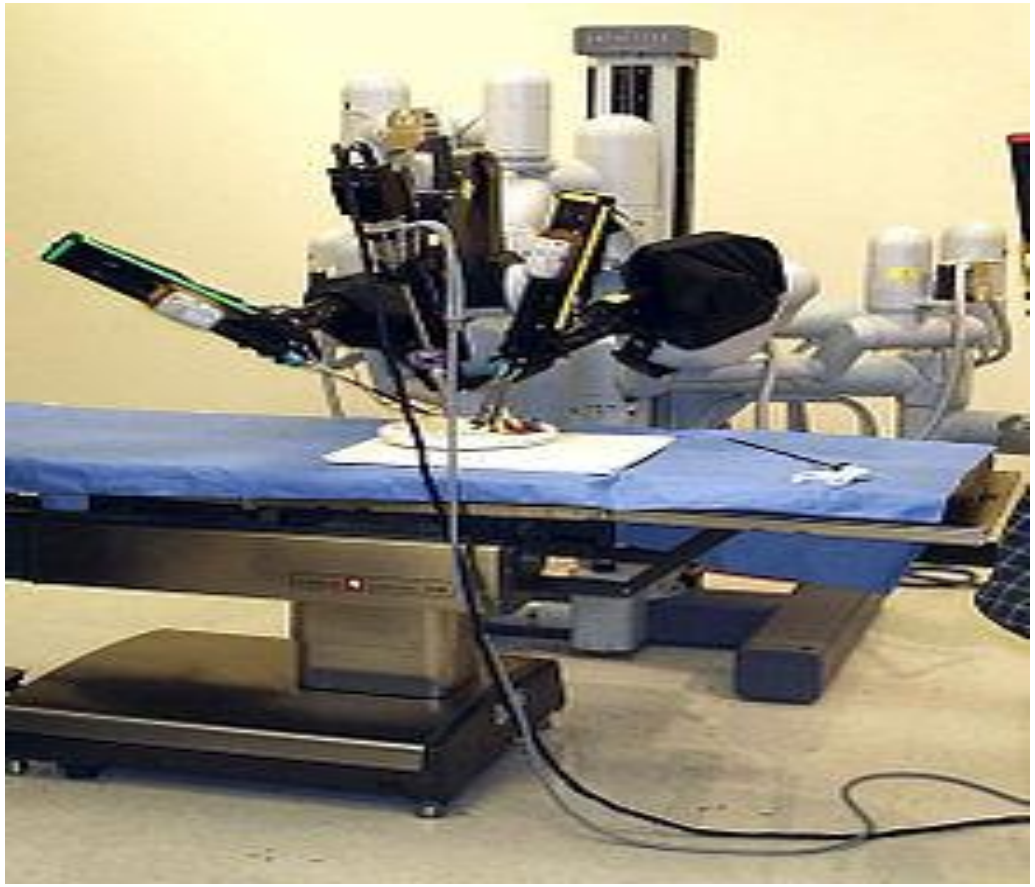
Types of Robots

- Passive
  - Retractor system
  - Position the tool and then hold

- Active
  - Robot would actively move the tool upon the surgeons command

ROBOTS IN MEDICINE

- PUMA 560

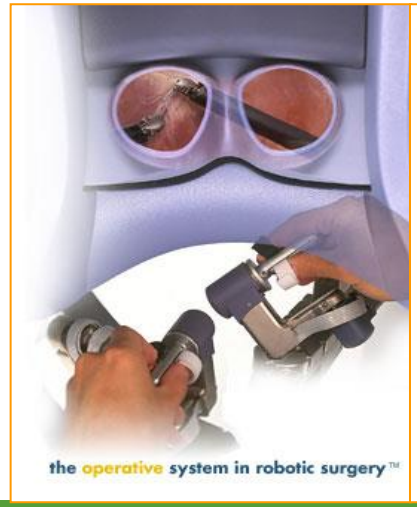


- DaVinci Robotic sytstem

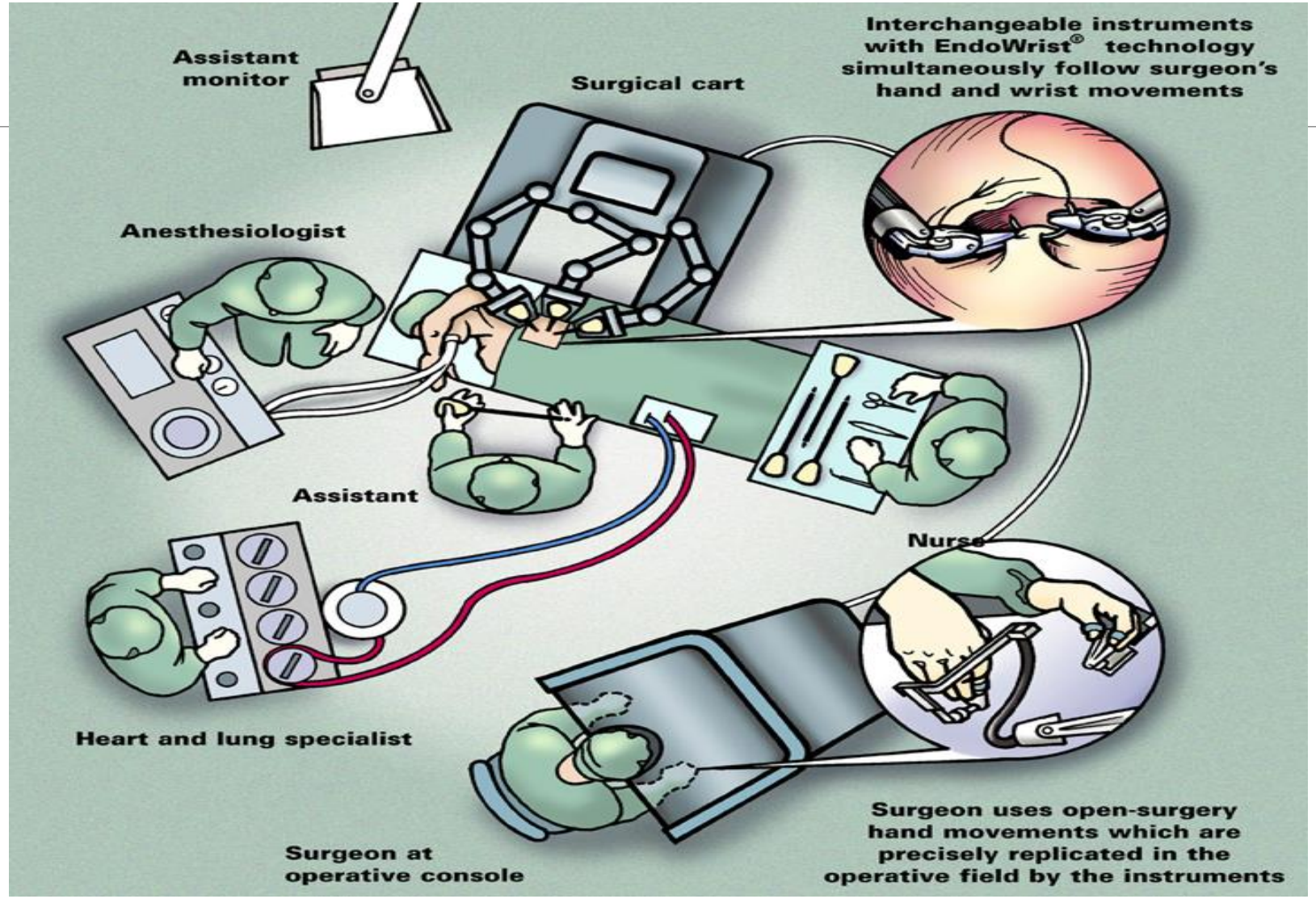
- ZEUS Surgical System

DaVinci Robotic System

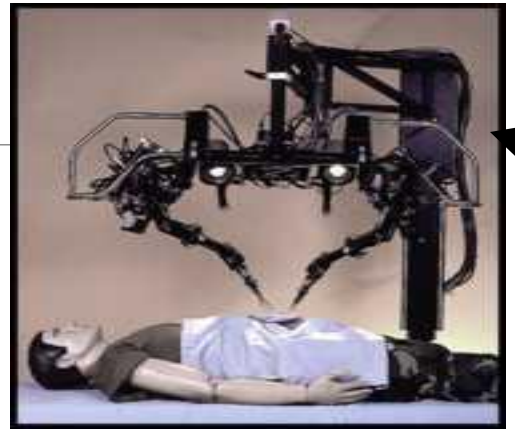
- Magnified (12x), stereoscopic 3Dvision
- Robotic wrist with 6 degrees of freedom
- Movements are scaled,filtered,translated



DaVinci System Schematic

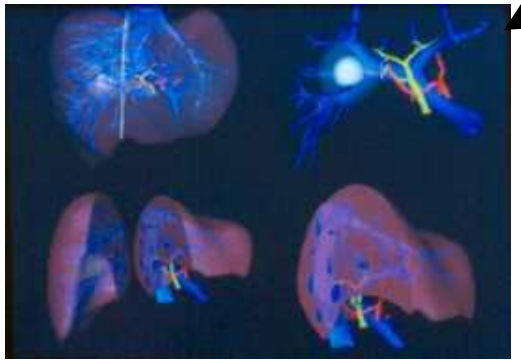


Total Integration of Surgical Care

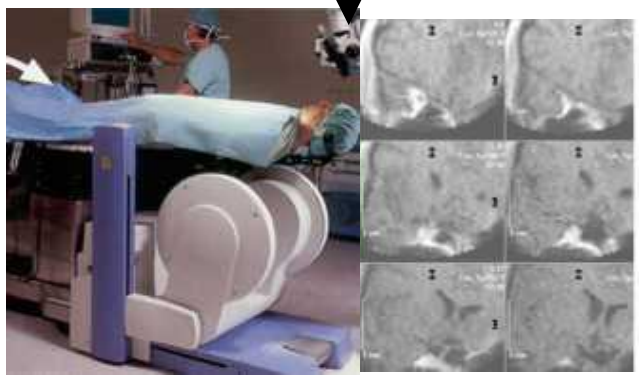


Remote Surgery

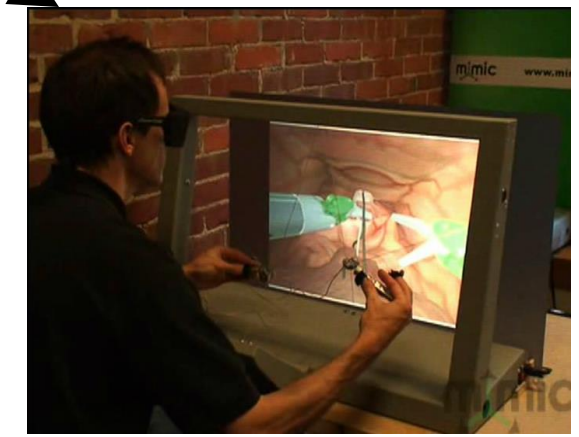
Minimally Invasive
& Open Surgery



Pre-operative planning
Surgical Rehearsal



Intra-operative navigation



Simulation & Training
Pre-operative Warmup

Operating Room with no People

Operating Room of the Future

ADVANTAGES:-

- Shorter hospital stay
- Reduced Trauma to the body
- Less anesthesia
- Less Blood loss
- Less post- operative pain
- Less pain
- Less risk of infection
- Less scarring
- Faster recovery and return to daily activities

DISADVANTAGES

- Human presence
- Fault consequence
- Time
- Cost
- Efficiency &Compatibility

APPLICATION

- General surgery
- Cardiology
- Gastrointestinal surgery
- Gynecology
- Neurosurgery
- Orthopedics
- Radiosurgery

Conclusions

- The rate of discovery of new technology is outpacing the ability of business, society, and healthcare to integrate and apply
- Robotic surgery is but one example of such technology that MAY reduce operative morbidity, hospital stay, and recovery, while POTENTIALLY improving clinical outcomes, but at what point do the BENEFITS justify the increased EXPENSE?


THANK
YOU