

Living on dry land: controlling guard cell movement and stomatal aperture

Plants and Biotechnology
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Plants adapted to land. How?

- Plants: The only eukaryotic organism that can make its own food.

- Plants are non-motile.

Plants must sense, change and adapt to the changing environment.

Today, we will focus on one of the most important adaptations of land plants, guard cells & their functions

a) photosynthesis;

b) water uptake

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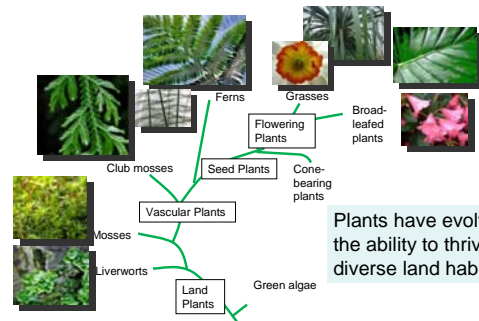
Outline

1. Land plants need to get CO₂ from the air to make its own food by photosynthesis
2. CO₂ enters plant via openings on leaf called "stomatal pores". Pore is surrounded by a pair of guard cells.
3. Plants need water for growth. Water is pulled up from roots to leaves in part due to water loss from pores.
4. Pore opens and closes in response to the environment.
 - a) in the day, pore opens
 - b) at dusk, pore closes
 - c) when atmospheric [CO₂] drops, pore opens
 - d) when there is drought, pore closes
5. What changes take place to cause opening or closure?
 - a) ions move in, followed by water. Turgor increase, guard cells swell
 - b) ions move out, followed by water. Turgor decrease.

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Plants are diverse



Plants have evolved the ability to thrive in diverse land habitats.

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Image courtesy: [iStockphoto.com](#)

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Guard cells first appeared in early land plants

We could not live without plants

- Plants produce most of the oxygen we breathe.

- Plants produce most of the chemically stored energy we consume as food and burn for fuel.

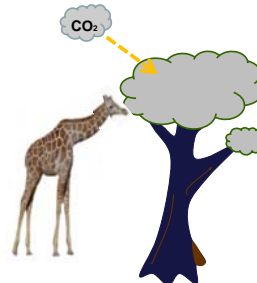
- Plants produce an amazing assortment of useful chemicals.



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Plants fix carbon dioxide into energy-rich molecules we animals can use as food

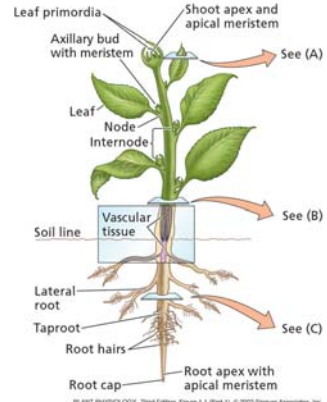


Plants convert CO₂ gas into sugars through the process of **photosynthesis**.

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Plants begin life when seeds germinate & produce seedlings

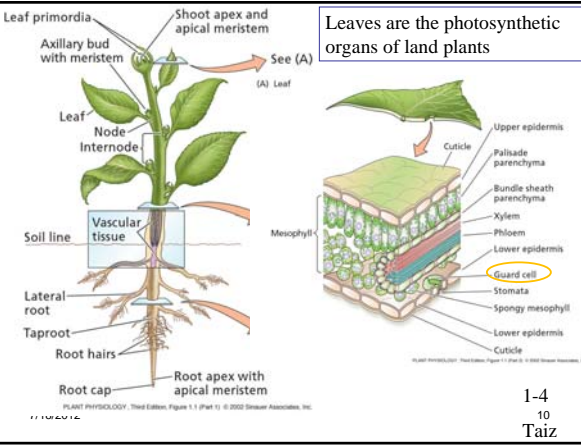
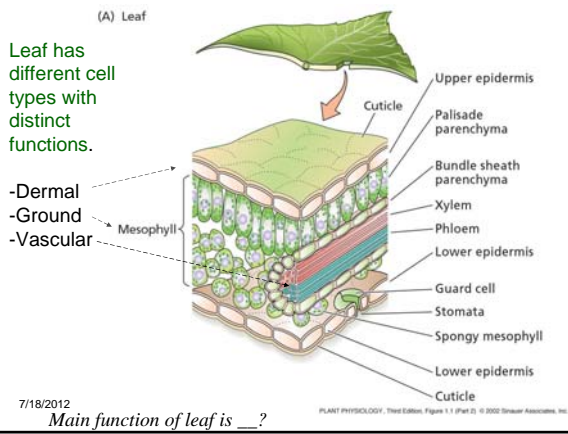


2. Development of the vegetative plant body.

Plants develop appropriate structures to carry out special functions.

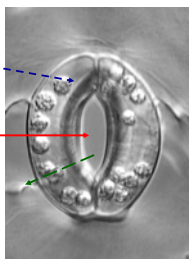
Vegetative plant body is made of 3 organs:

- leaf
- Stem
- root



All land plants have guard cells

- Guard cells are found on the epidermis of leaves.
- A pair of guard cells surround a slit that can open or close.
- CO₂ can diffuse inside the leaf through open pores.
- Water can escape out of the leaf through the open pores.
- It is critical that plants can control the opening and closing of the pores.
- Why? How?



B. Water Movement & Guard Cells

How do plants move water from roots to leaves?

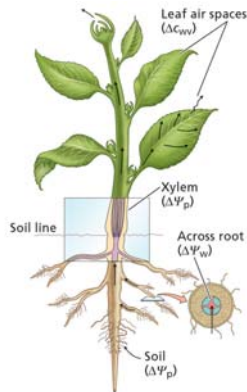
- What is the driving force for water transport from roots to the leaves?
- Pressure-driven bulk flow.
- Negative pressure is generated by water loss from the leaf pores (transpiration).

Guard cells also influence water uptake from root to leaf, & water loss from leaf

How? What is the driving force for water flow?

3 Main driving forces

- i. Root/soil (pressure gradient)
- ii. Across root (water potential)
- iii. Xylem (pressure potential)
- iv. Leaf/air (water vapor conc difference)



PLANT PHYSIOLOGY, Third Edition, Figure 4-1 © 2002 Sinauer Associates, Inc.

HOW DOES WATER MOVE ?

(into & within seed and seedling)

In which direction?

Water movement is **passive**, i.e. energetically downhill.
Water movement is down conc. gradient and pressure gradient

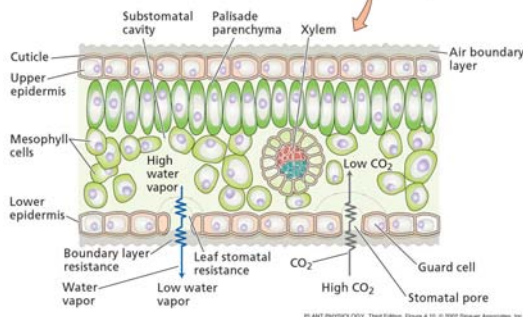
a. Three ways water move:

- 1) Diffusion- movement down a **conc. Gradient** [short distance]
- 2) Bulk Flow: movement down a **pressure gradient** [long distance]
- 3) Osmosis: movement across a **membrane** and down both **conc.** and **pressure gradient**

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4-10. Water vapor conc. difference causes water loss



PLANT PHYSIOLOGY, Third Edition, Figure 4-10 © 2002 Sinauer Associates, Inc.

Loss of water from the leaves produces negative potential in the leaf

What happens when soil becomes dry?

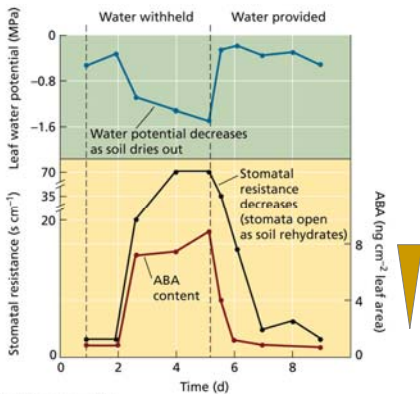
- How can plants reduce its water lose?
- How can plants reduce water uptake?
- Plants can sense drought stress.
- Plants respond by making a 'stress' hormone, ABA.
- ABA will induce changes to protect plant from drought stress.
Stomatal pore closes.

Let's see how?

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Figure 23.4 Changes in maize in response to water stress



PLANT PHYSIOLOGY, 5e, Figure 23.4

How do plants sense drought stress and then produce ABA?

Model:

1. Water stress is sensed first in the root
2. ABA is synthesized in root
3. ABA moves up via xylem to the leaf
4. ABA moves to guard cells in the leaf.

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Questions

- When do stomatal pores open?
- What controls stomatal pore opening?
What changes occur in guard cells?
- Think for a minute?

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Questions

- When do stomatal pores open?
• Ans: **in the day (light)**
- How do stomatal pores open?
What happens to guard cells?
Ans: **when guard cells increase in turgor. Ions enter cells, water follows, cells swell.**
- When do pores close?
Ans: **when it becomes night or when water is deficient.**

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18-8. Stomata. **Open and closed state**

What controls opening? Increase in turgor pressure

What controls closing? Decrease in turgor pressure

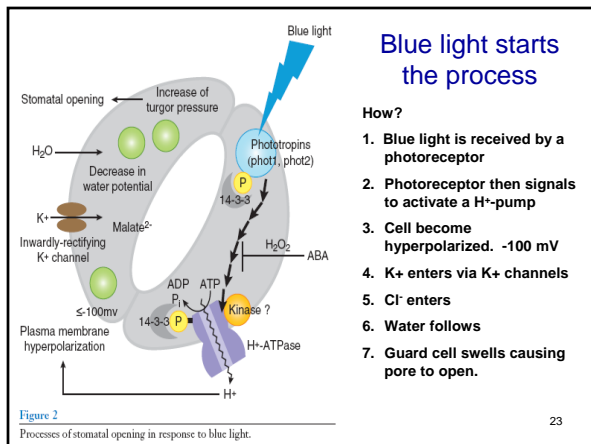
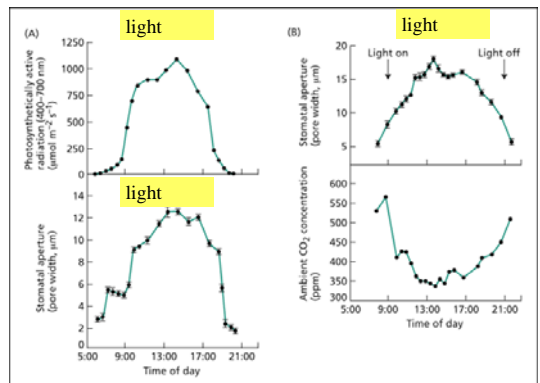


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A. **Photosynthesis & Guard cells**

Stomatal aperture is dependent on light



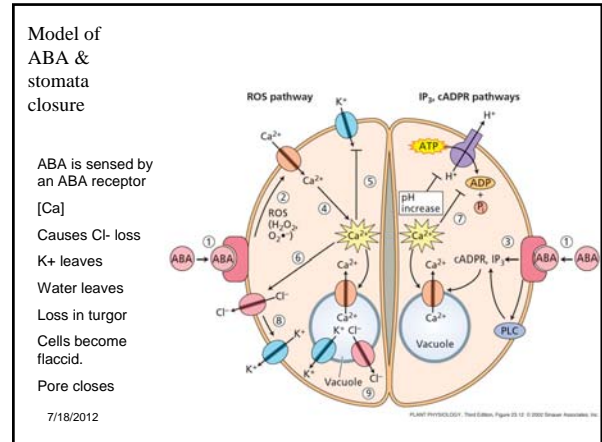
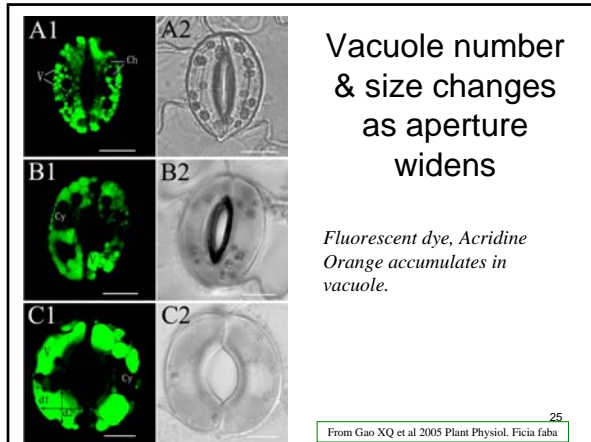
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At dusk or end of day, pore closes

- How?

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Recap- turn into questions

1. What molecules are needed by plants to make sugars and starch?
Ans. X, Y
2. What form of energy drives the process?
[what is X used for? What is Y used for?]
3. How does X enter the plant?
3. How does Y enter the plant?
4. Pores are formed by _____ (what cells) in _____ (what part(s)) of the plant.
5. What cues do plants sense, so pores open?
6. What signals do plants sense, so pores close?
7. What changes occur in the cells so pore opens?
8. How can you test these ideas?

Design an expt. #5, 6 and 7.

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What is the aim of your expt?

- How would you design the expt?
- What is the treatment (variable)?
- What is your negative control? Positive?
- How many samples are needed to get a reliable average reading?
- How long does it take for plants to respond to the signal?

Question & Discuss

- Is this true?
- How can I test this?
- 1. Does daylight really cause guard cell movement?
- 2. Is K⁺ and Cl⁻ the major ions to move in?
- 3. What would a stress hormone do to guard cells?

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Goals of Experiment

- Test **Light** vs **dark** on stomatal opening.
How would you test this?
- Test which ions are important
KCl, choline-Cl vs mannitol
How?
- What is the effect of ABA, the stress hormone?
How?

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