UNIT I

- Introduction
- Cell theory,
- Whitaker's kingdom classification
- Cell organelles, and their functions
- Homeostasis,
- Replication and cell Division
- Tissue differentiation
- Stem cells and their applications
- Genetic algorithms
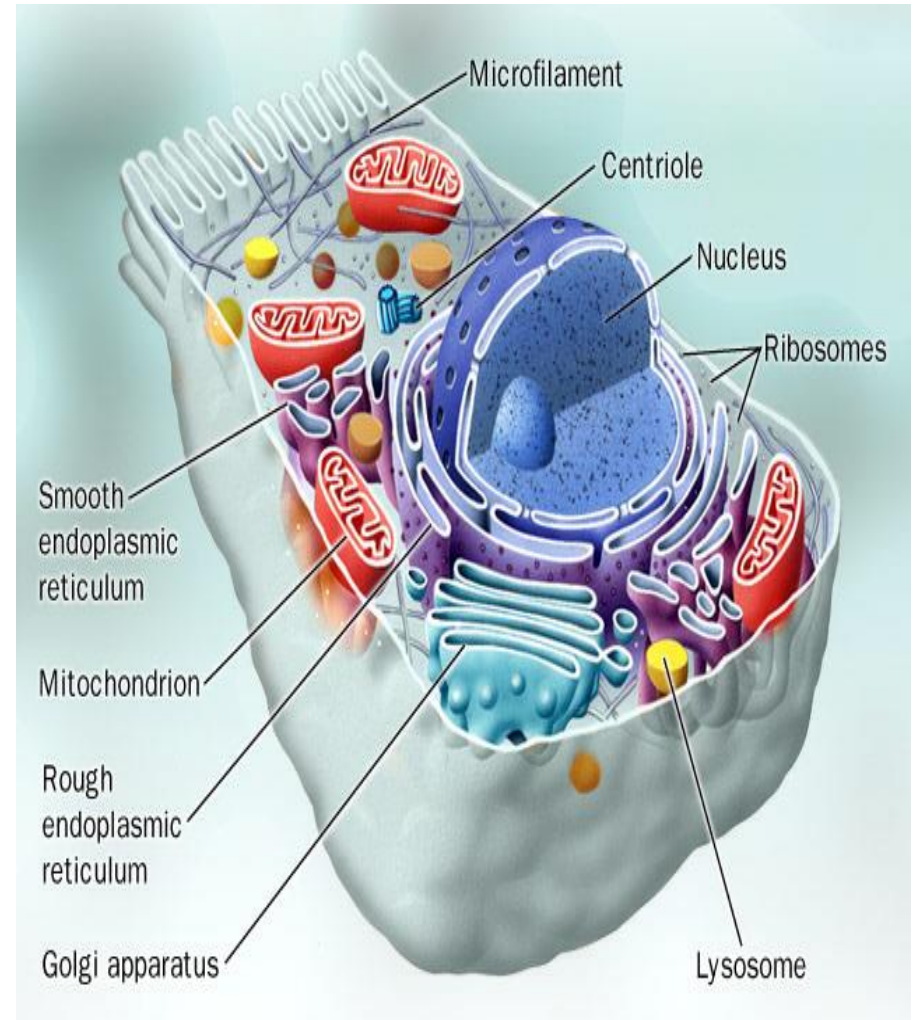
Introduction

Concept of evolution

- The process by which different kinds of living organism are believed to have developed from earlier forms during the history of the earth.

- Jean Baptistae Lamarck (1801)- spontaneous generation of species according to needs and functionalities of the mutation

- Charles darwin (1859)- Based on survival of the fittest mutations

Living Organism

- A living organism may be defined as a complex unit of physicochemical materials that is capable of self-regulation, metabolism, and reproduction.

- Furthermore, a living organism demonstrates the ability to interact with its environment, grow, move, and adapt.

What Are the Main Characteristics of organisms?

1. Made of **CELLS**
2. Require **ENERGY** (food)
3. **REPRODUCE** (species)
4. Maintain **HOMEOSTASIS**
5. **ORGANIZED**
6. **RESPOND** to environment
7. **GROW** and **DEVELOP**
8. **EXCHANGE** materials with surroundings (water, wastes, gases)

- Microfilament
- Centriole
- Nucleus
- Ribosomes
- Smooth endoplasmic reticulum
- Mitochondrion
- Rough endoplasmic reticulum
- Golgi apparatus
- Lysosome

Five Kingdoms and their chief characteristics

- Unicellular organisms that lack a nucleus and many of the specialized cell parts, called organelles. Such organisms are said to be prokaryotic (pro =''before''; karyotic =''kernel,'' ''nucleus'') and consist of bacteria.
- All of the other kingdoms consist of eukaryotic (eu = ''true'') organisms, which have cells that contain a nucleus and a fuller repertory of organelles.
- Whitaker's Five Kingdom Classification (1969)

R.H.Whittaker taxonomist was the first one to propose five kingdom classification.

	Monera	Protista	Fungi	Plantae	Animalia
Type	Unicellular Prokaryotes	Unicellular Eukaryotes	Multicellular Non green Eukaryotic	Multicellular, Eukaryotic	Multicellular Eukaryotic
Mode of nutrition	Autotrophic or Heterotrophic	Autotrophic or Heterotrophic	Saprophytic or Parasitic Sometimes Symbiotic	Autotrophic	Heterotrophic
Body	Lack well defined nucleus and cell organelles	Some organisms use pseudopodia or cilia or flagella for movement	Fungus is made up of long filaments called hyphae. The network of hyphae is mycelium	Exhibits high level of tissue differentiation and have specialized body organs.	Exhibits high level of tissue differentiation and have specialized body organs. They have well developed nervous system.
examples	Bacteria, Blue-green Algae	Amoeba, Paramecium, Euglena	Yeast, Rhizopus, Mushrooms moulds	Trees, Plants, Shrubs	Fish, Insects, Animals Humans, Birds

Cell-basic unit of life

- Smallest living form
- Inside the cell some structure transport
- Metabolize
- Respire
- Reproduce (Meiosis)
- Multiply (Mitosis)
- Energy producing
- Keep information

CELL THEORY

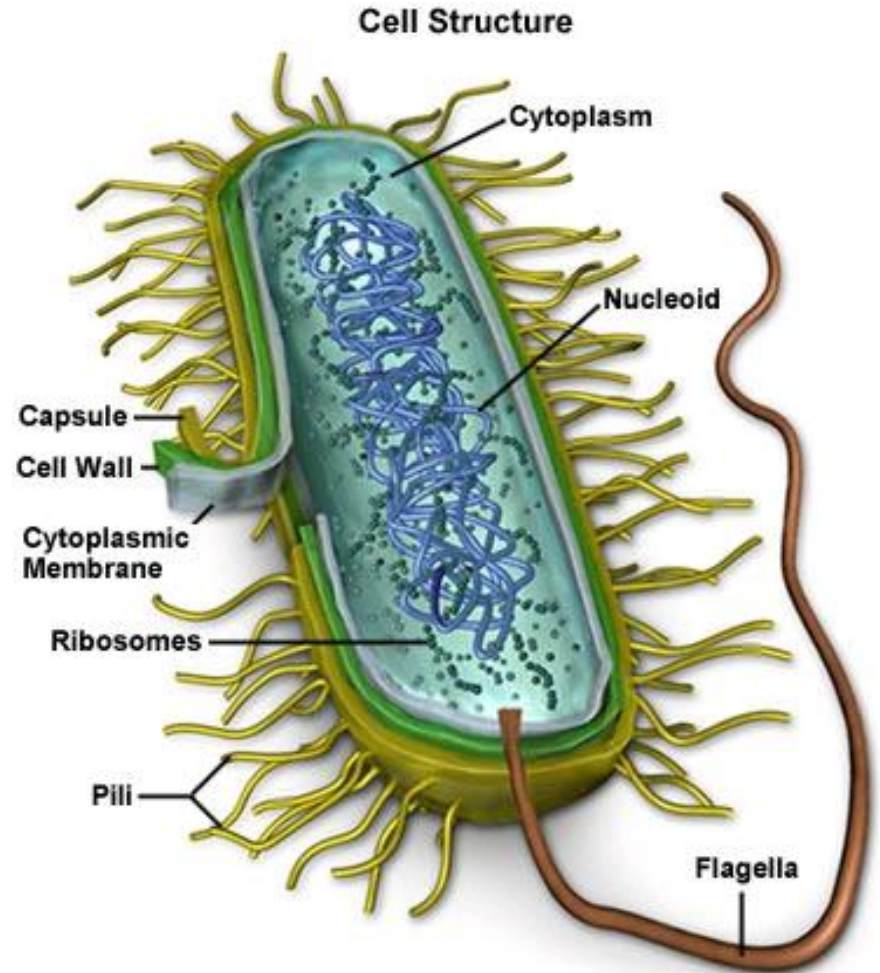- **All living things are made of cells**

- **Cells are the basic unit of structure and function in an organism (basic unit of life)**

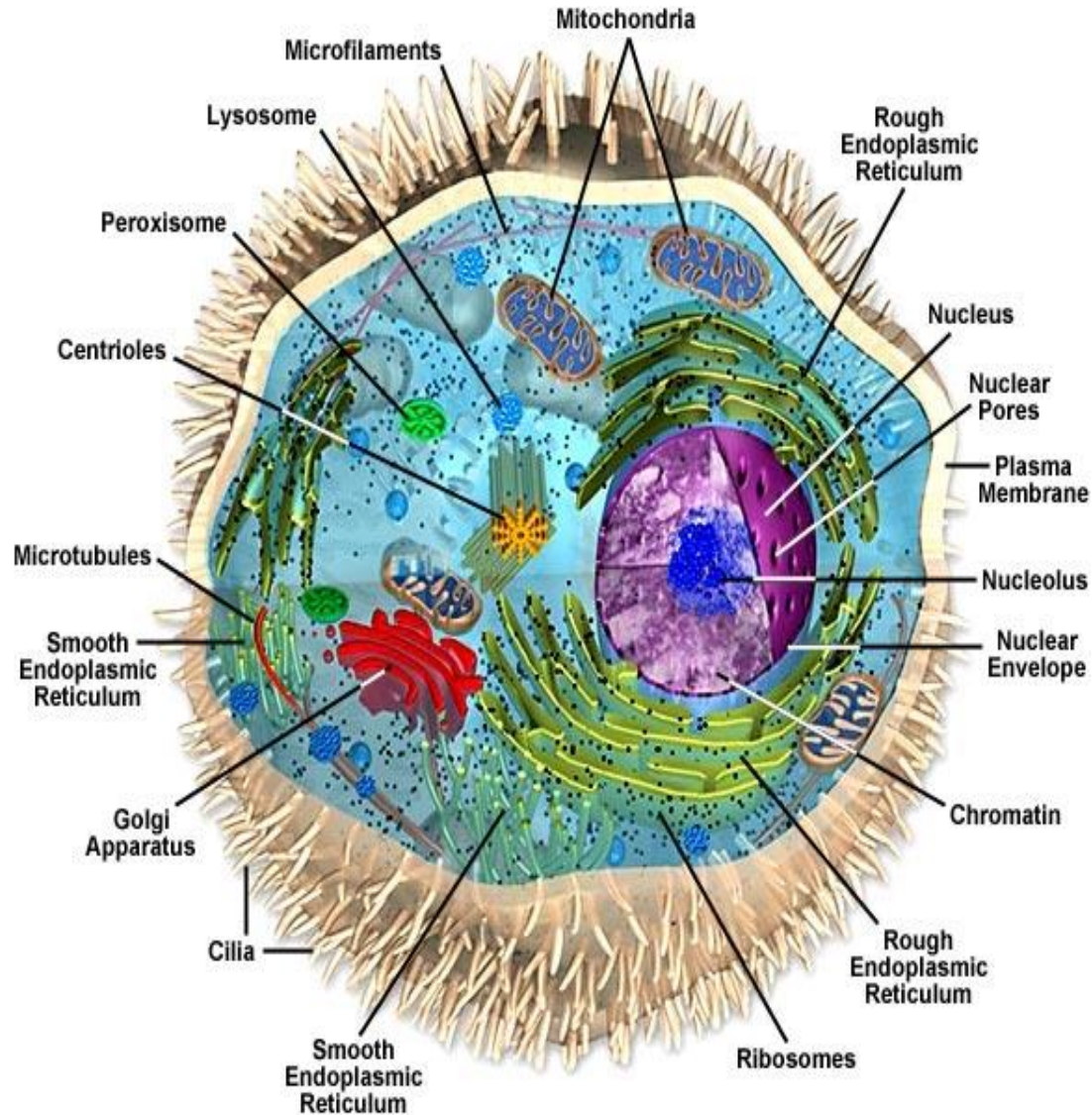- **Cells come from the reproduction of existing cells (cell division)**
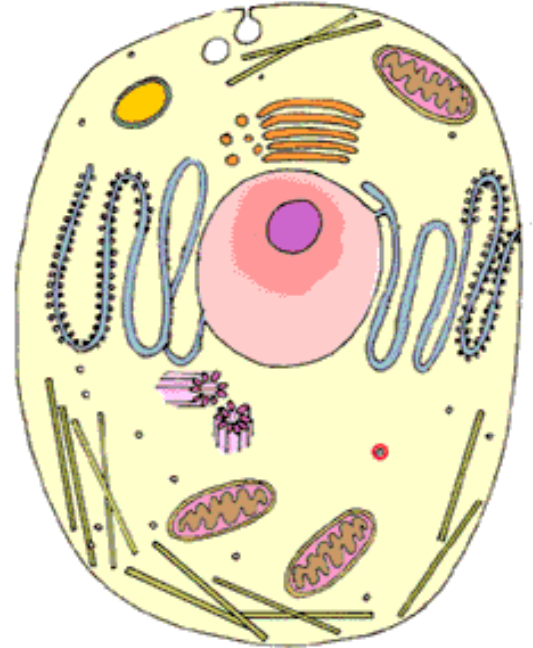
Prokaryotes

- **Nucleoid region** (center) contains the DNA

- **Surrounded by cell membrane & cell wall (peptidoglycan)**

- **Contain ribosomes (no membrane) in their cytoplasm to make proteins**

Cell Structure

- Cytoplasm
- Nucleoid
- Capsule
- Cell Wall
- Cytoplasmic Membrane
- Ribosomes
- Pili
- Flagella

Eukaryotes

- **Cells that HAVE a nucleus and membrane-bound organelles**
- **Includes protists, fungi, plants, and animals**
- **More complex type of cells**

Microfilaments

Mitochondria

Lysosome

Rough Endoplasmic Reticulum

Peroxisome

Nucleus

Centrioles

Nuclear Pores

Plasma Membrane

Microtubules

Nucleolus

Smooth Endoplasmic Reticulum

Nuclear Envelope

Golgi Apparatus

Chromatin

Cilia

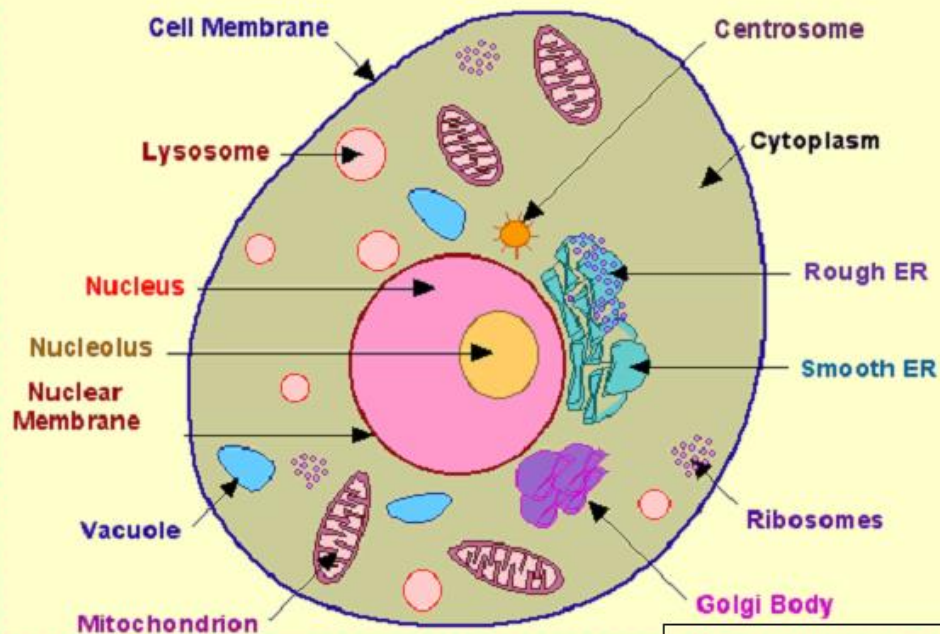Rough Endoplasmic Reticulum

Smooth Endoplasmic Reticulum

Ribosomes
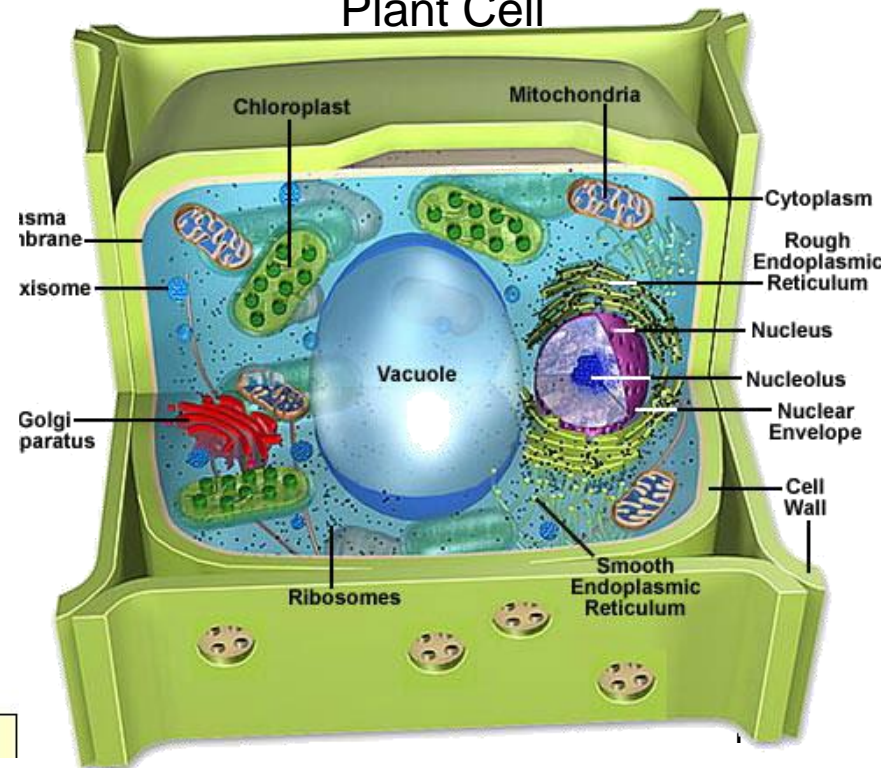
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Cell Structure and Function

Organelles

- **Very small (Microscopic)**
- **Perform various functions for a cell**
- **Found in the cytoplasm**
- **May or may not be membrane-bound**

Cross-Section of an Animal Cell

Cell Membrane
Centrosome
Lysosome
Cytoplasm
Nucleus
Rough ER
Nucleolus
Smooth ER
Nuclear Membrane
Vacuole
Ribosomes
Mitochondrion
Golgi Body

ER=ENDOPLASMIC RETICULUM

Plant Cell

Chloroplast
Mitochondria
Plasma Membrane
Cytoplasm
Peroxisome
Rough Endoplasmic Reticulum
Nucleus
Vacuole
Nucleolus
Nuclear Envelope
Golgi apparatus
Cell Wall
Ribosomes
Smooth Endoplasmic Reticulum
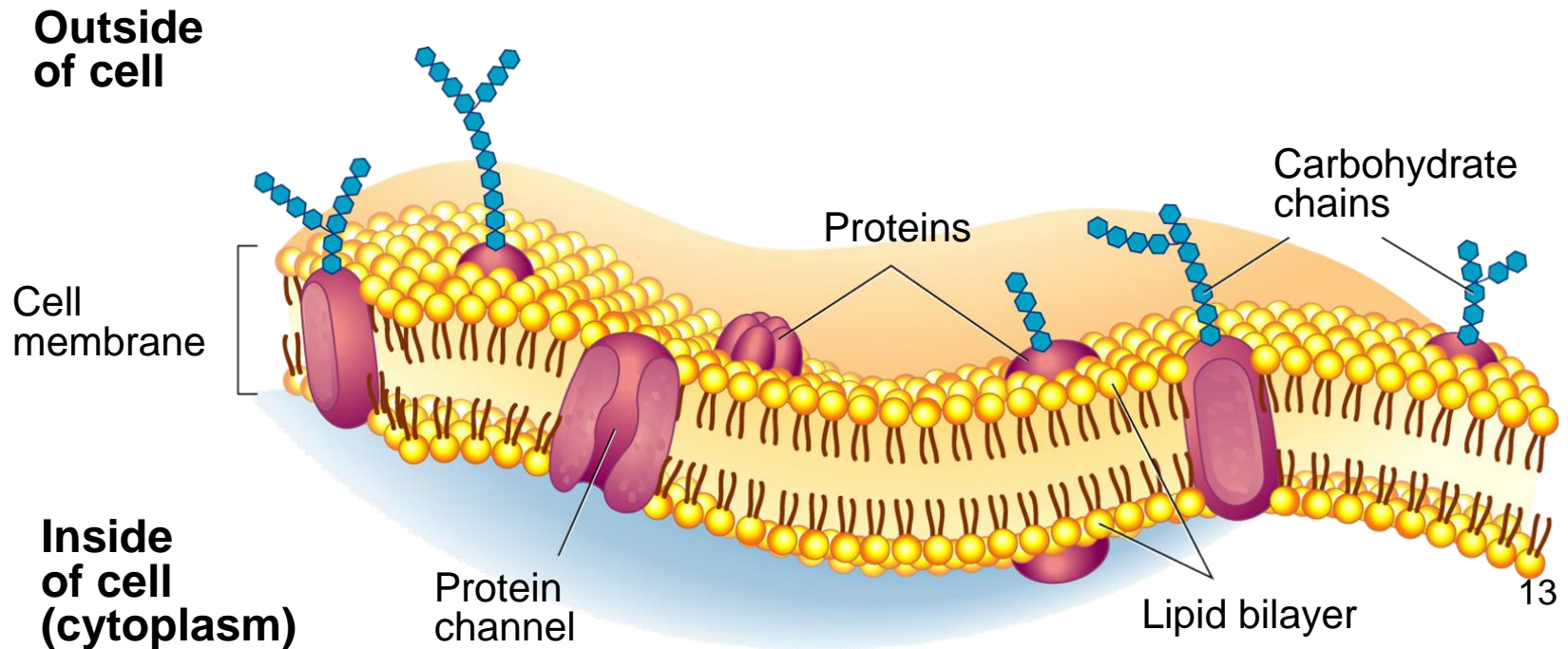
Cell or Plasma Membrane

- **Composed of double layer of phospholipids and proteins**
- **Surrounds outside of ALL cells**
- **Controls what enters or leaves the cell**
- **Living layer**

Outside of cell

Carbohydrate chains

Proteins

Cell membrane

Protein channel

Inside of cell (cytoplasm)

Lipid bilayer

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Cytoplasm of a Cell

- **Jelly-like** substance enclosed by **cell membrane**
- **Provides a medium for chemical reactions to take place**
- Contains **organelle**s to carry out specific jobs
- Found in **ALL** cells

cytoplasm
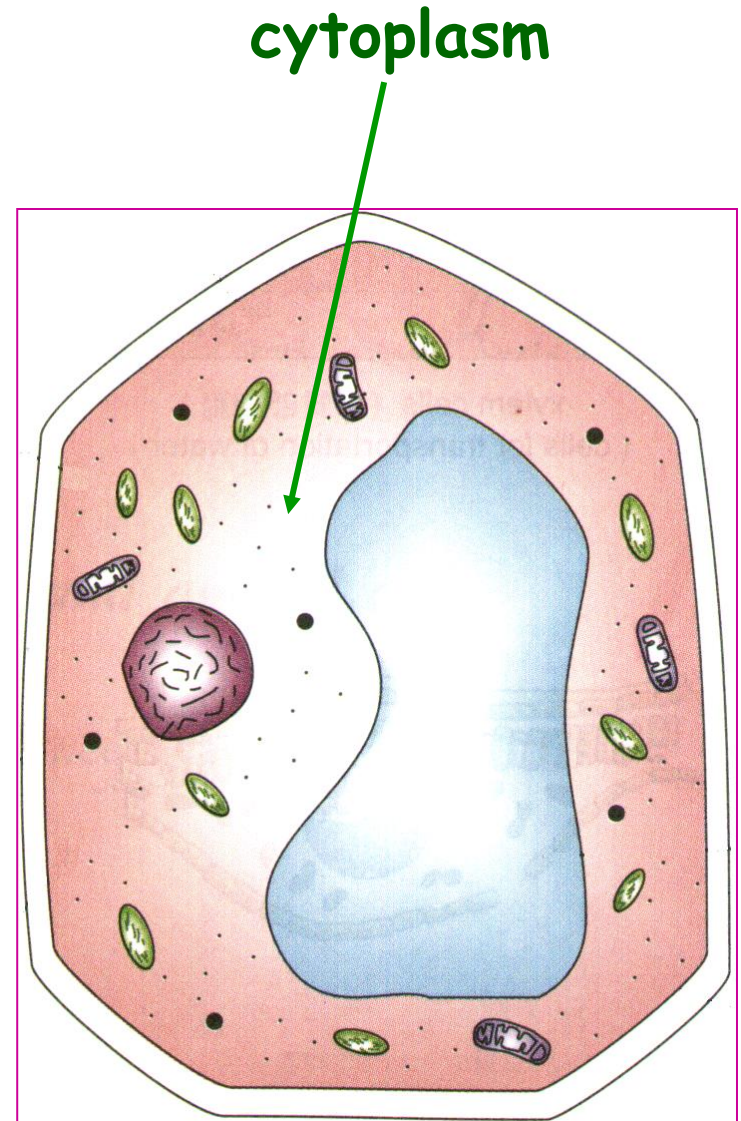
The Control Organelle - Nucleus

- **Controls the normal activities of the cell**
- **Contains the DNA in chromosomes**
- **Bounded by a nuclear envelope (membrane) with pores**
- **Usually the largest organelle**
- **Each cell has fixed number of chromosomes that carry genes**
- **Genes control cell characteristics**
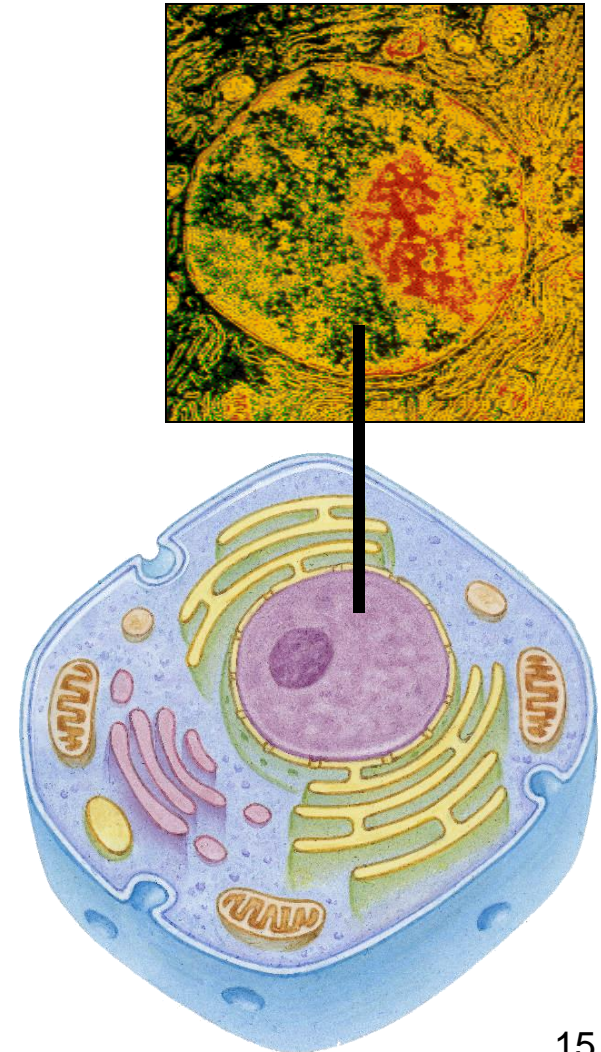
Nucleolus

- **Inside nucleus**
- **Cell may have 1 to 3 nucleoli**
- **Disappears when cell divides**
- **Makes ribosomes that make proteins**

Nucleolus

PORE
ENVELOPE
NUCLEOLUS
CHROMATIN

THE NUCLEUS

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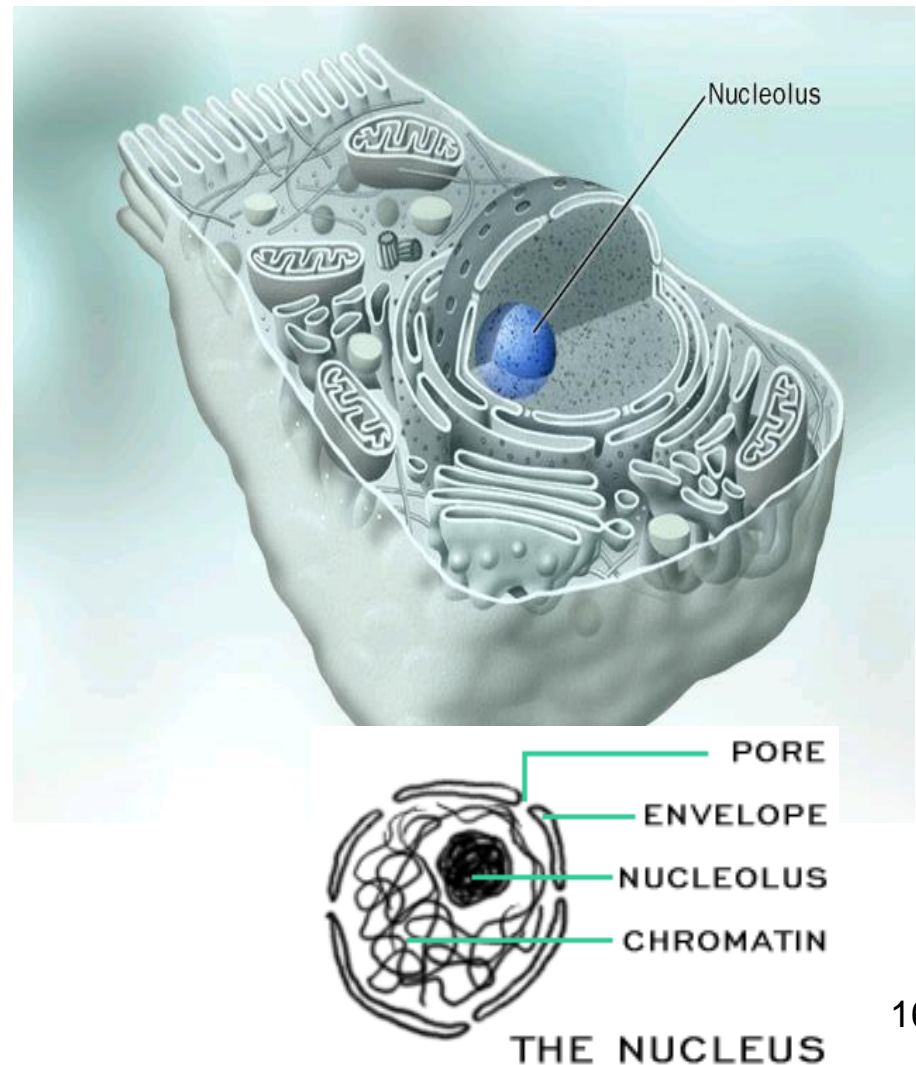
Cytoskeleton

- **Helps cell maintain cell shape**

- **Also help move organelles around**

- **Made of proteins**

- **Microfilaments are threadlike & made of ACTIN**

- **Microtubules are tube-like and made of TUBULIN**

vertebral column

Cytoskeleton

Microtubules

Microfilaments

17
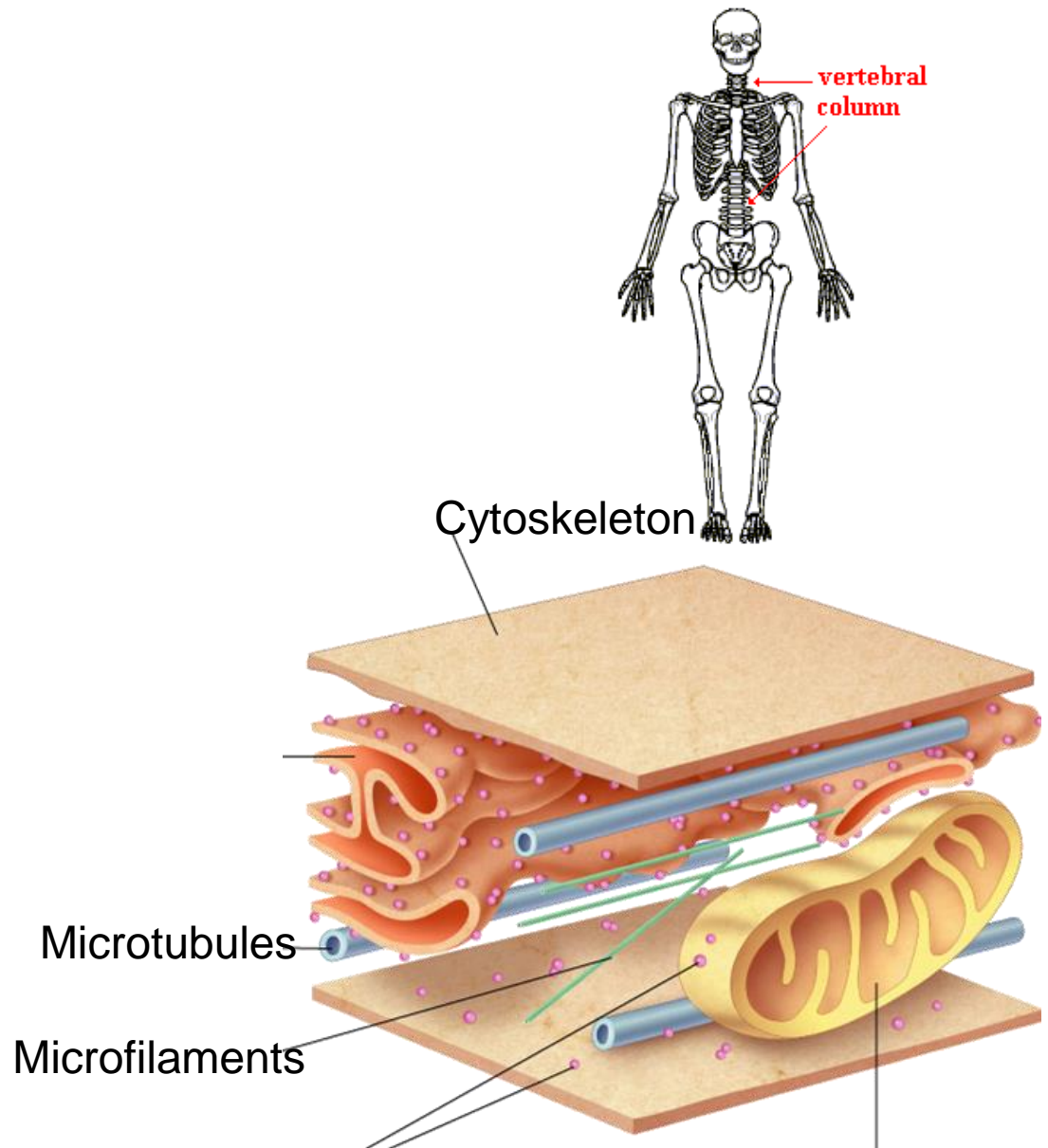
Centrioles
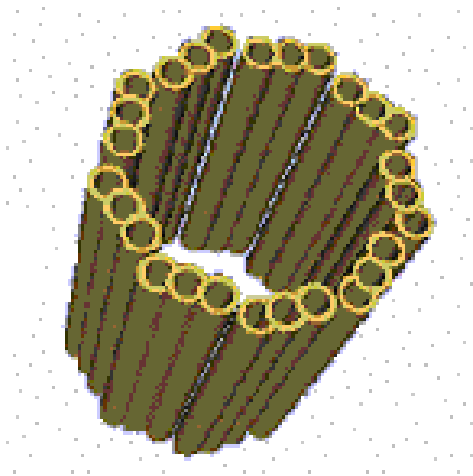
- Found only in **animal** cells
- **Paired** structures near nucleus
- Made of bundle of **microtubules**
- Appear during **cell division** forming **mitotic spindle**
- Help to **pull chromosome pairs apart** to opposite ends of the cell

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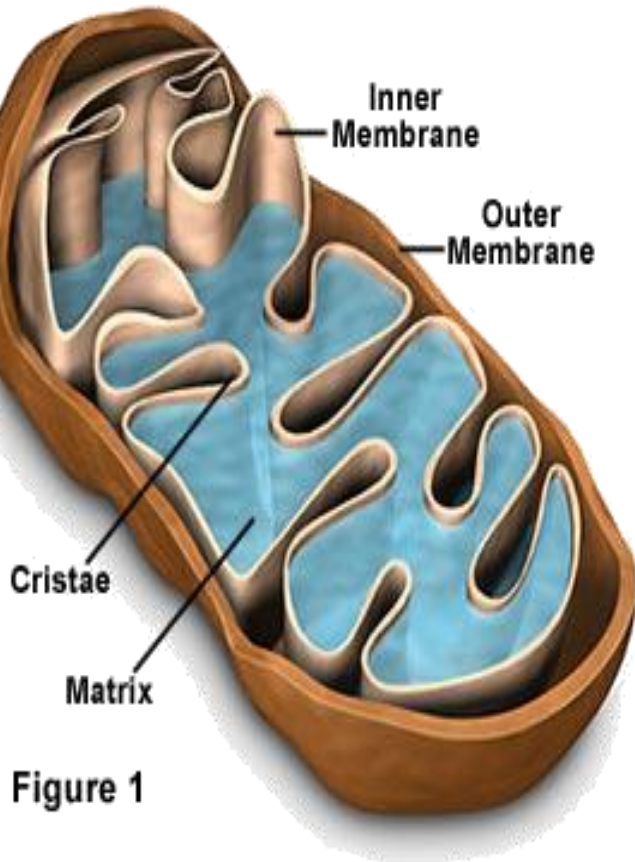
Mitochondrion
(plural = mitochondria)

- **"Powerhouse" of the cell**
- **Generate cellular energy (ATP)**
- **More active cells like muscle cells have MORE mitochondria**
- **Both plants & animal cells have mitochondria**
- **Site of CELLULAR RESPIRATION (burning glucose)**
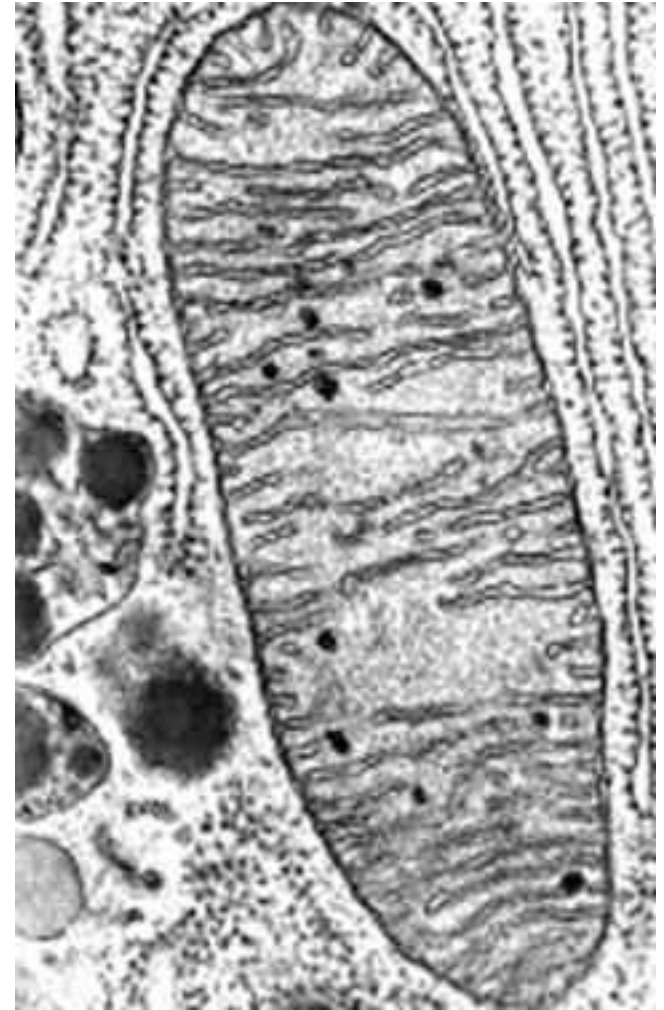
MITOCHONDRIA

Mitochondria Inner Structure

Inner Membrane

Outer Membrane

Cristae

Matrix

Figure 1

- **Surrounded by a DOUBLE membrane**
- **Has its own DNA**
  - Mitochondria come from cytoplasm in the egg cell during fertilization
  - Therefore you inherit your mitochondria from your mother!

- **Folded inner membrane called CRISTAE (increases surface area for more chemical reactions)**
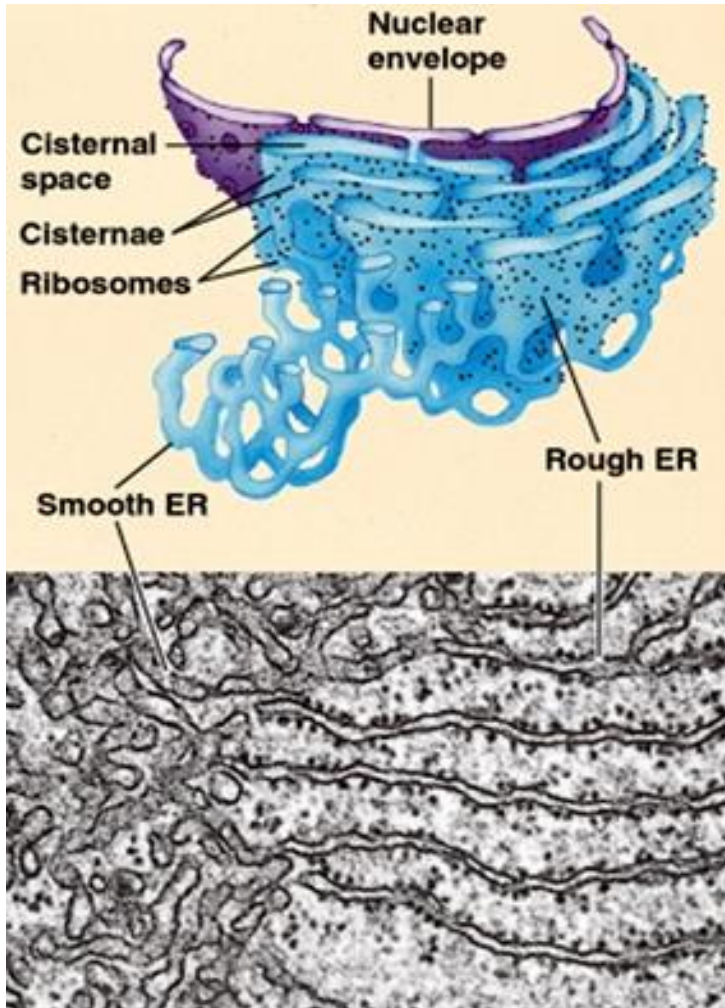- **Interior called MATRIX**

Endoplasmic Reticulum - ER

- **Network of hollow membrane tubules**
- **Connects to nuclear envelope & cell membrane**
- **Functions in Synthesis of cell products & Transport**
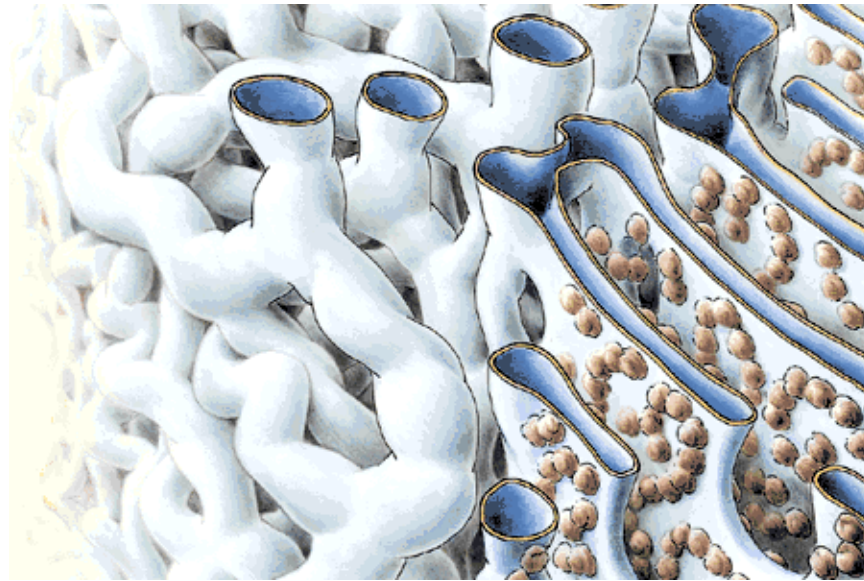
Two kinds of ER ---ROUGH & SMOOTH

Rough Endoplasmic Reticulum (Rough ER)

- **Has ribosomes on its surface**
- **Makes membrane proteins and proteins for EXPORT out of cell**
- **Proteins are made by ribosomes on ER surface**
- **They are then threaded into the interior of the Rough ER to be modified and transported**

Nuclear envelope

Cisternal space

Cisternae

Ribosomes

Smooth ER

Rough ER

Membrane
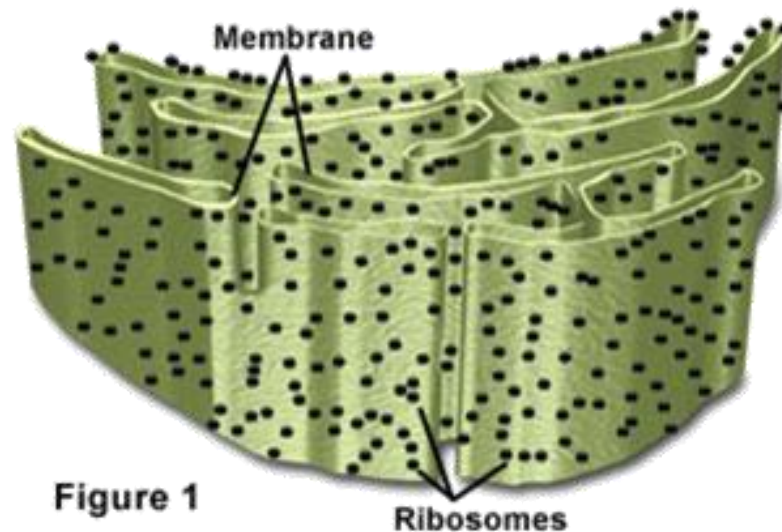
Figure 1

Ribosomes

Smooth Endoplasmic Reticulum

- *Smooth ER* lacks ribosomes on its surface
- Is **attached to the ends** of rough ER
- Makes cell products that are **USED INSIDE the cell**
- Makes membrane lipids **(steroids)**
- **Regulates calcium** (muscle cells)
- **Destroys toxic** substances (Liver)

Nuclear envelope

Rough ER

Ribosomes

Smooth ER
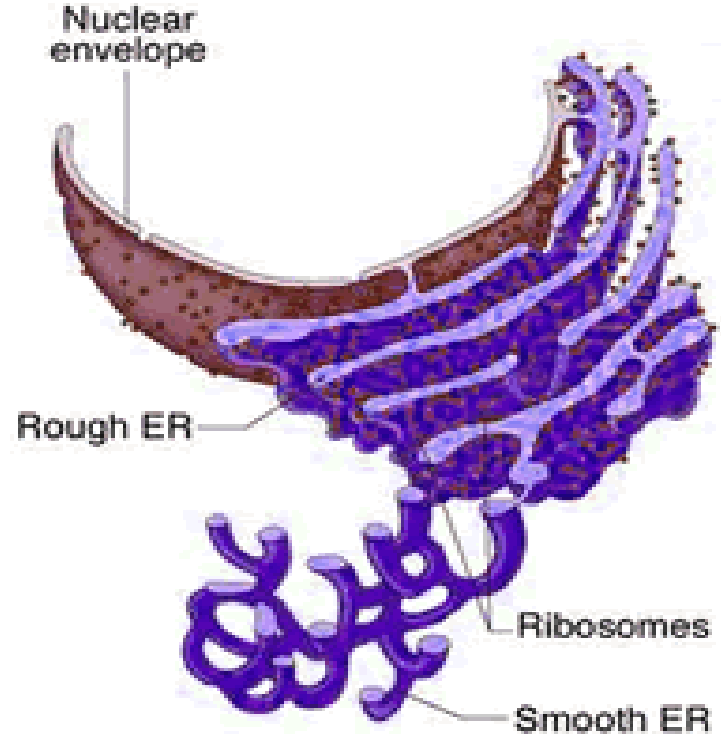
Includes nuclear membrane connected to ER connected to cell membrane (transport)

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Ribosomes

- **Made of PROTEINS and rRNA**
- **"Protein factories" for cell**
- **Join amino acids to make proteins**
- **Process called protein synthesis**
- **Can be attached to Rough ER OR Be free (unattached) in the cytoplasm**
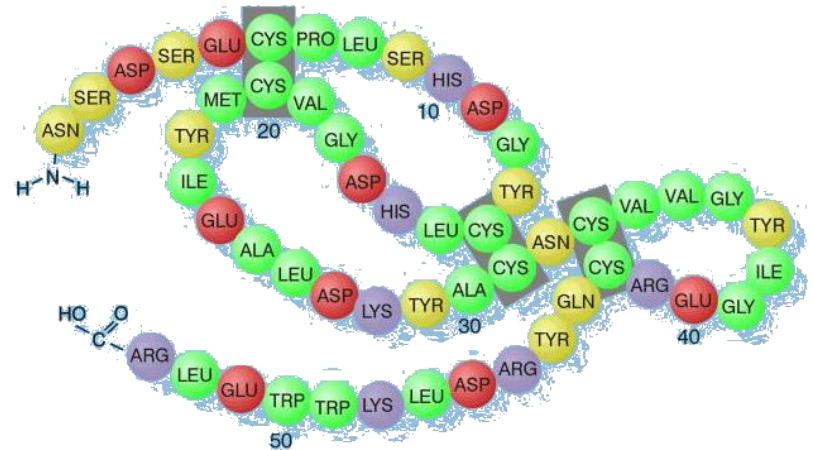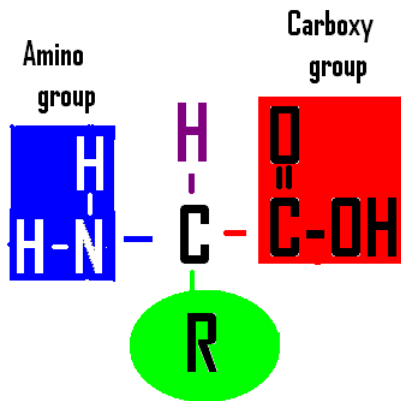
Golgi Bodies

- **Stacks of flattened sacs**

- **Have a shipping side (trans face) and receiving side (cis face)**

- **Receive proteins made by ER**

- **Transport vesicles with modified proteins pinch off the ends**

CIS
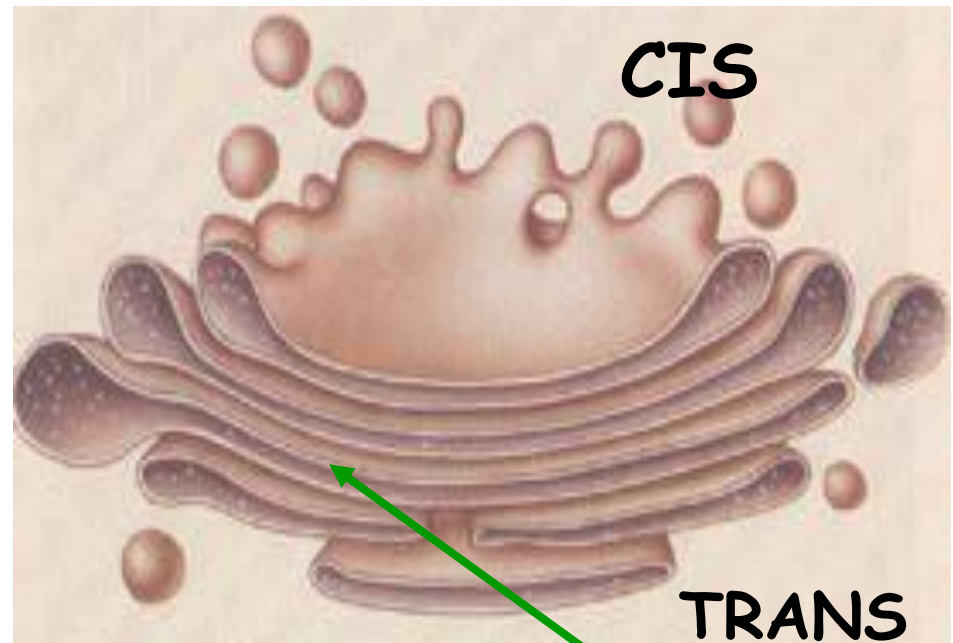
TRANS

Transport vesicle

Golgi Bodies

Look like a stack of pancakes
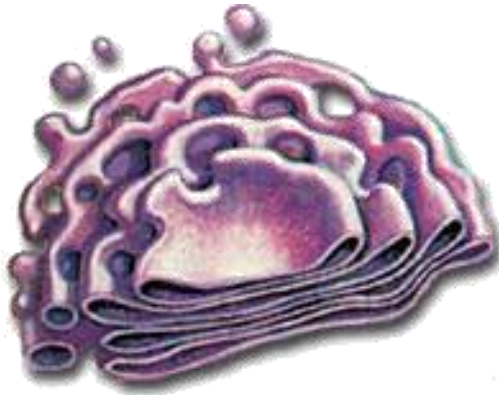
Modify, sort, & package
molecules from ER
for storage OR
transport out of cell

Lysosomes

- **Contain digestive enzymes**
- **Break down food, bacteria, and worn out cell parts for cells**
- **Programmed for cell death (AUTOLYSIS)**
- **Lyse (break open) & release enzymes to break down & recycle cell parts)**
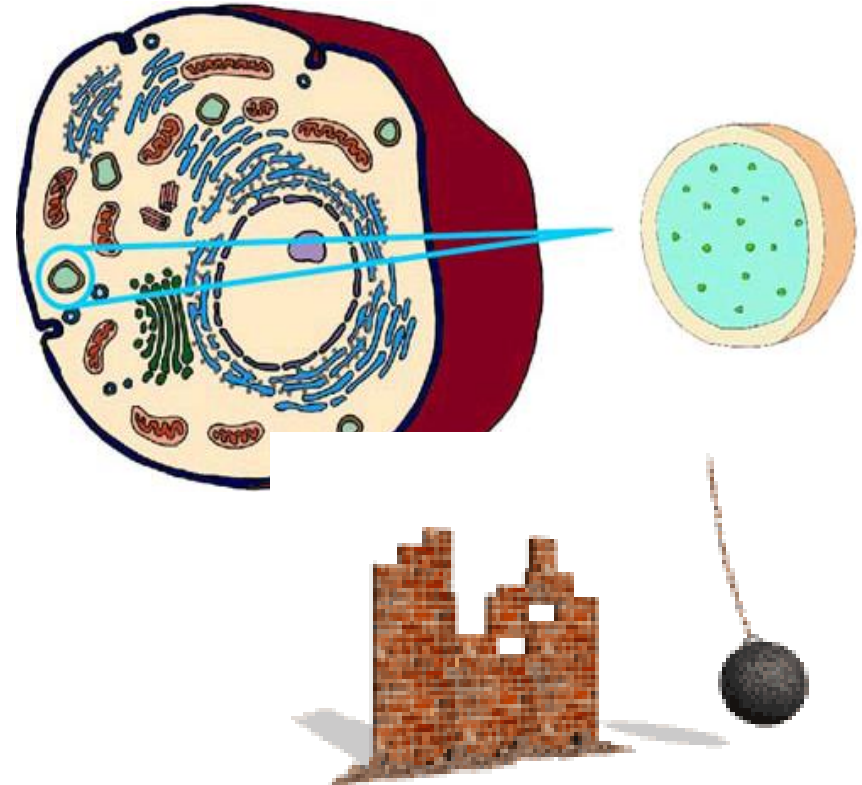
Lysosome Digestion

• **Cells take in food by phagocytosis**

• **Lysosomes digest the food & get rid of wastes**

LYSOSOME

Membrane — Hydrolytic enzymes

Transport proteins
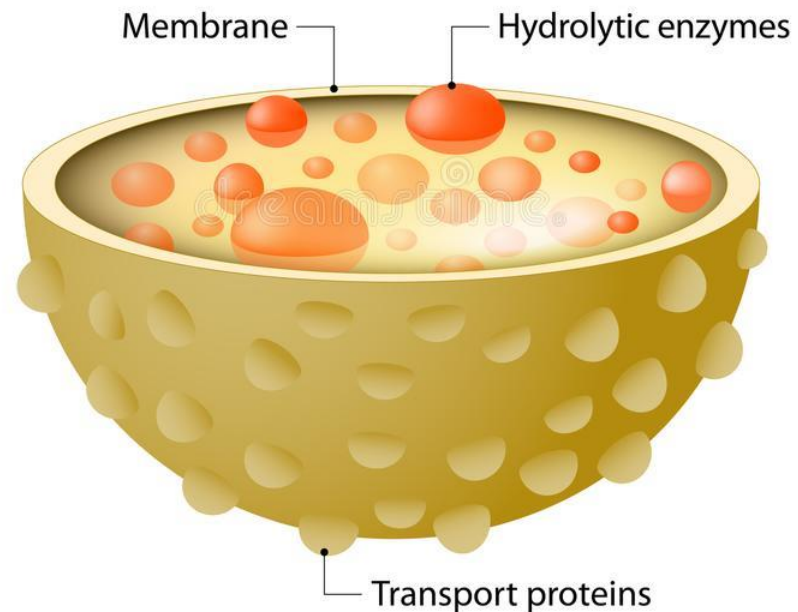
Vacuoles

- **Fluid filled** sacks for **storage**
- **Small or absent** in *animal* cells
- *Plant* cells have a **large Central Vacuole**
- **No vacuoles** in *bacterial* cells
- In plants, they store **Cell Sap**
- Includes storage of **sugars, proteins, minerals, lipids, wastes, salts, water, and enzymes**

Golgi Complex
Endoplasmic Reticulum
Mitochondria
Nucleus
Nucleolus
Cell Wall
Vacuole
Membrane
Lysosome
Cytoplasm
Chloroplast
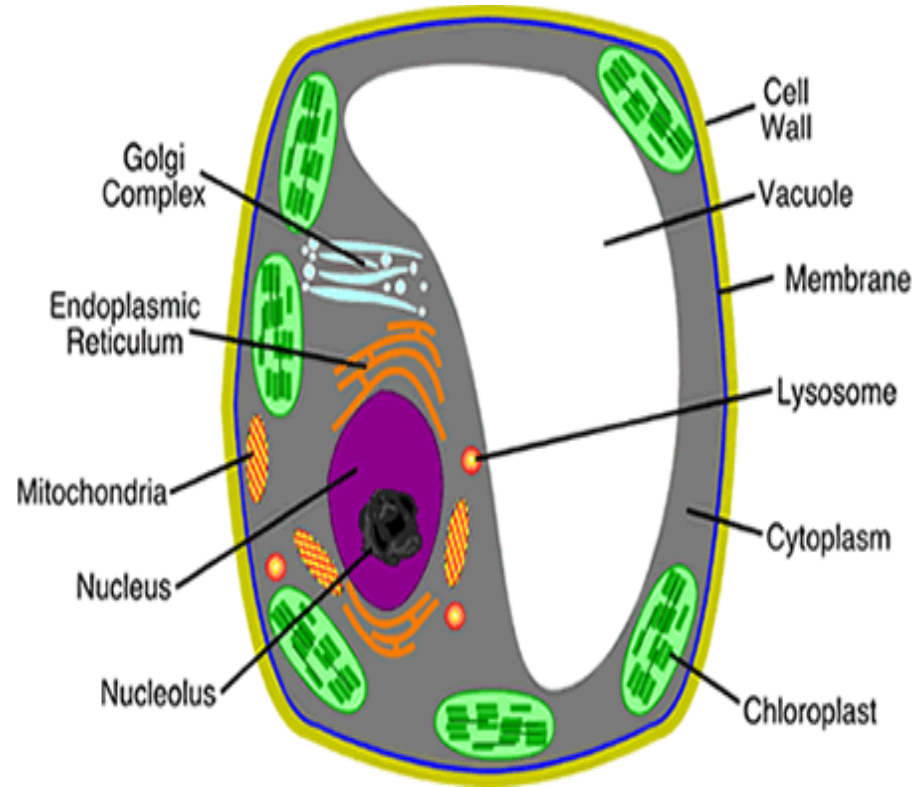
Chloroplasts

- **Found only in producers (organisms containing chlorophyll)**

- **Use energy from sunlight to make own food (glucose)**

- **Energy from sun stored in the Chemical Bonds of Sugars**

❖**Surrounded by DOUBLE membrane**

❖**Outer membrane smooth**

❖**Inner membrane modified into sacs called Thylakoids**

❖**Thylakoids in stacks called Grana & interconnected**

❖**Stroma – gel like material surrounding thylakoids**

Outer Membrane

Thylakoid

Stroma

Granum (Stack of Thylakoids)
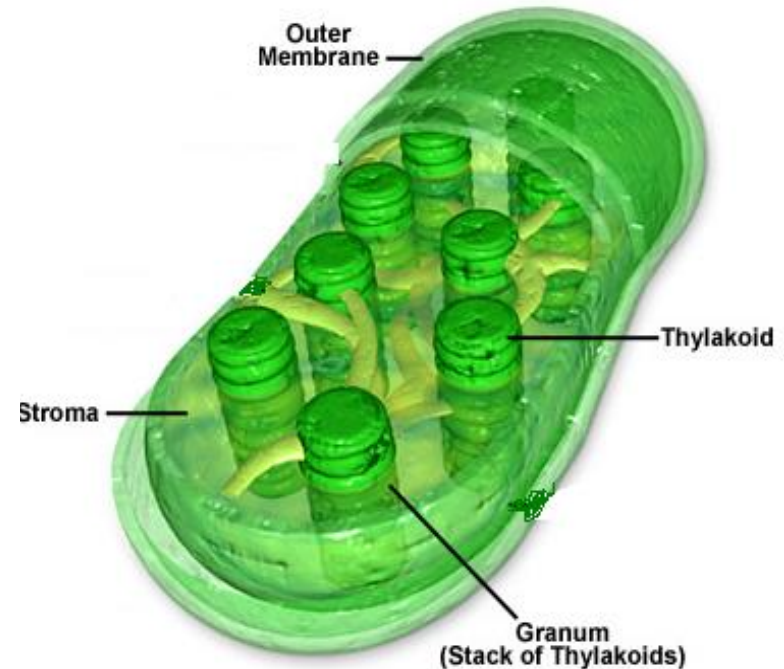
Chloroplasts

- **Contains its own DNA**
- **Contains enzymes & pigments for Photosynthesis**
- **Never in animal or bacterial cells**
- **Photosynthesis – food making process**
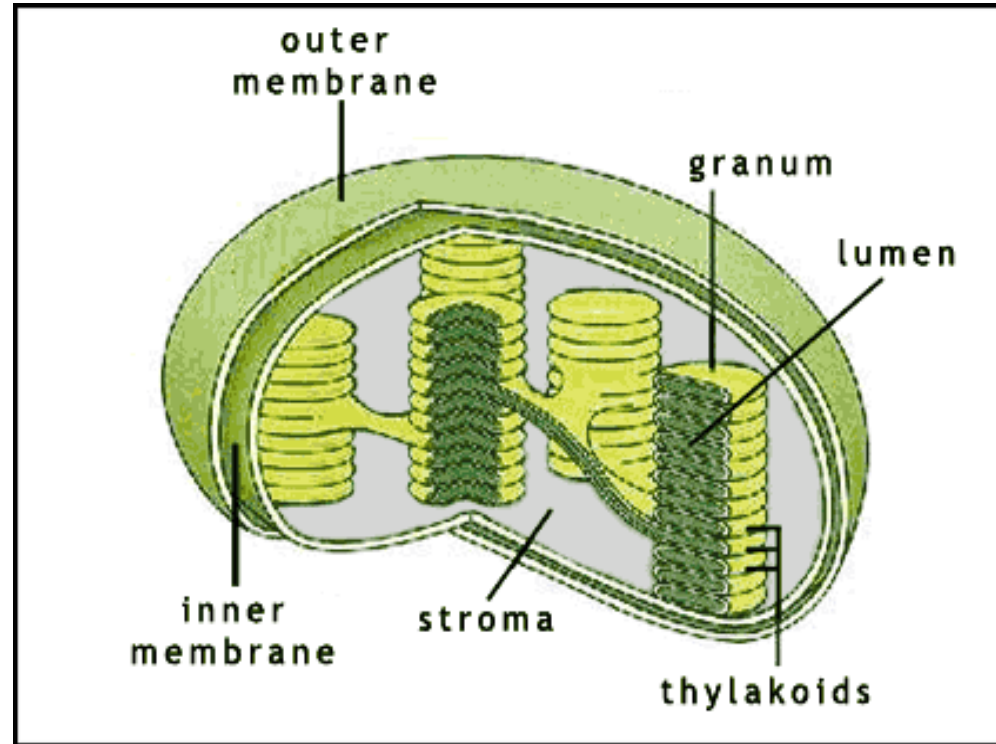
Homeostasis

Homeostasis

Definition : Maintenance of the relative stability of the physical and chemical aspects of the internal environment within a range compatible with cellular function.

Maintaining a constant internal environment with all that the cells need to survive (O_2, glucose, minerals, ions, and waste removal) is necessary for individual cells. The processes by which the body regulates its internal environment are referred to as *homeostasis*.

Components :   1) sensor
2) afferent pathway
3) integration center or comparator
4) efferent pathway
5) effector organ(s)

• Physiological control systems are the nervous system, endocrine system, and immune system through feedback mechanisms.

Homeostatic Control System

Is a functionally interconnected network of body components that operate to maintain a given physical or chemical factor in the internal environment relatively constant around an optimal level.

Can be classified as:

- Intrinsic (local controls) are inherent compensatory responses of an organ to a change
- Extrinsic controls are responses of an organ that are triggered by factors external to the organ , namely, by the nervous and endocrine systems

Extrinsic homeostatic systems

- **Nervous System**

- The nervous system maintains homeostasis by controlling and regulating the other parts of the body.

  – A deviation from a normal set point acts as a stimulus to a receptor, which sends nerve impulses to a regulating center in the brain. The brain directs an effector to act in such a way that an adaptive response takes place.

- The nervous system has two major portions: the **central nervous system** and the **peripheral nervous system**.

- Regulating centers are located in the central nervous system, consisting of the brain and spinal cord.

  – The hypothalamus is a portion of the brain particularly concerned with homeostasis; it influences the action of the medulla oblongata, a lower part of the brain, the autonomic nervous system, and the pituitary gland.

- The peripheral nervous system consists of the spinal nerves. The **autonomic nervous system** is a part of peripheral nervous system and contains motor neurons that control internal organs. It has two divisions, the **sympathetic** and **parasympathetic** systems.

Central nervous system

Brain

Spinal cord

Peripheral nervous system

Peripheral nerve

✤ADAM.

Hypothalamus

Pituitary gland

The hypothalamus and the pituitary in the brain control the normal secretion of thyroid hormones which in turn controls metabolism

Thyroid gland

✤ADAM.
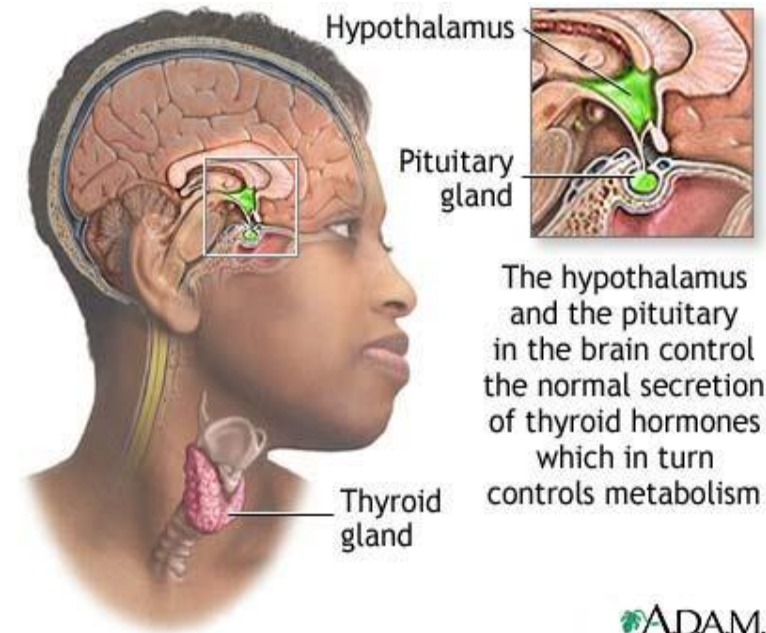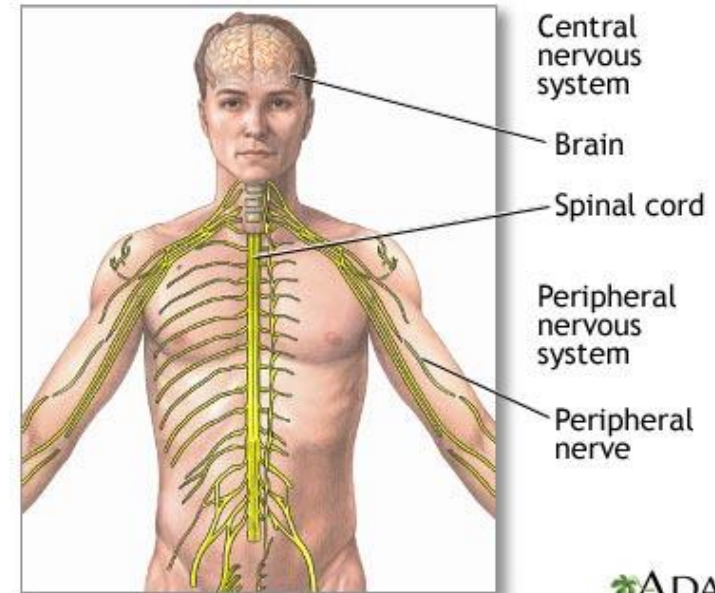
- **Endocrine System**

- The endocrine system consists of glands which secrete special compounds called **hormone**s into the bloodstream.

- Each hormone has an effect on one or more target tissues. In this way the endocrine system regulates the metabolism and development of most body cells and body systems.

- For e.g. the endocrine system has sex hormones that can activate sebaceous glands, development of mammary glands, alter dermal blood flow, and release lipids from adipocytes etc besides governing reproduction.

- In the muscular system, hormones adjust muscle metabolism, energy production, and growth.

- In the nervous system, hormones affect neural metabolism, regulate fluid/electrolyte balance and help with reproductive hormones that influence CNS (central nervous system), development and behaviours.

- In the cardiovascular system, hormones regulate heart rate and blood pressure.

- Hormones also have anti-inflammatory effects and control the lymphatic system.

Pineal gland
Hypothalamus
Pituitary gland
Thyroid gland
Parathyroid glands
Thymus
Adrenal glands (atop kidneys)
Pancreas
Ovary (female)
Testis (male)

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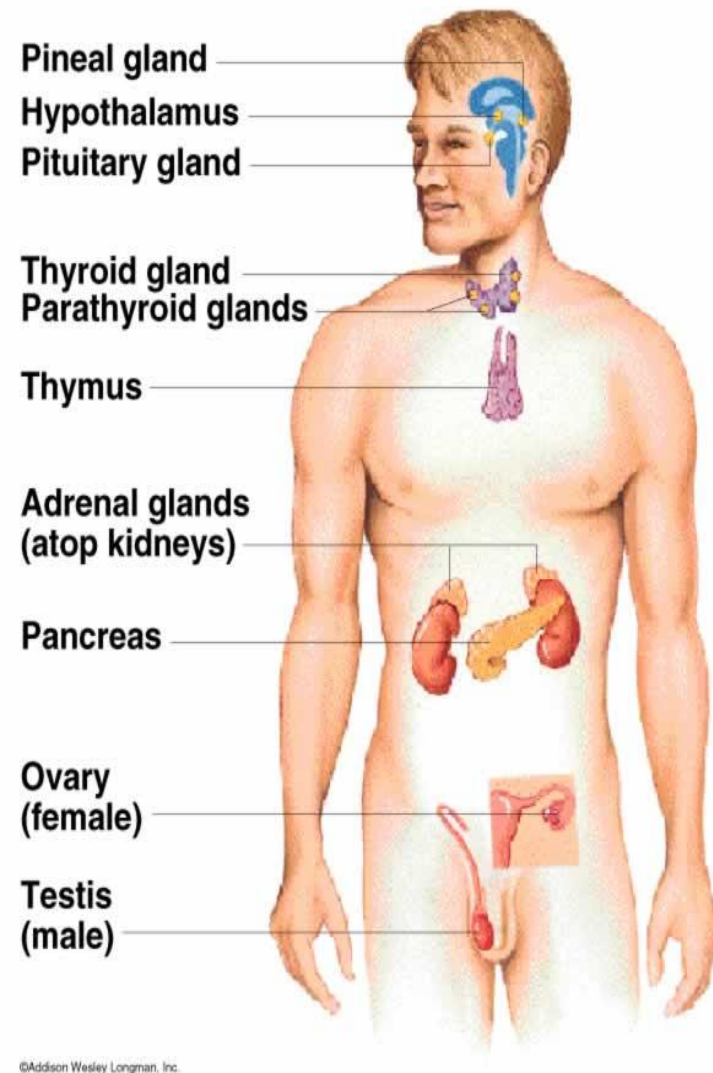
- Negative feedback : a control system that causes the value of a physiological measurement to change in the direction **opposite** to the initial deviation from set point.

- Positive feedback : a control system that causes the value of a physiological measurement to change in the **same** direction as the initial deviation from set point.

Negative feedback

hypothalamus
(control center)

nerve signal to turn off effector

nerve signal (temperature) to control center

nerve signal to turn on effector

heat output (shivering) increases

nerve endings (sensor)

heat output (shivering) decreases

Skeletal muscles (effector)

set point

Step ① Vascular spasm
- Smooth muscle contracts, causing vasoconstriction.

Step ② Platelet plug formation
- Injury to lining of vessel exposes collagen fibers; platelets adhere.

Collagen fibers

- Platelets release chemicals that make nearby platelets sticky; platelet plug forms.

Platelets

Step ③ Coagulation
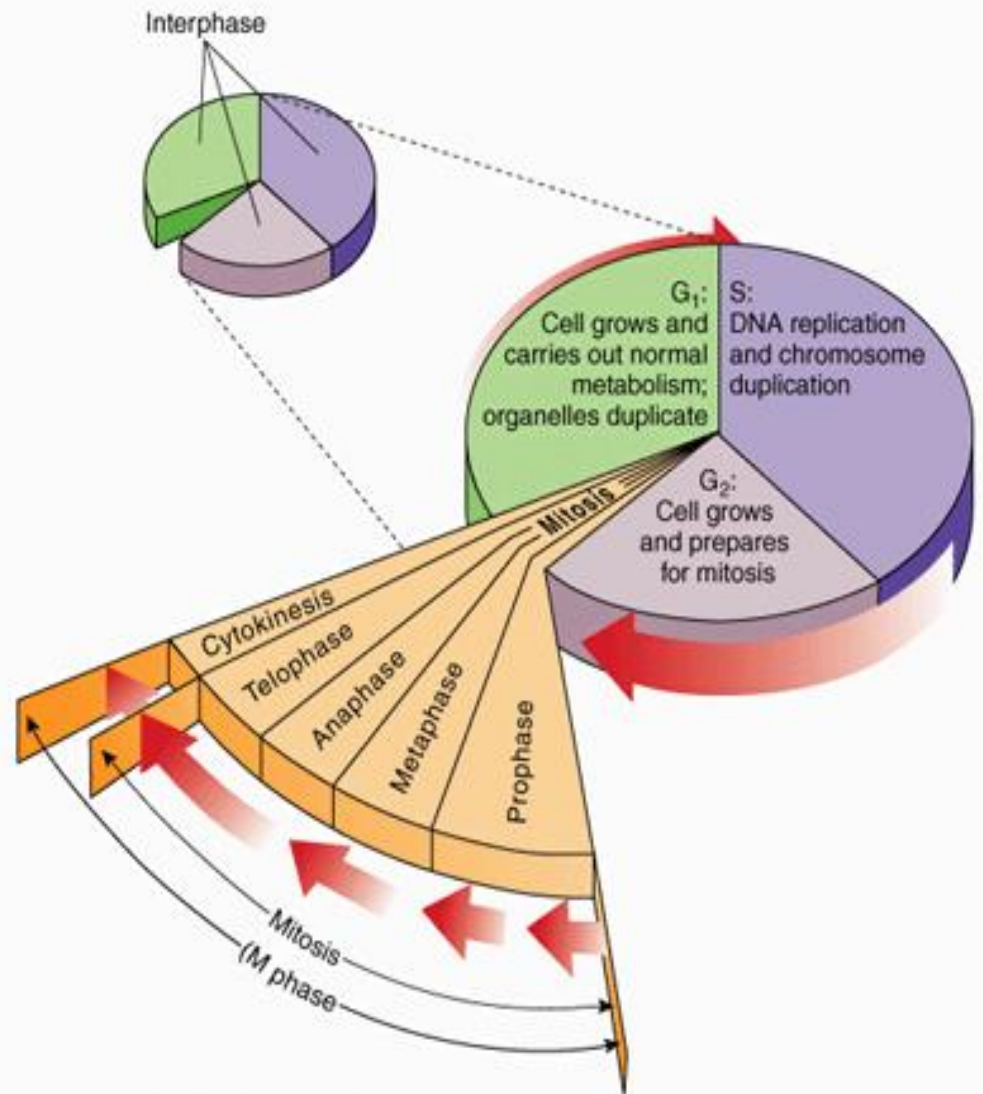- Fibrin forms a mesh that traps red blood cells and platelets, forming the clot.

Fibrin

Cell growth, reproduction, and differentiation

The Cell Cycle

- **Mitosis and meiosis are single steps in cell cycle**

- **G1, S, G2, and M phases**
  - **Cells not in process of dividing are in G0 phase**
  - **Chromosomes are duplicated in preparation for the next round of division during interphase**

Control of the Cell Cycle

- **The stimuli for entering the cell cycle is in the form of growth factors and cytokines that are capable of inducing mitotic divisions**

- **The cell cycle is highly regulated**
  - **Proteins whose concentrations rise & fall in a controlled manner**
    - **Cyclin and cyclin-dependent kinases (cdk)**
    - **p53 and pRb**
    - **Inhibitors of cdk**

- **Internal checkpoints & guardians monitor cell health**

- **Errors in this process can lead to uncontrollable growth and cancer**

Control of the Cell Cycle

- **Cell cycle control is focused at 3 places:**
- **G1 checkpoint**
- **G2 checkpoint**
- **M checkpoint**
  - **Before S phase (DNA synthesis)**
  - **At transition between G_2 and M phase**

First checkpoint

Second checkpoint

M G_1 S G_2 M

1ST mitosis

Levels of cytoplasmic regulating agents rise at these points.

2ND mitosis
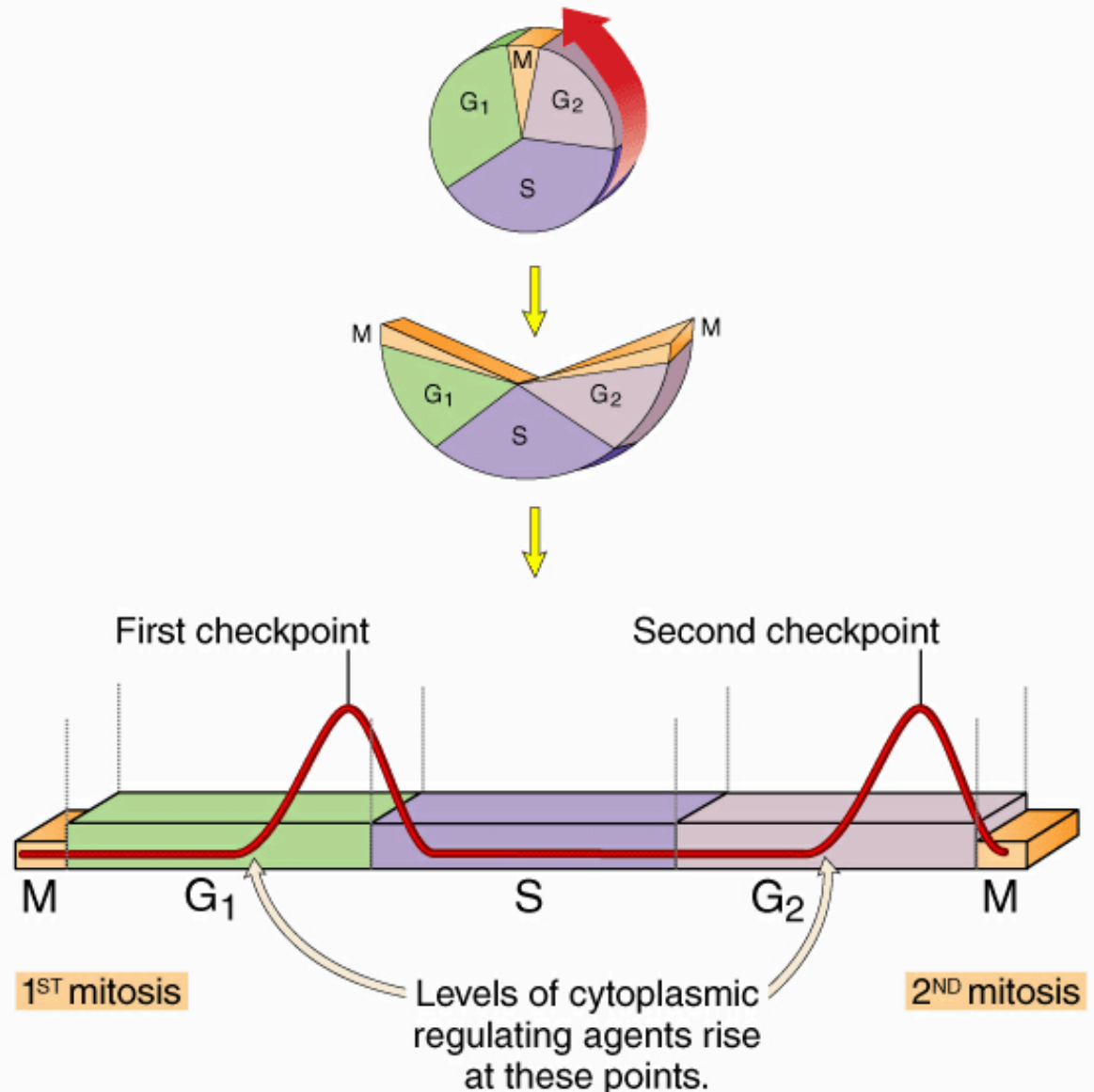
DNA replication-Binary fission

Daughter cells are identical copies

Chromosome

Plasma membrane

(1) (2) (3)

(4) (5) (6)
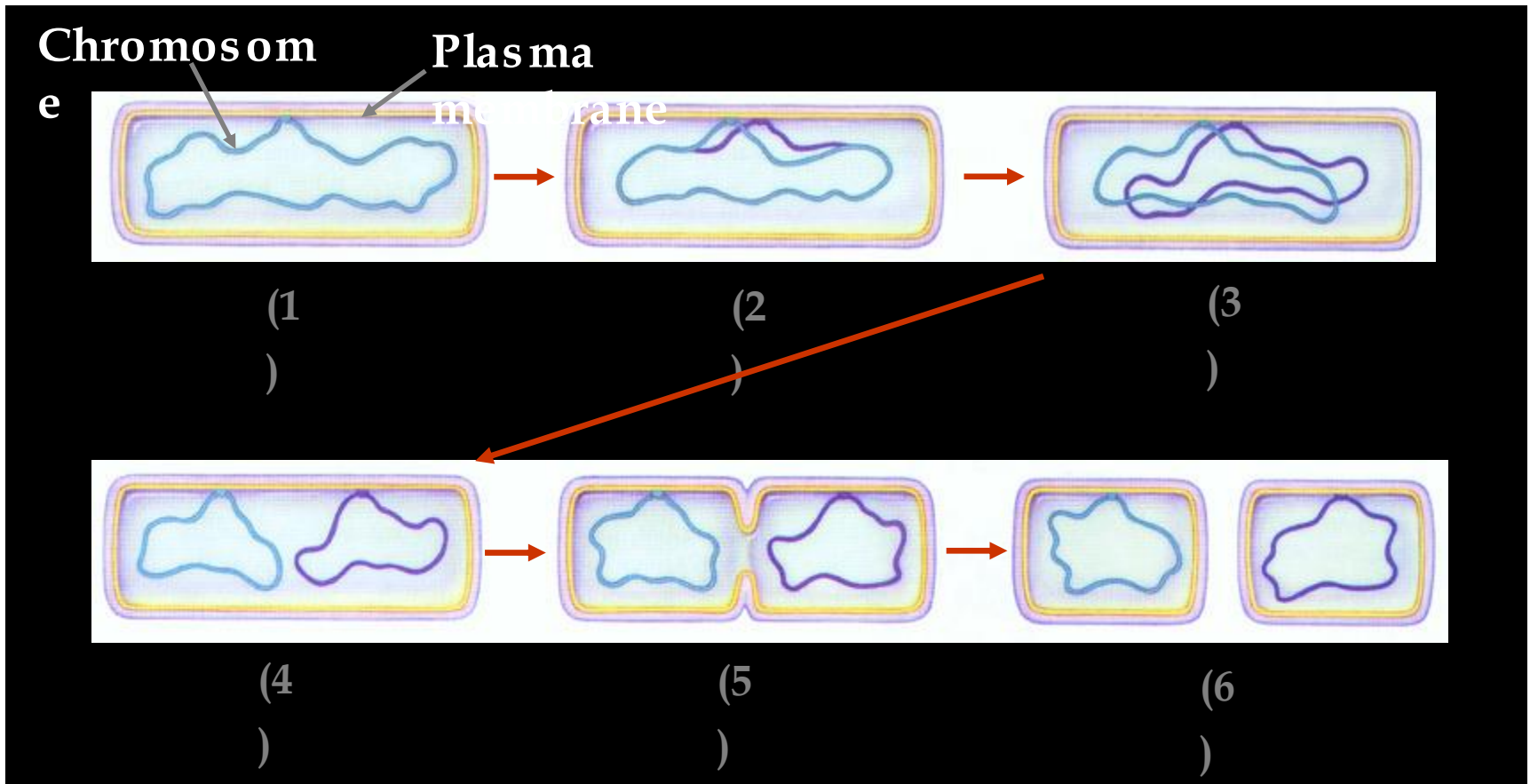
Neither mitosis nor meiosis occurs in prokaryotes

Bacteria

Reproduction

Asexual, through binary fission

No true sexual reproduction, since neither mitosis nor meiosis exist in prokaryotes

Horizontal transfer of genetic material
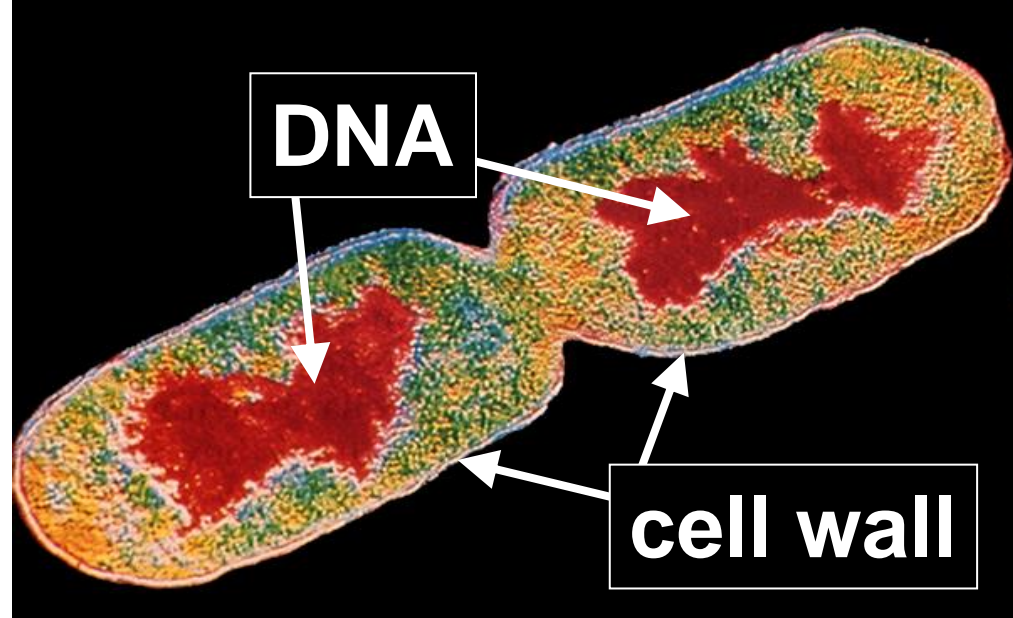
Transformation → Uptake of genetic material from the environment

Transduction → Transfer of genetic material between prokaryotes by viruses

Conjugation → Direct transfer of genetic material from one prokaryote to another

DNA

cell wall

Mitosis

•**Four phases**

–**1. Prophase:**
chromosomes condense,
spindle apparatus forms,
nuclear envelope breaks
down

–**2. Metaphase:**
chromosomes line up at
equator of cell

–**3. Anaphase: sister**
chromatids separate

–**4. Telophase: new**
nuclear envelopes form,
chromosomes unwind

pair of homologous, duplicated chromosomes

nuclear envelope

sister chromatids of one duplicated homologue
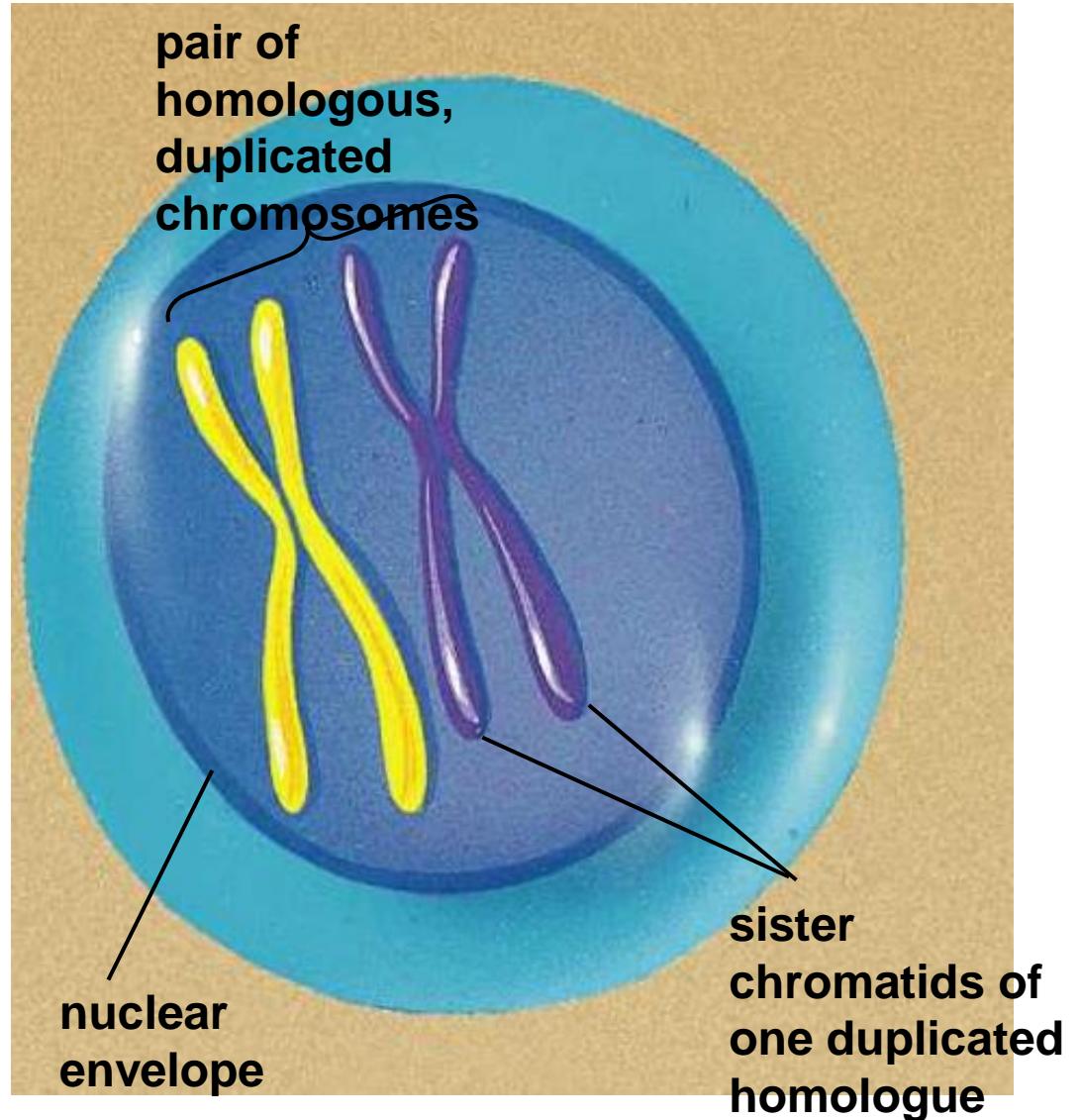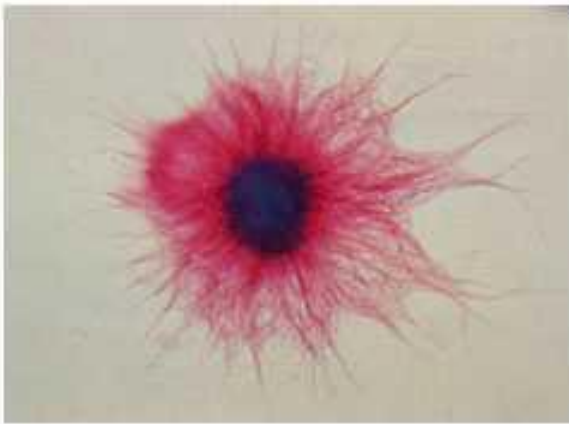
(a) Interphase in a seed cell: The chromosomes (blue) are in the thin, extended state and appear as a mass in the center of the cell. The spindle microtubules (red) extend outward from the nucleus to all parts of the cell.

(b) Late prophase: The chromosomes (blue) have condensed and attached to the spindle microtubules (red).
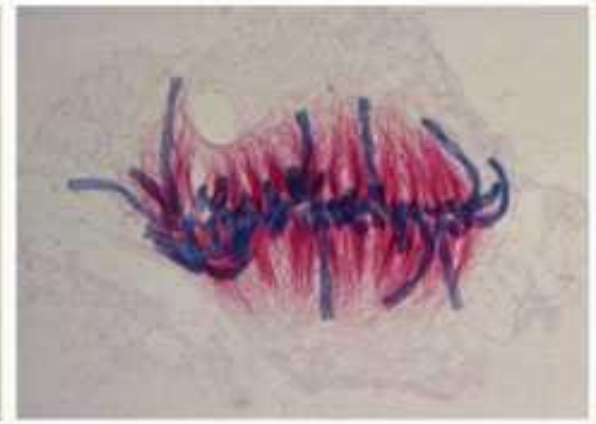
(c) Metaphase: The chromosomes have moved to the equator of the cell.

(d) Anaphase: Sister chromatids have separated, and one set has moved toward each pole.
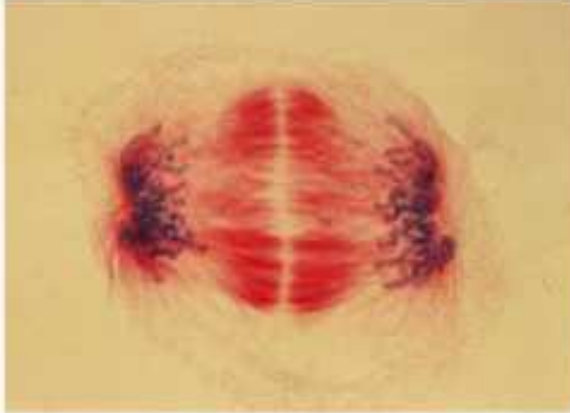
(e) Telophase: The chromosomes have gathered into two clusters, one at the site of each future nucleus.
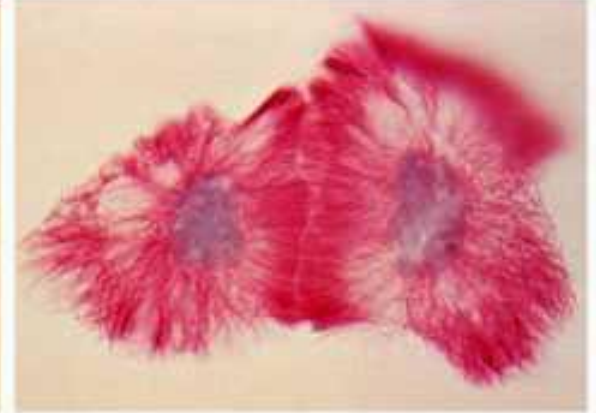
(f) Resumption of interphase: The chromosomes are relaxing again into their extended state. The spindle microtubules are disappearing, and the microtubules of the two daughter cells are rearranging into the interphase pattern.

Each new nucleus is genetically identical to the parent nucleus

Parent Cell Chromosomes have been replicated
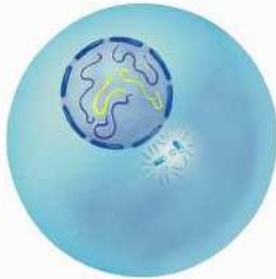
Daughter Cells Each cell has the same genetic makeup as the parent cell

Mitosis

CELL DIVISION

Mitosis

or somatic cell division

A cell divides producing two genetically identical daughter cells.

- new cells are produced for growth or repair of aging or damaged tissues.
- for asexual reproduction.

Interphase:
The stage between two successive cell divisions.
- Prior to mitosis, thin strands of DNA in a cell thicken into chromosomes, which then duplicate.

1 Early Prophase:
- The centrioles divide and, with the asters, move apart.
- The nuclear membrane begins to disintegrate.
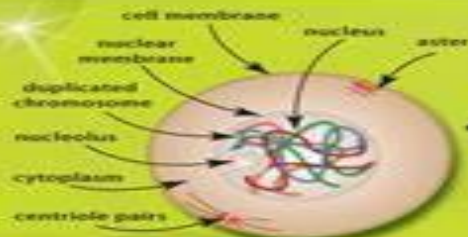
2 Late Prophase:
- The centrioles and asters are pushed to the opposite poles of the cell.
- Spindle fibres extend between the poles.
- The nuclear membrane and nucleolus have almost disappeared.

3 Metaphase:
- The nuclear membrane disappears completely.
- The double chromosomes, their centromeres attached to the spindle fibres, align at the metaphase plate, the midline of the cell.
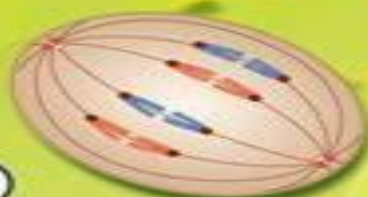
4 Early Anaphase:
- The centromeres split, half moving to one pole and half to the other pole.

5 Late Anaphase:
- The chromosomes have almost reached their respective poles.
- The cell membrane begins to contract at the midline.

6 Telophase:
- The cell membrane completes contraction, closing over to split the cell in two.
- Nuclear membranes form around the chromatin masses within each new daughter cell.

Mitosis completed:
- There are now two cells, with structures and chromosomes identical to each other and to the original cell.

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Meiosis

Characteristics of meiosis

- **1. Occurs in sex cells (germ cells) and produces gametes**

- **2. A reductional division resulting in haploid cells**

- **3. Involves two sequential divisions resulting in four cells**

- **4. Produces cells that are genetically different because of genetic recombination (crossing-over).**

Meiosis produces gametes for sexual reproduction

- **Multiplies number of cells but also reduces chromosome number in each daughter cell to exactly half the number present before meiosis**

- **Daughter cells get 1 member of each homologous pair, i.e. 1 allele for each gene**

- **Mitosis produces 2 daughter cells**

- **Meiosis produces 4 daughter cells**

- **All body cells in humans are diploid, *except* gametes**

- **Cells with 1 member of each homologous pair are haploid**

Meiosis

Parent Cell (2n)

Daughter Cells (1n)

each chromosome has 2 chromatids

Gamete Cells (1n)

1st division

2nd division

Mitosis

- Body cell
- diploid parent cell
- 2N
- dad / mom
- Cell wall
- Nuclear envelope

Prophase
- chromosomes condense
- Nuclear envelope disolves.
- 2N
- centromere chromatids

Metaphase
- Indivudual chromosomes align in middle (metaphase plate)
- 2N
- Spindel fibers.

Anaphase
- Sister chromatids seperate into indivudual chromosome + pull apart.
- 2N

Telophase
- nuclear envelope reforms
- chromosome decondense
- 2N

CytoKenisis
- 2 diploid daughter cells form
- identical to parent.
- 2N

Meiosis

- Body cell
- diploid parent cell
- 2N
- dad / mom
- Nuclear envelope
- cell wall

Prophase I
- Chromosomes condense
- Nuclear envelope breaks dow
- bivalents form
  (bivalent: pair of homologou chromosomes that are associated w/ one another — one mom — one dad.)
- 2N
- Centromere chromatid
- crossing over occurs.

Metaphase I
- Homologous pairs align at the middle (metaphase plate)
  (Homologous chromosomes: Chromosome pairs — one from dad, one from mom)
- 2N

Anaphase I
- Homologous chromosomes move to the oppisite poles of the cell.
- 2N

Telophase I
- Homologous chromosomes seperate
- 2N

Cytokenesis
- 2 haploid cells result.
- N

Prophase II
- Spindles apparatus forms

Metaphase II
- Chromosomes line in middle
- N

Anaphase II
- Sister chromatids seperate + move to opposite sides
- N

Telophase II
- chromosomes move to oppisite po
- N

Cytokenisis
- 4 Haploid daughter cells.
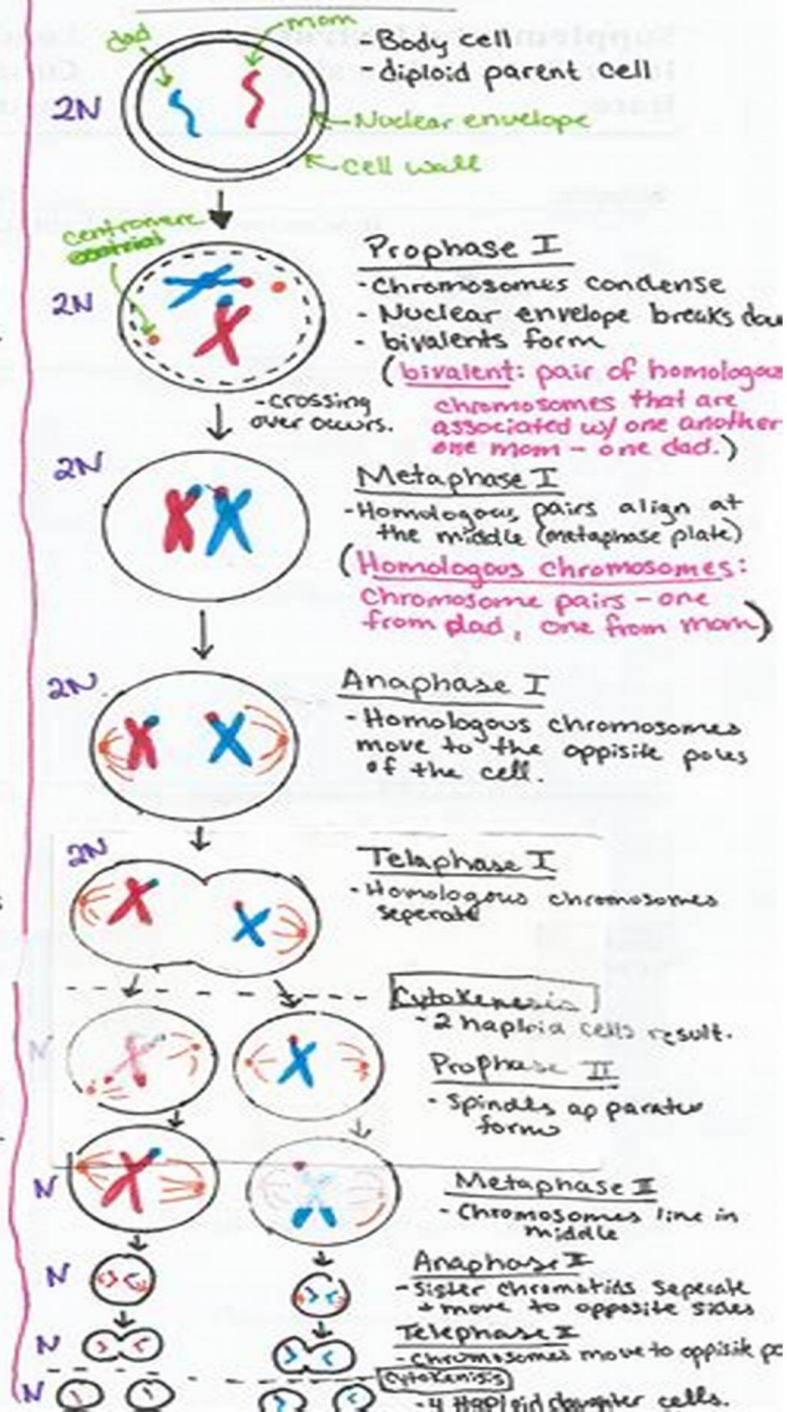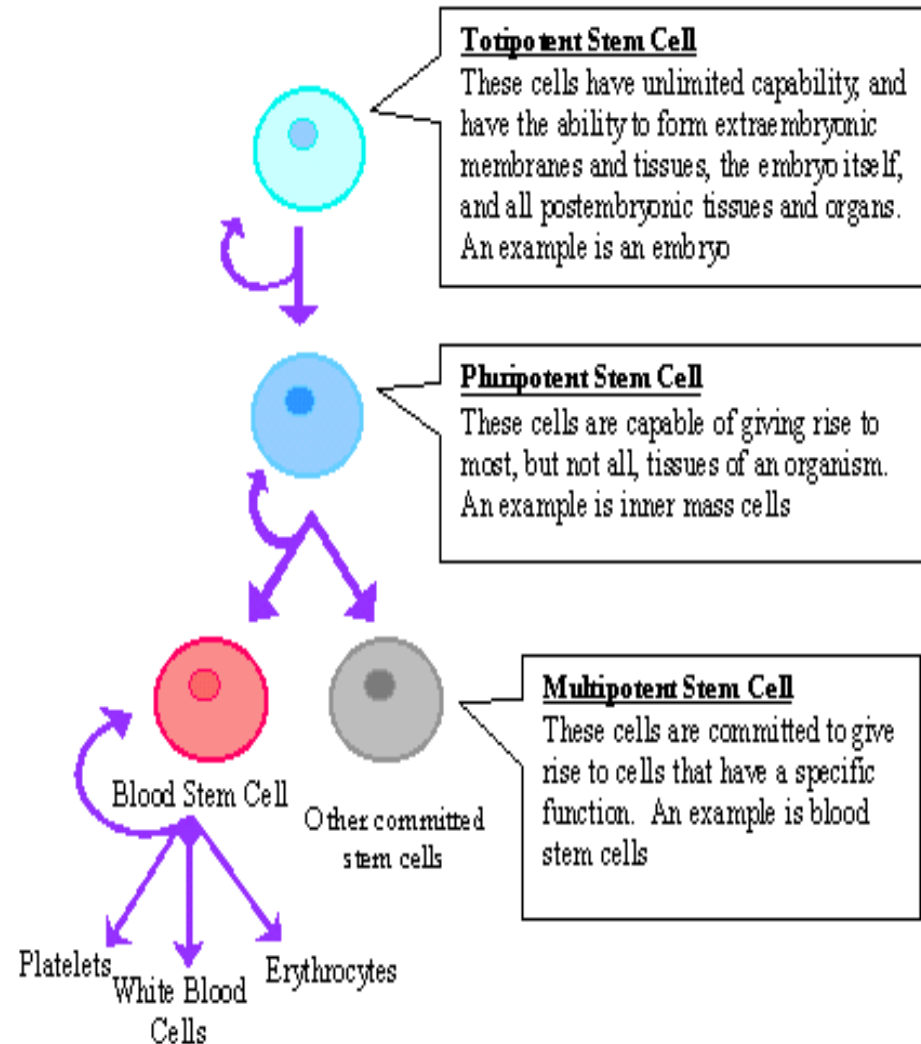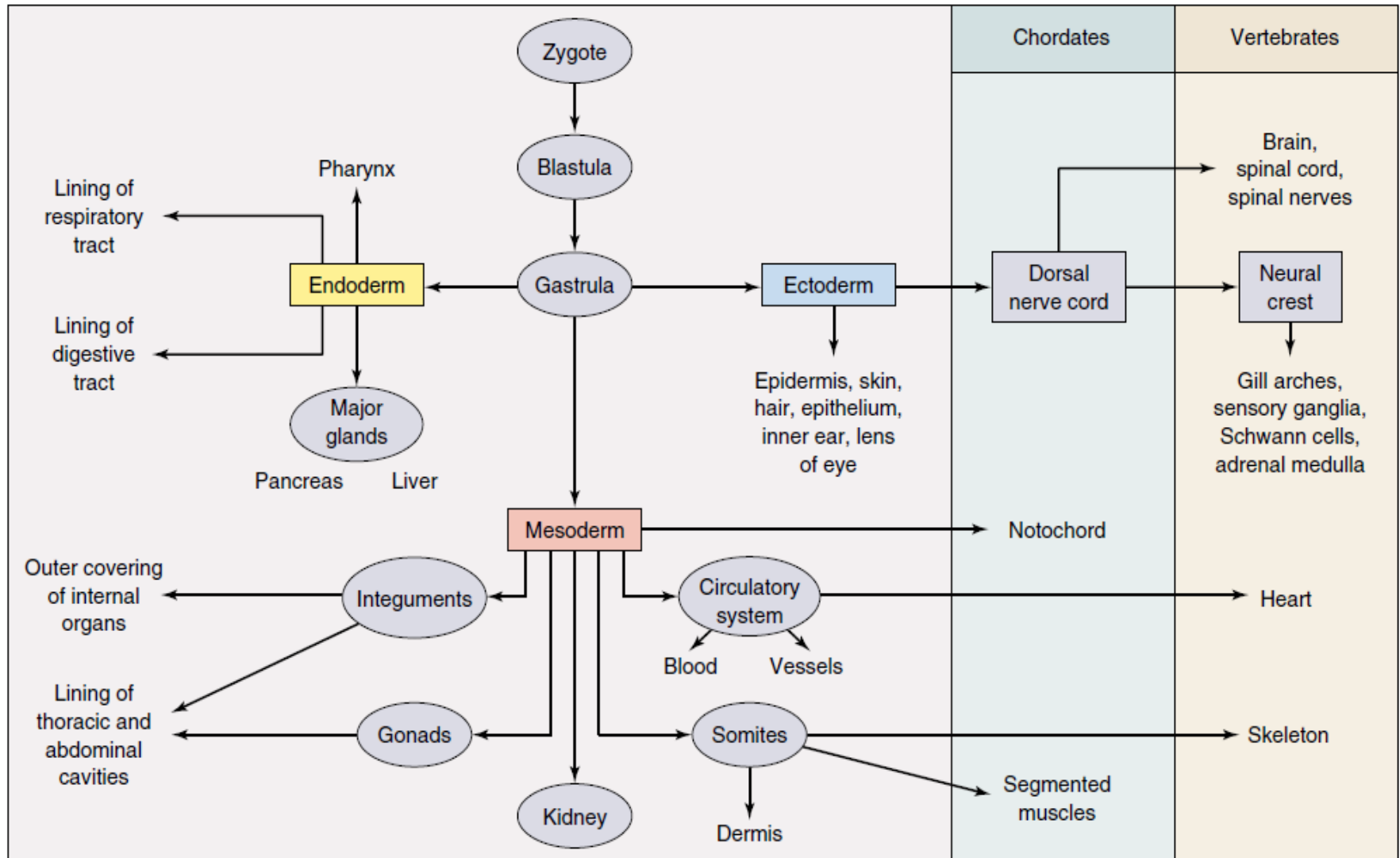- N

Cell Differentiation

- The process of altering the pattern of gene expression and thus becoming a cell of a particular type is called cell differentiation.

- Presence of chemicals (or other influences) starts altering the decisions as to which genes will be turned on or off.

- The zygote is a **totipotent** cell - its daughter cells can become any cell type. As the development proceeds, some of the cells become **pluripotent** - they can become many, but not all cell types.

- Later on, the specificity narrows down further and a particular stem cell can turn into only a very limited number of cell types, e.g., a few types of blood cells, but not bone or brain cells or anything else. That is why embryonic stem cell research is much more promising than the adult stem cell research.

Totipotent Stem Cell
These cells have unlimited capability, and have the ability to form extraembryonic membranes and tissues, the embryo itself, and all postembryonic tissues and organs. An example is an embryo

Pluripotent Stem Cell
These cells are capable of giving rise to most, but not all, tissues of an organism. An example is inner mass cells

Multipotent Stem Cell
These cells are committed to give rise to cells that have a specific function. An example is blood stem cells

Blood Stem Cell

Other committed stem cells
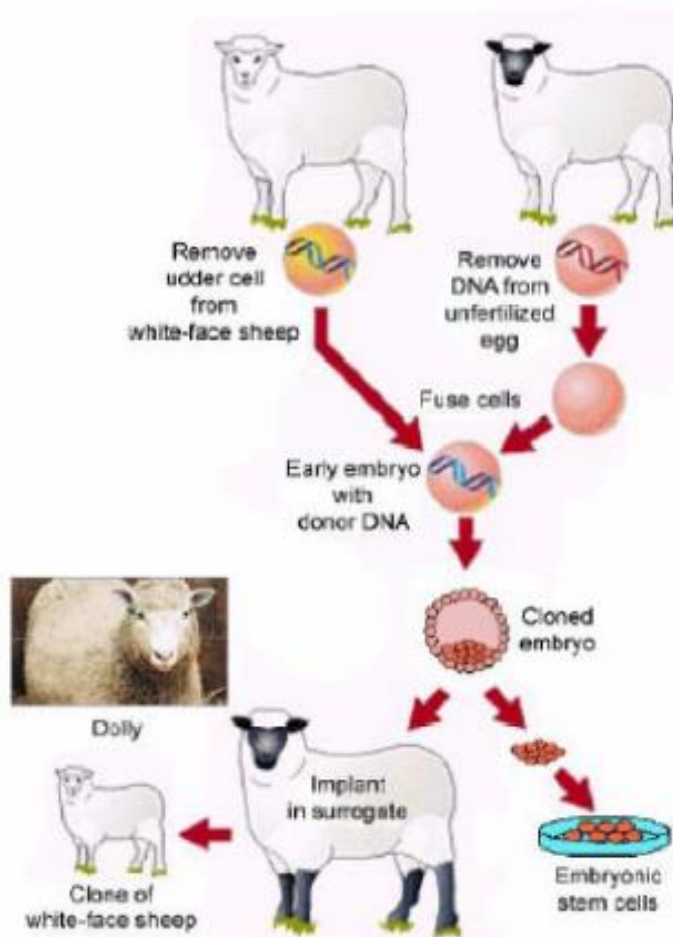
Platelets

White Blood Cells

Erythrocytes

52

Differentiation of different tissues and organs

Stem cells and tissue engineering

Stem cell (SC)- Stem Cells are the cells which has the ability to divide for indefinite periods and which can give rise to specialized cells of various tissues of body.

Importance
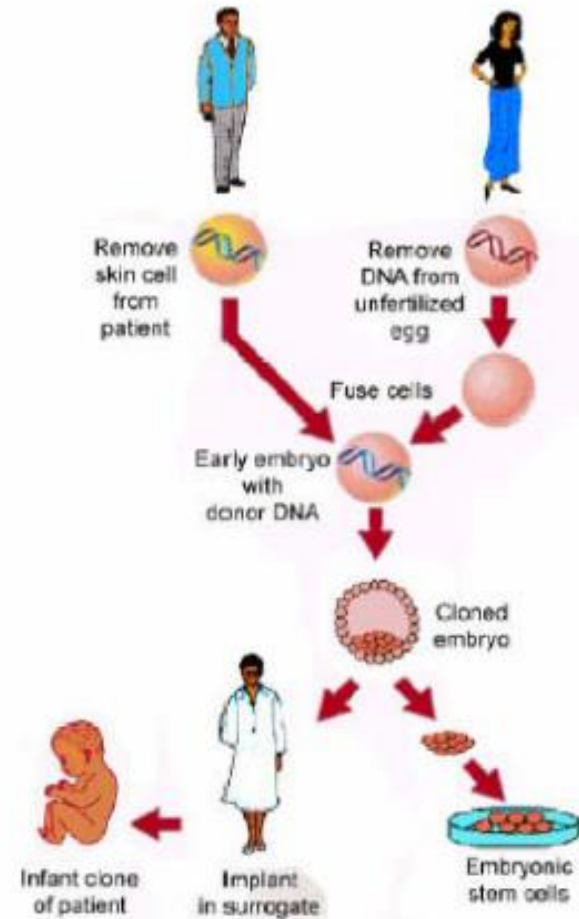
Properties

- Two defining property-Ability to **differentiate** into other cells, ability to **self regenerate**

- It can be maintained in the *in vitro* conditions for extended period using artificial medium

- Its karyotype remains stable even after many division

- It can produce any type of adult cells of the organisms.

Classification of stem cells

Unipotent - cell which can make exact copies of itself indefinitely, can differentiate, and produce same type of cells eg. Adult muscle stem cell

Totipotent- can become any cell type

eg: Morula stage of Embryos

Pluripotent- almost any kind of cell except placenta

eg: Embryonic SC

Multipotent- Produces limited range of cell types

Adult SC: nerve cells, blood cells, muscle cells, bone and skin cells.

Sources of stem cells

1. EMBRYONIC STEM CELLS

    -Isolated from blastocyst stage of embryos

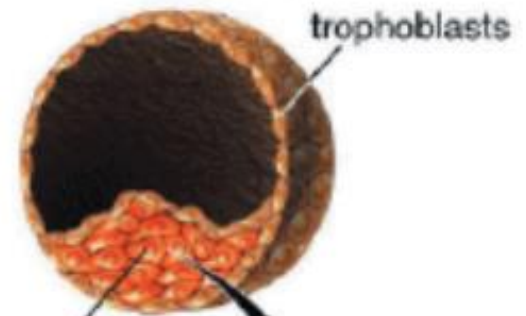   -Pluripotent (capable of developing into almost all the cell types of the body) in nature

2. ADULT STEM CELLS

    -It is present in all the organs, but very little amount

    - They are multipotent (ability of a single stem cell to develop into more than one cell type but with ability to differentiate into a closely related family of cells).

Culture of embryonic stem cells

- Collection of embryos from IVF centres

- Isolation of ICM (inner cell mass) from the blastocyst stage

- Transfer ICM to the center of culture plate containing feeder cells and growth medium

- It can be differentiated to any cells by adding specific medium

Blastocyst
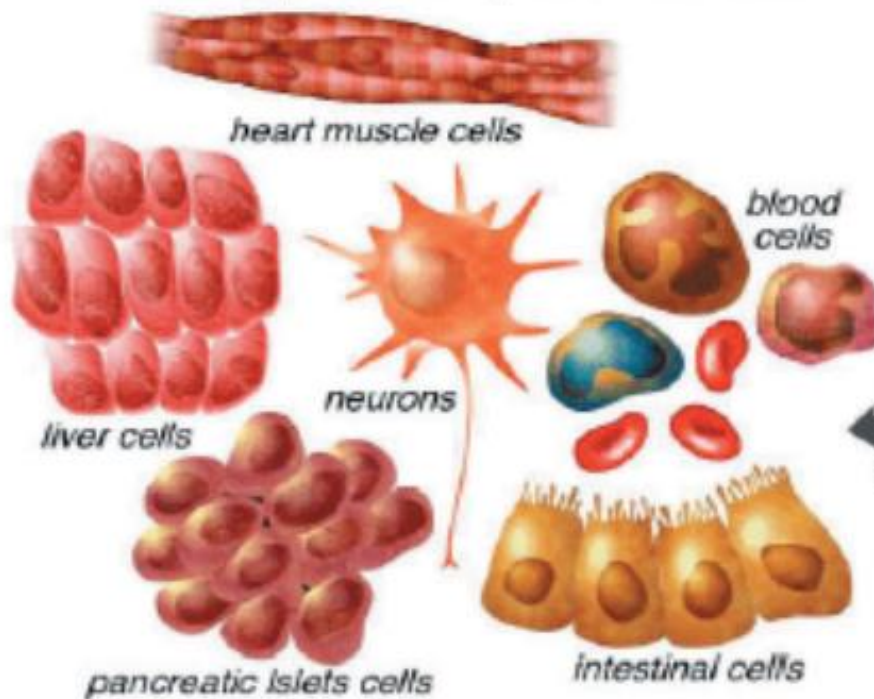(64 to 200 cell stage, cross-section)

trophoblasts

Inner cell mass

Propagation in Culture

Development of specialized cells

heart muscle cells

liver cells

neurons

blood cells

pancreatic islets cells

intestinal cells

Differentiation

Pluripotent embryonic stem cells

In vitro fertilization

Sperm Egg

Fertilized egg

Morula Blastocyst **Remove inner cell mass**

Pluripotent stem cells

Skin cell Pancreatic cell

Nerve cell

Transplant to patient

Illustration by Cell Imaging Core of the Center for Reproductive Sciences.
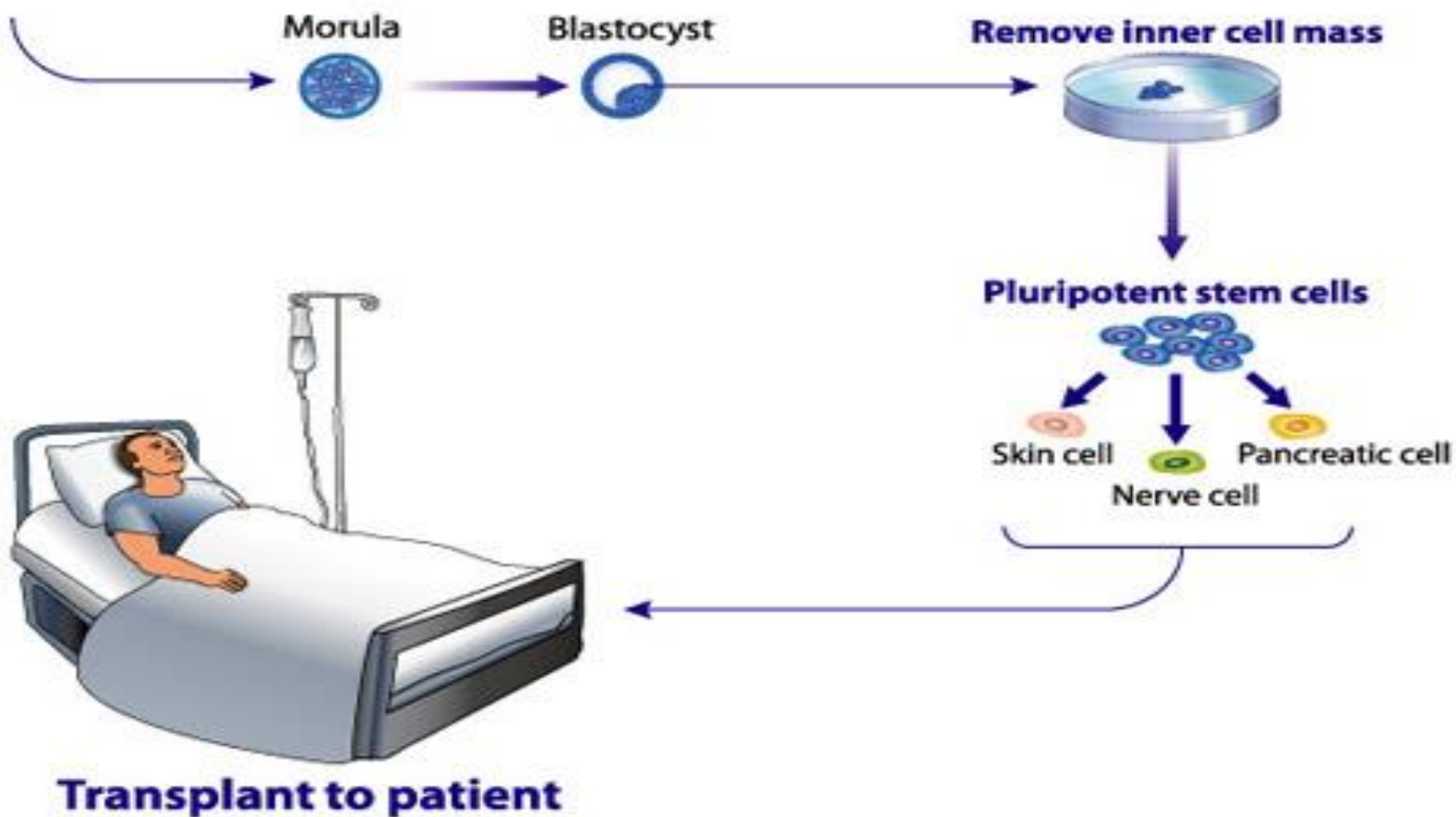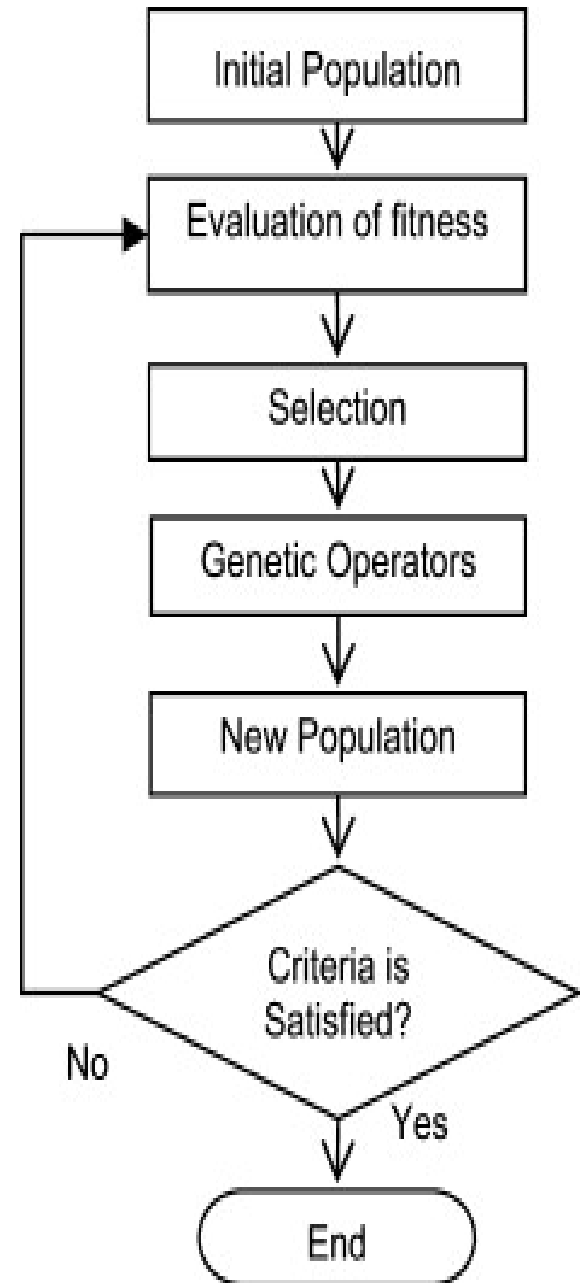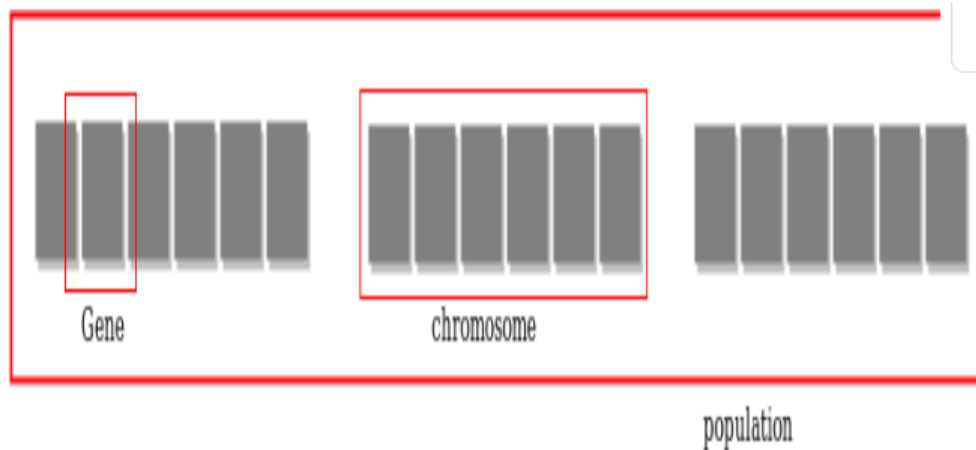
Genetic Algorithms

- **Genetic algorithms (GA) in programming, simulate the process of natural selection** which means those species who can adapt to changes in their environment are able to survive and reproduce and go to next generation. In simple words, they simulate "survival of the fittest" among individual of consecutive generation for solving a problem.

- Genetic algorithms are based on an analogy with genetic structure and behaviour of chromosomes of the population.

- Following is the foundation of GAs based on this analogy –

1. Individual in population compete for resources and mate

2. Those individuals who are successful (fittest) then mate to create more offspring than others

3. Genes from "fittest" parent propagate throughout the generation, that is sometimes parents create offspring which is better than either parent.

4. Thus each successive generation is more suited for their environment.

Initial Population

Evaluation of fitness

Selection

Genetic Operators

New Population

Criteria is Satisfied?

No

Yes

End

Components of a search space in Genetic algorithm

- Gene represents a single solution to a problem
- chromosome (individual) is composed of several genes or multiple similar solutions.
- population of individuals are maintained within search space - all solutions to the problem

The whole algorithm can be summarized as –
1) Randomly initialize n populations
2) Determine fitness of population
3) Until convergence repeat:
    a) Select parents from population
    b) Crossover and generate new population
    c) Perform mutation on new population
    d) Calculate fitness for new population

The Fitness score

- The GAs maintains the population of n individuals (chromosome/solutions) along with their fitness scores.

- The individuals having better fitness scores are given more chance to reproduce than others.

- The individuals with better fitness scores are selected who mate and produce **better offspring** by combining chromosomes of parents.

- Always the new generation of solutions will have better fitness than the parent population.

Operators for GA
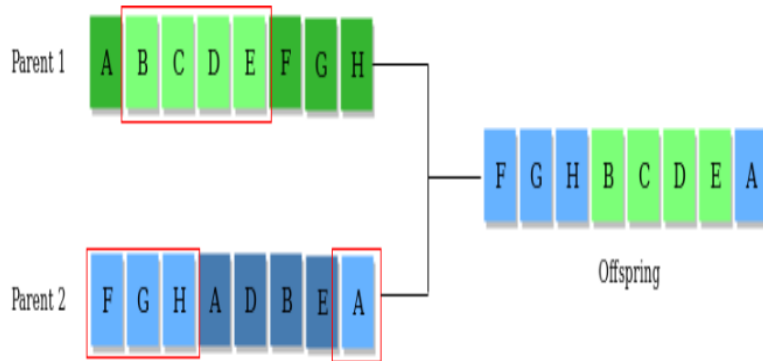
Crossover

Mutation

- The Algorithm uses certain biological concepts as operators to find better solutions

- **CrossOver**

- **Mutation**

- **Selection** (best fitness score in previous generation)

Uses of GA

Genetic Algorithms are primarily used in optimization problems of various kinds, but they are frequently used in other application areas

- **Optimization** − Genetic Algorithms are most commonly used in optimization problems wherein we have to maximize or minimize a given objective function value under a given set of constraints

- **DNA Analysis** − GAs have been used to determine the structure of DNA using spectrometric data about the sample.

- **Neural Networks** − GAs are also used to train neural networks, particularly recurrent neural networks.

- **Parallelization −** GAs also have very good parallel capabilities, and prove to be very effective means in solving certain problems, and also provide a good area for research.

Advantages-disadvantages of GA

- Does not require any derivative information (which may not be available for many real-world problems).

- Is faster and more efficient as compared to the traditional methods.

- Provides a list of "good" solutions and not just a single solution.

- GAs are not suited for all problems, especially problems which are simple and for which derivative information is available.

- Fitness value is calculated repeatedly which might be computationally expensive

- Being stochastic, there are no guarantees on the optimality or the quality of the solution.

Thank you