Life and Cells

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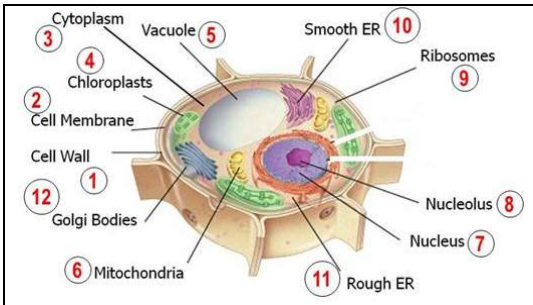


Notes:

Kehidupan terletak pada sel karena tidak ada kehidupan yang tanpa sel, tetapi satu sel saja dapat mendukung kehidupan sebagaimana ditunjukkan organisme sel tunggal (unicellular organism) seperti bakteri, arkea (archea), protozoa, serta ganggang sel dan jamur sel tunggal.
Kehidupan yang terdapat dalam sel ditentukan oleh semua komponen sel yang sangat terbatas dalam organisme sel tunggal.

Teaching should be such that what is offered is perceived as a valuable gift and not as a hard duty. *Albert Einstein*

LEARNING OUTCOME

Students, after mastering materials of the present lecture, should be able

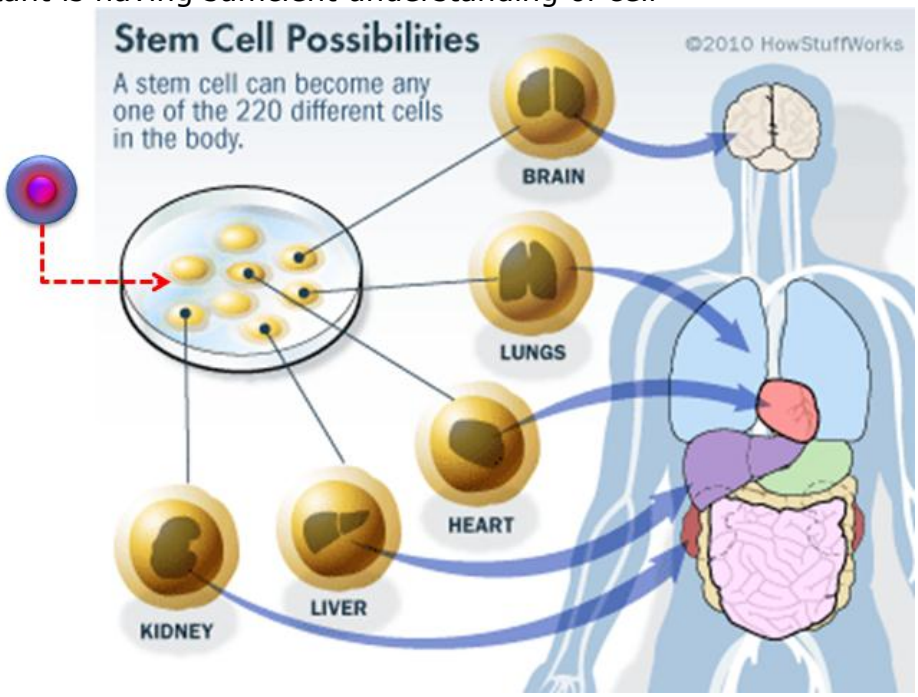
1. to explain the organization and the activity of living systems
2. to explain basic description of cells and cell theory
3. to explain cell structure and cell constituents
4. to explain the function of the cell constituents
5. to illustrate the importance of cell as the building block of live

LECTURE OUTLINE

1. INTRODUCTION Biological Organization Quark 2. CELLS Prokaryotes and Eukaryotes Animal and Plant Cells	3. PLANT CELL STRUCTURE 4. STEM CELL

STEM CELL

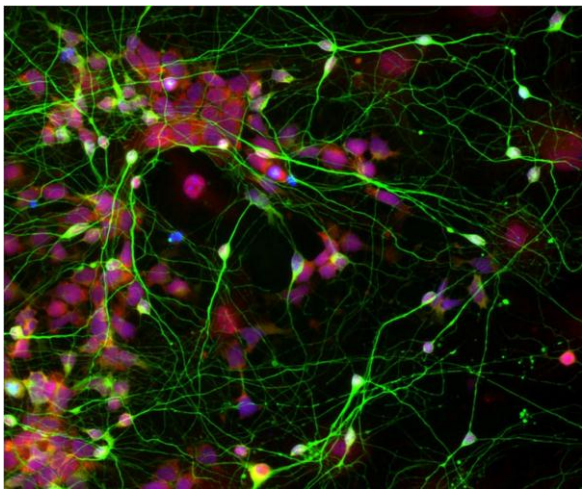
How important is having sufficient understanding of cell



Stem cells are undifferentiated biological *cells* that can differentiate into specialized *cells* and can divide (through mitosis) to produce more *stem cells*.
http://s.hswstatic.com/gif/stem-cell-possibilities.gif

Breakthrough in understanding how stem cells become specialized . By Jessica Moore, August 4, 2016
Scientists at Sanford Burnham Prebys Medical Discovery Institute (SBP) have made a major advance in understanding how the cells of an organism, which all contain the same genetic information, come to be so diverse.

- A new study published in *Molecular Cell* shows that a protein called **OCT4** narrows down the range of cell types that stem cells can become.
- The findings could impact efforts to produce specific types of cells for future therapies to treat a broad range of diseases, as well as aid the understanding of which cells are affected by drugs that influence cell specialization.



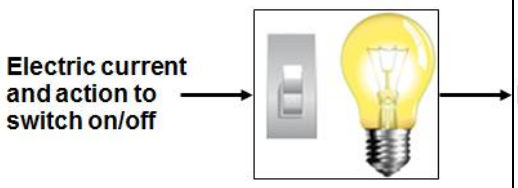
http://beaker.sbpdiscovery.org/wp-content/uploads/2016/08/stem-cell-reprogramming.jpg

Notes:

1. INTRODUCTION

1. Biological Organization

- **Life is a performance of living systems**, and systems are considered **alive** when the systems are **working**, and contrarily **dead** when the systems are **not working**.



- Life systems can be understood from the biological organization of living systems
- Life is not easy to define, but characterized by organization and activity/ability
- **Biological Organization**
  1. Subatomic Particles
  2. **Atoms**
  3. Molecules (Small Molecules, Macromolecules & Molecular Assemblies)
  4. Organelle
  5. **Cell**
  6. Tissue
  7. Organ
  8. Organ System
  9. **Organism**
  10. Population
  11. Species
  12. Community
  13. Ecosystem
  14. **Biosphere**

1. **Subatomic Particles:** Protons, neutrons and electrons are the main subatomic particles which reside in a substance.
2. **Atoms:** Atoms are defined as the smallest unit or the basic building blocks of matter which make up all objects. Atoms are made up of equal number of protons and

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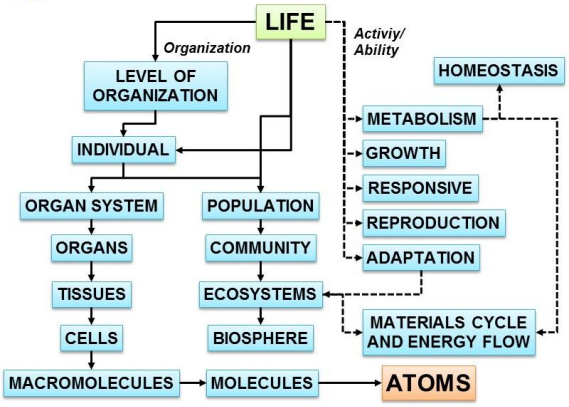
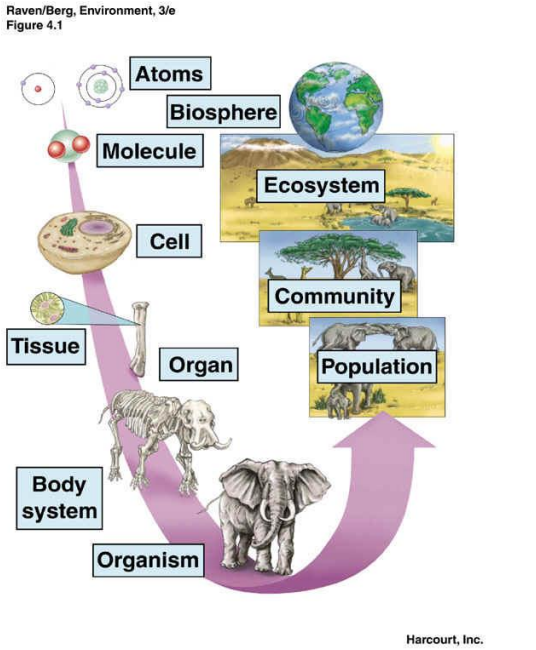




www.desktopclass.com/education/fafsc/levels-o...

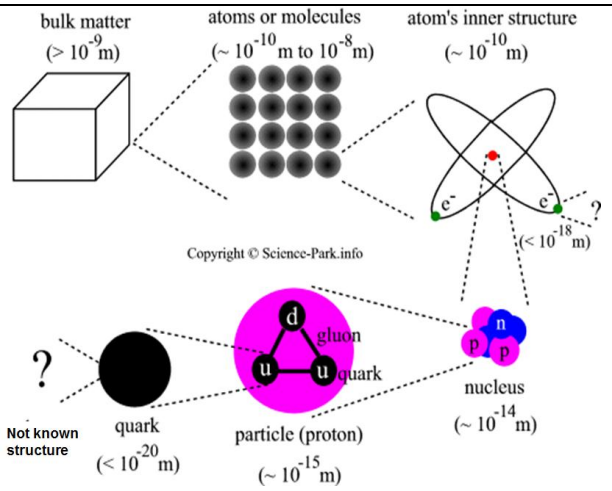
Notes:

electrons

3. **Molecules**
   - **Small Molecules:** Larger molecules are made up of some building blocks and these blocks are attributed as small molecules. Examples of such molecules are amino acids, fatty acids, glucose, etc.
   - **Macromolecules:** Macromolecules are defined as large or gigantic molecules which populate a cell and render the important functions of life. Examples are carbohydrates, lipids, proteins, nucleic acids, etc.
   - **Molecular Assemblies:** These assemblies are organized sets which comprise one or more molecular entity (i.e. the microtubule, conveyor belts inside the cells, and the cell membrane or plasma membrane).

4. **Organelle:** Organelle means little organs and is a specialized part of a cell (i.e. the nucleus, endoplasmic reticulum, mitochondria, etc.)
5. **Cell:** The smallest unit of life (living organisms), and is the structural and functional units of organisms (i.e. bacteria, amoeba, archaebacteria, etc, are all single-celled organisms, and humans and many other organisms are multicellular)
6. **Tissue:** It is a group of cells with similar or different characteristics, and attributed with a particular set of functions in the body of the living organismn (i.e. meristematic and permanent tissues in plants).
7. **Organ:** It is an organization of different types of tissues
8. **Organ System:** It is a group of organs for performing a broad set of functions, particularly in multi-cellular organisms.
9. Organism: It can be regarded as the complete framework of organ systems, organs, organelle and all other components which work in their own specific way in order to carry out the various processes of life (i.e. plants, animals, humans, bacterium, etc).
10. Population: A group of inter-breeding organisms of the same species inhabiting a defined area is termed as a population.
11. Species: Species is merely a defining term given to a specific kind of organism.

12. Community: A group of interacting organisms of different species living in a given area is termed as a community.
13. Ecosystem: An ecosystem is made up of both biotic or abiotic components of the environment such as the climate, landscape, animals and plants; interaction of a group of organisms and their environment, to be precise!
14. Biosphere: It is simply defined as the regions on, below, and above the surface, and atmosphere of the Earth where living organisms exist.



2. Quark

- Quarks are believed to be one of the basic building blocks of matter.
- Quarks were first discovered in experiments done at the Stanford Linear Accelerator Center in the late 1960's and early 1970's.
- Three families of quarks are known to exist, and each family contains two quarks.
- **Up and Down quarks**, the quarks that join together to form protons and neutrons.
- **Strange and Charm quarks** only exist at high energies.
- **Top and Bottom quarks** only exist at very high energies. The Top quark was finally discovered in 1995 at the Fermi National Accelerator Laboratory.

Notes:

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2. CELLS

1. Basic Description

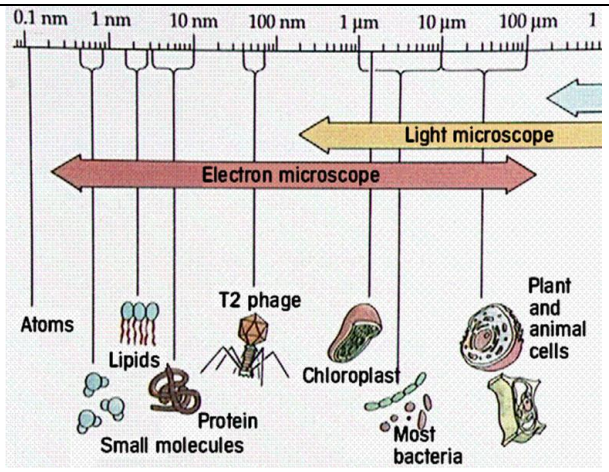
- Cells of plants are tiny, measuring on average about 10-100 mm across (1 cm = 100-1000 cells).
- **Cells** are
  - the basic units of life, building blocks of organisms, the smallest unit of living matter , and the structural and functional units of all living organisms.
  - the biological unit of an organism that is capable of independent functioning - it can live on its own under the right conditions.
  - basic units consisting of one or more nuclei, cytoplasm, and various organelles, all surrounded by a semipermeable cell membrane

2. History

- **Robert Hooke**. The cell was first discovered in 1665 by Robert Hooke examining very thin slices of cork and saw a multitude of tiny pores that remarked looked like the walled compartments of a honeycomb which was then called cells.
- ***Micrographi****a.* The description of these cells (which were actually non-living cell walls), without structure or function understanding, was published in *Micrographia*. His cell observations gave no indication of the nucleus and other organelles found in most living cells.

Significant Events in Cell Biology

1655 Cells of a tree cork was first observed by Robert Hooke.
1674 Protozoa was observed by Leeuwenhoek.
1683 Bacteria was observed by Leeuwenhoek.
1831 Nucleus was first identified by Robert Brown.
1838 **The Cell Theory was proposed by**



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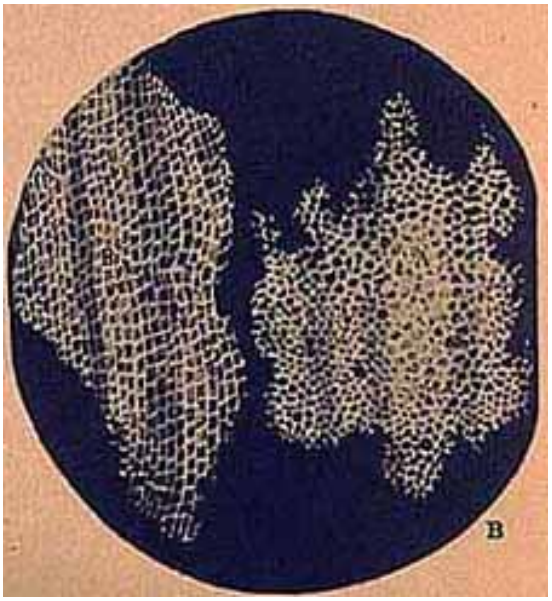


Notes:

Schleiden and Schwann (after ± 183 yrs).

1857 Mitochondria was described by Kolliker.
1869 DNA was isolated for the first time by Miescher.
1882 Bacteria was identified by Kock.
1898 Golgi apparatus was discovered by Golgi.
1931 Transmission Electron Microscope was built by Ruska.
1953 DNA double-helix structure was proposed by Watson and Crick.
1965 - First commercial Scanning Electron Microscope produced.
1997 First sheep cloned.
1998 - Mice cloned.
2003 - Human genome DNA sequence draft completed.
2010 The first synthetic cell was created at the J. C. Venter Inst. **(after 355 yrs)**

3. Cell Theory

Cell theory refers to the idea that cells are the basic unit of structure in every living thing.

1. All organisms are composed of one or more cells.
2. The cell is the basic living unit of organization for all living things
3. All cells arise from preexisting cells
4. Cells contain all of the hereditary information

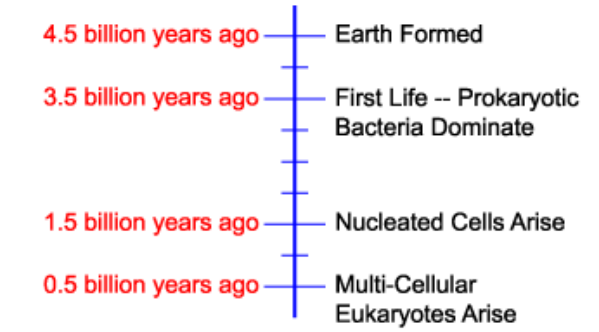
The modern tenets of the Cell Theory include:

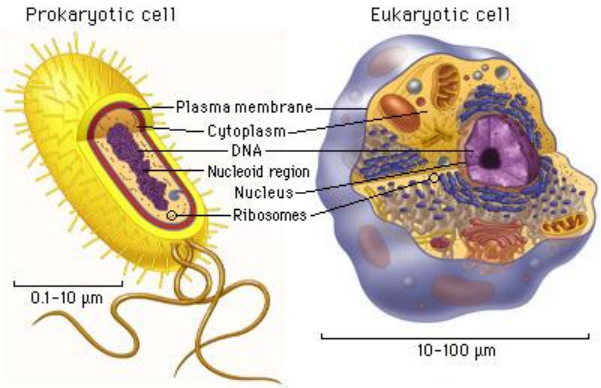
1. all known living things are made up of cells.
2. the cell is structural & functional unit of all living things.
3. all cells come from pre-existing cells by division. (Spontaneous Generation does not occur).
4. cells contains hereditary information which is passed from cell to cell during cell division.
5. all cells are basically the same in chemical composition.
6. all energy flow (metabolism & biochemistry) of life occurs within cells.

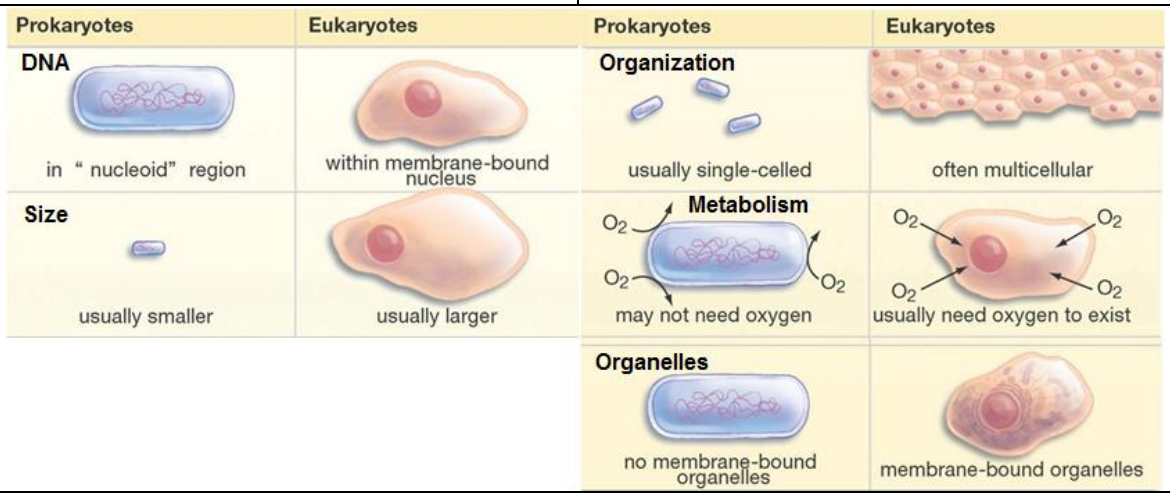
4. Type of Cells

Cells can be subdivided into two subcategories: ***Prokaryotes & Eukaryotes***

- ***Prokaryotes***:
  - the term means "before the nucleus"
  - lack a nucleus (though they do have circular DNA)
  - lack other membrane-bound organelles (though they do contain ribosomes)
  - Bacteria and Archaea are two divisions of prokaryotes.
- ***Eukaryotes***:
  - have distinct nuclei and membrane-bound organelles (mitochondria, chloroplasts, lysosomes, rough and smooth endoplasmic reticulum, vacuoles).
  - possess organized chromosomes which store genetic material.





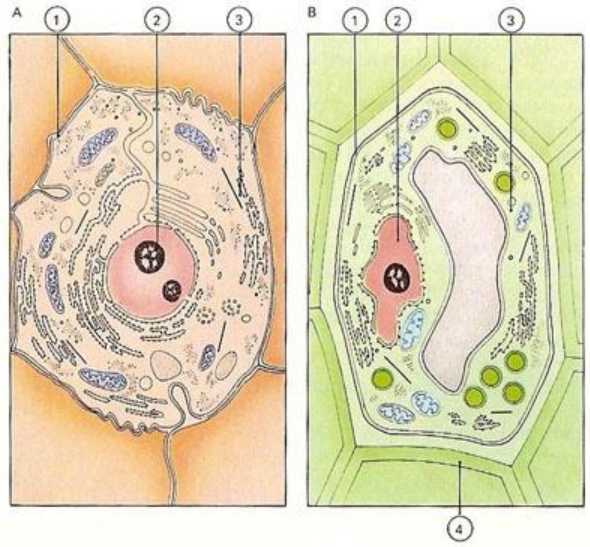


5. Animal and Plant cells

- Both animal (A) and plant (B) cells have
  - a cell membrane (1),
  - nucleus (2), and
  - cytoplasm (3).

- Plant cells have also
  - a cell wall (4) and
  - certain organelles, notably chloroplasts,

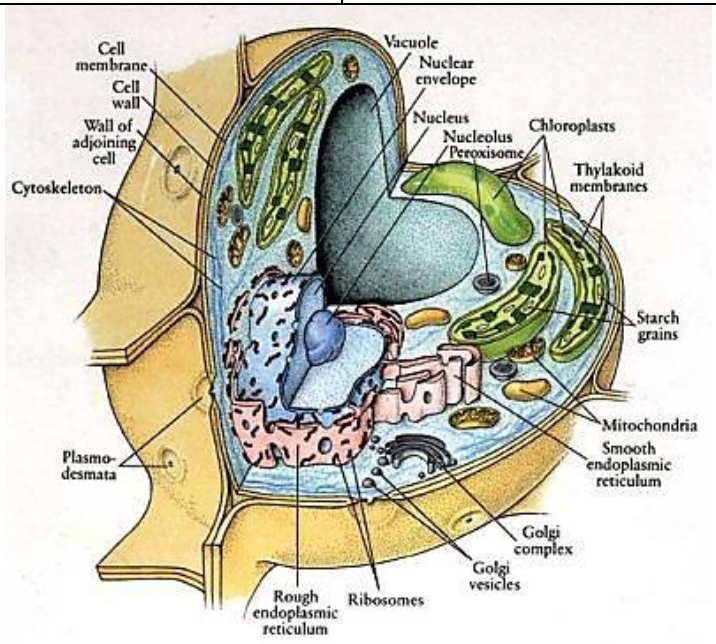
  which are unique to plant cells



3. PLANT CELL STRUCTURE

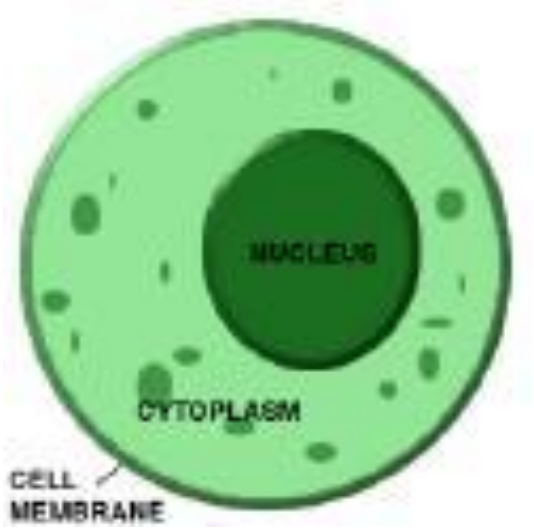
Main components

1. Cytoplasm
2. Nucleoplasm
3. Nucleus – largest organelle
4. Nucleolus (nucleoli plural)
   - Chromatin
   - Chromosomes
5. Ribosomes
6. Endoplasmic reticulum (ER)
   - Smooth ER
   - Rough ER
7. Golgi Complex
8. Lysosomes (in animals)
9. Vacuoles
10. Mitochondria
11. Chloroplasts
12. Other plastids
13. Microbodies
14. Cytoskeleton
15. Cell Wall
16. Membrane
17. Endosome



An electron micrograph of a **wheat leaf cell**. Note the ring of cytoplasm-containing chloroplast (→) that surrounds a large vacuole (courtesy of Kitty Plaskitt)

1. **Cytoplasm**
   - It is the jelly-like fluid that fills a cell outside of nucleus, and made up of mostly water and salt.
   - It provides mechanical support to the internal structures and biochemical support to the cell.
2. **Nucleoplasm**
   - It is a gelatinous liquid within the nucleus that surrounds the chromosomes and the nucleoli membrane. It functions to support DNA and nucleolus in the nucleus
3. **Nucleus** – largest organelle
   - It contains DNA, nucleolus and nucleoplasm, and is bound by a double membrane known as the nuclear envelope with many nuclear pores
   - It is the control center of the cell
4. **Nucleolus** (nucleoli plural)
   - It is composed of protein, RNA, and DNA, and also known as the ribosome factory.
   - Ribosomes leave through pores and are found free in the cytoplasm or associated with Endoplasmic reticulum



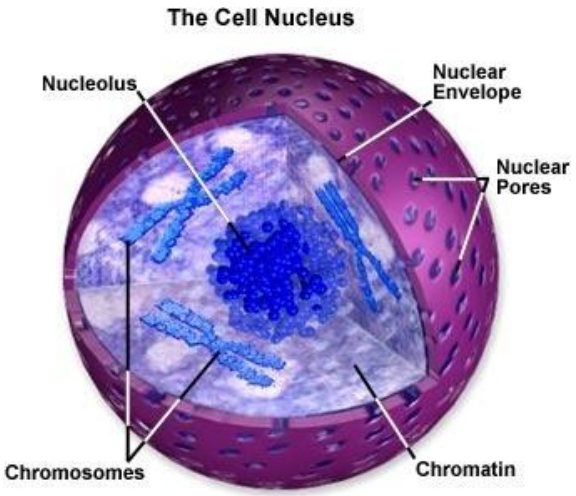
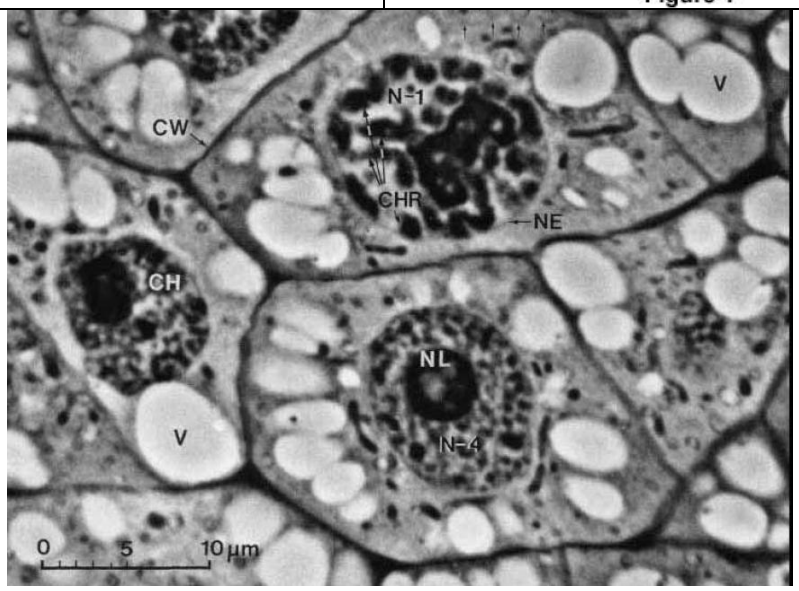


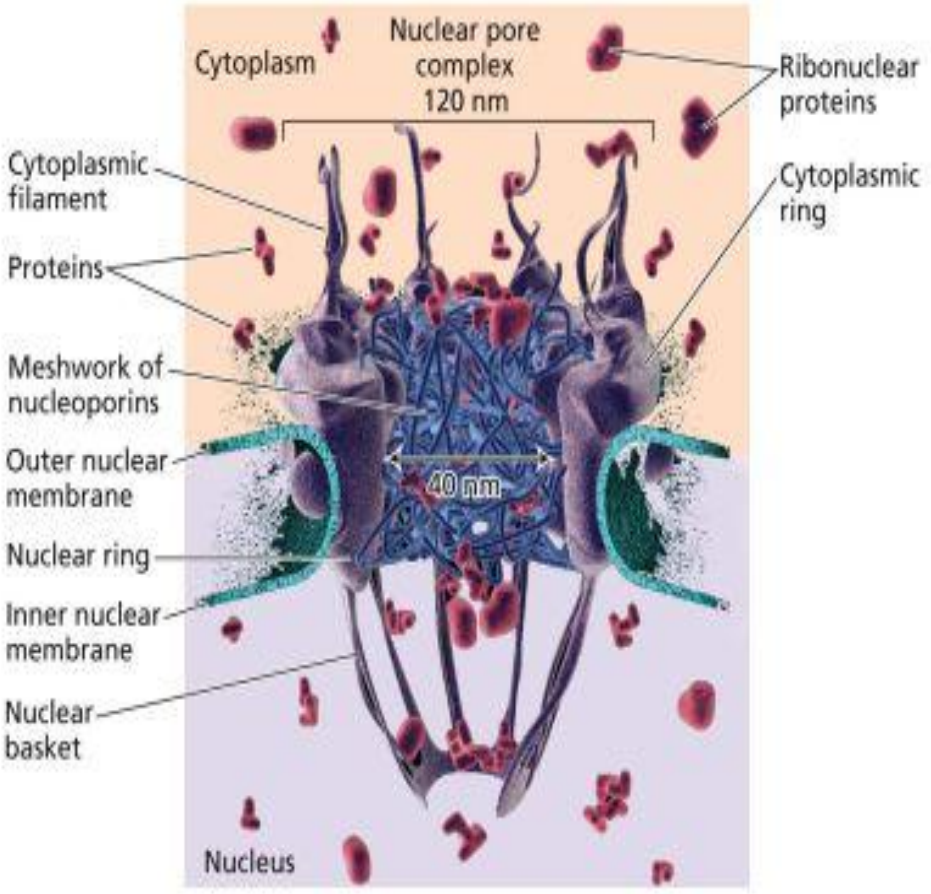
Figure 1



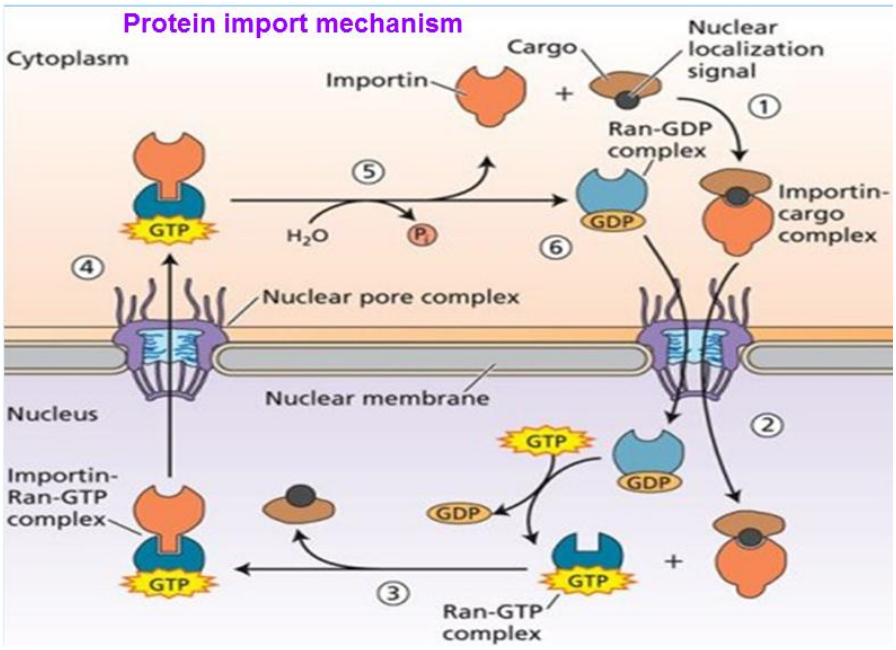
The Plant Cell under Electron Microscopy. Source: Gunning (1996)

Notes:

Nuclear pore complex acts as a supramolecular sieve that allows molecules to enter and exit nuclear cell



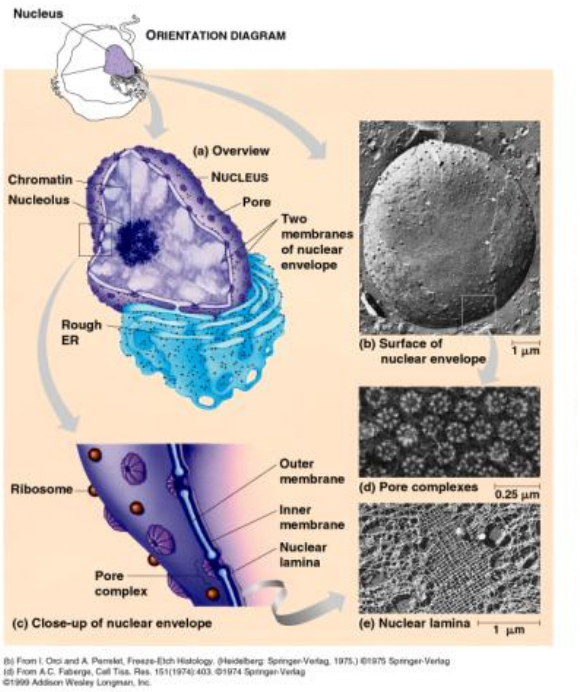
Web Figure 1.6.A Nuclear pore complex spans both membranes of the nuclear envelope. The proteins that make up the pore are called **nucleoporins**.



Web Figure 1.7.A The mechanism of protein import into the nucleus. (After Lodish *et al*. 2004.)

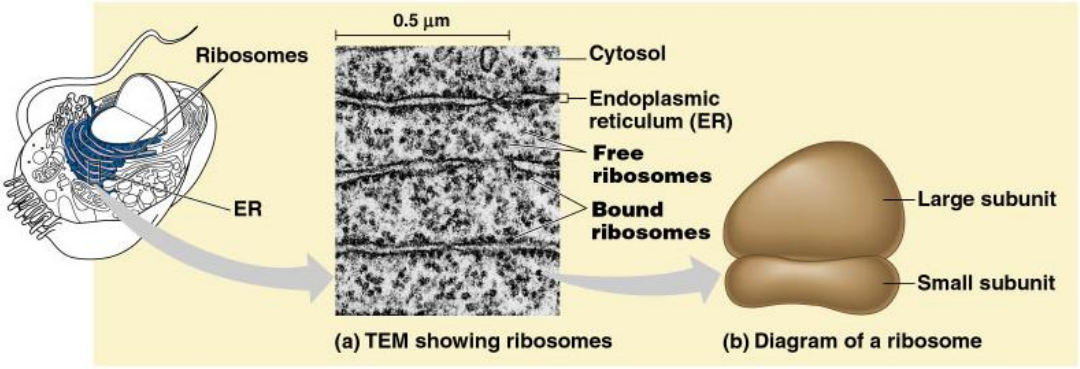
Genetic material in the Nucleus

- **Chromatin**
  - Seen in cells that are not dividing
  - Decondensed DNA associated with RNA and proteins
- **Chromosomes**
  - Seen in cells that are dividing
  - Condensed DNA in a highly organized and compact form
  - *nucleolus*: rRNA; ribosome synthesis



5. Ribosomes

- It consist of small particles of RNA and protein lying free in the cytoplasm or else attached to the endoplasmic reticulum.
- They aggregate in clusters, chains, spirals, or other polyribosome configurations when they are engaged in protein synthesis.

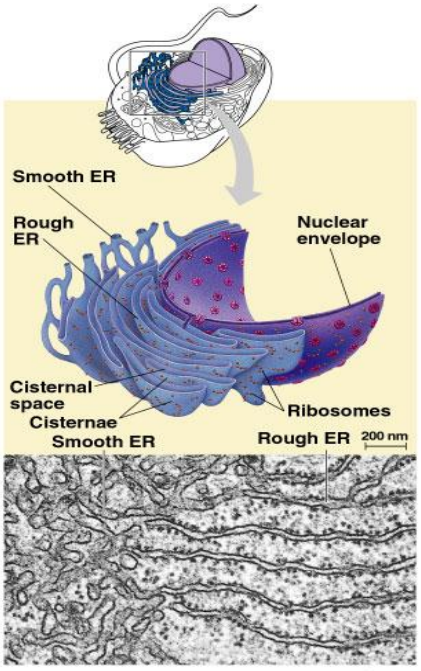


TEM = Transmission Electron Microscopy

Notes:

6. Endoplasmic reticulum (ER)

- It is membranous cisternae that ramify through the cytoplasm, occasionally connected to the outer membrane of the nuclear envelope. Membranes act to divide up the cytoplasm into compartments and channels
- Function: The internal delivery system of the cell.
- Smooth ER
  - no ribosomes;
  - Functions: synthesis of lipids, phosolipid & steroid ; metabolism of carbohydrates; detoxification of drugs and poisons.
- **Rough ER**
  - with ribosomes;
  - Functions: synthesis of secretory proteins (glycoproteins) & membrane production.



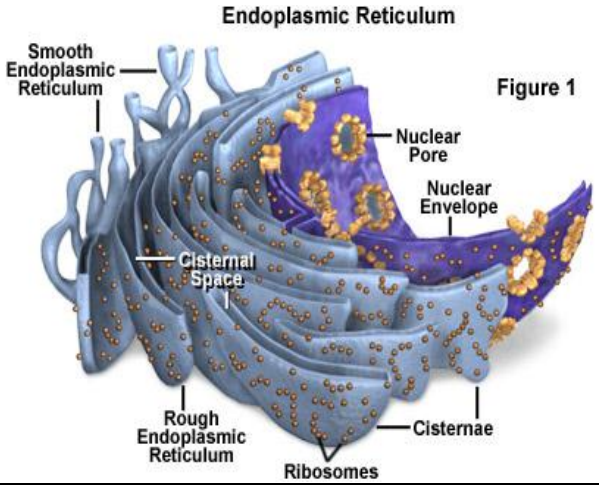
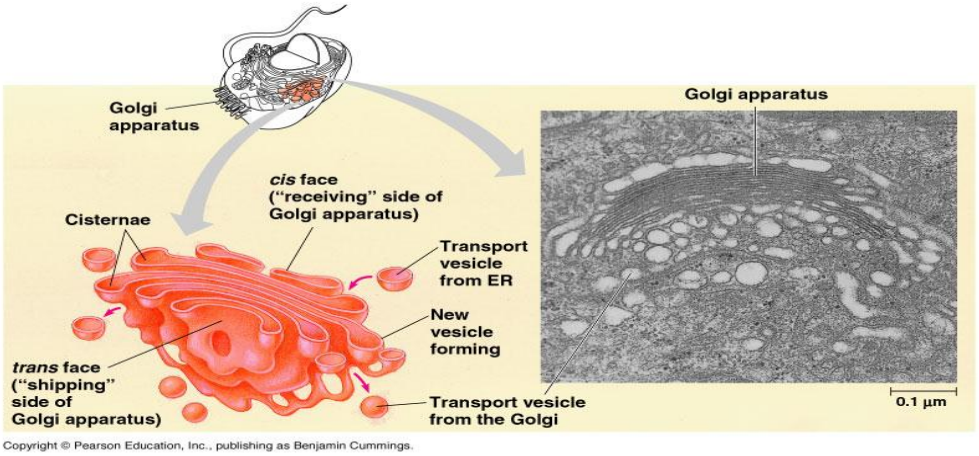


Figure 1

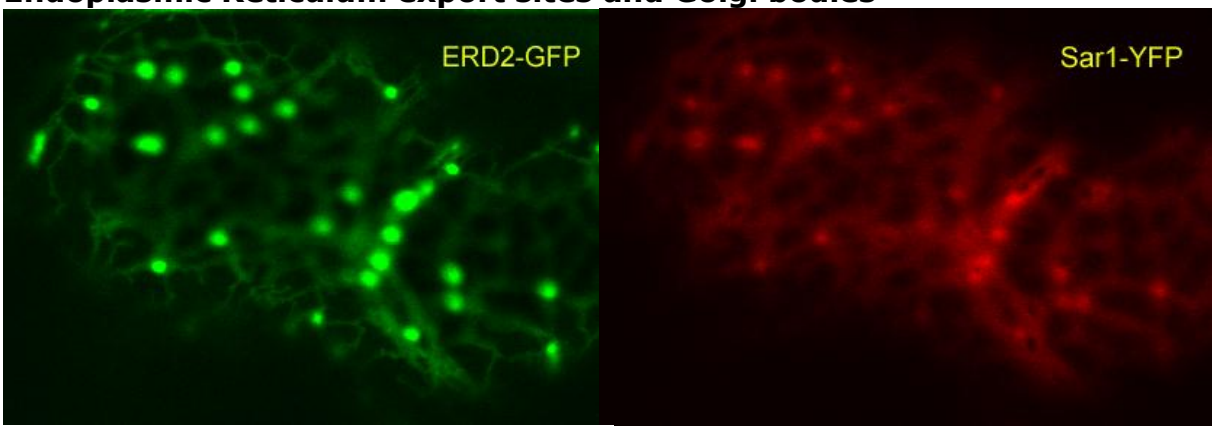
7. Golgi Complex

- It, also called the golgi apparatus or golgi body, looks like a stack of pancakes, and is located near the nucleus.
- The golgi body packages proteins and carbohydrates into membrane-bound vesicles for "export" from the cell.



Notes:

Endoplasmic Reticulum export sites and Golgi bodies



ER export sites + Golgi bodies

behave as

SMSU

(single mobile secretory units)

in plant cells

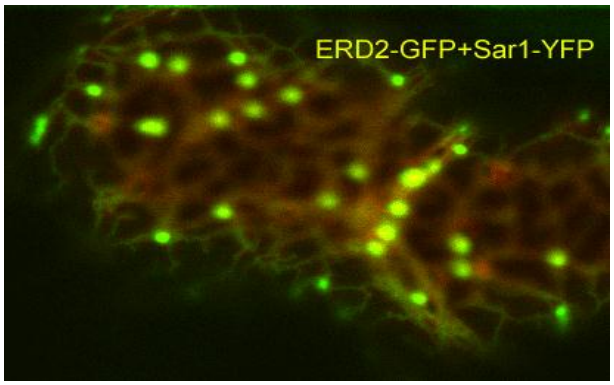
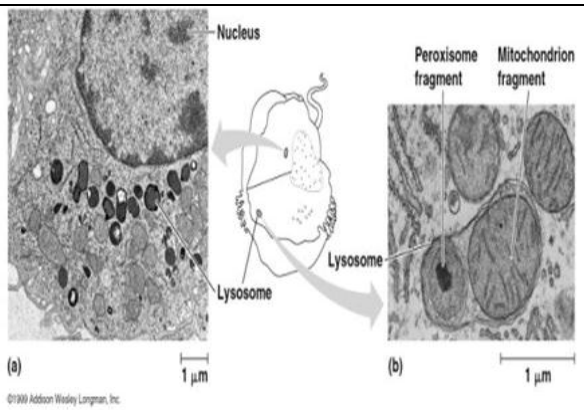


Image and Movies from daSilva LL, Snapp EL, Denecke J, Lippincott-Schwartz J, Hawes C, Brandizzi F.. *Plant Cell.* 2004 Jul 16(7):1753-71. Epub 2004 Jun 18. http://5e.plantphys.net/image.php?id=699

Notes:

8. Lysosomes (in animals)

- sac of hydrolytic enzymes (powerful digestive enzymes); digestion of macromolecules
- Function as the cell's recycling center by digesting worn-out organelles or materials ingested by cell:
  - **Autophagy**: recycle cell's own organic material
  - **Tay-Sachs disease**~lipid-digestion disorder
  - **Rheumatoid arthritis** is due to damage in joints due to leaky white blood cell lysosomes

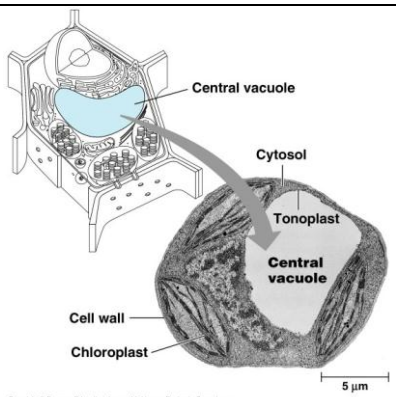


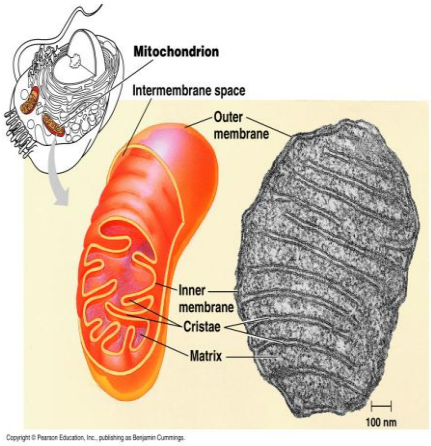
Notes:

9. Vacuoles

- membrane-bound sacs (larger than vesicles)
- Food (phagocytosis)
- Contractile (pump excess water)
- Central (storage in plants) tonoplast membrane

Phagocytosis is the process of ingestion of harmful foreign particles often by phagocytes (cells or organelles)





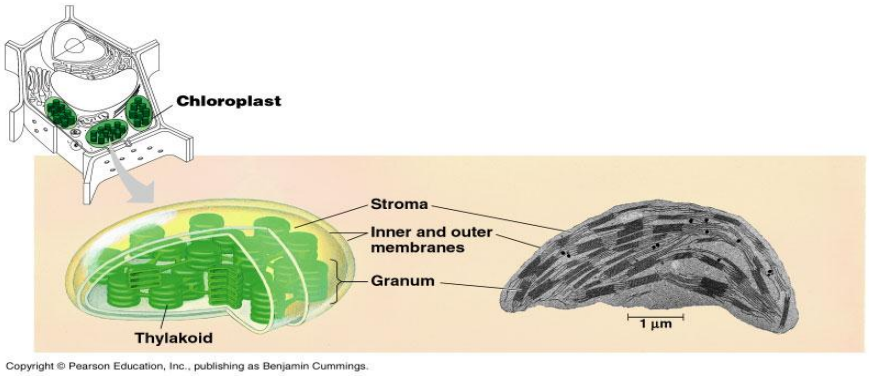
10. Mitochondria

- quantity in cell correlated with metabolic activity;
- cellular respiration;
- double membranous (phospholipid);
- cristae/matrix;
- intermembrane space;
- contain own DNA

Notes:

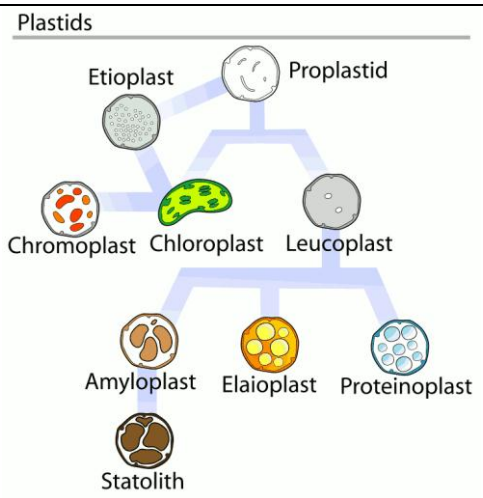
11. Chloroplasts

- Type of plastid; Site of photosynthesis & Also double membrane bound
- thylakoids (flattened disks); grana (stacked thylakoids); stroma; Pigments (chorophyl and others)
- Also have their own DNA molecules



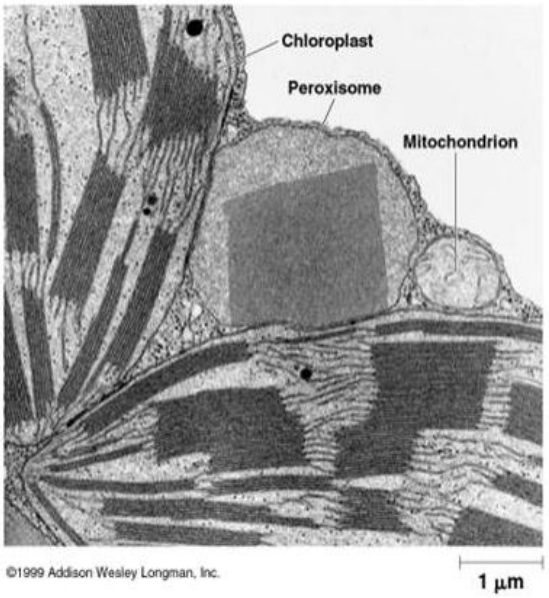
12. Other plastids

- **Leukoplasts**
  - transform glucose in to starch
  - store starch and are colorless
- **Chromoplasts**
  - store colored pigments
- **Elaioplast**
  - store lipid in plants
  - house oil body deposits
- **Gerontoplasts**
  - basically chloroplasts that are going through the aging process



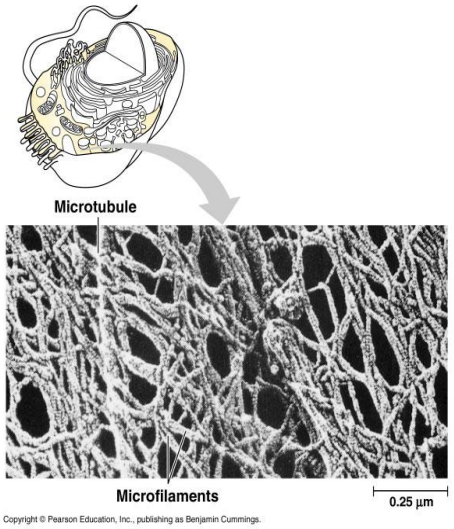
12. Microbodies

- A *microbody* is a type of organelle that is found in the *cells* of *plants*, protozoa, and animals. These consist of peroxisomes, glyoxysomes, glycosomes and hydrogenosomes.
  - **peroxisomes**, single membrane
    - break down H_2O_2 then converted to water, Metabolism of fatty acids; detoxification of alcohol (liver)
  - **glyoxysomes** are important in germinating seeds
    - Organelles involved with Energy Production and Utilization



14. The Cytoskeleton

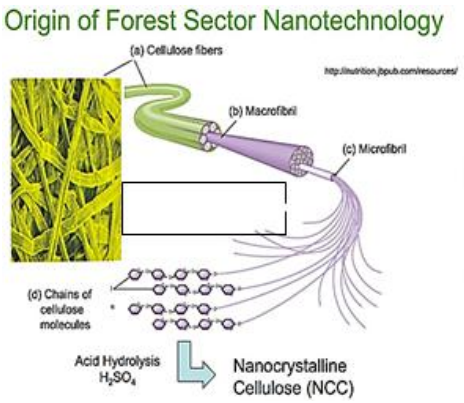
- Fibrous network in cytoplasm
- Support, cell motility, biochemical regulation
- Microtubules:
  - thickest;
  - tubulin protein;
  - shape, support, transport, chromosome separation
- Microfilaments :
  - Thinnest;
  - actin protein filaments;
  - motility, cell division, shape
- Intermediate filaments:
  - middle diameter;
  - keratin; shape, nucleus anchorage

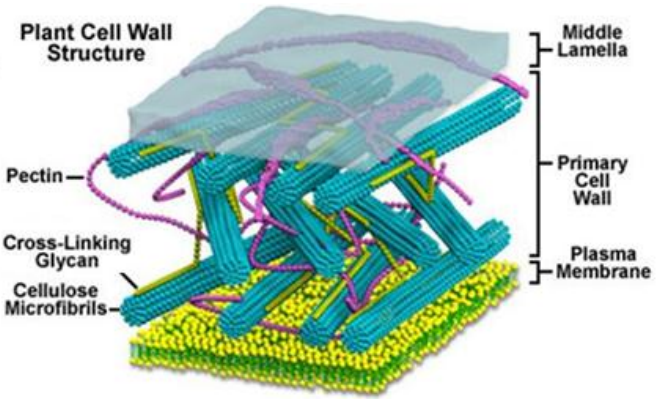


15. Cell Wall

- The composition of the cell wall differs from one species to the other.
  - In bacteria the cell wall is made up of peptidoglycans.
  - The Archean cell wall is made of glycoproteins and polysaccharides.
  - In fungi cell walls are made of glucosamine and chitin.
  - In algae it is composed of glycoproteins and polysaccharides.
  - The plant cell wall is mainly composed of cellulose, hemicellulose, glycoproteins, pectins and lignin.
- Plant cell wall performs essential functions like providing shape, tensile strength and protection and also helps the cell develop turgor pressure to maintain the pressure of the cell contents.

Plant cell wall consists of three layers:
- the primary cell wall,
- secondary cell wall and
- the middle lamella.



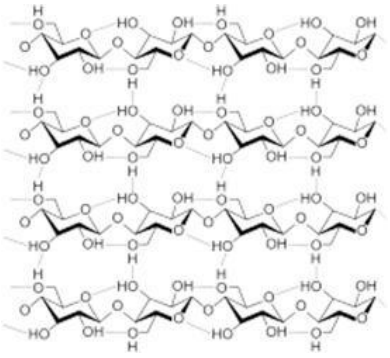


The middle lamella, first layer formed during cell division, is rich in pectin and the outermost layer joining adjacent plant cells and holds them together.

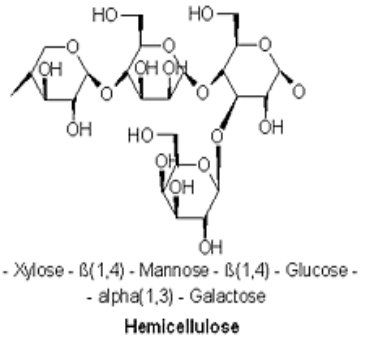
The primary cell wall, formed after the middle lamella, is composed of pectin, hemicellulose and glycoproteins. The layer consists of a framework of cellulose micro-fibrils, in a gel-like matrix. It is thin, flexible and extensible layer.

The secondary cell wall is a thick layer formed inside the primary cell wall. It is extremely rigid and provides strength. It is composed of cellulose, hemicellulose and lignin.

A strand of cellulose (conformation I_α), showing the hydrogen bonds (dashed) within and between cellulose moleculesn



($C_6H_{10}O_5$)

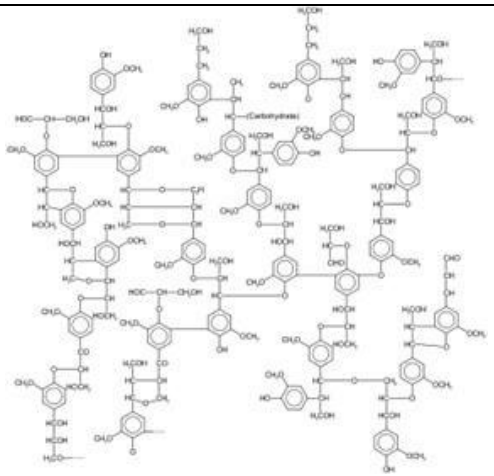


Most common molecular motif of hemicellulose

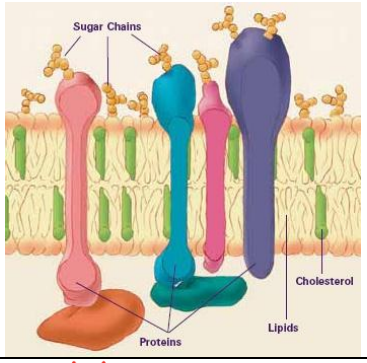
16. Membrane

- The membrane that surrounds a cell is made up of lipids and proteins.
- Depending on the membrane's location and role in the body, lipids can make up anywhere from 20 to 80 % of the membrane, with the remainder being proteins.
- Cholesterol, which is not found in plant cells, is a type of lipid that helps stiffen the membrane.

Notes:



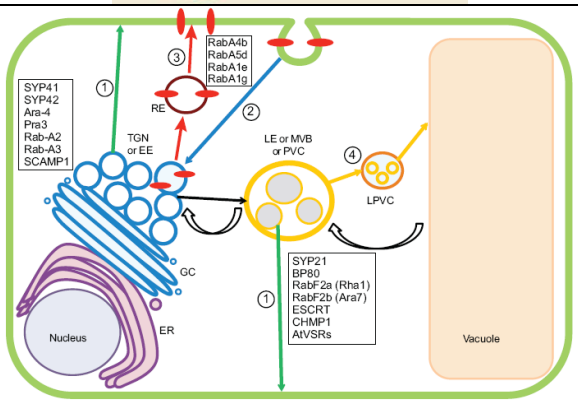
An example of a possible lignin structure



17. Endosome

- Endosomes are a heterogeneous collection of organelles that function in:
  (i) the sorting and delivery of internalized material from the cell surface and
  (ii) the transport of materials from the Golgi to the lysosome or vacuole.

  TGN = *trans*-Golgi *network*), **EE** = *early endosomes*, **LE** = *late endosome*, **MVB** = *multivesicular body*, **PVC** = *prevacuolar compartment*, **LPVC** = *late prevacuolar compartment*, & **RE** = *recycling endosome*. Proteins associated with the TGN, RE & MVB are shown.



Source: Contento & Bassham
http://jcs.biologists.org/content/125/15/3511

Notes:

Notes:

4. STEM CELLS

What are Stem cells?

1. Definitions

- **Stem cells** – undifferentiated CELLS that have the ability:
  - to divide for indefinite periods in culture
  - to become specialized cells

- **Differentiation**
  - the process whereby cells become specialized
  - produces stems cells with decreasing potential

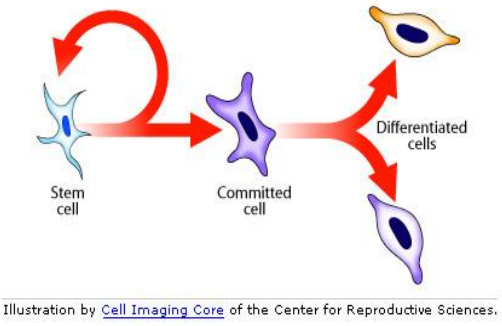


Illustration by Cell Imaging Core of the Center for Reproductive Sciences.

Notes:

2. Stem Cell in Plants

In plants, stem cells are localized in "meristems"

MBoC (4) figure 21-111 and 112 © Garland Publishing

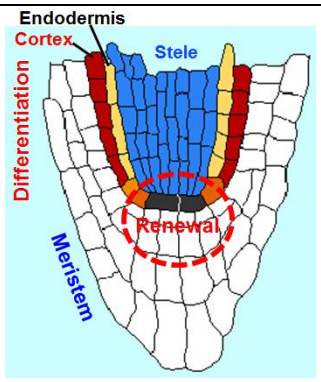
Shoot apical meristem, Root apical meristem. Lateral or axial meristems & Floral meristem

Notes:

Cell fate in root is determined by position
Cells leave meristem and enter files (colors) and differentiate into specific fates (stele, endodermis, cortex etc.)

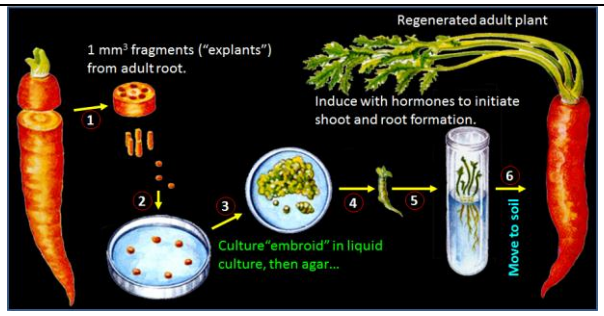
Cells of adult plants remain TOTIPOTENT: cloning a carrot

Culture explants in liquid culture medium→ Cells "differentiate" and begin to divide, forming "callus" tissue



3. Cell Potentials

- **Totipotent**
  having *unlimited capability*. Totipotent cells have the capacity to specialize into extraembryonic membranes and all cells of the embryo.
- **Pluripotent**
  having *high capability.* Pluripotent cells are capable of giving rise to most tissues of an organism.
- **Multipotent**
  having *moderate capability.* Multipotent cells are capable of giving rise to many tissues of an organism.



Moore et al Figure 9.2 Wm C Brown Publishing

Notes:

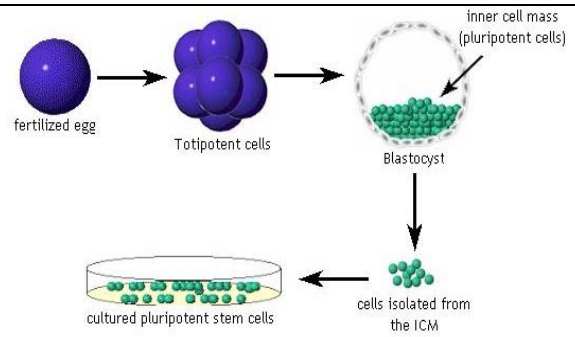
4. Types of Stem cells

Two "types" of stem cells

- Embryonic (ES)
- Adult (non-embryonic) (AS)

Embryonic (ES)

1. Embryos are the result of *In Vitro Fertilization* (IVF)
2. Cells are taken from the Inner Cell Mass (ICM) of a blastocyst
3. ICM cells are nourished in a Petridis in an incubator
4. Cells are given different types of Factors/chemicals
5. These cells can give rise to most types of cells



Notes:

Adult Stem Cells

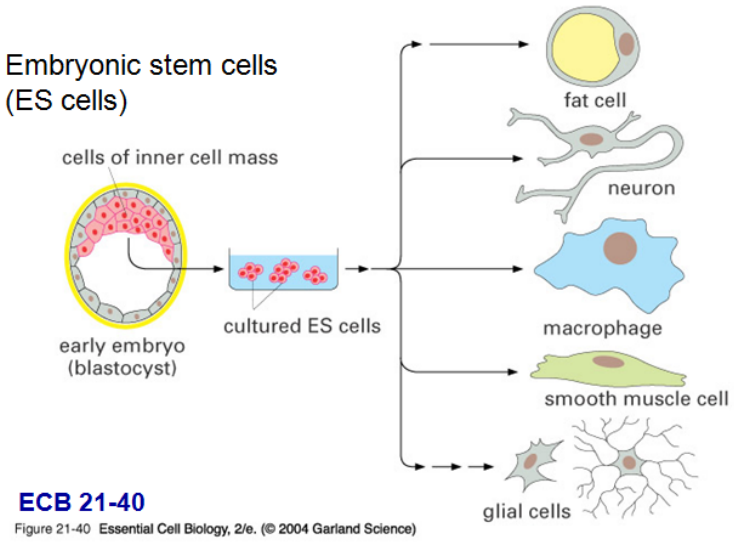
- Adult tissues reported to contain stem cells include: brain, bone marrow, peripheral blood, blood vessels, skeletal muscle, skin and liver.
- There are a very small number of stem cells in each tissue.

Stem Cells differ by

Origin		Different "potentials"
• Embryonic • Adult	✘	• Totipotent • Pluripotent • Multipotent

Cells from young animal embryos are also totipotent

- **Totipotent** - capable of forming all differentiated cells of adult
- **Pluripotent** - capable of forming more than 1 differentiated cell type



5. Differentiation occurs in three stages

- Fertilized animal eggs and early embryonic cells can give rise to all the different cell types of the body, they are considered "**totipoten**t."
  - Identical twins
- Cell fates become progressively restricted during development, a process called *"differentiation."*
- Differentiation occurs in three stages
  - Specification
    - Fate is not absolute
    - Cell identity subject to change
  - Determination
    - Fate is fixed, and cannot change in response to environment
  - Differentiation
    - Changes in cell structure and function

6. Totipotency Loss

How do cells lose totipotency?

- Gross DNA rearrangement or loss (rare?)
  - B-lymphocytes (make antibodies) splice genes encoding IgG HC.
  - Mammalian erythrocytes (red blood cells) enucleate.
- Terminal differentiation (some tissues/cells)
  - Loss of cell division capacity: muscle, neurons, others.
- Altered gene expression (most common)
  - Transcriptional regulation by transcription factors,
  - Reversible, in principle (with difficulty).

Stem cells that resupply differentiated cells are pluripotent: example blood

- Blood cells must be renewed, and are not capable of cell division (red blood cells lack a nucleus)
- Hemopoetic stem cell:
  - divides to renew itself for lifespan of animal
  - can form a limited number of cell types (pluripotent)
  - but not differentiated

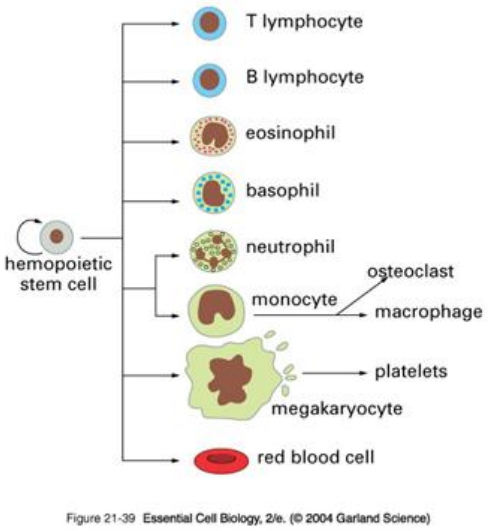


Figure 21-39 Essential Cell Biology, 2/e. (© 2004 Garland Science)

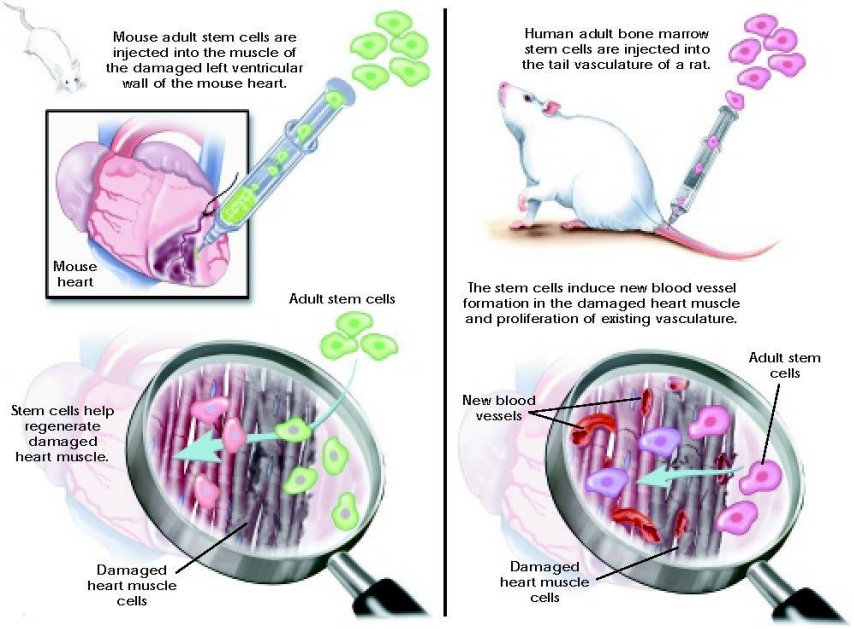
ECB 21-39

5. STEM CELL CASE

1. Importance

- Stem cells are important for living organisms for many reasons.
- Stem cells offer the possibility of a renewable source of replacement cells and tissues to treat diseases;
  Parkinson's and Alzheimer's diseases,
  spinal cord injury,
  stroke,
  burns,
  heart disease,
  diabetes,
  osteoarthritis, and
  rheumatoid arthritis.

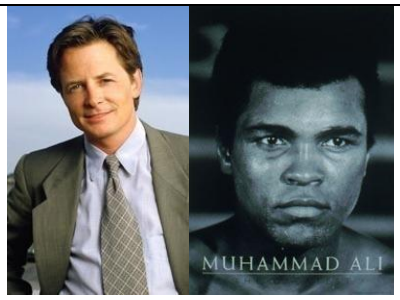
2. Disease Treatment



Heart disease

Parkinson's disease

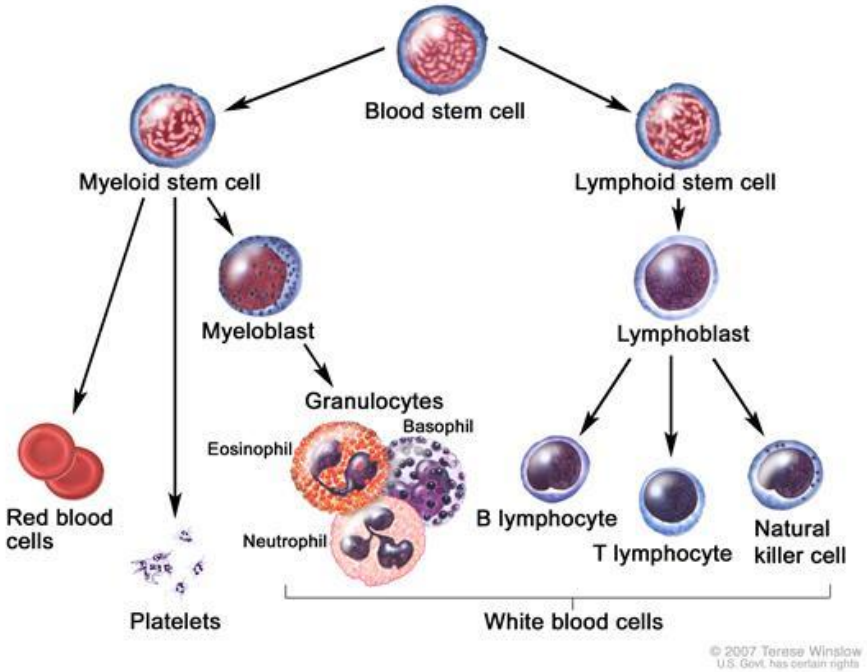
- Loss of dopamine-producing cells in the brain
- Goal: stem cell replacement
- Hope for treat-ment of diabetes, osteoarthritis etc.
- Using embryonic stem cells from patient would eliminate risk of rejection



Mouse embryonic stem cells - cured mouse Parkinson's disease (model system)

Leukemia

- Most blood cells develop from cells in the **bone marrow** called stem cells. Bone marrow is the soft material in the center of most bones.
- In a person with leukemia, the bone marrow makes abnormal white blood cells (leukemia cells)
- Leukemia cells don't die, and may crowd out normal white blood cells, red blood cells, and platelets which makes it hard for normal blood cells to do their work.
- The white blood cells that are formed from myeloid blasts are different from the white blood cells that are formed from lymphoid blasts.



The myeloid stem cell develops into

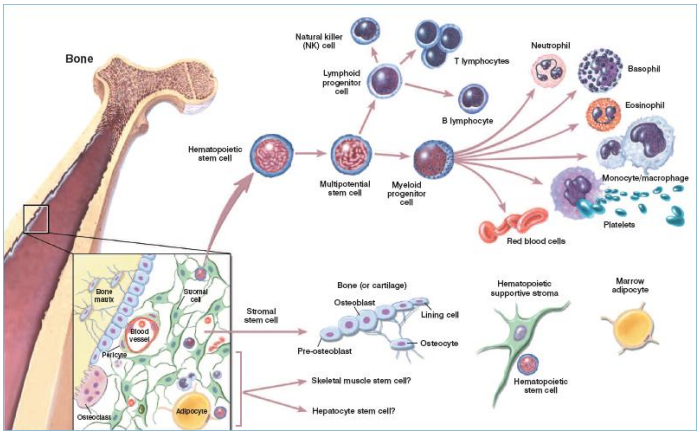
1. **Red blood cells** that carry oxygen and other materials to all tissues of the body
2. **White blood cells** that fight infection and disease
3. **Platelets** that help prevent bleeding by causing blood clots to form.

The lymphoid stem cell develops into a lymphoblast cell and then into one of three types of lymphocytes (white blood cells)

1. B lymphocytes that make antibodies to help fight infection.
2. T lymphocytes that help B lymphocytes make antibodies to help fight infection.
3. Natural killer cells that attack cancer cells and viruses.

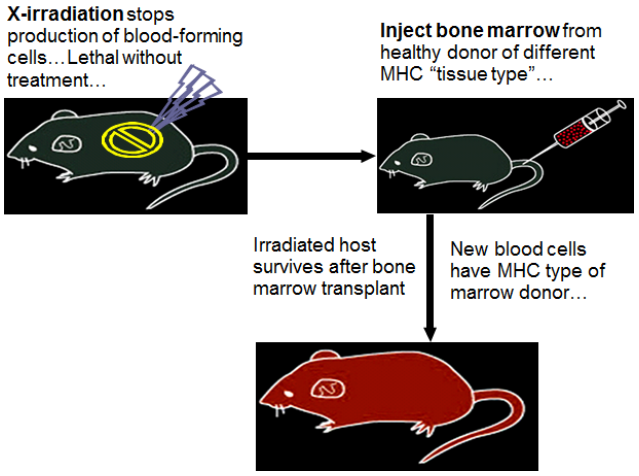
Bone marrow contains hemopoietic stem cells for blood cells

Hematopoietic and stromal cell differentiation.



© 2001 Terese Winslow (assisted by Lydia Kibiuk)
https://stemcells.nih.gov/info/Regenerative_Medicine/2006Chapter2.htm

Bone marrow contains hemopoietic stem cells for blood cells



MBoC (4) figure 22-34 © Garland Publishing

Notes:

SUCCESS

1. Know where to find the information, and how to use it – That's the secrete of success (*Albert Einstein*)
2. I never teach my pupils, I only attempt to provide the conditions in which they can learn (*Albert Einstein*)

3. The first step of success is to get information about or understanding of a subject (knowledge)
4. No one prohibits you to be a great human being, but you
5. Do not wait somebody else to tell you what to do

QUIZ

1. What is quark?
2. Who is Robert Hooke?
3. Who are Schleiden and Schwann?
4. What does it mean by prokaryote in general?
5. What is Nucleoplasm?
6. What is the function of nucleolus?
7. What is chromatin?
8. What is the function of smooth endoplasmic reticulum
9. What is the function of rough endoplasmic reticulum
10. What is the function of golgi complex