GNERAL BOTANY

FOR THE FIRST STAGE OF BIOLOGY DEPARTMENT
COLLEGE OF EDUCATION FOR PURE SCIENCE

UNIVERSITY OF ANBAR

BY

DR. MAHMOOD AL SHAHEEN

2021 - 2022

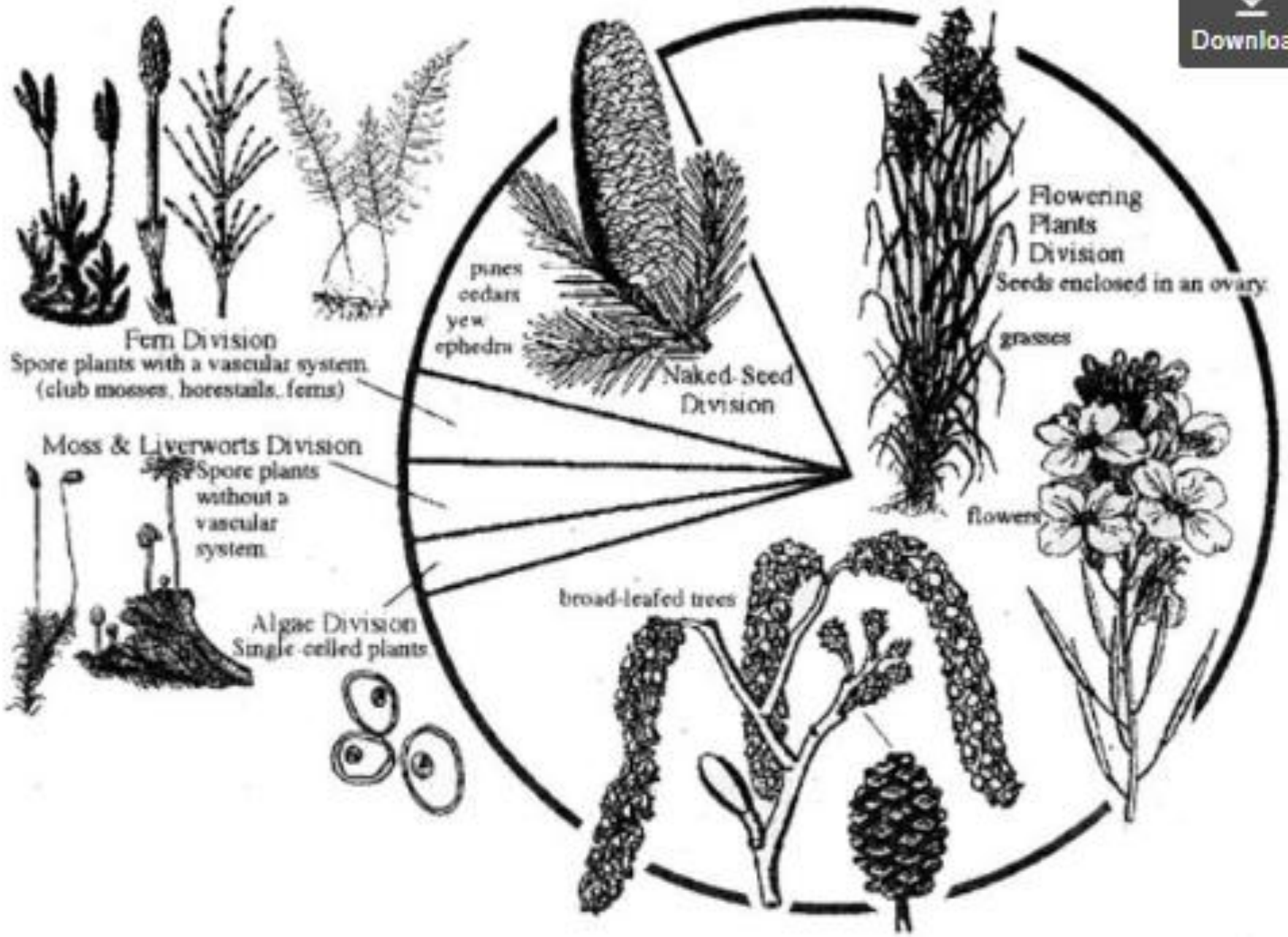
What is Botany?

- It is the science of plant life
- A person engaged in the study of botany is called a botanist.
- Botany covers a wide range of scientific disciplines including structure, growth, reproduction, metabolism, development, diseases, chemical properties, and evolutionary relationships among taxonomic groups.
- Botany began with early human efforts to identify edible, medicinal and poisonous plants, making it one of the oldest branches of science.

- It is estimated that there are at least 260,000 species of plants in the world today. They range in size and complexity from small, one inch tall **mosses** to **giant sequoia trees,** *the largest organisms on Earth*, growing as tall as 100 meters.
- Thought to have evolved from the **green algae,** plants have been around since the early **Paleozoic Era,** more than 500 million years ago.
- The earliest fossil evidence of land plants dates to the **Ordovician Period,** (505 to 438 million years ago).

- By the **Carboniferous Period**, about 355 million years ago, most of the Earth was covered by forests of primitive vascular plants, such as lycopods (scale trees) and gymnosperms (pine trees, ginkgos).
- **Angiosperms**, the flowering plants, didn't develop until the end of the **Cretaceous Period**, about 65 million years ago - just as the dinosaurs became extinct.

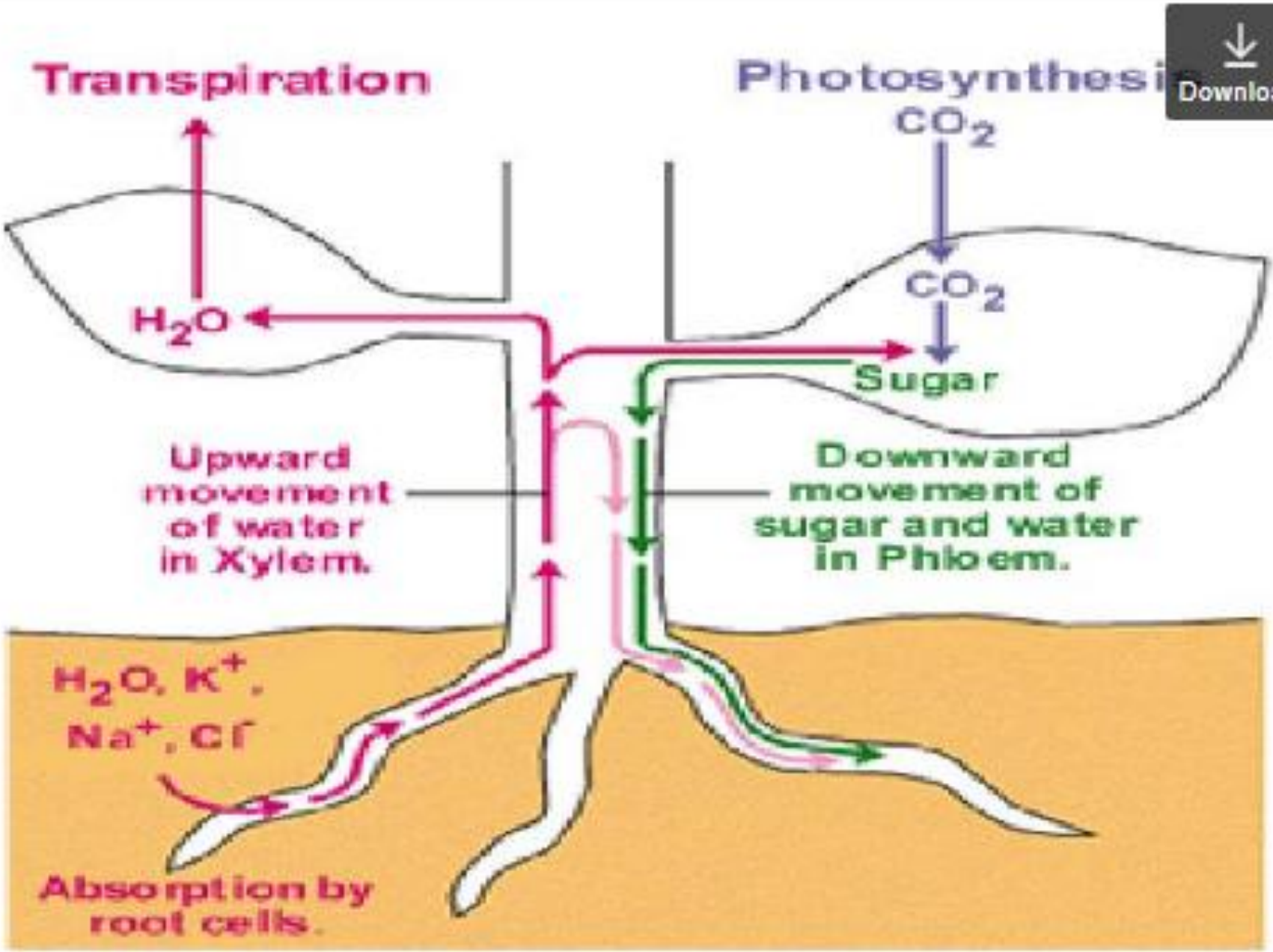
- By the **Carboniferous Period**, about 355 million years ago, most of the Earth was covered by forests of primitive vascular plants, such as lycopods (scale trees) and gymnosperms (pine trees, ginkgos).
- **Angiosperms**, the flowering plants, didn't develop until the end of the **Cretaceous Period**, about 65 million years ago - just as the dinosaurs became extinct.


Fern Division
Spore plants with a vascular system
(club mosses, horestails, ferns)
Moss & Liverworts Division
Spore plants
without a
vascular
system
Algae Division
Single-celled plants
pines
cedars
yew
ephedra
Naked-Seed
Division
Flowering
Plants
Division
Seeds enclosed in an ovary
grasses
flowers
broad-leafed trees

Plants can be divided into two basic groups: **vascular** and **nonvascular**.

- **Vascular plants** are considered to be more advanced than nonvascular plants because they have specialized tissues, namely **xylem**, which is involved in structural support and water conduction, and **phloem**, which functions in food conduction. They also have **roots**, **stems**, and **leaves**, representing a high form of organization.

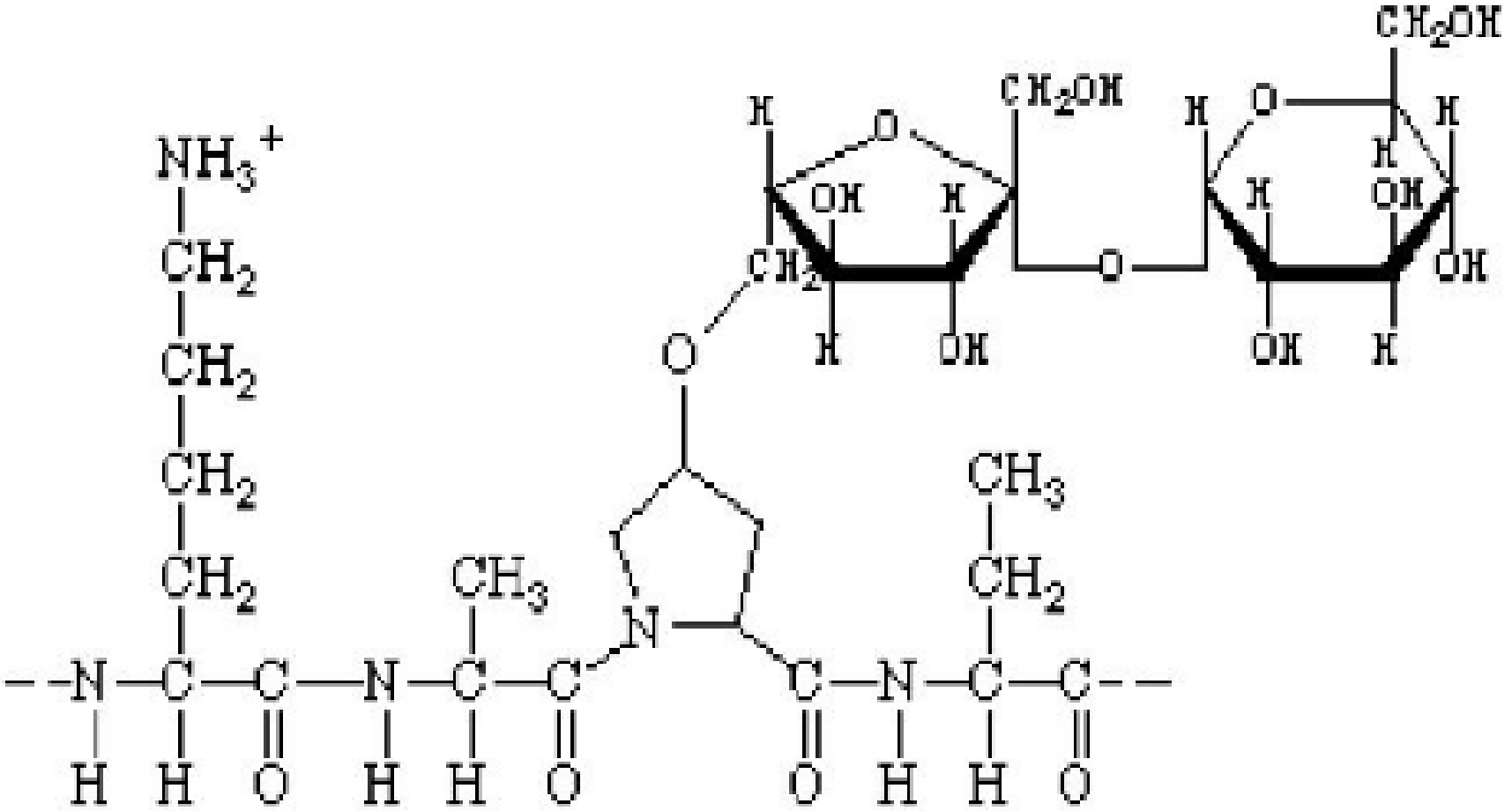
- **Nonvascular plants**, members of the division **Bryophyta**, the mosses, are usually no more than one or two inches tall, because they do not have specialized tissues for support and nutrient transportation. They are more dependent on their environment to maintain appropriate amounts of moisture and tend to inhabit damp, shady areas.


Transpiration
Photosynthesis
CO_2
CO_2
H_2O
Sugar
Upward movement of water in Xylem.
Downward movement of sugar and water in Phloem.
H_2O, K^+, Na^+, Cl^-
Absorption by root cells.

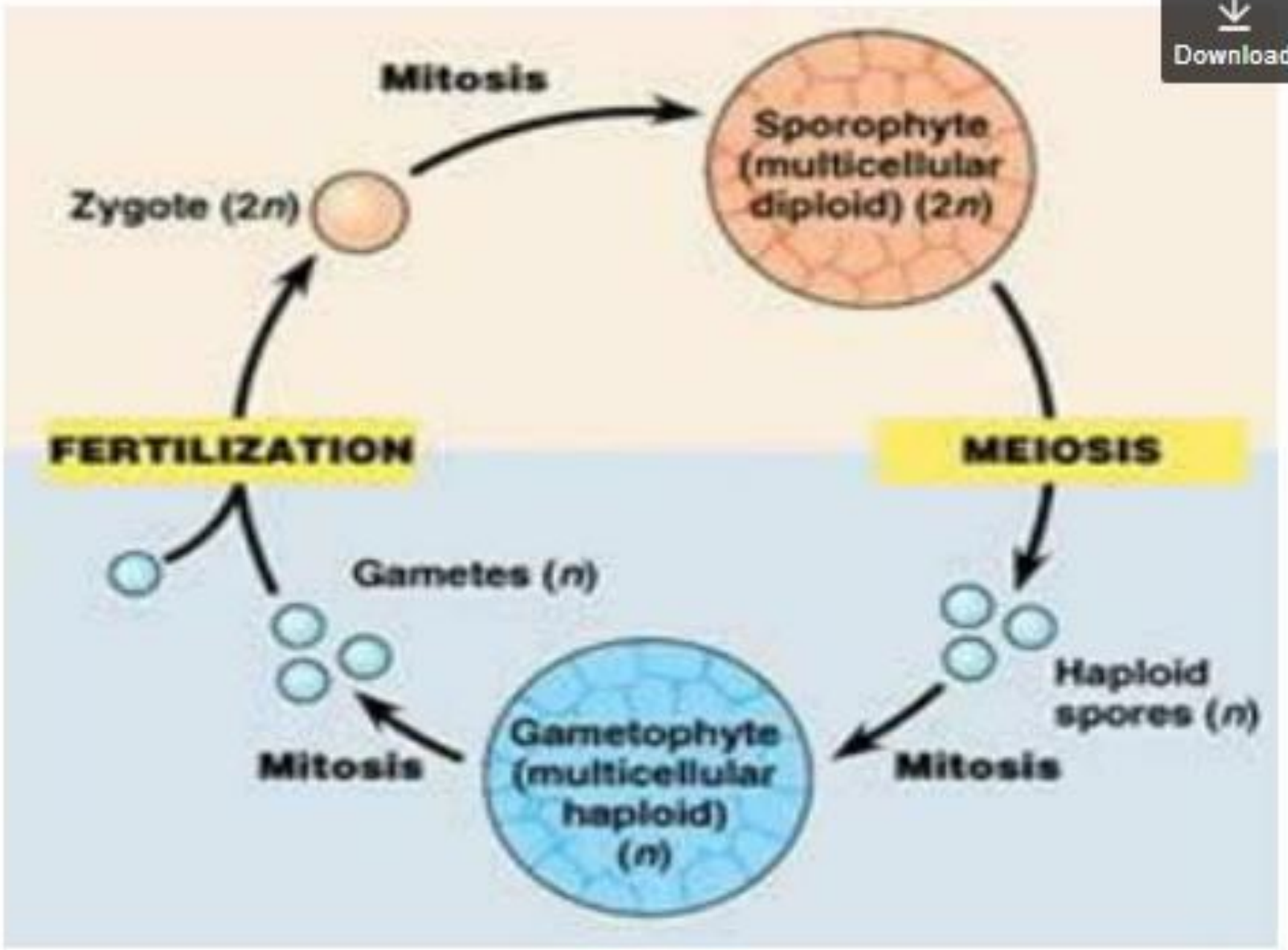
Alternation of generations

- **Alternation of generations** occurs in all plants. A **haploid** gametophyte generation (with single chromosomes) produces gametes via mitosis. The union of gametes produces the **diploid** sporophyte generation (with pairs of chromosomes), which in turn produces spores via meiosis.

Structural Proteins

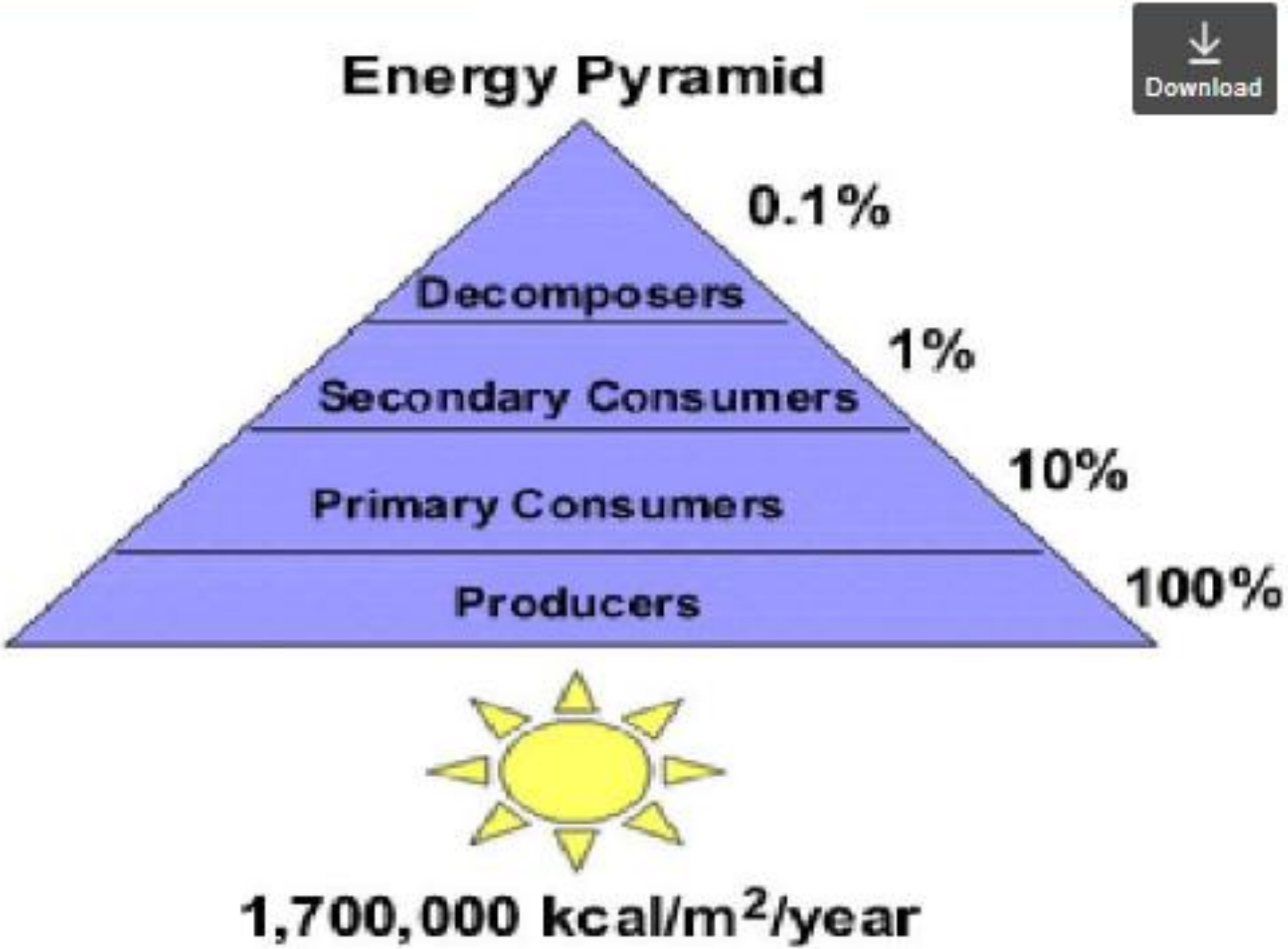


- Any reproductive process that does not involve meiosis or fertilization is said to be **asexual**, or **vegetative reproduction**. The absence of fertilization means that such an event can occur in the sporophyte generation or the gametophyte stage.


Mitosis
Sporophyte (multicellular diploid) (2n)
Zygote (2n)
FERTILIZATION
MEIOSIS
Gametes (n)
Haploid spores (n)
Mitosis
Gametophyte (multicellular haploid) (n)
Mitosis

- **Plants are the foundation of the Earth's ecosystem.** Without them, complex animal life (such as humans) could not survive. All living things are dependent either directly or indirectly on the energy produced by photosynthesis, and the byproduct of this process, oxygen, is essential to animals. Plants also reduce the amount of carbon dioxide present in the atmosphere, reduce soil erosion, and influence water levels and quality.

- Animals must consume protein to obtain nitrogen, but plants are able to use inorganic forms of the element and do not need an outside source of protein. However, plants require significant amounts of water, which is needed for the photosynthetic process, to maintain cell structure and facilitate growth, and as a means of bringing nutrients to plant cells.

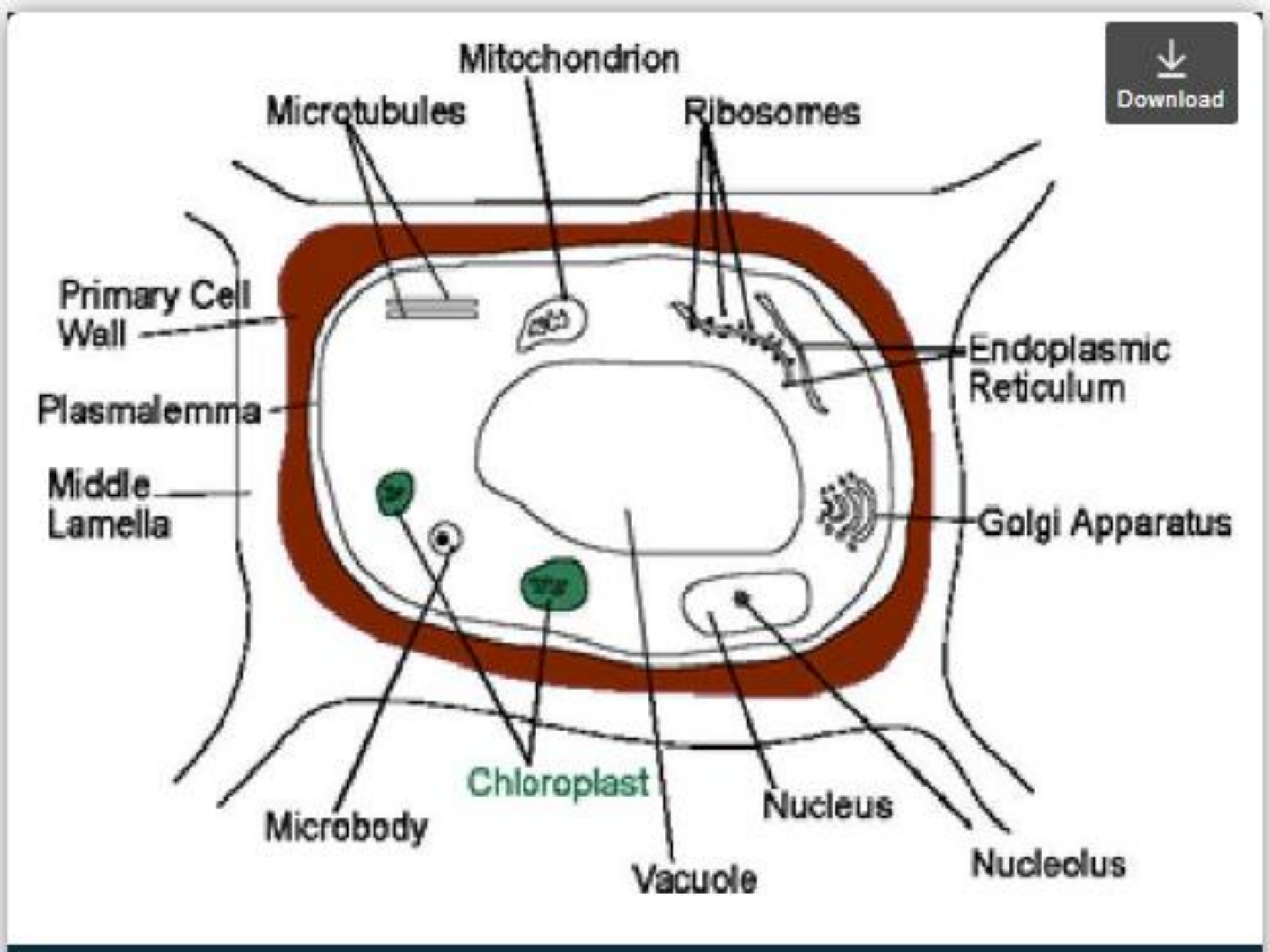

Energy Pyramid
Download
0.1%
Decomposers
1%
Secondary Consumers
10%
Primary Consumers
100%
Producers
1,700,000 kcal/m2/year

- **17 elements are required by plants:**
- 3 supplied naturally by air and water - comprise the bulk of the plant C, H, O
- 6 macronutrients - required at 0.1 to 6% of the dry weight of plants N, P, K, S, Ca, Mg
- 8 micronutrients - required at 1 to 300 ppm of the dry weight of plants Fe, Zn, Cu, Mo, B, Mn, Cl, Ni

- calcium, Ca - (1) Cacium pectates in middle lamella of cell wall cement cells together. (2) Required for normal cell division and meristem growth. (3) Stabilizes membranes
- sulfur, S - Component of several amino acids.
- iron, Fe - (1) Required for chlorophyll synthesis. (2) Component of many enzymes and carriers, especially those of electron transport chain.

- zinc, Zn - Required for hormone synthesis.
- manganese, Mn - (1) Required for chlorophyll synthesis. (2) Activates many enzymes.
- copper, Cu - (1) Required for chlorophyll synthesis. (2) Component of many enzymes and carriers, especially those of electron transport chain.

- These differences in plant size and structure result from the different structures of the various cells that make up the organs of the plant body. Two cell organelles are most important for plant characteristics - the **cell wall** and **chloroplasts**.


Mitochondrion
Microtubules
Ribosomes
Primary Cell Wall
Plasmalemma
Middle Lamella
Endoplasmic Reticulum
Golgi Apparatus
Chloroplast
Microbody
Vacuole
Nucleus
Nucleolus

The cell wall is composed of three layers:

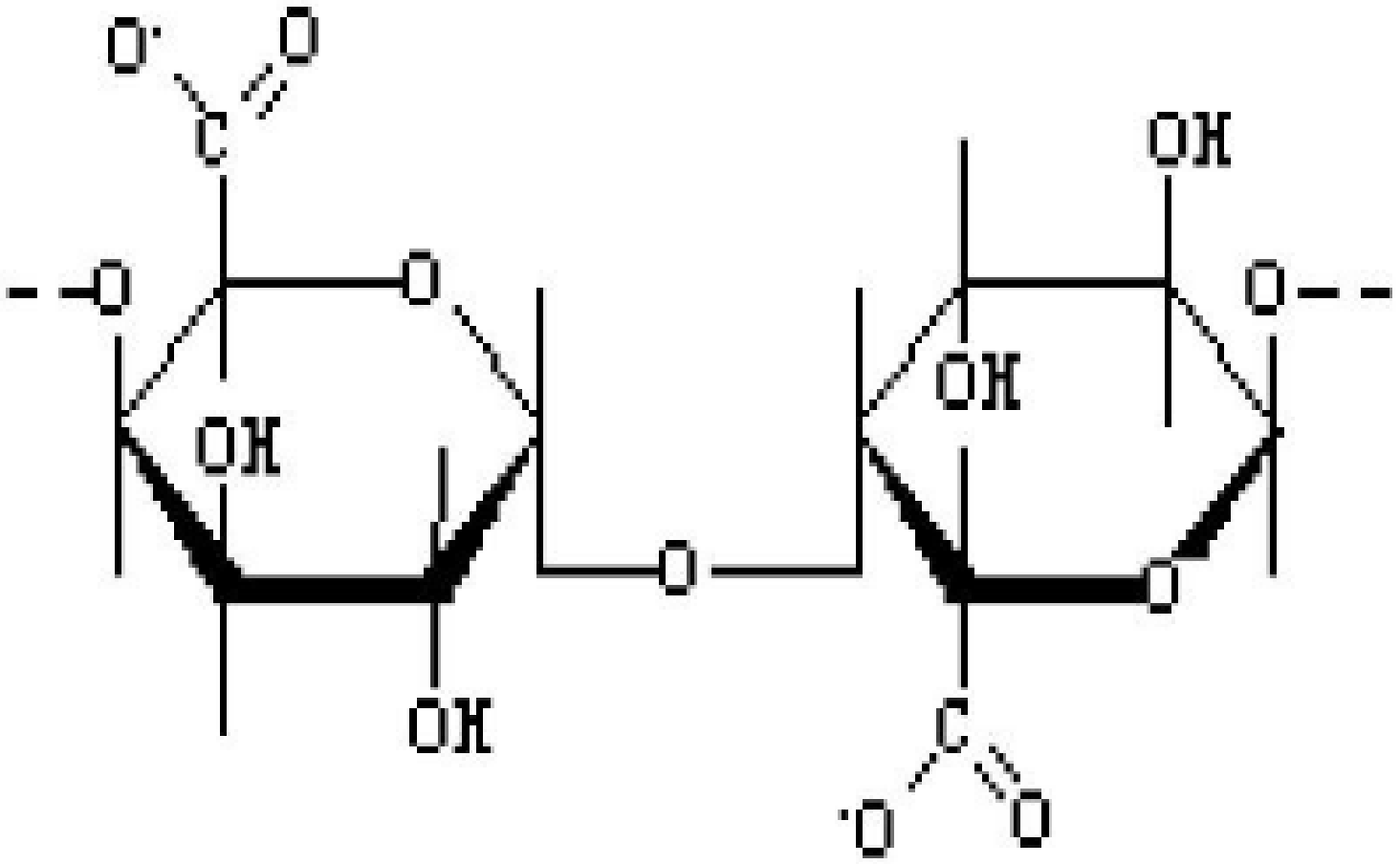
- **Middle lamella:** the first layer formed during cell division. It makes up the outer wall of the cell and is shared by adjacent cells and cements them firmly together. It is composed of pectic compounds and protein.
- **Primary wall:** formed inside the middle lamella and consists of a rigid skeleton of cellulose microfibrils embedded in a gel-like matrix composed of pectic and cellulose compounds. This wall contains everything that is located between the plasma membrane and the cuticle.

Functions of the primary wall:

- Structural and mechanical support.
- Maintain and determine cell shape.
- Resist internal turgor pressure of cell.
- control rate and direction of growth.
- ultimately responsible for plant architecture and form.
- carbohydrate storage - walls of seeds may be metabolized.
- cell-cell interactions.

- **Secondary wall:** formed after cell enlargement is completed. The secondary wall is extremely rigid and provides compression (vertical) strength. It is made of cellulose and lignin. **Plasmodesmata** are small passages that penetrate the layers of the cell wall. They provide pathways for transporting cytoplasmic molecules from one cell to another.

Pectic Acid



- **Pectin:** polymer of 200+ galacturonic acid molecules
- many of the carboxyl groups are methylated ($COOCH_3$)
- less hydrated then pectic acid but soluble in hot water
- another major component of middle lamella but also found in primary walls

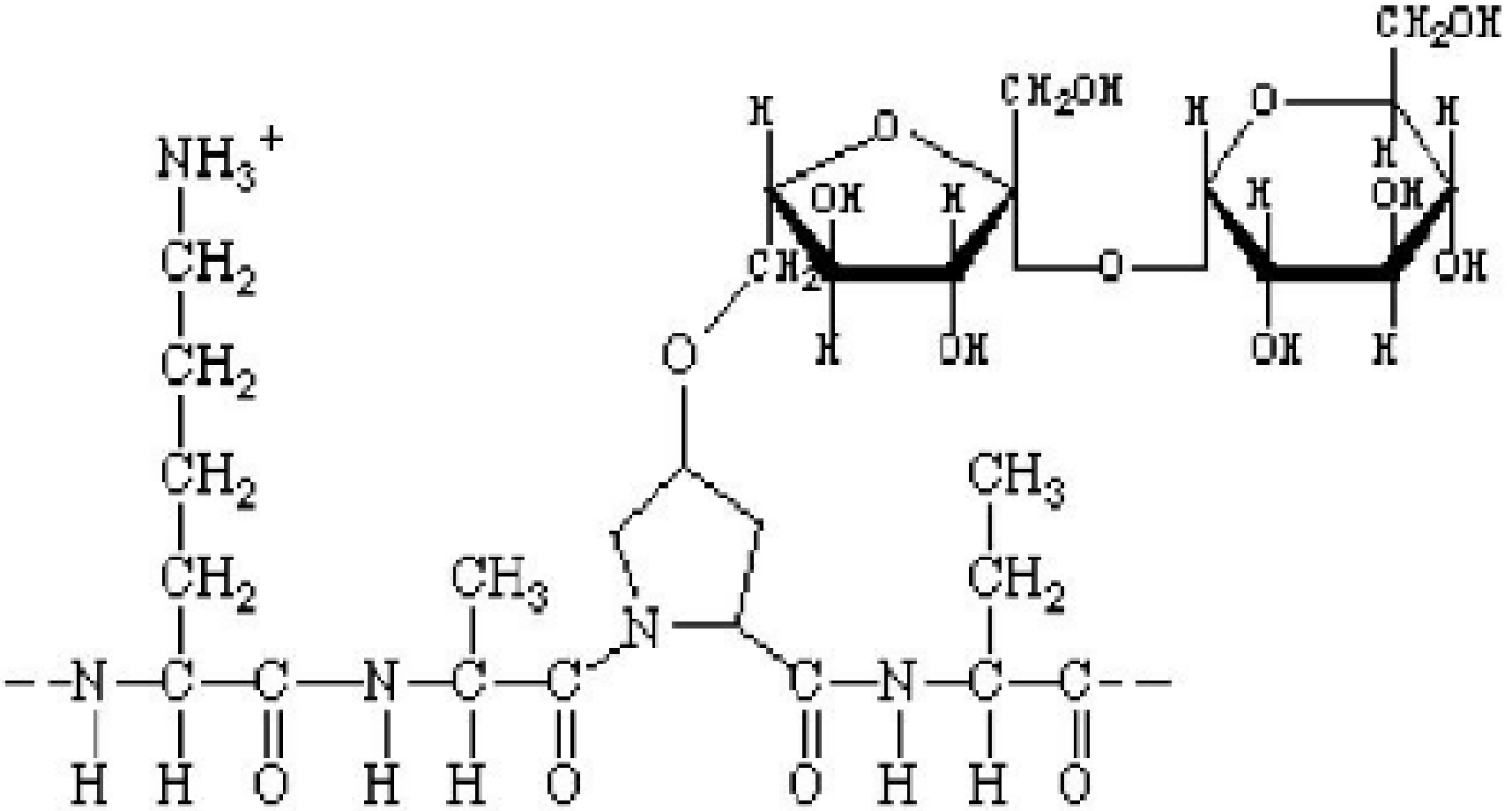
- **Structural proteins:**
- One type of cell wall protein, called glycoproteins, contains carbohydrate side chains on certain amino acids.

- One common group of cell wall proteins are characterized by having an abundance of the amino acid hydroxyproline.

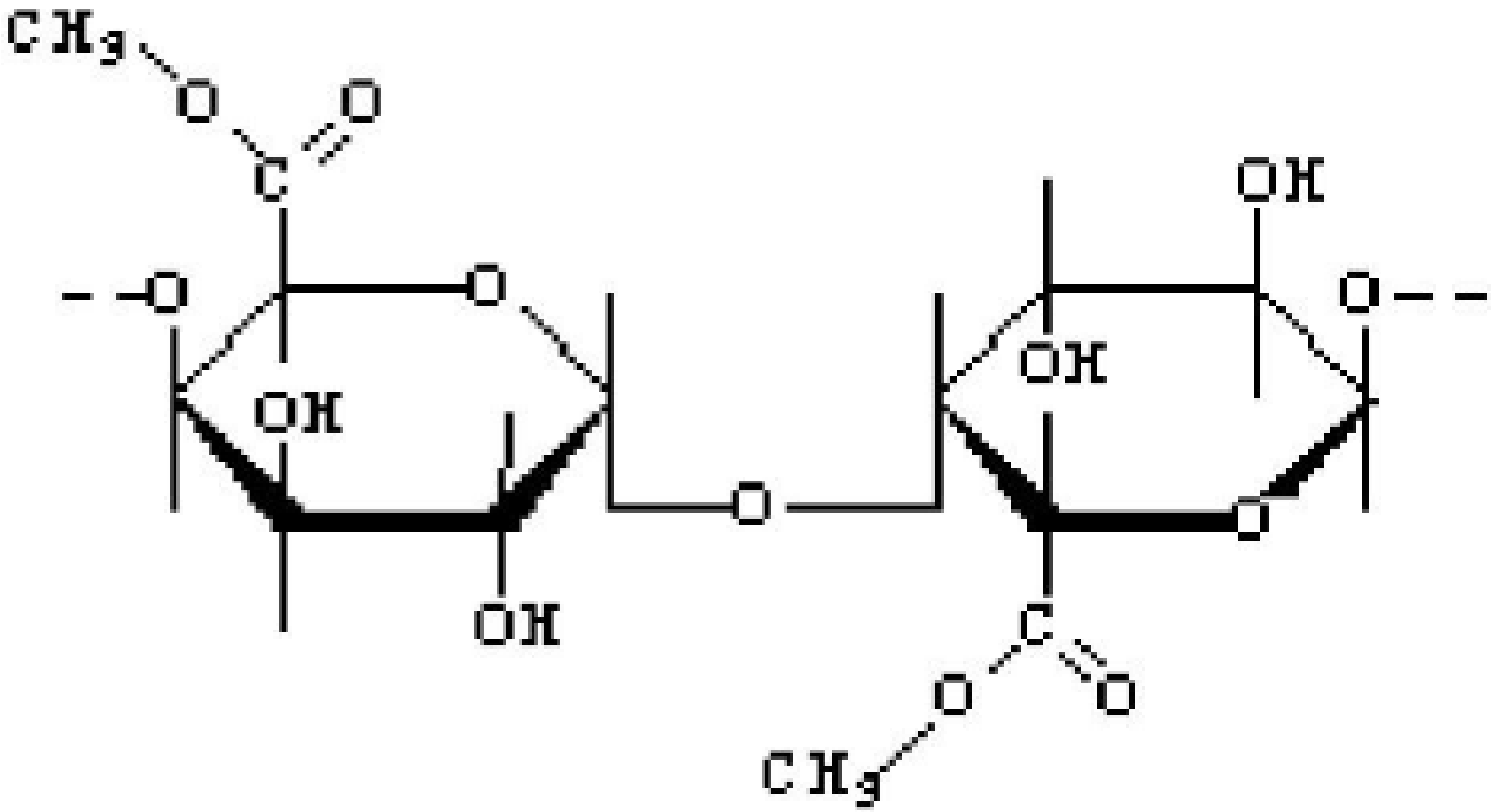
- Structural proteins are found in all layers of the plant cell wall but they are more abundant in the primary wall layer.

- The polysaccharide-rich primary walls are the major textural component of plant-derived foods. The ripening of fruits and vegetables is associated with changes in wall structure and composition.
- Plant-derived beverages often contain significant amounts of wall polysaccharides. Some wall polysaccharides bind heavy metals, stimulate the immune system, or regulate serum cholesterol.
- Wall polysaccharides are used commercially as gums, gels, and stabilizers. Thus, cell wall structure and organization is of interest to the plant scientist, the food processing industry, and the **nutritionist**.

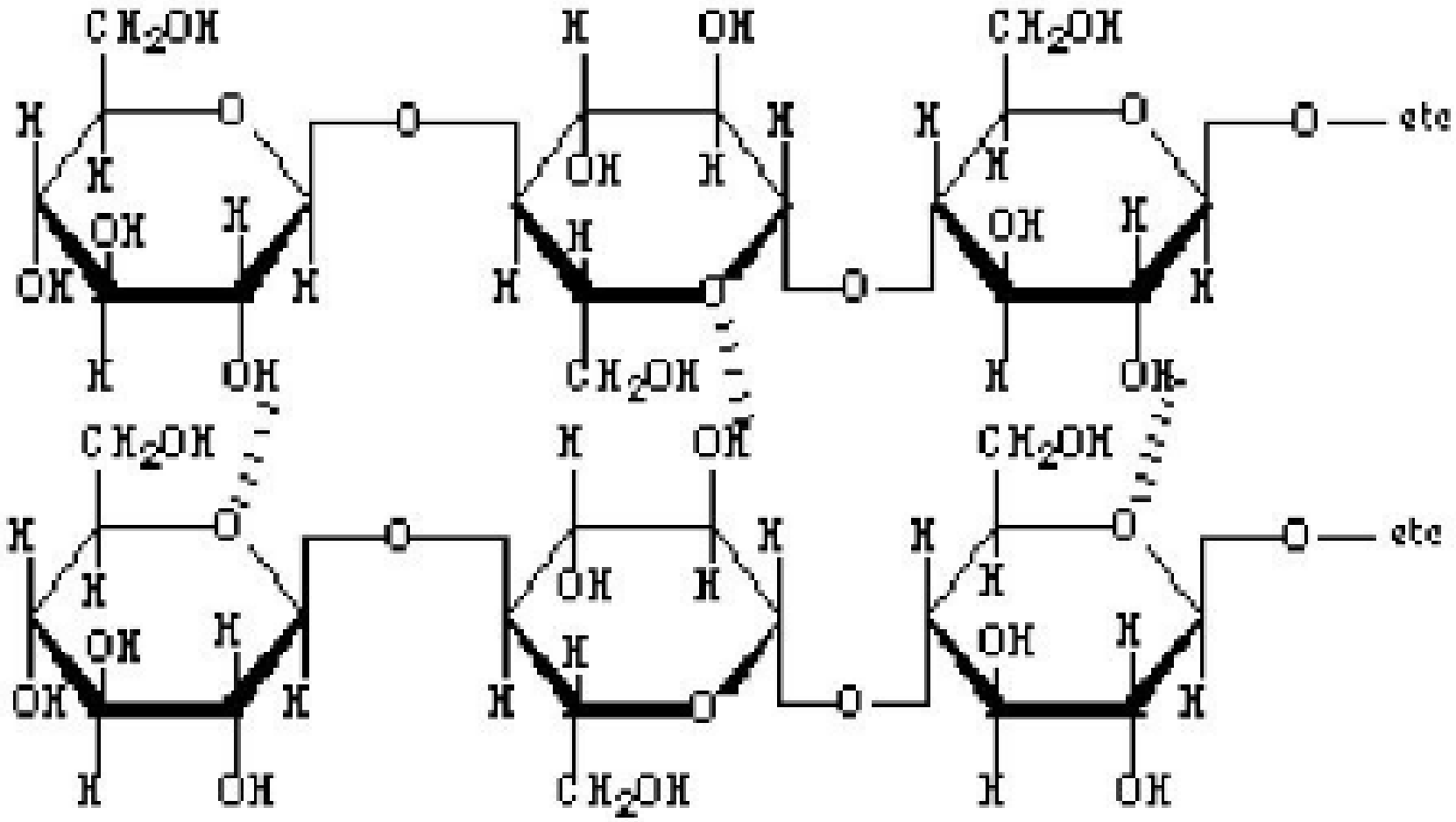
Structural Proteins

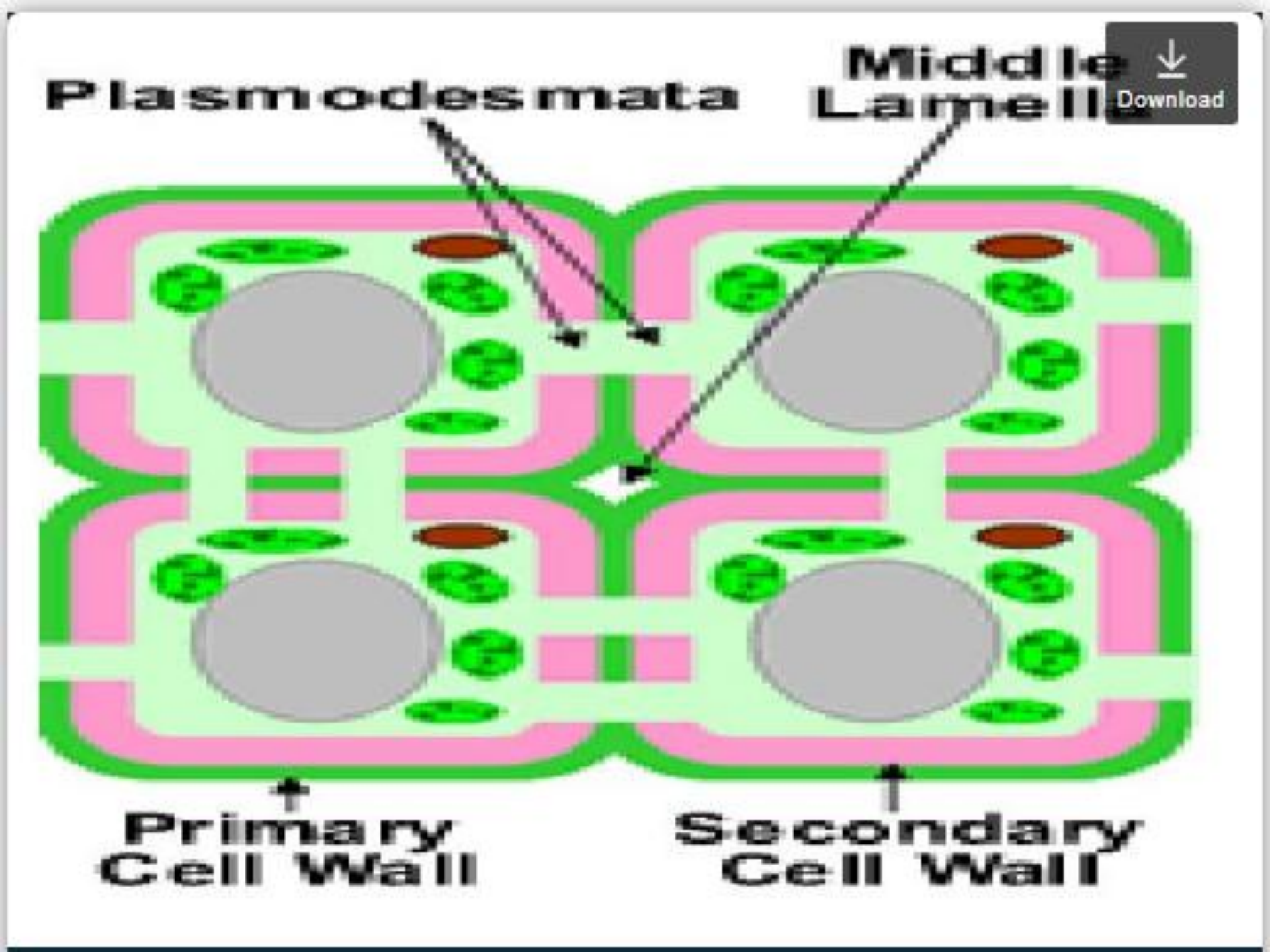


Pectin



Cellulose



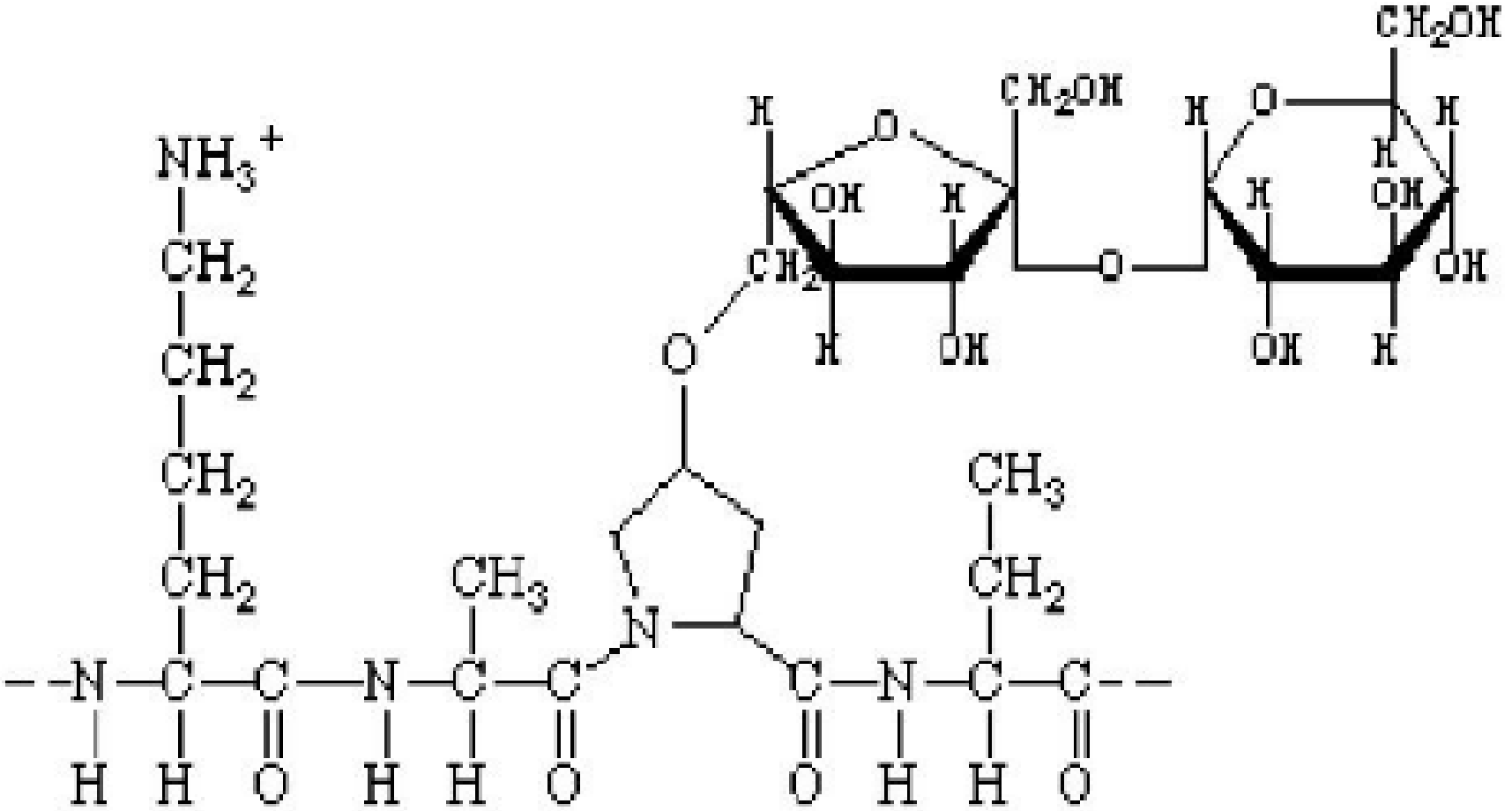

Plasmodesmata
Middle Lamella
Primary Cell Wall
Secondary Cell Wall

Cell Wall Composition

- **Pectic acid:**
- polymer of over 100 galacturonic acid molecules
- very hydrophilic and soluble - become very hydrated
- forms salts and salt bridges with Ca^{+2} and Mg^{+2} that are insoluble gels
- major component of middle lamella but also found in primary walls

- nitrogen, N - Component of chlorophyll; amino acids, proteins and enzymes; nucleic acids (RNA and DNA); some plant hormones. phosphorus, P - Component of the high energy compounds ATP, NADPH and NADP; nucleic acids (DNA and RNA); and phospholipids.
- potassium, K - (1) Needed for protein and enzyme synthesis and activation. (2) Involved in maintaining proper water balance. (3) Needed for photosynthesis.
- magnesium, Mg - (1) Component of chlorophyll. (2) Activates many enzymes.

Structural Proteins



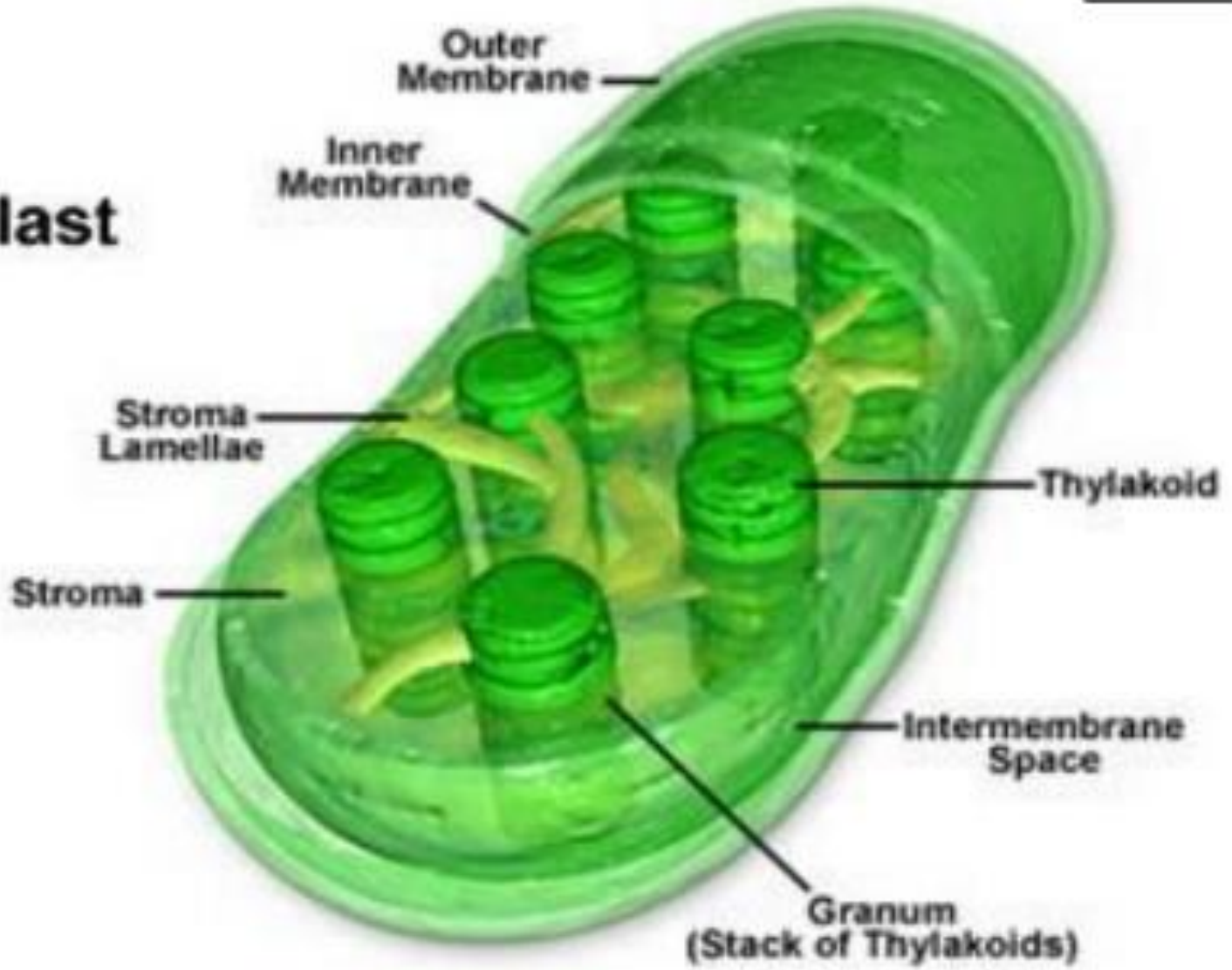
- **Chloroplasts** are the sites of photosynthesis in plant cells.
- All of the green structures in plants, including stems and unripened fruit, contain chloroplasts, but the majority of photosynthesis activity in most plants occurs in the leaves. On the average, the chloroplast density on the surface of a leaf is about one-half million per square millimeter.

- Chloroplasts are one of several types of **plastids,** plant cell organelles that are involved in energy storage and the synthesis of metabolic materials. The colorless **leucoplasts** are involved in the synthesis of starch, oils, and proteins. Yellow-to-red colored **chromoplasts** manufacture carotenoids, and the green colored chloroplasts contain the pigments chlorophyll a and chlorophyll b, which are able to absorb the light energy needed for photosynthesis to occur.
- The numbers of the various types of plastids are based upon the needs of the cell, which may be influenced by environmental conditions.

- Inside the inner membrane is a complex mix of enzymes and water called **stroma**. The stroma is a semi-fluid material that contains dissolved enzymes and fills most of the chloroplast's volume. Like mitochondria, chloroplasts possess their own genomes (DNA), therefore the stroma contains chloroplast DNA and special ribosomes and RNA.
- Embedded in the stroma is a complex network of stacked sacs. Each stack is called a **granum**.

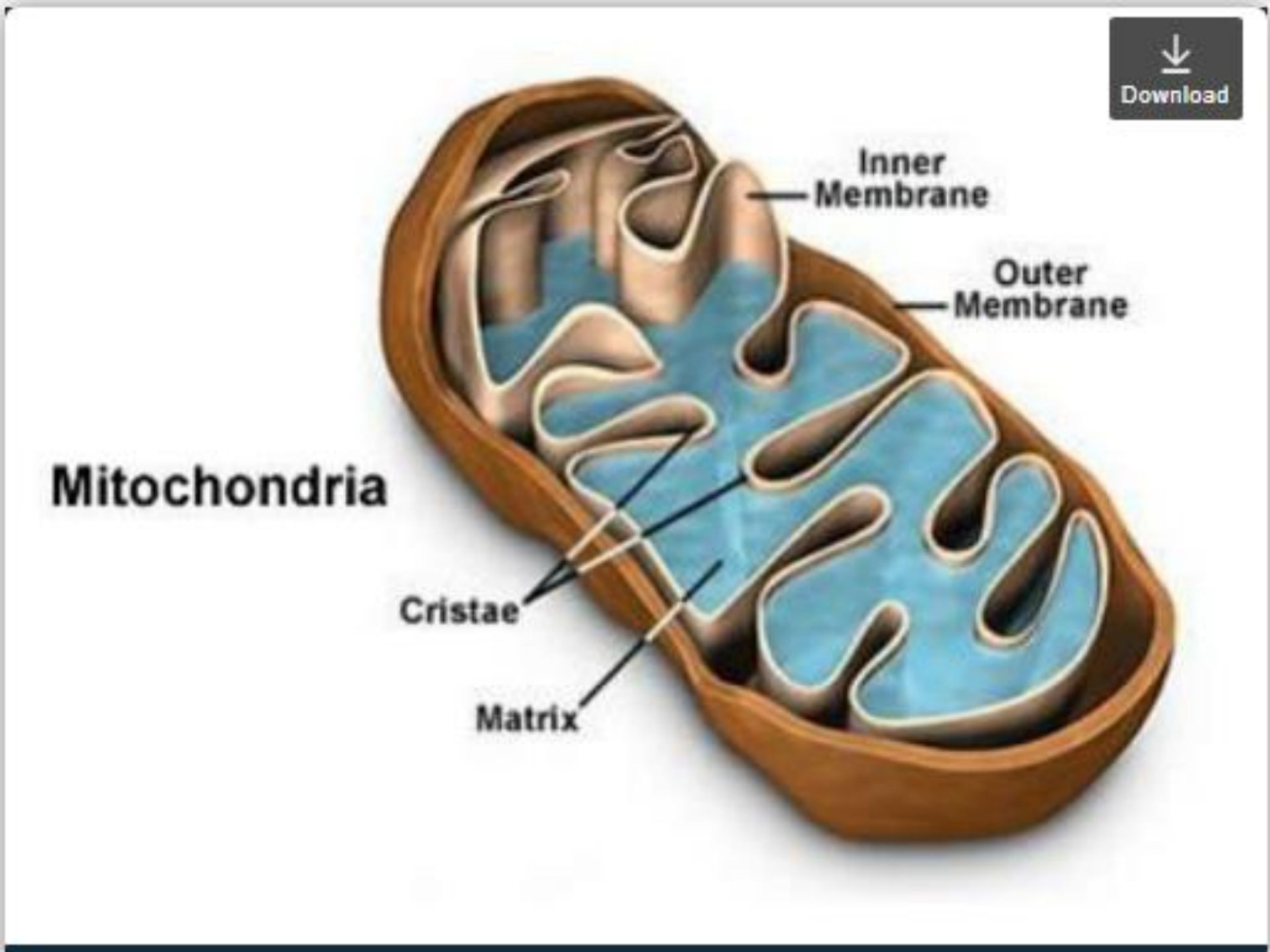
- Each of the flattened sacs which make up the granum is called a **thylakoid**.

Chloroplast



- Plant cells are remarkable in that they have two organelles specialized for energy production: **chloroplasts**, which create energy through photosynthesis, and **mitochondria**, which generate energy through respiration.

- Both the mitochondria and the chloroplast have their own DNA and reproduce independently of the cell in which it is found; an apparent case of **endosymbiosis**.
- Scientists hypothesize that millions of years ago small, free-living prokaryotes were engulfed, but not consumed, by larger prokaryotes. These organisms may have been able to resist the digestive enzymes of the engulfing organism.


Download
Inner Membrane
Outer Membrane
Mitochondria
Cristae
Matrix

- According to DNA evidence, the eukaryotic organisms that later became plants likely added the photosynthetic pathway in this way, by acquiring a photosynthetic bacteria as an endosymbiont.
- As suggested by this hypothesis, the two organisms developed a symbiotic relationship over time, the larger organism providing the smaller with nutrients and the smaller organism providing ATP molecules to the larger one. Eventually, the larger organism developed into the eukaryotic cell, the smaller organism into the chloroplast.
According to DNA evidence, the eukaryotic organisms that later became plants likely added the photosynthetic pathway in this way, by acquiring a photosynthetic bacteria as an endosymbiont.

- nitrogen, N - Component of chlorophyll; amino acids, proteins and enzymes; nucleic acids (RNA and DNA); some plant hormones. phosphorus, P - Component of the high energy compounds ATP, NADPH and NADP; nucleic acids (DNA and RNA); and phospholipids.
- potassium, K - (1) Needed for protein and enzyme synthesis and activation. (2) Involved in maintaining proper water balance. (3) Needed for photosynthesis.
- magnesium, Mg - (1) Component of chlorophyll. (2) Activates many enzymes.