

Lecture 20:

Abiotic stresses

Drought stress

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What is stress?

- ... **an external condition that adversely affects growth, development, and/or productivity**
- **Stresses trigger a wide range of plant responses:**
 - altered gene expression
 - cellular metabolism
 - changes in growth rates and crop yields

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Types of Stress

- Biotic - **imposed by other organisms**
- Abiotic - **arising from an excess or deficit in the physical or chemical environment**
 - Biotic and abiotic stresses can reduce average plant productivity by 65% to 87%, depending on the crop

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Effect of drought on yield of corn and soybean

Yields of corn and soybean crops in the United States

Year	Crop yield (percentage of 10-year average)		
	Corn	Soybean	
1979	104	106	
1980	87	88	Severe drought
1981	104	100	
1982	108	104	
1983	77	87	Severe drought
1984	101	93	
1985	112	113	
1986	113	110	
1987	114	111	
1988	80	89	Severe drought

Source: U.S. Department of Agriculture 1989.

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Environmental conditions that can cause stress

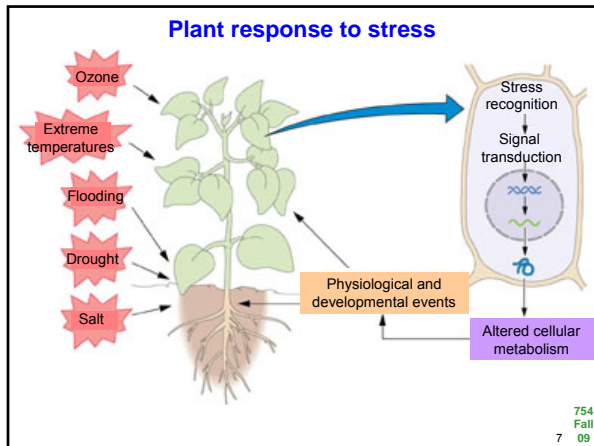
- Flooding
- Drought
- High or low temperatures
- Excessive soil salinity
- Inadequate minerals in the soil
- Too much or too little light
- Air pollutants (ozone, sulfur dioxide)

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Resistance or sensitivity of plants to stress depends on:

- The species
- The genotype
- Developmental age

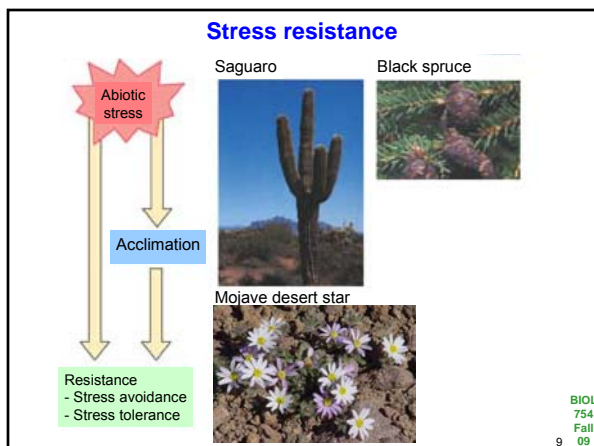
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Stress resistance mechanisms

- **Avoidance mechanisms**
 - prevent exposure to stress
 - Examples: drought avoidance traits such as low water-use efficiency and early reproduction in *Impatiens capensis* (jewelweed); avoidance of salt stress: achieved by excretion of crystalline salt from glands or hairs of leaves; *Acanthus ilicifolius* = sea holly)
- **Tolerance mechanisms**
 - permit the plant to withstand stress (osmotic adjustment)
- **Acclimation**
 - alter their physiology in response to stress
 - Example: Stress acclimation in *Arabidopsis* involves rapid stress-induced expression of the genes coding for the dehydration responsive element binding factor (DREB), a transcription activator

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Changes in gene expression to stress

- A stress response is initiated when plants recognize stress at the cellular level.
- Stress recognition activates **signal transduction pathways** that transmit information within the individual cell and throughout the plant.
- Changes in gene expression may modify growth and development and even influence reproductive capabilities.

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Regulation of plant stress responses

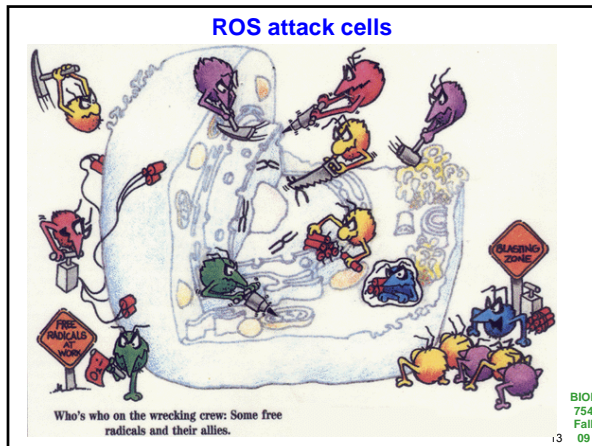
- Abscisic acid (ABA)
- Jasmonic acid
- Ethylene
- Calcium (secondary messenger)

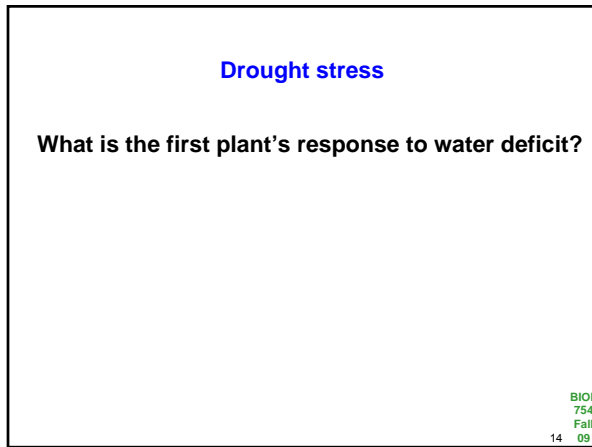
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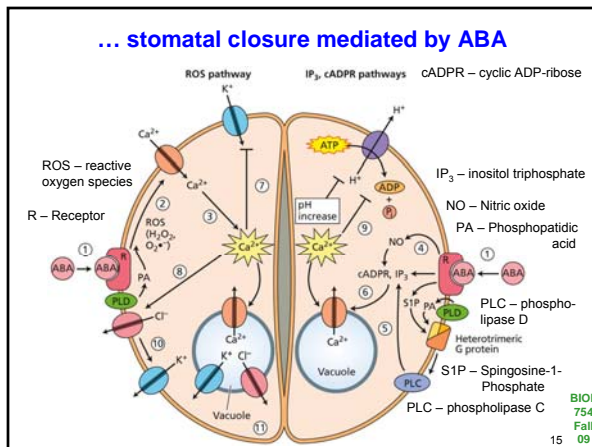
Exposure to environmental stress conditions causes the generation of reactive oxygen species (ROS) – Oxidative Stress

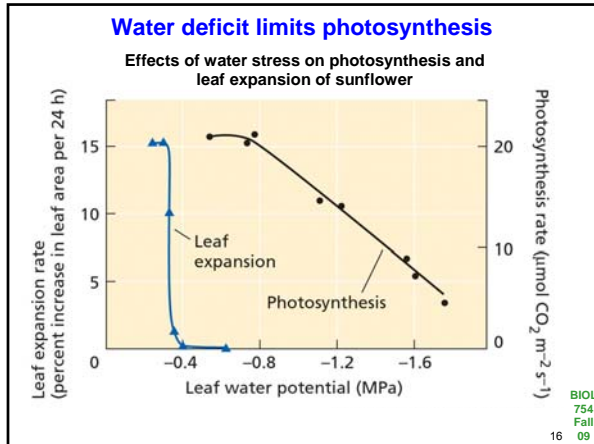
- Drought
- Extremes of temperature
- Salinity
- Air pollutants (ozone, sulfur dioxide)
- High light
- Herbicides (paraquat = methyl viologen)

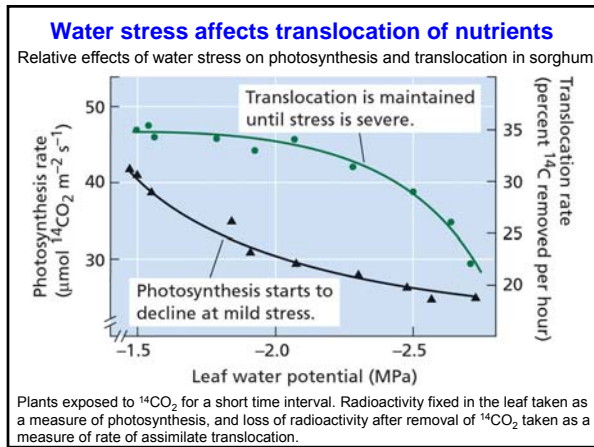
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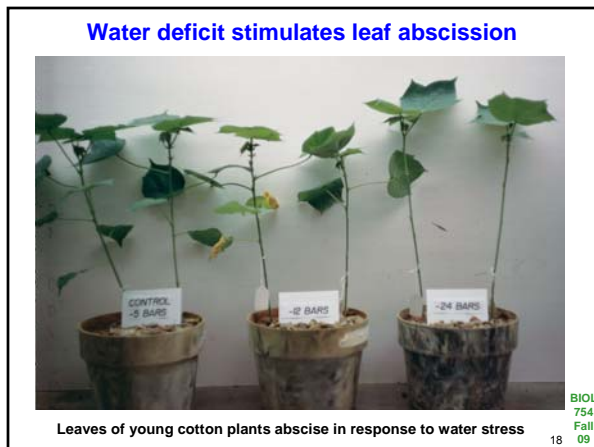


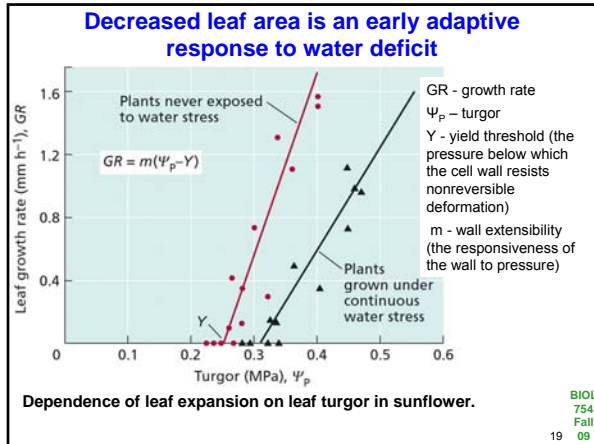


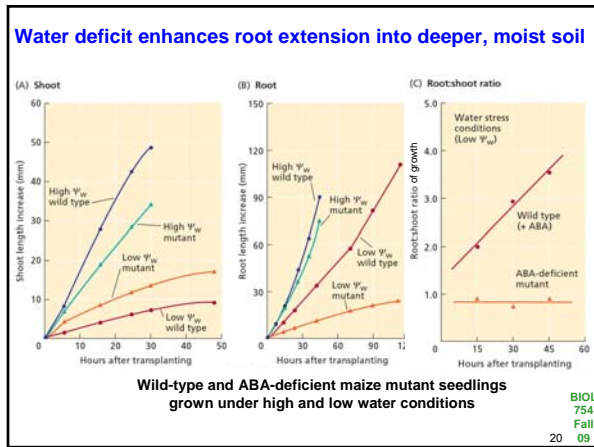


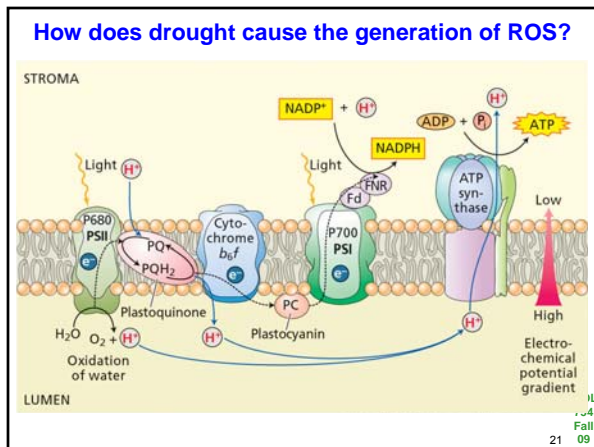




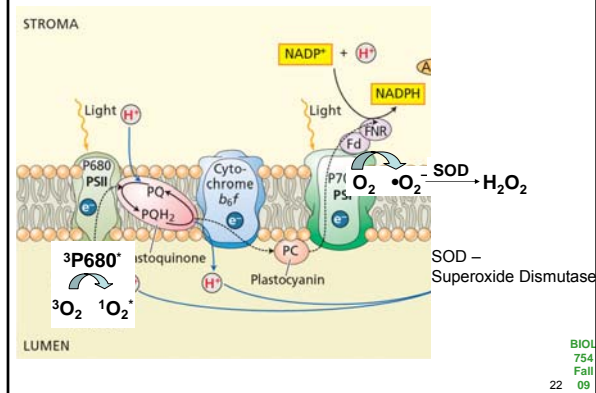




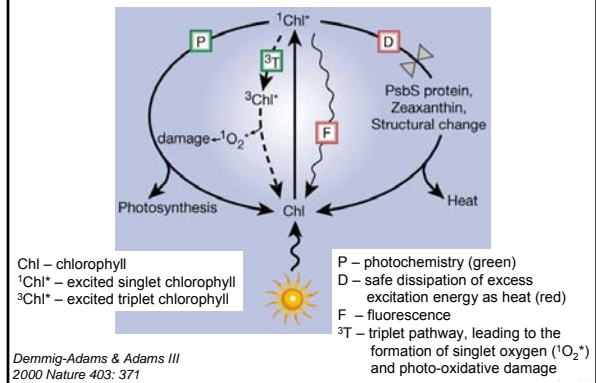




How does drought cause the generation of ROS?



Fates of sunlight absorbed in the light-harvesting chlorophyll complexes



ROS scavenging systems in plants

