WEIHENSTEPHAN · TRIESDORF
University of Applied Sciences

Plant Basics

Helix Aldinger-Sommer, Prof. Dr. Thorsten Haase

Weihenstephan-Triesdorf University of Applied Sciences

Agenda

Plant Basics

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2. *Anatomy*
3. *Physiology*
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    3. *Transport within the plant*
    4. *Hormones*
4. *Plant development and growth*
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Introduction

Crop production is a branch of agriculture. To cultivate plants, we must first understand how a plant is structured and how it grows. In this chapter, we will therefore learn about key plant components and their functions. We will examine plant metabolism and the plant life cycle. We will also explore the general process of plant cultivation.

Taxonomy

Plant taxonomy is the science that describes, names and classifies plants. The aim is to ensure that when people talk about ‘the same plant’, they really do mean the same plant.

Example: pepper

Piper nigrum (spice) vs. *Capsicum annuum* (vegetable)

https://www.lubera.com/images/600/Pfeffer-ub-foto-Fotoliaid41089535.jpg

https://www.mein-schoener-garten.de/pflanzen/gemuese/paprika

Taxonomy

Plants are classified according to a predefined hierarchy:

- Kingdom (Plantae – Plants)
- Division (e.g. Angiosperms - flowering plants)
- Class
- Order
- Family
- Genus
- Species

The scientific/latin name consists of the genus (capitalised) and the species (lowercase).
Taking pepper as an example, we can see that the vegetable pepper (*Capsicum annuum*) belongs to a different genus and species than the spice (*Piper nigrum)*.

Taxonomy

Furthermore, plant species can be subdivided into varieties. Within each species, there are very different varieties. Take potatoes, for example: Laura, Allians, Beyonce. Varieties, in turn, differ in terms of, for example, ripening behaviour, disease resistance/tolerance and yield potential.

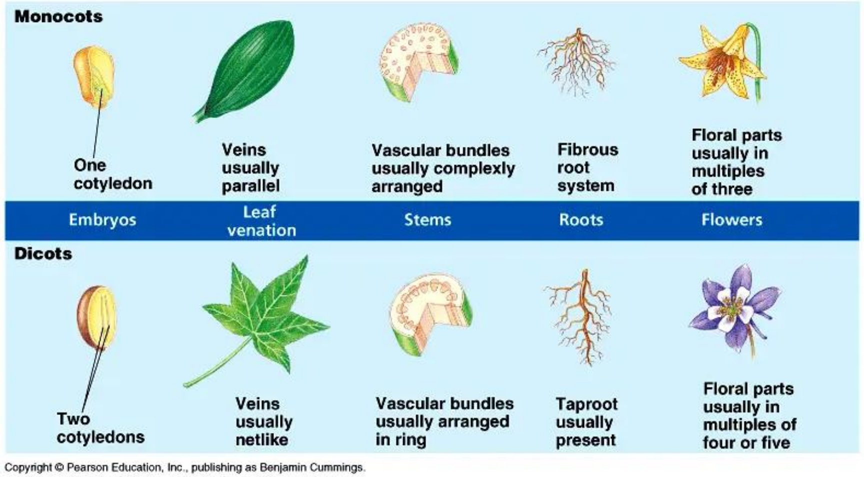
Many crops can be broadly classified according to their family:

- Sweet grasses (Pocaceae)
- Legumes (Fabaceae)
- Nightshades (Solanaceae)
- Cruciferous plants (Brassicaceae)

Knowledge of plant families is important to us because crops from the same families are susceptible to the same diseases and pests. This can help us to adapt our cultivation strategy and crop rotation.

Taxonomy

Flowering plants can also be easily distinguished by their cotyledons (the leaves that appear first after germination). On the one hand, there are monocots with parallel leaf veins and a fibrous root system, e.g. sweet grasses. On the other hand, there are dicots with reticulate leaves and often a taproot, e.g. vegetables.



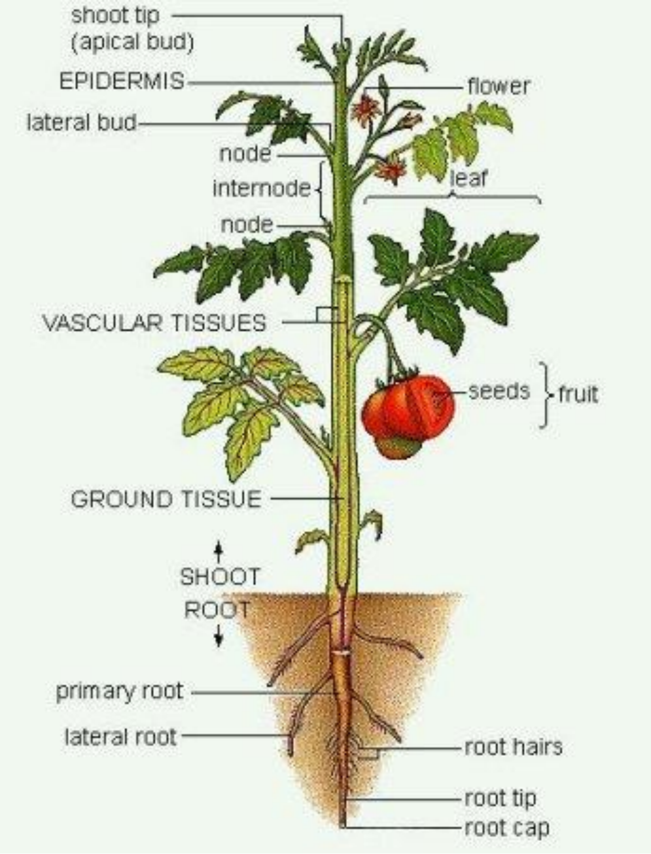
https://www.holganix.com/blog/monocots-vs-dicots-what-you-need-to-know

Anatomy

Plants consist of three basic organs: the root, the stem and the leaves. Each of these has specific functions and roles.

Roots anchor plants in the soil, absorb water and nutrients, and store organic matter. Some plants release substances through their roots (root exudates) that can have beneficial effects on soil organisms and nutrient availability.

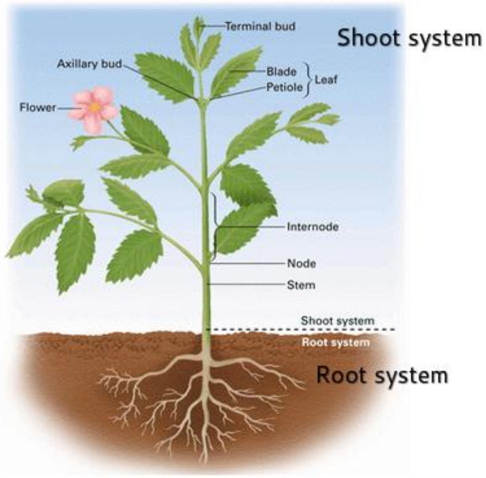
More information here: Hiremath, Shivanand & Prasanna, Narsing & Sudhakar, S & Nigam, Rashmi & Kumar, Sanjay & Elangovan, Marimuthu & Mohanan, Arvind. (2024). A Review on Role of Root Exudates in Shaping Plant-Microbe-Pathogen Interactions. Journal of Advances in Microbiology. 24. 1-17. 10.9734/jamb/2024/v24i12868.

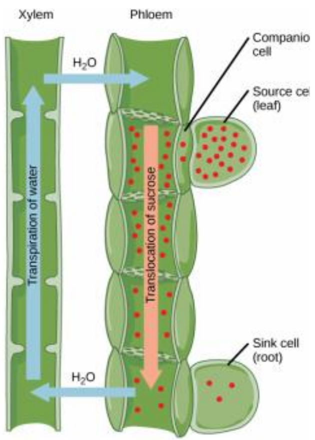


https://universe-review.ca/R10-34-anatomy2.htm

Anatomy

The shoot connects the organs responsible for the plant’s nutrition, namely the roots and leaves. The shoot contains the vascular bundles (xylem and phloem) through which water and nutrients are transported within the plant. In some crop species, the shoot can also act as a storage organ; for example, potatoes are stolons, which are part of the shoot (albeit underground).





https://plantsproject2.weebly.com/parts-of-a-plant.html

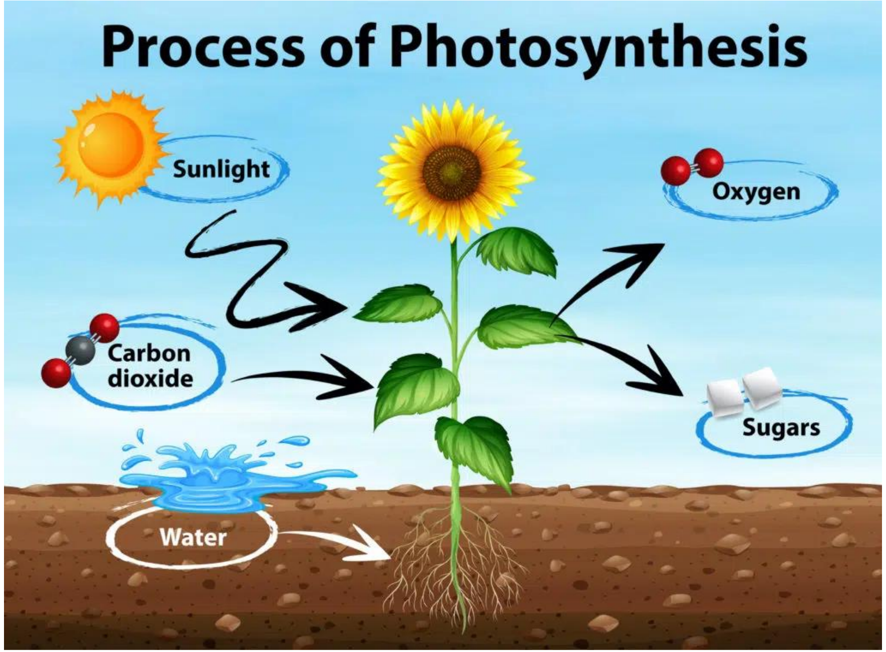
Anatomy

Photosynthesis takes place in the leaves, where the sun's radiant energy is converted into chemical energy. Chlorophyll, the green pigment, is essential for photosynthesis; this is where photosynthesis occurs. Flowers are the reproductive organs of a plant. After fertilisation, they develop into fruit. From a botanical point of view, the flowers of a plant consist of compressed shoots and surrounding leaves. There are many different types of flowers. Hermaphroditic flowers contain both stamens and carpels, whilst unisexual flowers contain only male or female parts. Plants with hermaphroditic flowers may be monoecious, meaning they have both male and female flowers (e.g. maize, spruce). Dioecious plants bear only female or only male flowers (e.g. hops, poplar).

Physiology - Photosynthesis

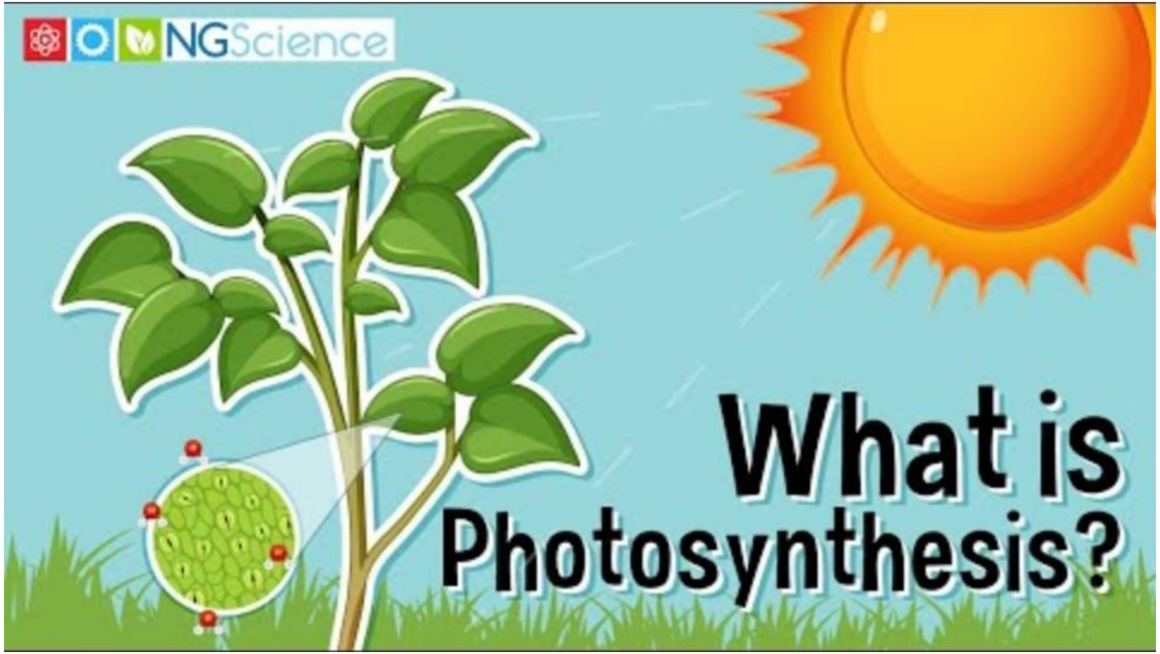
Green plants can produce their own food (sugar) using sunlight, water and carbon dioxide. This process is called photosynthesis. Oxygen is produced as a by-product and released into the air. As we learnt in the chapter on plant anatomy, photosynthesis takes place in the chlorophyll . This is a component of plant cells.

Practical relevance: The colour of plants is a good indicator of their state of health. As long as a plant is well supplied with light, water and nutrients, it is green in colour due to chlorophyll and is able to carry out photosynthesis. Patterns, spots, yellowing and wilting can be visible signs of disease, a lack of water or nutrients, or stress.



https://www.science-sparks.com/what-is-photosynthesis/)

Physiology - Photosynthesis



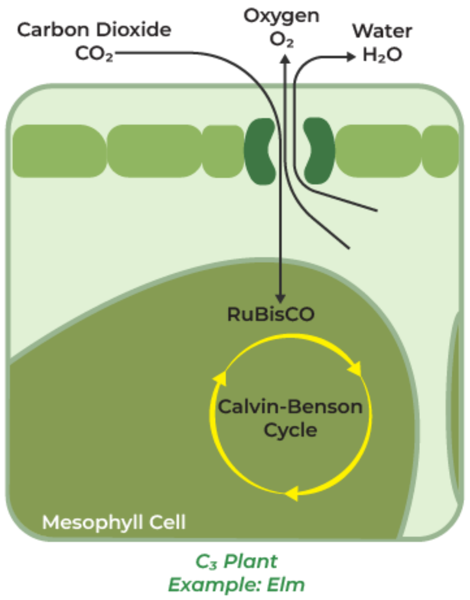
https://www.youtube.com/watch?v=E22APTvfwyE

Physiology – Photosynthesis C3

C3 plants (such as wheat, rapeseed, potatoes and peas) are the ‘standard version’ of photosynthesis. They absorb CO_2 directly from the air and immediately convert it into sugar – but this comes with a major drawback:

Their key enzyme, Rubisco, cannot distinguish between CO_2 and oxygen (O_2). This becomes a problem in hot and dry conditions.

Because they lose a lot of water through their stomata in hot weather (to absorb CO_2), they are susceptible to drought stress. They also require a relatively large amount of nitrogen, as their inefficient enzyme, Rubisco, needs to be produced in large quantities.



https://www.geeksforgeeks.org/biology/c4-plants/

Physiology – Photosynthesis C4

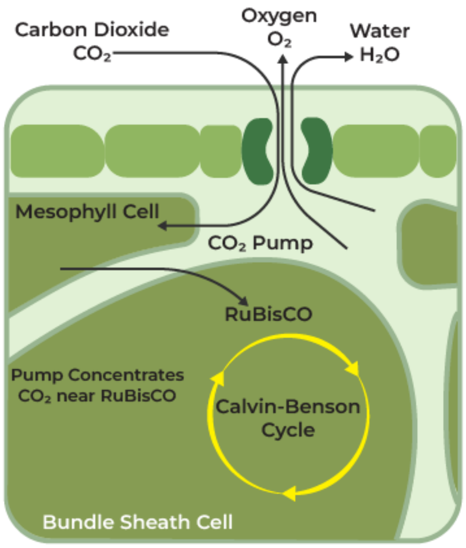
C4 plants are evolutionary specialists adapted to hot, sunny and dry environments. They ‘circumvent’ the main problem faced by normal plants (photorespiration) by spatially separating CO_2 uptake and utilisation.

They first capture CO_2 from the air in a special preliminary stage (a **four-carbon molecule**) and transport it to another type of cell, where it is then used in concentrated form for the actual photosynthesis. This protects the key enzyme Rubisco from harmful ‘photorespiration’, which severely weakens normal C3 plants in hot conditions.

They can keep their stomata open for shorter periods because they use CO_2 very efficiently. Fewer open stomata = less water evaporation.

Examples:

Maize, Sugar cane, Sorghum



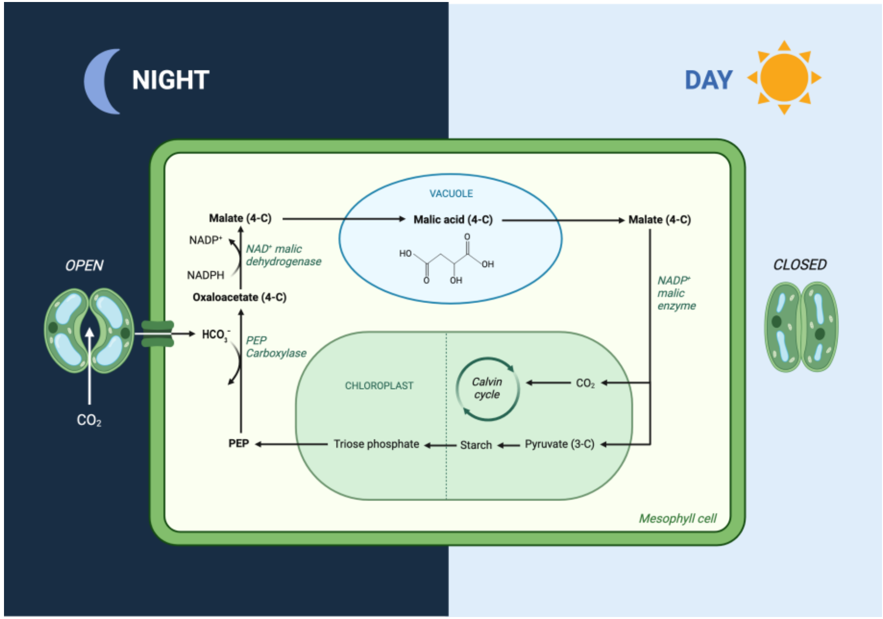
C_4 Plant
Example: Corn

https://www.geeksforgeeks.org/biology/c4-plants/

Physiology – Photosynthesis CAM

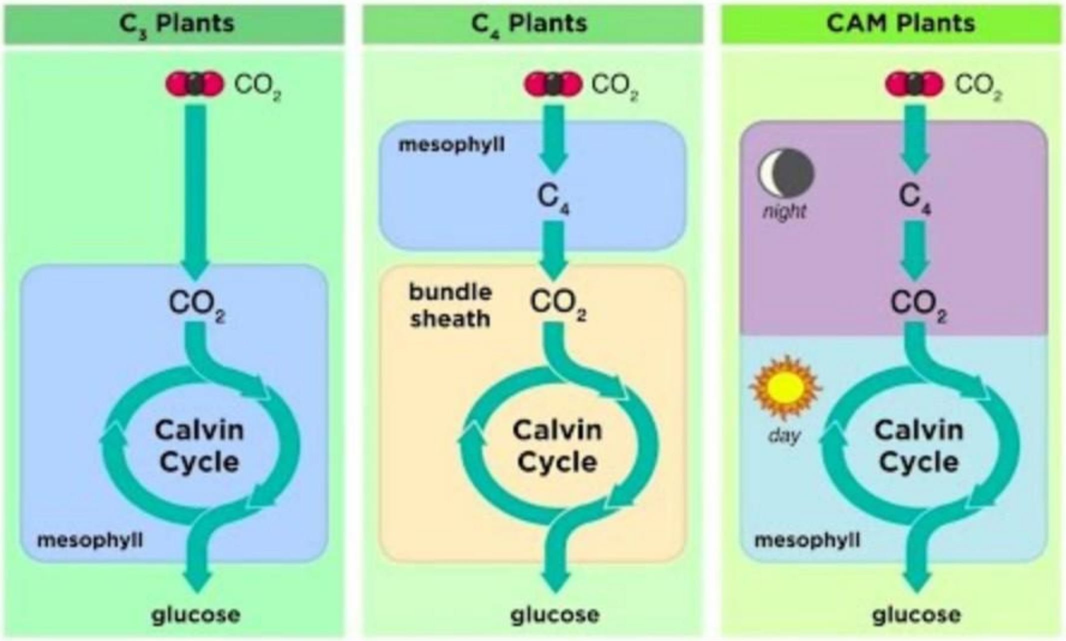
CAM (Crassulacean Acid Metabolism) plants are a specialised group adapted to extremely arid conditions. Highly water-efficient, they thrive in dry environments where other plants struggle, thanks to a unique photosynthetic pathway that minimises water loss while still capturing carbon dioxide (CO_2).

Examples: pineapple, agave



https://www.monash.edu/student-academic-success/biology/photosynthesis/photosynthesis-in-c3,-c4-and-cam-plants#Photosynthesis_in_CAM_plants_and_their_adaptations_for_photosynthesis

Physiology - Photosynthesis

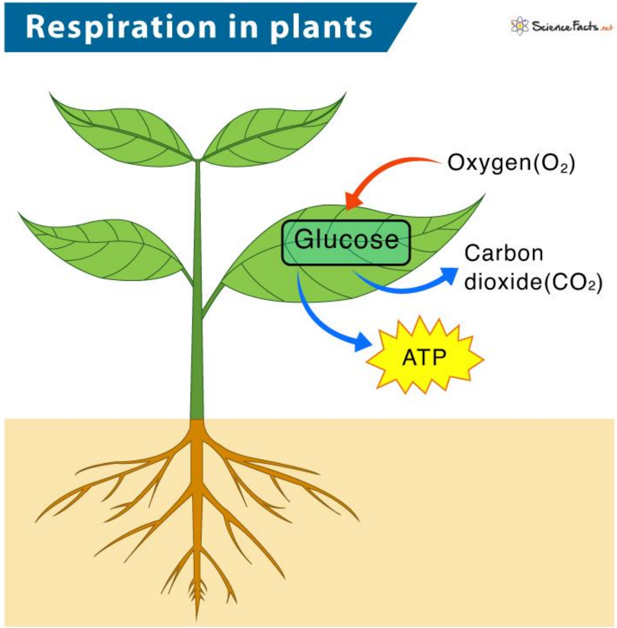


https://www.youtube.com/watch?v=8oodcy8SEBk

Physiology - Respiration

Once the plant has produced sugar, i.e. carbohydrates, it uses them up again during respiration. During respiration, sugar is 'burned' in the plant's tiny powerhouses, the mitochondria, to produce energy-rich molecules (adenosine triphosphate/ATP).

The plant needs this energy for growth, transport and flower formation, for example. Unlike photosynthesis, respiration does not require sunlight, so it takes place continuously (day and night).

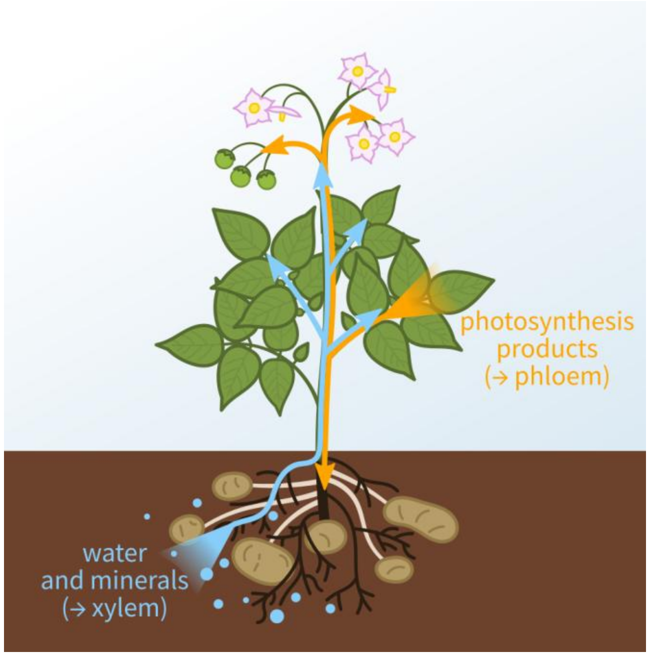


https://www.sciencefacts.net/respiration-in-plants.html

Physiology – Transport within the plant

Plants absorb water and nutrients through their roots and must transport these to every part of the plant. This transport takes place in conduits known as xylem. For water to rise upwards against the force of gravity at all, it is essential that water evaporates through the leaf pores (known as stomata). This creates a suction force that pulls the column of water upwards through the xylem.

However, the sugar produced during photosynthesis in the green parts of the plant must then be transported to all the plant’s cells so that energy can be generated in the mitochondria. Sugar is therefore transported from the source to the sink via the phloem.



https://de.wikipedia.org/wiki/Xylem

Physiology – Transport within the plant

Why is this knowledge relevant at all?
If we understand how phloem and xylem work, we can identify the symptoms of nutrient deficiency in plants. For example, magnesium deficiency can be recognised by the fact that the older leaves turn yellow first, particularly the interveinal areas (the space between the leaf veins). As a 'rescue mechanism', the plant transfers magnesium from old leaves to young leaves, actively drawing magnesium out of the leaves via the phloem. As magnesium is a key component of chlorophyll, a deficiency is directly linked to the colour of the leaves.

https://www.mein-schoener-garten.de/themen/magnesiumduenger

Physiology – Hormones

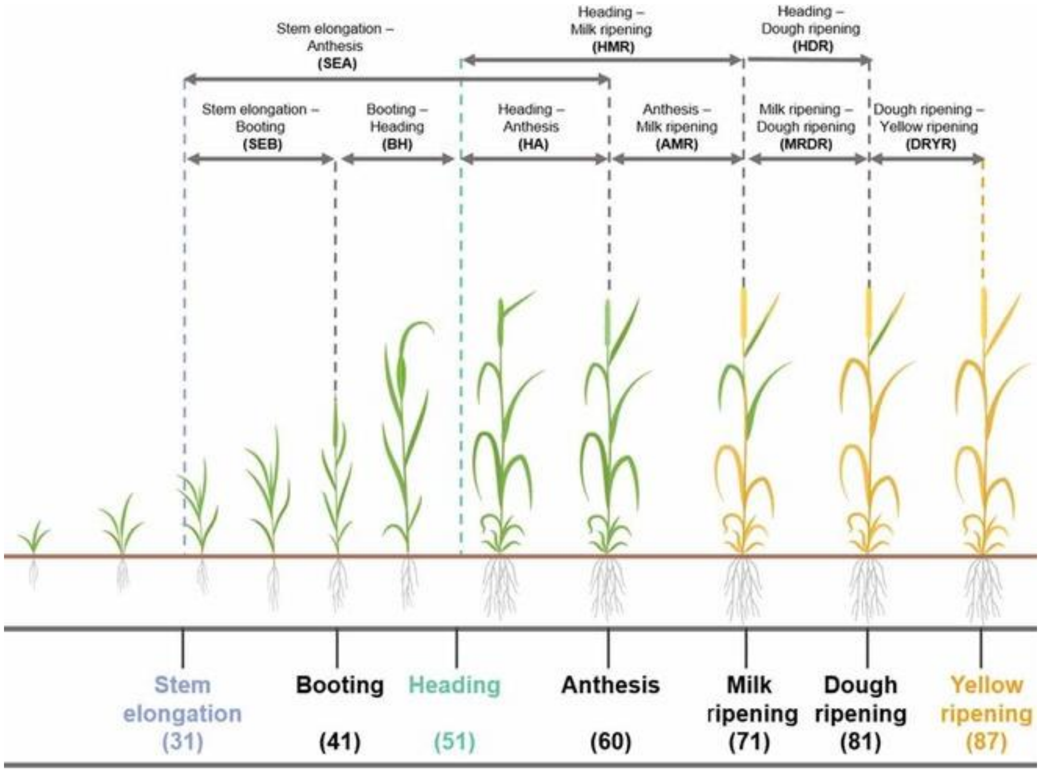
It is not only in humans that all processes are controlled by hormones. Hormones are also of great importance in plants. We will therefore outline some of the key hormones and their functions here.

- Auxins: Promote cell growth, particularly in shoot tips and young tissues.
- Cytokinins: Promote cell division, delay ageing, and regulate shoot and root growth
- Gibberellins: Promote cell division, delay ageing, regulate shoot and root growth
- Abscisic acid: Regulates water balance, inhibits growth, promotes seed dormancy
- Ethylene: Promotes fruit ripening, flower opening and leaf abscission (shedding); used to control fruit ripening and storage

Plant development and growth – Growth stages

Plant development can be described using growth stages. There is an international code for this, known as the BBCH code.

Info: The principal growth stages need not proceed in the strict sequence defined by the ascending order of the figures but can occasionally also proceed in parallel.



https://www.researchgate.net/figure/Overview-of-phenological-stages-with-BBCH-code-from-the-PHASE-model-stem-elongation_fig2_377860484

Plant development and growth – Growth stages

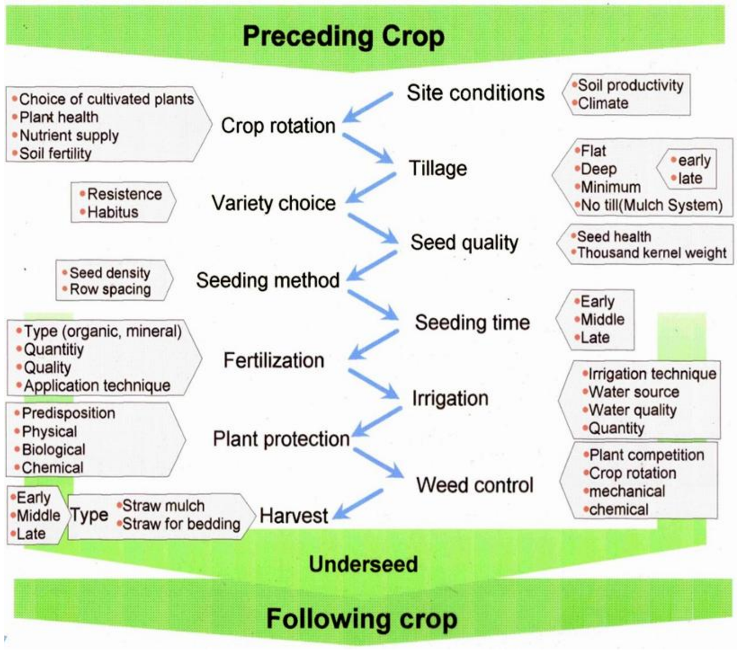
Principal growth stages	Stage Description
0	Germination / sprouting / bud development
1	Leaf development
2	Formation of side shoots, tillering
3	Stem elongation or rosette growth, shoot development
4	Development of harvestable vegetative plant parts, bolting
5	Inflorescence emergence, heading
6	Flowering
7	Development of fruit
8	Ripening or maturity of fruit and seed
9	Senescence, beginning of dormancy

Plant development and growth – Growth stages

https://www.youtube.com/watch?v=69R_k8ROUnM

Plant development and growth – Cultivation steps

This graphic provides an overview of the process and the decisions required in an agricultural production process. The following slides explain some of these steps in more detail.



Source: Hans-Peter Piorr

Plant development and growth – Cultivation steps

Our final section is the most practical and, as a result, probably the most interesting. Most agricultural crops are grown using the same system, although there are exceptions, such as perennial crops. The aim is to provide a general overview of crop production. Further details will be covered in the first semester in the Plant Production module.

1. Sowing/planting: Before sowing or planting, however, the best growing conditions for the plant must first be created through soil preparation and, in many cases, fertilisation.

https://amazone.de/de-de/produkte-digitale-loesungen/landtechnik/saetechnik/mechanische-saemaschinen/anbau-saemaschine-d9-79978

Plant development and growth – Cultivation steps

2. Fertilisation: The plant develops. To create optimal growing conditions, fertilisation usually takes place during the growing season. Determining the optimal time for fertilisation is often difficult but can now be managed effectively with the aid of sensors. Fertilisation can be carried out using either synthetic fertilisers or organic fertilisers (manure, slurry, compost).

Fertiliser spreader

https://rauch.de/duengerstreuer/scheibenstreuer/anbaustreuer/axis-m.html

Slurry tanker

https://zunhammer.de/category/produkte/

Plant development and growth – Cultivation steps

3. Plant protection: During the growing season, crops often face competition. Weeds, diseases or pests can weaken or destroy the crop. Mechanical, chemical and biological measures are available to combat these threats. Here too, sensors and digital solutions used in modern agriculture can be very helpful.

Chemical plant protection

https://www.kuhn.de/ackerbau/feldspritzen/gezogene-feldspritzen/metris-2

Mechanical plant protection

https://www.treffler.net/agrartechnik/produkte/striegel/

Plant development and growth – Cultivation steps

4. Harvesting and storage: At the time of harvest, the crop must have reached the optimum stage of ripeness. Storage should take place under optimum environmental conditions to ensure a long shelf life.

Combine harvester

https://www.claas.com/de-de/landmaschinen/maehdrescher/lexion-6000

Thank you very much for your interest!

Contact details

Prof. Dr. Thorsten Haase

thorsten.haase@hswt.de

Room D1.230

Please feel free to use the **Moodle course forum** if you have any questions!