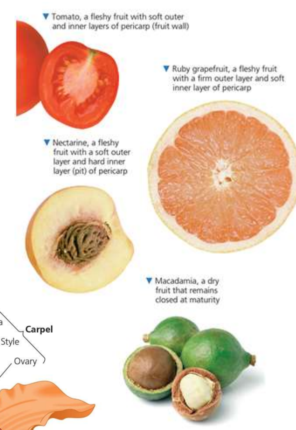
SLE 132 – Form and Function
Structure of Flowering Plants

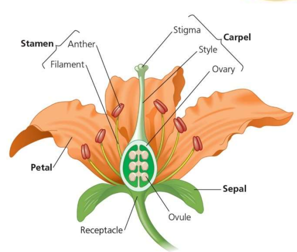
DEAKIN COLLEGE in association with DEAKIN UNIVERSITY AUSTRALIA

Introduction to Angiosperms

- Reproductive structures in angiosperms are flowers and fruits
- Most widespread and diverse of all plants – dominate kingdom Plantae (250 000 spp.)
- All classified in a single Phylum Anthophyta



Some variations in fruit structure.



▲ **Figure 30.9** The structure of an idealised flower.

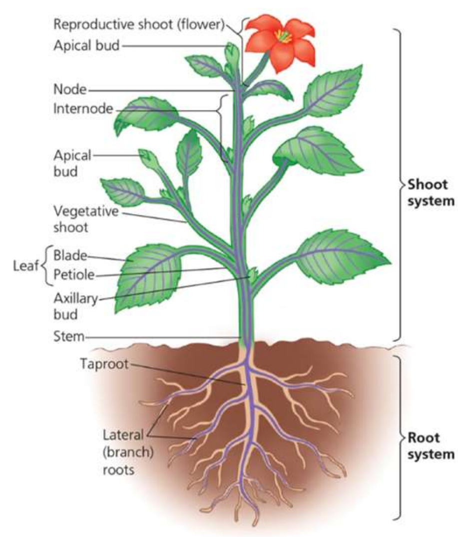
Structure of flowering plants

Plants, like multicellular animals, have organs composed of different tissues, which in turn are composed of cells.

- Three basic organs evolved: **roots, stems, and leaves**
- They are organised into a root system and a shoot system
- **Roots** rely on sugar produced by photosynthesis in the shoot system
- **Shoots** rely on water and minerals absorbed by the root system

Structure of flowering plants

- The Shoot system is above ground and deals with photosynthesis and reproduction
- The root system is below ground, it absorbs water and minerals and anchors the plant



▲ **Figure 35.2 An overview of a flowering plant.** The plant body is divided into a root system and a shoot system, connected by vascular tissue (purple strands in this diagram) that is continuous throughout the plant. The plant shown is an idealised eudicot.

Roots

Roots are multicellular organs with important functions:

- **Anchoring** the plant
- **Absorbing** minerals and water
- **Transport** nutrients
- **Storing** organic nutrients (food)

Three different types of roots, which inhabit different environments:

- **Tap roots** – penetrate deeply into the soil (eudicots)
- **Fibrous roots** – more shallow, lateral roots (monocots/seedless vascular plants)
- **Adventitious** – roots arise from stems or leaves

Roots

- Deepest root belongs to a desert plant *Boscia albitrunca* – 68m deep.
- **Taproot** system consists of one main vertical root that gives rise to lateral roots, or branch roots

Seedless vascular plants and monocots have a fibrous root system characterised by thin lateral roots with no main root

Root hairs increase surface area

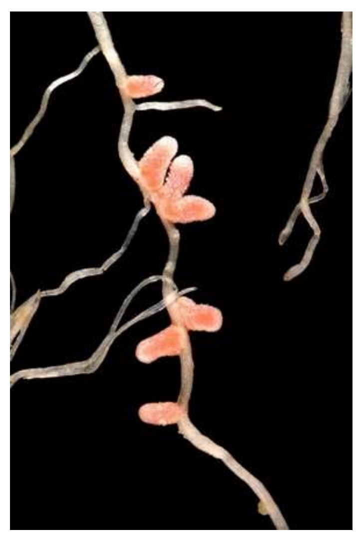
- In most plants, absorption of water and minerals occurs over the root hairs.
- Vast numbers of tiny root hairs increase the surface area of the root
- Allows increased diffusion area

◀ **Figure 35.3 Root hairs of a radish seedling.** Root hairs grow by the thousands just behind the tip of each root. By increasing the root's surface area, they greatly enhance the absorption of water and minerals from the soil.

Root associations help to aid absorption

2 Main Types

- **Mychorrhizae** – fungal association
  - increases phosphorus uptake in plants
- **Nodules** – swellings due to bacterial or mychorrhizae associations
  - allow atmospheric nitrogen fixation

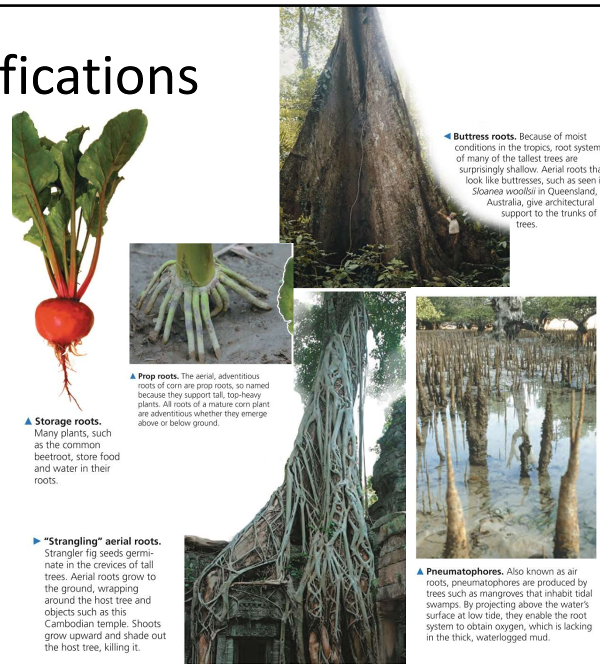


Root Modifications

Allow for survival in different habitats and nutrient storage

For example:

- Adventurous Roots
- Prop Roots
- Pneumatophores in mangroves
- Aerial roots in ivy
- Swollen Tap Roots



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Shoots/Stems

A stem is an organ consisting of the stem itself, leaves and reproductive organs

- An alternating system of **nodes**, the <u>points at which leaves are attached</u>
- **Internodes**, the <u>stem segments</u> between nodes

Functions include:

- **Support** of leaves
- Plant **growth** to access light
- **Transport** of water and nutrients
- Food **Storage**

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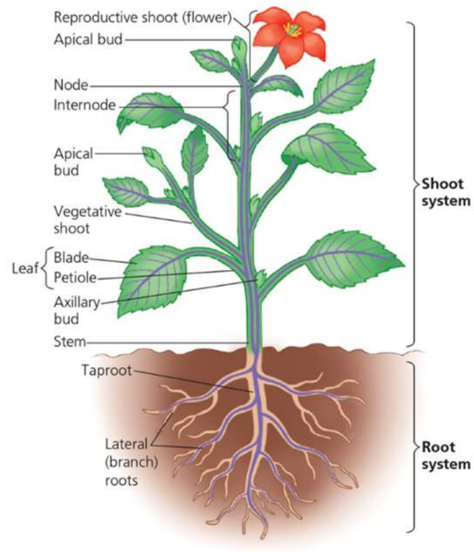
Stems

Nodes give rise to flowers or leaves

Internodes are spaces between nodes

Axillary bud: structure with the potential to form a lateral shoot or branch

Apical bud (terminal bud): located near the shoot tip, causes elongation of young shoot

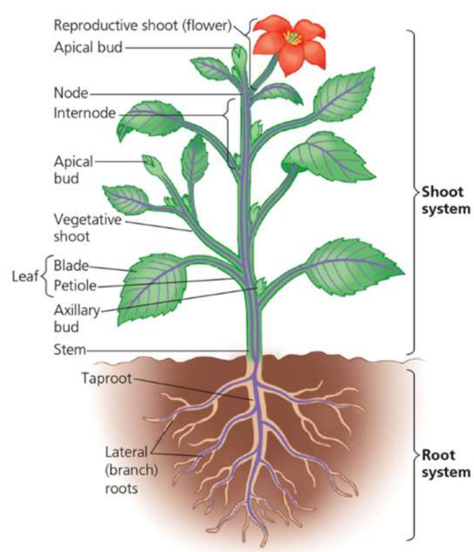


▲ **Figure 35.2 An overview of a flowering plant.** The plant body is divided into a root system and a shoot system, connected by vascular tissue (purple strands in this diagram) that is continuous throughout the plant. The plant shown is an idealised eudicot.

Stems

Exhibit **apical dominance**

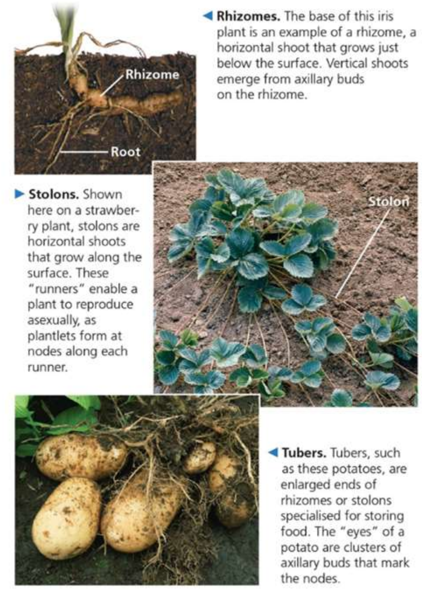
- Inhibition of axillary buds by an apical bud
- Helps maintain dormancy in most non-apical buds
- <u>Allows for elongation</u>


Reproductive shoot (flower)
Apical bud
Node
Internode
Apical bud
Vegetative shoot
Leaf
Blade
Petiole
Axillary bud
Stem
Taproot
Lateral (branch) roots
Shoot system
Root system

▲ **Figure 35.2 An overview of a flowering plant.** The plant body is divided into a root system and a shoot system, connected by vascular tissue (purple strands in this diagram) that is continuous throughout the plant. The plant shown is an idealised eudicot.

Stem modifications

- **Rhizome** – underground stem
- **Stolon** – horizontal stem
- **Tuber** – swollen ends of rhizomes (e.g. potatoes)
- **Bulbs** – vertical underground shoots formed from swollen leaf (e.g. Onion)

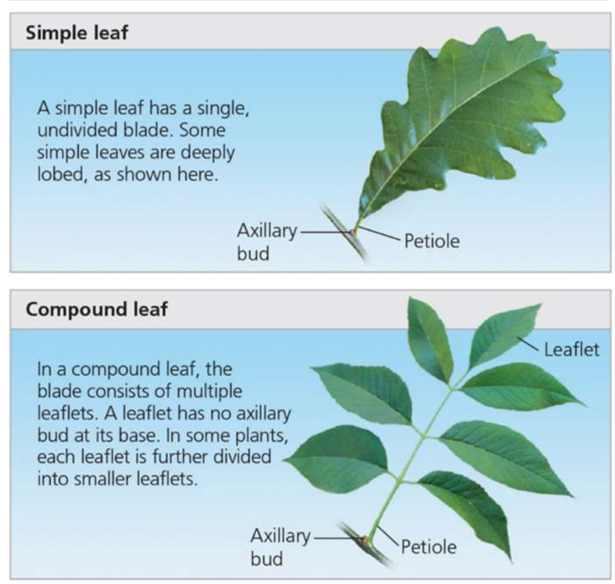


▲ **Figure 35.5** **Evolutionary adaptations of stems.**

Leaves

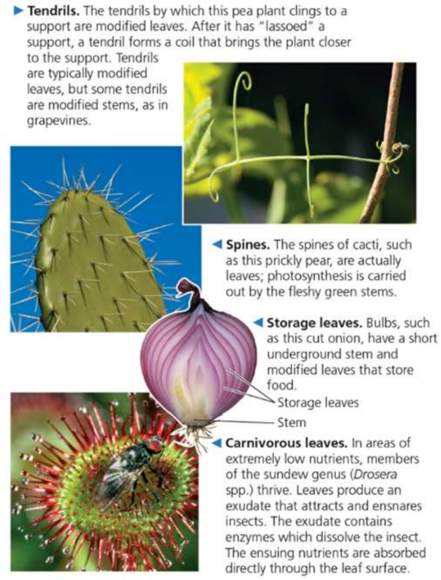
- The leaf is the **main photosynthetic organ** of most vascular plants
- Leaves generally consist of a flattened blade and a stalk called the **petiole**, which joins the leaf to a **node** of the stem

▼ **Figure 35.6** **Simple versus compound leaves.**



Leaf Modifications

- **Tendrils** – pea, cucumber
- **Spines** – on cacti
- **Bracts** – Floral leaves associated with reproductive structure
- **Venus Fly Trap**
- **Pitcher** of pitcher plants
- **Reproductive leaves**



▲ **Figure 35.7** **Evolutionary adaptations of leaves.**

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Monocots and Dicots

Phylum Anthophyta (Flowering Plants) is divided into 2 classes:

Monocotyledons (65 000 species)

- Grasses, Lilies, Irises, Orchids, Palms, Sugar Cane and Wheat Plants

Dicotyledons (175 000 species)

- Shrubs, Trees (not conifers), Herbs

Monocots and Dicots have different

- **Morphology** – External Structure of plant
- **Anatomy** – Internal structure of the plant

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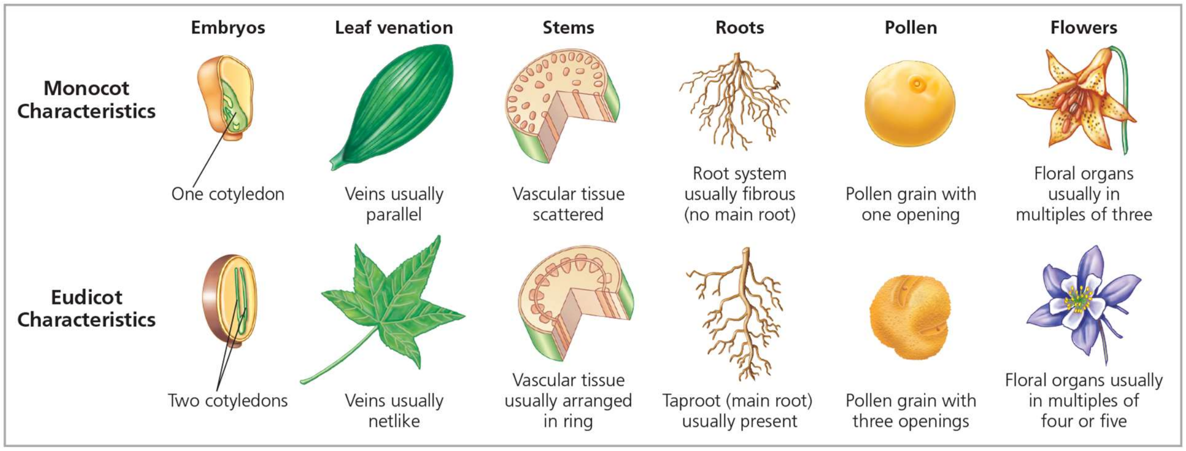
Phylum Anthophyta (Flowering Plants)



▲ **Figure 30.17** **Characteristics of monocots and eudicots.**

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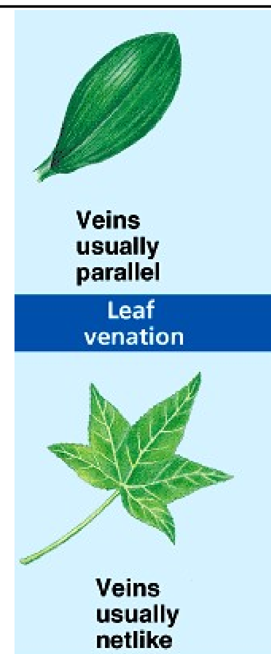
Monocots and dicots

Differ in the arrangement of veins, the vascular tissue of leaves

– Most monocots have parallel veins

– Most dicots have branching veins

In classifying angiosperms, taxonomists may use leaf morphology as a criterion



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Plants have three levels of organisation

1. Cells (see before class activity - this material is examinable)

2. Tissues

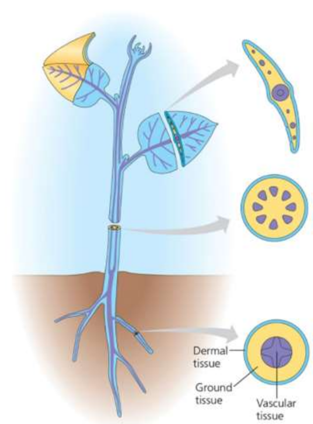
3. Plant Organs

Cells are grouped into Tissues

- Tissues that contain one cell type are called simple tissues
- Tissues that contain more than one type of cell type are called complex tissues

There are 3 Tissue systems

- **Dermal** (epidermis) system
- **Ground** Tissue system
- **Vascular** Tissue system



▲ **Figure 35.8** **The three tissue systems.** The dermal tissue system (blue) provides a protective cover for the entire body of a plant. The vascular tissue system (purple), which transports materials between the root and shoot systems, is also continuous throughout the plant but is arranged differently in each organ. The ground tissue system (yellow), which is responsible for most of the metabolic functions, is located between the dermal tissue and the vascular tissue in each organ.

Epidermis or dermal system

- In young plants forms the **outer covering**
- Variable functionally and structurally
- A <u>waxy coating</u> called the **cuticle** helps prevent water loss from the epidermis
- Mainly formed from **Parenchyma cells**

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Ground Tissue

Often forms:

- **Cortex** in roots
- **Cortex** in pith in stems
- Used as **packing and support** tissue

Mainly parenchyma cells with some sclerenchyma and collenchyma cells

Have diverse Functions including: **Photosynthesis, Storage and Support**

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Vascular system

Includes both **phloem and xylem** tissue

- Both are complex tissues

Xylem

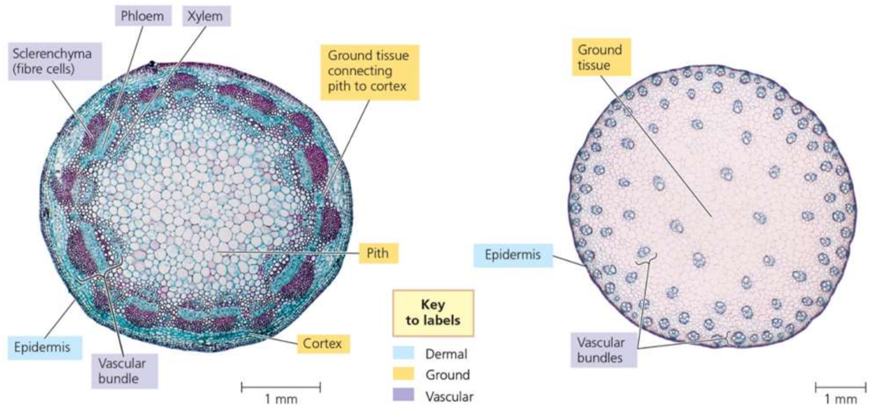
- Water conducting tissue
- Vessel members, tracheids, sclerenchyma and parenchyma
- Water moves from roots to the leaves (one direction)

Vascular System

Phloem

- Sieve cells or sieve tube members, companion cells, parenchyma and sclerenchyma cells
- Transports sugars and other organic solutes
- Movement is in any direction (called **translocation**)

Structure of Stems



(a) Cross-section of stem with vascular bundles forming a ring (typical of eudicots). Ground tissue towards the inside is called pith, and ground tissue towards the outside is called cortex (LM).

(b) Cross-section of stem with scattered vascular bundles (typical of monocots). In such an arrangement, ground tissue is not partitioned into pith and cortex (LM).

▲ **Figure 35.17 Organisation of primary tissues in young stems.**

? Why aren't the terms *pith* and *cortex* used to describe the ground tissue of monocot stems?

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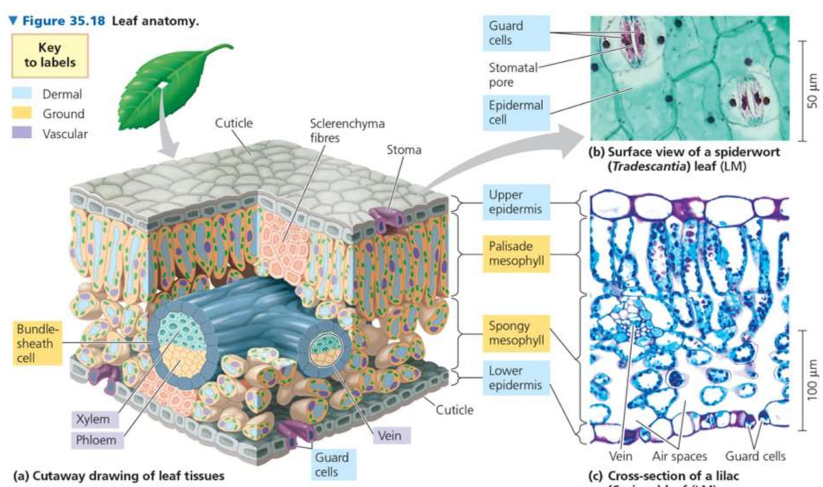
Structure of Leaves

Leaf mostly made up of photosynthetic Parenchyma cells

▼ **Figure 35.18 Leaf anatomy.**



(a) Cutaway drawing of leaf tissues

(b) Surface view of a spiderwort (*Tradescantia*) leaf (LM)

(c) Cross-section of a lilac (*Syringa*) leaf (LM)

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Quick Question

1. Which of the following best characterise the eudicots?

a) Flower parts in threes
b) Leaves with parallel veins
c) An embryo with two seed leaves
d) Stems with scattered vascular bundles

Quick Question

2. Which of the following is a function of roots?

a) Absorbs water only
b) Absorbs nutrients from the soil only
c) Stores food only
d) Stores food and absorbs nutrients and water from the soil

Quick Question

3. Which of the following are projections found on roots that increase the surface area?

a) Root hairs

b) Cotyledons

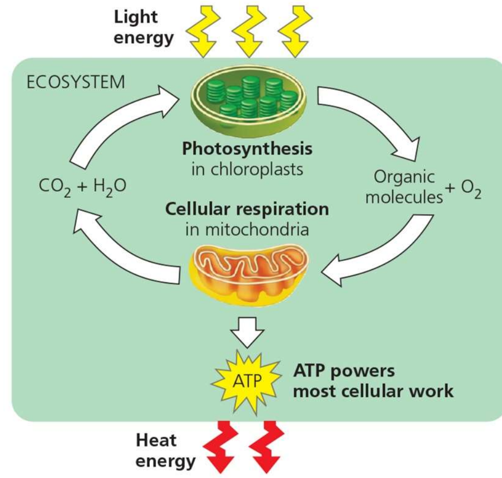
c) Nodes

d) Mesophyll

SLE 132 – Form and Function
Photosynthesis

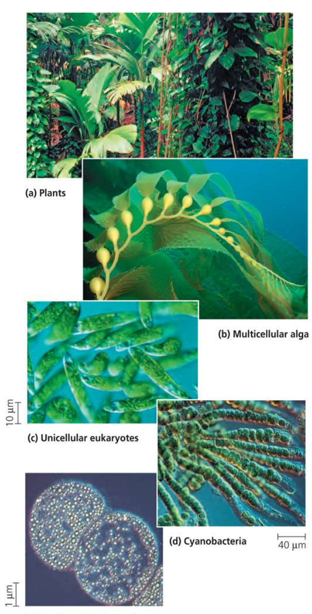
Photosynthesis

- Conversion of solar energy into chemical energy
- All energy in the ecosystem comes from the sun via plants
- Light energy powers a process that makes sugars and O_2 from CO_2 and Water
- Occurs on the thylakoid membranes and stroma of chloroplasts



▲ **Figure 9.2 Energy flow and chemical recycling in ecosystems.** Energy flows into an ecosystem as sunlight and ultimately leaves as heat, while the chemical elements essential to life are recycled.

Autotrophs



▲ **Figure 10.2 Photoautotrophs.** These organisms use light energy to drive the synthesis of organic molecules from carbon dioxide and (in most cases) water. They feed themselves and the entire living world. **(a)** On land, plants are the predominant producers of food. In aquatic environments, photoautotrophs include unicellular and **(b)** multicellular algae, such as this kelp; **(c)** some non-algal unicellular eukaryotes, such as *Euglena*; **(d)** the prokaryotes called cyanobacteria; and **(e)** other photosynthetic prokaryotes, such as these purple sulphur bacteria, which produce sulphur (the yellow globules within the cells) (c–e, LMs).

Autotrophs sustain themselves – no nutrients derived from other organisms

Producers of the biosphere,

- produce organic molecules (from CO_2) and inorganic molecules

Almost all plants fall into this group

Photoautotrophs: use energy of sunlight to make organic molecules from H_2O and CO_2

Heterotrophs

- Obtain their organic material from other organisms
- ***Consumers*** of the biosphere
- Almost all heterotrophs, including humans, depend on photoautotrophs for food and O_2

Table 27.1 Major Nutritional Modes

Mode of Nutrition	Energy Source	Carbon Source	Types of Organisms
Autotroph			
Photo-autotroph	Light	CO_2	Photosynthetic prokaryotes, including cyanobacteria; plants; certain protists (algae)
Chemo-autotroph	Inorganic chemicals	CO_2	Certain prokaryotes (for example, *Sulfolobus*)
Heterotroph			
Photo-heterotroph	Light	Organic com-pounds	Certain prokaryotes
Chemo-heterotroph	Organic com-pounds	Organic com-pounds	Many prokaryotes and protists; fungi; animals; some parasitic plants

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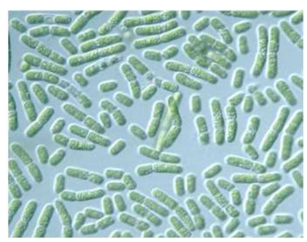
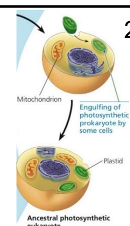
Photosynthesis converts light energy to chemical energy

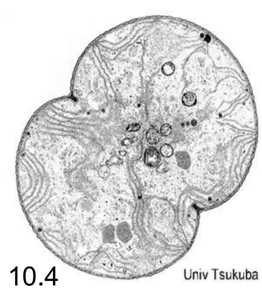
- Chloroplasts are structurally similar to, and evolved from, photosynthetic bacteria
- The structural organisation of these cells allows for the chemical reactions of photosynthesis



cyanobacteria

25.9





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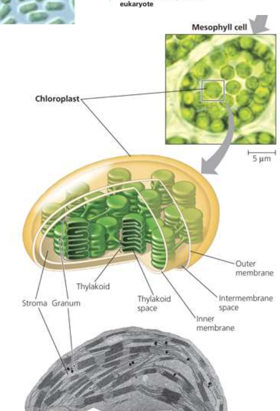

▲ Figure 10.3 Zooming in on the location of photosynthesis in a plant.

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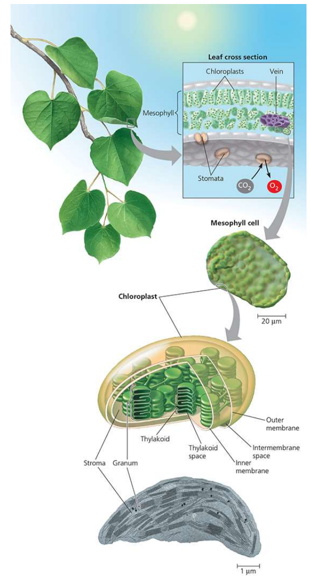
Chloroplasts: the organelles of photosynthesis

- Leaves are the major sites of photosynthesis
  - the energy organs of the plant
- **Chlorophyll** - the green pigment within chloroplasts
- Green because green light is reflected
  - (or absorbed the least well)
- **Light energy** absorbed by chlorophyll <u>drives the synthesis</u> of organic molecules in the chloroplast
- CO_2 enters, and O_2 exits the leaf, through microscopic pores called **stomata –** H_2O is also lost

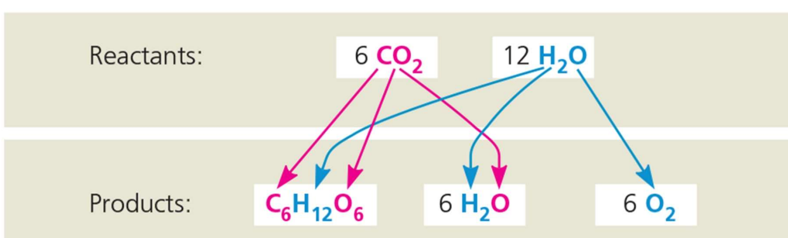


▲ **Figure 10.4 Zooming in on the location of photosynthesis in a plant.** Leaves are the major organs of photosynthesis in plants. These pictures take you into a leaf, then into a cell, and finally into a chloroplast, the organelle where photosynthesis occurs (middle, LM; bottom, TEM).

Photosynthesis

Photosynthesis can be summarised as the following equation:

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



▲ **Figure 10.5 Tracking atoms through photosynthesis.** The atoms from CO_2 are shown in magenta, and the atoms from H_2O are shown in blue.

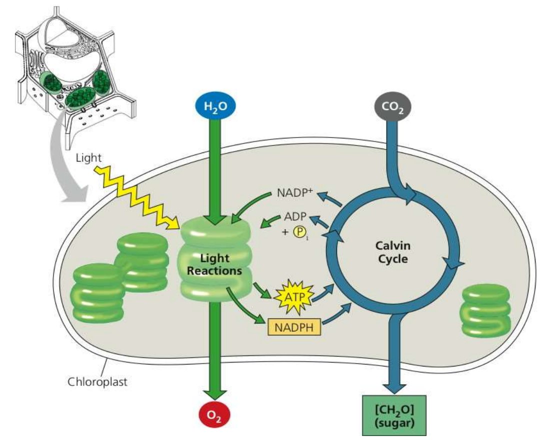
Photosynthesis consists of 2 stages:

- **The light reactions** (*photo) – use light to make ATP and NADPH*
- **The Calvin cycle** *(carbon fixation) – Products from light reactions are used to 'fix' carbon molecules*

The light reactions (in the thylakoids):

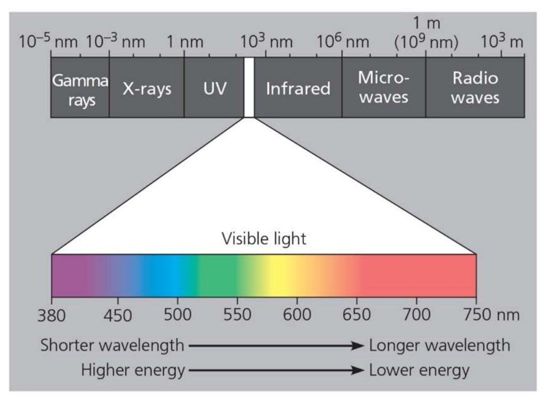
- split H_2O
- release O_2
- reduce $NADP^+$ to NADPH (Hydrogen ions and electrons)
- generate ATP from ADP by **Photo-phosphorylation**

But first…



The nature of Light

- The **electromagnetic spectrum** is the entire range of electromagnetic energy, or radiation.
- **Visible light** consists of wavelengths that produce the colours we can see.
- Light also behaves as though it consists of discrete particles, called **photons**.

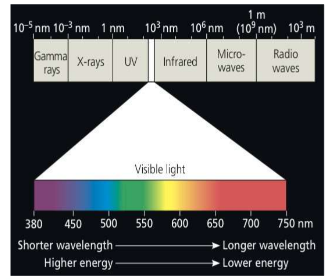


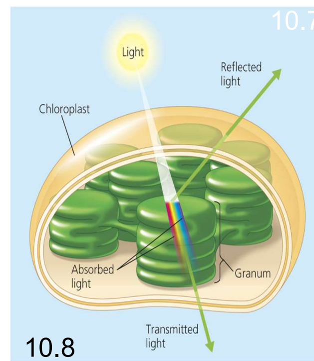
▲ **Figure 10.7 The electromagnetic spectrum.** White light is a mixture of all wavelengths of visible light. A prism can sort white light into its component colours by bending light of different wavelengths at different angles. (Droplets of water in the atmosphere can act as prisms, causing a rainbow to form.) Visible light drives photosynthesis.

Photosynthetic pigments: the light receptors

Pigments: substances that absorb visible light

- Different pigments **absorb** different wavelengths
- Wavelengths that are not absorbed are **reflected or transmitted**
- Leaves appear green because <u>chloroplyll reflects & transmits green light</u>





3 classes of pigments, reflect and transmit these colours:

chlorophylls
green

carotenoids
red, yellow, orange

phycobilins
red, blue

FYI - Chloroplast pigments

Type of pigment	Occurance
Cholrophylls Chlorophyll a	All higher plants and algae
Cholophyll b	All higher plants and algae
Chorophyll c	Diatoms and brown algae
Chorophyll d	Red Algae
Careteniods β – carotene	Higher plants and most algae
α – carotene	Most plants and some algae
Luteol	Green Algae, red algae and higher plants
Violaxanthol	Higher plants
Flucoxxanthol	Diatoms and brown algae
Phycobilins Phycoerythrins	Red algae and in some blue green algae
Phycocyanins	Blue Green algae and in some red algae
Allochycocyanins	Blue Green algae and red algae

Pigments

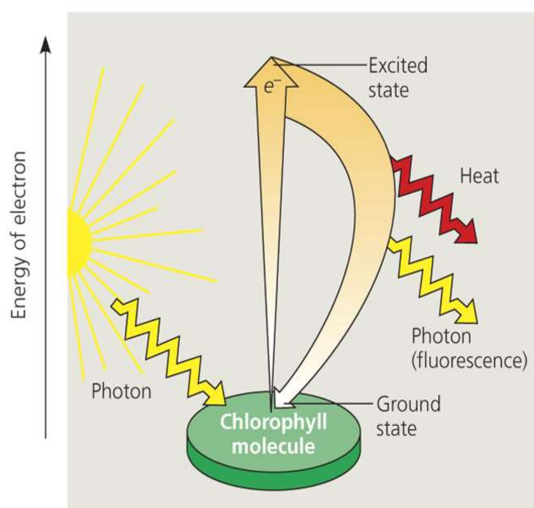
- **Chlorophyll *a*** is the main photosynthetic pigment.
- Accessory pigments, such as **chlorophyll *b***, broaden the spectrum of light used for photosynthesis.
- Accessory pigments, called **carotenoids**, absorb excessive light that would damage chlorophyll.

Pigments

- All pigments have **double bonds**
- This means all pigments have electrons which can be excited
- An **'excited electron'** is one that has been ejected from one energy orbital to another
- This means that it has a higher energy

Excitation of chlorophyll by light

- When a pigment absorbs light, it goes from ground state to an excited state (**unstable**)
- When excited electrons fall back to the ground state, photons are given off (**fluorescence**)
- If illuminated, an isolated solution of chlorophyll will fluoresce, **giving off light & heat**



(a) Excitation of isolated chlorophyll molecule

10.12

Week 8 Class 2

Now you have been introduced to photosynthesis, in the next class we will explore the workings of the different reactions and processes in photosynthesis.