# Unit 02- Chemical and Cellular Basis of Life

**2.1.3 Examines the chemical nature and functions of main organic compounds of organisms.**

Structure and function of the four main types of organic compounds found in organisms.

Carbohydrates, lipids , proteins, and nucleic acids

- describe the basic chemical nature of four main types of organic compounds found in organisms
- elaborate on the functions of four major types of organic compounds.
- identify  structure and functions

# Elemental composition of living matter

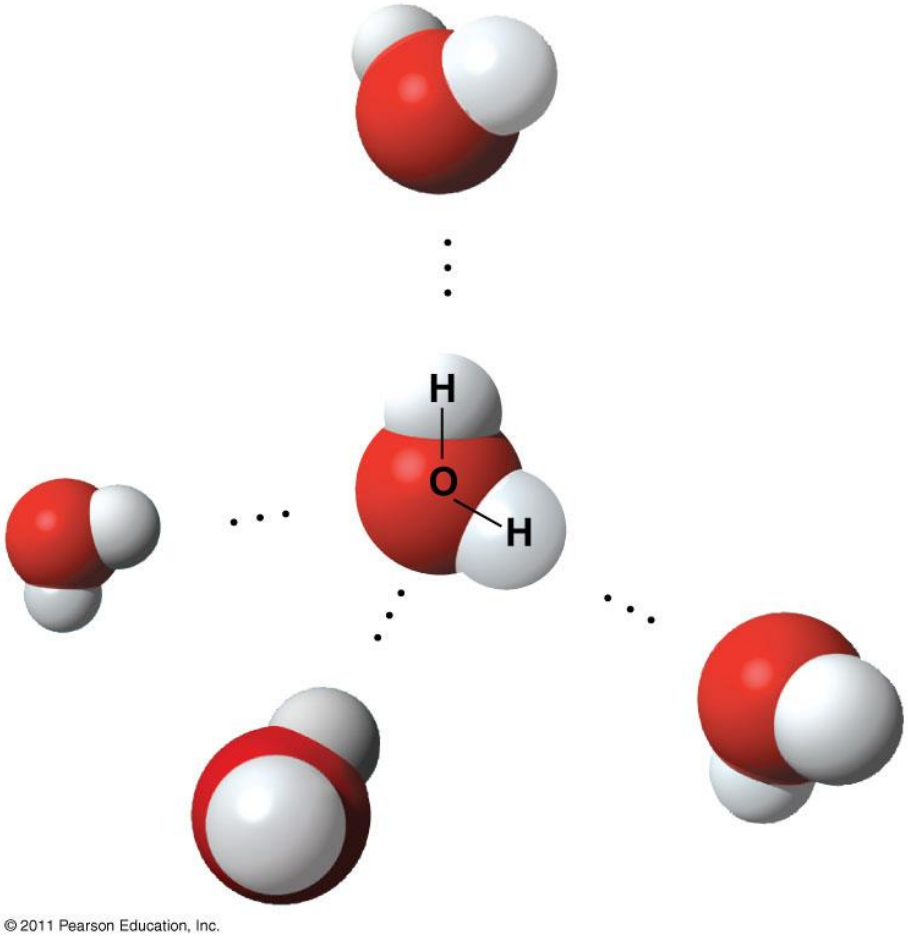
- 20-25% elements are essential to continue healthy life and reproduce. (in human 25 elements are essential and plants 17 elements are essential)
- O, C, H, N make up 96% of living matter
- Ca, P, K, S – make up of most of the remaining 4% of living matter
- Trace elements require < 0.01% dry weight of the body mass.

## Table 2.1 Elements in the Human Body

| Element | Symbol | Percentage of Body Mass (including water) | |
|---|---|---|---|
| Oxygen | O | 65.0% | 96.3% |
| Carbon | C | 18.5% | |
| Hydrogen | H | 9.5% | |
| Nitrogen | N | 3.3% | |
| Calcium | Ca | 1.5% | 3.7% |
| Phosphorus | P | 1.0% | |
| Potassium | K | 0.4% | |
| Sulfur | S | 0.3% | |
| Sodium | Na | 0.2% | |
| Chlorine | Cl | 0.2% | |
| Magnesium | Mg | 0.1% | |

Trace elements (less than 0.01% of mass): Boron (B), chromium (Cr), cobalt (Co), copper (Cu), fluorine (F), iodine (I), iron (Fe), manganese (Mn), molybdenum (Mo), selenium (Se), silicon (Si), tin (Sn), vanadium (V), zinc (Zn)

# Physical and chemical properties of water important for life



# The importance of water for life

- To act as transport medium
- Regulation of temperature
- High surface tension
- Changing density according to the temperature
- Act as solvent
- Act as a reactant

no need to describe all points mentioned in previous syllabus

# Chemical nature and functions of main organic compounds of organisms

- Carbohydrates – no need to give 1-6, 1-4 glycosidic links
- Lipids
- Proteins
- Nucleic acids – DNA and RNA
  - No need to explain DNA replication and protein synthesis here
  - (ADP,ATP,NAD,NADP,FAD) and their major role

## 2.2.0 Examines cell as the basic functioning unit of life

- 2.2.1 Elaborates on the contribution of microscopes to the expansion of knowledge on cells and cellular organization
- 2.2.2 Describes the historical background of cell and analyses the structure and functions of the sub cellular units

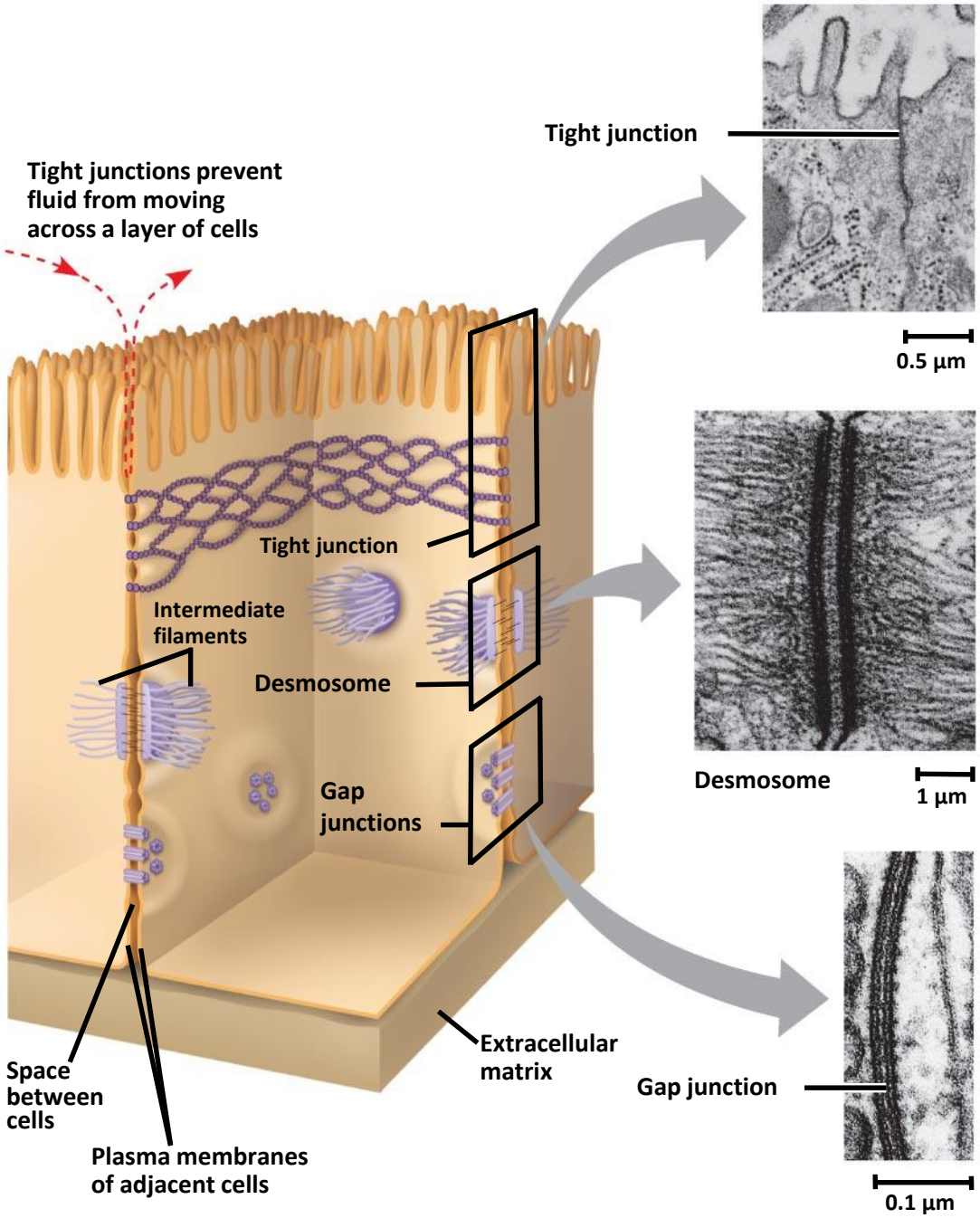
**2.2.2 Describe the historical background of cell and analyses the structure and functions of the sub cellular units.**

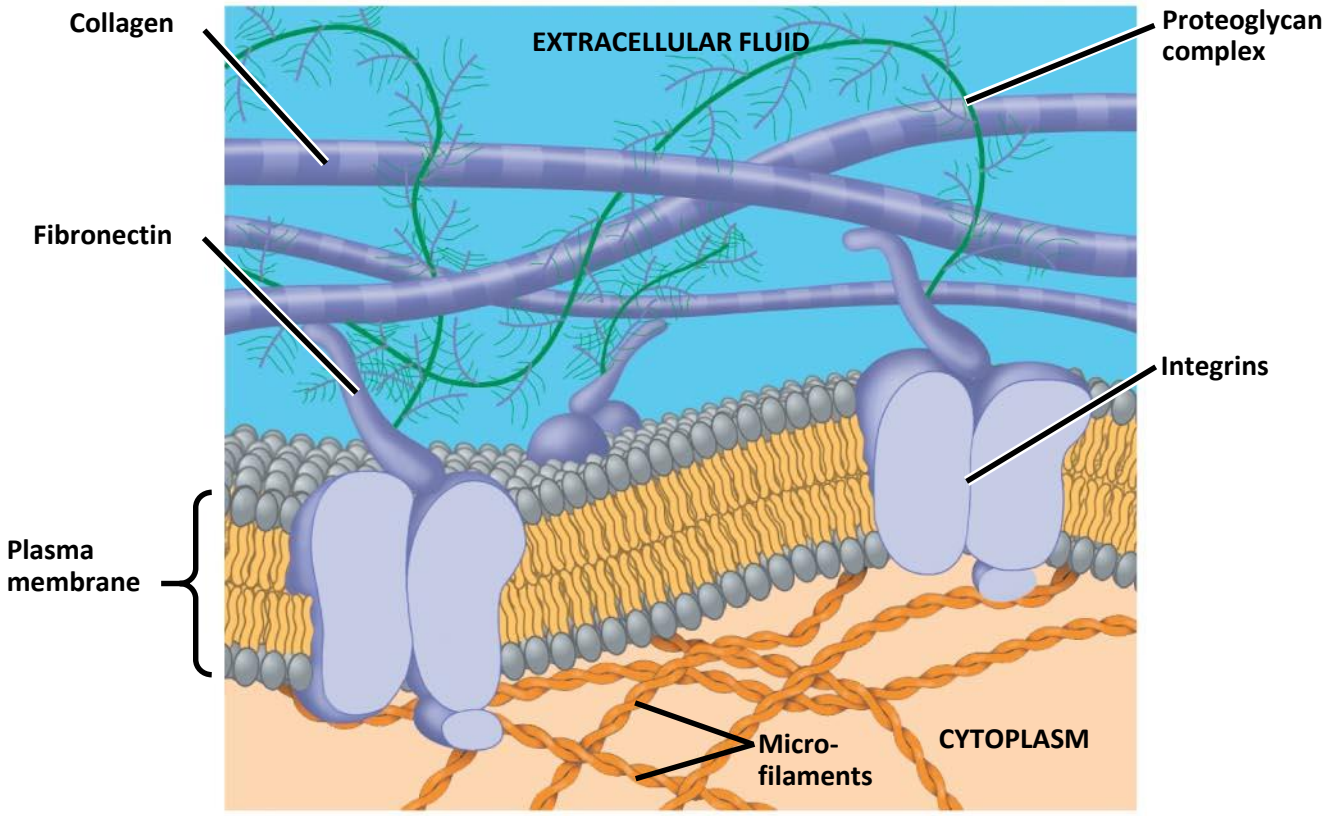
- describe extra cellular components

•Extra cellular components

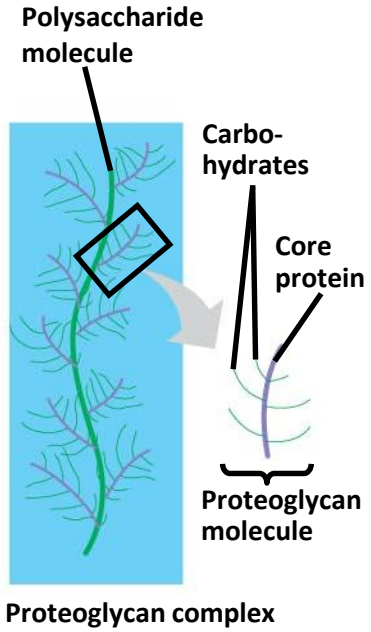
- Cell wall
- Cell junctions

Extracellular matrix of animal cells



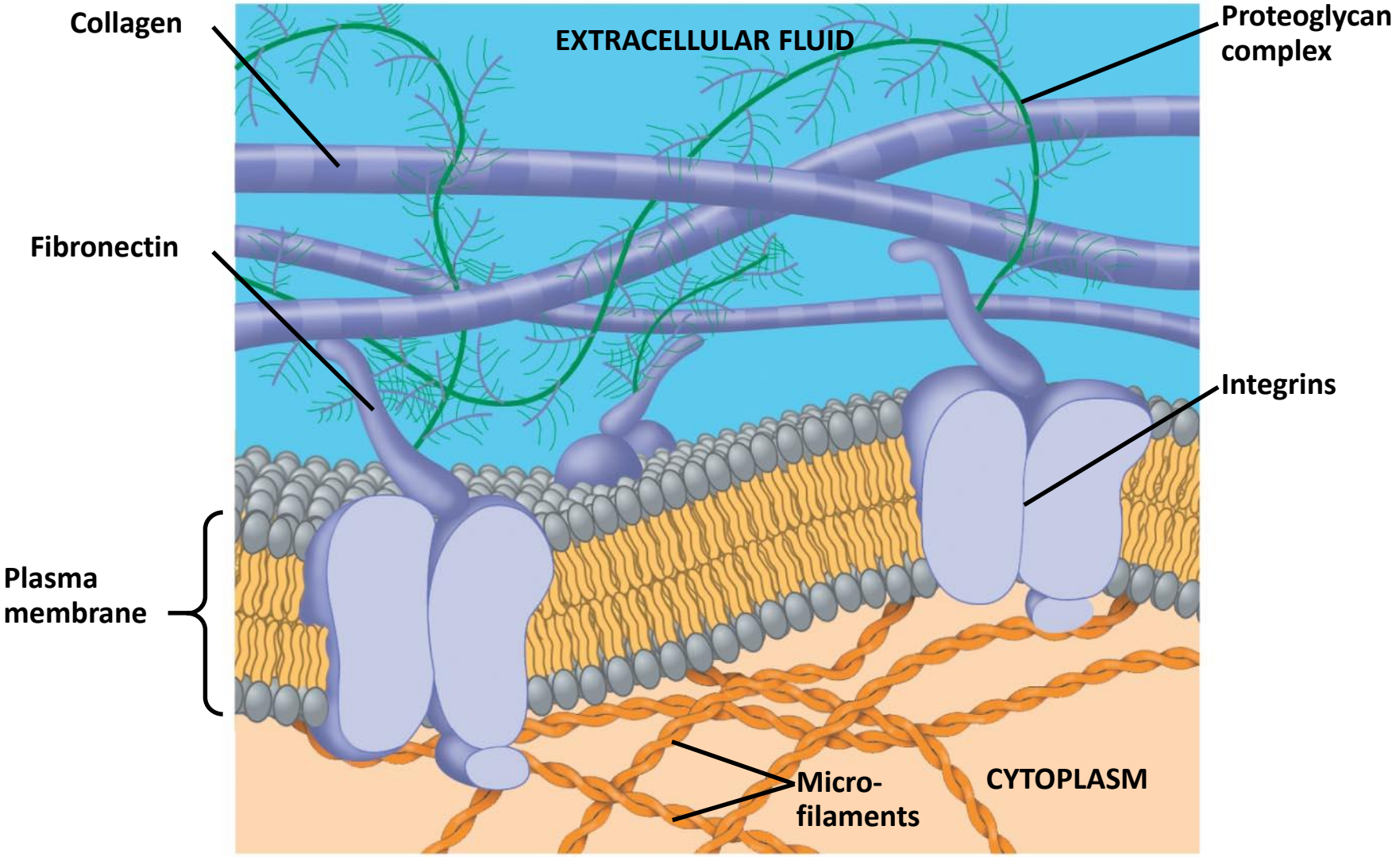


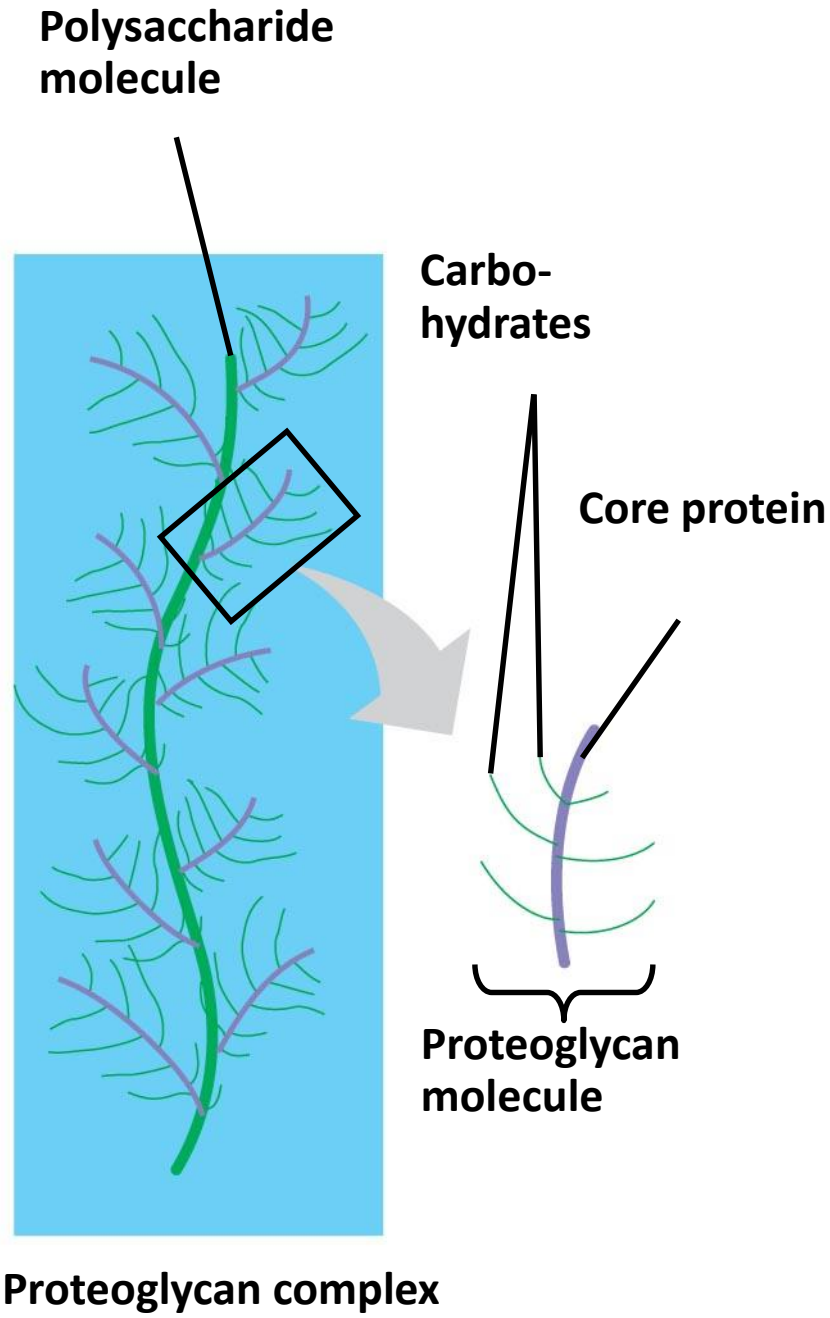


# Extra cellular matrix (ECM)

- Present in animal cells
- Varies from one cell to another based on composition and structure
- Three types of Glycoproteins are present in ECM
  - Collagen
  - Proteoglycan
  - Fibronectin





**2.3.1 Describe the cell cycle and the process of cell division**

Cell cycle

Chromosomes

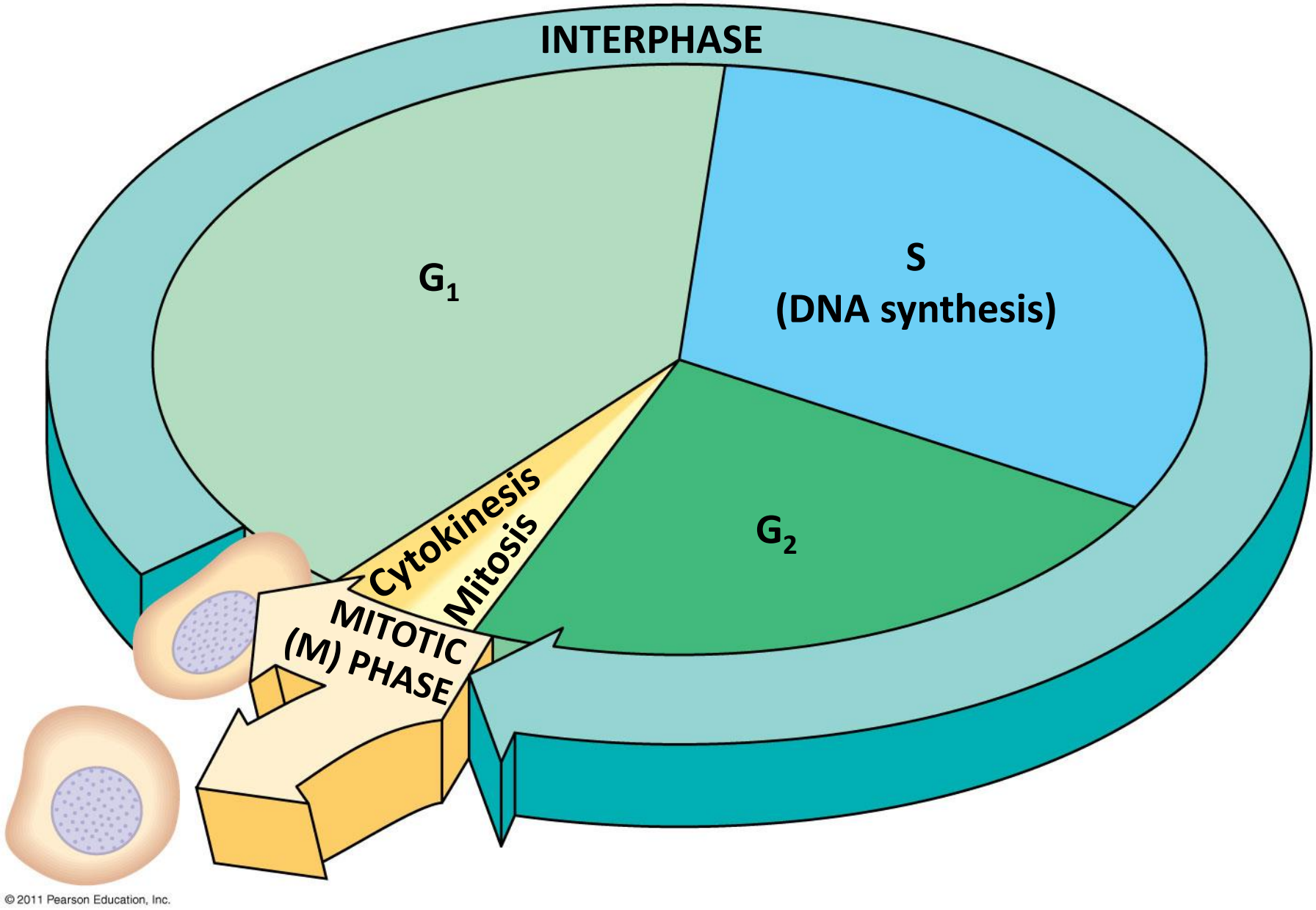
Mitosis

Behaviour of chromosomes and other parts of a cell during mitosis

Significance of mitosis.

- elaborate on the phases and main events of cell cycle.
- describe the structure of chromosome
- discuss the main events that occur in each phase
- discuss the main events that occur in each phase of mitosis and meiosis

# Cell cycle


INTERPHASE
G1
S
(DNA synthesis)
G2
Cytokinesis
Mitosis
MITOTIC
(M) PHASE
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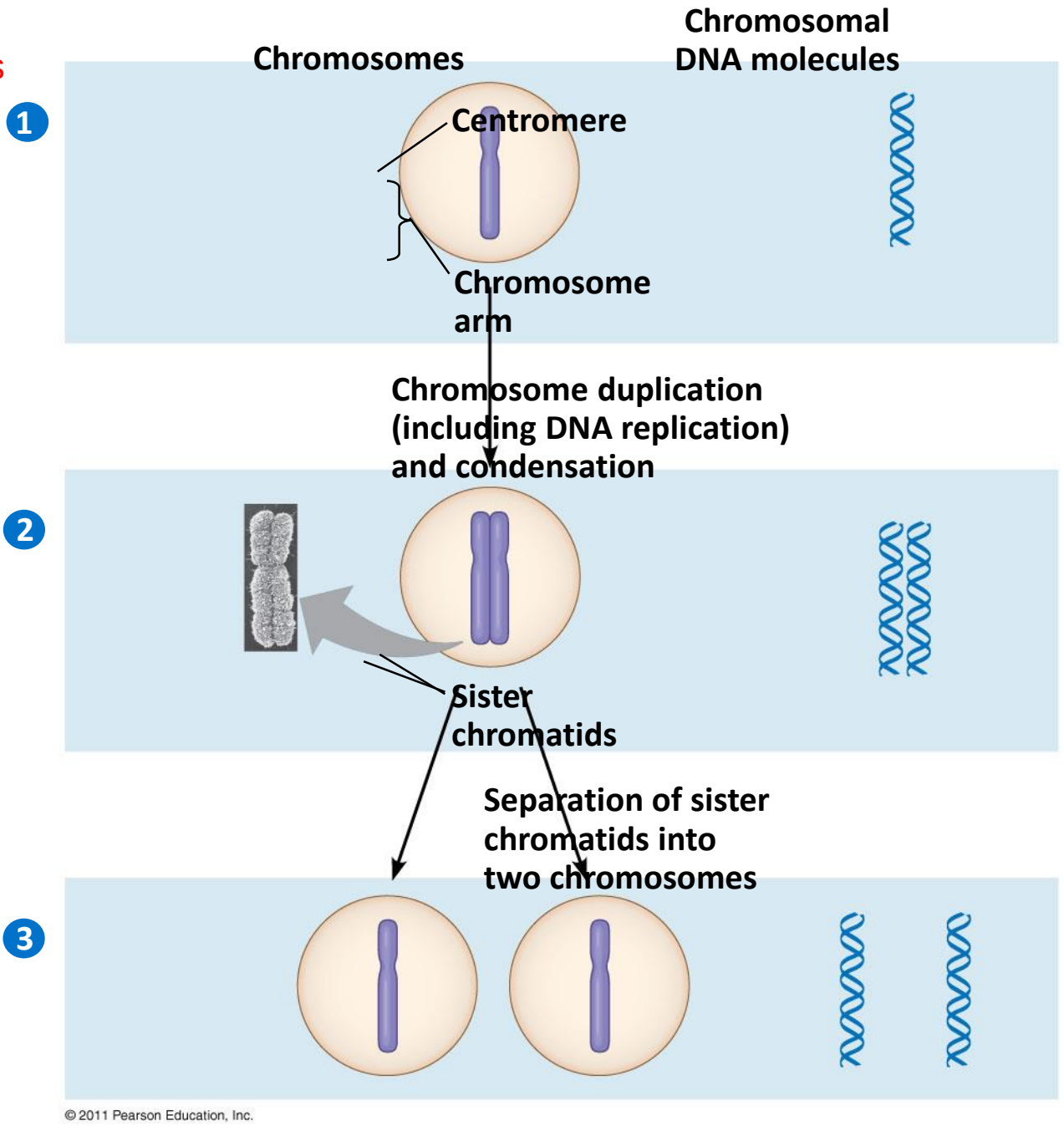
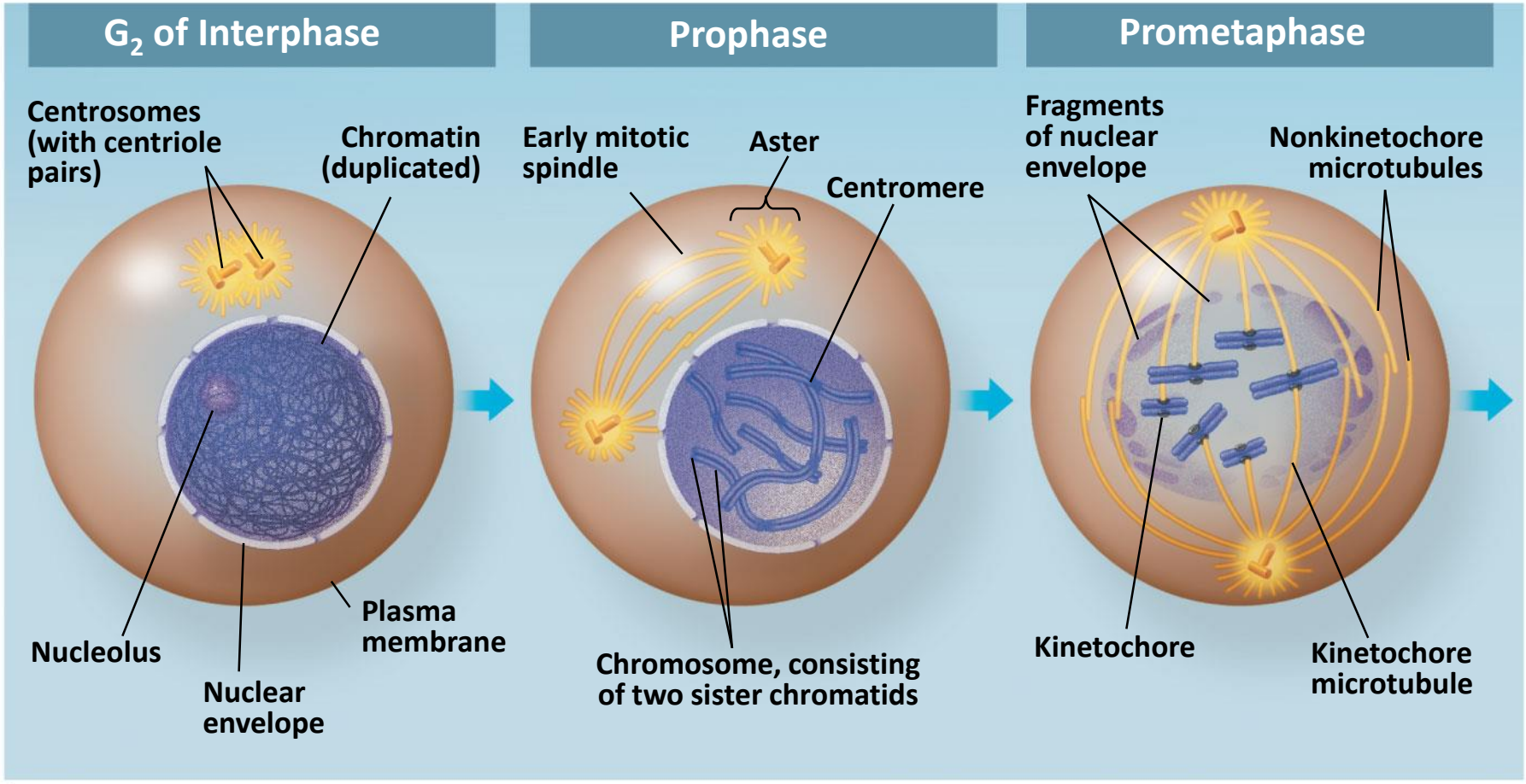
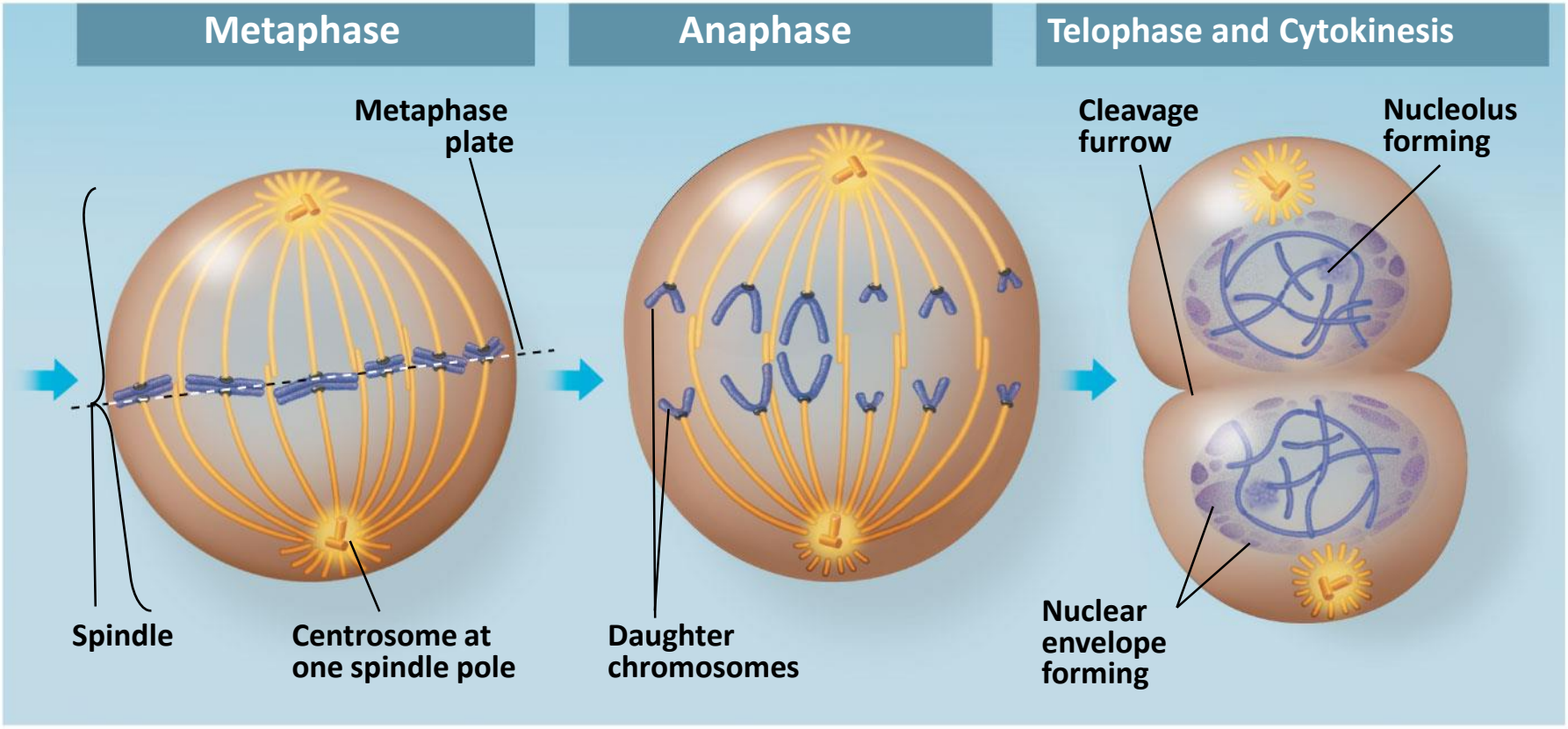
Chromosomes , sister -chromatids

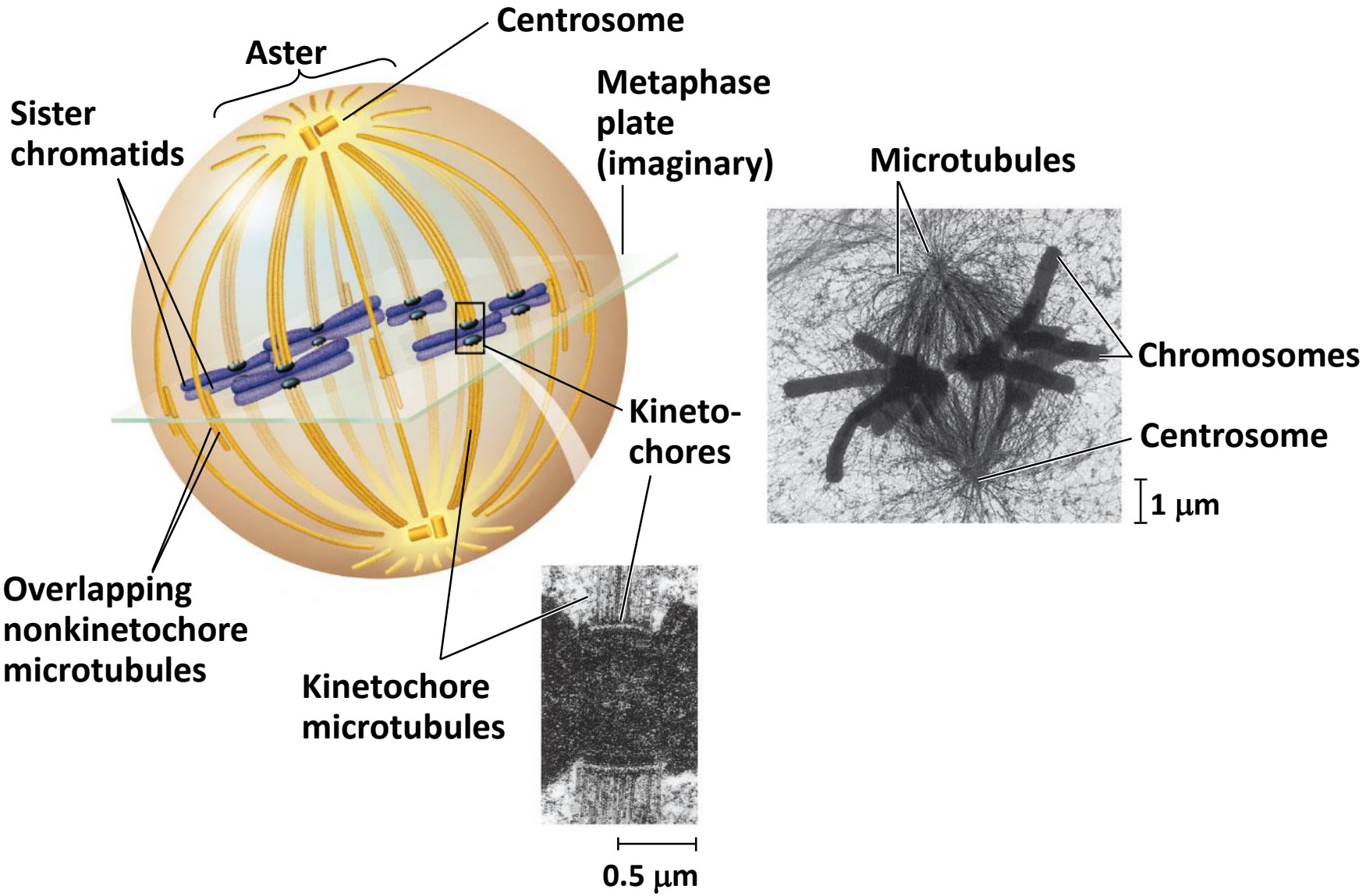


# Mitosis



# Mitosis cont.





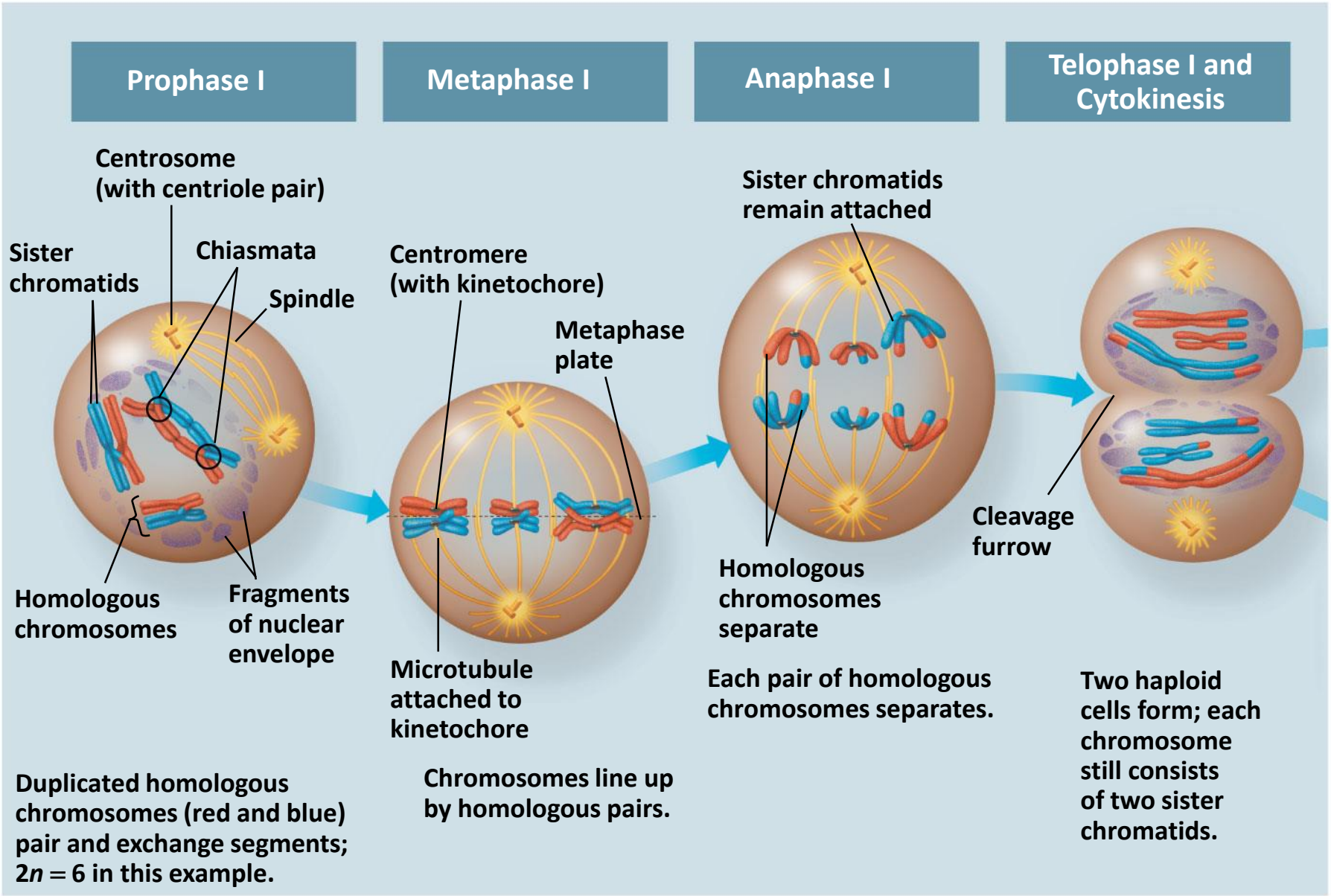
**2.3.1 Describe the cell cycle and the process of cell division**

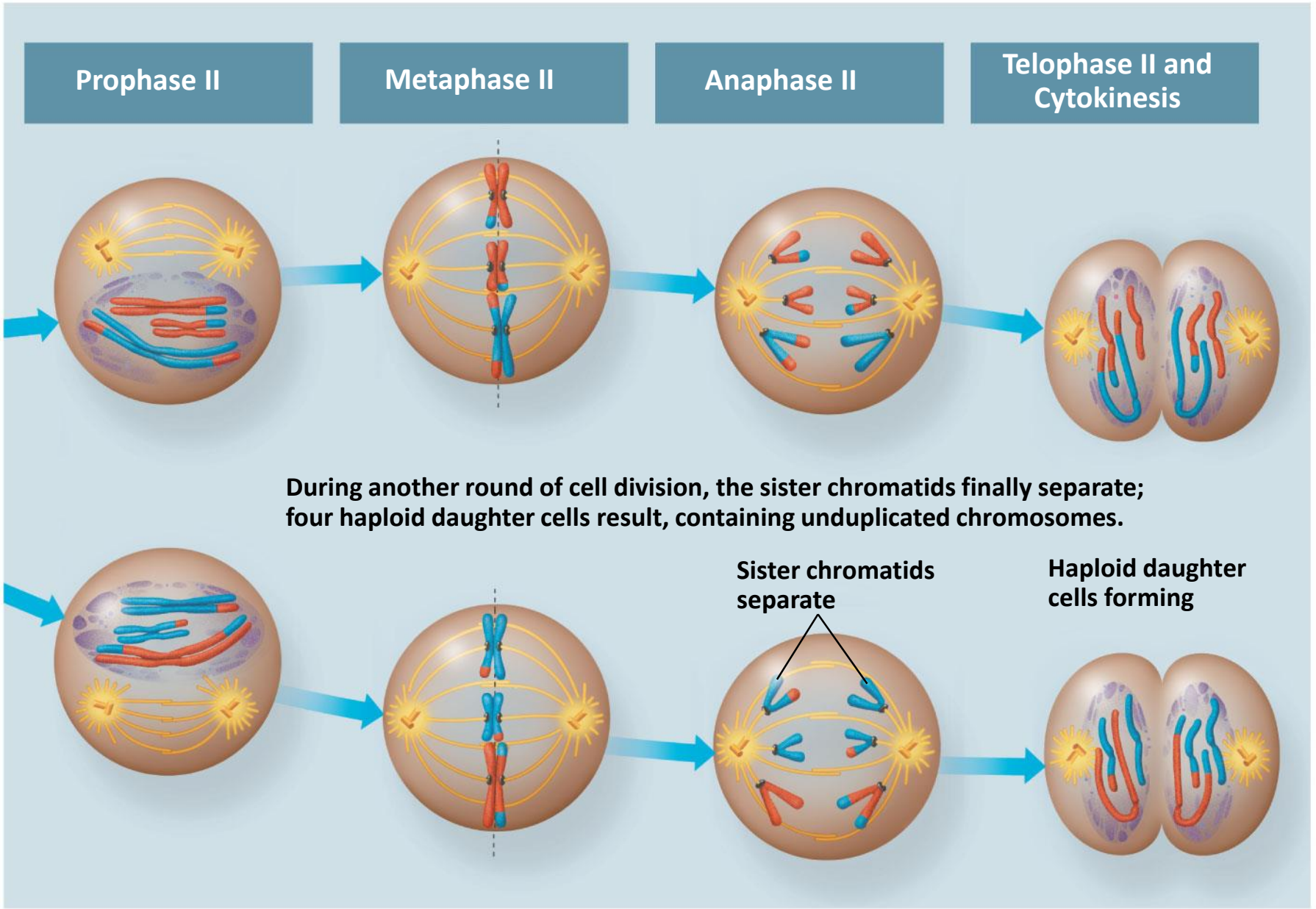
Meiosis

- Behaviour of chromosomes and other parts of a cell during meiosis- crossing over, independent assortment, separation of homologous chromosomes, separation of sister chromatids
- Significance of meiosis

Galls, tumours and cancers

- describe the stages in mitosis and meiosis with reference to chromosomal behavior
- Explain how meiosis impact variations among organisms
- describe the significance of synaptonemal complex and kinetochore
- compare and contrasts mitosis and meiosis





- The timing and rate of cell division in different parts of a plant or animal are crucial to normal growth, development and maintenance.
- The different rate in same cells occurs in different times. eg. skin cells during wound healing
- Some of the differentiated mature cells do not divide at all. eg. nerve cells muscle cells.
- In those cells they enter to $G_0$ state during the G1 phase.
- Other cells such as liver cells can enter to normal cell cycle when certain external cues such as growth factors released during injury.

- Cell division is driven by external and internal factors. They may be chemical or physical factors.
- Chemical factors such as growth factors, physical factors such as density dependent inhibition and anchorage dependence are needed for cell division normally.
- Cancer cells exhibit neither density – dependent inhibition nor anchorage dependence.
- Cancer cells do not respond normally to the body's control mechanisms.
- They divide excessively and invade other tissues. If unchecked, they can kill the organism.
- Cancer cells do not heed the normal signals that regulate the cell cycle.

- They do not need growth factors. They may make required growth factor themselves or giving signals to go head cell cycle without growth factors. Another possibility is an abnormal cell cycle control system.
- Scientists now believe that this may due to all.
- The problem begins when a single cell in a tissue undergoes transformation, the process converts a normal cell to a cancer cell.
- If the body immune system cannot recognize and destroys it this leads to proliferate cells and form a tumor.

- If the abnormal cells remain at the original site, the lump is called a benign tumor. Most benign tumors do not cause serious problems and can be completely removed by surgery.
- A malignant tumor becomes invasive and attack one or more organs. An individual with a malignant tumor is said to have cancer.
- A few tumor cells may separate from the original tumor enter blood vessels or lymph vessels, and travel to other parts of the body. They may proliferate and form a new tumor.
- This spread of cancer cells to locations distant from their original site is called metastasis.

# Galls in plants

- This occur due to uncontrolled mitotic division of plant cell.

Crown gall

- Galls are the bizarre lumps, bumps and growths that develop on different parts of plants after being invaded by some very unique organisms.

- Galls have a range of causers, including viruses, fungi, bacteria, insects and mites.

- Usually the gall causer in some way attacks or penetrates the plant's growing tissues and causes the host to reorganize its cells and to develop an **abnormal** growth.

- They may provide their inhabitants with any combination of food, shelter and protection from predators.

- It is a parasitic relationship, in that the invader benefits, while the host may be harmed.

- But in many cases, no obvious harm is apparent.

**2.4.1 Analyses the energy relationships in metabolic processes**

- Metabolism
- Need of energy for living systems

Anabolic and catabolic reactions

- Energy requirements in relation to body size, activity and environment
- ATP Structure and importance of ATP
- Role of electronic carriers

(NAD $^{+}$ , NADP and FAD)

- explain metabolism as sum of anabolic and catabolic reactions
- highlight the need of energy for living systems
- list the cellular processes involving energy
- relate energy requirements of organisms in relation to body size, activity and environment
- explain catabolic and anabolic reactions with examples
- discuss the structure and the importance of ATP as a universal energy currency unit
- appreciate the role of ATP in universal energy transaction

**2.4.2 Investigates the role of enzymes in regulating metabolic reactions**

Enzymes

General characteristics of enzymes

Mechanism of enzymatic reaction

Induced fit mechanism

- construct an appropriate definition for the term ‘enzymes’
- explain the general characteristics of enzymes and their role
- describe a mechanism for enzyme activity using suitable diagrams

**2.4.2 Investigates the role of enzymes in regulating metabolic reactions**

Cofactors

- Co enzymes
- Inorganic ions
- Factors affecting enzymatic reactions

pH

Temperature

Substrate concentration

Inhibitors-competitive, non competitive

- describe the importance of co-factors for enzymatic activities
- explain how pH, temperature, substrate concentration, enzyme concentration and inhibitors (competitive and non competitive) affect the rate of enzyme activity

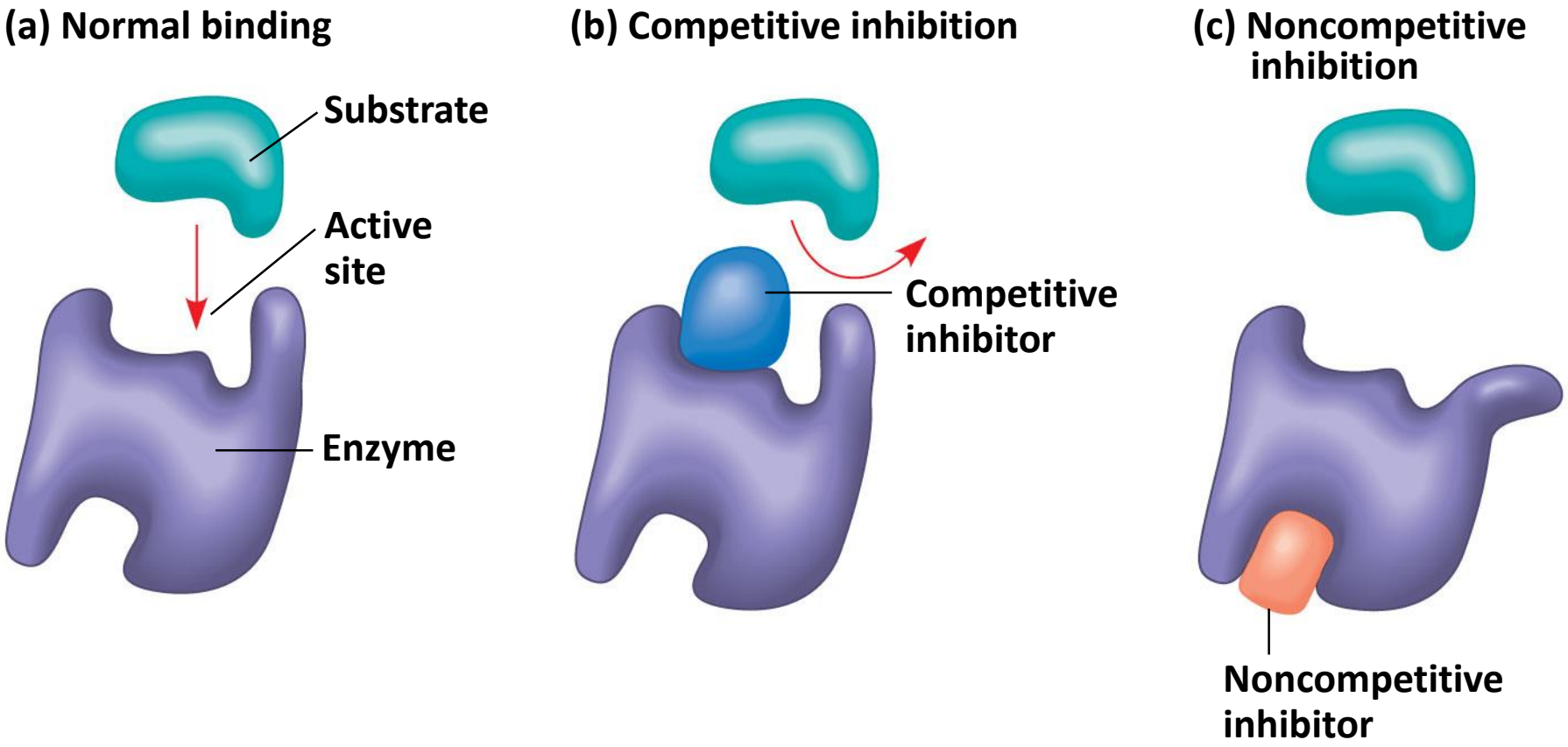
# *Cofactors*

- **Cofactors** are nonprotein enzyme helpers
- Cofactors may be inorganic (such as a metal in ionic form) or organic
- An organic cofactor is called a **coenzyme**
- Coenzymes include vitamins

# *Enzyme Inhibitors*

- **Competitive inhibitors** bind to the active site of an enzyme, competing with the substrate
- **Noncompetitive inhibitors** bind to another part of an enzyme, causing the enzyme to change shape and making the active site less effective
- Examples of inhibitors include toxins, poisons, pesticides, and antibiotics

Figure 8.17



## 2.4.2 Investigates the role of enzymes in regulating metabolic reactions

Regulation mechanism of enzymaric activity in cells

Allosteric activity or inhibition

Feedback inhibition

- Briefly explain the regulation mechanisms found in cells

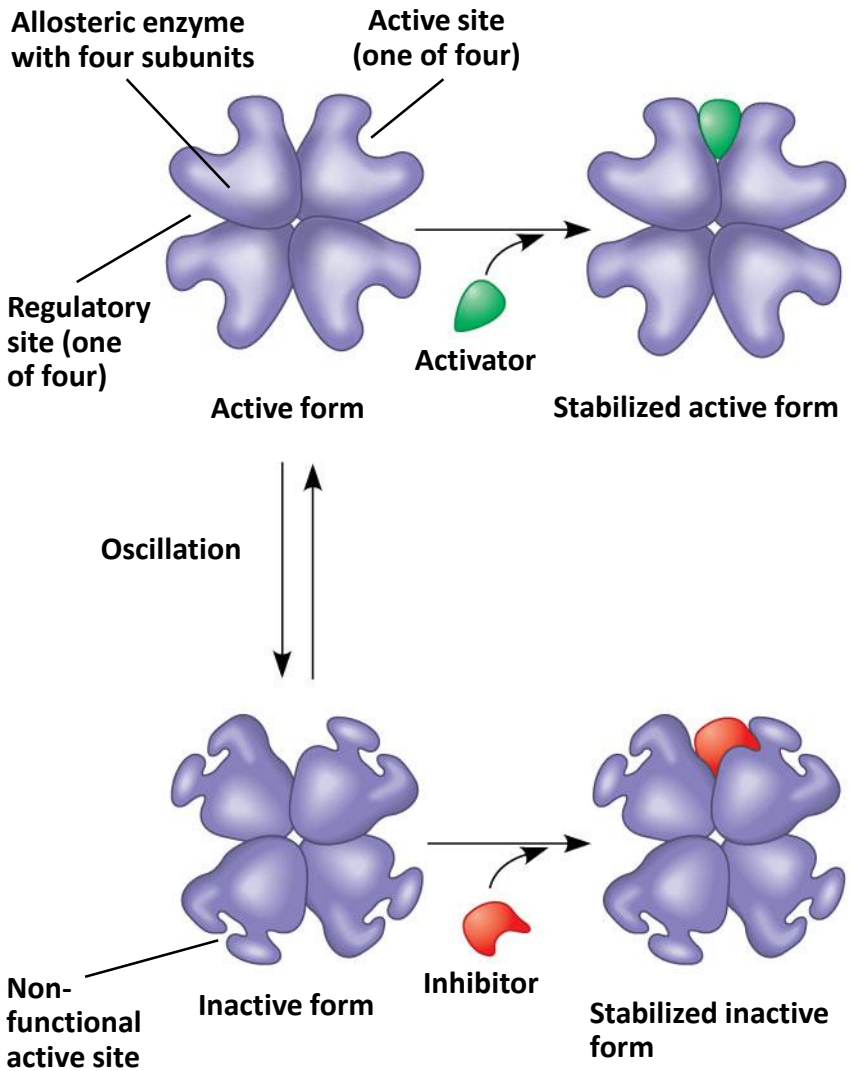
# Allosteric Regulation of Enzymes

- **Allosteric regulation** may either inhibit or stimulate an enzyme's activity
- Allosteric regulation occurs when a regulatory molecule binds to a protein at one site and affects the protein's function at another site

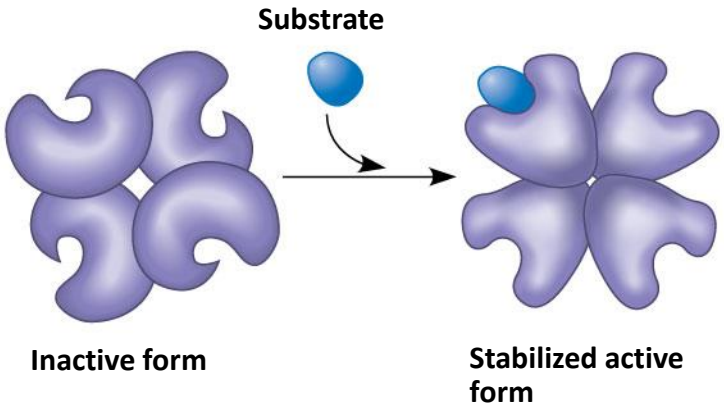
# *Allosteric Activation and Inhibition*

- Most allosterically regulated enzymes are made from polypeptide subunits
- Each enzyme has active and inactive forms
- The binding of an activator stabilizes the active form of the enzyme
- The binding of an inhibitor stabilizes the inactive form of the enzyme

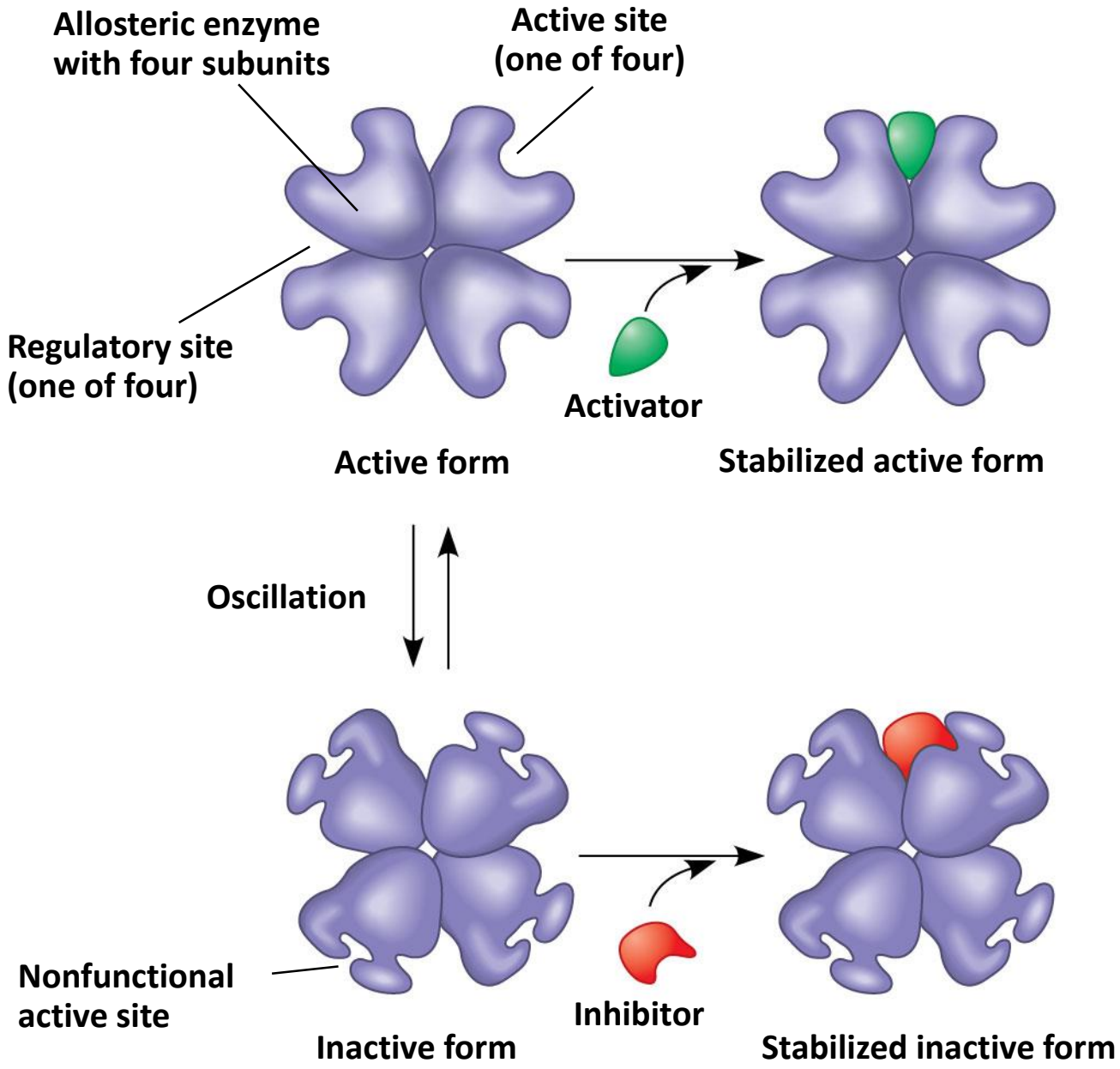
(a) Allosteric activators and inhibitors



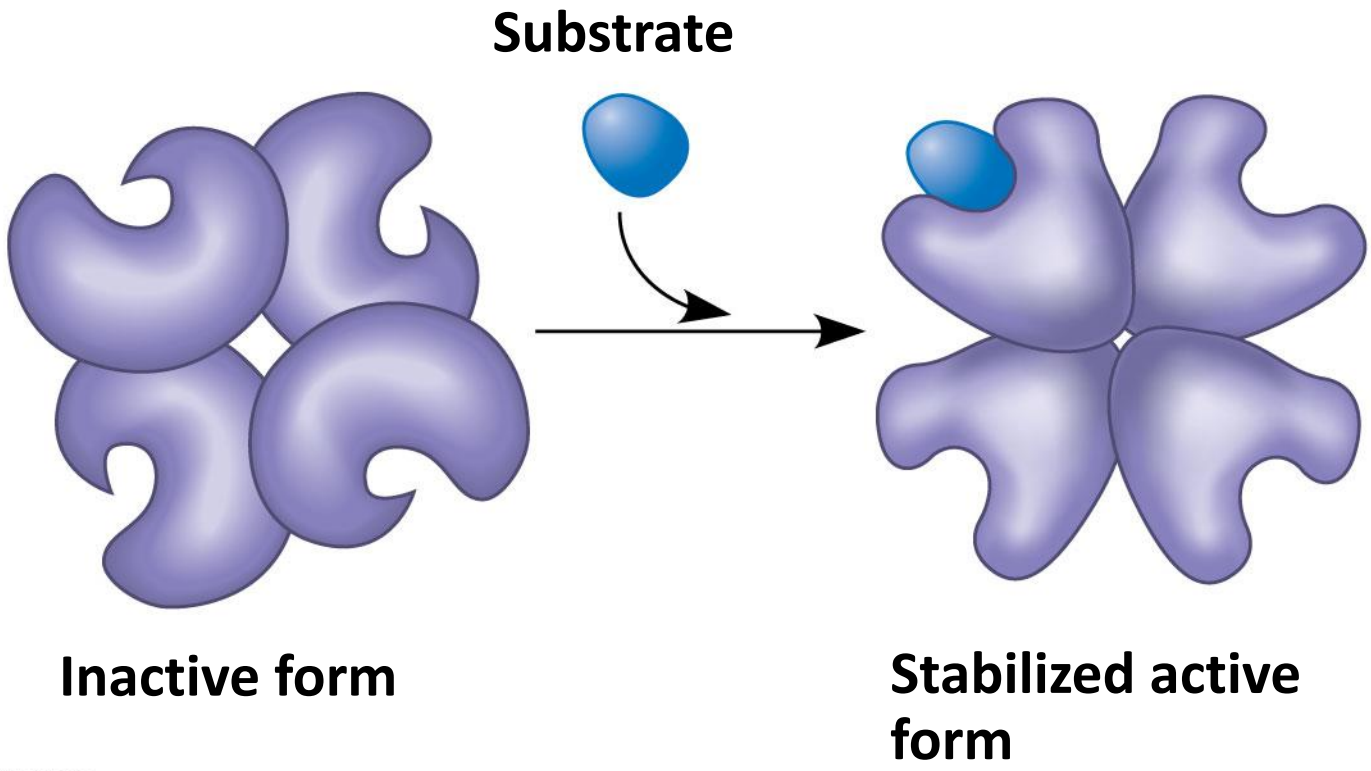

(b) Cooperativity: another type of allosteric activation



(a) Allosteric activators and inhibitors

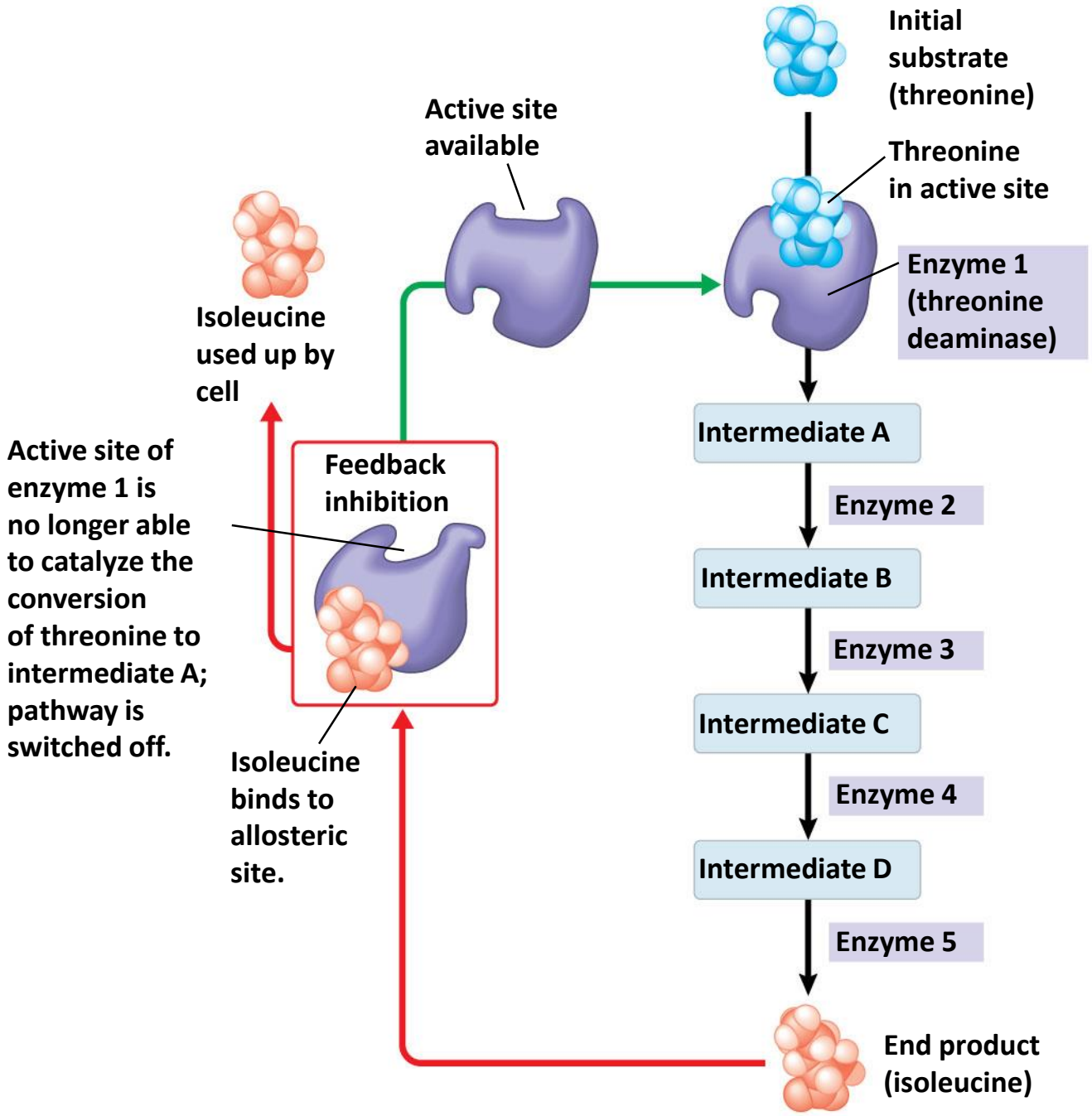


## (b) Cooperativity: another type of allosteric activation



# *Feedback Inhibition*

- In **feedback inhibition**, the end product of a metabolic pathway shuts down the pathway
- Feedback inhibition prevents a cell from wasting chemical resources by synthesizing more product than is needed



**2.4.0 Investigates energy relationships in metabolic processes of organisms**

2.4.3 Examines photosynthesis as an energy fixing mechanism

- Photosynthesis

2.4.4Examines cellular respiration as a process of obtaining energy

- Cellular respiration