INTRODUCTION TO CELLULAR BIOLOGY

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LAY OUT

PART I : CELLS - THE STARTING POINT

- LIVING ORGANISMS
- PROKARYOTES AND EUKARYOTES CELLS
- THE BASICS OF CELL
- CELL ORGANELLES
- CELL NUCLEUS

PART II :DNA: STRUCTURE AND FUNCTION

- POLARITY OF DNA
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PART III : THE CENTRAL DOGMA

- RNA: STRUCTURE AND FUNCTION
- CELL DIVISION
- WHAT IS PROTEIN
- PROTEIN SYNTHESIS
- PROTEIN FOLDING

CELLS - THE STARTING POINT

- Millions of different types of organisms that inhabit the earth has at least one thing is common- they are made of cells
- Cell is the smallest and basic unit of an organism that is classified as living.
- Cell is an independent entity- capable of creating copies of itself by growing and dividing into two identical daughter cells.
- It provide structure for the body- take in nutrients from food - convert into energy - carry out specialized functions.

CELLS - THE STARTING POINT cont'd

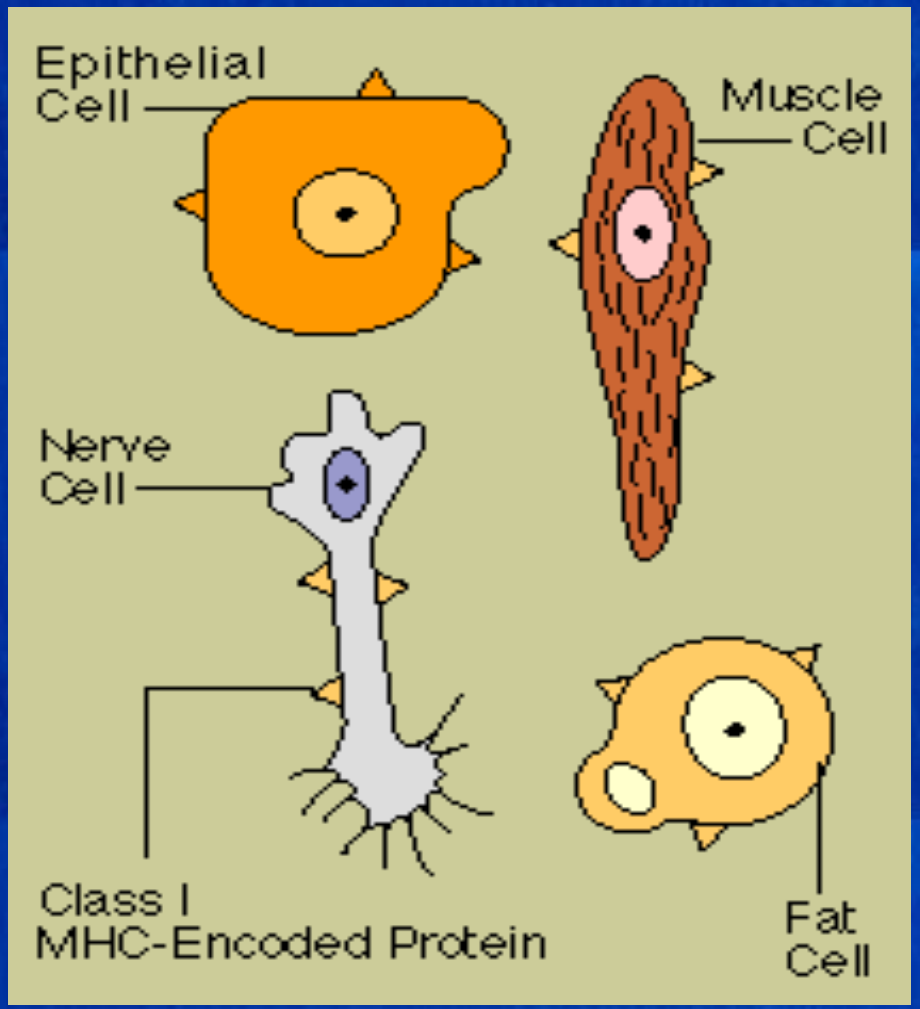
- Each cell stores its own set of instructions for carrying out each of these activities.
- Cells are very small e.g. a Bacterium- one cell- 1 micron in diameter.
- Humans are made up of trillions of cells (100 trillions).
- A typical cell mass is 1nanogram- largest known cell is ostrich egg (2 pounds)- longest cell is the nerve cell- 2 feet long.
- There are smaller pieces to cells that include **proteins** and **organelles**.

TYPES OF CELL

Main Types of Cells
1. Animal-like cells
2. Plant-like cells

Animal- like cells

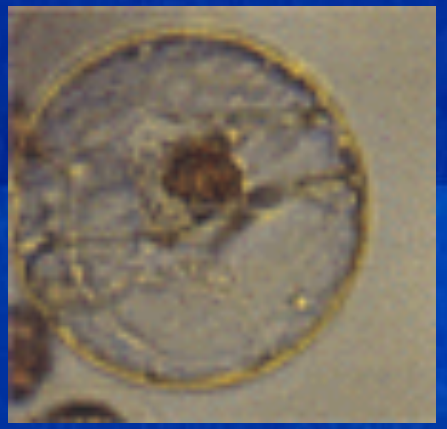
- An animal cell - a tiny micro-organism to a nerve cell in human brain.
- Humans may have hundreds of types of cells.
- Some cells are used to carry oxygen through the blood (red blood cells) and others might be specific to the heart.

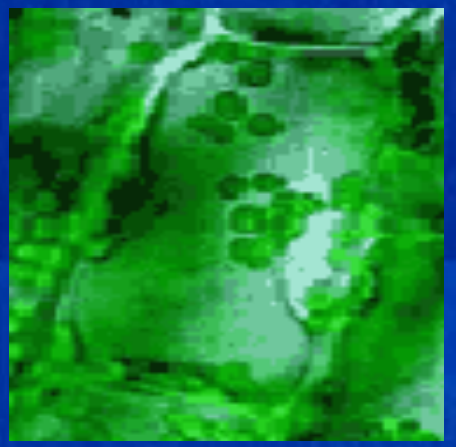


TYPES OF CELL cont'd

Plant-like cells :

- Plant cells –easy to identify - they have a protective structure called a cell wall made of cellulose.
- Plants also have organelles like the chloroplast and large water-filled vacuoles.





LIVING ORGANISMS

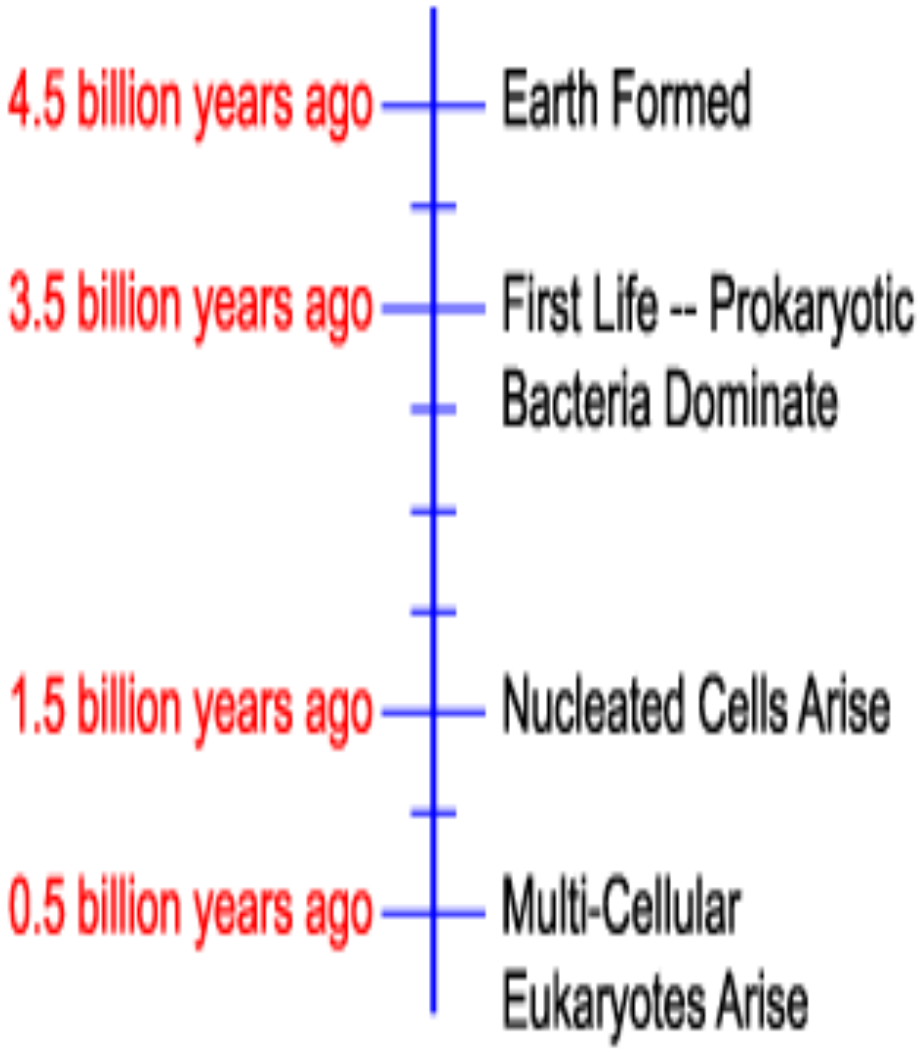
Divided into two classes based on cell anatomy

1. PROKARYOTES:

- Prokaryotes- usually independent and uni-cellular.
- Prokaryotes -consists of two different groups of organisms called Bacteria and Archaea.

2. EUKARYOTES:

- Eukaryotes- complex multi-cellular organisms- Animals, Plants and Fungi.
- They also include unicellular organisms such as Yeast and Amoebas.



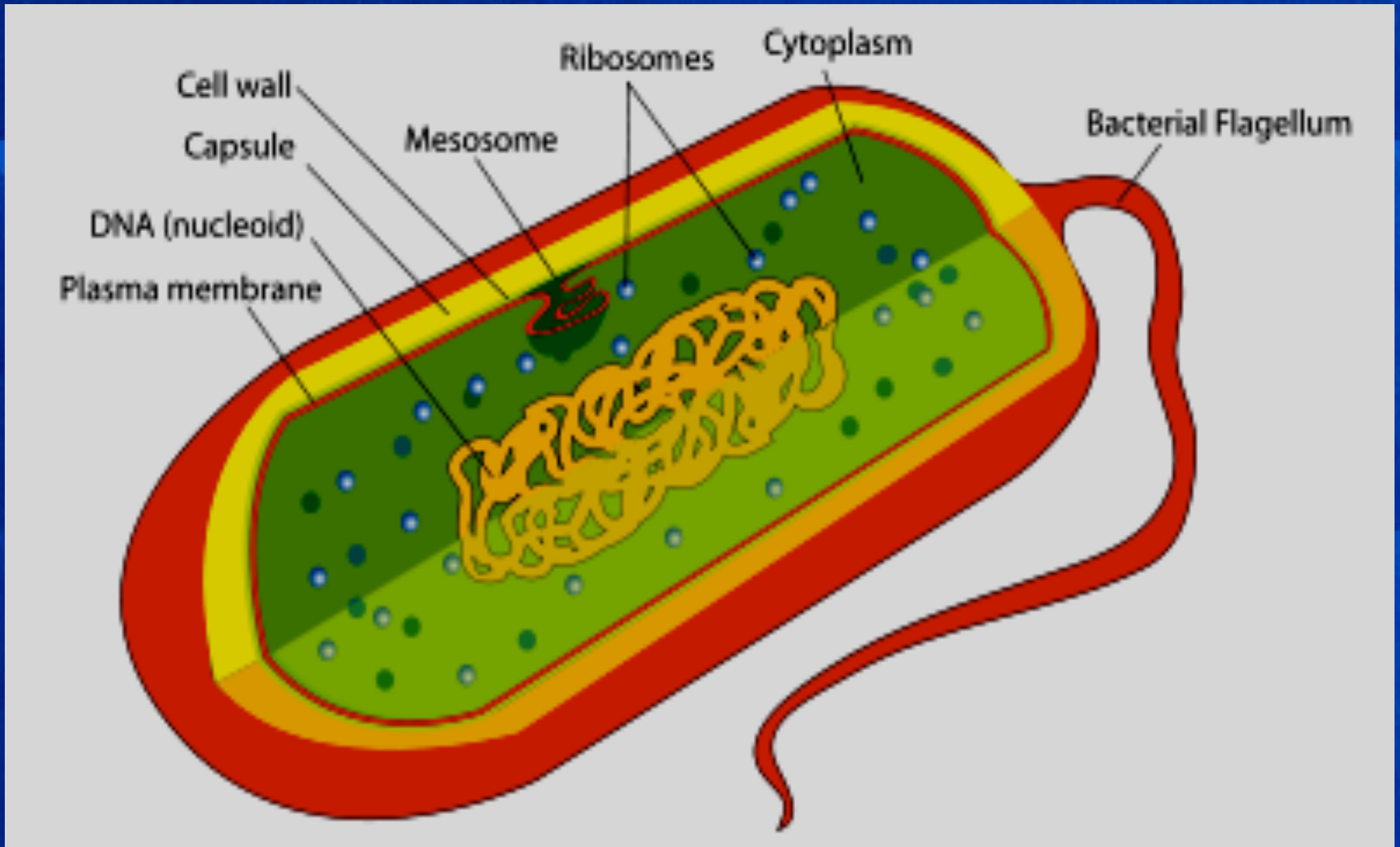
PROKARYOTES ORGANISM

- Prokaryotes- the simplest and the first types of organisms to evolve on earth about 4 billion years ago.
- Prokaryotes- organisms whose cells do not contain a nucleus
- Prokaryotes lack most of the intracellular organelles and structures- an important exception is the ribosome.
- Most functions of organelles- such as mitochondria, chloroplasts, and the Golgi apparatus- are taken over by the prokaryotic plasma membrane.

PROKARYOTIC CELL

1. Flagellum- a long, slender projection from the cell body- function is to propel a uni-cellular or small multi-cellular organism.
2. Pilus - is a hair like appendage found on the surface of many bacteria.
3. Cell envelope- consisting of a capsule - a cell wall - and a plasma membrane.
4. Cytoplasmic region- contains the cell genome (DNA) and ribosomes.
5. Mesosomes - rosette-like clusters of folds in the plasma membrane - important for cellular respiration.

BACTERIAL CELL



EUKARYOTES ORGANISM

- There are many different types of eukaryotic organism – animals, plants, fungi and protists.
- Animals and plants are the most familiar eukaryotic cells.
- Fungi and many protists have some substantial differences.
- The cells of eukaryotes organisms are complex and contain a nucleus and other membranes- bound structures.
- Different cells in eukaryotes organism – like human- look and function differently.

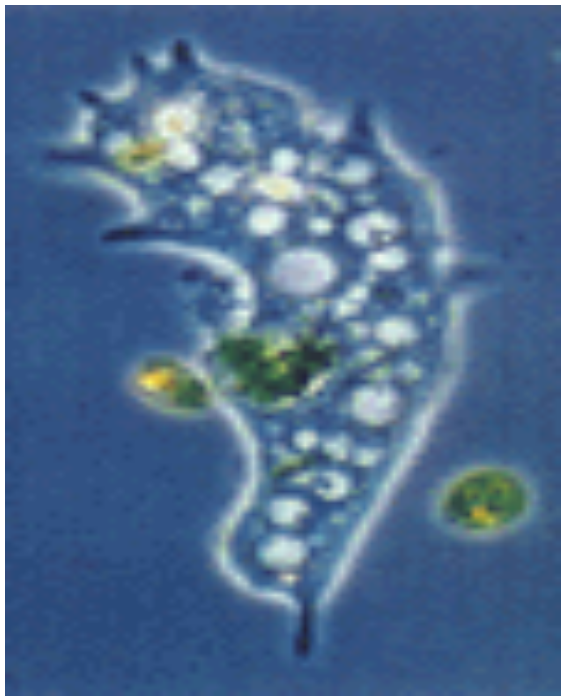
EUKARYOTIC- FUNGI

Fungi- decomposers of dead animal and plant matter.

- Break dead organic matter- simple compounds that can be absorbed by the plants around it.
- During this- fungi returns carbon dioxide to the atmosphere.
- Green plants use the carbon dioxide during photosynthesis to produce food.
- Oxygen is released into the atmosphere during the process of photosynthesis.
- Animal and human life depends on the fungi for survival.
- Some fungi - like mushrooms- are used as ingredients in recipes. They add flavor to meals.

EUKARYOTIC-PROTISTA

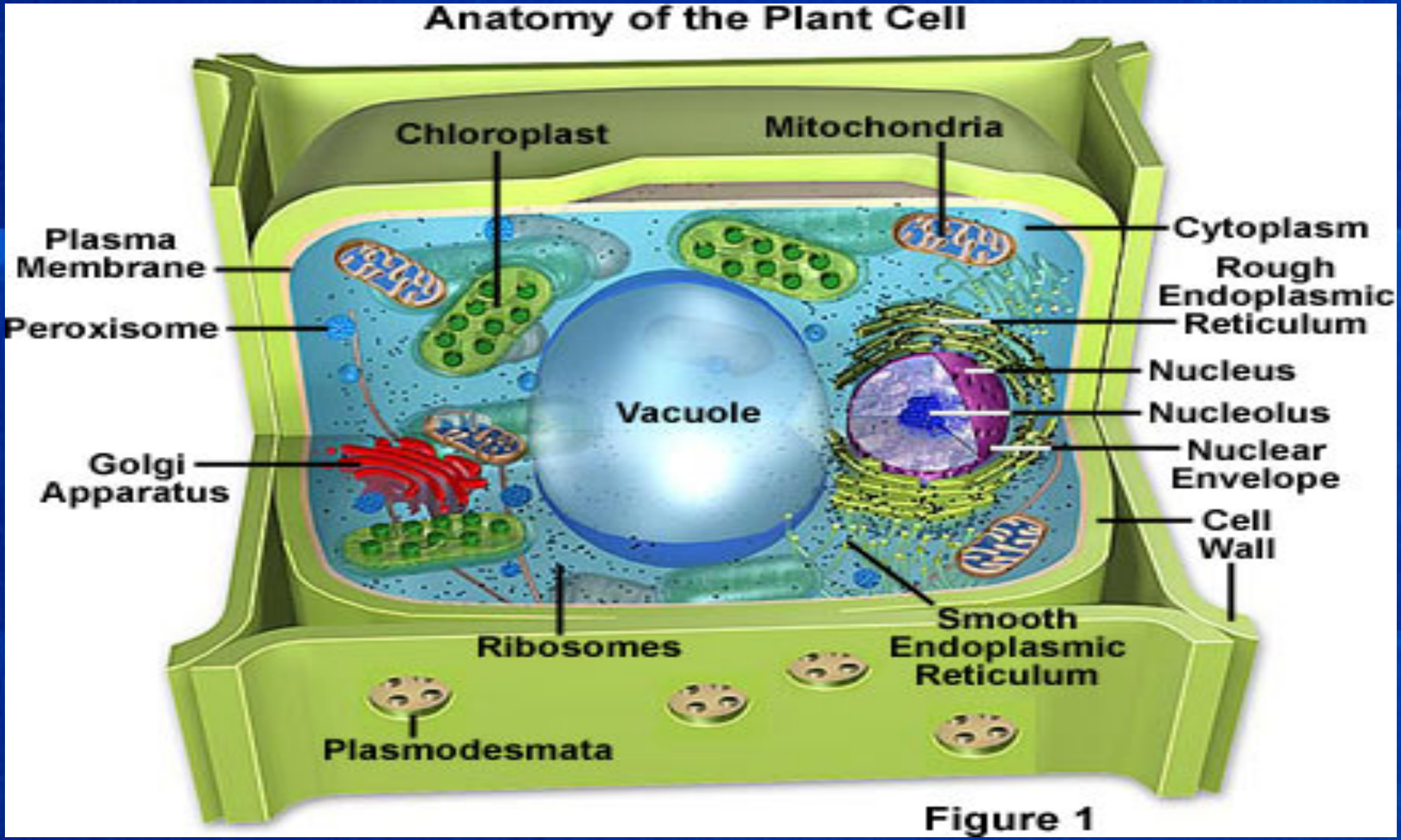
- Protists - the ancestors of plants- animals and fungi.
- They may have been around as long as two billion years.
- A protist is an organism made of a single cell - yet it can live- eat- and reproduce like other living things.
- One of the most fascinating protists is the amoeba.
- Amoebas- like animals- eat other smaller living creatures in order to survive. Yet they do not have teeth or mouths.



EUKARYOTES –PLANTS CELL

- **Plant Cell Structure**
- Plant cells have membrane-enclosed nuclei and organelles.
- Chloroplast -contains chlorophyll- gives plants their green color- enables them to use sunlight to convert water and carbon dioxide into sugars and carbohydrates - photosynthesis.
- Vacuole- a membrane-bound sac- plays roles in intracellular digestion - the release of cellular waste products.
- Vacuoles tend to be large in plant cells- typically is 50% of the cell- yet it can take up to 95% of the cell
- It is responsible for maintaining the shape and structure of the cell.
- Plant cells don't increase in size by expanding the cytoplasm, rather they increase the size of their vacuoles.
- When a plant is well-watered, water collects in cell vacuoles producing rigidity in the plant

PLANT CELL


Anatomy of the Plant Cell
Chloroplast
Mitochondria
Plasma Membrane
Cytoplasm
Rough Endoplasmic Reticulum
Peroxisome
Nucleus
Vacuole
Nucleolus
Golgi Apparatus
Nuclear Envelope
Cell Wall
Ribosomes
Smooth Endoplasmic Reticulum
Plasmodesmata
Figure 1

EUKARYOTES –ANIMAL CELL

HUMAN CELL

- Each of the 100 trillion cells in human being is a living structure- survive for months or years- provided its surrounding fluids contain appropriate nutrients.
- To understand the function of organs and other structures of the body- understanding of basic organization of the cell and the functions of its component parts is needed.

ORGANIZATION OF THE CELL

- A typical cell has two major parts- the *nucleus* and the *cytoplasm*.
- The nucleus is separated- cytoplasm by a nuclear membrane- cytoplasm is separated from the surrounding fluids by a cell membrane- plasma membrane.
- The different substances that make up the cell are collectively called **protoplasm**.
- Protoplasm- composed of five basic substances: water, ions, proteins, lipids and carbohydrates.

CELL : PROTOPLASM

WATER:

- Principal fluid of the cell.
- Present in most cells- except fat cell.
- Concentration of water is 75-85 %.
- Many cellular chemicals are dissolved in water- other suspended in it as solid particulates.

CELL : PROTOPLASM cont'd

- IONS:
- The most important ions in cell – potassium, magnesium, phosphate, sulfate, bicarbonate.
- Smaller quantities of sodium, chloride and calcium.
- The ions provide inorganic chemicals for cellular reactions.

CELL : PROTOPLASM cont'd

- **PROTEINS:**
- **After water – the most abundant substances in most cells are proteins.**
- **Normally constitute 10 to 20 % 0f the cell mass.**
- **Divided into two types;**

1. **Structural proteins- form of long filaments- make microtubules that provide cytoskeleton to cellular organelles**
2. **Functional proteins- mainly the enzymes of the cell- mobile in cell fluids- catalyze specific chemical reactions.**

CELL : PROTOPLASM cont'd

- LIPIDS:
- Usually grouped together because of their common property of being soluble in fat solvents.
- Important lipids- phospholipids and cholesterol.
- Constitute only 2% of the total cell mass.
- Some cells contain lipid– neutral fat- 95 % of fat cell.

CELL : PROTOPLASM cont'd

- CARBOHYDRATES:
- Little structural function in the cell except as part s of glycoprotein molecules.
- Carbohydrates play a major role in the nutrition of the cell.
- Most human cells do not maintain large stores of carbohydrates.
- The amount usually averages about 1% of their total mass- increases to as much as 3 % in muscle cells and occasionally 6% in liver cell.
- Carbohydrates in form of glucose is present in extracellular fluids and glycogen in the cell.

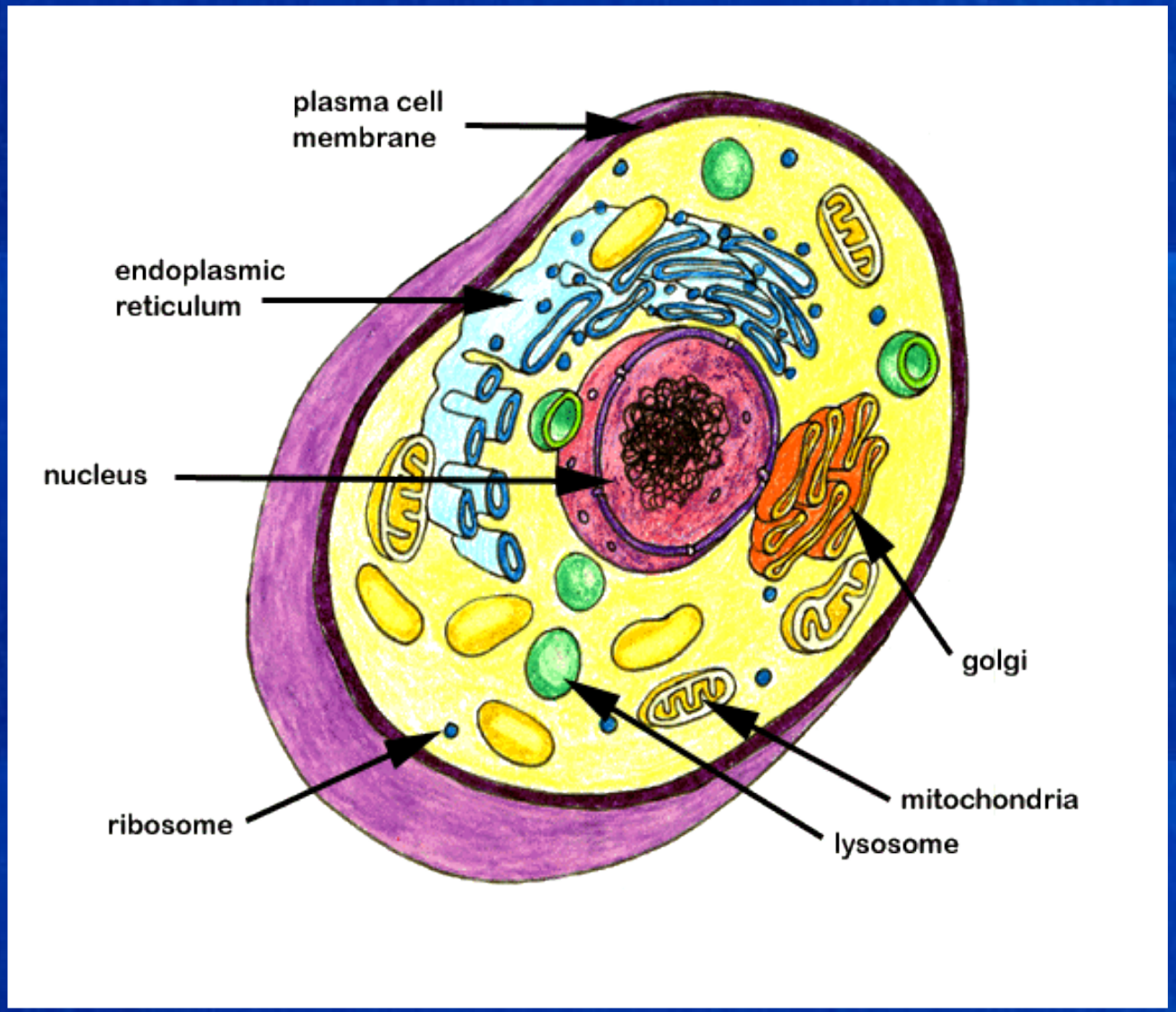
CELL: PHYSICAL STRUCTURE

The Basics

- Cell Membrane
- Cytoplasm
- Cytoskeleton

Organelles

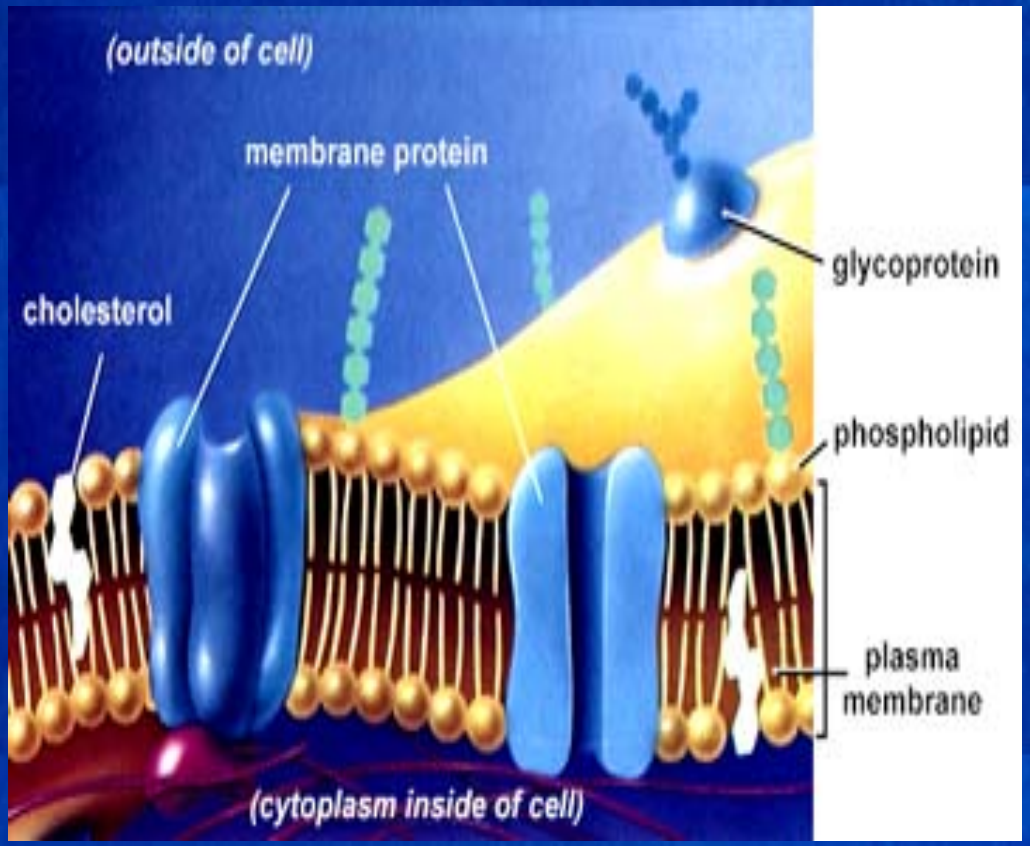
- Centrioles
- Endoplasmic Reticulum (ER)
- Golgi Apparatus
- Lysosomes
- Microvilli
- Mitochondria
- Nucleus
- Peroxisome
- Ribosomes



CELL:THE BASICS

Cell Membrane

- Outer lining of a eukaryotic cell is called the plasma membrane.
- It separates and protects a cell from its surrounding environment.
- It is made of a double layer of proteins and lipids - fat-like molecules.
- Variety of molecules are embedded within it that act as channels and pumps, moving different molecules into and out of the cell



CELL: THE BASICS cont'd

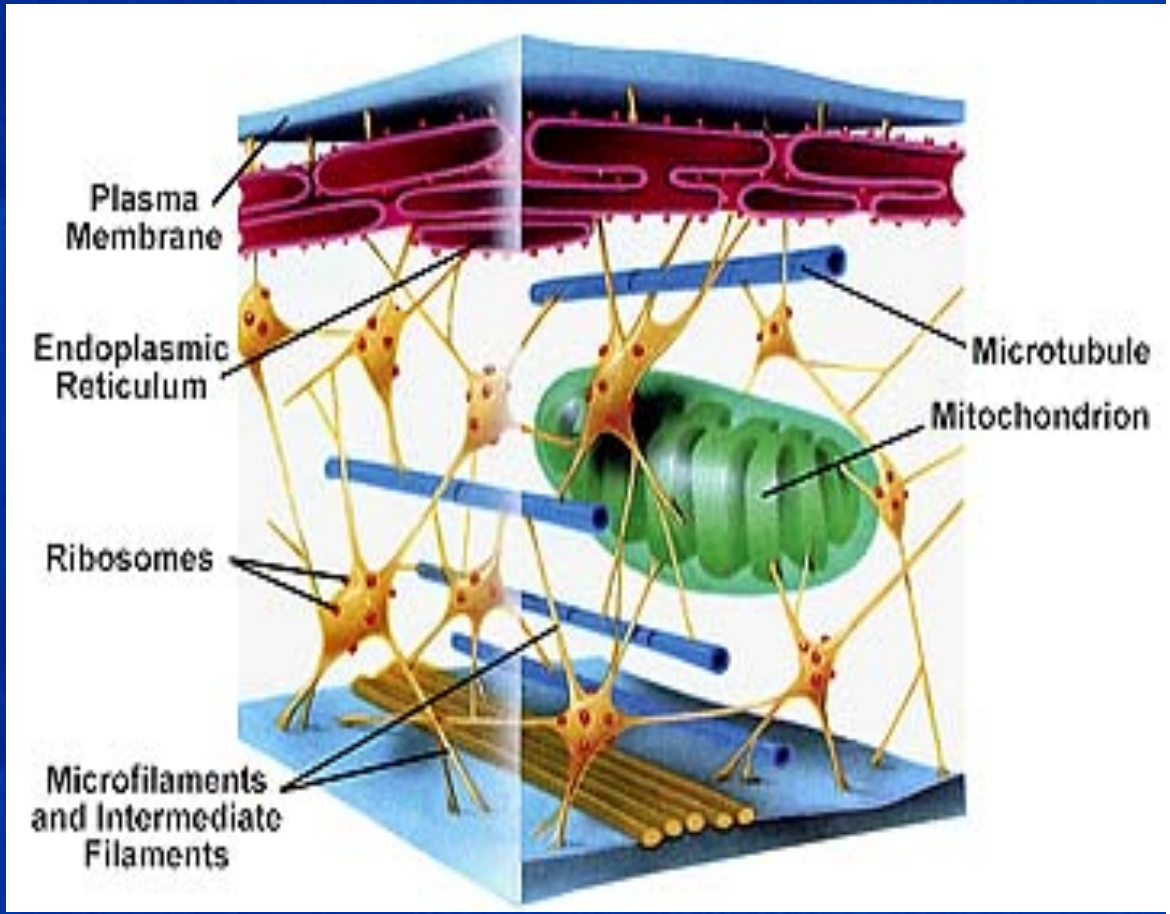
Cytoplasm (Cytosol)

- A jelly-like substance that is sometimes described as "the cell-matrix".
- It holds the organelles in place within the cell.
- It contains dissolved nutrients-mainly proteins, electrolytes and glucose.
- It helps to break down waste products.
- The nucleus flows with the cytoplasm changing its shape as it moves.
- The function of the cytoplasm - the organelles which reside in it- are critical for a cell's survival.

CELL: THE BASICS cont'd

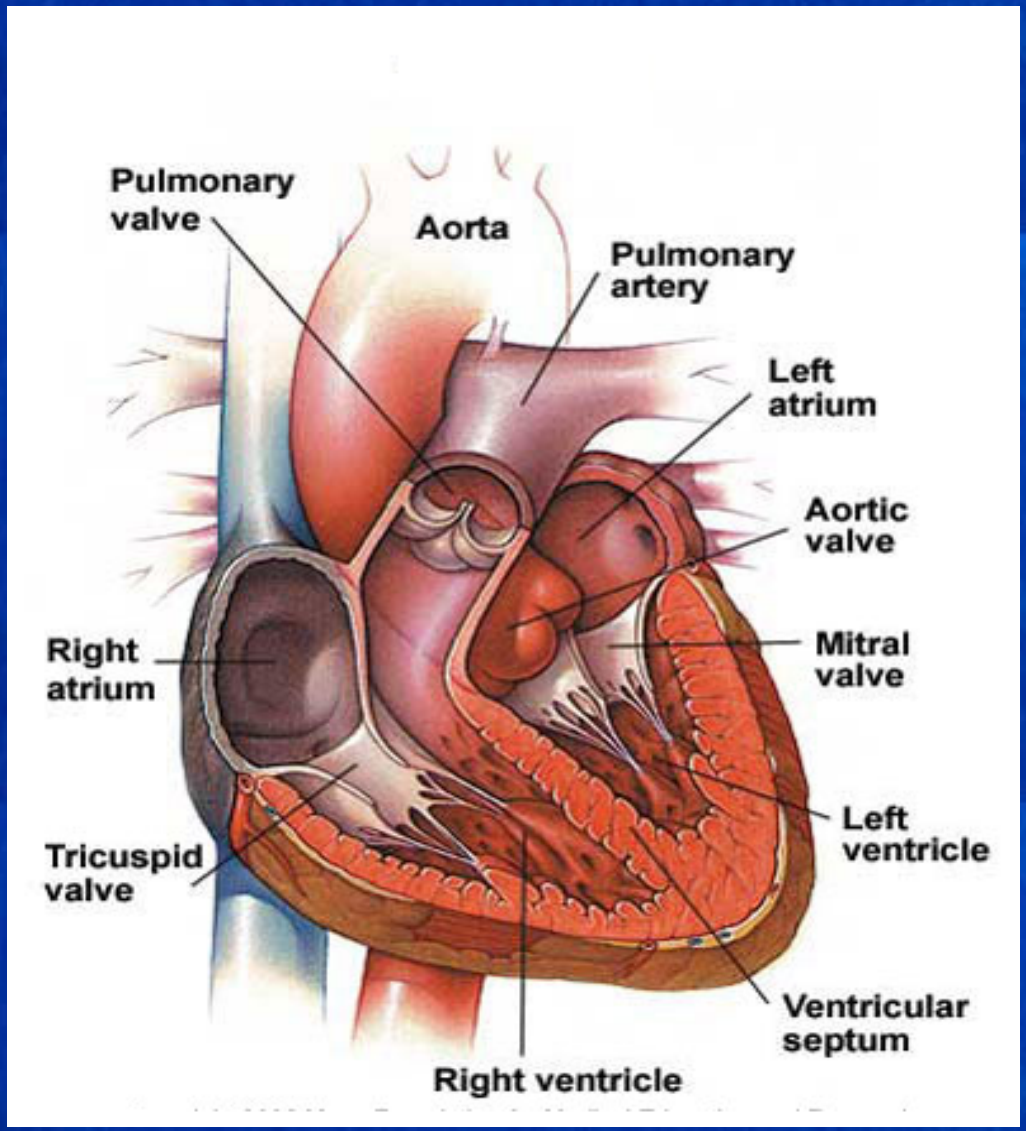
Cytoskeleton

The cytoskeleton acts to organize and maintain the cell's shape.
Anchors organelles in place.
Moves parts of the cell in processes of growth and mobility.
The eukaryotic cytoskeleton is composed of microfilaments, intermediate filaments and microtubules.
There is a great number of proteins associated with them, each controlling a cell's structure by directing, bundling, and aligning filaments.



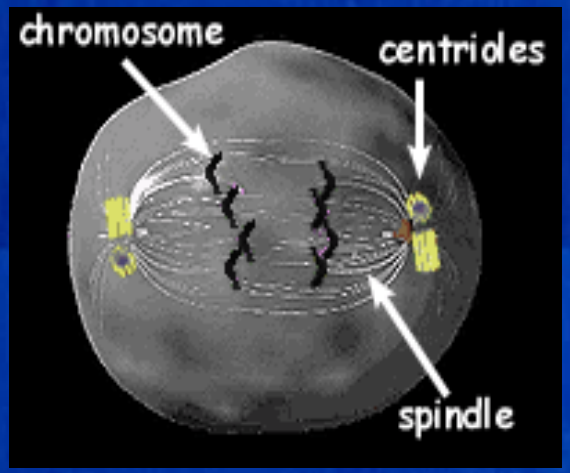
CELL ORGANELLES

- The human body contains many different organs, such as the heart, lung, and kidney, with each organ performing a different function.
- Cells also have a set of "little organs," called organelles, that are adapted and/or specialized for carrying out one or more vital functions.
- Membrane-bound organelles are found only in eukaryotes.



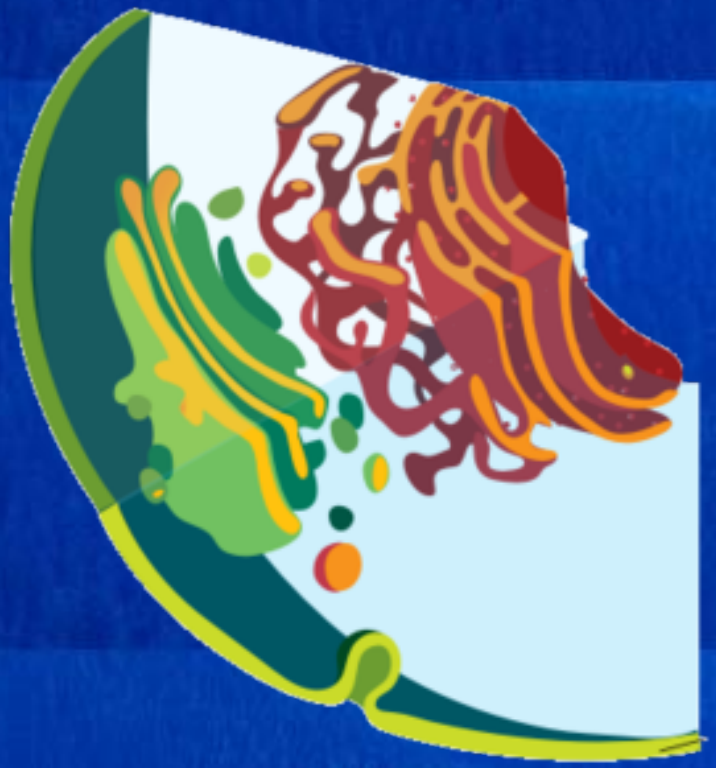
THE CENTRIOLES- CHROMOSOME ORGANIZER

- Centrioles are cylindrical structures - found in animal cells.
- Composed of groupings of microtubules arranged in a 9 + 3 pattern.
- They help during the cell division in both mitosis and meiosis.
- Found near the nucleus - they cannot be seen when the cell is not dividing.
- When two centrioles are found next to each other, they are usually at right angles.
- Centrioles participate in cell division as forming the mitotic spindle when the time comes for the cell to split.



ENDOPLASMIC RETICULUM (ER)

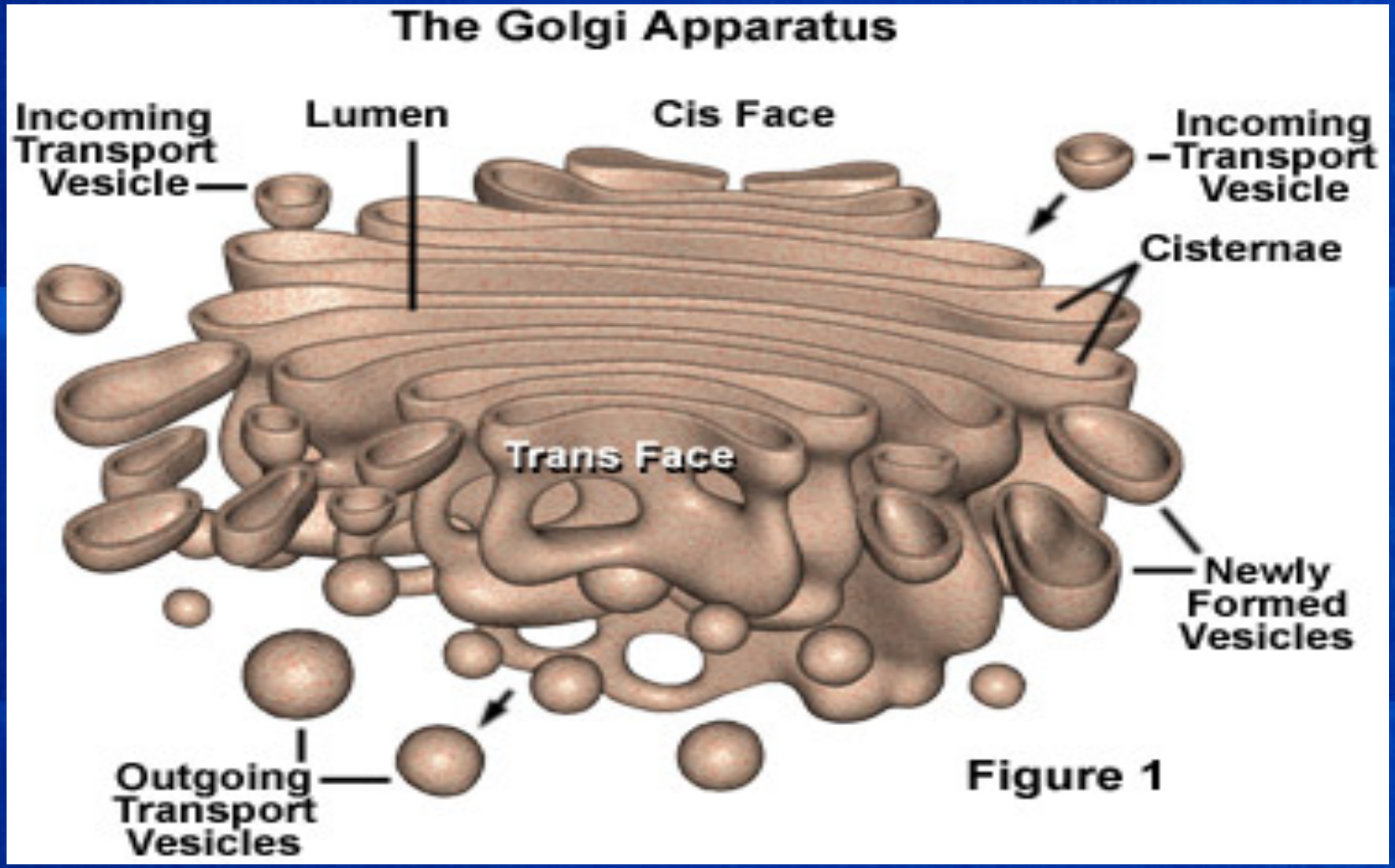
- Endoplasmic Reticulum (ER) - A system of membrane-enclosed channels which ramifies throughout the cytoplasm of the cell.
- It comes in two types--smooth and rough - rough ER has ribosome all over its outer surface.
- The endoplasmic reticulum is where proteins and lipids are produced within the cell.
- It is also concerned with the transport of these materials within the cell.
- Smooth ER is responsible for generating new layers for Golgi bodies.



THE GOLGI APPARATUS

- Each cell contains a number of Golgi apparatus /bodies.
- Golgi apparatus are like little stacks of hollow membrane pancakes.
- Function - to process materials arrive from the smooth ER - pack products into small structures called "Golgi vesicles."
- Two types of Golgi vesicles – Microbodies and Secretory vesicles.
- Microbodies remain in the cell - contain usually enzymes- needed by the cell - but remain package away from the cell's other contents.
- The best known microbodies is the lysosome.

THE GOLGI APPARATUS

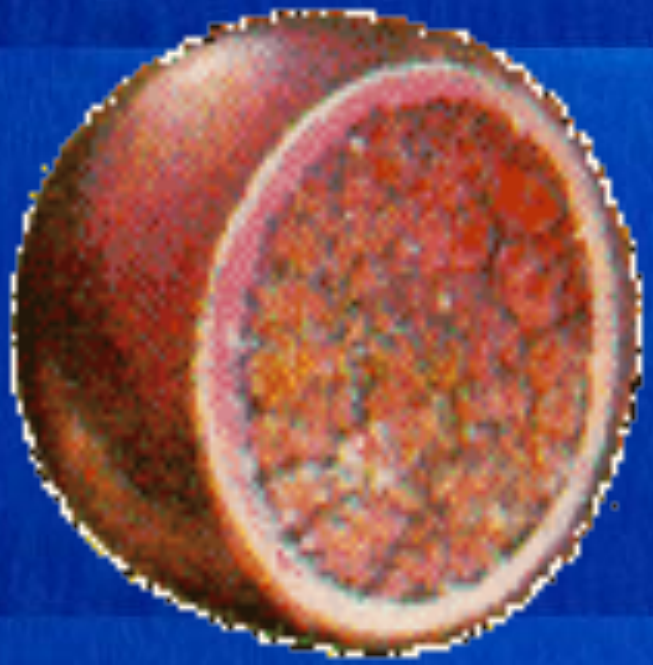


VESICLE

- Small intracellular - membrane-enclosed sac that stores or transports substances.
- The vesicle is separated from cytosol by at least one lipid bilayer.
- Basic tool - organizing metabolism- transport and enzyme storage.
- Vesicles- made in the Golgi apparatus- in the endoplasmic reticulum or from parts of the plasma membrane.
- Transport vesicles can move proteins from the rough endoplasmic reticulum to the Golgi apparatus.

THE LYSOSOMES
- CELL's DIGESTIVE SYSTEM

- Lysosomes - synthesized by the endoplasmic reticulum and the Golgi complex.
- Lysosomes are tiny sacs (500 nm) filled with digestive enzymes - enable the cell to utilize its nutrients.
- Lysosomes also destroy the cell after it has died – due to diseases/ conditions.



Peroxisome

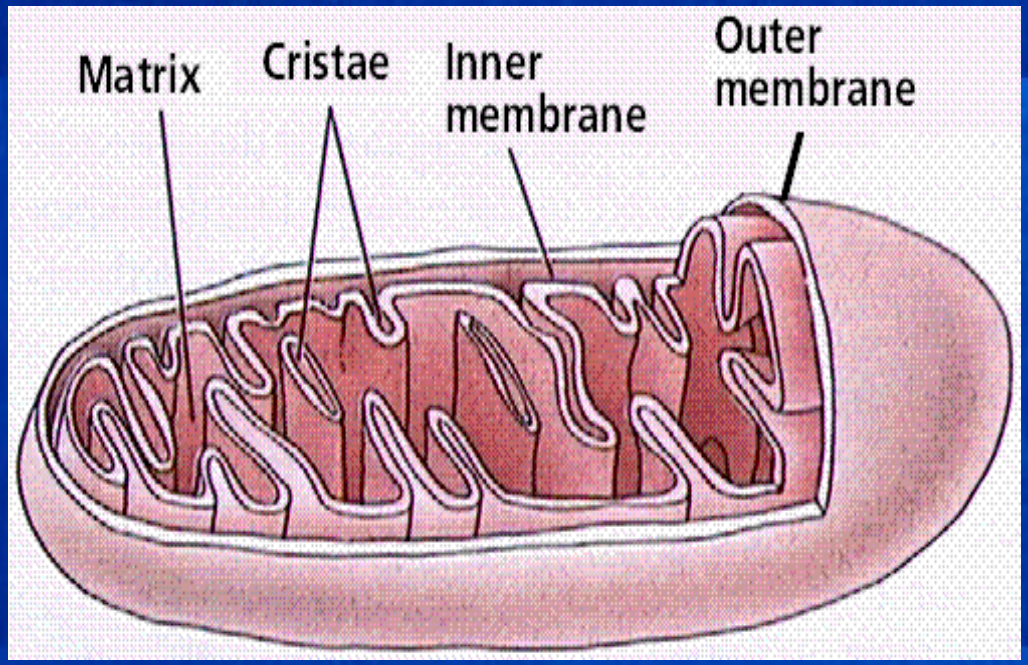
- Membrane-bound organelles containing an assortment of enzymes-catalyze a variety of metabolic reactions

MICROVILLI

- Microvilli - is the plural of "Microvillus".
- Microvilli - finger-like projections on the outer-surface of the cell.
- Not all cells have microvilli.
- Function is to increase the surface area of the cell - the area through which diffusion of materials both into, and out of, the cell is possible.
- They are particularly apparent on the surfaces of absorptive and secretary cells. I

THE MITOCHONDRIA- CELL's POWER HOUSE

- Mitochondria- a plural term- appropriate as these are not found alone.
- Mitochondria - often referred to as the power plants of the cell- the reactions that produce energy take place in mitochondria.
- The quantity of mitochondria within cells varies with the type of cell.
- Generally, the more energy a cell needs, the more mitochondria it contains



Cell Vacuole

- Vacuoles are membrane-bound sacs within the cytoplasm of a cell that function in several different ways.
- Vacuoles in animal cells - however, tend to be much smaller - and are more commonly used to temporarily store materials or to transport substances.

THE NUCLEUS- A CELL's CENTER

- The cell nucleus is the most important organelle found in a eukaryotic cell.
- Spherical in shape - separated from the cytoplasm by a double nuclear membrane .
- Contain nuclear pores that permit - nutrients, waste, and cellular information- to pass both into, and out of, the nucleus.
- The nucleus is the "Control Center" - contains DNA (genetic information) - for the formation of proteins.
- DNA is transcribed into a special RNA- mRNA- then transported out of the nucleus -where it is translated into a specific protein molecule.
- In prokaryotes, DNA processing takes place in the cytoplasm.

THE NUCLEUS :NUCLEOLUS

- **NUCLEOLUS:**
- Is a dense spherical structure within the nucleus of a cell.
- It contains ribonucleic acid (RNA) for the synthesis of ribosomes and also has an important role in the production of proteins and RNA.
- The nucleolus is a part of the nucleus of the cell that disappears during cell division.

THE RIBOSOMES-THE PROTEIN PRODUCTION MACHINE

- Each cell contains thousands of ribosome- miniature 'protein factories- composes 25% of cell's mass.
- Stationary type: embedded in rough endoplasmic reticulum
- Mobile type: injects proteins directly into cytoplasm
- The mRNA leaves the nucleus and travels to the cell's ribosomes - where translation occurs.
- The formation of new protein molecules from amino acid based on information encoded in DNA/RNA.
- One thing that all humans cells have in common – from brain –eye-muscle-skin cell is DNA.

DNA-Blue print of life

DNA:STRUCTURE AND FUNCTION

PART II :

DNA:STRUCTURE AND FUNCTION

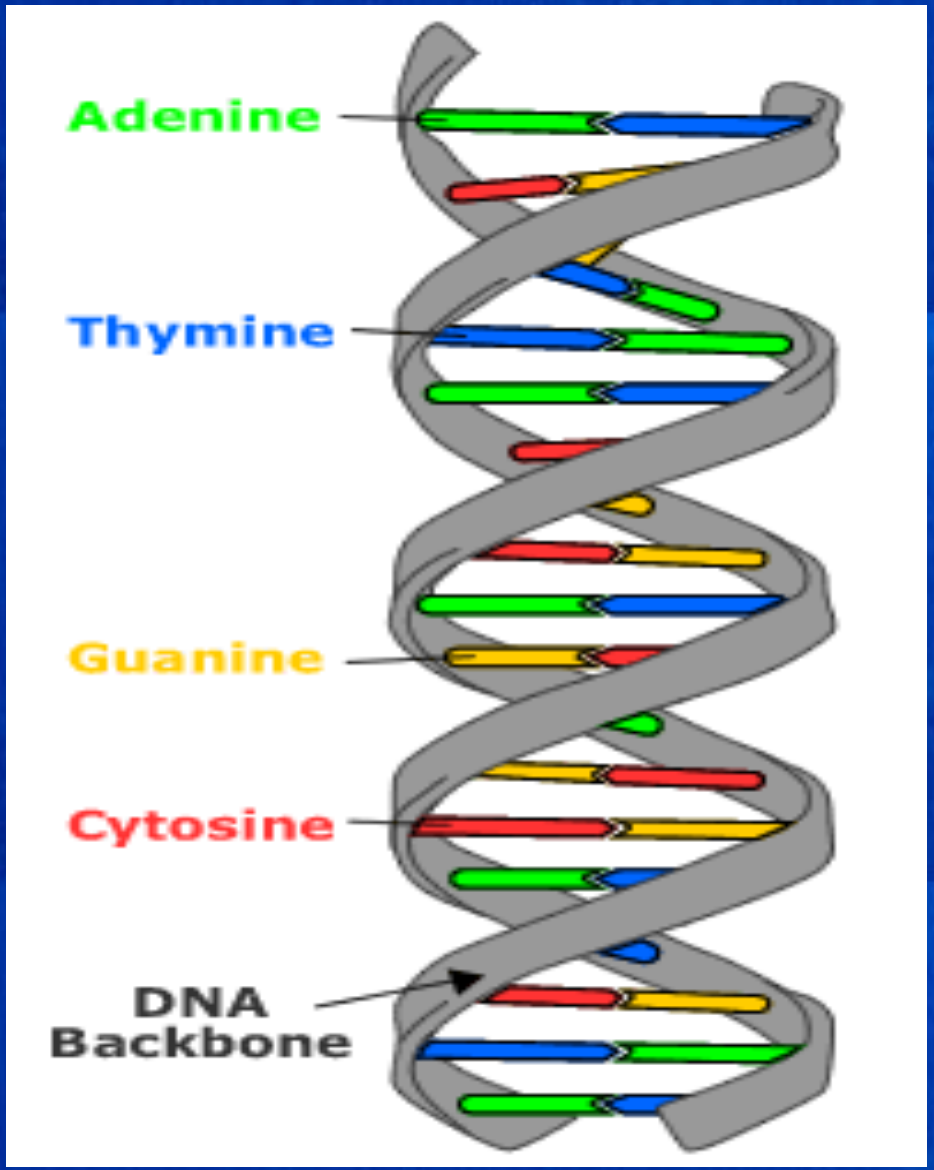
- DNA- Deoxyribonucleic Acid
- DNA- found with in the nucleus of eukaryotic organisms
- In 1940s DNA- identified as the carrier of genetic information- contains the instruction for a cell.
- Determines how animal / human characteristics are passed from one generation to other.

1. Whether a person has blue eyes or brown
2. Whether he or she has dark or blonde hair

Determined by DNA

STRUCTURE OF DNA

- The building blocks of the DNA molecules are called nucleotides
- Nucleotides linked together into a chain by covalent bond- DNA strand
- In 1953 Watson and Crick discovered the double helix structure of DNA molecule.
- The two strands of DNA molecule held together by hydrogen bonds.



NUCLEOTIDES

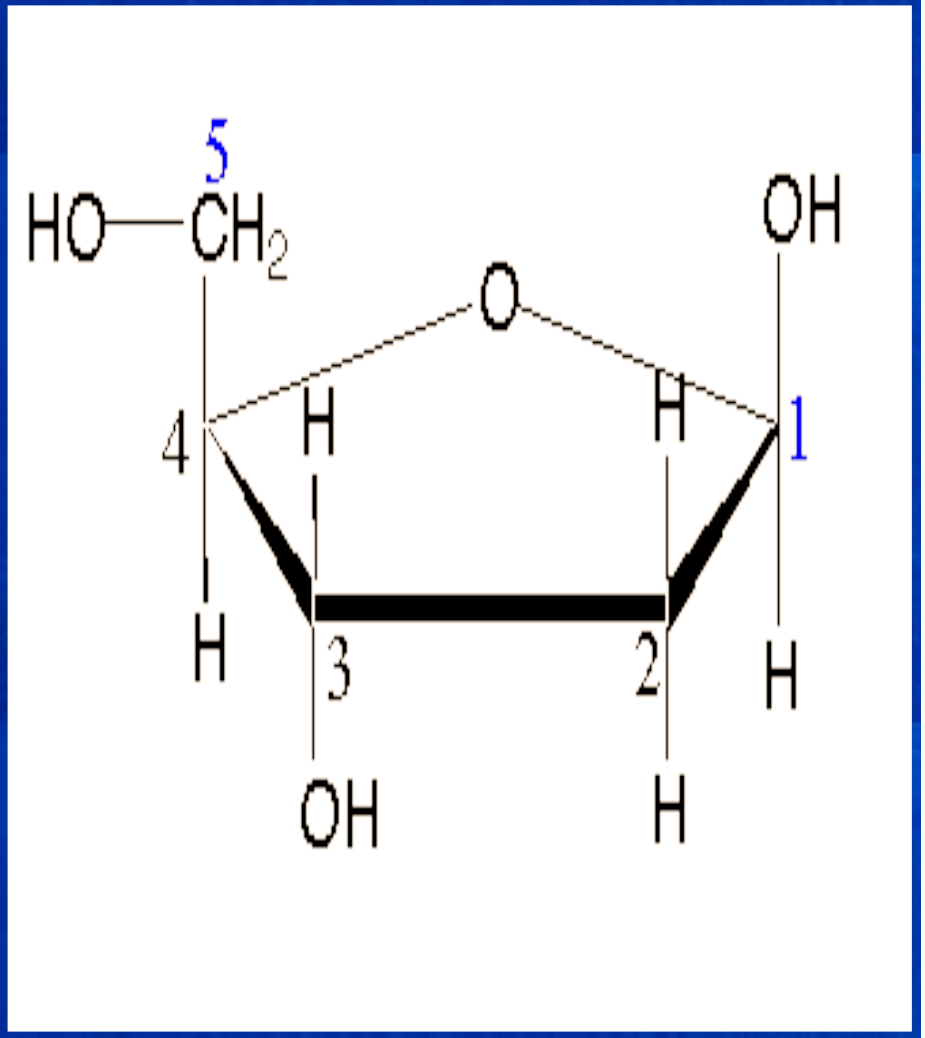
- Each nucleotide is composed of three parts.

1. A Deoxyribose Sugar
2. A Phosphate group
3. A Nitrogen base

The deoxyribose molecule occupies the center position in the nucleotide- a phosphate group on one side and a base on the other. The phosphate group of each nucleotide is also linked to the deoxyribose of the adjacent nucleotide in the chain.

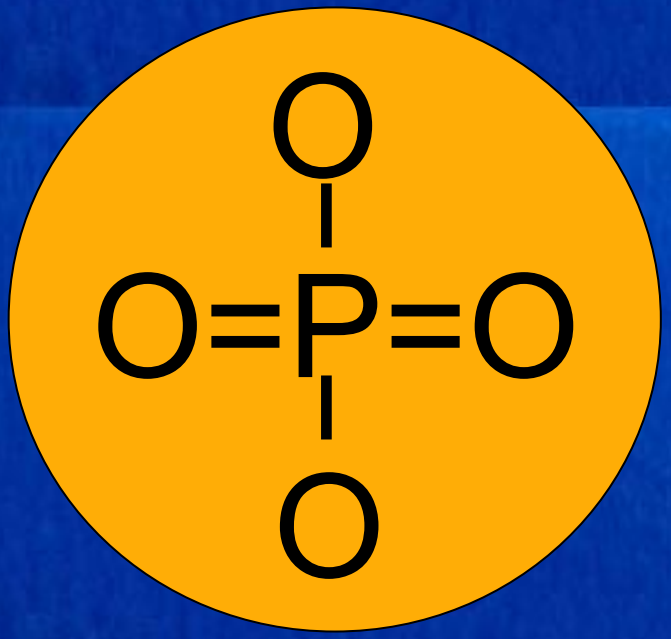
The Deoxyribose Sugar

- The deoxyribose sugar in DNA is a pentose - a five-carbon sugar.
- Four carbons and an oxygen make up the five- membered ring.
- The carbon constituents of the sugar ring are numbered 1'-4' (pronounced "one-prime carbon"), starting with the carbon to the right of the oxygen going clockwise. The fifth carbon (5') branches from the 4' carbon.
- The DNA sugar is called a **deoxyribose** because it is lacking a hydroxyl group at the 2' position.



PHOSPHATE GROUP

- The phosphate group is the second part of the **backbone** of the DNA molecule.
- A Phosphate group- acts as a bridge between adjacent deoxyribose sugars which carries in turn the nitrogenous base.
- The end of the chain on which the phosphate is exposed is called the 5' end - because the phosphate binds to the carbon on the 5' position.
- DNA is always read from 5' to 3'



NITROGEN BASES

There are two classes of nitrogenous bases.

1.Purines:

The purines are characterized by their double-ringed structure**.**

i) Adenine (A)

ii) Guanine (G)

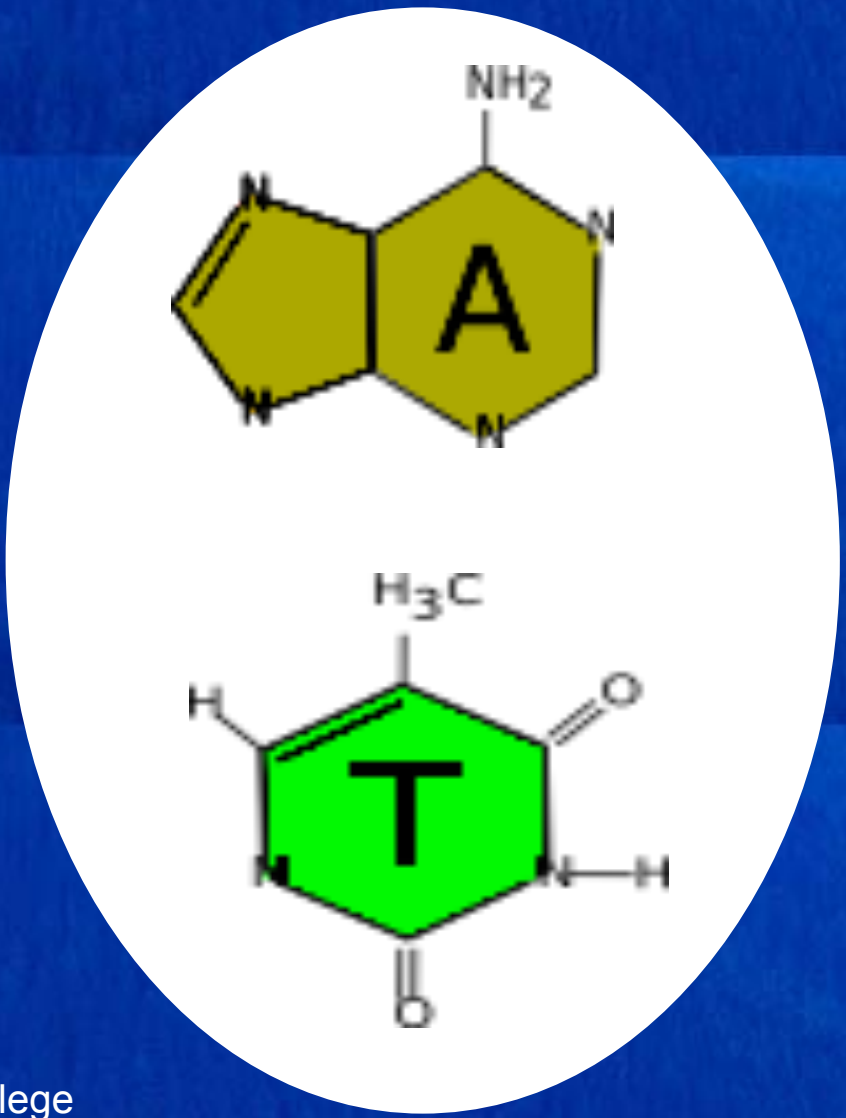
2. Pyrimidenes:

The pyrimidenes have a single ring.

iii) Cytosine (C)

iv) Thymine (T)

The number of purine bases equals number of pyrimidine bases



NITROGEN BASES cont'd

The bases do not pair at random

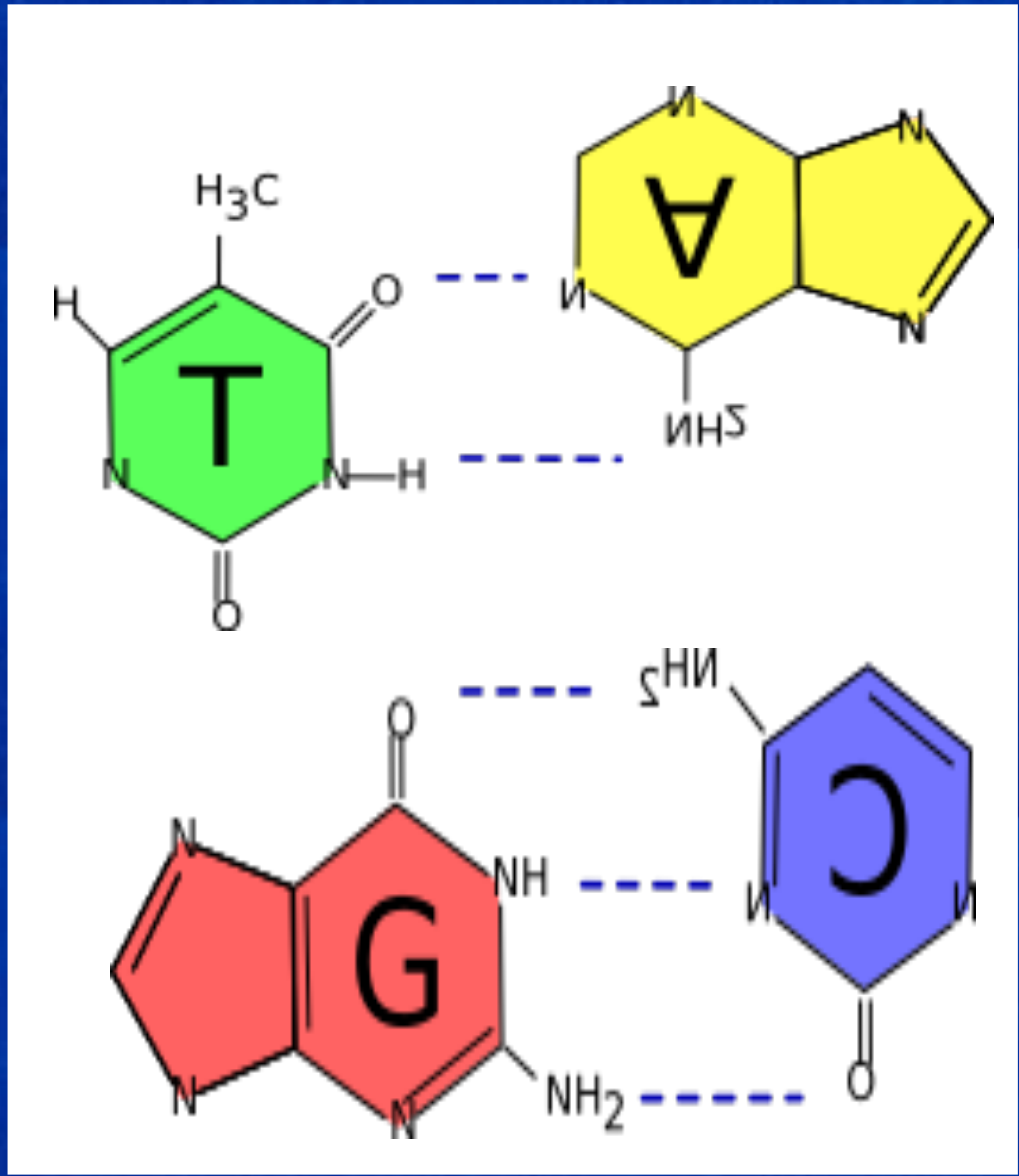
A -complementary to T

Two hydrogen bonds between **A-T**

C-complementary to G

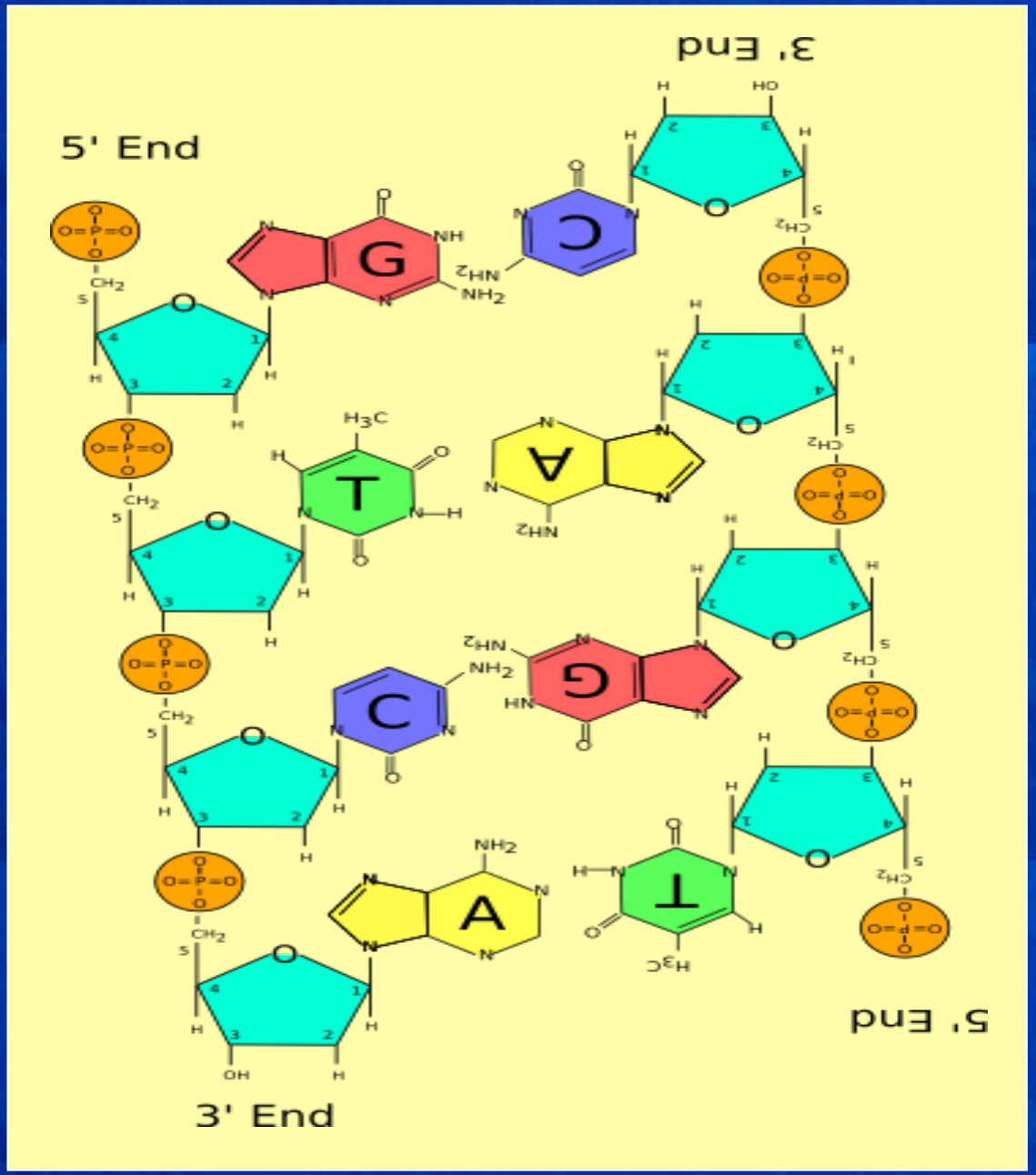
Three hydrogen bonds between **G-C**

The hydrogen bond is 20 times weaker than covalent bond



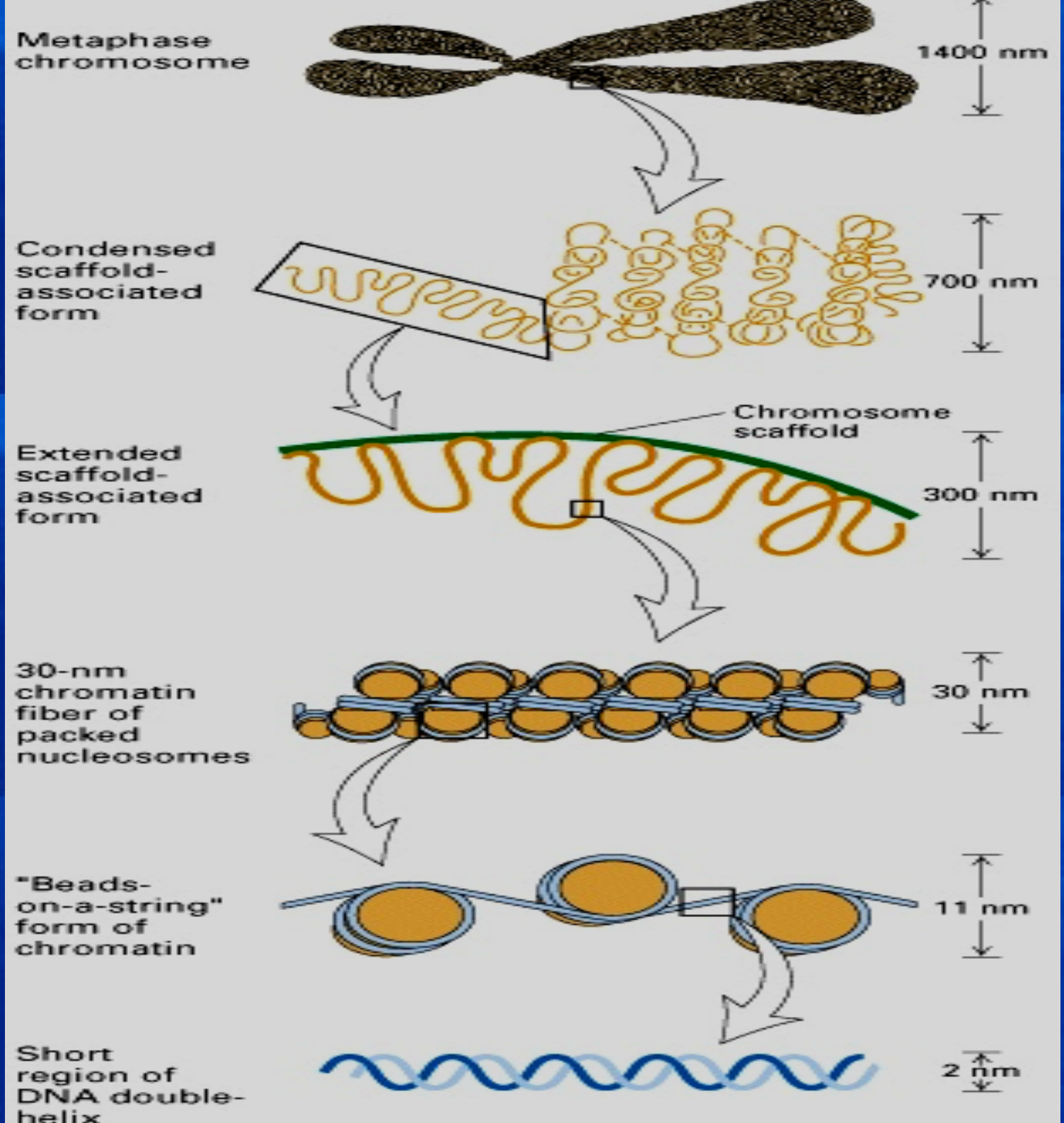
POLARITY OF DNA

- Two ends of DNA strands are chemically different
- The one end- five prime 5’- terminates with a phosphate group attached to the fifth carbon on sugar-ring
- The second end- three prime 3’- terminates with hydroxyl group on the third carbon on the sugar -ring



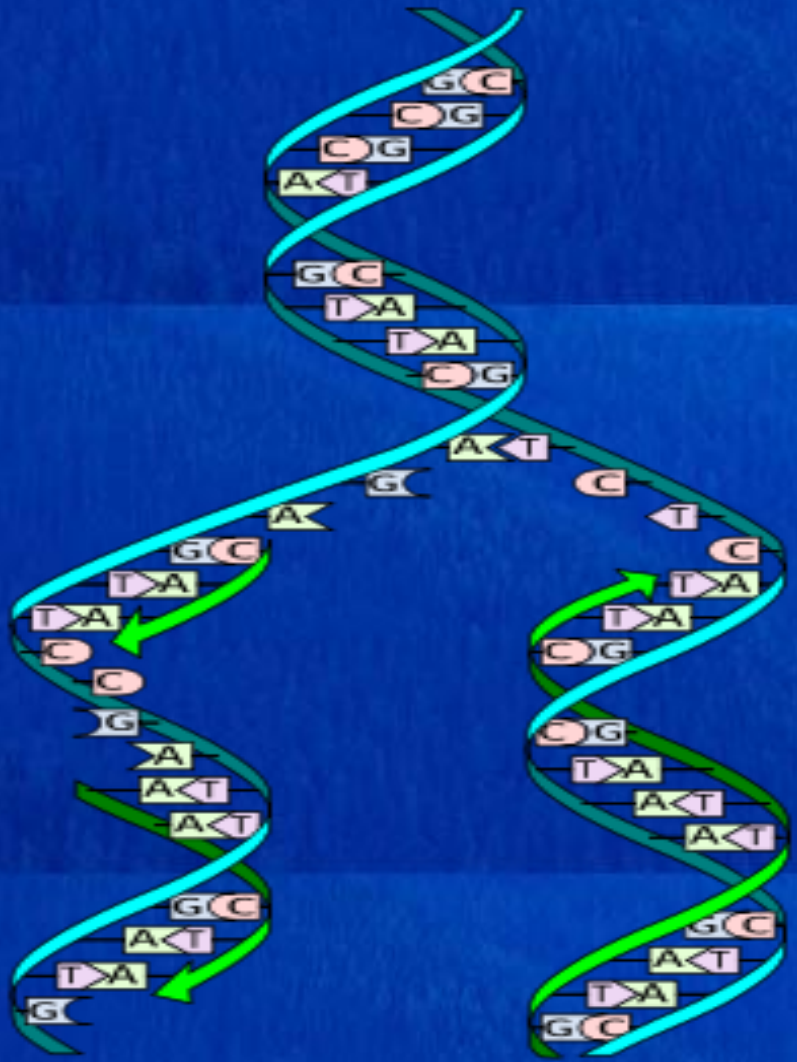
DNA PACKAGING

- The human DNA – 1.5 to 2 meter
- The nucleus diameter – 6 micrometer
- The DNA must be compact to fit in nucleus
- The DNA must be organized enough to become uncoiled- to be replicated and transcribed
- The DNA packaged along with proteins – Histones - complex form - Chromatin
- The continuous folding of chromatin –the chromosomes
- Some organisms have only one chromosome- human cells have 23 pairs of chromosomes.
- Humans are diploid-each cell has two copies of each chromosome - one from each parent.
- The entire genetic material called Genome


Metaphase chromosome
1400 nm
Condensed scaffold-associated form
700 nm
Chromosome scaffold
Extended scaffold-associated form
300 nm
30-nm chromatin fiber of packed nucleosomes
30 nm
"Beads-on-a-string" form of chromatin
11 nm
Short region of DNA double-helix
2 nm

DNA REPLICATION

- DNA Replication -Production of two complete identical double helixes from one original DNA molecule.
- In a eukaryotes- , DNA replication must happen before cell division.
- Prokaryotes replicate their DNA throughout the interval between cell divisions.
- Enzymes-proteins - catalyze biochemical reaction- essential for DNA replication.



DNA REPLICATION cont'd

- DNA strand is separated-forming a Y-shaped junction- called Replication fork by enzyme – helicase.
- A short DNA segment-primer- base paired - the template by primase enzyme.
- Finally, DNA polymerase enzyme – synthesizes a new DNA strand by adding free nucleotides.
- An error in new DNA molecule - Mutation. The DNA polymerase has ability- Proof reading- the rate of error is very low (1 per 10 *9 bases)
- The replication fork is asymmetrical –one new DNA strand is formed on template running from 3' to 5' – leading strand. Other is formed on template running 5' to 3' –the lagging strand
- DNA polymerase cannot build a strand in the 3' → 5' direction- leading strand can continuously synthesize DNA (from 5' to 3') - the lagging strand is synthesized in short DNA segments -Okazaki fragments.

GENES: THE DNA SENTENCE

- A Gene is a section of DNA strand that carries the instructions for a specific function

How a section of DNA gives instruction?

- In any language "words" seldom convey complete or understandable information
- A set of words that convey a complete thought is a sentence. The DNA language consists of four words. Each "word" - single unit of DNA molecule – Nucleotide
- Each "sentence" is a large string of nucleotides called a gene- a sequence of A's, T's, C's and G's – in a particular order- that codes for a defined biochemical function – usually through the production

  of particular protein.
- The transformation of gene into a protein is called expression

GENES have specific jobs at specific times

NOT ALL GENES ARE TURNED ON ALL THE TIME

THE CENTRAL DOGMA

PART III

THE CENTRAL DOGMA

- Cells are capable of synthesizing new proteins- based on information encoded in DNA/RNA
- Proteins – biological molecules give living cells- forms and function
- Protein synthesis generally consists of two major steps: transcription and translation.

1. Transcription – DNA information copied into RNA.
2. Translation – Proteins are synthesized using the information in the RNA as a template

RNA: STRUCTURE AND FUNCTION

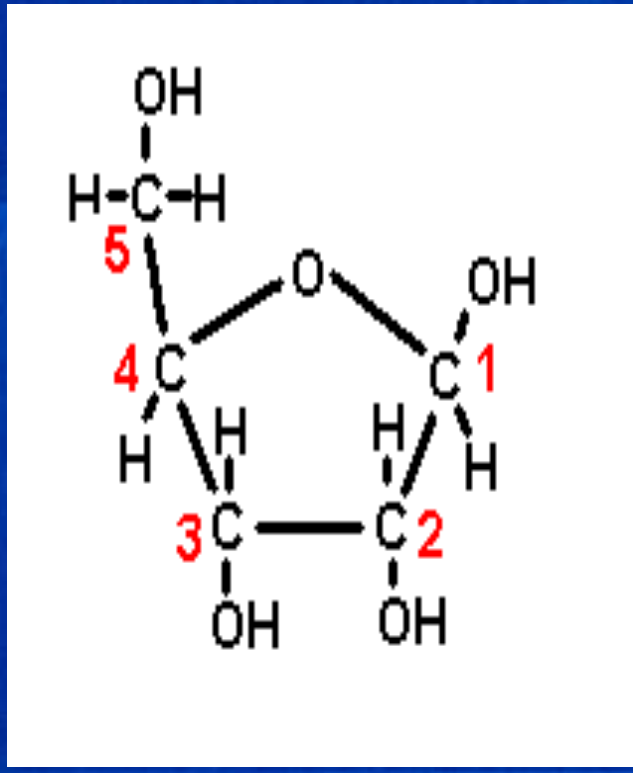
- Both nucleic acids DNA/RNA are sugar-phosphate polymers -nitrogen bases attached to the sugars of the backbone.

They differ in composition:

- The sugar in RNA is ribose, not the deoxyribose in DNA.
- The base Uracilis present in RNA instead of thymine.

They also differ in size and structure:

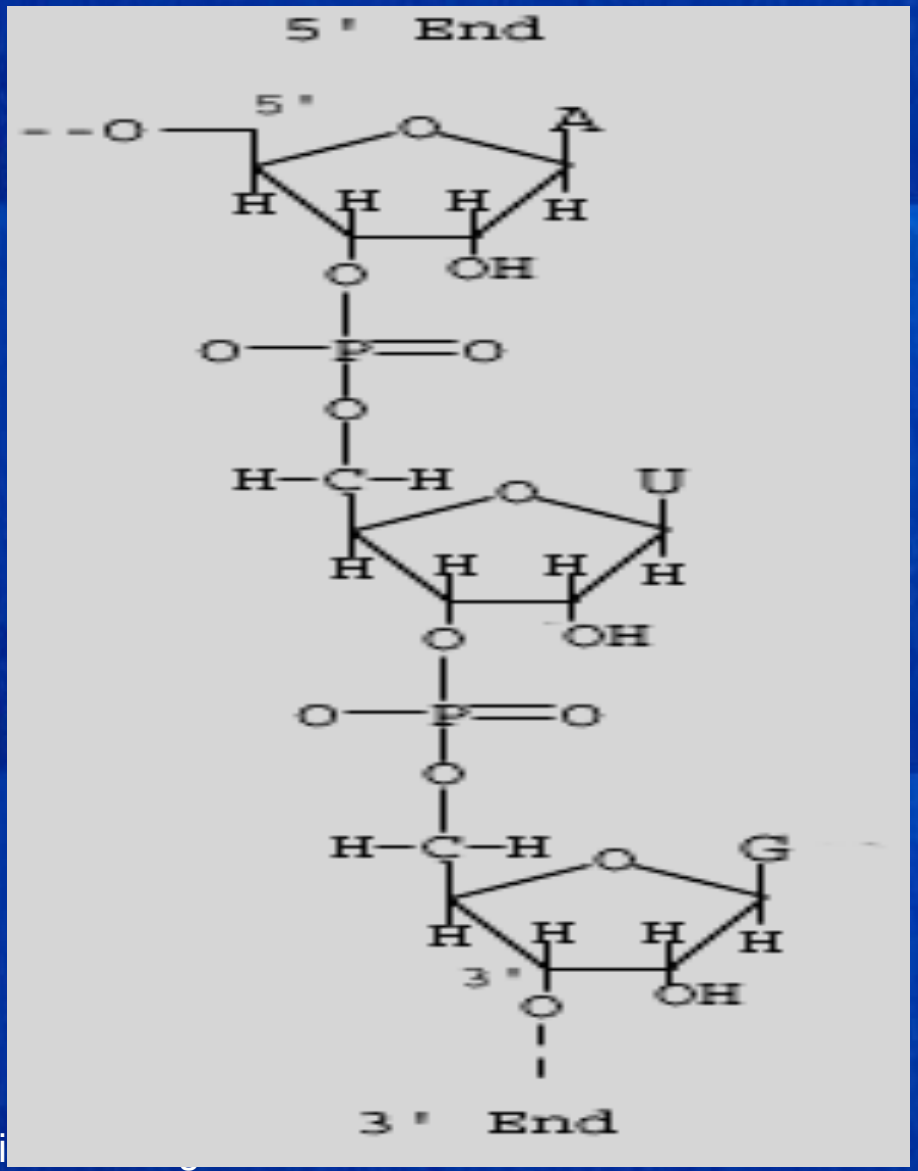
- RNA molecules are smaller (shorter) than DNA molecules.
- RNA is single-stranded, not double-stranded like DNA.



- The differ in function - DNA has only one function- ***STORING GENETIC INFORMATION*** in its sequence of nucleotide bases. But there are three main kinds of ribonucleic acid, each of which has a specific job to do.

TYPES OF RNA

- **Ribosomal RNAs** -exist outside the nucleus - structures called ribosomes - a complex consisting of about 60% ribosomal RNA **(rRNA)** and 40% protein.
- **Messenger RNAs**- the nucleic acids - "record" information from DNA in the cell nucleus - carry it to the ribosomes - known as messenger RNAs **(mRNA).**
- **Transfer RNAs**-The function of transfer RNAs **(tRNA)** is to deliver amino acids one by one to protein chains growing at ribosomes.



CELL DIVISION

- For unicellular organisms –reproduction is cell duplication.
- By replicating all their parts and then splitting into two cells- by Binary fission.
- This process not just give two new cells but also two new organisms

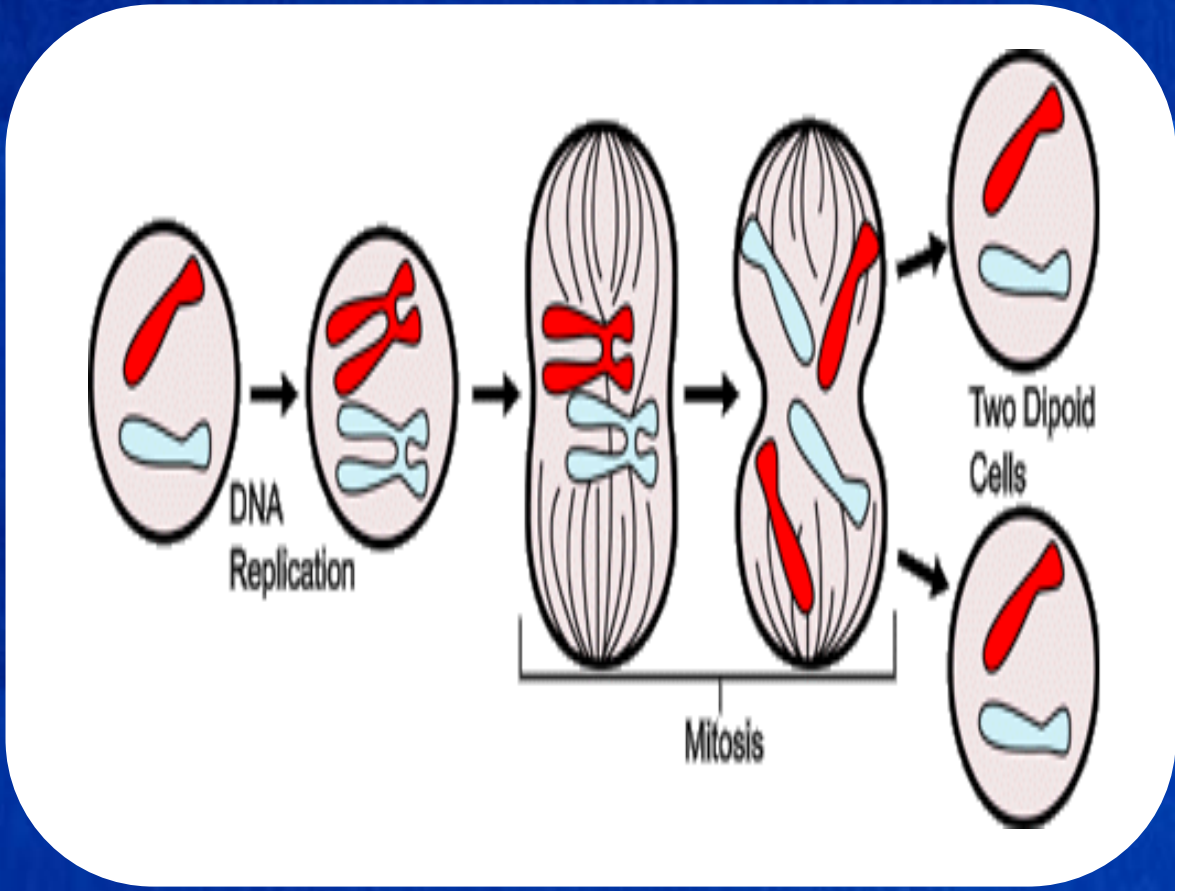
For multi-cellular organisms, cell replication and reproduction are two separate processes.

1. MITOSIS- Replication
2. MEIOSIS – Reproduction
3. CYTOKINESIS- The division of the cytoplasm- separating the organelles and other cellular components.

CELL DIVISION- MITOSIS

Multi -cellular organism replace damaged cells through replication process – Mitosis

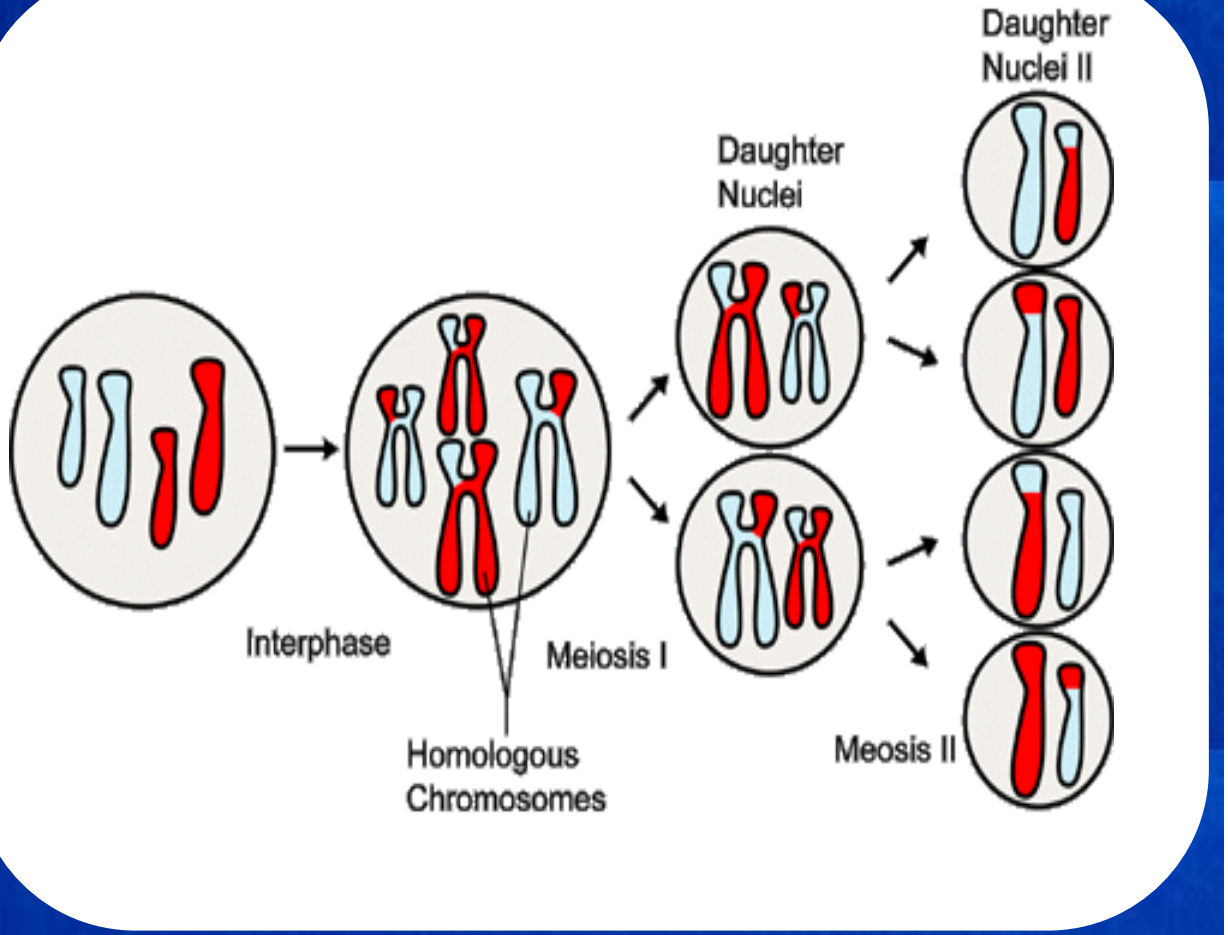
Mitosis – process by which the diploid nucleus (two sets of homologous chromosomes- same gene) of a cell divided to produce two genetically-identical daughter nuclei – both still diploid.



CELL DIVISION- MEIOSIS

Multi-cellular organism reproduce new organism through a process – Meiosis

- A diploid somatic cell-undergo meiosis to produce haploid cells - usually four.
- Haploid cells serve as gametes- egg and sperm - in multicellular organisms - fusing to form new diploid cells.
- Meiosis reduce the chromosome number by half.



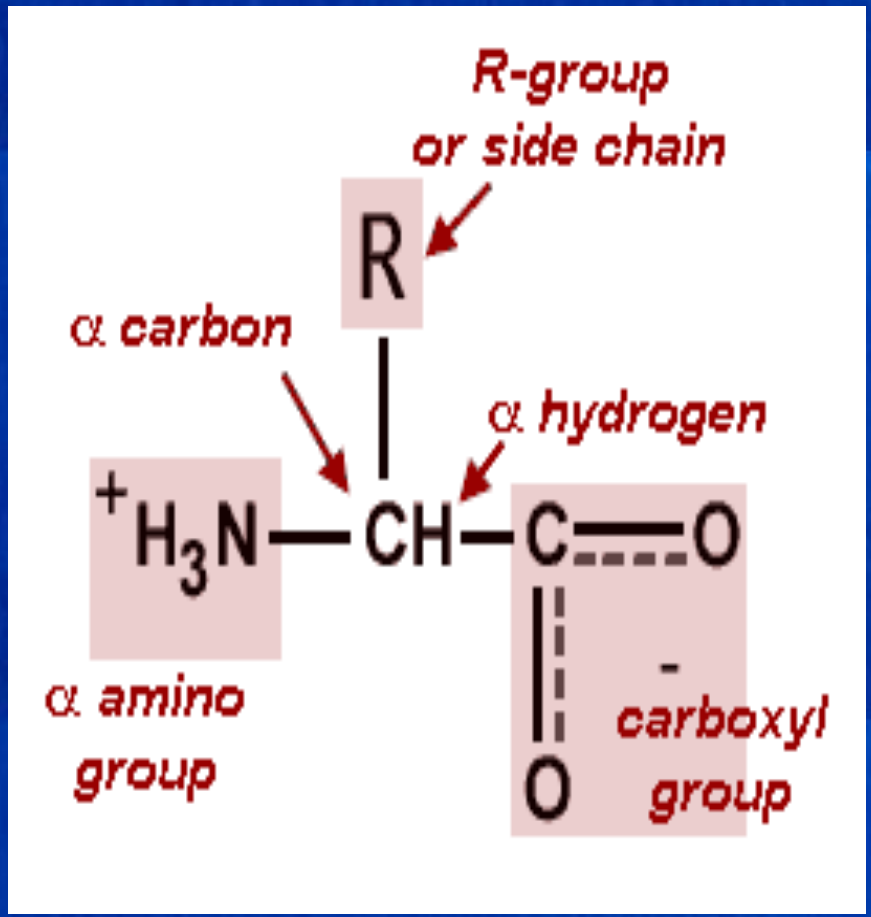
WHAT IS PROTEIN

- Proteins- the principal constituents of cells- drive most of its functions.
- Proteins – composed of a linear chains- polypeptides- of amino acids linked with peptide bonds.
- There are twenty different amino acids
- Order of amino acids in protein molecule determine its structure and function
- Protein may serve as:

1. **Enzymes**: make new molecules and catalyze nearly all chemical processes in cells
2. **Hormones**: transmit signals throughout the body
3. **Structural components**: give cells their shape and help them move
4. **Antibodies:** recognize foreign molecules
5. **Transport molecules:** carry oxygen.

AMINO ACIDS

- Amino acids are the subunits of proteins.
- The chain of amino acids takes on different shapes to form different proteins.
- Various shapes allow proteins to take different characteristics in cell.
- All amino acids found in proteins have same basic structure- differing only in the structure of the R-group.
- The simplest and smallest -amino acid is glycine - the R-group is a hydrogen (H).
- The carboxyl group of one amino acids binds to amino group of another to form a peptide bond.
- A chain like molecule of amino acids is called polypeptide.



PROTEIN SYNTHESIS

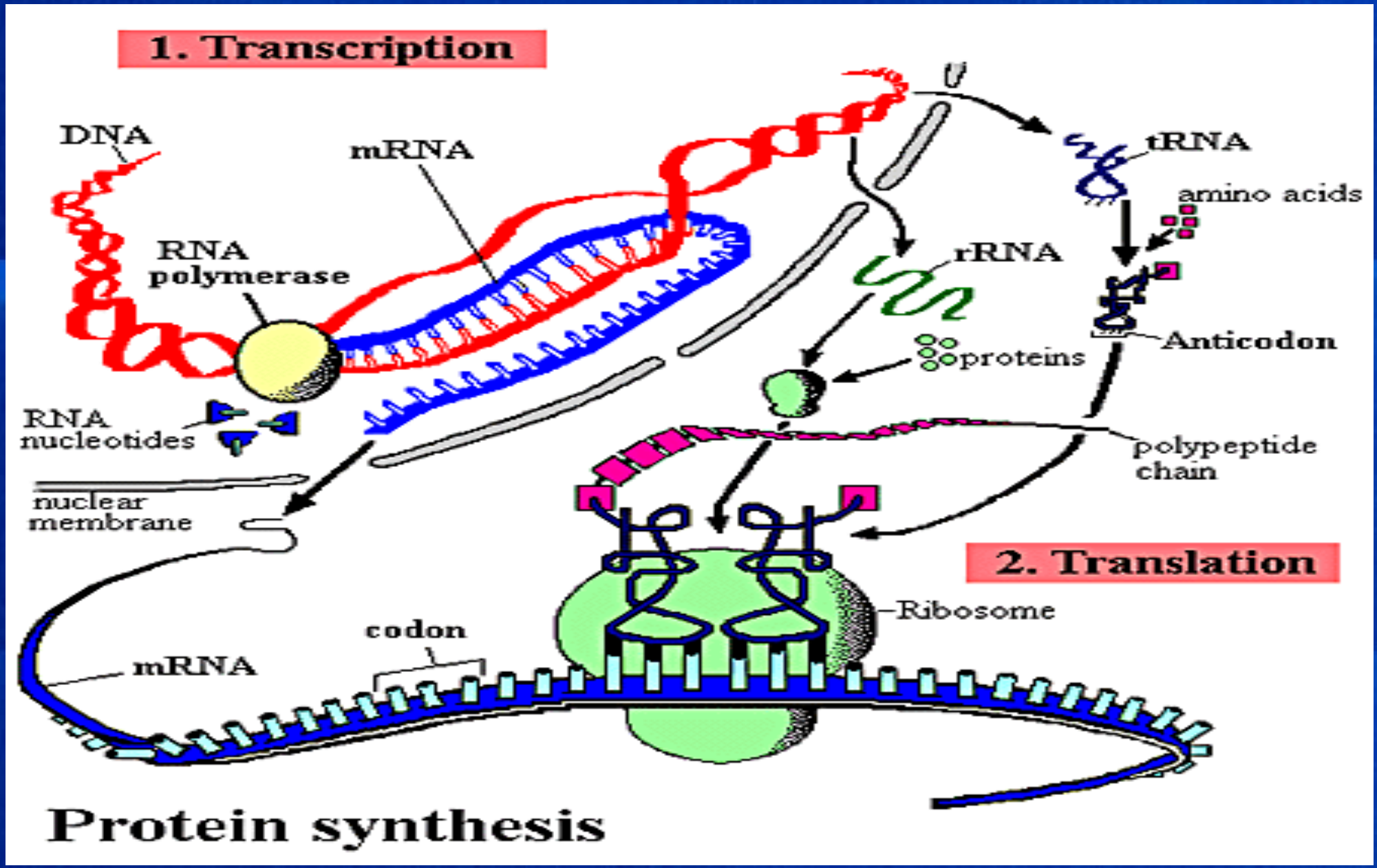
Protein synthesis generally consists of two major steps:

1. **TRANSCRIPTION**
2. **TRANSLATION**

Transcription: Transferring the code from DNA to RNA,

- One strand of the DNA double helix is used as a template by the RNA polymerase to synthesize a messenger RNA (mRNA).
- The mRNA migrates from the nucleus to the cytoplasm.
- The coding mRNA sequence can be described as a unit of three nucleotides called a **codon**.
- Deciphering the code in the resulting mRNA is a little more complex.

PROTEIN SYNTHESIS cont'd



PROTEIN SYNTHESIS cont'd

TRANSLATION

- Translation involves 3 processes: initiation, elongation, and termination.

Initiation

- The mRNA binds to protein-RNA complexes called **ribosome.**
- A unique initiation codon (AUG) –determines the beginning point of translation.
- There are 64 different sets of codons and only 20 amino acids- the genetic code is redundant
- Some amino acids are specified by more than one triplet

Elongation

- The tRNA match each triplet on mRNA to its corresponding amino acids and elongates the new polypeptide chain synthesized on the ribosome.
- The ribosome moves from codon to codon along the mRNA.

Termination

- A release factor binds to the stop codon - terminating translation and releasing the complete polypeptide from the ribosome.
- There are three different termination codons, UAA, UAG and UGA.

The Genetic Code

	U	C	A	G	
U	UUU Phenyl alanine UUC UUG Leucine UUA	UCU Serine UCC UCA UCG	UAU Tyrosine UAC UAA Stop UAG	UGU Cysteine UGC UGA Stop UGG Tryptophan	U C A G
C	CUU Leucine CUC CUA CUG	CCU Proline CCC CCA CCG	CAU Histidine CAC CAA Glutamine CAG	CGU Arginine CGC CGA CGG	U C A G
A	AUU Isoleucine AUC AUA AUG Methionine	ACU Threonine ACC ACA ACG	AAU Asparagine AAC AAA Lysine AAG	AGU Serine AGC AGA Arginine AGG	U C A G
G	GUU Valine GUC GUA GUG	GCU Alanine GCC GCA GCG	GAU Aspartic acid GAC GAA Glutamic acid GAG	GGU Glycine GGC GGA GGG	U C A G

PROTEIN FOLDING

- All proteins start out on a ribosome as a linear sequence of amino acids.
- This linear sequence must fold during and after the synthesis so that the protein can take up its native state -for the proteins to function properly.
- This self-assembly of proteins into specific 3-dimensional native structures is referred to as protein folding and is critical to the functioning of the proteins as enzymes or antibodies.
- The native conformation of a protein is only marginally stable because it depends on the environment. Modest changes in the environment can cause structural changes in the protein, thus affecting its function.
- A protein loses its biological function as a result of a loss of three-dimensional structure- the protein has undergone denaturation.

PROTEIN FOLDING cont'd

- The different protein structures can be classified by four levels of folding- each successive one being constructed from the preceding one.

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

- Primary Structure:

The linear sequence of amino acids in protein defines its primary structure.

PROTEIN FOLDING cont'd

Secondary Structure:

- The hydrogen- bond interaction among strands of amino acids gives rise to the first level of folding- alpha-helices and beta- pleated sheets.
- **The alpha-helix**
- In an alpha-helix, the protein chain is coiled like a loosely-coiled spring. The "alpha" means that if you look down the length of the spring, the coiling is happening in a clockwise direction as it goes away from you.
- **Beta-pleated sheets**
- In a beta-pleated sheet, the chains are folded so that they lie alongside each other- heading in opposite directions.

PROTEIN FOLDING cont'd

Tertiary Structure:

Interaction between alpha-helices and beta-sheets comprise the second level of folding-protein domains.

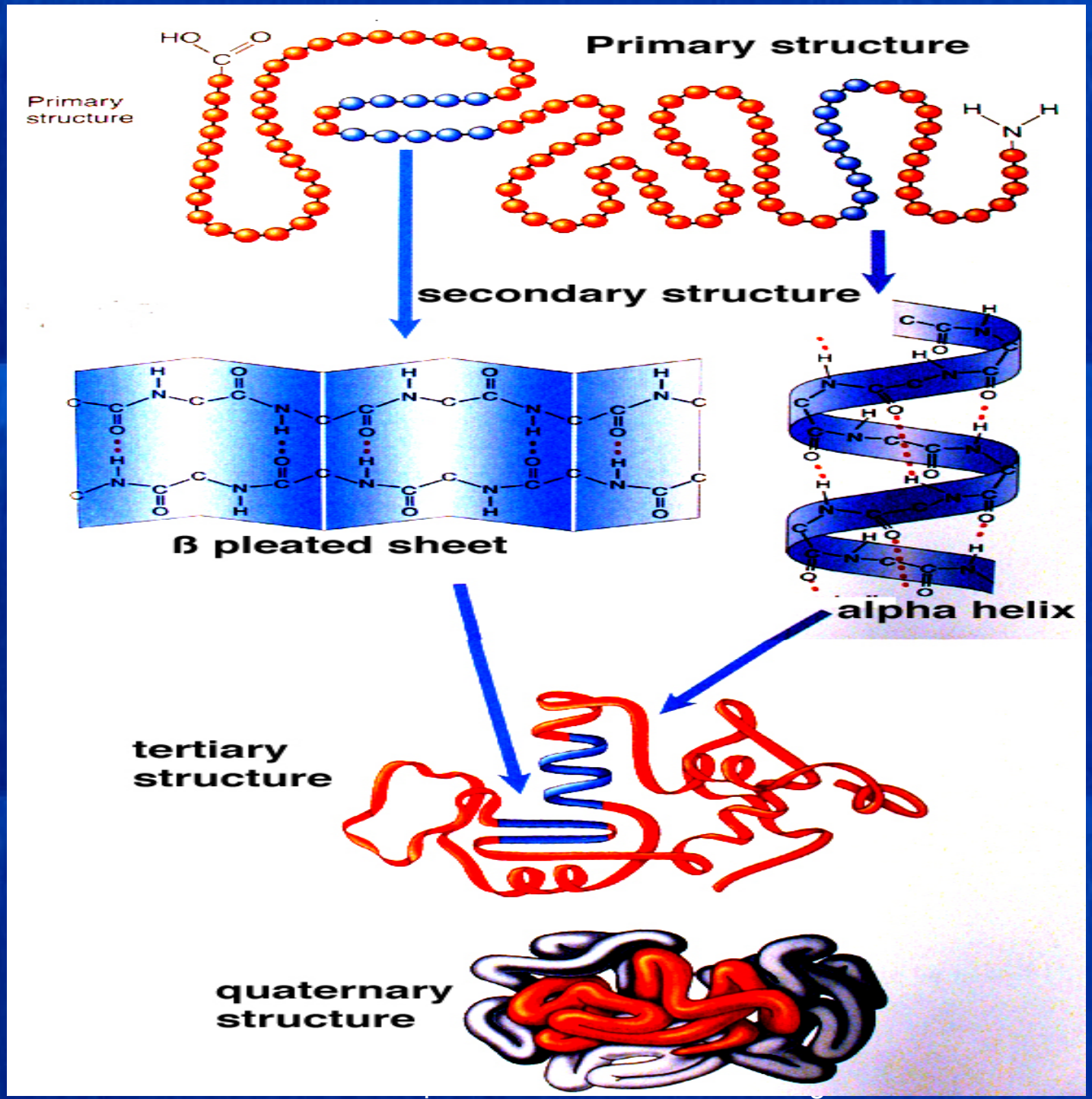
Protein domains strung together through third level folding to form small globular proteins.

The combination of second and third level of folding yields tertiary structure.

PROTEIN FOLDING cont'd

Quaternary Structure:

- In order to achieve enhanced function- small globular proteins often come together to form aggregates.
- A famous example of quaternary structure is hemoglobin.


Primary structure
Primary structure
secondary structure
ß pleated sheet
alpha helix
tertiary structure
quaternary structure

PROTEIN FOLDING PROBLEM

- One of the large challenges in modern science is working out how proteins curl up into their complex shapes.
- They do this in fractions of a second, always adopting the same three-dimensional form,
- In nature, protein folding takes place in the order of microseconds (10–6 seconds).
- The exact rule that uniquely determines the amino-acid sequence of a protein from the corresponding DNA sequence is known.
- The second part of the genetic code, that is the ability to determine the full 3D structure of the protein from its amino-acid sequence, is still missing.
- This is the essence of the so-called "protein folding problem": given an amino-acid sequence how does one predict the 3D shape that this protein will take upon folding?

PROTEIN FOLDING PROBLEM

Understanding protein folding is important due to its applications in the field of biomedicine (drug design, Mad Cow disease cause, etc.,) and nanotechnology (self-assembly of nano -machines).

- Since it is this shape that ultimately determines the biological function of a protein, solving the problem is of great importance.

ACKNOWLEDGEMENT

I would like to thank:

WORLD WIDE WEB

For this presentation – Important WONDER of PHYSICS and TECHNOLOGY.

THANK YOU