BASIC CELL BIOLOGY AND ITS APPLICATION
BI - 1202

CELL

CELL THEORY

Every organism consists of cell, and cell is the smallest functional unit of the living thing. Cell is originally comes from the previous one.

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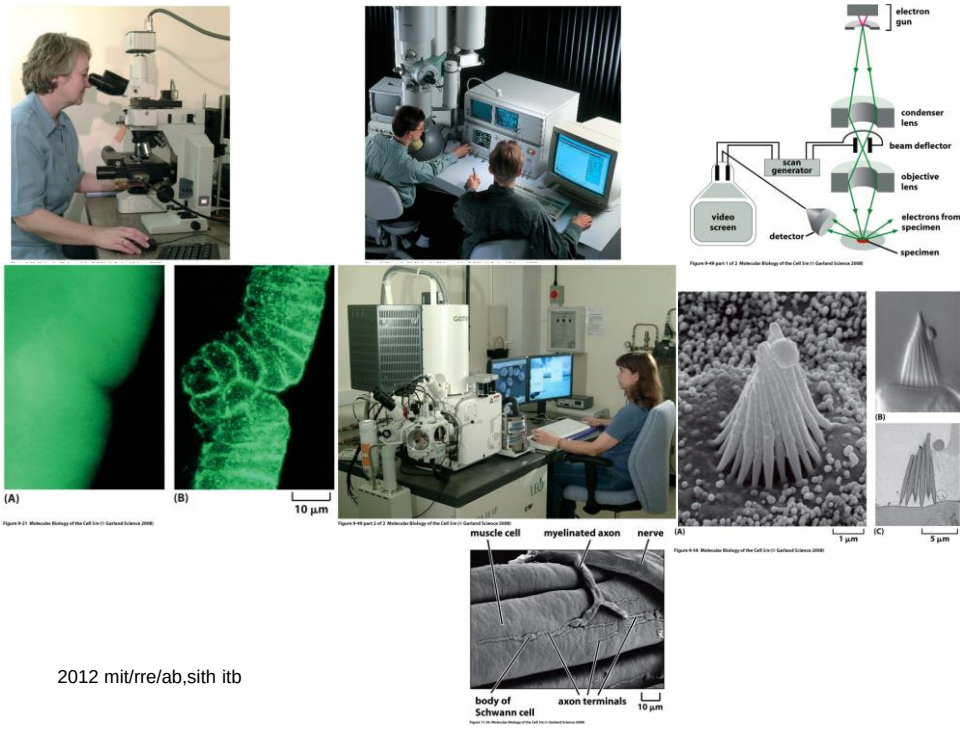
Cell Biology – A Journey

- **Microscopic biology began in 1665**
- **Robert Hooke (1635-1703) discovered organisms are made up of cells**
- **Antonie Philips van Leeuwenhoek (1674)**
  Discovery of protozoa, bacteria
- **Matthias Schleiden (1804-1881) and Theodor Schwann (1810-1882) further expanded the study of cells in 1830s**

Schwann



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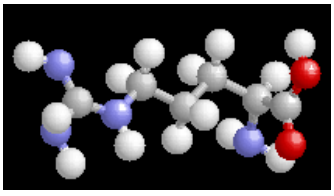
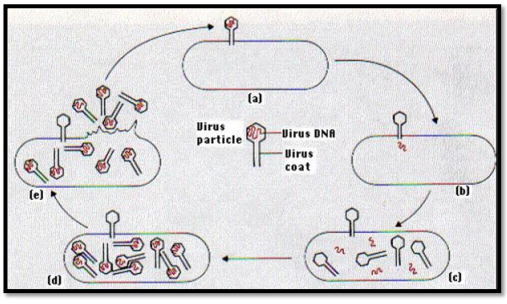
Major events in the history of Molecular Biology 1800 - 1870

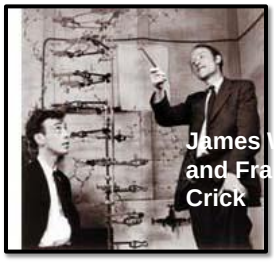
- **1865 Gregor Mendel discover the basic rules of heredity of garden pea.**
  - **An individual organism has two alternative heredity units for a given trait (dominant trait vs. recessive trait)**
- **1899 Richard Altmann renamed nuclein to nucleic acid.**
- **By 1900, chemical structures of all 20 amino acids had been identified**



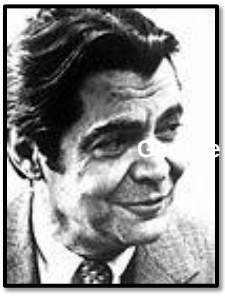
- **1911 – Thomas Hunt Morgan discovers genes on chromosomes are the discrete units of heredity**
- **1952 – Alfred Hershey and Martha Chase make genes from DNA**



Major events in the history of Molecular Biology 1952 - 1960

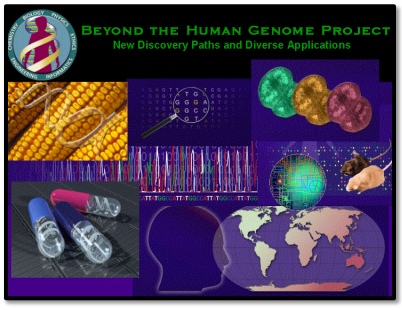


- **1952-1953 James D. Watson and Francis H. C. Crick deduced the double helical structure of DNA**
- **1956 George Emil Palade showed the site of enzymes manufacturing in the cytoplasm is made on RNA organelles called ribosomes.**



Major events in the history of Molecular Biology 1986 - 1995

- **1986 Human Genome Initiative announced**
- **1995 John Craig Venter: First bacterial genomes sequenced**



- **1996 First eukaryotic genome-yeast-sequenced**

John Craig Venter

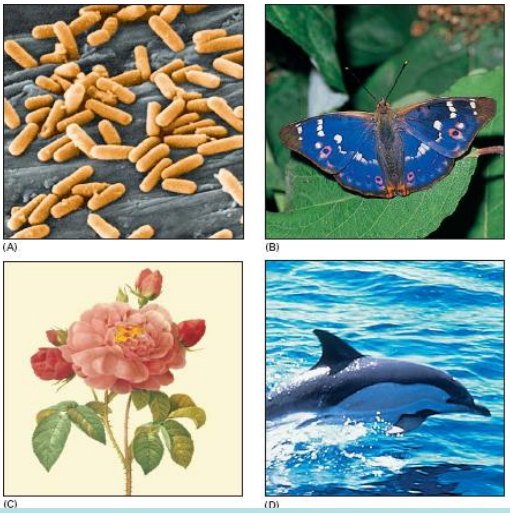
Major events in the history of Molecular Biology 2003- Present

- **April 2003 Human Genome Project Completed. Mouse genome is sequenced.**

Mice, including cultured cells

Development of body tissues
Function of mammalian immune system
Formation and function of brain and nervous system
Models of cancers and other human diseases
Gene regulation and inheritance
Infectious disease

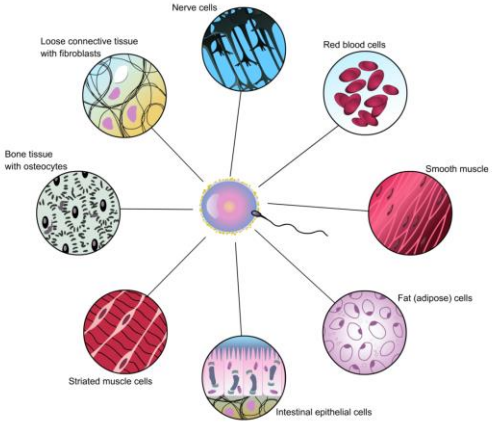
- **April 2004 Rat genome sequenced.**

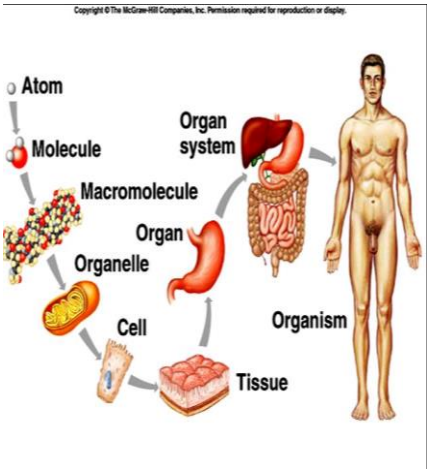


All the living things consist of cell.
All organisms are composed of one or more cells.
Cells are the smallest living units of all living organisms.
Cells arise only by division of a previously existing cell.

Bacteria, buterfly, rose, dolphin consist of cells that have similar basic chemical structure , and work with the same basic principles

Cells and Human Body





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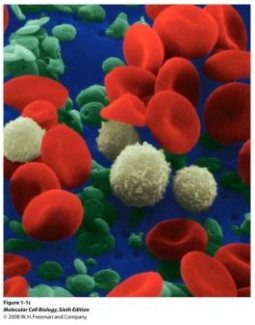
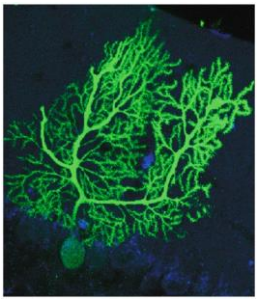
Single cell organisms – Multi cell organisms

-> multi cell organisms -> higher degree or organization of cells within the organism -> specialization of cells



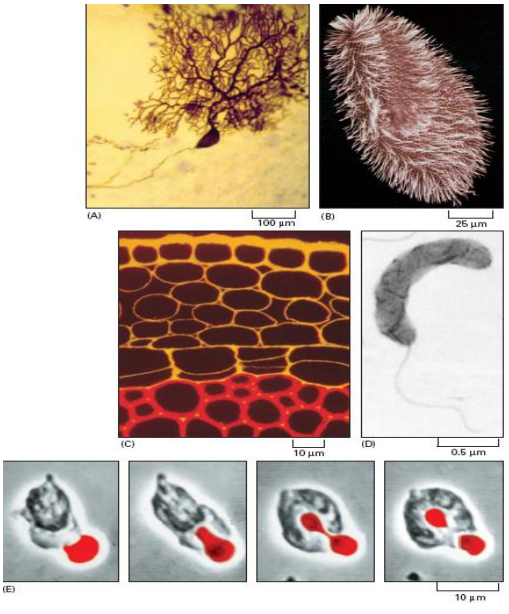
Human blood cells

Human intestine



Purkinje neuron of cerebellum

11



Cell has various shape and size

(A) Neuron from cerebrum (the part that control movement). Cell branching out to receive signals from approximately 100,000 other neurons.

(B) *Paramecium*. protozoa—big single cell —swim using its cilia that covers all the surface

.

(C) A piece of young stem, consists of several cell types, yellow is pectin and red is cellulose.

(D) bacterium, *Bdellovibrio bacteriovorus*, *uses a single terminal flagellum to move.* Bacterium attacks, kills and eats othe bacteria.

(E) Human white blood cell (a neutrophil), approaching and eating red blood cell.

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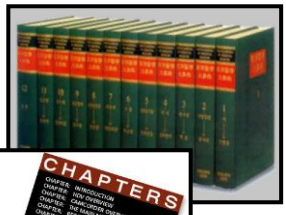
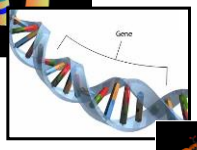
Inside a Living Cell

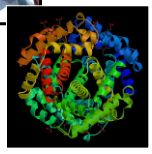
Life alphabet
4 letters
A, T, G, C

English
alphabet
26 letters

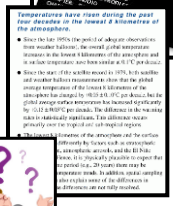


Structure
Static





Function
Dynamic



Function
Dynamic

Cell dimension

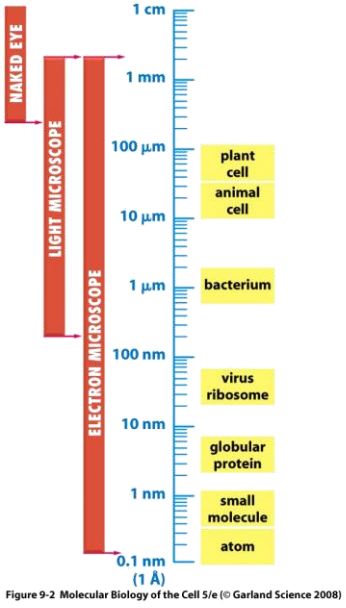
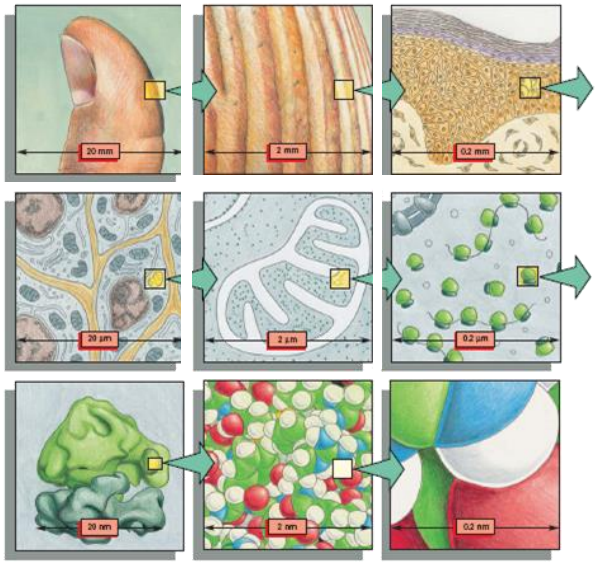


Figure 9-2 Molecular Biology of the Cell 5/e (© Garland Science 2008)



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BASIC CHRACTERISTIC OF CELL

- **Cell is very complex, yet organized.**
- **Cell has genetic program and has the way to use that program.**
- **Cells can reproduce themselves.**
- **Cell needs, gains and uses the energy**
- **Cell performs many kinds of chemical recations**
- **Cell involved in various mechanical activities.**
- **Cell responds to various triggers**
- **Cell is able to self regulating**

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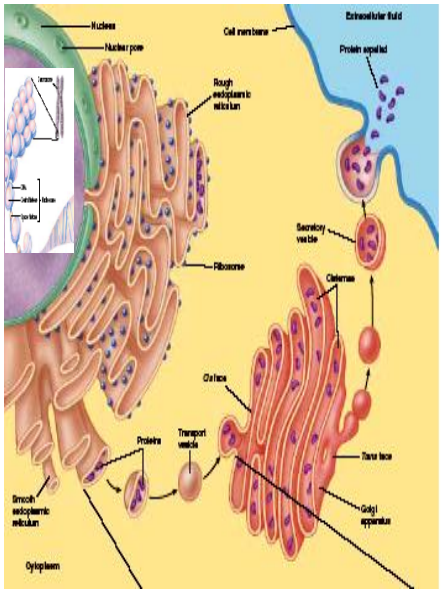
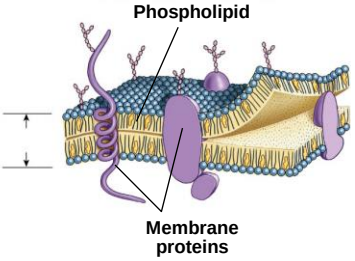
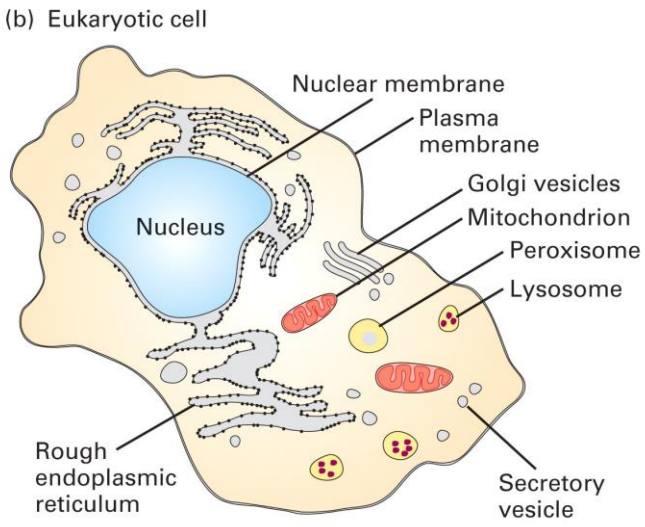


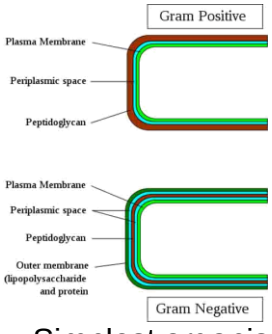
Cell Characteristics

- Genetic material
  - single circular molecule of DNA in prokaryotes
  - double helix located in nucleus in eukaryotes – nuclear envelope (double bilayer membrane)
- Cytoplasm fills cell interior –
  - sugars, amino acids,
  - proteins - organelles
- Plasma membrane encloses
  - the cell – phospholipid bilayer

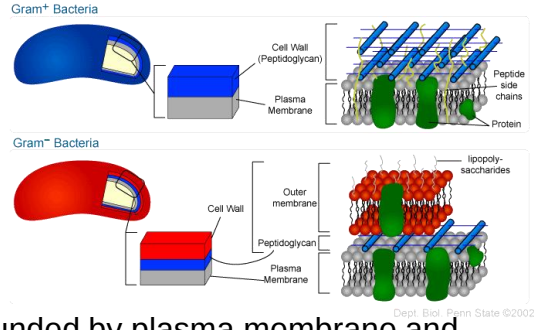


Generalized Eukaryotic Cell



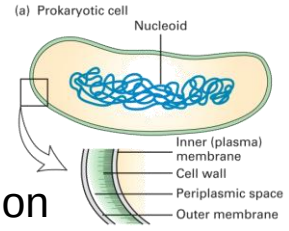


Prokaryotic Cells

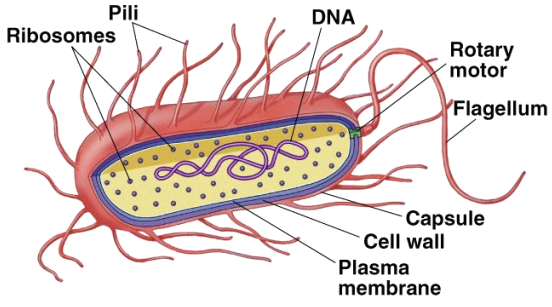


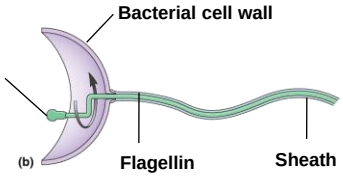
- Simplest organisms
  - Cytoplasm is surrounded by plasma membrane and encased in a rigid cell wall composed of peptidoglycan.
    - no distinct interior compartments
      - gram-positive – thick single layer wall that retains a violet dye from Gram stain procedure
      - gram-negative – multilayered wall does not retain dye
        - » Susceptibility of bacteria to antibiotics depends on cell wall structure.

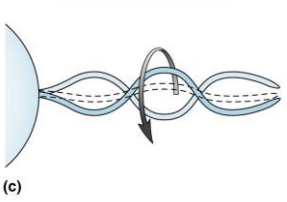
Prokaryotic Cells



- Some use flagellum for locomotion
  - threadlike structures protruding from cell surface

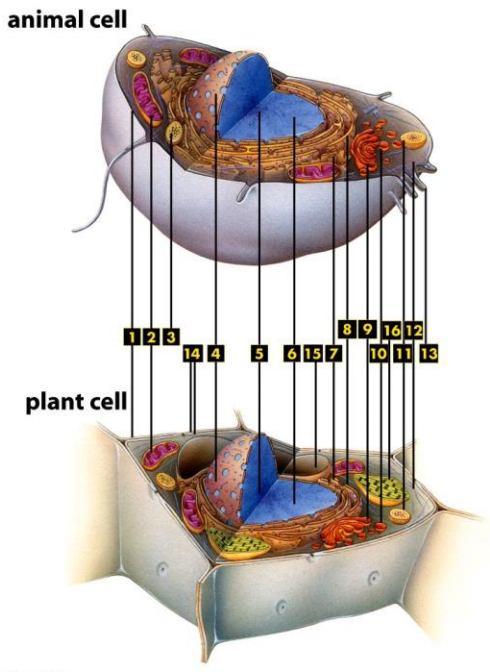






Eukaryotic Cells

- Characterized by compartmentalization by an endomembrane system, and the presence of membrane-bound organelles.
  - Central vacuole – plants, storage
  - Vesicles (smaller)
  - Chromosomes - DNA and protein
  - Cytoskeleton (internal protein scaffolding)
  - Cell walls – plants and fungi



1 Plasma membrane
2 Mitochondria
3 Lysosomes
4 Nuclear envelope
5 Nucleolus
6 Nucleus
7 Smooth endoplasmic reticulum (SER)
8 Rough endoplasmic reticulum (ER)
9 Golgi complex
10 Secretory vesicles
11 Peroxisomes
12 Cytoskeletal fibers
13 Microvilli
14 Cell wall
15 Vacuole
16 Chloroplast

Figure 9-1
Molecular Cell Biology, Sixth Edition

Nucleus

- Repository for genetic material
- Directs activities of the cell
- Usually single, some cells several, RBC none
  - Nucleolus - region of intensive ribosomal RNA synthesis
- Surface of nucleus bound by two phospholipid bilayer membranes
  - nuclear membrane
  - Nuclear pores – protein gatekeepers
    - Usually proteins going in and RNA going out

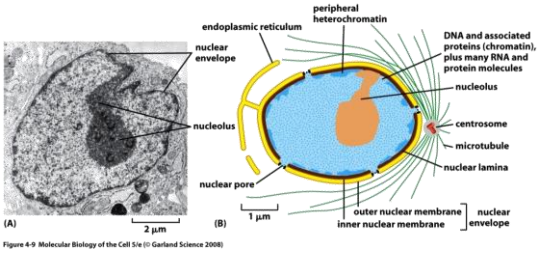
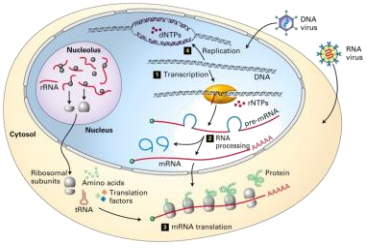
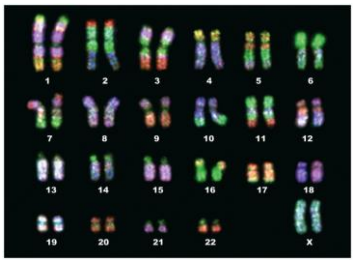


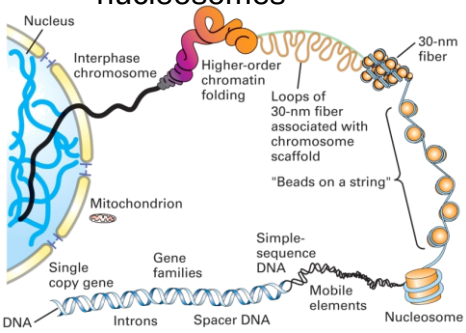
Figure 4-9 Molecular Biology of the Cell 5/e (© Garland Science 2008)

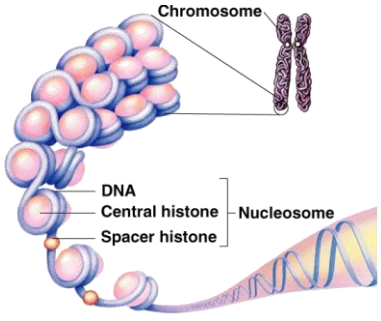


Chromosomes

- DNA of eukaryotes is divided into linear chromosomes.
  - exist as strands of chromatin, except during cell division
  - associated with packaging histones, packaging proteins
    - nucleosomes

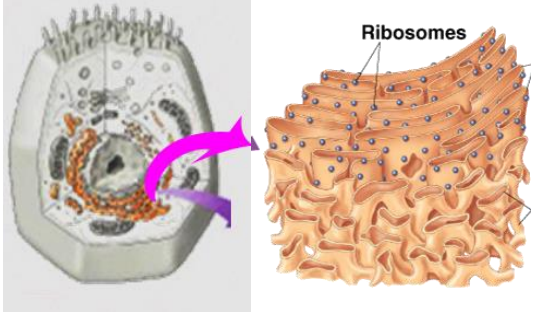






Endomembrane System

- Compartmentalizes cell, channeling passage of molecules through cell's interior
- Largest internal membrane
- Composed of Lipid bilayer
- Serves as system of channels from the nucleus
- Functions in storage and secretion.



Endoplasmic reticulum

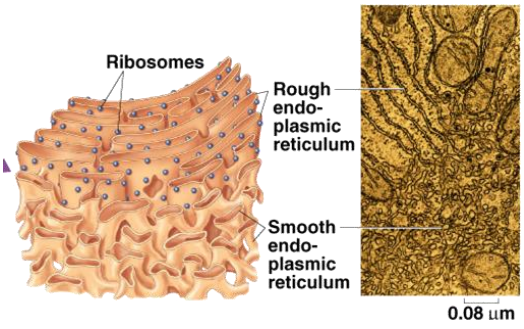
Site of synthesis of fatty acids
membrane lipids
carbohydrates

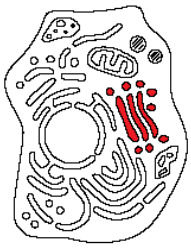
Smooth ER
•lack associated ribosomes

Site of synthesis of membrane proteins
secreted/some sorted proteins

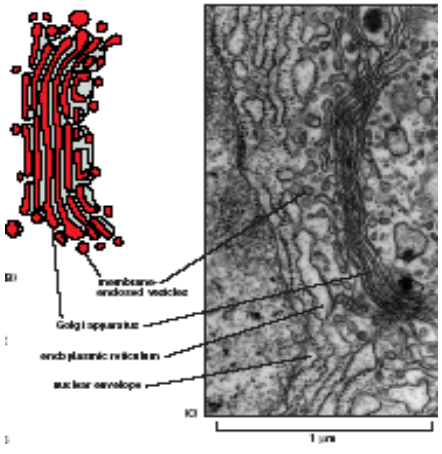
Rough ER
•associated ribosomes

- Most cell ER is rER
- Hepatocytes have lots of sER - important organ for lipid metabolism





Golgi apparatus receives and modify molecules from ER chemically and transported outside the cell or other place.



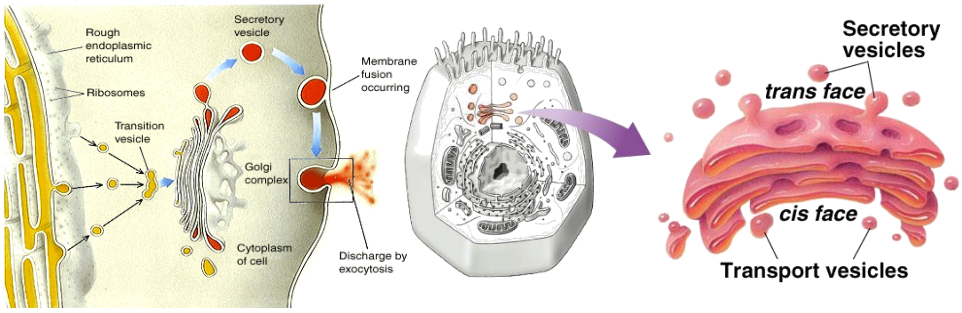
Golgi apparatus is in red color

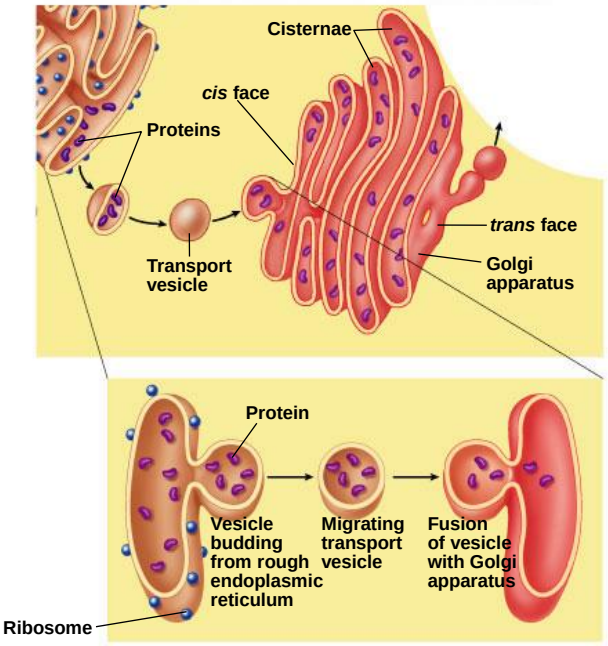
Golgi apparatus is a flat of stacking discus, where small vesicles separate or join.

This organelle involved in synthesize and packaging molecules that will be excreted outside the cell and also to direct newly synthesize protein to move to the correct compartment of the cell.

Endomembrane System

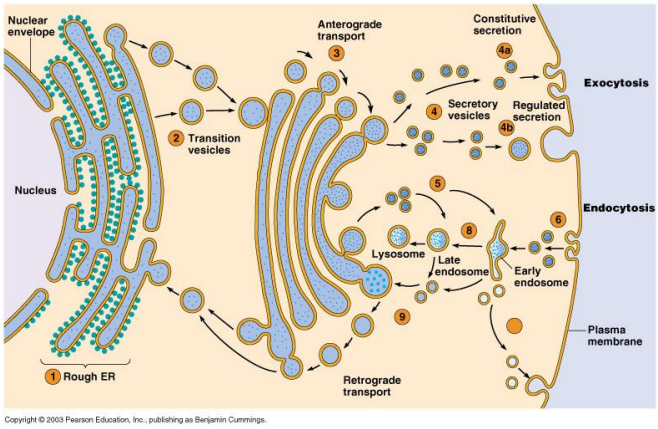
- Golgi apparatus
  - – collection of Golgi bodies
    - collect, package, and distribute molecules synthesized at one location in the cell and utilized at another location
    - Front - *cis* , Back – *trans*
    - Cisternae – stacked membrane folds





Endomembrane System

- Vesicles
  - Lysosomes
  - Microbodies



Endomembrane System

- Vesicles
  - Lysosomes - membrane-bound vesicles containing digestive enzymes – from Golgi

Lysosomes

Cellular dustbin

Acidic

Degradation of cellular molecules

Degradation of extracellular molecules

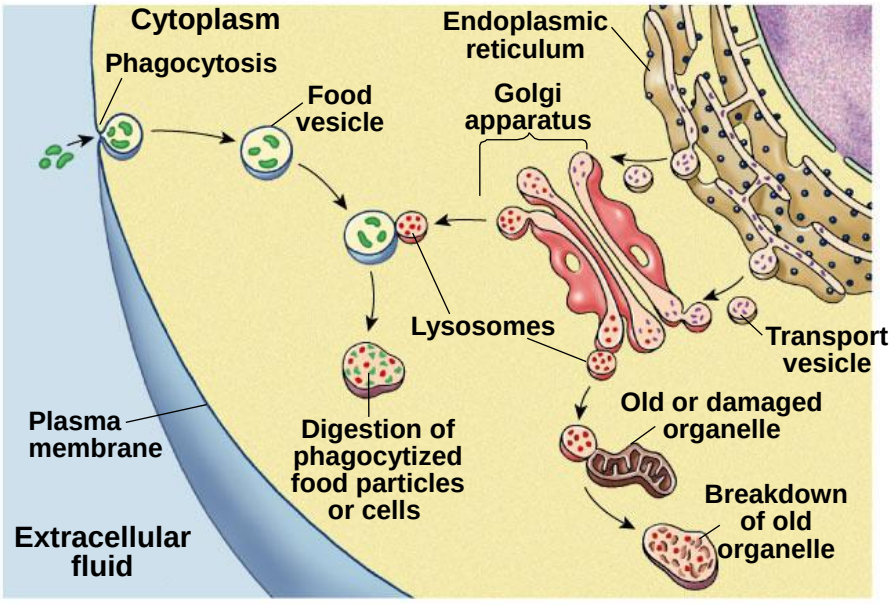
endocytosis - liquid

phagocytosis - solids

Contains acid hydrolases - rel inactive at pH 7.2

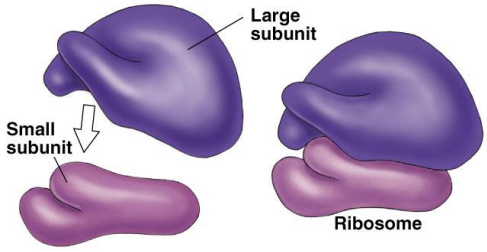
Endomembrane System

- Vesicles
  - Microbodies - enzyme-bearing, membrane-enclosed vesicles.
    - Peroxisomes - contain enzymes that catalyze the removal of electrons and associated hydrogen atoms
    - Peroxisome – named for hydrogen peroxide produced as a by-product
    - Enzyme breaks down to water and oxygen

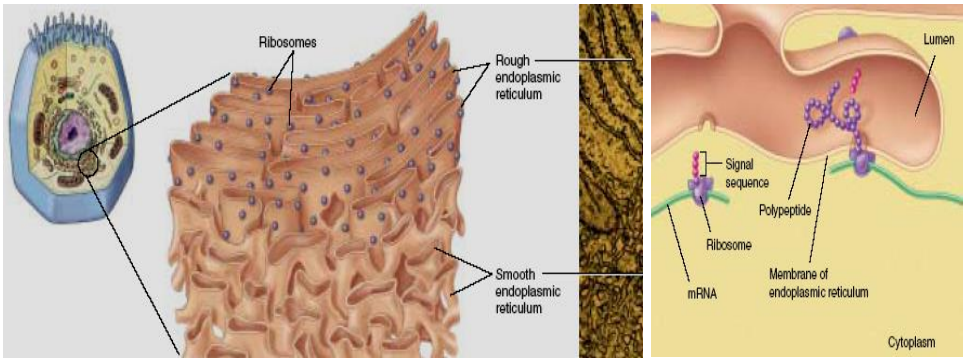


Ribosomes

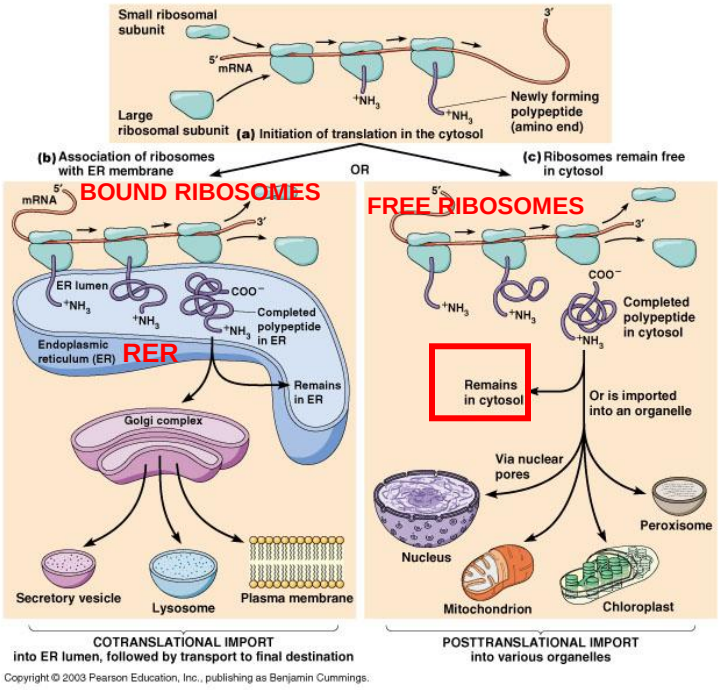
- Ribosomes are RNA-protein complexes composed of two subunits that join and attach to messenger RNA.
  - site of protein synthesis
  - assembled in nucleoli



Ribosomes



Ribosomes bind with one side of rough ER; the other side of ribosome is the place for synthesizing new proteins. Smooth ER has small amount or no ribosomes.



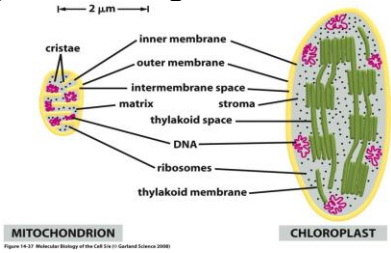
PROTEIN TARGET-ING AND SORTING

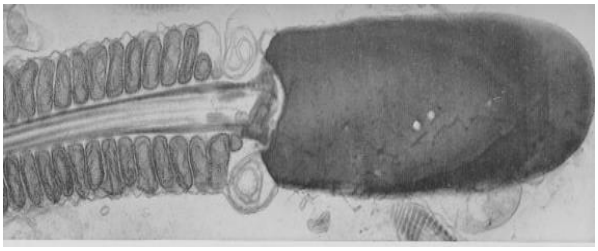
2 paths

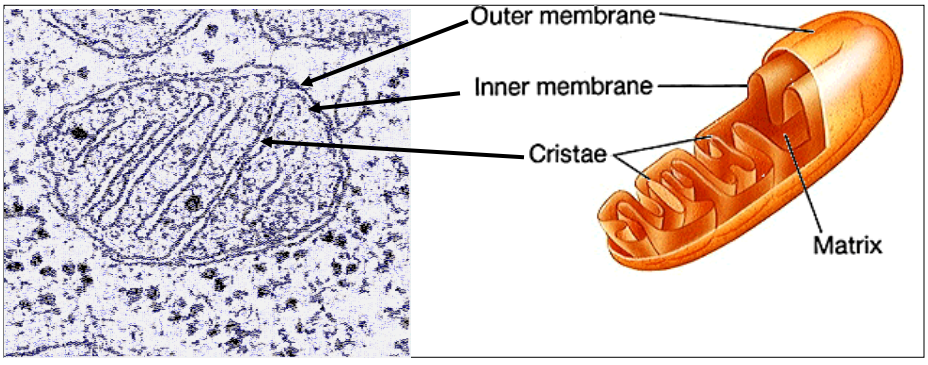
35

Organelles With DNA

- Mitochondria
  - bounded by exterior and interior membranes
  - interior partitioned by cristae
- Chloroplasts
  - have enclosed internal compartments of stacked grana, containing thylakoids
  - found in photosynthetic organisms



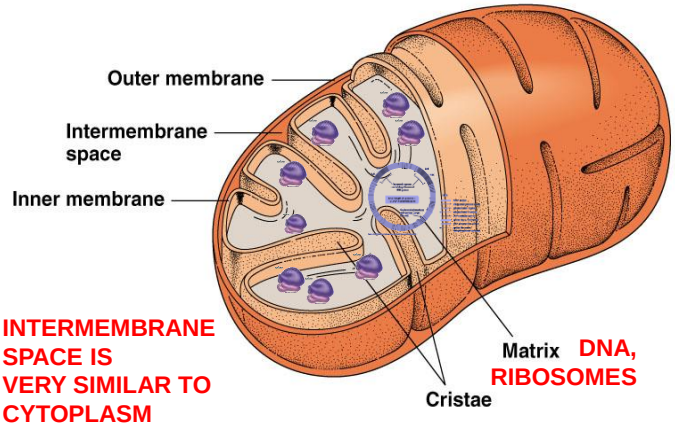




most of our ATP MADE AT INNER MEMBRANE

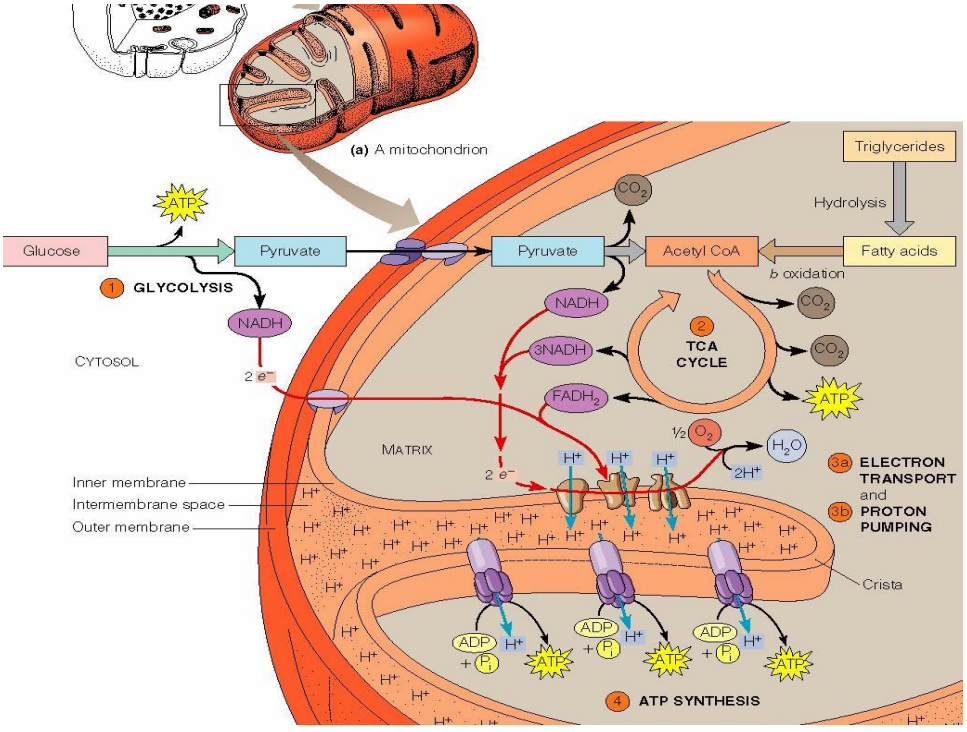
OUTER MEMBRANE IS LIKE A SIEVE HAS LOTS OF PORINS- VERY POROUS FOR MOLECULES < 5000 DALTONS

INNER MEMBRANE IS NOT POROUS- NO PORINS- PREVENTS EVEN H+ FROM PASSING



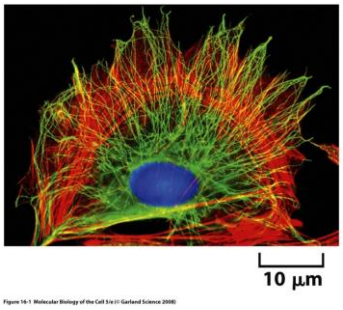
INTERMEMBRANE SPACE IS VERY SIMILAR TO CYTOPLASM

(a) Schematic diagram

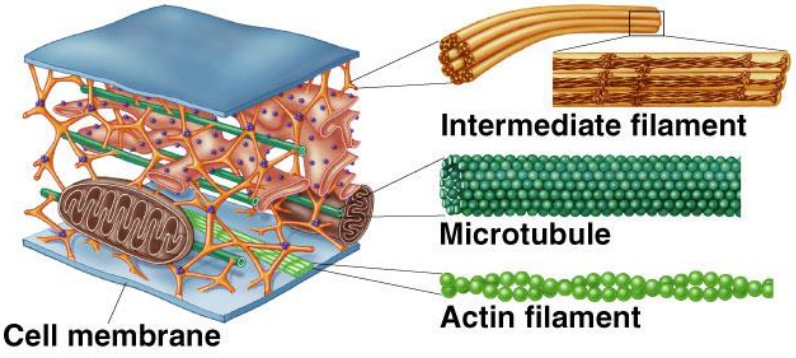


Cytoskeleton

- Network of protein fibers supporting cell shape and anchoring organelles
  - Actin filaments
    - cell movement
  - Microtubules
    - Hollow tubes
    - Facilitate cell movement
    - Centrioles – barrel shaped
    - organelles occur in pairs –
    - help assemble animal cell's microtubules
  - Intermediate filaments
    - Stable - don't break down



Cytoskeleton



Animal Cells

- Animal cells lack cell walls.
  - form extracellular matrix
    - provides support, strength, and resilience

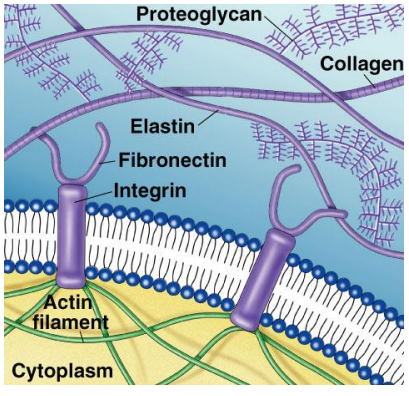


Table 5.2 Eukaryotic Cell Structures and Their Functions

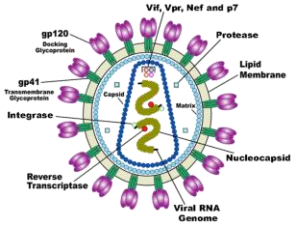
Structure	Description	Function
Cell wall 	Outer layer of cellulose or chitin; or absent	Protection; support
Cytoskeleton 	Network of protein filaments	Structural support; cell movement
Flagella (cilia) 	Cellular extensions with 9 + 2 arrangement of pairs of microtubules	Motility or moving fluids over surfaces
Plasma membrane 	Lipid bilayer with embedded proteins	Regulates what passes into and out of cell; cell-to-cell recognition
Endoplasmic reticulum (ER) 	Network of internal membranes	Forms compartments and vesicles; participates in protein and lipid synthesis
Nucleus 	Structure (usually spherical) that contains chromosomes and is surrounded by double membrane	Control center of cell; directs protein synthesis and cell reproduction

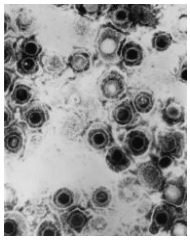
Structure	Description	Formation
Golgi apparatus 	Stacks of flattened vesicles	Packages proteins for export from cell; forms secretory vesicles
Lysosomes 	Vesicles derived from Golgi apparatus that contain hydrolytic digestive enzymes	Digest worn-out organelles and cell debris; play role in cell death
Microbodies 	Vesicles that are formed from incorporation of lipids and proteins and that contain oxidative and other enzymes	Isolate particular chemical activities from rest of cell
Mitochondria 	Bacteria-like elements with double membrane	"Power plants" of the cell; sites of oxidative metabolism
Chloroplasts 	Bacteria-like elements with membranes containing chlorophyll, a photosynthetic pigment	Sites of photosynthesis
Chromosomes 	Long threads of DNA that form a complex with protein	Contain hereditary information
Nucleolus 	Site of genes for rRNA synthesis	Assembles ribosomes
Ribosomes 	Small, complex assemblies of protein and RNA, often bound to endoplasmic reticulum	Sites of protein synthesis

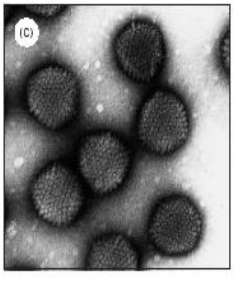
Table 5.3 A Comparison of Prokaryotic, Animal, and Plant Cells

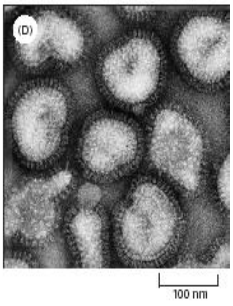
	Prokaryote	Animal	Plant
EXTERIOR STRUCTURES			
Cell wall	Present (protein-polysaccharide)	Absent	Present (cellulose)
Cell membrane	Present	Present	Present
Flagella/cilia	May be present (single strand)	May be present	Absent except in sperm of a few species
INTERIOR STRUCTURES			
ER	Absent	Usually present	Usually present
Ribosomes	Present	Present	Present
Microtubules	Absent	Present	Present
Centrioles	Absent	Present	Absent
Golgi apparatus	Absent	Present	Present
Nucleus	Absent	Present	Present
Mitochondria	Absent	Present	Present
Chloroplasts	Absent	Absent	Present
Chromosomes	A single circle of DNA	Multiple; DNA-protein complex	Multiple; DNA-protein complex
Lysosomes	Absent	Usually present	Present
Vacuoles	Absent	Absent or small	Usually a large single vacuole

Virus ???









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Electron micrographs from virus

(A) Human immunodeficiency virus (**HIV**) is a lentivirus (a member of the retrovirus family) that causes *acquired immunodeficiency syndrome* (AIDS). It is a RNA viruses

(B) Herpes simplex virus 1 and **2** (**HSV-1** and **HSV-2**), also known as **Human herpes virus 1** and **2** (**HHV-1** and **-2**), are two members of the herpes virus family, Herpesviridae, that infect humans**. DNA-virus**

(C) *Adenovirus,* virus that contains DNA- can infects human cels.

(D) *Influenza virus*, virus that contains RNA with the protein capsule that covered by lipid bilayer envelope. Protein virus is embedded in bilayer membrane (looks like needle)