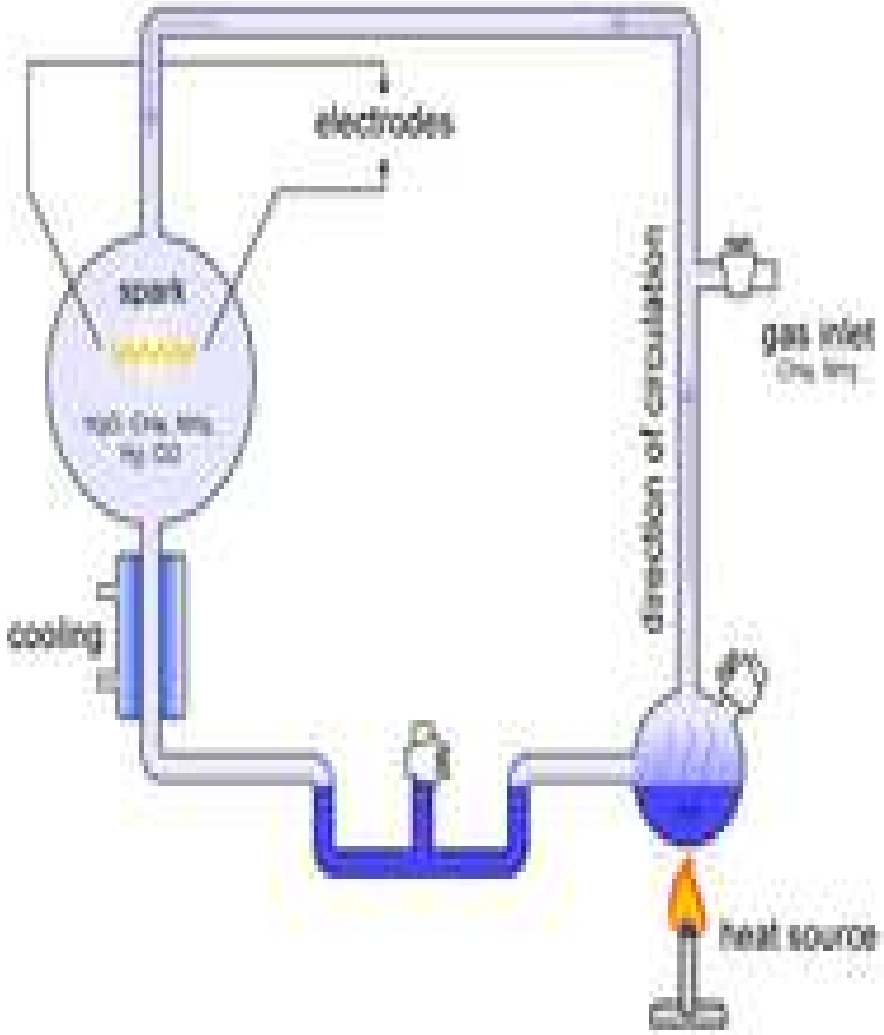
Session II
Cell and Molecular Biology of Living Systems

Miller Urey Experiments
(used water, methane, ammonia & hydrogen)



CNN: Mon August 20, 2007

Scientists: Artificial life likely in 3 to 10 years

- There are three major hurdles to creating synthetic life:

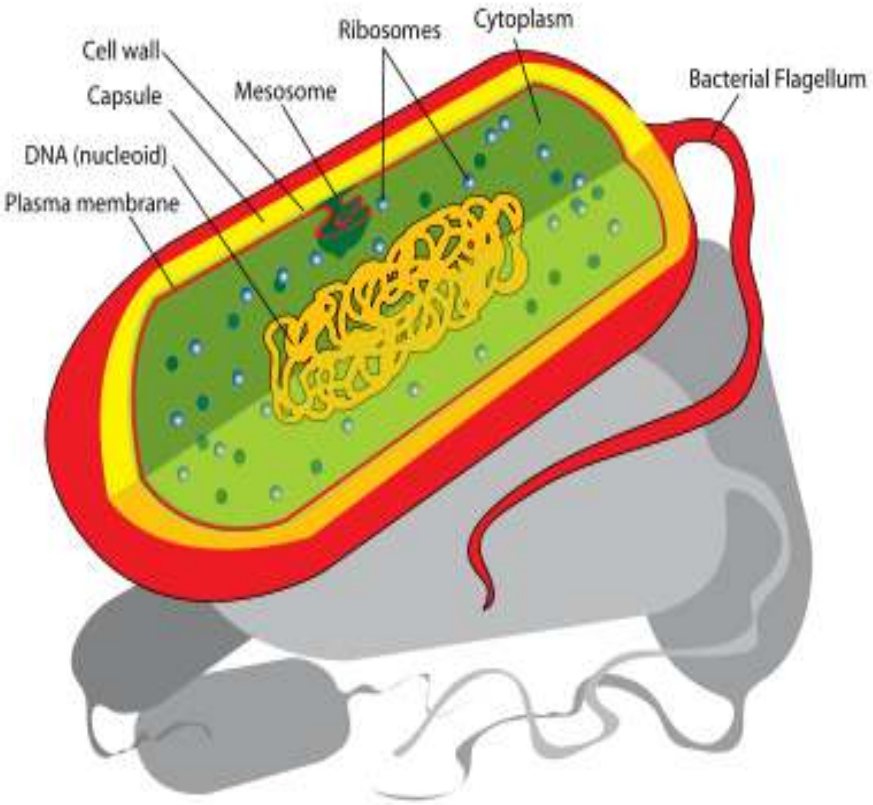
- A container, or membrane,
  for the cell to keep bad molecules out, allow good ones

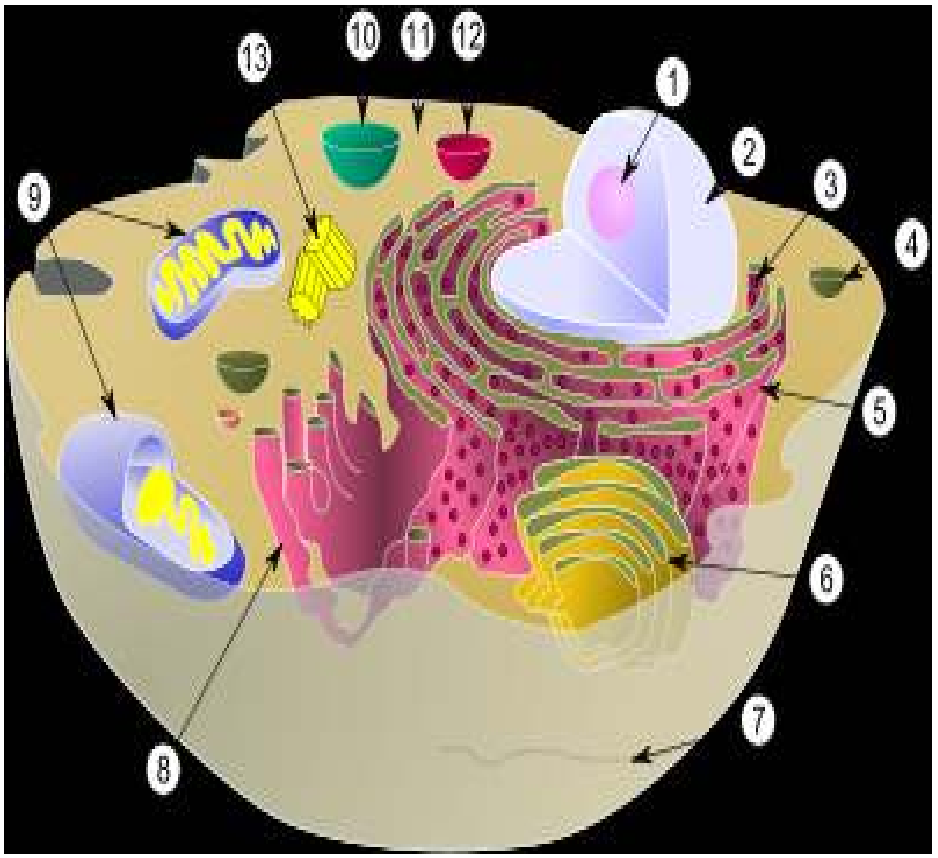
- A system that controls the functions of the cell, enabling it to reproduce and mutate in response to environmental changes

- A metabolism that extracts raw materials from the environment as food and then changes it into energy.

One of the leaders in the field, Jack Szostak at Harvard Medical School, predicts that within the next six months, scientists will report evidence that the first step -- creating a cell membrane -- is "not a big problem." Scientists are using fatty acids in that effort. Szostak is also optimistic about the next step -- getting nucleotides, the building blocks of DNA, to form a working genetic system.

Cells – old & new

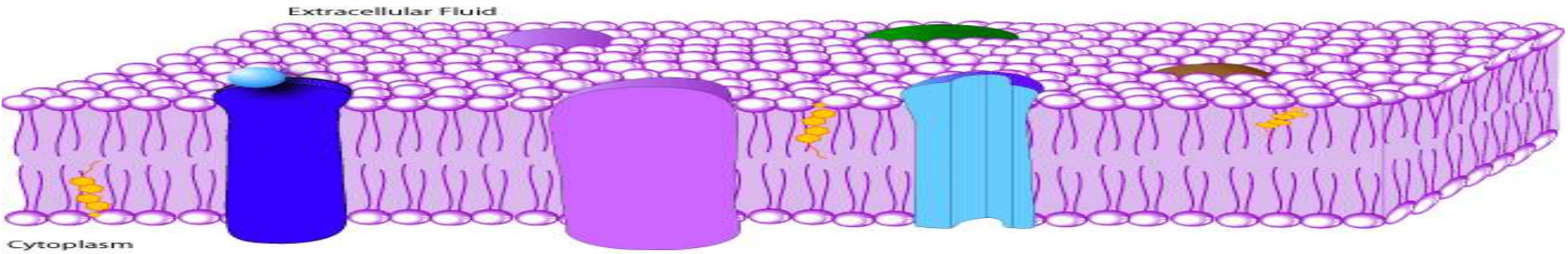




ribosome
endoplasmic reticulum
Golgi
Cytoskeleton
mitochondria
vacuole
cytoplasm
lysosome
centrioles

	Prokaryotes	Eukaryotes
Typical organisms	Bacteria, Archaea	Fungi, Plants, Animals
Typical size	~ 1-10 µm	~ 10-100 µm
Nucleus	no real nucleus	real nucleus with double membrane
DNA	circular (usually)	linear molecules
RNA-/protein-synthesis	coupled in cytoplasm	RNA-synthesis inside the nucleus protein synthesis in cytoplasm
Cytoplasmatic structure	very few structures	highly structured by endomembranes and cytoskeleton
Mitochondria	none	one to several dozen (though some lack mitochondria)
Chloroplasts	none	in algae and plants
Organization	usually single cells	single cells, colonies, higher multicellular organisms with specialized cells
Cell division	Binary fission (simple division)	Mitosis (fission or budding) Meiosis

The Cell Membrane



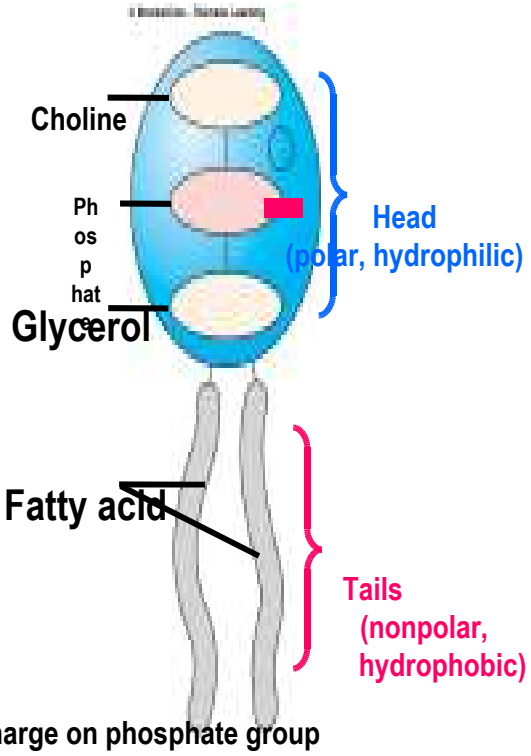
Cell membrane is composed of **lipids & proteins**

Lipids are amphipathic – ie Hydrophilic end facing the fluids (ICF & ECF)
Hydrophobic hydrocarbon tail (facing each other)

Proteins – embedded in the cell membrane.
Transmembrane proteins: that span the entire bilayer
(channels, carriers, pumps & receptors)

Integral proteins: present only on one side of cell membrane
(act as enzymes and activate/inactivate metabolic processes)

Extrinsic Proteins: bind to intracellular surface – cytoskeleton
: bind to extracellular surface - glycocalyx



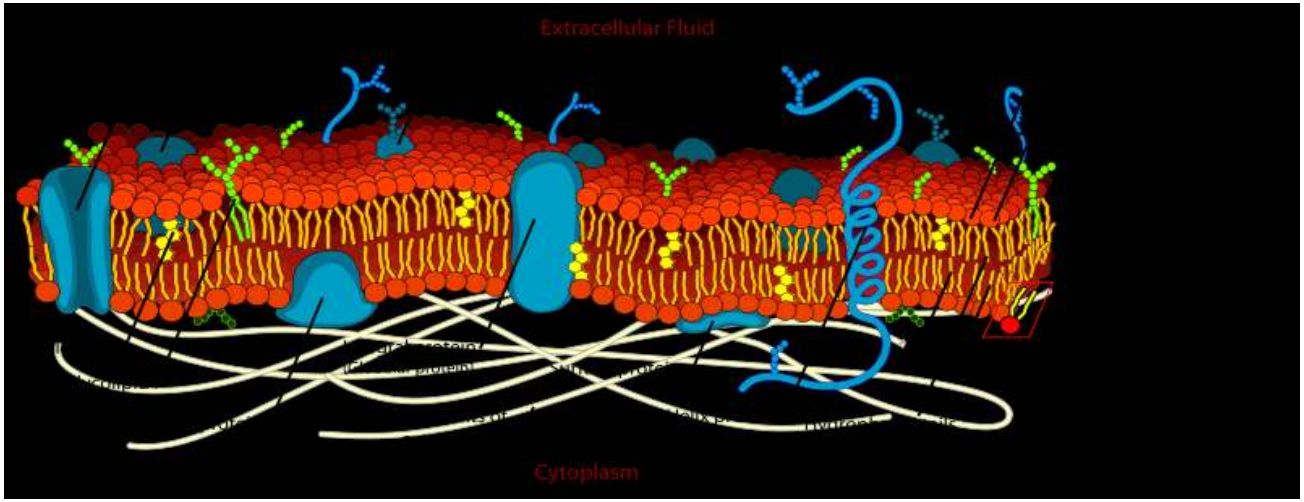
Cell Membrane

- Biomolecules constantly move across cell membrane

- ECF: composition is maintained by all the systems acting in a coordinated fashion

- ICF: composition is maintained by cell membrane by

- Transport across cell membranes occurs by:
- Diffusion
- Osmosis
- Active transport
- Vesicular transport



Passive transport across cell membranes

- **Diffusion**: passive movement of down concentration gradient

- **Facilitated Diffusion**:for larger molecules. is a carrier (protein)-mediated process that enables LARGE molecules to flow thru' cell membrane channels ex: *glucose into RBCs when insulin is present*

- **Osmosis**: the passive **flow of water molecules** across a selectively permeable membrane down an osmotic pressure gradient

- *Changes in plasma osmolarity cause cells to shrink or swell (as the osmotic pressure difference causes water to flow in or out of cells)*

Active Transport Processes

always require energy

- **Uses a transmembrane Protein to move molecules**
- **Primary**: directly use energy from hydrolysis of ATP
- **Secondary**: indirect energy
- **Carrier types**: transport one/two particles in the same direction (Uniporters & Symporters) or transport molecules in opposite directions (Antiporters)

Vesicular (Bulk) Transport

Extracellular/Intracellular material is trapped within vesicles for transport

- **Endocytosis**: Extracellular material is trapped within vesicles formed by invagination of the cell membrane. Ex: Iron & Cholesterol are transported into cells by receptor-mediated endocystosis

- **Exocytosis**: Intracellular material trapped within vesicles, fuse with the cell membrane and release contents to the ECF Ex: hormones, digestive enzymes, neurotransmitters transported by exocytosis

Transmembrane Proteins form

- **Channels**: thru' which diffusion occurs
- **Carriers**: for Active transport of materials
- **Pumps**: for Active transport of ions
- **Receptors**: when activated, initiate intracellular reactions

Basic Cell Processes

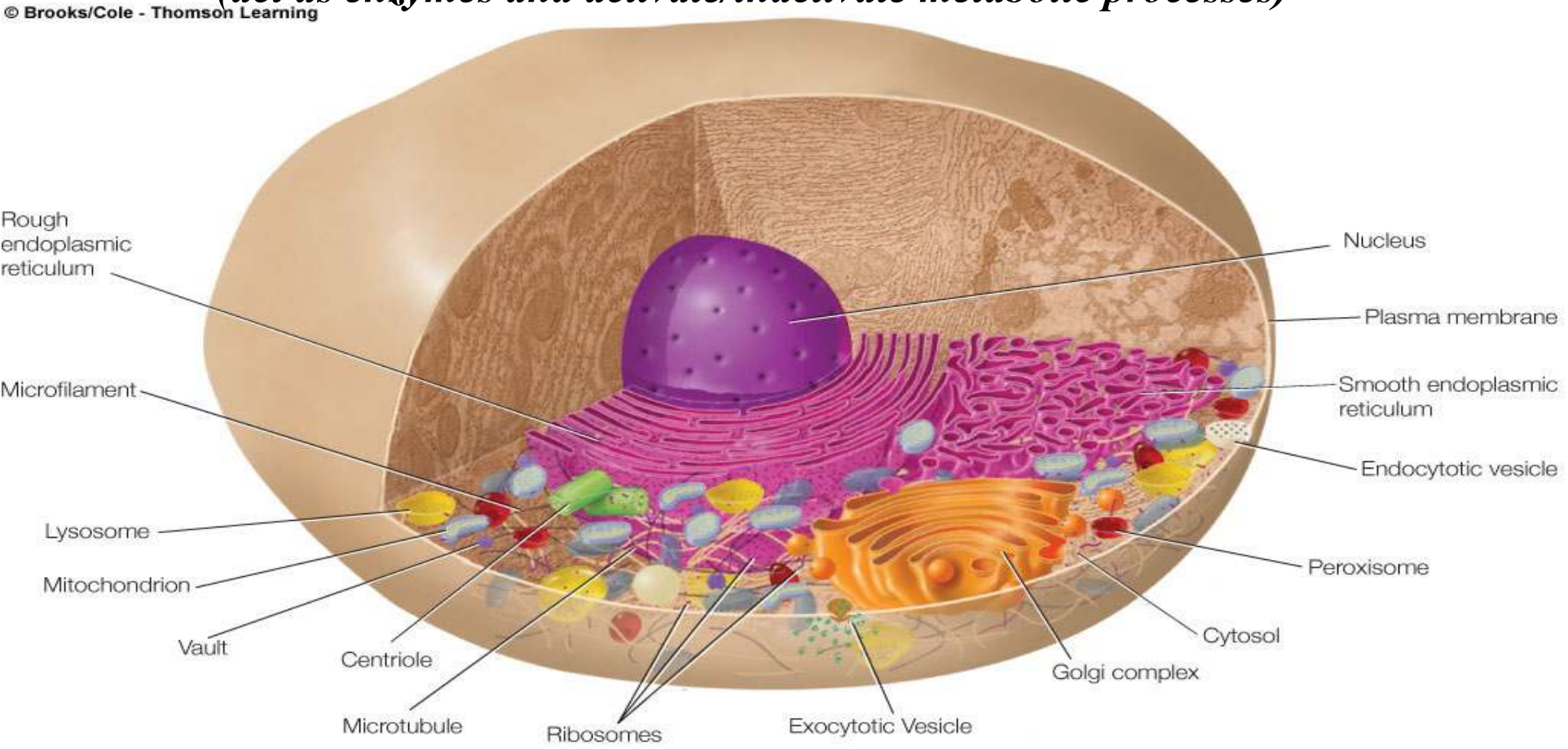
DNA Replication

Cell Division (Mitosis & Meiosis)

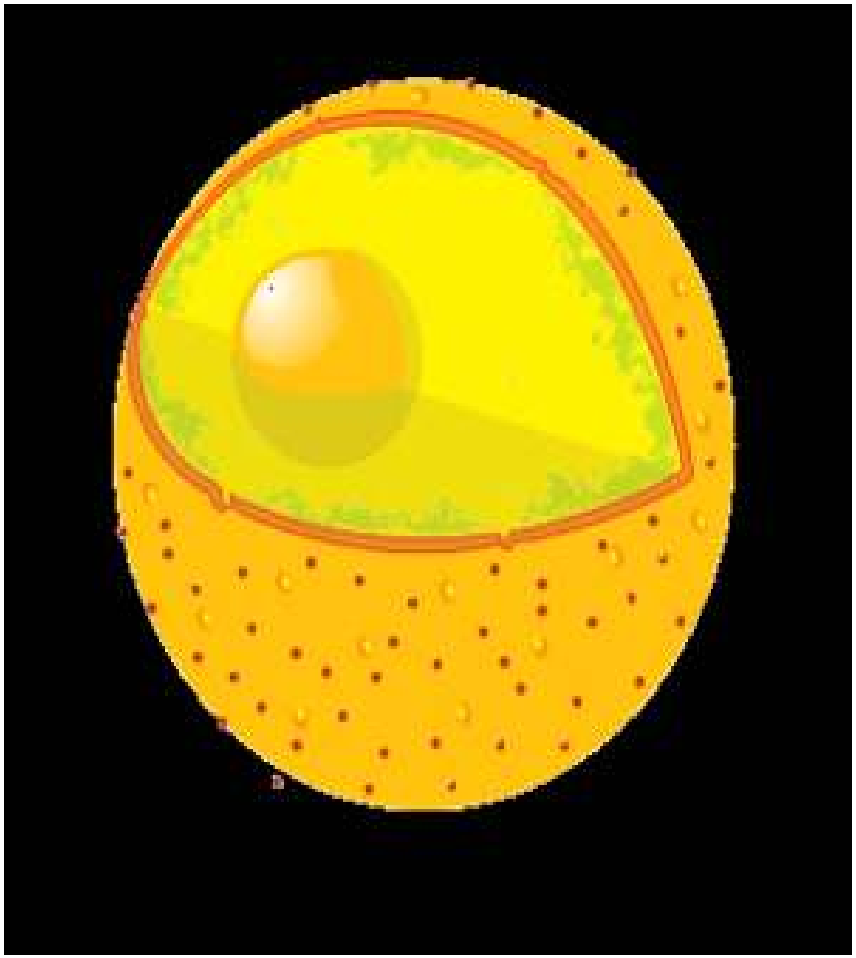
Cell Respiration

Protein Synthesis

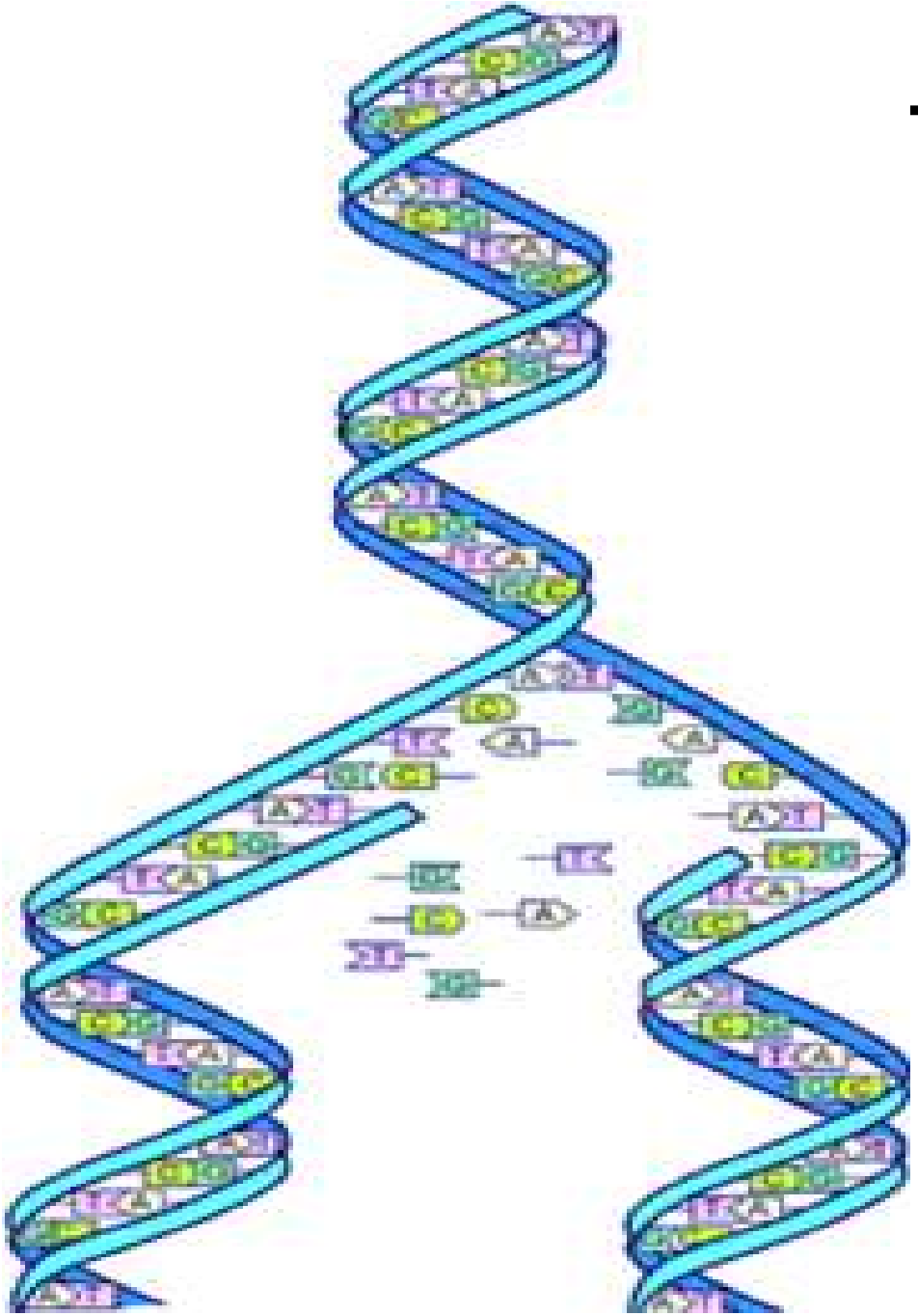
Integral proteins: present only on one side of cell membrane
(act as enzymes and activate/inactivate metabolic processes)

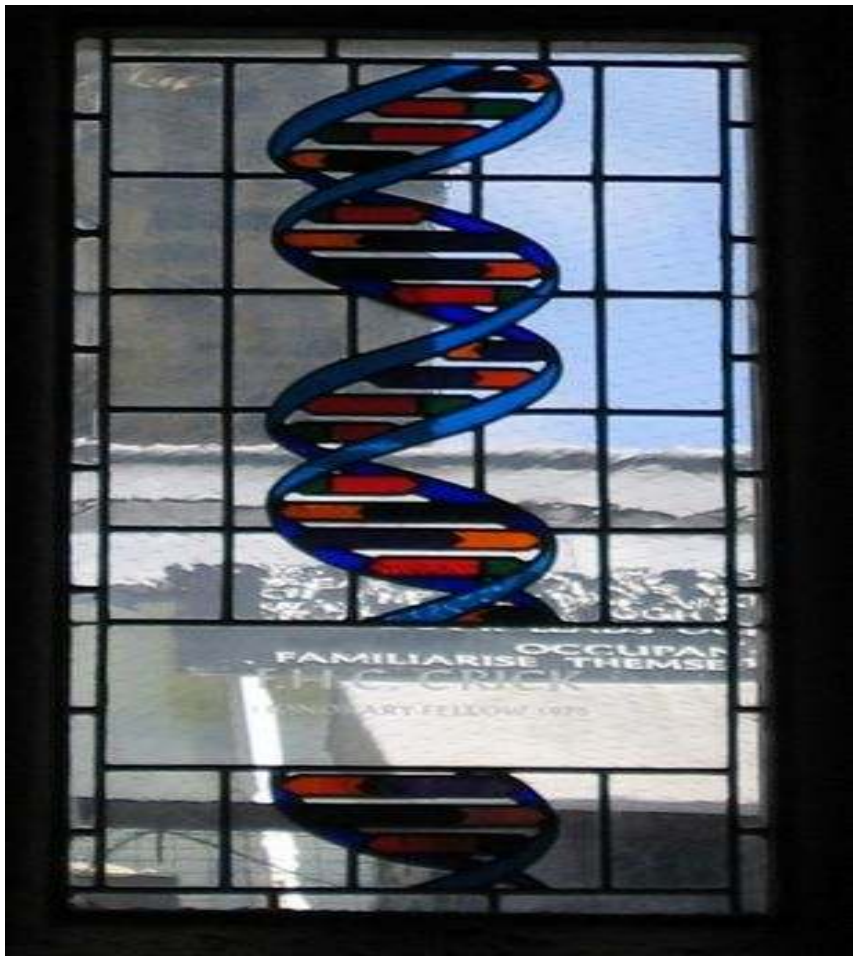


Nucleus & Endoplasmic Reticulum

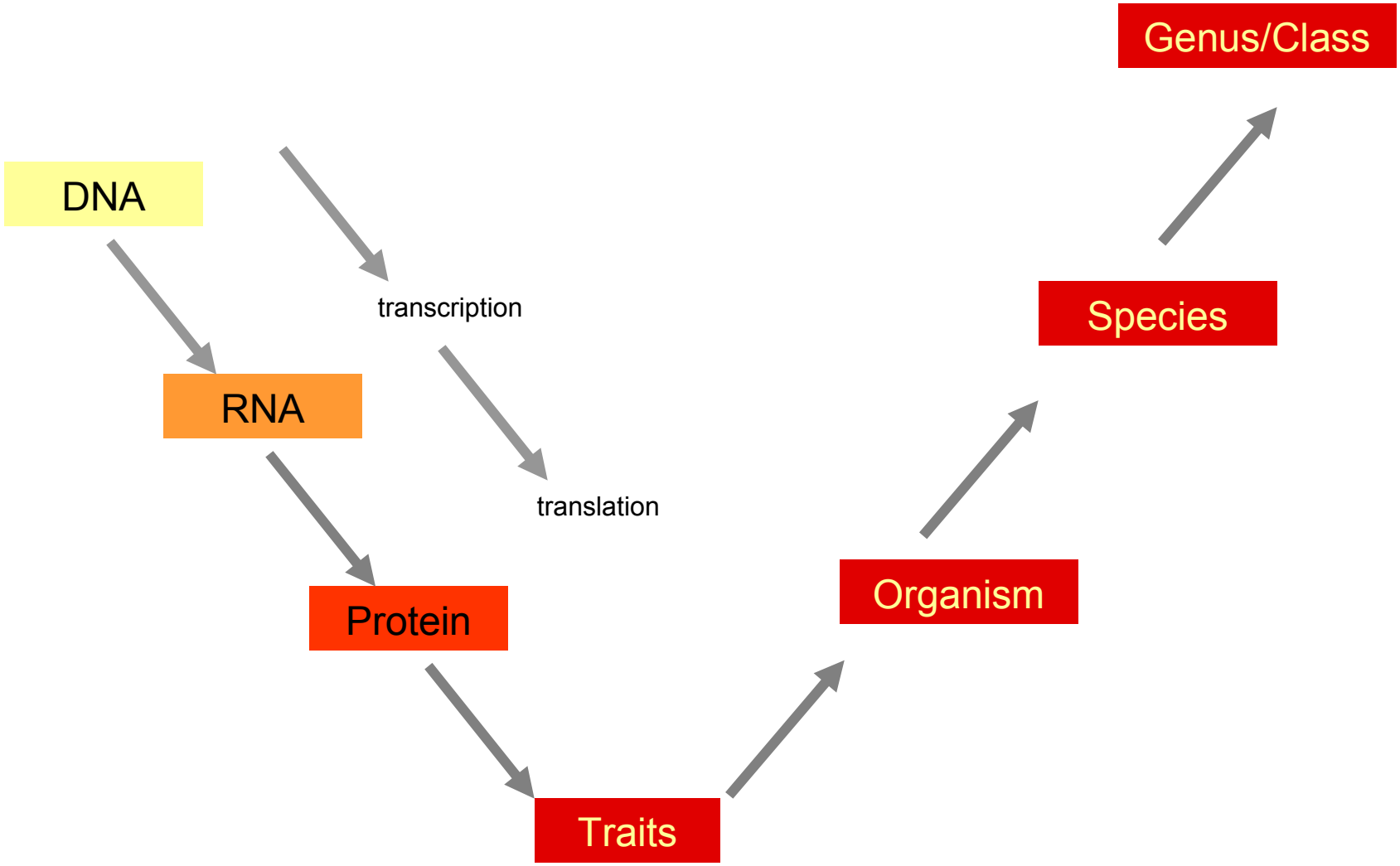


The Double Helix





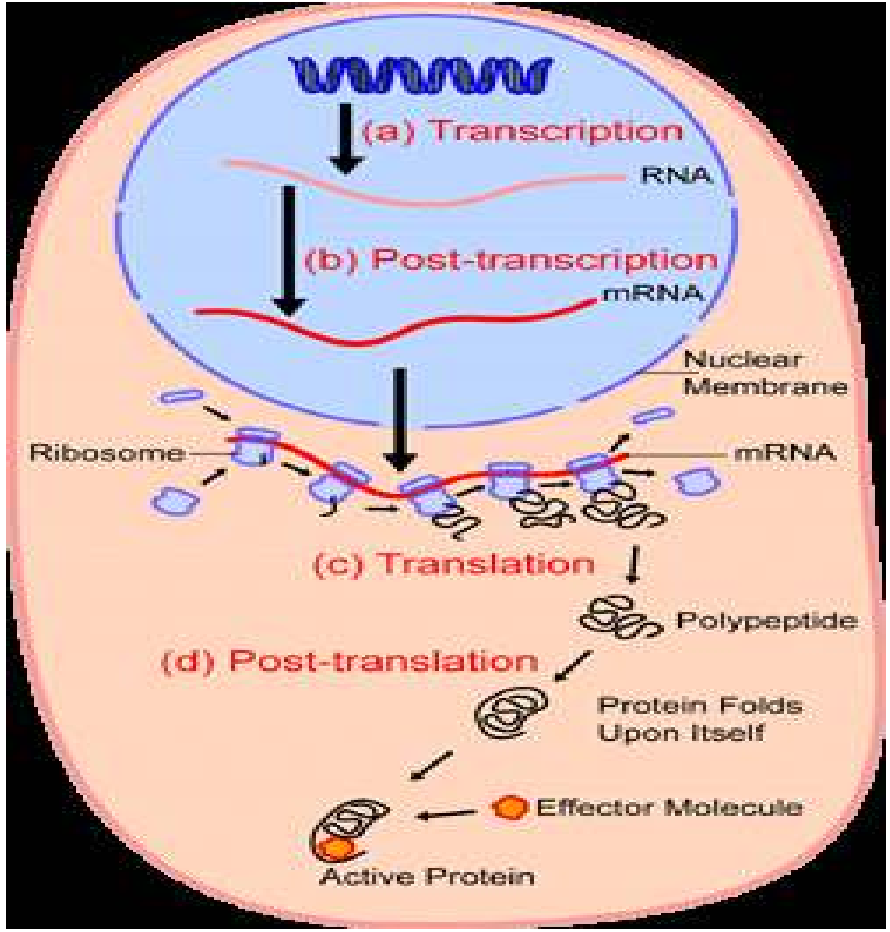
Gene Expression



Protein Synthesis

Transcription in the Nucleus

Translation in the Cytoplasm



DNA → **RNA** → **Protein**

mRNA: carries a code for a particular protein from the nucleus into the cytoplasm.

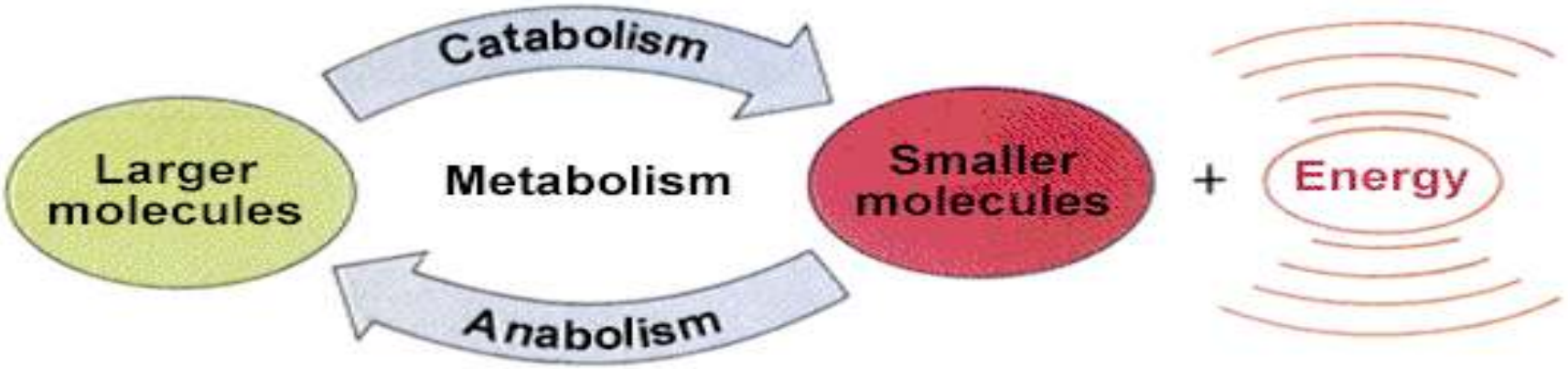
tRNA: interprets the message on the mRNA.

rRNA: makes up the ribosomes, the site where protein synthesis occurs.

Tissues – Groups of Cells performing similar basic functions

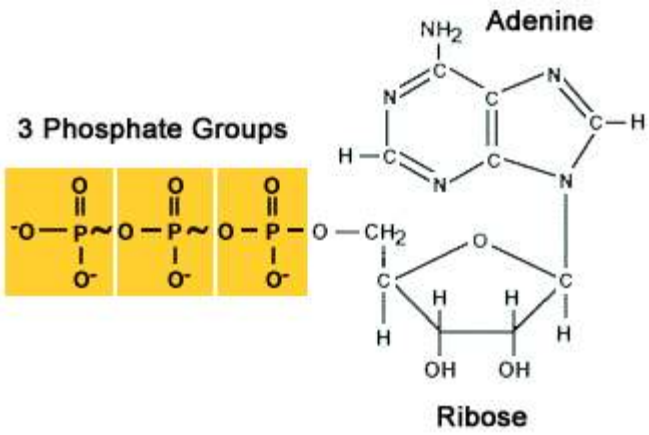
- Epithelial Tissue
- Connective Tissue
- Nervous Tissue
- Muscle Tissue

Metabolism

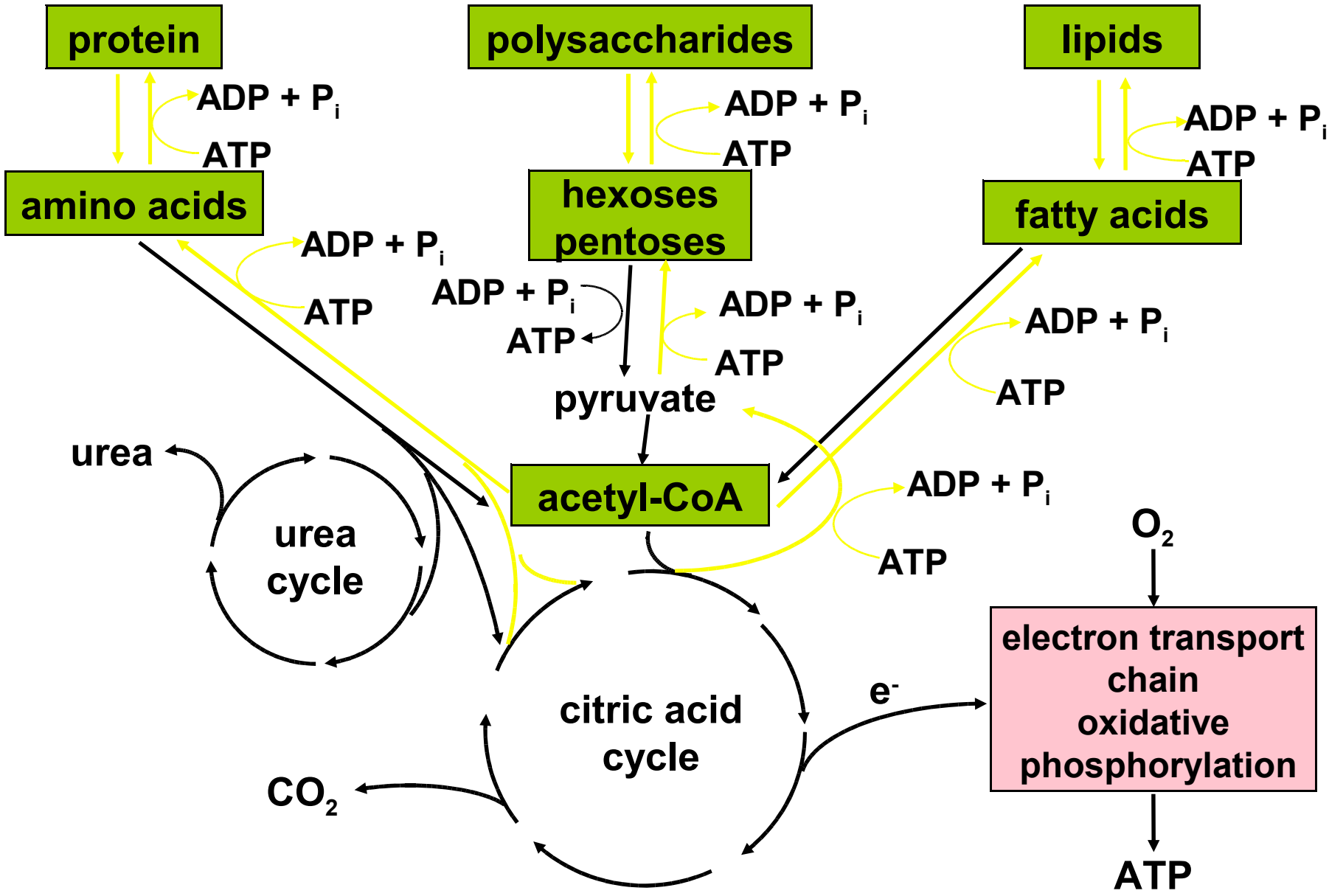


Photosynthesis to derive their (plants') energy.

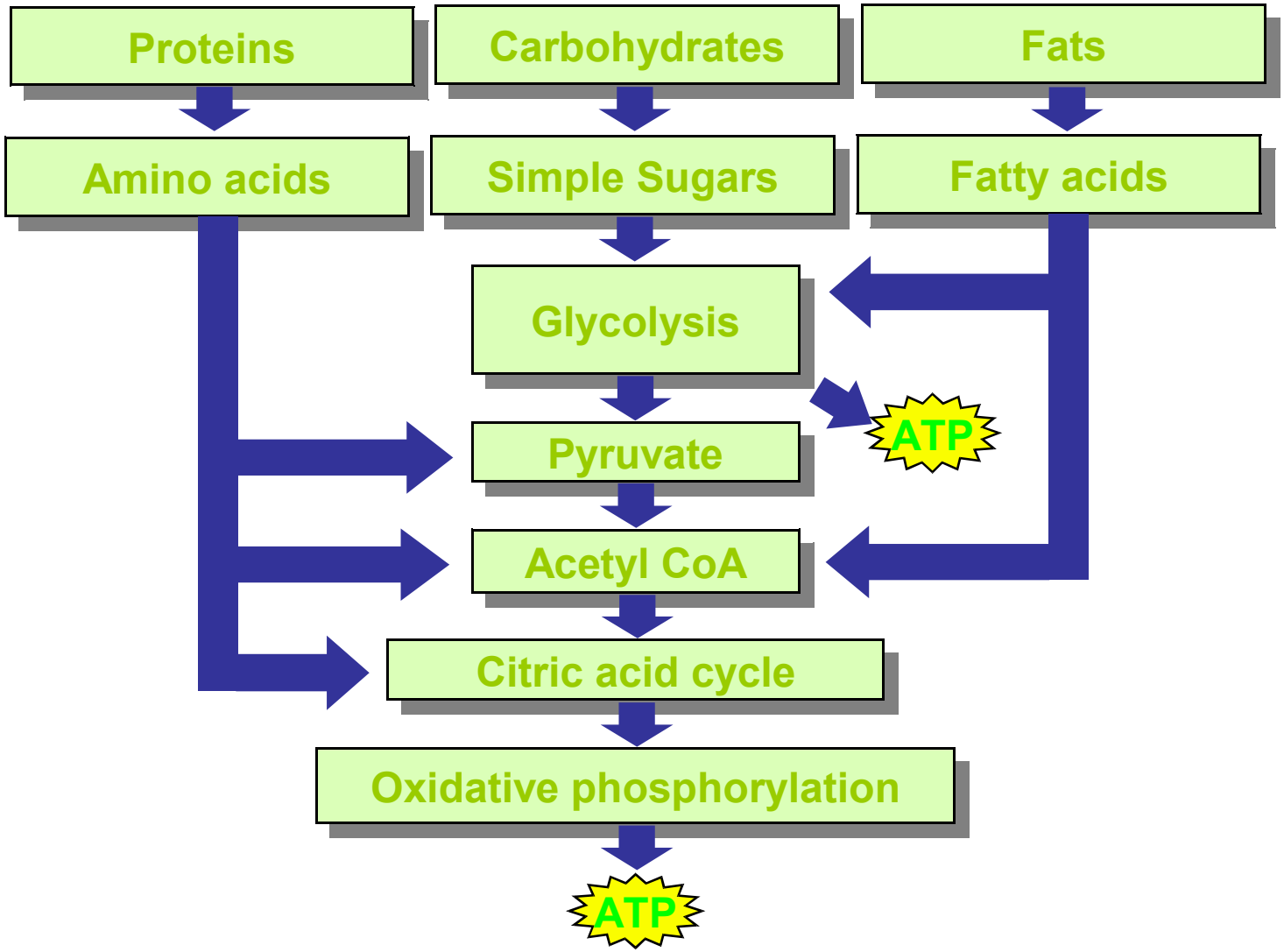
$6CO_2 + 12H_2O + \text{sunlight} \rightarrow C_6H_{12}O_6 + 6H_2O + 6O_2$



Cell Metabolism



Catabolic Processes



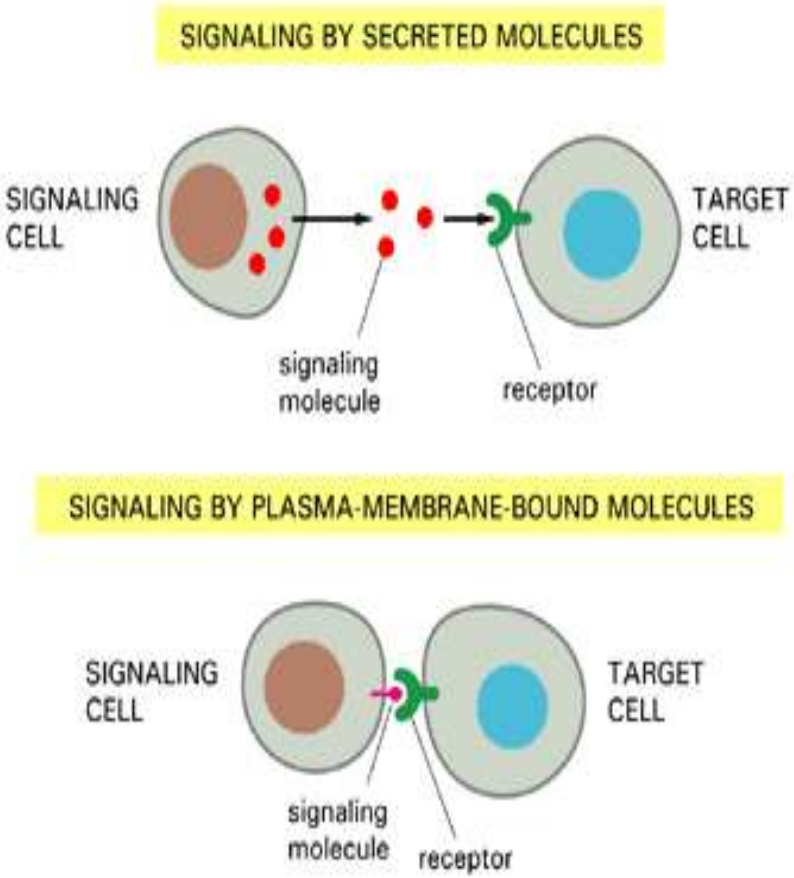
Stage 1

Stage 2

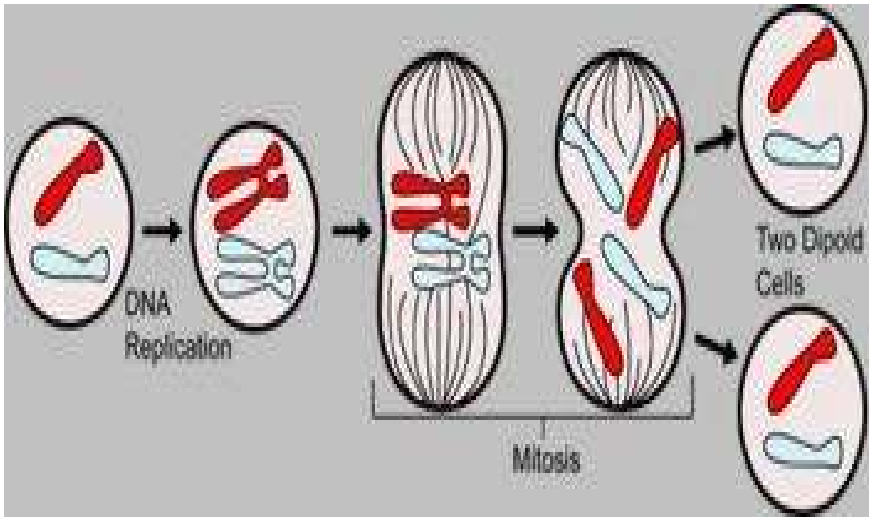
Stage 3

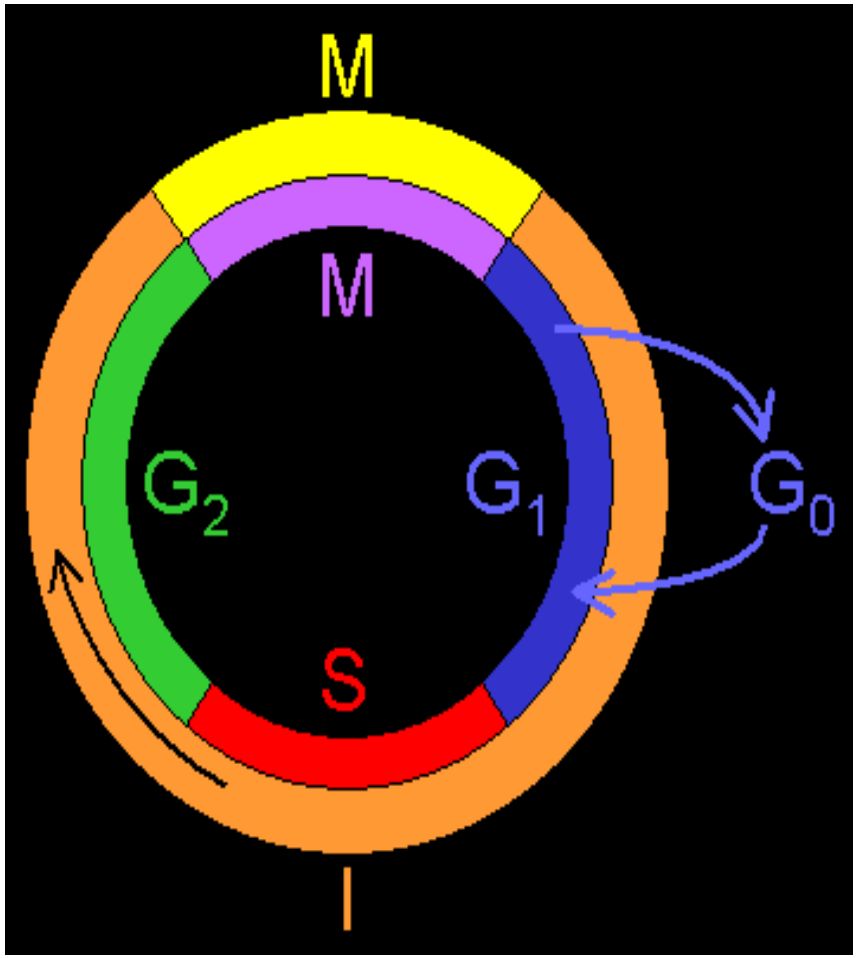
Cell-to-Cell Communication

- The ability of cells to perceive and correctly respond to their microenvironment is the basis of development, tissue repair, and immunity as well as normal tissue homeostasis.
- Errors in cellular information processing are responsible for diseases such as cancer, autoimmunity, and diabetes

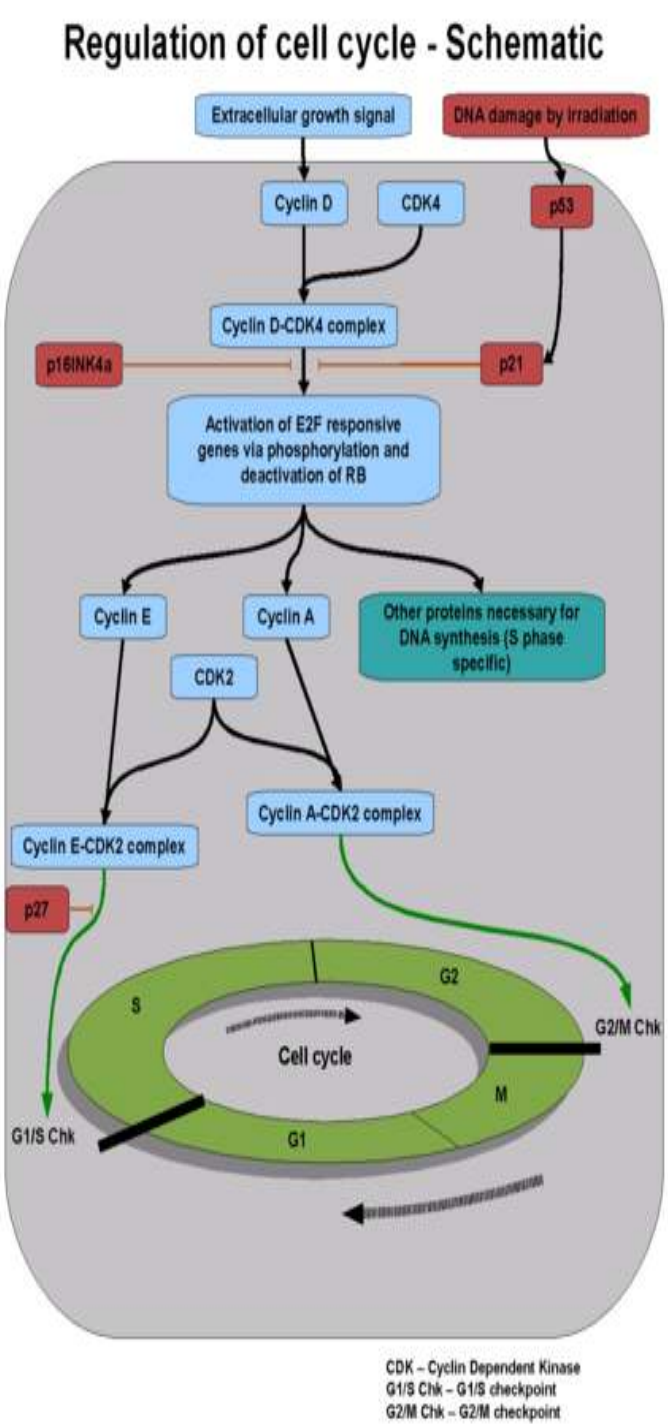


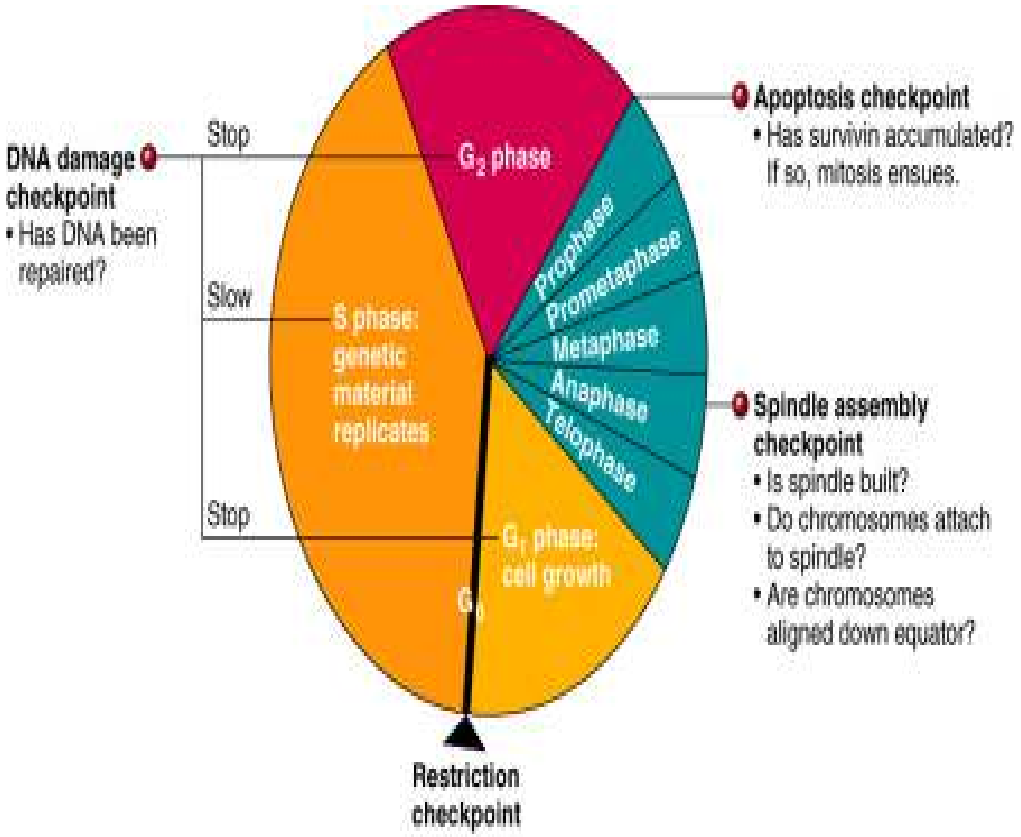
Cell Division





Cell Cycle


Regulation of cell cycle - Schematic
Extracellular growth signal
DNA damage by irradiation
Cyclin D
CDK4
p53
Cyclin D-CDK4 complex
p16INK4a
p21
Activation of E2F responsive genes via phosphorylation and deactivation of RB
Cyclin E
Cyclin A
Other proteins necessary for DNA synthesis (S phase specific)
CDK2
Cyclin A-CDK2 complex
Cyclin E-CDK2 complex
p27
S
G2
G2/M Chk
Cell cycle
M
G1/S Chk
G1
CDK – Cyclin Dependent Kinase
G1/S Chk – G1/S checkpoint
G2/M Chk – G2/M checkpoint


DNA damage checkpoint
• Has DNA been repaired?
Stop
Slow
Stop
G2 phase
S phase: genetic material replicates
G1 phase: cell growth
G0
Prophase
Prometaphase
Metaphase
Anaphase
Telophase
Apoptosis checkpoint
• Has survivin accumulated? If so, mitosis ensues.
Spindle assembly checkpoint
• Is spindle built?
• Do chromosomes attach to spindle?
• Are chromosomes aligned down equator?
Restriction checkpoint

What is Cancer ?

- Cancer is a group of >100+ diseases caused by loss of cell cycle control.
-
- Cancer is associated with abnormal uncontrolled cell growth.

- Tumor Vs Cancer

- Benign Vs Malignant

7 WARNING SIGNS OF CANCER

- C - Change in Bowel or bladder habits
- A - Sore that does not heal
- U - Unusual bleeding or discharge
- T - Thickening or lump in breast/elsewhere
- I - Indigestion or difficulty swallowing
- O- Obvious change in wart or mole
- N - Nagging cough or hoarseness

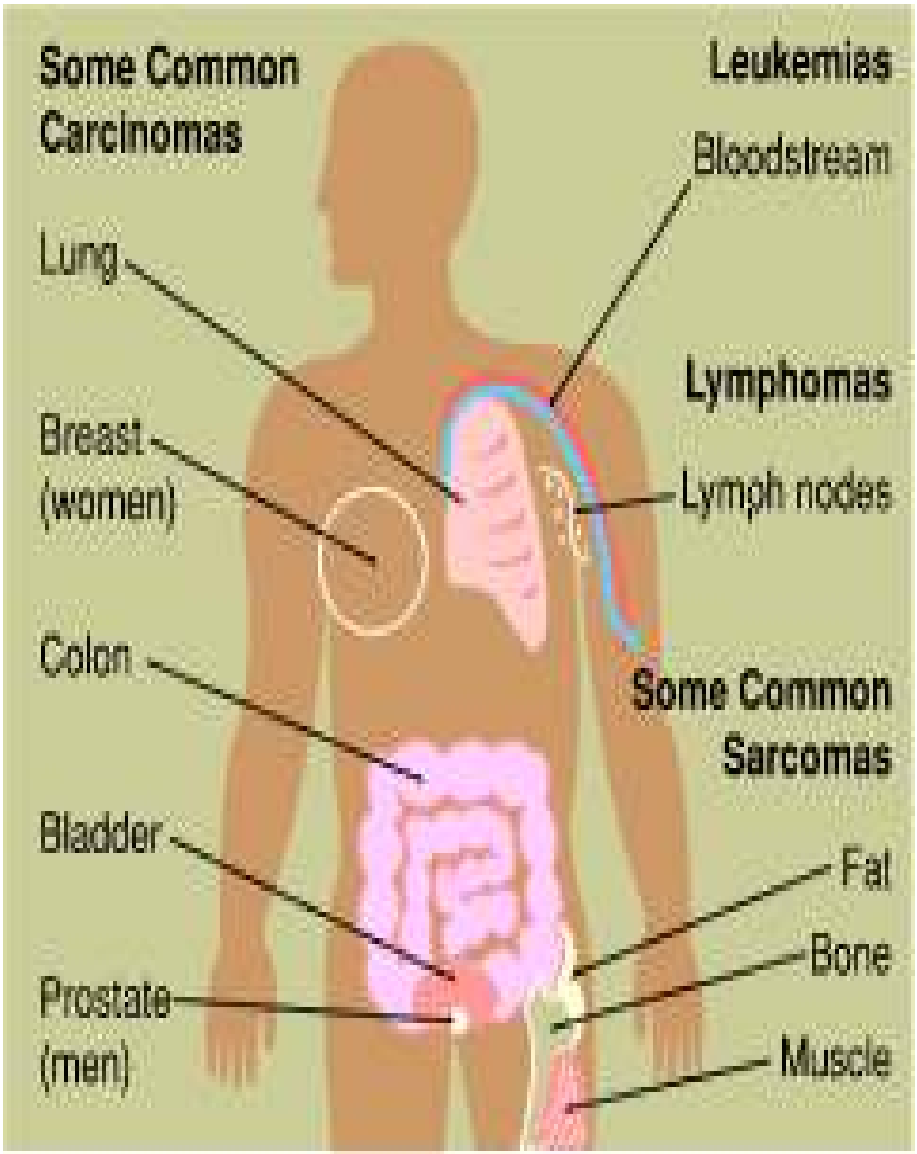
CAUSES OF CANCER

- EXTERNAL - Chemicals, radiation, viruses
- INTERNAL - Hormones, immune conditions, inherited
- Lifestyle/environmental:account for most cancer risk
- Cigarette smoking which remains the most significant factor.

CANCER DIETARY FACTS

- 1/3 of all cancer deaths in the U.S. relate to dietary factors
- Types of food consumed and amount of fat are risk factors for some cancers in women, particularly breast cancer
- Fat calories should not exceed 30% of the total with no more that 10% in saturated fat.
- Fruits and Vegetables - of many deep colors. 5-A-Day Plan or more servings of fruits and vegetables are good.
- Fibrous, cruciferous, soy products and legumes are protective factors against cancers of the gastrointestinal and respiratory

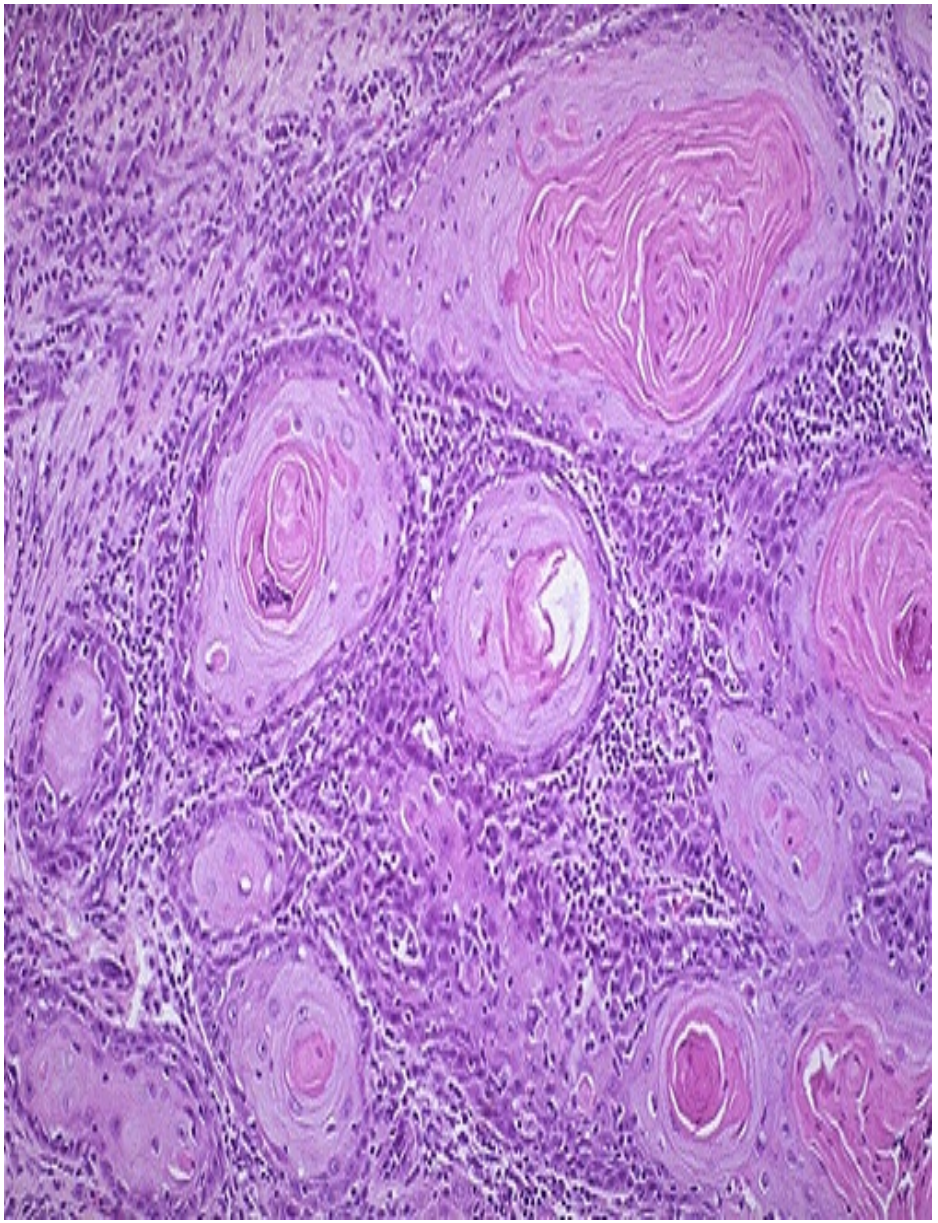
Cancer - Types



- Carcinomas
- Sarcomas
- Blood Cancers
  - Leukemia
  - Lymphoma
  - Myeloma

Normal

Cancer



Thank You!