THE CELL

Though chemical analysis of living things is possible, because of its complex organization and interaction of molecules Life in the form of living cell can not be produced

Cell is the smallest living entity which serves living building blocks for the immensely complicated whole body.

THE CELL

Life in the form of living cell can not be produced

Cell theory – relation between cell and life

- Cell is the smallest structural & functional unit. Can carry out living processes
- Functional activities related to the specific structural property
- Living building blocks of animal or plant
- Organism's structure and function depends upon characteristics of its cells
- All new life & new cells are formed from preexisting cell
- Cells of one organism are fundamentally similar in structure & function

Observation of cell

➢Cannot be seen by naked eye – smallest visible particle is 5-10 times larger than typical cell

➢Seen by microscope – middle of 17^{th} century

➢Better vision of cells in tissues with 'soapy mixture' of fluid inside – early 19^{th} century

➢Electron microscopy – internal structure of cell – 1940

➢Recently,- powerful microscopes, biochemical techniques, cell culture technology, genetic engineering

Overview of Cell structure –Total trillion cells

- 200 different cell types

3 Subdivisions

Plasma membrane

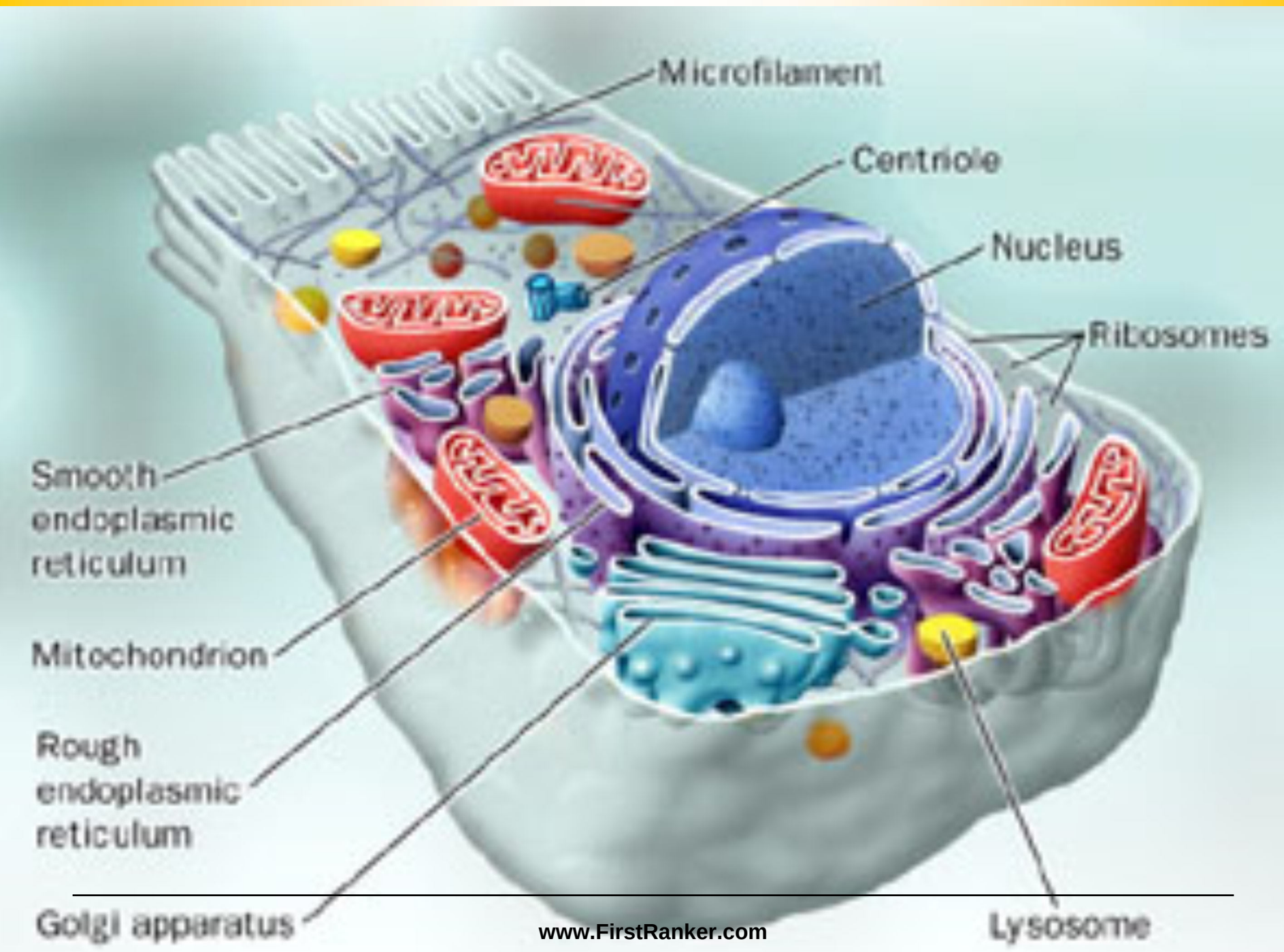
Encloses the cell

Nucleus

Contain cells genetic material

Cytoplasm

Portion of cell interior not occupied by nucleus



Plasma membrane –

- thin membranous structure enclosing each cell
- Oily barrier bet. ECF & ICF
- Holds contents of cell
- Gated wall – selective movement of mol. Bet ICF & ECF

Nucleus –

- Largest, single, organized compartment
- Spherical or oval, near the centre
- surrounded by double layered nuclear membrane having nuclear pores allowing traffic between nucleus and cytoplasm
- Genetic material in nucleus – DNA

Functions of nucleus

directs synthesis of proteins

Structural and enzymes controlling chemical reactions

- serves as genetic blue print during cell duplication

- Continue identical type of cell line within the body and in reproductive cell to transfer genetic material to next generation

DNA provides 'instructions' through 3types of RNA

Messenger RNA → Ribosomal RNA → Transfer RNA

Cytoplasm → Cytosol
Cytoplasm → Organelles

I Cytosol

Complex gel like liquid → Site for compatible chemical reactions

elaborate protein network (cytoskeleton) →
-gives shape
-Provides internal organization
-Regulates its movements

II Organelles — distinct,
highly organized,
membrane enclosed,
occupies about ½ of total cell volume

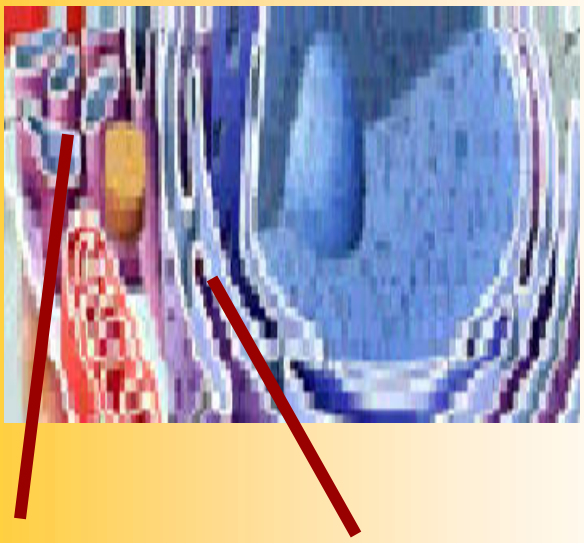
Each organelle — 'Speciality shops' in cell
Separate compartment
Separate contents

6 main types of organelles

- Endoplasmic reticulum
  - Rough ER
  - Smooth ER
- Golgi complex
- Lysosomes
- Peroxysomes
- Mitochondria
- Vaults

- similar in all cells
- contain specific set of chemicals required for particular cellular function
- can carryout incompatible chemical reactions simultaneously

Endoplasmic reticulum -- protein and lipid manufacturing factory.



Elaborate, fluid filled extensively distributed, membranous system

2 types continuous with each other and their relative amount varies with the function of cell

SER – network of tiny interconnected tubules

RER – project outwards from SER as stacks of flattened sacks

- outer surface of membrane studded with ribosomes – rough granular appearance

New protein on ribosomal RNA

↓

Released in ER lumen

↙ ↘

Exterior as hormones or enzymes

Construction of new cell membrane or organelles

Synthesis of lipids by enzymes present in the membrane → released to lumen with protein → pressed → attachment of carbohydrate → buds off as transport vesicle

Smooth ER -No ribosome, so not involved in protein synthesis,

- serve as a central packaging & discharge site for molecules which are to be transported from ER

-formation of Transport vesicles which contain new protein and lipid and is membrane bound and passes to Golgi complex , formation of peroxisomes

- Membrane used is replaced by newly formed protein & lipid

Additional responsibilities in different cells

1) Steroid secreting cells have abundant SER

2) Liver cells – membrane of SER contain enzymes involved in detoxification

3) In muscle cells SER stores Ca++ which plays imp. role in process of muscle contraction

Golgi Complex

Stacks of flattened, curved, membrane bound sacs or cisterns

-may not be physically connected with each other

-thin at the center and dilated at the periphery

- Number varies –cells specialized in pr. synthesis may have 100s of sacs

Mechanism of function

Transport vesicles containing Cargo from SER fuses with the inner most sac of Golgi complex → material travel through the layers of sacs to the outer sacs in the form of transport vesicles

During transit

1) raw material → final finished product

2) sorting and directing the finished products

a) secretion to exterior of cell

b) construction of new plasma membrane

c) incorporated in other organelles e.g. lysosomes

Secretory vesicles

Membrane with specific proteins

- Recognition marker for cargo on inner surface
- Coat proteins for curling of membrane
- Docking marker on outer side inside coat protein – v-SNARE

Cargo – conc. finished product with appropriate a.a. sequence acting as sorting signal

Exocytosis

Budding off vesicles in cytosol seperating specialized finished products from cytosol .

↓

Movement towards membrane on appropriate signals

↓

Attachment with special pr. marker on target membrane – t SNARE

↓

Fusion of membrane

↓

Opening of vesicle

↓

Release of secretion

Peculiarities of secretary process

1) Once pr. is synthesized does come in contact with cytosol

2) Synthesis and storage are well ahead of time of requirement

3)Diffferent secretory vesicles for different destination

Lysosomes

- Membrane enclosed sacs containing powerful hydrolytic enzymes
- Average number – 300 per cell
- No fixed structure- vary in size and shape
- 0.2 – 0.5 μm in diameter
- Granular when inactive
- Membrane protects rest of the cell
- Membrane and enzymes from Golgi complex

Extracellular material to be tackled by lysosome is brought into the cell by

endocytosis

3 types

pinocytosis

All cells

Receptor mediated endocytosis

phagocytosis

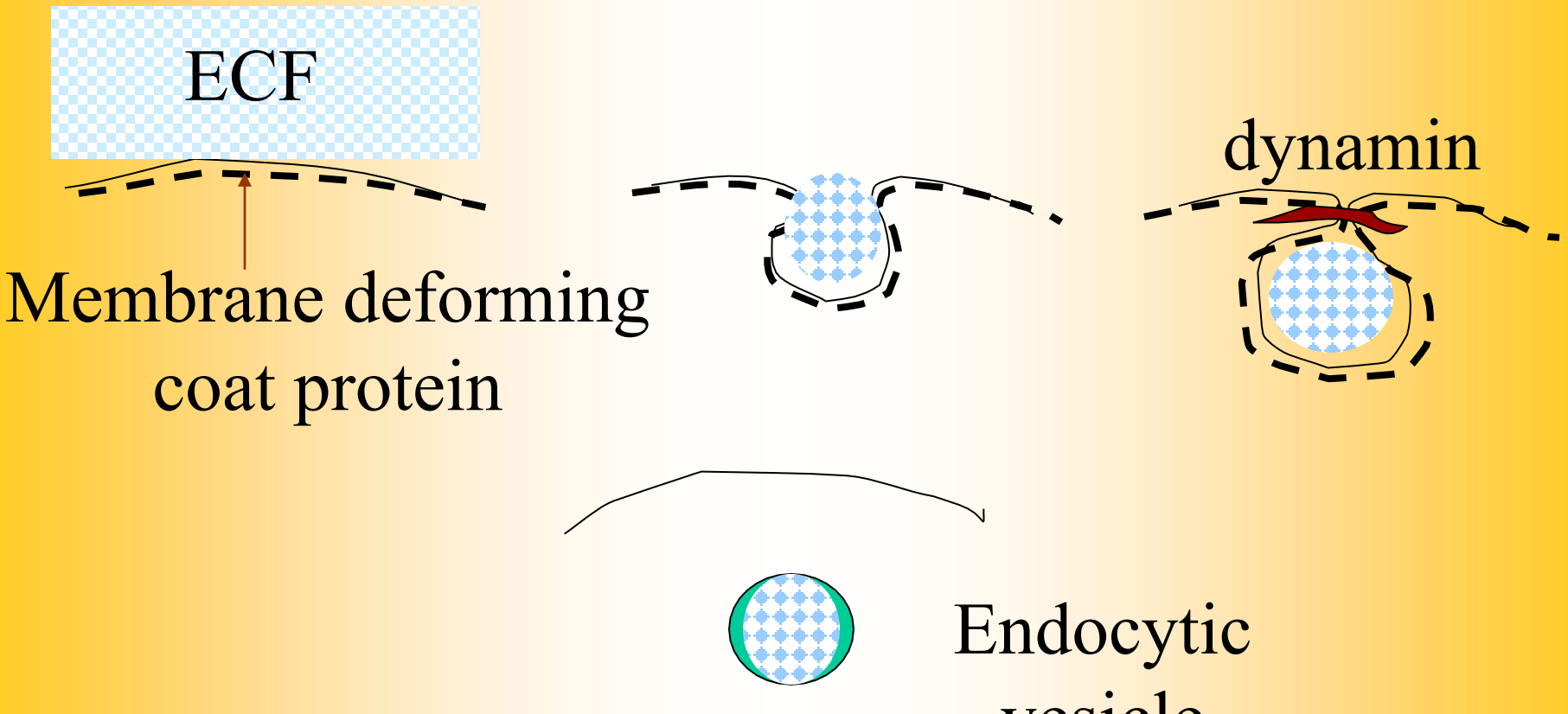
Specialised cells

A.Pinocytosis - Cell drinking nonselective

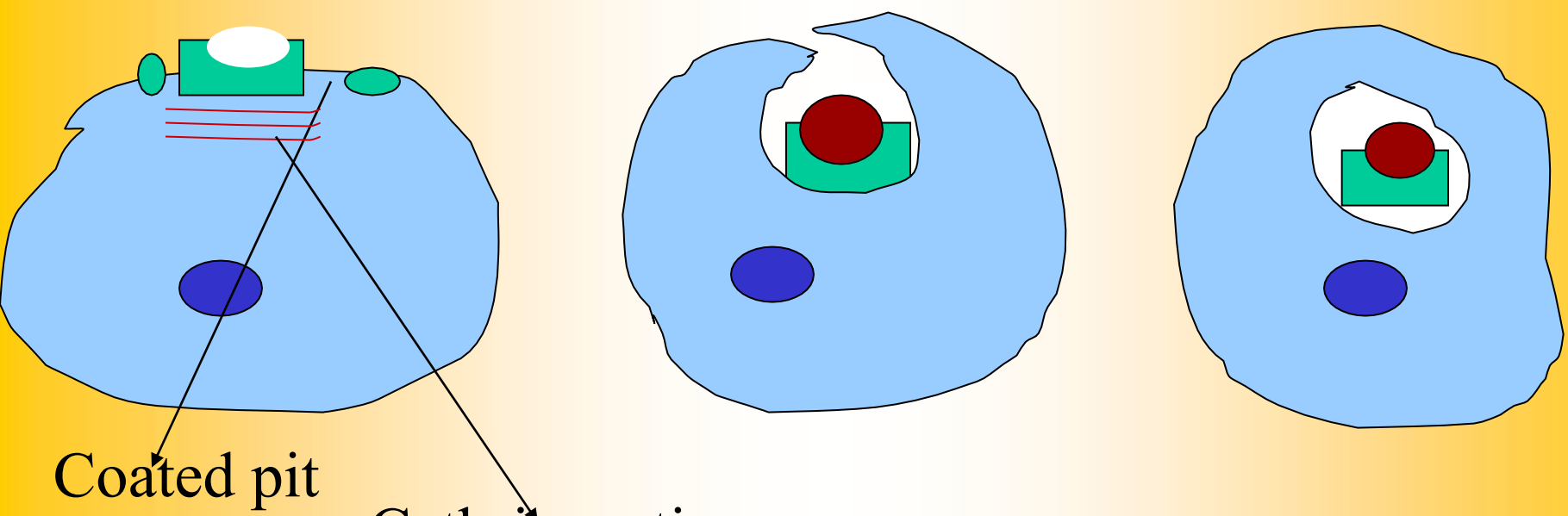
B. continuous process seen in all cells

- Membrane deforming protein attached to membrane
- Formation of pouch by dipping of membrane
- Sealing of ends
- Endocytic vesicle with ECF
- Vesicle is pinched off by protein Dynamin
- ECF to the cell and loss of extra plasma membrane added during exocytosis

Pinocytosis

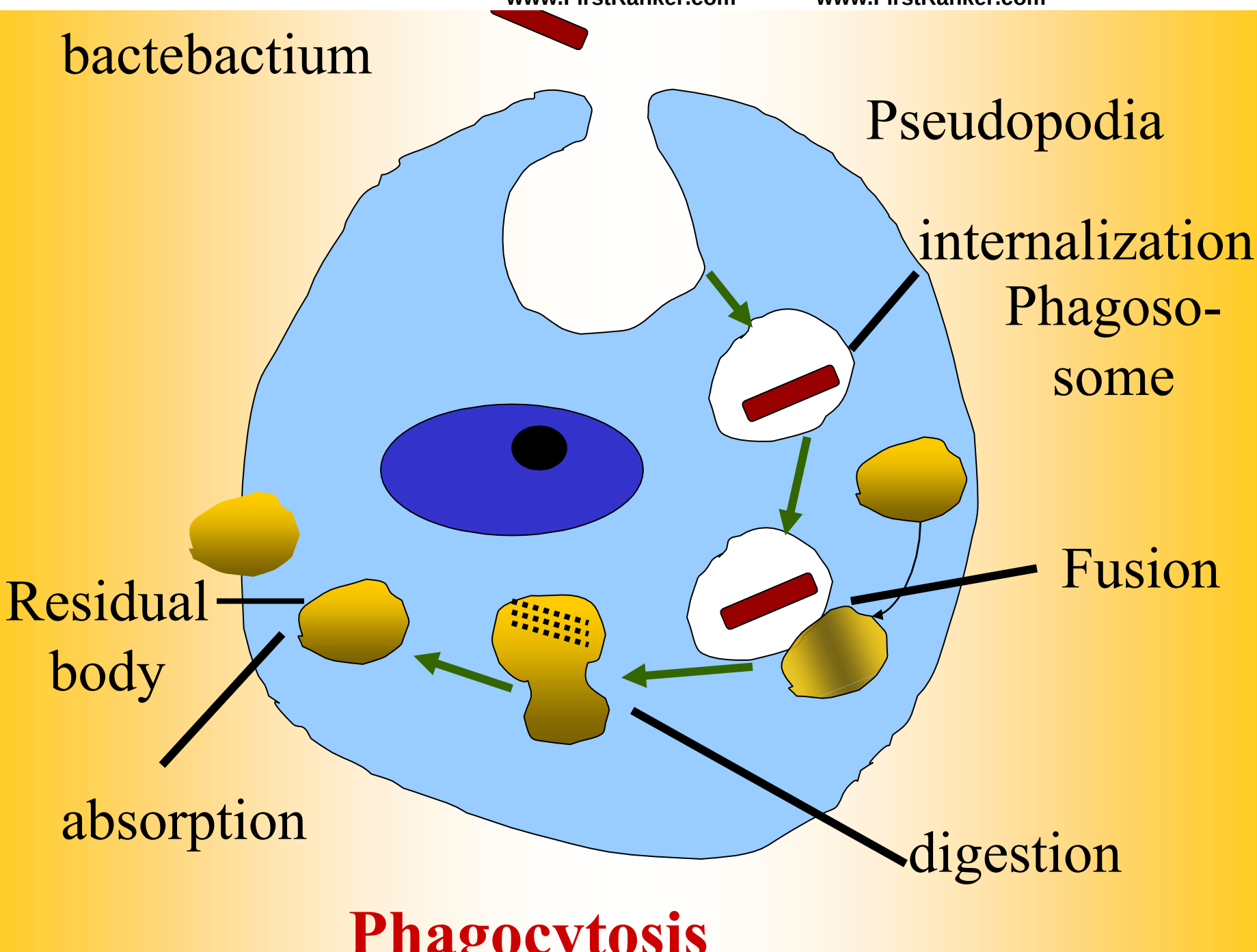


B. Receptor mediated endocytosis – highly selective process to import imp. specific large molecules. Requires energy & Ca^{++}



C. Phagocytosis

- Internalization of large multimolecular particles by specialized cells e.g. certain types of w.b.c.s (Professional phagocytes)



Phagocytosis

Autophagy –

Role in regression of organ – uterus, mammary glands

Removal of aged or damaged organelles

Rupture of lysosomal membrane CAUSES SELF DESTRUCTION but minimal damage because optimum pH for hydrolytic enzymes is acidic.

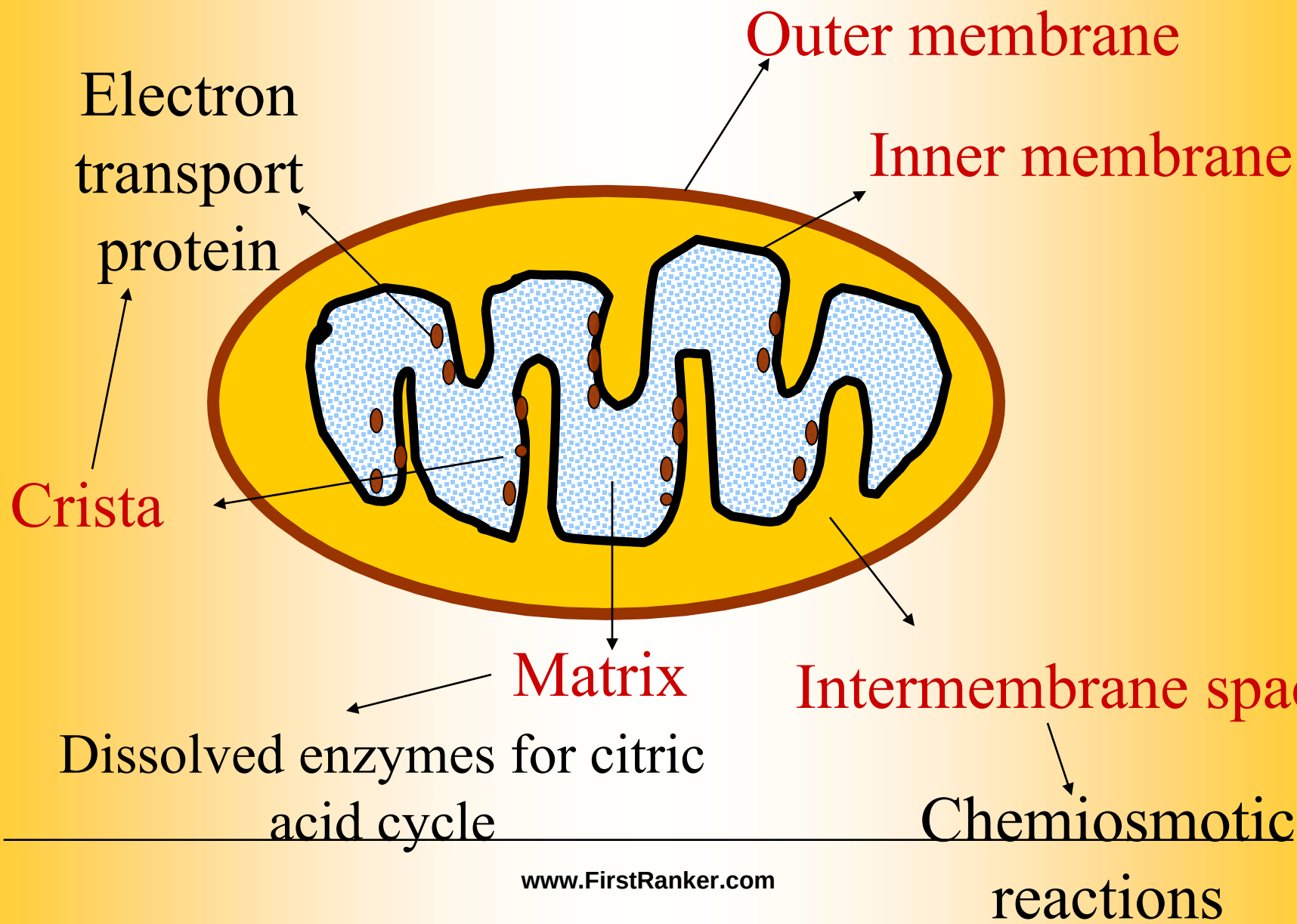
Damage to nuclear DNA alters genetic properties

Deficiency of one or more enzymes lead to storage disease e.g. TAY SACHS disease-

Peroxisomes

- Several hundreds
- ½ to 1/3 size of lysosomes
- Transport of H+ across membrane so acidic pH
- Membrane enclosed sacs with powerful oxidizing enzymes which use O2 to remove hydrogen from organic molecules and detoxify wastes produced in the cell or foreign toxic compound by formation of H2O2 which is oxidant but accumulation is prevented by catalase which is antioxidant
- $H_2O_2 \rightarrow H_2O + O_2$

Mitochondria



- 100s-1000s in single cell
- Energy organelle or power plant
- Extract energy from nutrient and transfer in to usable form
- Number and location in cell varies
- Round shaped or oval
- Possess their own DNA which produces molecules required for generating energy
- Defect in DNA lead to degenerative diseases or ageing
- Double membrane – outer smooth, inner folded forming cristae

Energy release from the nutrients and its storage

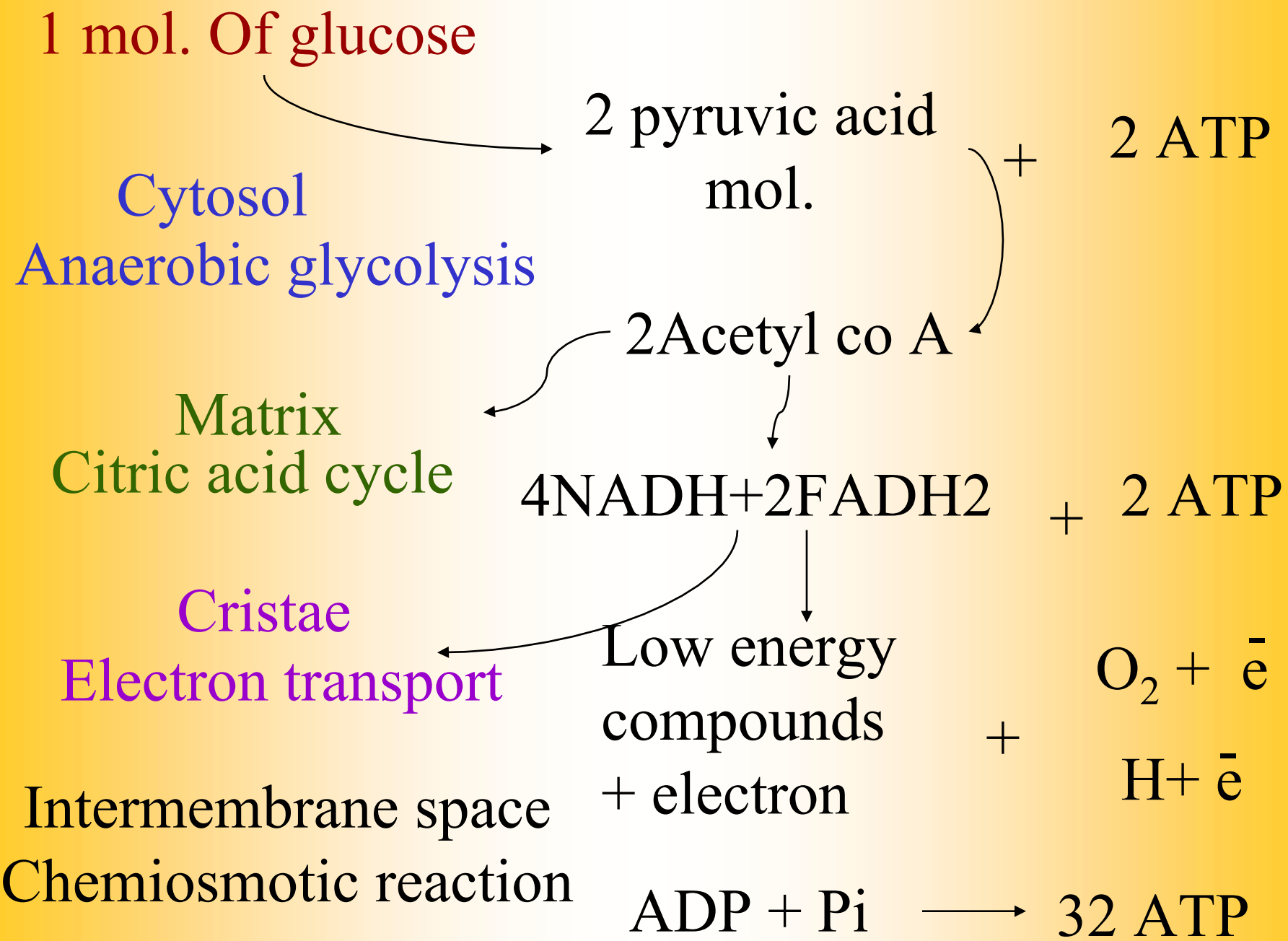
Dietary food → Energy in carbon bonds

→ digestion

Smaller absorbable molecules

→ Through cell

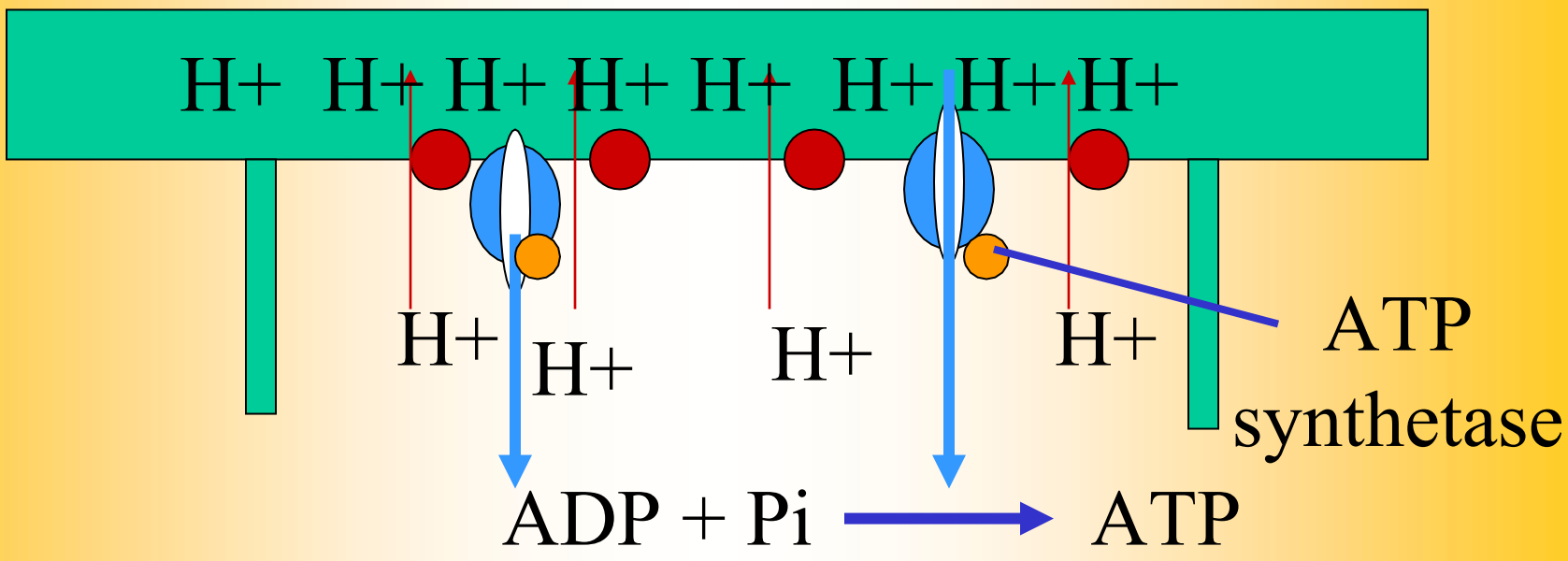
In the cell through membrane



Synthesis of ATP- Oxidative phosphorylation

- Release of energy during electron transport reactions used for active uptake of H+ by inner membrane
- Accumulation of H+ in intermembrane space
- Transport of H+ through channels in inner membrane
- Activation of ATP sythetase attached to channel protein
- ADP + Pi ___ ATP (32mol) with utilization of O2 from atm.

Chemiosmotic reactions



Uses of ATP

1. Synthesis of new chemical compounds for secretion and growth

2. Membrane transport

3. Mechanical work

Vaults

- 3 times larger than ribosomes
- Octagonal barrels with hollow interior
- Not seen with ordinary stain
- Pass through nuclear pore
- transporting messenger RNA and other material across nuclear membrane
- May be responsible for multi drug resistance in cancer cells.

Cytosol

- Semi liquid surrounding organelles
- Highly organized gel like mass with different composition at diff. sites
- Cytoskeleton is dispersed through out
- enzymes regulating intermediary reactions
- Ribosomal protein synthesis (used for cell)
- Storage of fats, glycogen (Inclusions), secretory vesicles

Cytoskeleton

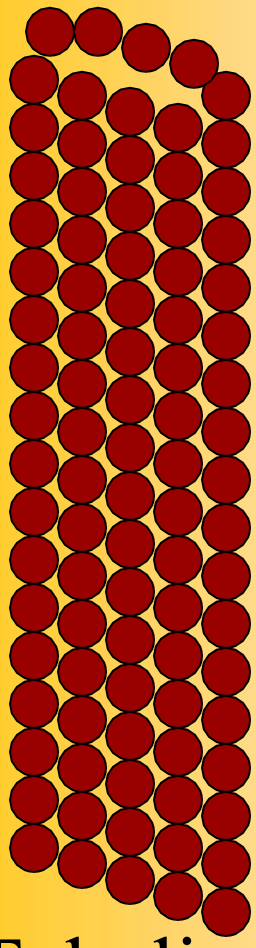
Complex protein network portion of cytosol which act as ‘bones and muscles ‘ of the cell.giving shape , support and control their movements

3 elements

Microtubules microfilament intermediate filaments

Microtubules

Largest skeletal element, slender, long hollow unbranched tubes



Tubulin subunit

Functions

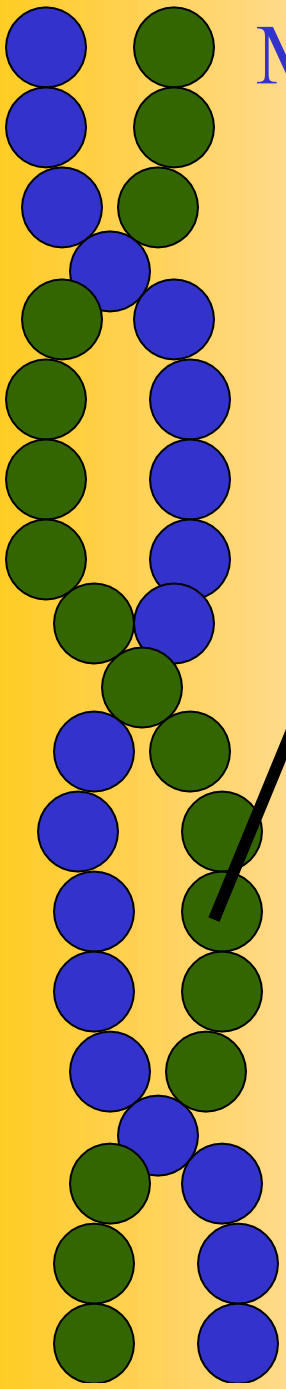
A) Maintains asymmetric cell shape e.g.

B) axon

B) Transport of secretary vesicles and other materials in any direction by use of motor protein and energy

- Movement of specialized cell projection such as cilia, flagellum
- Distribution of chromosomes during mitosis of spindles

Microfilament



- Smallest element of cytoskeleton
- Actin is present in most cells
- 2 strands of globular actin
- Role in the cell -

Cellular contractile system

Mechanical stiffener for

cellular projection-microvilli

Intermediate filaments

Tough, maintain structure integrity of cell and resist mechanical stress

e.g. microfilaments in axon

Keratin in skin cells

Functional systems of cells

I. Ingestion

II. Digestion of foreign substances

III. Synthesis and formation of new structures

IV. Energy extraction

V. Locomotion – ameboid movement,

VI. ciliary movement