INDIAN ACADEMY
Degree College - Autonomous

DEPARTMENT OF MICROBIOLOGY

FOUNDATION COURSE IN MICROBIOLOGY

FOR I YEAR BSc MICROBIOLOGY(CMB)

ACADEMIC YEAR 2022 - 2023

OCTOBER – NOVEMBER 2022

OBJECTIVES

- To bridge basic knowledge of biological and chemical principles with Microbiology.
- To enhance the integrated learning experience with other subjects in Life Science during bachelor's degree.
- To gain a broader perspective on Microbiology including the relevance of microbes in medicine, public health, safety and industry

PEDAGOGY

- Power point presentation
- Animated and simulation videos
- Lecture notes

SYLLABUS

Sl.No.	Syllabus	Hours allotted	Teacher in charge
1.	**Aim** To acquire the knowledge of different branches of Microbiology	01	Dr. Sahithya K.
	Topic Introduction to diverse domains of Microbiology		
	Outcome Students become familiar with basic and applied branches of Microbiology		
2.	**Aim** To understand the importance of elementary principles in microscopy	01	Prof. P Rajarajan
	Topic Introduction to the basic principles of microscopy		
	Outcome Students become familiar with basic principles of microscopy		
3.	**Aim** To study the ultra-structure, virulence and its importance in microorganisms	03	Dr. Anu Kiruthika S.
	Topic Ultra-structure of microorganisms and virulence		
	Outcome Students obtain clarity on morphology, internal structure and virulence of microbes		
4.	**Aim** To study normal microflora and entry of pathogens		

		03	Dr. Malaiyarasa Pandian
	Topic Microbial interactions with human – mode of entry by etiological agents and infection		
	Outcome Students get a fair idea of the role of microorganism in human body, its entry, disease causing mechanism.		
5.	**Aim** To study human body's resistance to microorganisms	02	Prof. P Rajarajan
	Topic Immune system, immunity, antigens and antibodies, vaccines		
	Outcome Students get to understand the basics of immunity, prevention of diseases and the need for vaccines		
6.	**Aim** To learn the passage genetic information of microbes	03	Dr. Anu Kiruthika S.
	Topic Central dogma and its relevance to microbial cell functions		
	Outcome Students get the idea of inherited DNA translating into a protein		
7.	**Aim** To study the applications of rDNA technology	04	Dr. Malaiyarasa Pandian P
	Topic Introduction on basics and applications of genetic engineering in human welfare (medicine and agriculture)		
	Outcome Students understand the concept of technological advancements in human welfare		
8.	**Aim** To explore the pathways involved in fermentation by microbes	02	Dr. Sahithya K.
	Topic Microbial physiology – fermentation, Pasteur's effect, bacterial photosynthesis		
	Outcome Students attain clarity on the production of high energy molecule production through pathways		

9.	**Aim** To study industrially important microbes, fermentor and important products	02	Dr. Sahithya K
	Topic Introduction to Industrial Microbiology		
	Outcome Learners obtain basic knowledge of Microbes in industry, summary of upstream and downstream processes.		
10.	**Aim** To understand the scope of the subject	01	Prof. P Rajarajan
	Topic Scope of Microbiology		
	Outcome Learners get to know the thrust area in the fields to get job and progression to higher studies		

OVERALL OUTCOMES

- Students can easily relate and understand the concepts in Microbiology
- Students acquire knowledge of microorganisms in multifarious applications and connect well during lectures.

EVALUATION METHODS

- Conducting quiz
- Snap test

REFERENCE BOOKS

1. Prescott's Microbiology 9th edition Edited by Willey,Sherwood and Woolverton and Published by McGraw-Hill Education
2. A Textbook of Microbiology by R. C. Dubey and D. K. Maheshwari 5th edition and Published by S. Chand & Company Ltd.
3. Textbook of Microbiology by Ananthanarayan and Jayaram Paniker 8th edition Published by Orient Blackswan

Basics of Microscopy

Physical Principles

- A microscope (Greek: *mikron* = small and *scopeos* = to look).

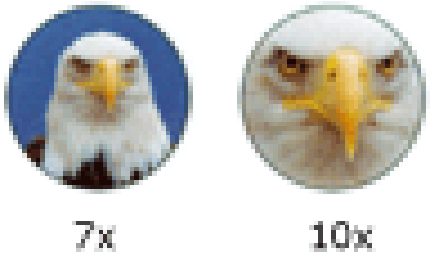
- **MICROSCOPE:** Is an instrument for viewing objects that are too small to be seen by the naked or unaided eye.

- **MICROSCOPY:** The science of investigating small objects using such an instrument is called microscopy.

Two Important Principles

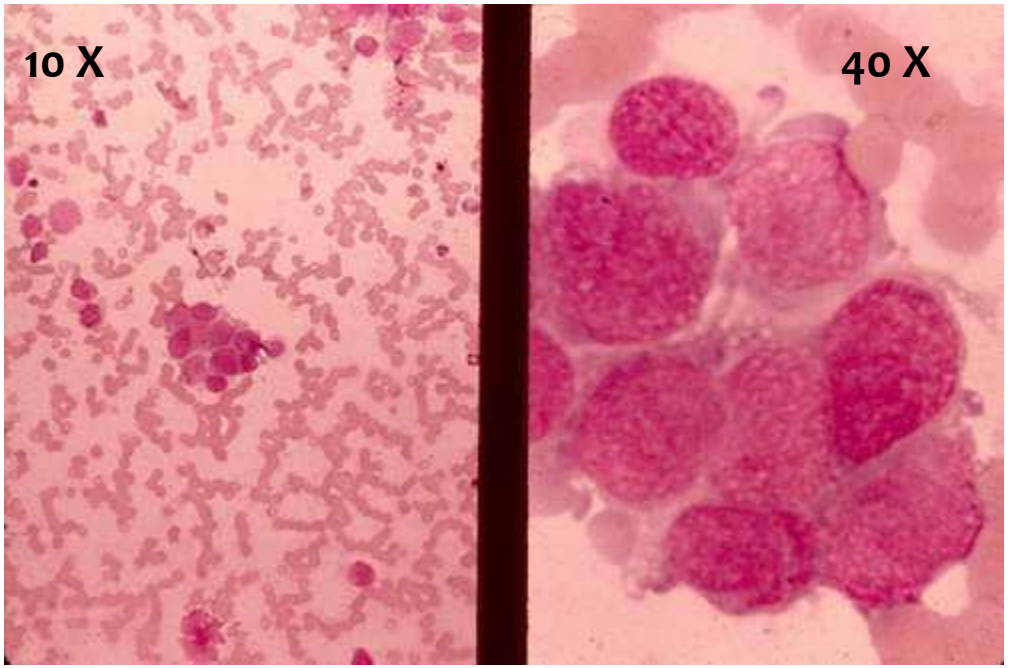
* Magnification
* Resolution

Comparing Powers of Magnification



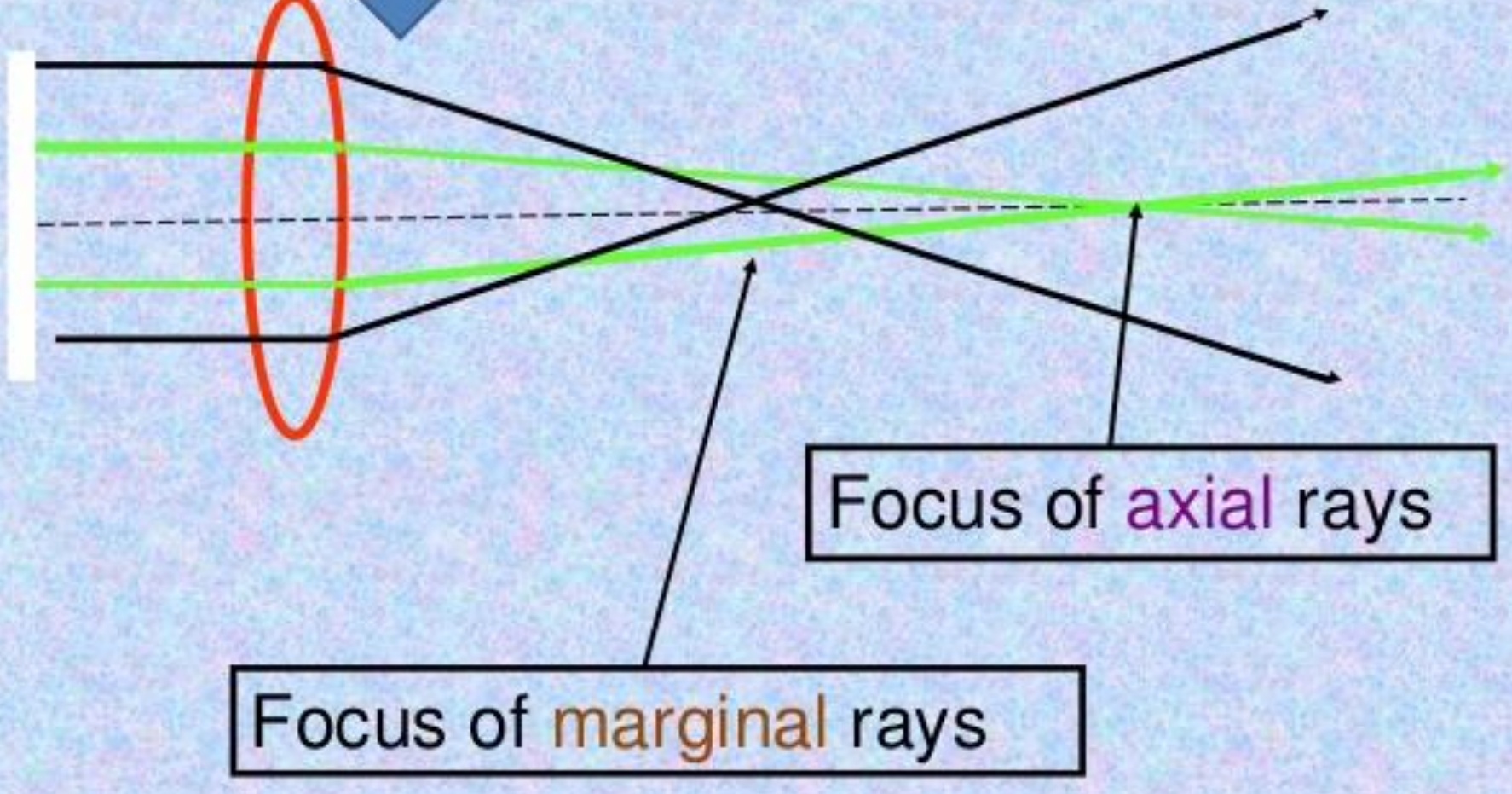
We can see better details with higher the powers of magnification, but we cannot see as much of the image.

Which of these images would be viewed at a higher power of magnification?

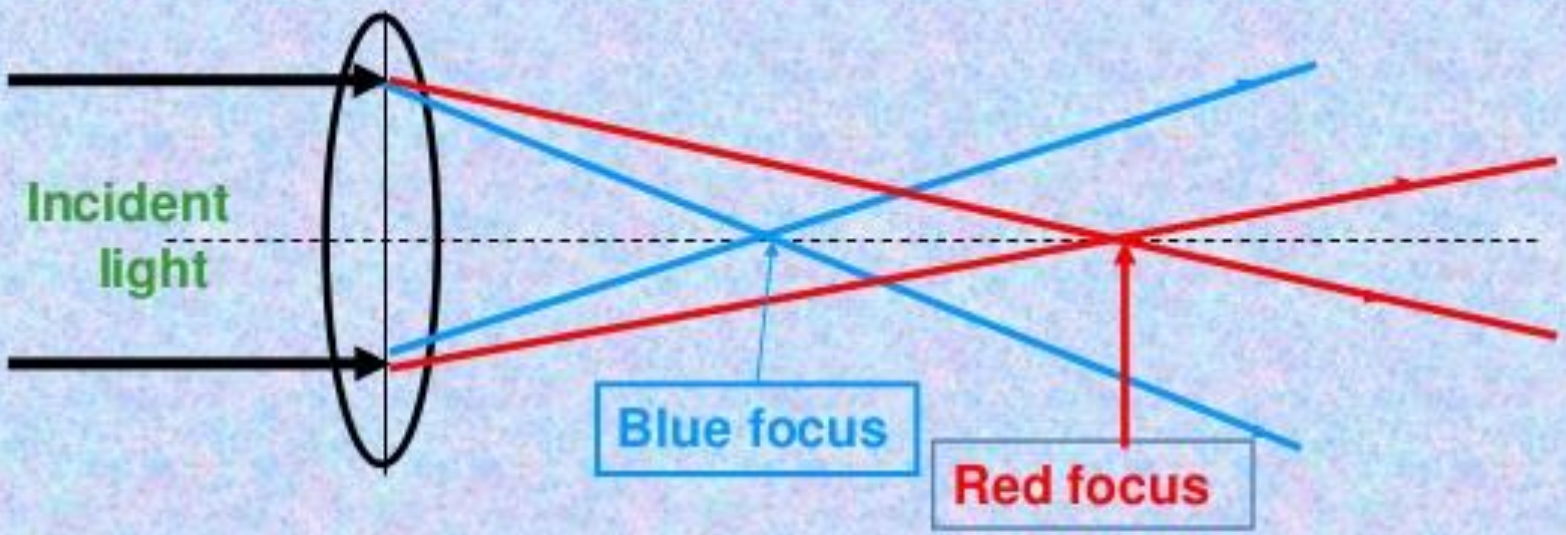


ABERRATION

SPHERICAL CHROMATIC

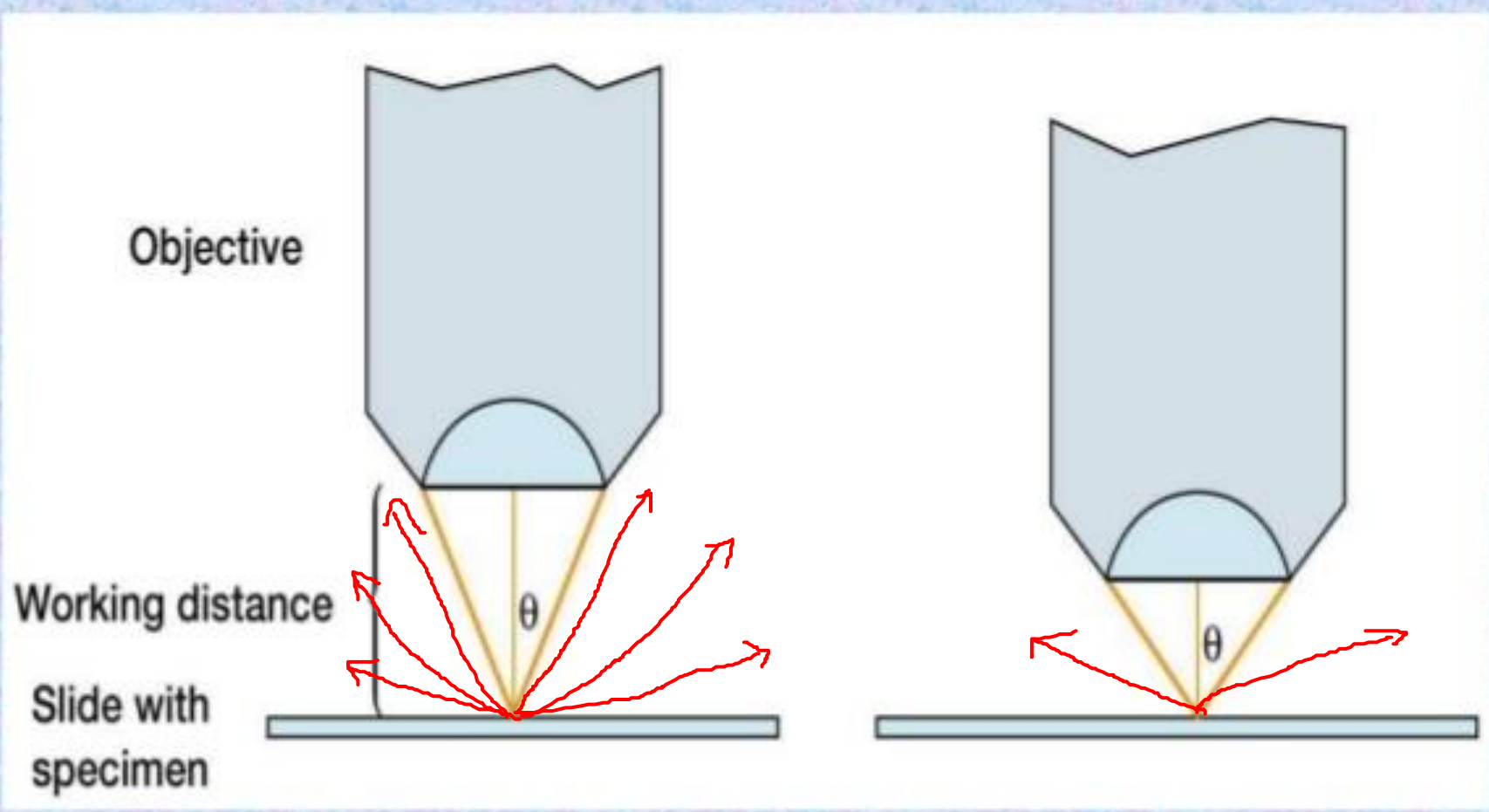


- Chromatic aberration

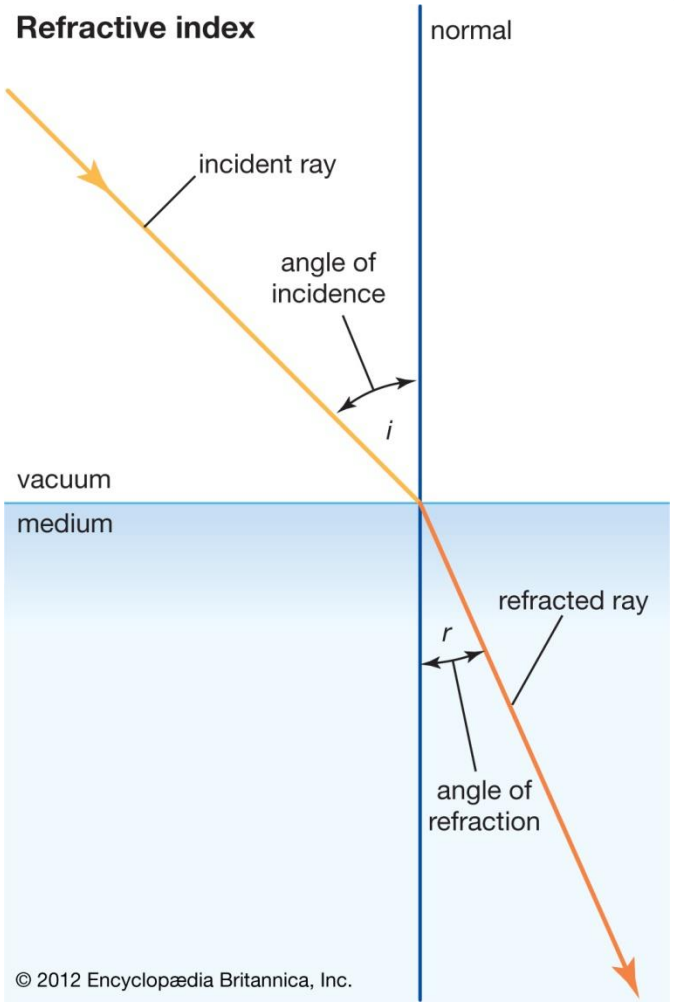


WORKING DISTANCE

Distance between the front surface of lens and surface of cover glass or specimen.



Refractive Index



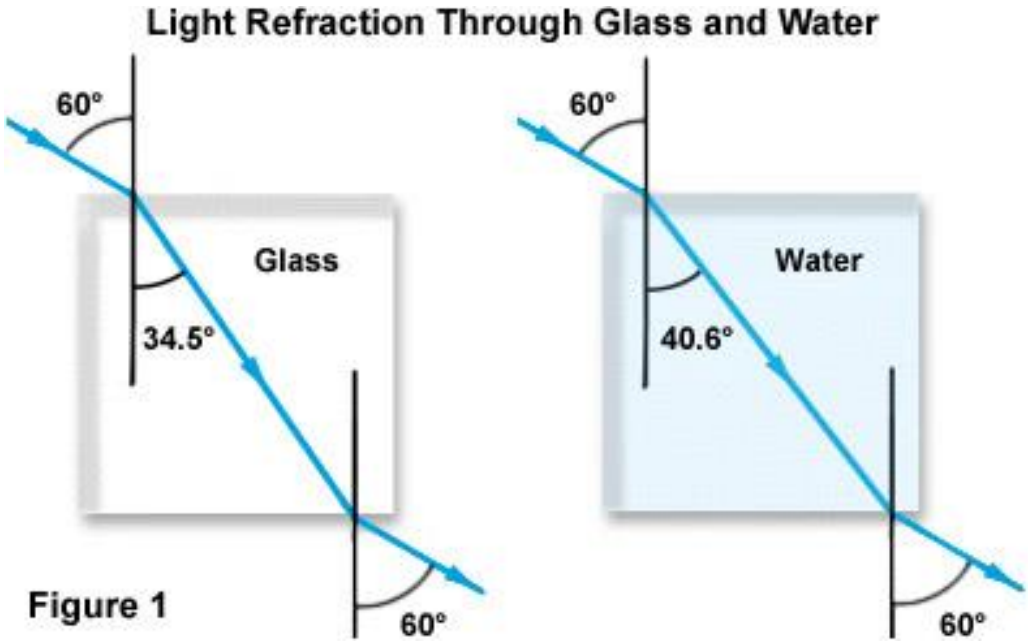
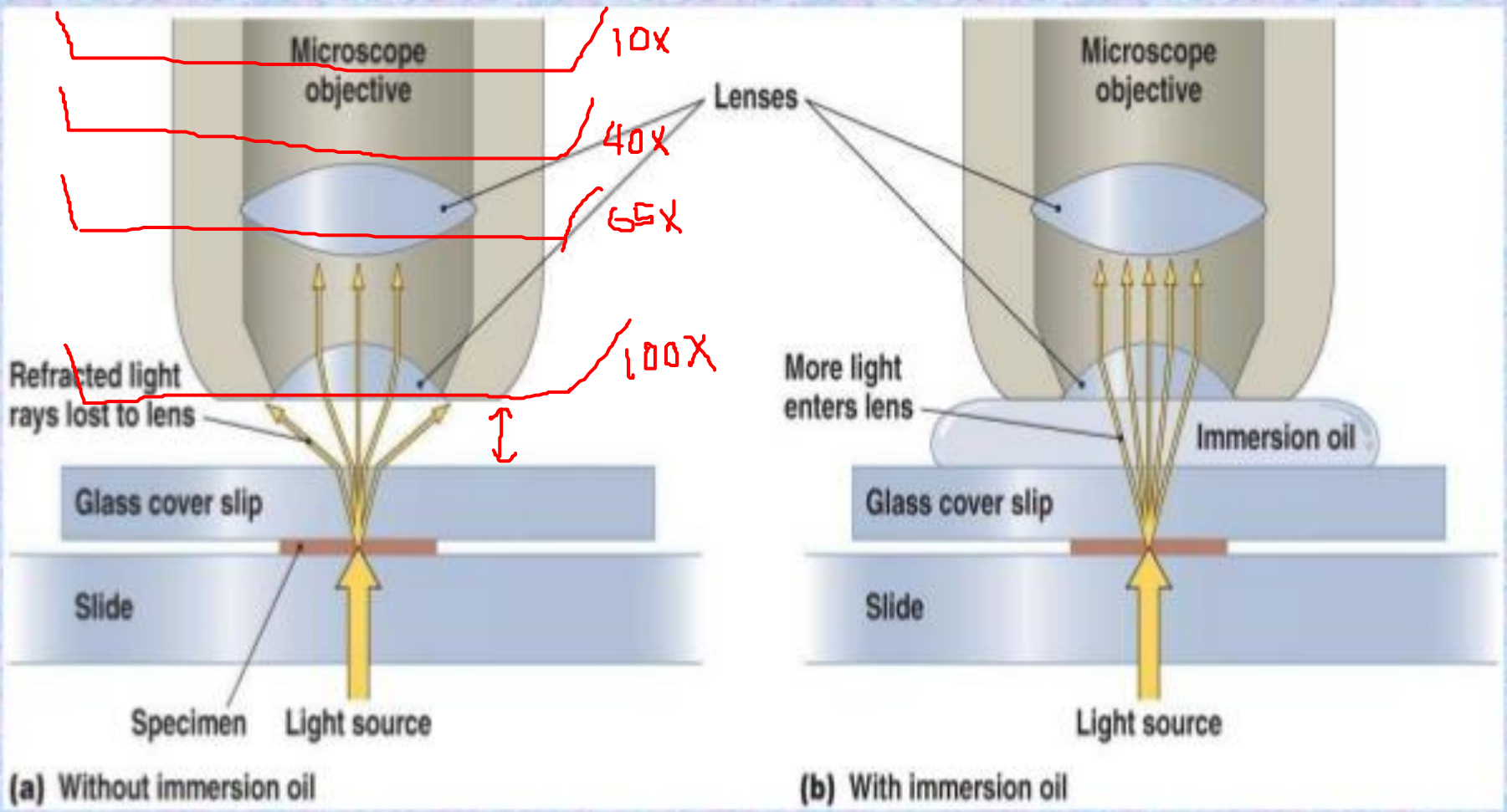


Figure 1

THE EFFECTS OF IMMERSION OIL ON RESOLUTION



Immune System, Immunity & Vaccines

An overview of Immune System, Immunity & Vaccines

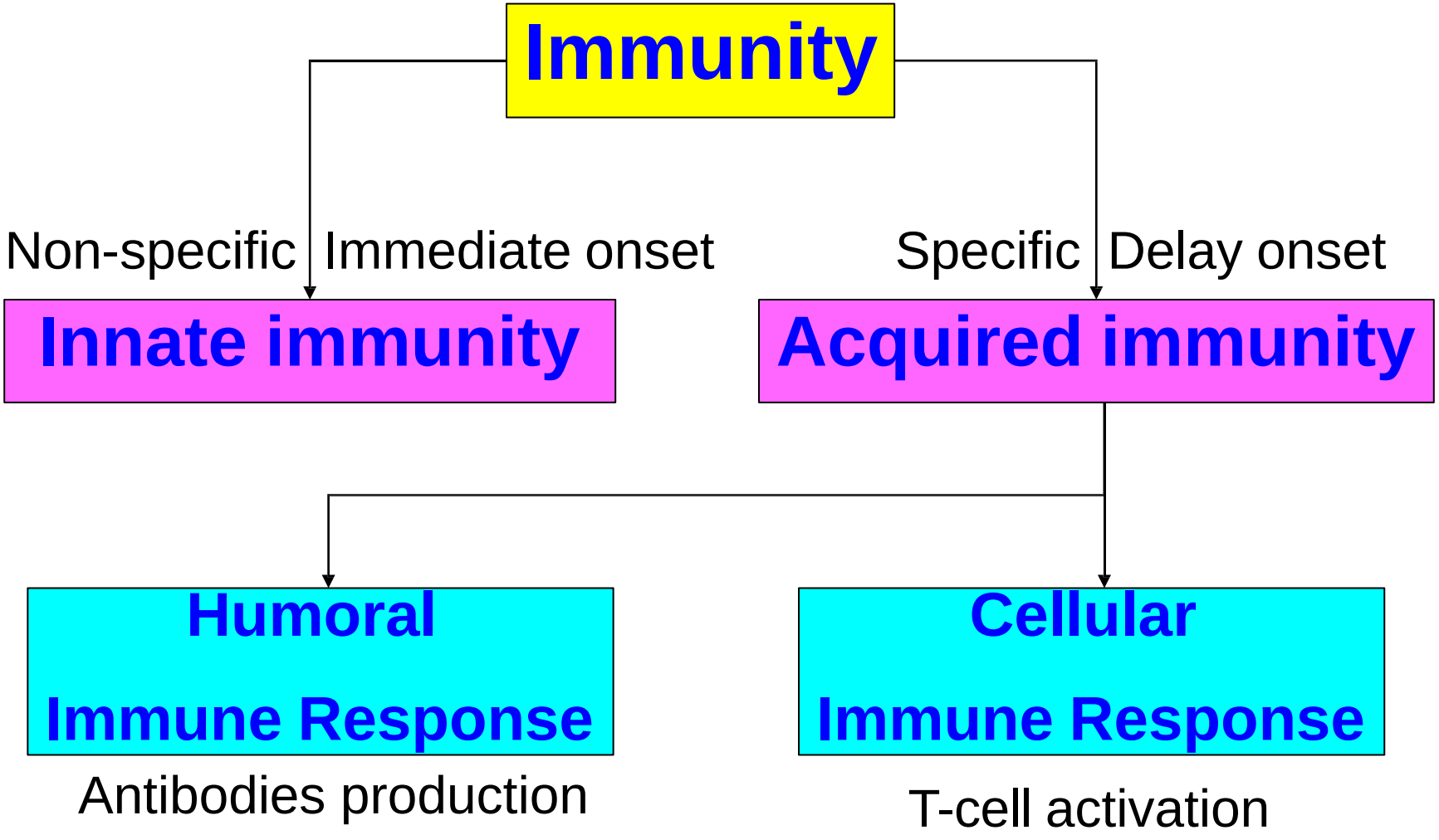
Types of Immunity

- **Inborn or innate immunity:** It is present at birth; This is our First Line Of Defense.
- **Acquired or specific:** It is not present at birth but becomes part of our immune system as the lymphoid system develops.
- **1970: WHO defined immunity as immune response to antigen/pathogen (Foreign body) in form of**
- **Humoral** (activation of B-lymphocytes)
- **Cellular** (activation of T-lymphocytes)

Two types of immunity

1. **Innate (non-adaptive)**
   - first line of immune response
   - relies on mechanisms that exist before infection
2. **Acquired (adaptive)**
   - Second line of response (if innate fails to control the situation)
   - relies on mechanisms that adapt after infection
   - handled by T- and B- lymphocytes
   - one cell determines one antigenic determinant

THE EVOLUTION OF IMMUNITY

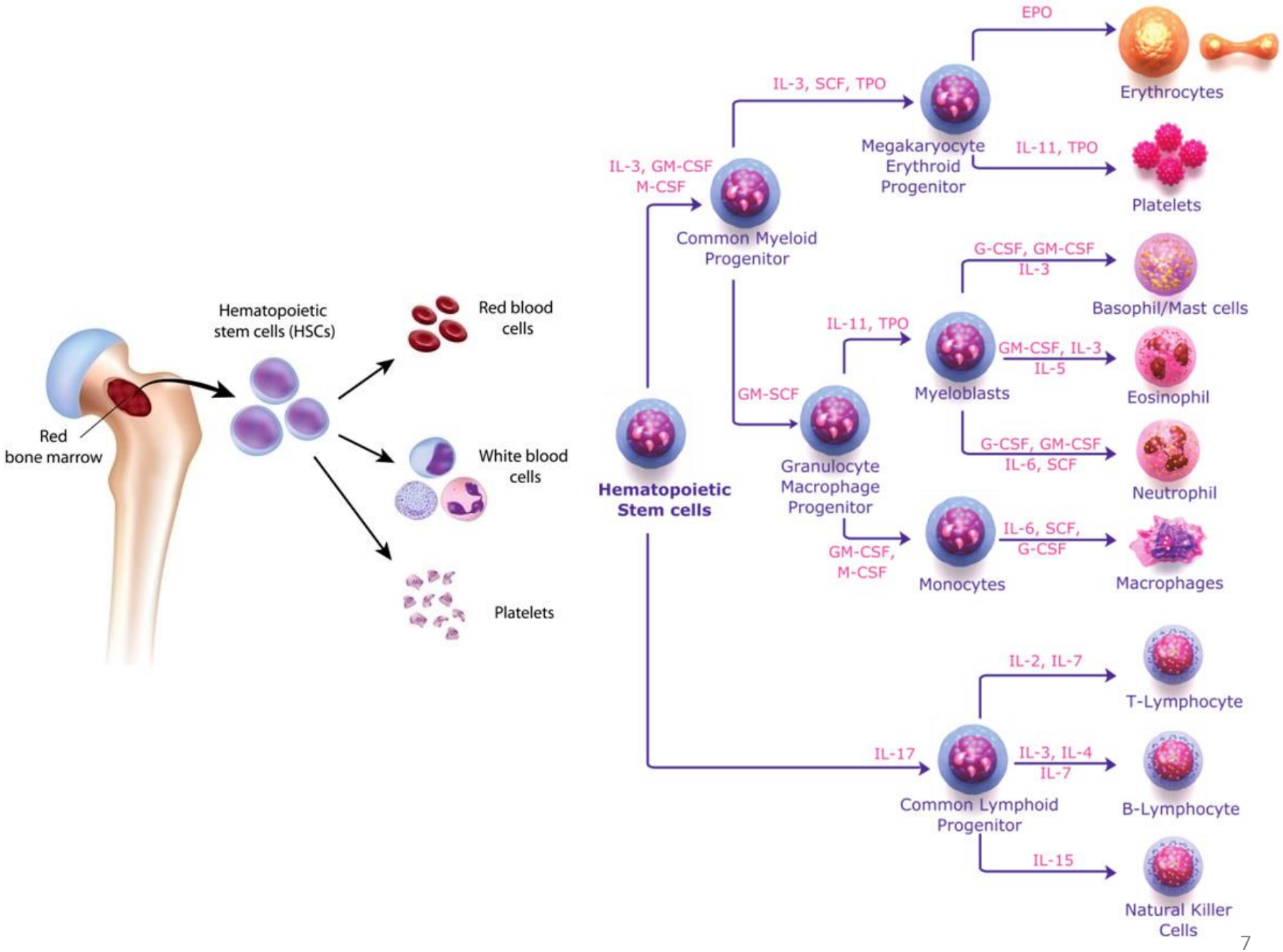


Lymphoid organs (Immune system)

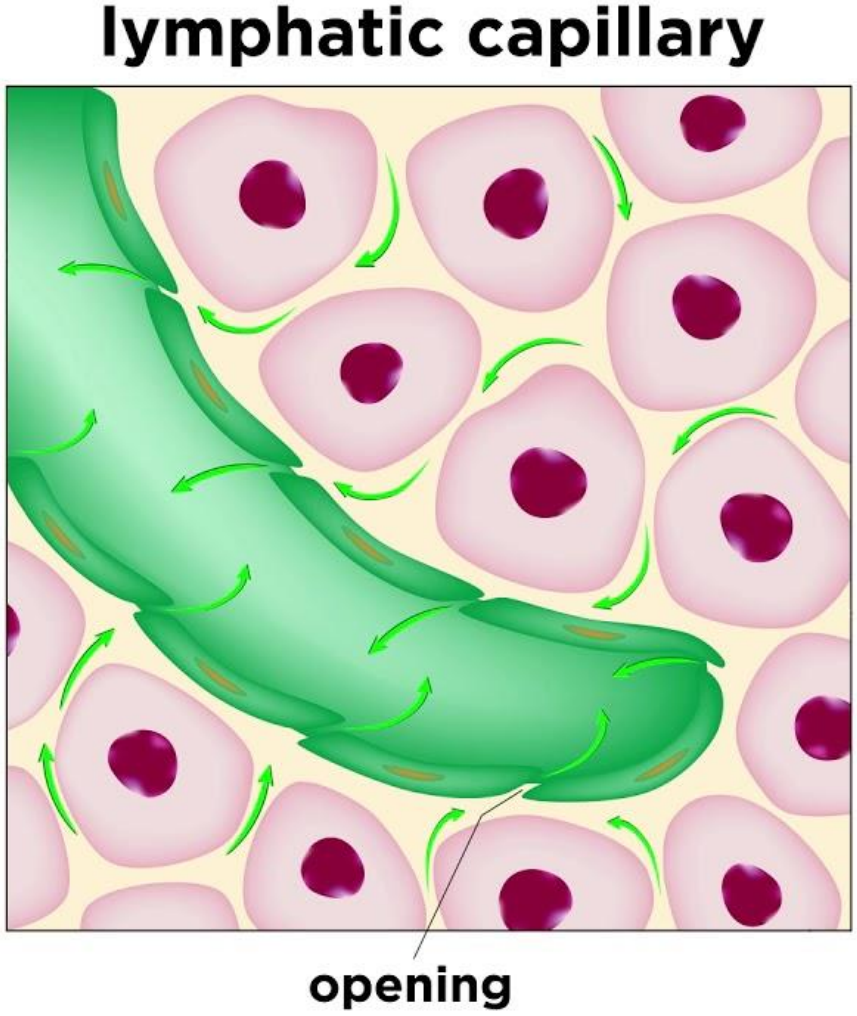
- Primary Lymphoid Organs
  - Bone Marrow and Thymus
  - Maturation Site
- Secondary Lymphoid Organs
  - Spleen, lymph nodes,
  - MALT (mucosal associated lymph tissue)
  - GALT (gut associated lymph tissue)
  - Trap antigen, APC, Lymphocyte Proliferation

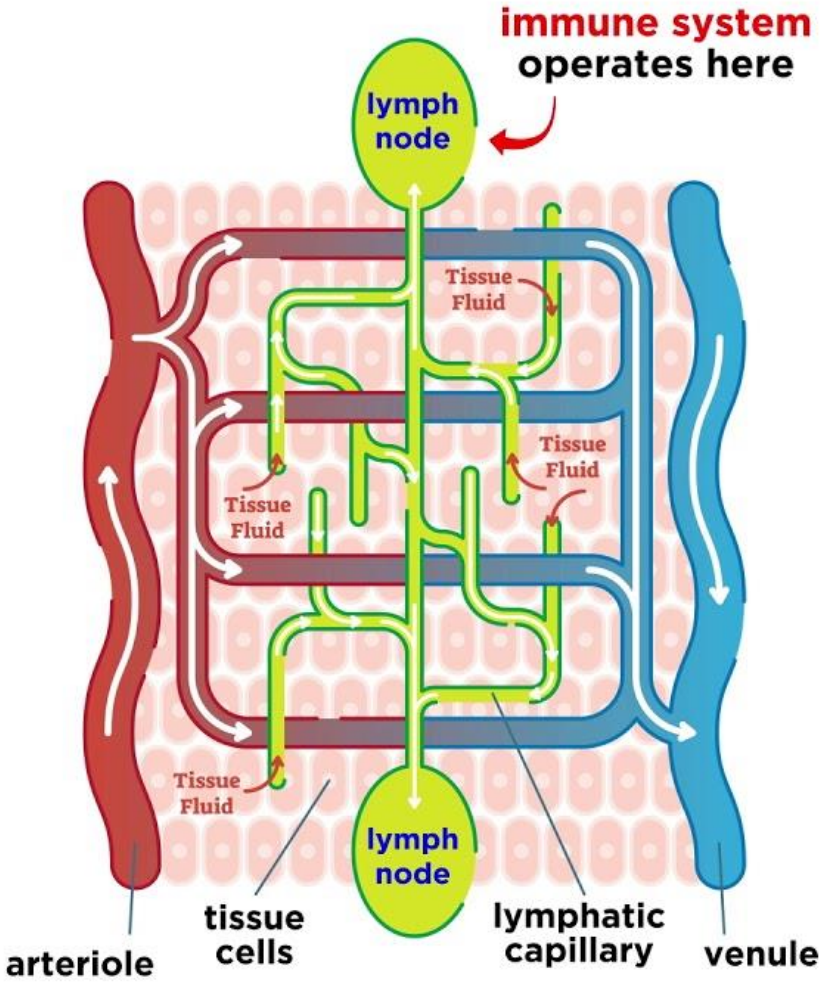
ORIGIN OF CELLS OF THE IMMUNE SYSTEM

- Derived from common progenitor cell in bone marrow
  - Pluripotent hematopoietic stem cell
- **Progenitor Stem Cells**
  - **Erythroid lineage**
    - Erythrocytes and Megakaryocytes
  - **Myeloid lineage**
    - Monocyte/macrophage, dendritic cells, PMN's, mast cells
  - **Lymphoid lineage**
    - Small and large lymphocytes


Hematopoietic stem cells (HSCs)
Red blood cells
White blood cells
Platelets
Red bone marrow
Hematopoietic Stem cells
IL-3, SCF, TPO
EPO
Erythrocytes
Megakaryocyte Erythroid Progenitor
IL-11, TPO
Platelets
IL-3, GM-CSF M-CSF
Common Myeloid Progenitor
G-CSF, GM-CSF IL-3
Basophil/Mast cells
IL-11, TPO
GM-CSF, IL-3 IL-5
Myeloblasts
Eosinophil
GM-SCF
Granulocyte Macrophage Progenitor
G-CSF, GM-CSF IL-6, SCF
Neutrophil
GM-CSF, M-CSF
IL-6, SCF, G-CSF
Monocytes
Macrophages
IL-2, IL-7
T-Lymphocyte
IL-17
IL-3, IL-4 IL-7
Common Lymphoid Progenitor
B-Lymphocyte
IL-15
Natural Killer Cells

LYMPHATICS


lymphatic capillary
opening


immune system
operates here
lymph node
Tissue Fluid
Tissue Fluid
Tissue Fluid
Tissue Fluid
lymph node
arteriole
tissue cells
lymphatic capillary
venule

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ACADEMIC YEAR 2022 - 2023

November 2022

OBJECTIVES

- To communicate the basic knowledge in general microbiology with detailed applications of microbes in medicine, environment, public health, safety and industry
- To enhance the students knowledge on the advanced sections of Microbiology in the recent years
- To gain a broader perspective on fundamentals of Applied Microbiology

PEDAGOGY

- Power point presentation
- Animated and simulation videos
- Lecture notes

SYLLABUS

Sl.No.	Syllabus	Hours allotted	Teacher in charge
1.	**Aim** To acquire knowledge of eukaryotic organisms **Topic** Isolation, cultivation and characteristic features of fungi, protozoa and algae **Outcome** Various methods involved in isolation, identification and cultivation of eukaryotic organisms can understand.	03	Dr. Anu Kiruthika S
2.	**Aim** To understand the fundamentals of genomics and proteomics. **Topic** Transcriptomics and metabolomics and their applications in various applied areas of biology. **Outcome** Enhanced awareness on bioinformatics and computational genomics.	03	Prof. P Rajarajan
3.	**Aim** To study the basics of plant tissue culture **Topic** Genetic transformation in plants and applications of plant tissue culture **Outcome** Provides fundamental knowledge on plant genetic engineering and plant based industrial products production.	03	Dr. Sahithya K.

4.	**Aim** To study the cellular functions of different types of cells **Topic** Introduction to different receptors, modes of cellular signalling and signal amplification **Outcome** Role of different cell receptors and its importance in human system	03	Dr. P. Malaiyarasa Pandian
5.	**Aim** To gain insights about nanomaterials and nanotechnology **Topic** Synthesis approaches, characterization and applications in nanomedicine **Outcome** Biological applications of nanomaterials can understand.	02	Prof. P Rajarajan
6.	**Aim** To understand the importance of metagenomics **Topic** Sequencing techniques, data analysis and applications in the field of environmental remediation and agriculture **Outcome** Learners get the idea of microbial diversity in the environment.	03	Dr. P. Malaiyarasa Pandian
7.	**Aim** To study human intestinal microbiota **Topic** Examples of probiotic strains in commercial products **Outcome** Reflects the importance of probiotics and prebiotics.	01	Dr. Anu Kiruthika S.
8.	**Aim** To study the applications of recombinant DNA technology **Topic** Discussion on various techniques involved in the production of recombinant products and GMOs **Outcome** An understanding on application of genetic engineering techniques in basic and applied experimental biology	03	Dr. K Sahithya
9.	**Aim** To study impact of environmental pollutants on		

	ecosystems and biota **Topic** Detection and quantification of environmental contamination **Outcome** Significance of prevention and remediation of environmental pollution can understand	03	Dr. Malaiyarasa P.
10.	**Aim** To study industrially important microbes and important products **Outcome** Various sources of microbes for industrial applications	03	Dr. K Sahithya
11.	**Aim** To understand concepts of entrepreneurship such as Planning, decision making, leadership, organizations and authority **Topic** Basic requirements for establishing a bio-based start up and company **Outcome** Imparts basic understanding and skills required for a successful entrepreneur	02	Dr. Anu Kiruthika S.
	Aim To understand the scope of the subject **Topic** Scope of Microbiology and its career prospects **Outcome** After finishing master's degree, fields to get job, eligibility of higher studies	01	Prof. P Rajarajan

OUTCOMES

- Students can easily understand the advanced concepts in Microbiology
- Students acquire knowledge of microbiological applications and opportunities in the field of microbiology.

EVALUATION METHODS

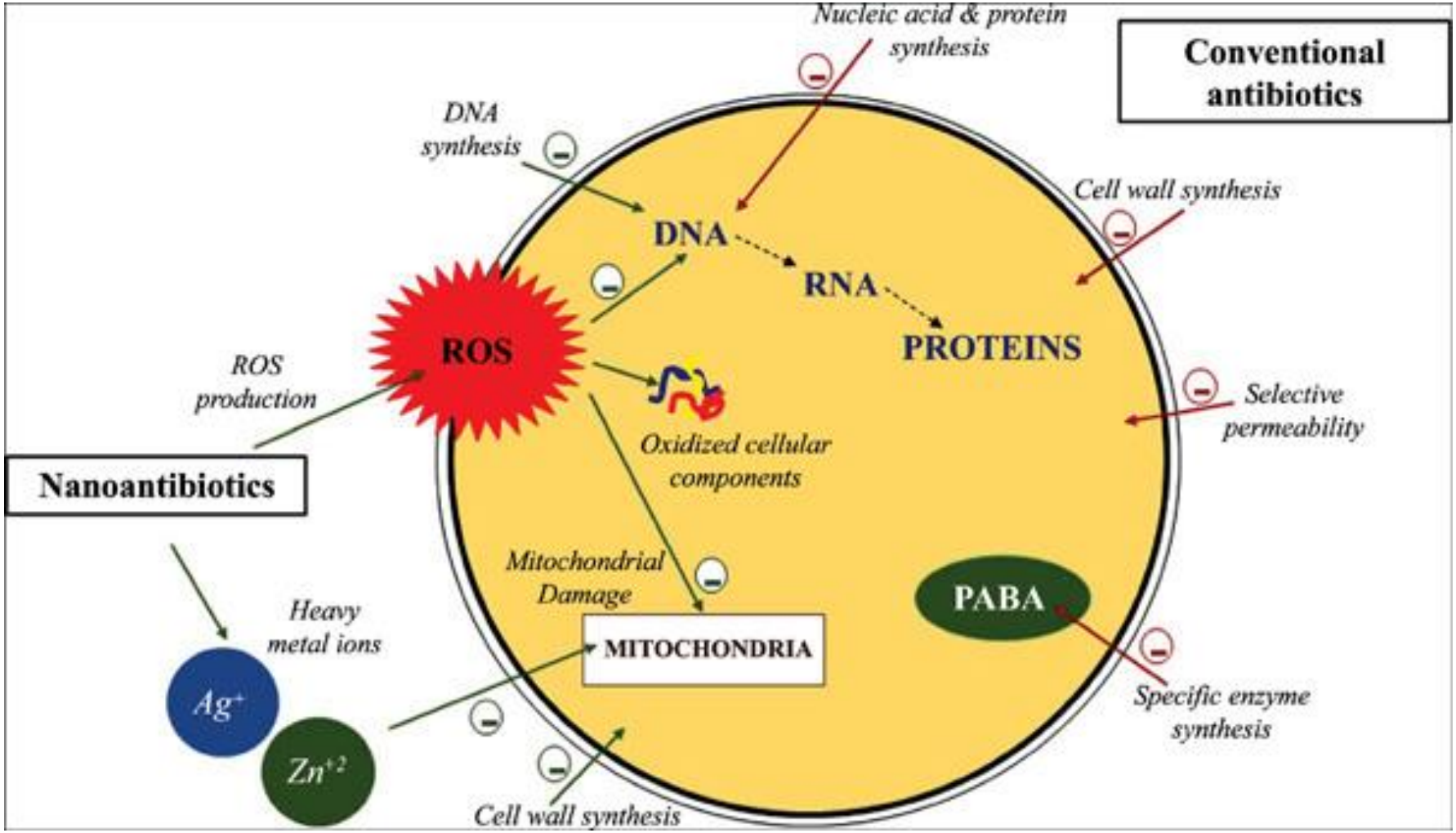
- Conducting quiz
- Snap test
- Group discussion

REFERENCE BOOKS

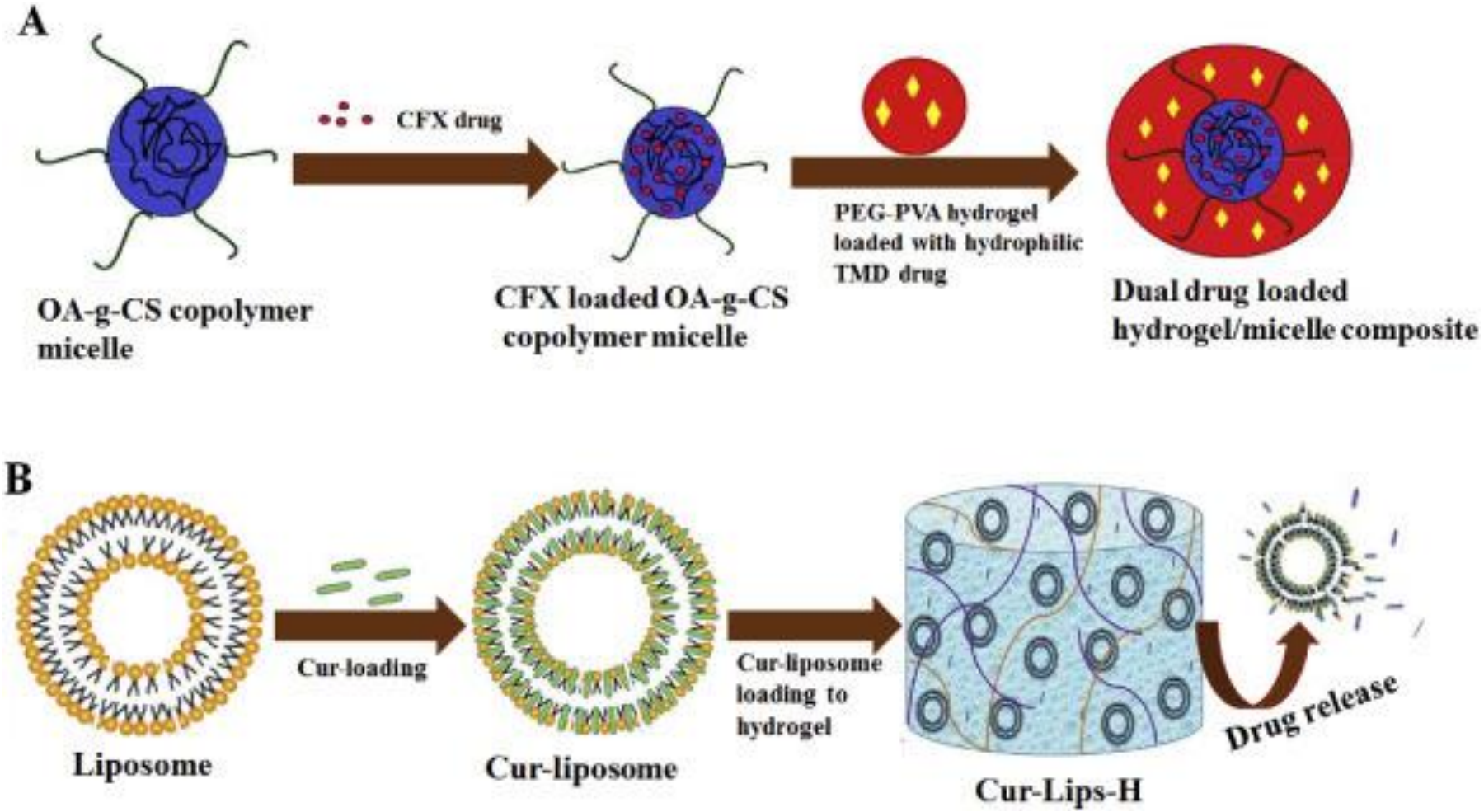
1. Concepts and Techniques in Genomics and Proteomics by N Saraswathy & P Ramalingam (2011) Published by Elsevier Science.
2. Recent Developments in Applied Microbiology and Biochemistry by Buddolla Viswanath (2020) Published by Elsevier Science.
3. Applied Microbiology by S. M. Reddy, S. Girisham & G. Narendra Babu (2017) Published by Scientific Publishers.
4. Plant Tissue Culture: An Introductory Text by Sant Saran Bhojwani, Prem Kumar Dantu (2013) Published by Springer India
5. Introduction to Nano: Basics to Nanoscience and Nanotechnology by Amretashis Sengupta & Chandan Kumar Sarkar (2015) Published by Springer Berlin Heidelberg.

NANOTECHNOLOGY IN MICROBIOLOGY

Nanoantibiotics

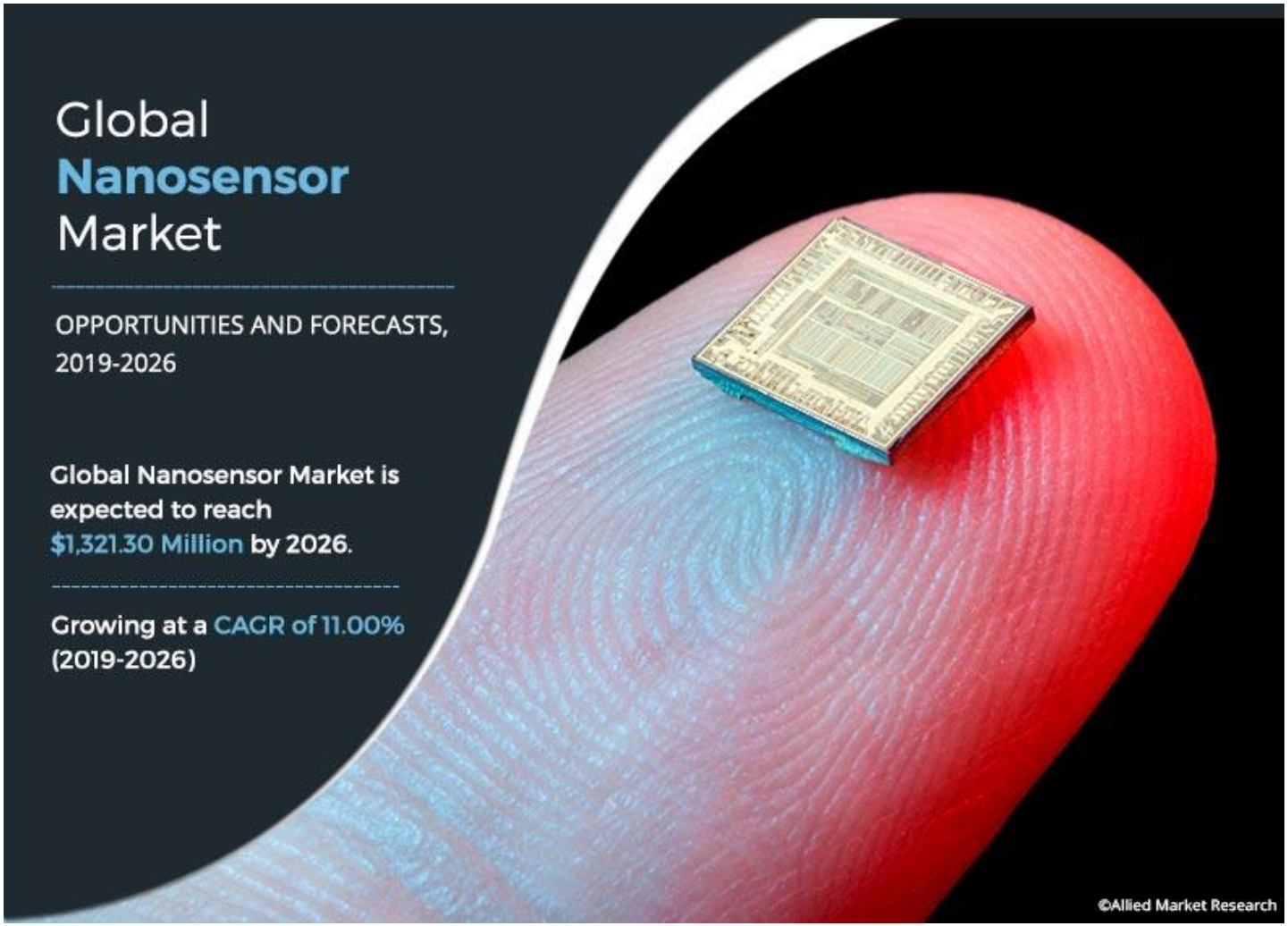


Nanocomposite hydrogel systems



Smart drugs

Nanosensors



GENOMICS & PROTEOMICS

WHAT DO YOU MEAN BY GENOMICS?

The term genome introduced by **H. Winkler** in 1920

The term genomics coined by **T.H. Roderick** in 1987

Genome + Omics ⟶ Genomics

Genomics is a an area of life science that deals with

the study of the genomes of organisms

- **Today genomics includes:**

✓ sequencing of genomes

✓ determination of the complete set of proteins encoded by an organism

✓ the functioning of genes and metabolic pathways in an organism

Where do we get these sequences from?

✓ Through genome sequencing projects

The **Genome** Is **All The DNA** In A Cell

- All the DNA on all the chromosomes
- Includes genes, intergenic sequences, repeats

- Specifically, it is all the DNA in an organelle
- **Eukaryotes can have 2-3 genomes**
  - Nuclear genome
  - Mitochondrial genome
  - Plastid genome
- If not specified, "genome" usually refers to the nuclear genome

How Many Types Of Genome???

- **Prokaryotic genomes**
- **Eukaryotic Genomes**
- *Nuclear Genomes*
- *Mitochondrial genomes*
- *Choloroplast genomes*

GENOME SEQUENCING- HISTORY

- The first genome to be sequenced was that of *Haemophilus influenzae* in 1995.
- The *E. coli* genome was completely sequenced in 1997.
- Yeast (*Saccharomyces cerevisiae*) (12.8 x 106 bp) and worm (*Caenorhabditis elegans*) genomes were the first eukaryotic genomes to be sequenced in 1999.
- Genomes of *Drosophila melanogaster* and *Arabidopsis thaliana* were sequenced in 2000.

GENOME SEQUENCING PROJECT

Human Genome project

- The Human Genome Project officially began on Oct. 1, 1990.
- Completed in 13 years
- **Mission of HGP:**
- To understand the human genome and the role it plays in both health and disease.
- The U.S. govt. project coordinated by the Department of Energy and the National Institutes of Health
- **Francis Collins**, Director of the HGP and the National Human Genome Research Institute **(NHGRI)**

THE GENOME IS OUR GENETIC BLUEPRINT

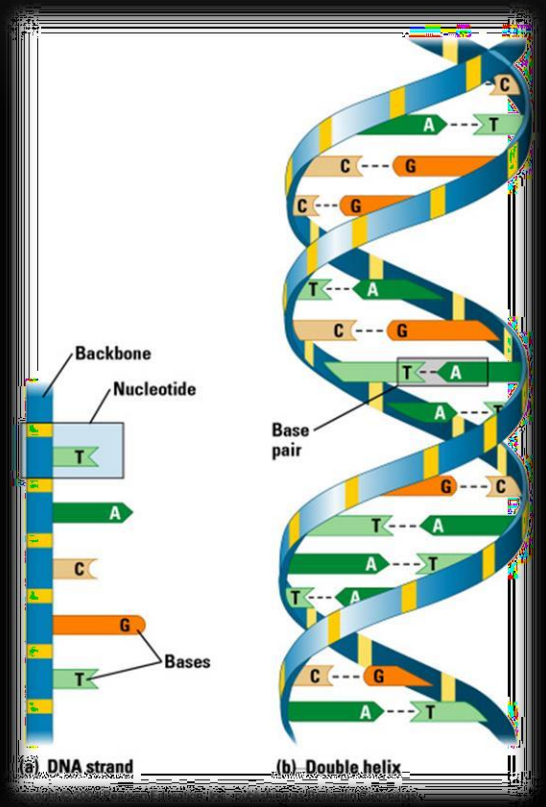
- Nearly every human cell contains 23 pairs of chromosomes

  1 - 22 and XY or XX

  - **XY = Male**
  - **XX = Female**
- Length of chr 1-22, X, Y together is ~3.2 billion bases

The genome is who we are from the inside!

- **Chromosomes consist of DNA**
  - molecular strings of A, C, G, & T
  - base pairs, A-T, C-G
- **Genes**
  - DNA sequences that encode proteins
  - less than 3% of human genome



AIMS OF THE PROJECT:

- To identify the approximate 100,000 genes in the human DNA.
- Determine the sequences of the 3 billion bases that make up human DNA.
- Store this information in databases.
- Develop tools for data analysis.
- Address the ethical, legal, and social issues that arise from genome research.

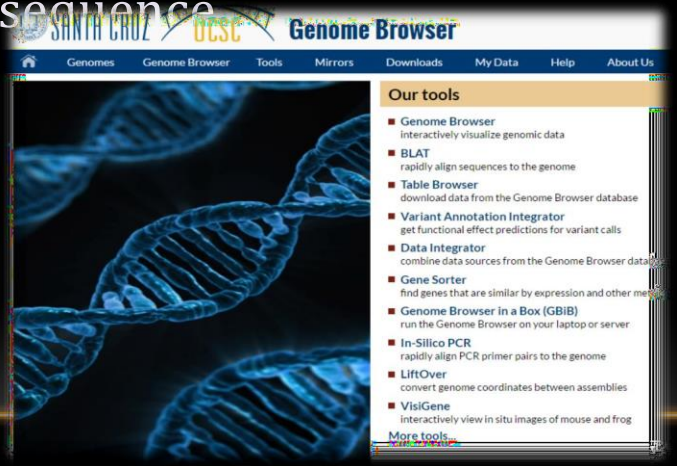
How was it done…

First, it was the Assembly

- The DNA sequence is so long that no technology can read it all at once, so it was broken into pieces.
- There were millions of **clones** (small sequence fragments).
- The assembly process included finding where the pieces overlapped in order to put the draft together.

UCSC put the human genome sequence on the web July 7, 2000

- UCSC put the human genome sequence on CD in October 2000, with varying results
- Publication of 90 percent of the sequence in February 2001 issueof the journal *Nature*.
- Completion of 99.99% of the genome as finished sequence in July 2003.



Next …the **Annotation**

- Where are the **genes**?
- How do genes work?
- How do scientists use this information for scientific understanding and to benefit us?

- **What do genes do anyway?**
- We only have ~27,000 genes, so that means that each gene has to do a lot.
- Genes make proteins that make up nearly all we are (muscles, hair, eyes).
- Almost everything that happens in our body happens because of proteins
- **(walking, digestion, fighting disease).**

or

Eye Color is determined by genes

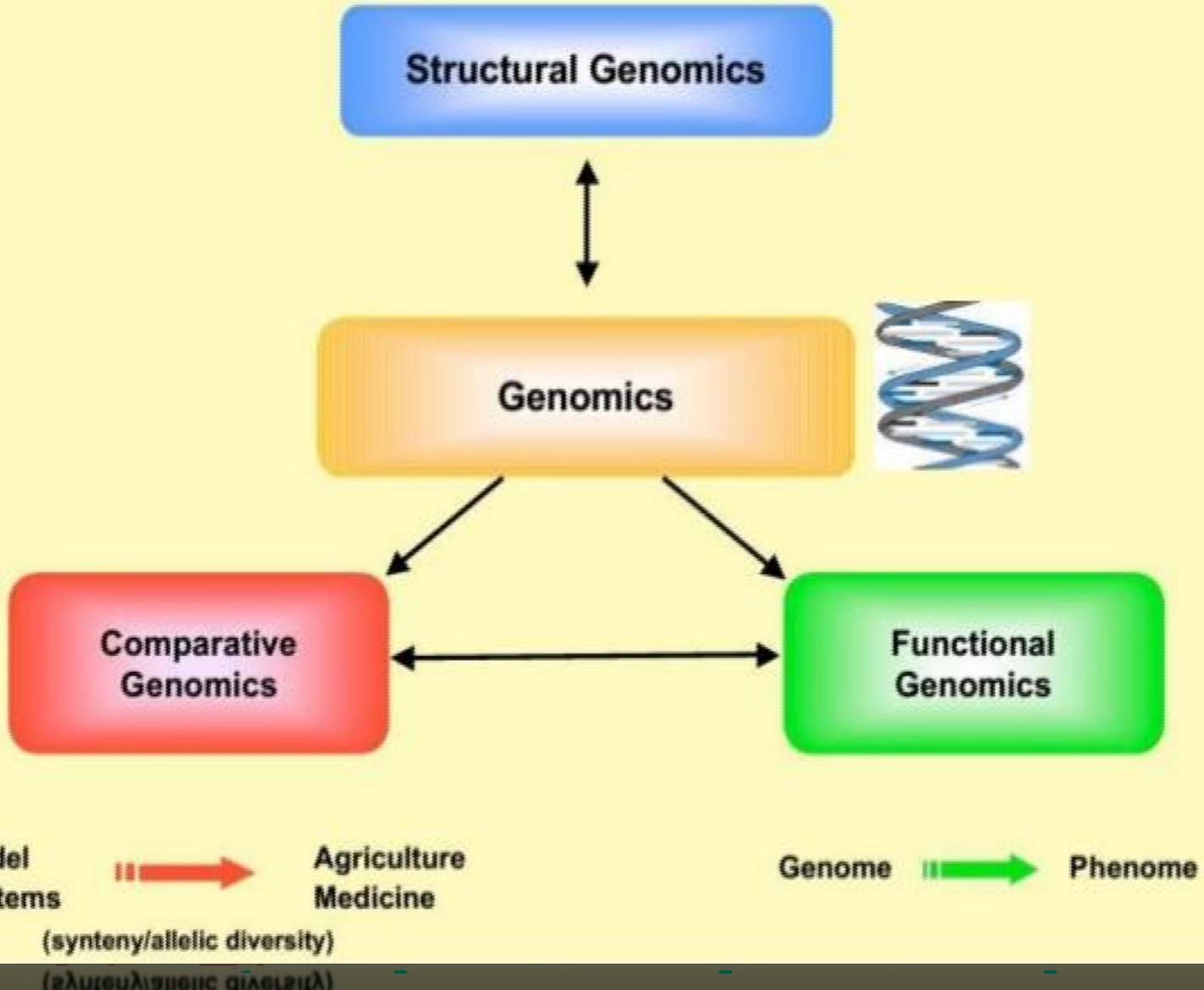
From our genome so far…

- Relatively small number of human genes, less than 30,000
- Have a complex architecture (which is yet to be analyzed completely)
- We know where 85% of genes are in the sequence.
- We don’t know where the other 15% are because we haven’t seen them “on” (they may only be expressed during fetal development).
- We only know what about 20% of our genes do so far.

What Does The Draft Human Genome Sequence Tell Us?

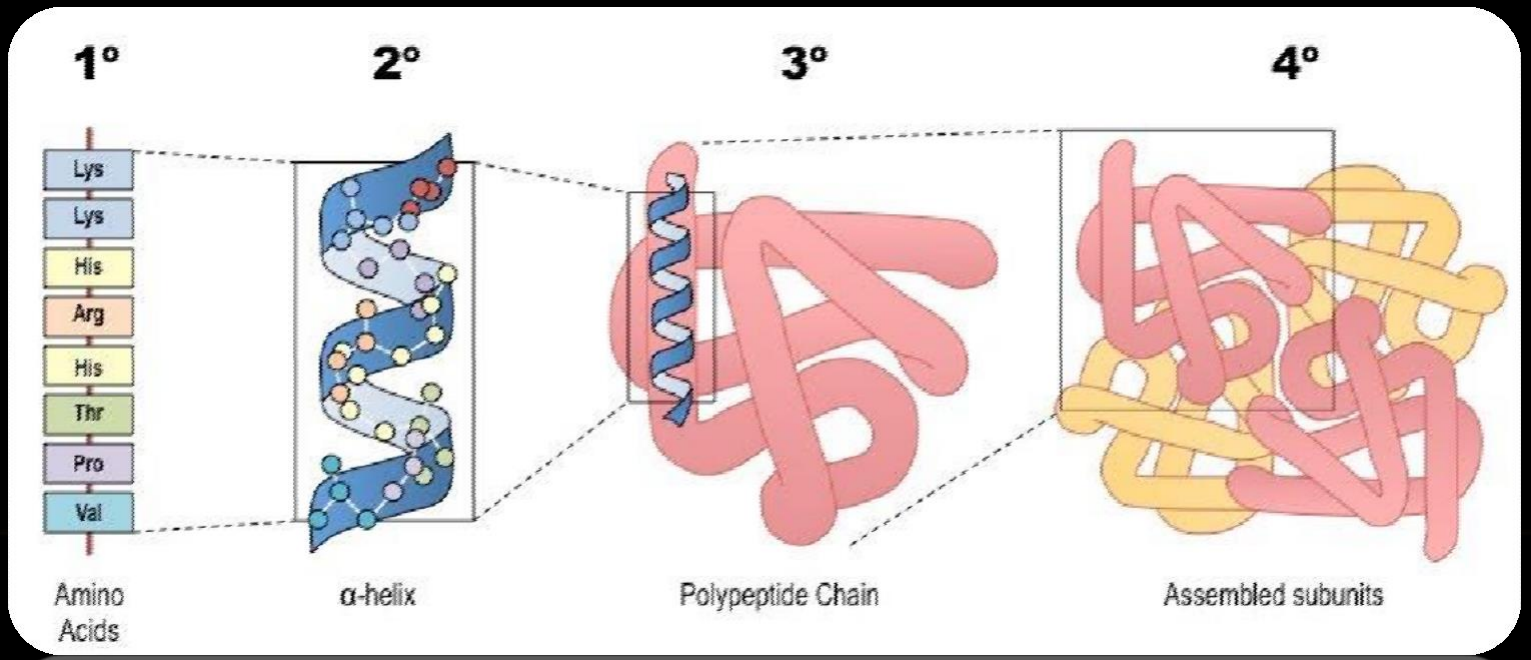
- The human genome contains 3.2 billion chemical nucleotide bases (A, C, T, & G)
- Takes **95** years to read

Types of genomics :



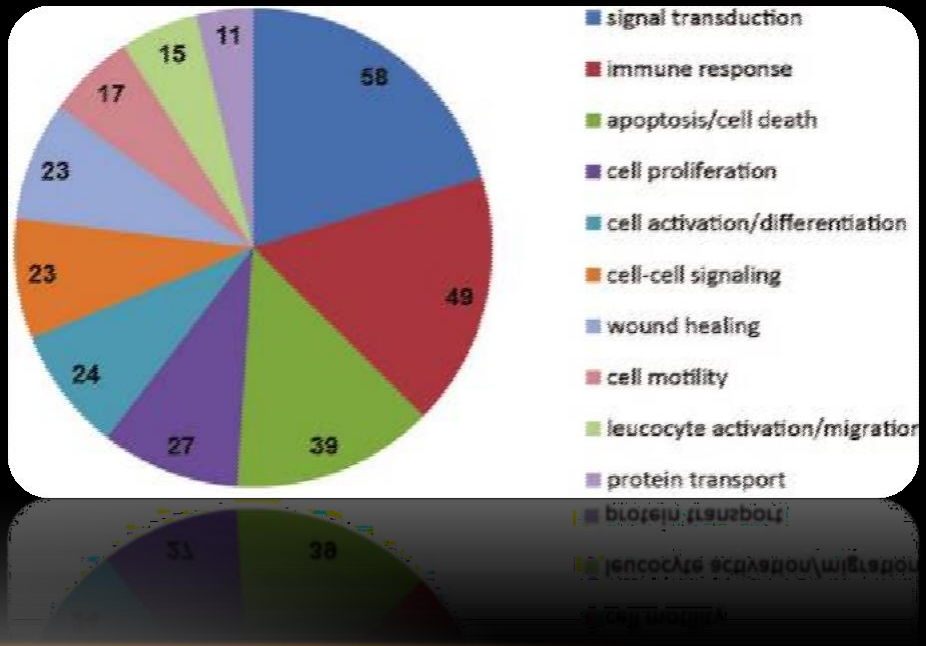
STRUCTURAL GENOMICS

- Effort aimed at determining the three-dimensional **structures** of gene products
- Using efficient and high-throughput mode
- **For Proteins- Structural proteomics!**
- Understanding novel proteins and 3D structures



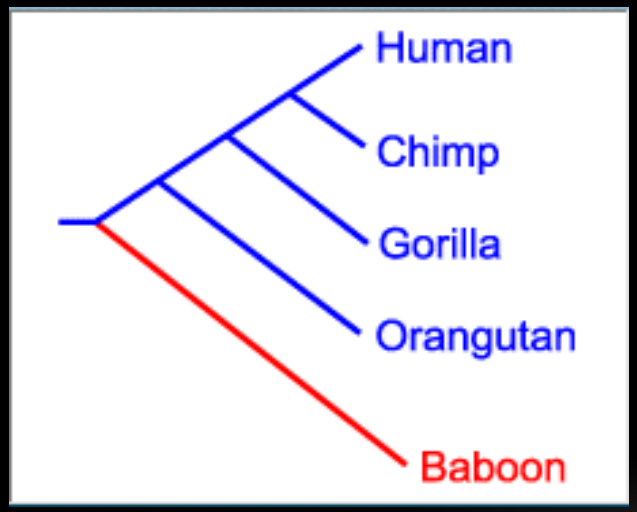
FUNCTIONAL GENOMICS

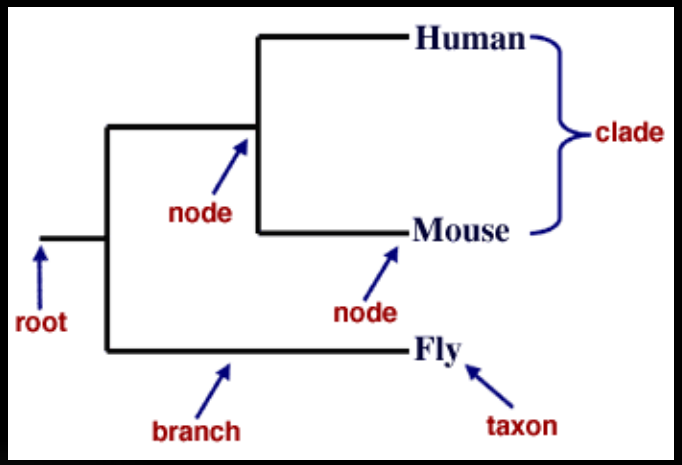
- Identify functions of gene and non-gene sequences
- Describe gene & protein functions
- Gene & Protein interaction
- Genotype- Phenotype



COMPARATIVE GENOMICS

- Compare genome sequence between different species
- To better understand the evolutionary relationships
- Determine the function of each genome





MUTATIONAL GENOMICS

- Study of genome in terms of mutations that occur in the DNA or Genome of an individual
- **Also termed as gene function determination**
- **Understand the mutations in**

✓ Coding sequences

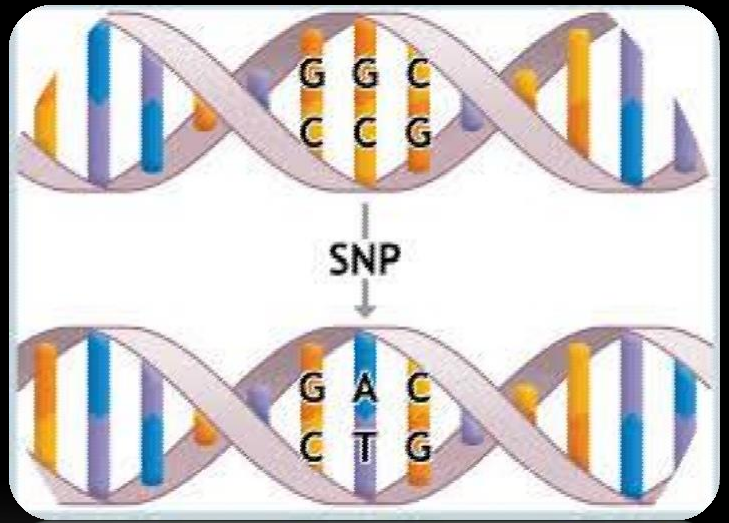
✓ Non coding sequences

- **Due to Repeat sequences:**

✓ Minisatellites

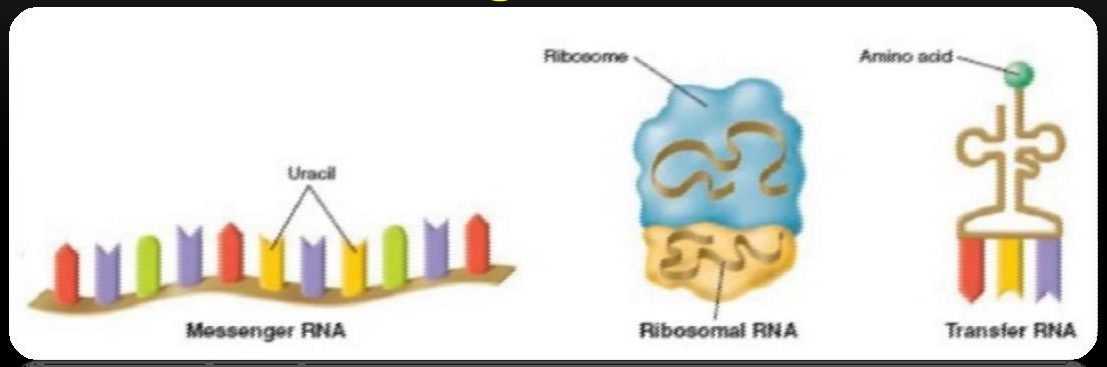
✓ Microsatellites

- **SNP**



TRANSCRIPTOMICS

- The set of all RNA molecules including:



- ✓ mRNA
- ✓ rRNA
- ✓ tRNA
- ✓ non-coding RNA produced in one or a population of cells

Transcriptomics, is a global way of looking at gene expression patterns

TRANSCRIPTOME PROFILING

- Deep investigation of the transcriptome
- Study the transcriptional activity
- Proteins coded by the RNA transcript
- Study gene fusions etc…

Annotate the RNA transcript

PROTEOMICS

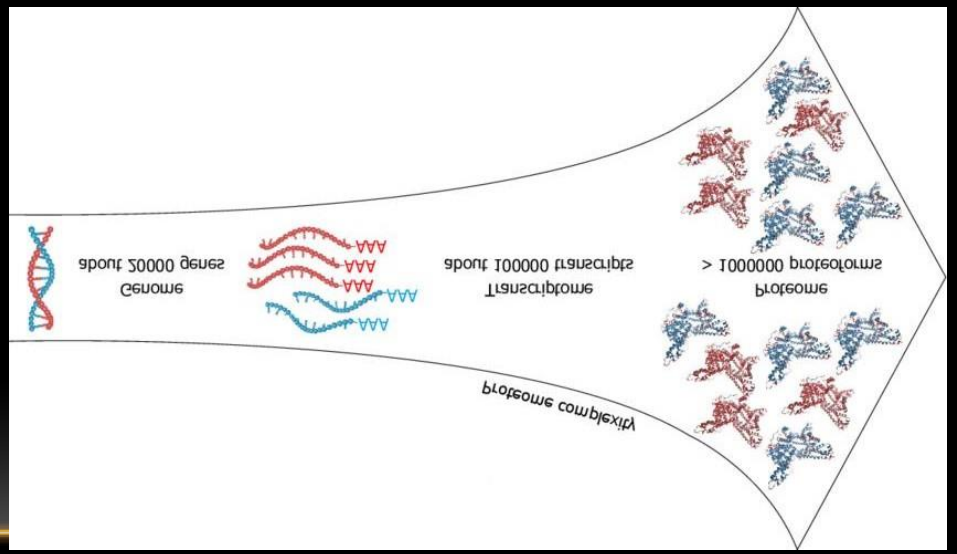
We all are made up of proteins

WHY PROTEOMICS?

Fact:

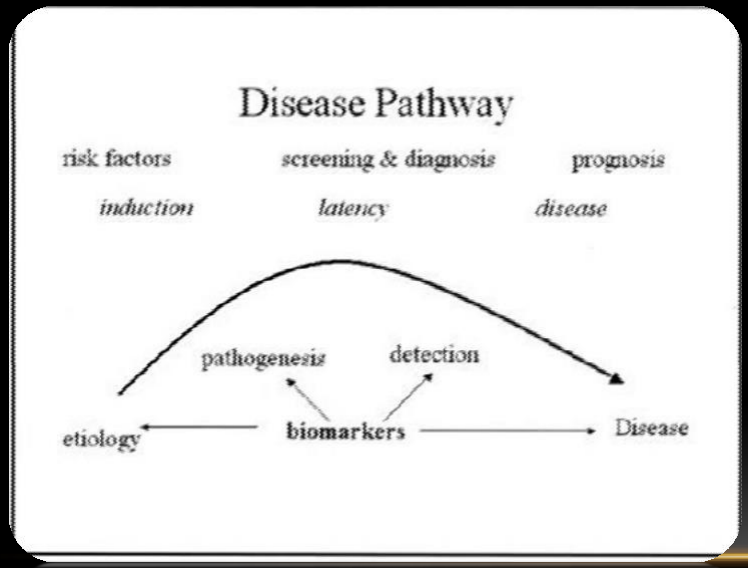
- Genome ~ 26,000-31,000 protein encoding genes
- **Human proteins ≥ 1 million**
- **Proteomics –**
- Study of the full protein complement of organisms

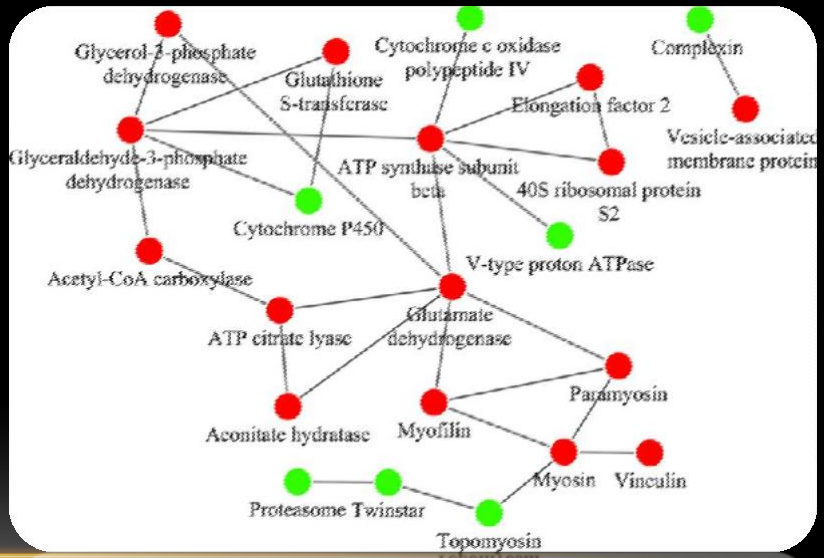
e.g. plasma, cells and tissue



UNDERSTANDING THE PROTEOME ALLOWS…

- Characterisation of proteins
- Understanding protein interactions
- Identification of disease biomarkers





MAJOR APPLICATIONS...

GENOMICS, TRANCRIPTOMICS, PROTEOMICS

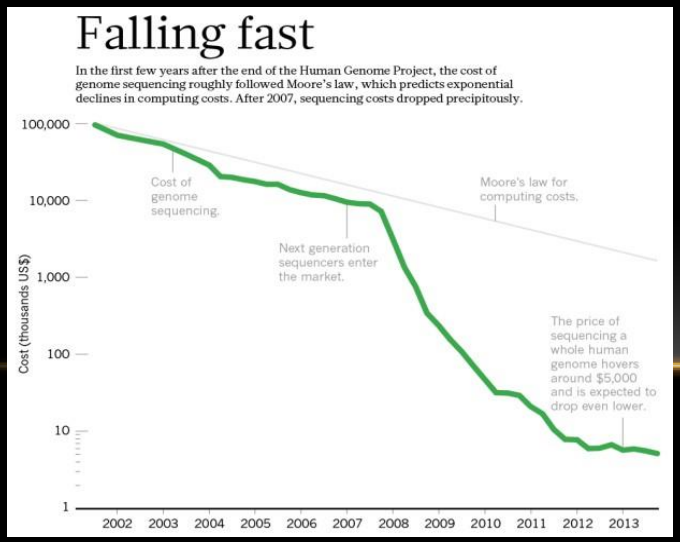
- Gene prediction
- ORF Finding
- Metagenomics
- Next Generation Sequencing
- Computer Aided Drug Design

NEXT GENERATION SEQUENCING

- DNA sequencing technology which has revolutionised genomic research
- Determining the number and order of nucleotides that make up a given molecule of DNA.
- Using NGS an entire human genome can be sequenced within a single day.
- In contrast to the previous Sanger sequencing technology
- A number of different modern sequencing technologies including:

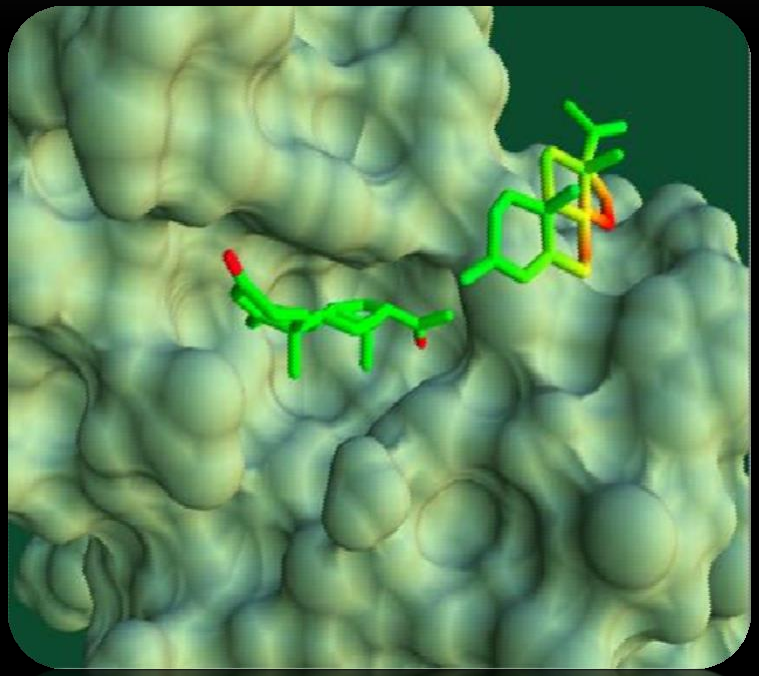
  Illunmina, Roche 454 sequencing, Ion Torrent , PacBio etc.

- Cost

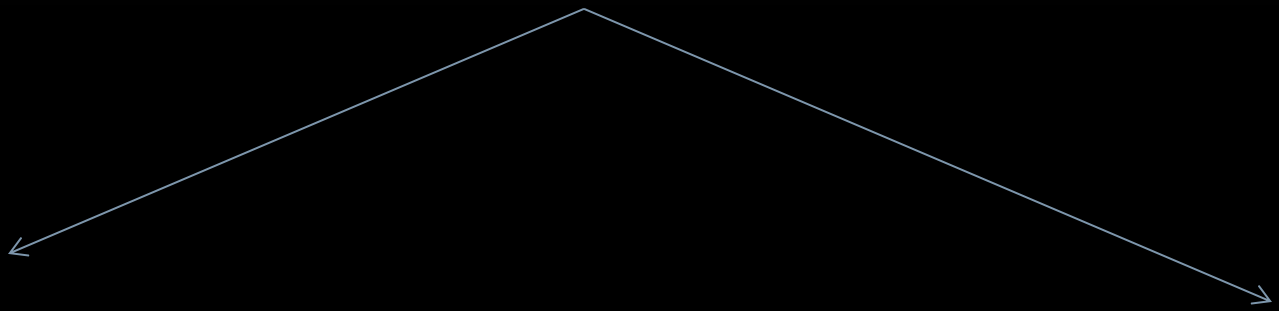


Method	Read Length
Sanger	600-1000 bp
454	300-500 bp
Illumina	~100 bp
Ion Torrent	~200 bp

COMPUTER AIDED DRUG DESIGN



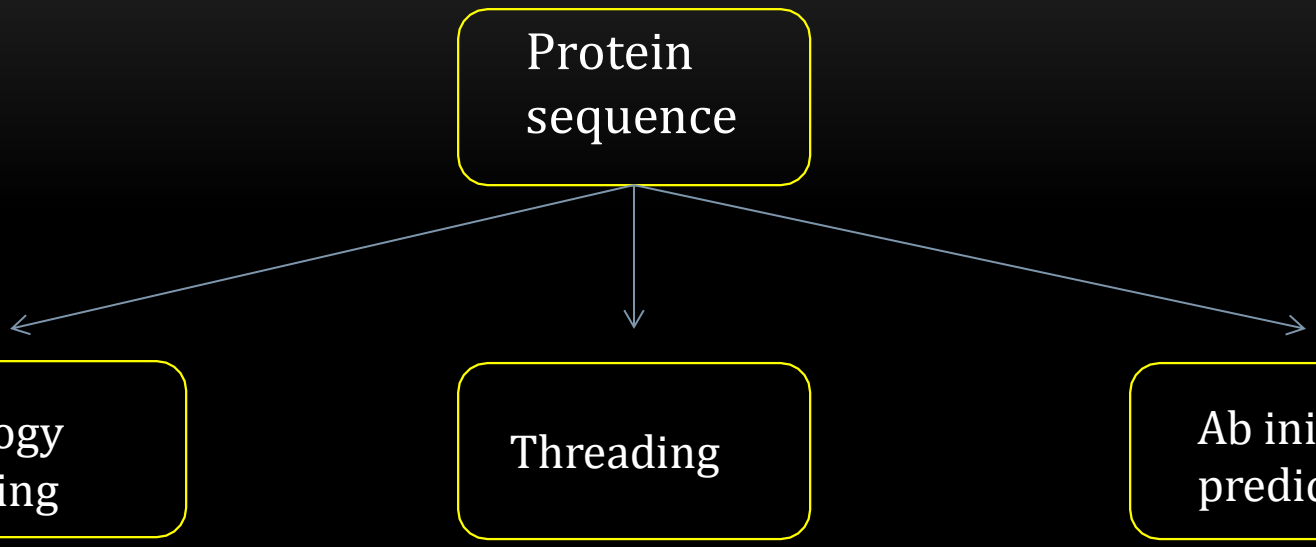
COMPUTER AIDED DRUG DISCOVERY



Choosing the right "one" among millions: ***virtual screening***

Designing the right "one" from chemical building blocks: ***de novo drug design***

PREDICT TERTIARY STRUCTURE



- Find homologous sequence
- Homology > 30%
- Keeping in view of the template structure

Swiss PDB Viewer , MODELLER

If homologous sequence is < 30 % similar we use this method

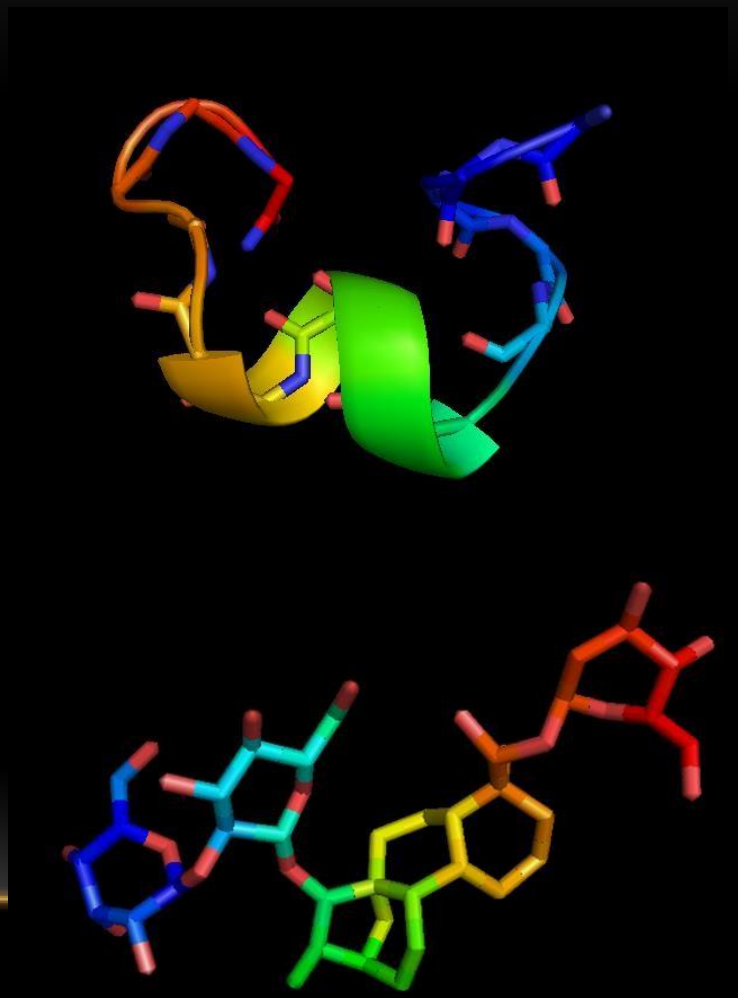
iTASSER, PHYRE

Prediction of structure from scratch using the knowledge of amino acid properties

ROSETTA

STRUCTURE VISUALIZATION

RASMOL
MOLMOL
PYMOL
SPDBV



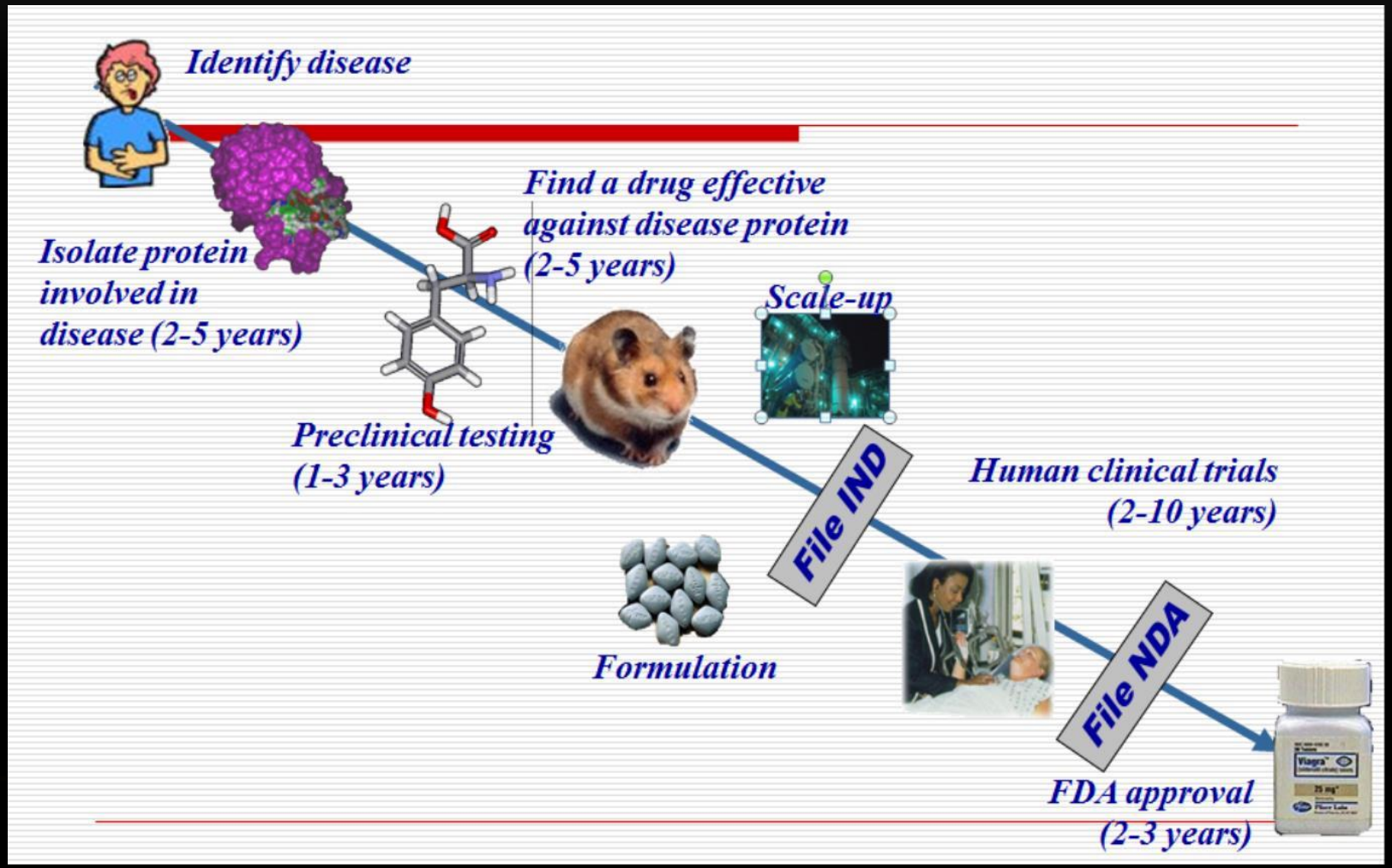
TIME & MONEY …

- 10-12 Years
- 1 Drug/Year
- Rs 400 Crores
- 5000 to even 50000 screenings

Returns too are striking…

- ***Lipitor*, cholesterol reducer from Pfizer sold for 8.6 Billion US$ in 2001**

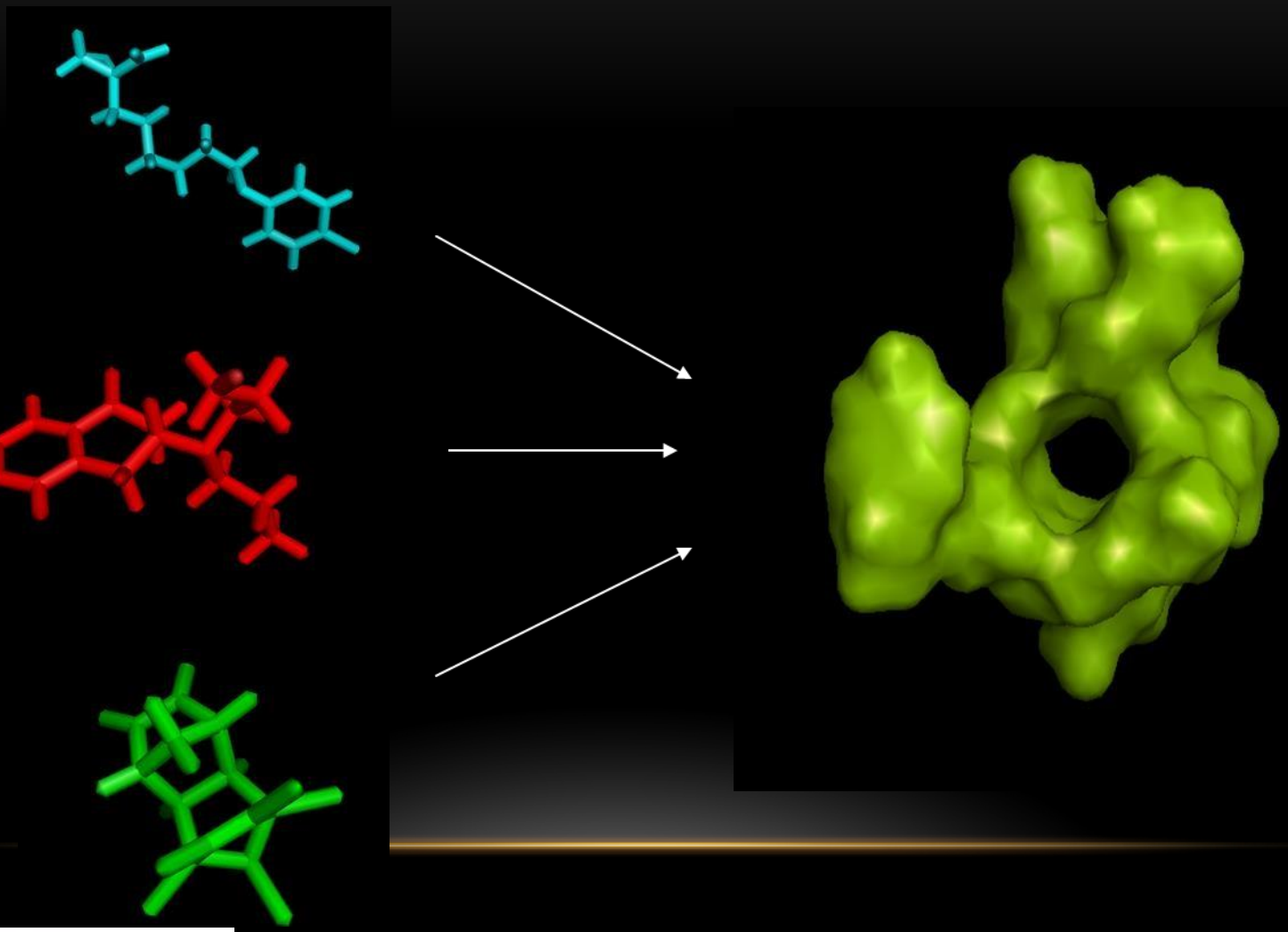
DRUG PIPELINE



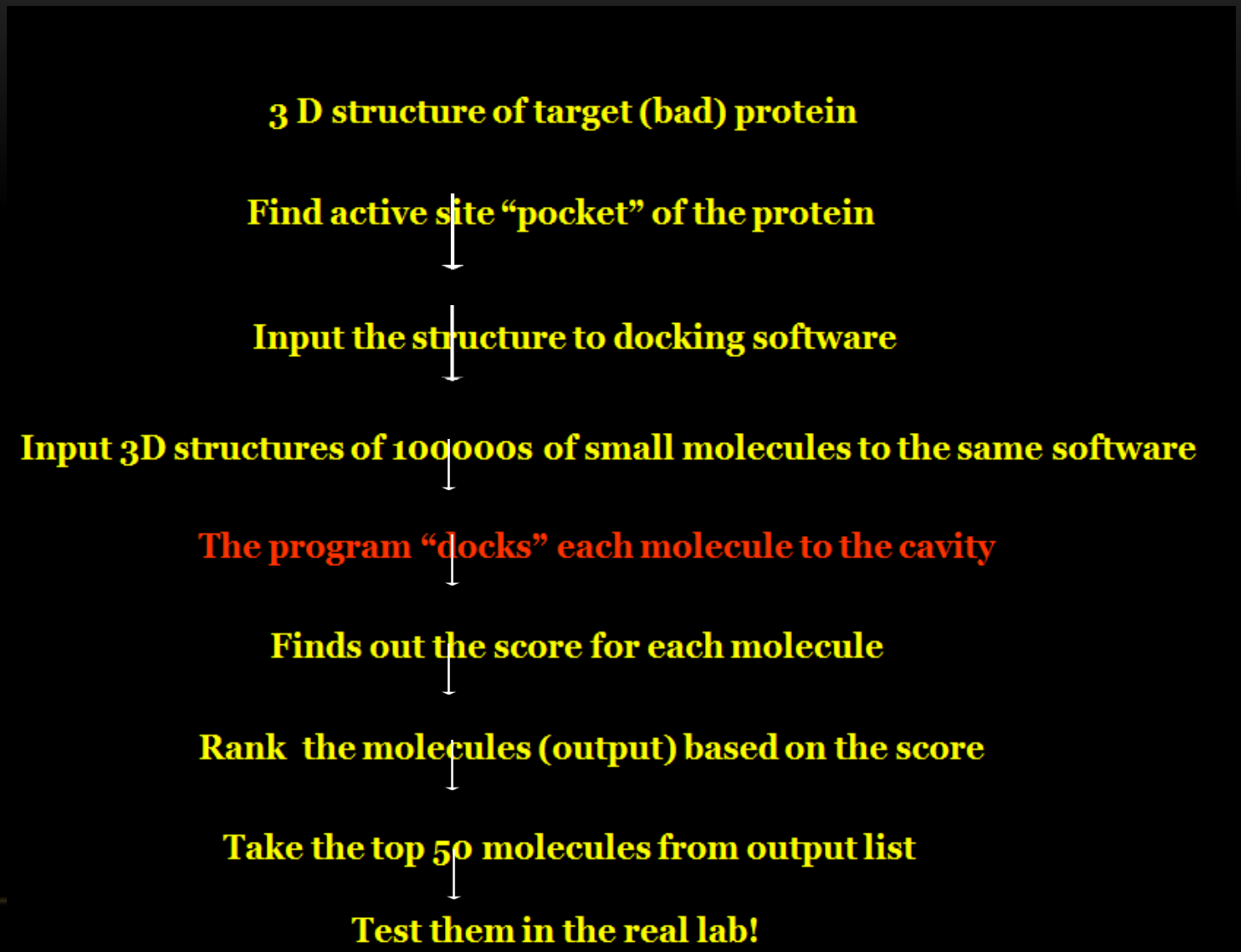
IMPORTANT TERMS

- Target- a molecule important in a disease-usually a protein
- Ligand- a small molecule binds to a larger one
- Active site- ligand binding site
- Hit- a ligand which can geometrically fit to the binding site
- Lead- hit with biological activity
- DRUG- Ligand that can modulate the function of target in desired way

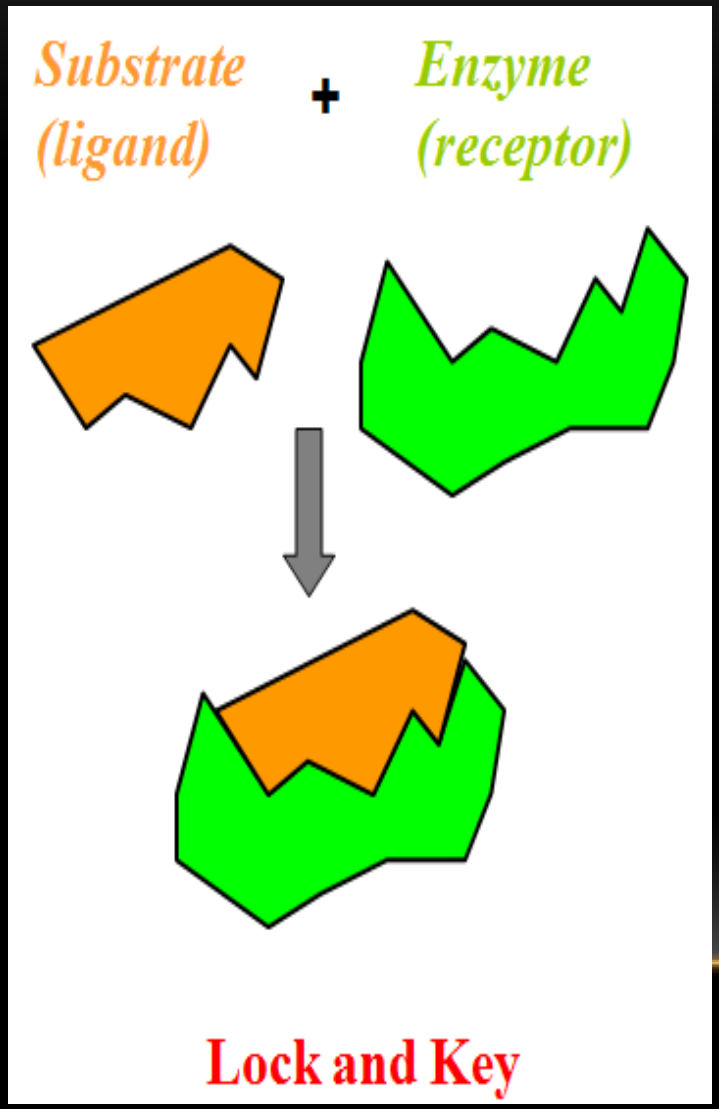
20000 molecules → 30 – 50

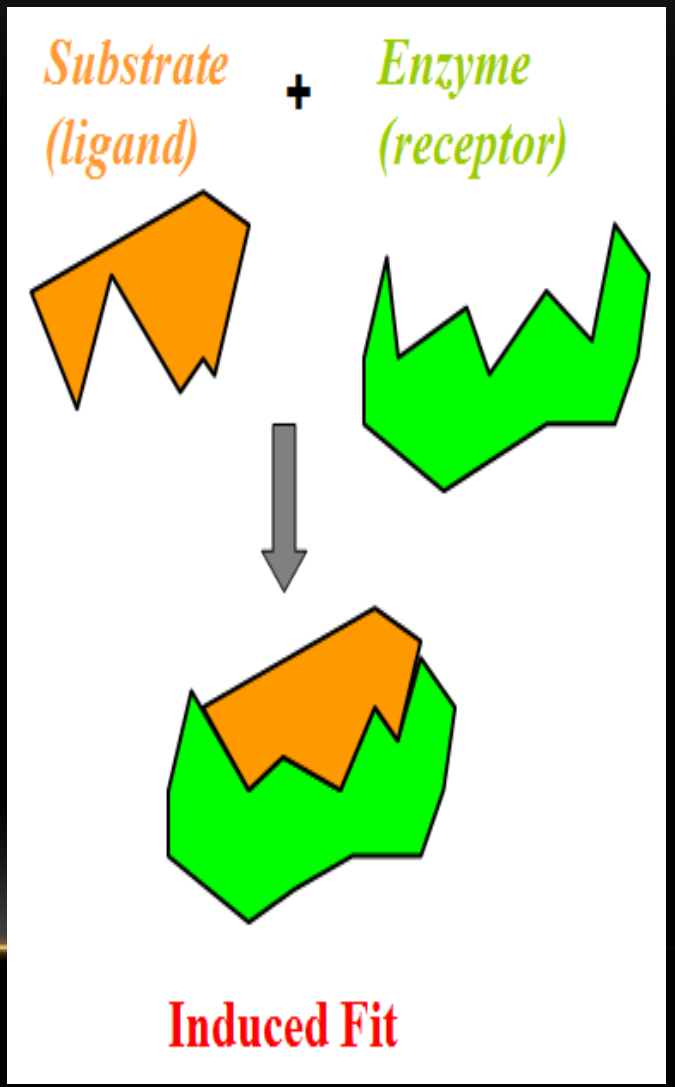


STEPS

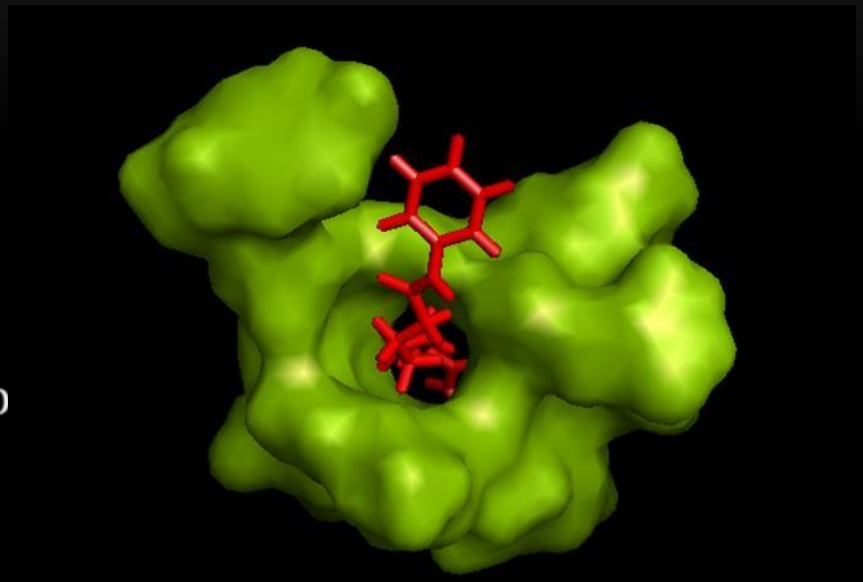

3 D structure of target (bad) protein
Find active site "pocket" of the protein
Input the structure to docking software
Input 3D structures of 1000000s of small molecules to the same software
The program "docks" each molecule to the cavity
Finds out the score for each molecule
Rank the molecules (output) based on the score
Take the top 50 molecules from output list
Test them in the real lab!

ENZYME – SUBSTRATE BINDING: 2 MODELS





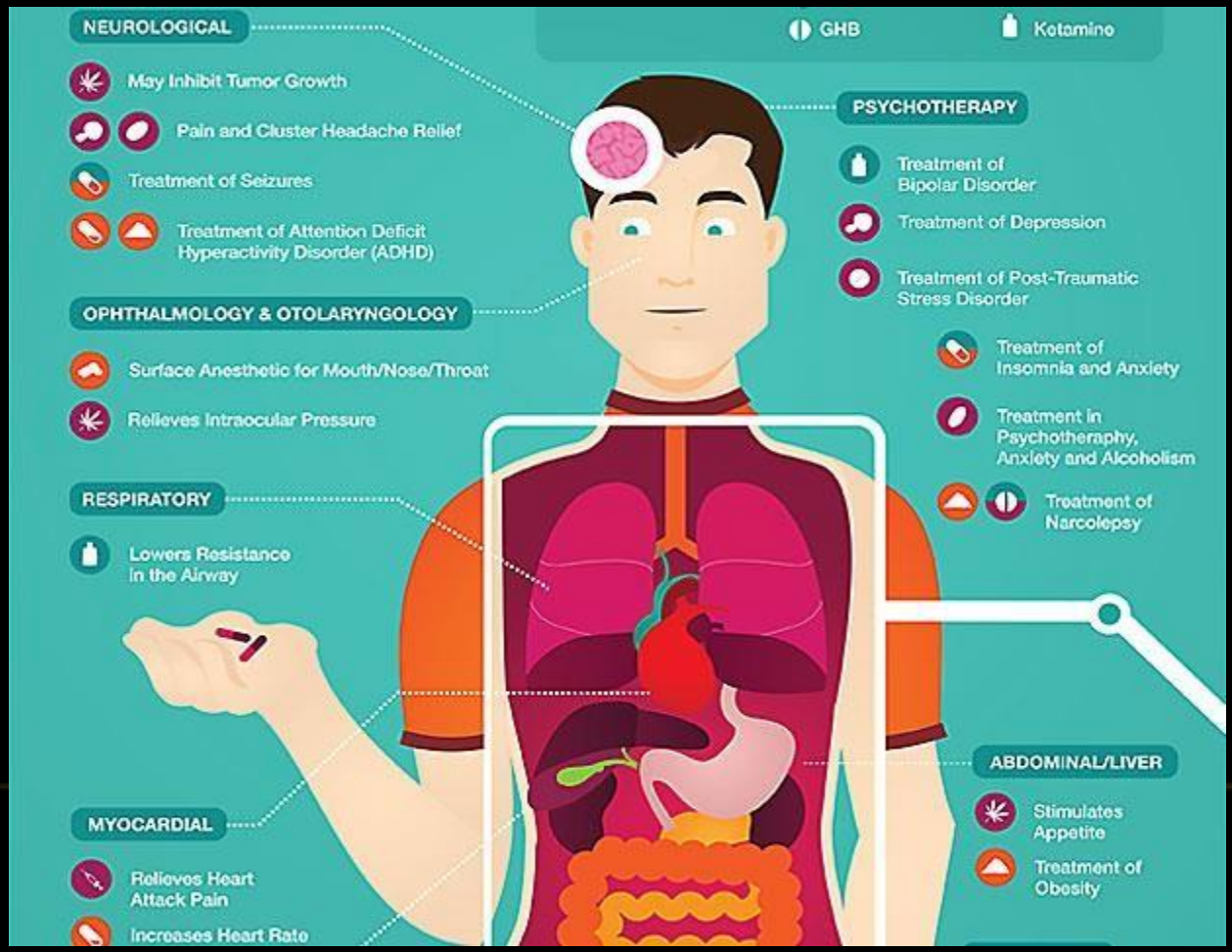
- **Docking Software-**
  - ✓ Discovery Studio, Schrodinger
  - ✓ Auto Dock. Phyredock, Patch dock



- **Mostly drug activity is obtained through binding of one molecule to the pocket of another.**
- **ADME Test**
  - ✓ Absorption, Distribution, Metabolization, & Excretion

MORE IS NOT ALWAYS BETTER

- Be careful about dosage amounts




Thank You ...