Tree Biology

Photosynthesis:

- Light Energy
  - $\text{CO}_2 + \text{H}_2\text{O} \xrightarrow{\text{Photosynthesis}} \text{O}_2$
  - Energy Released
  - Stored Energy (sugars)
  - Respiration

- $\text{CO}_2 + \text{H}_2\text{O} \xrightarrow{\text{Respiration}} \text{O}_2$

Structure of a tree:

- Cambium (secondary meristem)
- Sapwood (xylem)
- Heartwood (xylem)
- Cuticle
- Upper epidermis
- Palisade layer
- Vascular tissue (leaf vein)
- Spongy layer
- Lower epidermis
- Guard cells
- Stomate
Tree biology includes ...

- **Structure = Anatomy**
- **Function = Physiology**
- (Above- and below-ground)
- **Processes**
  - Photosynthesis
  - Respiration
  - Transpiration
  - Hormones
  - Translocation
- **Compartmentalization** – CODIT
Tree biology includes …

- **Structure = Anatomy**
- **Function = Physiology**
- (Above- and below-ground)
- **Processes**
  - Photosynthesis
  - Respiration
  - Transpiration
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  - Translocation
- **Compartmentalization – CODIT**
Tree biology includes …

- **Structure** = Anatomy
- **Function** = Physiology
- (Above- and below-ground)
- **Processes**
  - Photosynthesis
  - Respiration
  - Transpiration
  - Hormones
  - Translocation

- **Compartmentalization** – CODIT
Tree biology includes …

- **Structure = Anatomy**
- **Function = Physiology**
- (Above- and below-ground)
- **Processes**
  - Photosynthesis
  - Respiration
  - Transpiration
  - Hormones
  - Translocation
- **Compartmentalization – CODIT**
- **Plant Growth Regulators (PGRs)**
And they’re all related.

- **Structure** = Anatomy
- **Function** = Physiology
- (Above- and below-ground)
- **Processes**
  - Photosynthesis
  - Respiration
  - Transpiration
  - Hormones
  - Translocation
- **Compartmentalization** – CODIT
Which topic do you need most?

• A. Anatomy  (slide #8)
• B. Physiology  (slide #109)
• C. Processes (Ps, Rs, Ts, translocation)
  – Photosynthesis  (#116)
  – Water movement in stem  (#80)
  – Water from leaves  (#110)
  – Tradeoffs  (#120)
• D. Compartmentalization (CODIT)  (#137)
• E. Plant Growth Regulators (PGRs)  (#150)
Anatomy
The stem ...
Bur oak
1 - Bark (outer bark)
Fargo – what’s the function of the bark?
1 - Bark (outer bark)
Protection (environment, insects, diseases, animals)
Bark – details … that you’ll never use
2 - Phloem - “inner bark”
2 - Phloem - “inner bark”
Bismarck – What does the phloem do?
2 - Phloem - “inner bark”
Transport sugar (energy) and plant growth regulators
Top to bottom
3 - Cambium
3 - Cambium
Dickinson – What does the cambium do?
3 - Cambium - cell division
Growth (diameter)
To the inside ➔ xylem
To the outside ➔ phloem
4 - Xylem - “wood”
More later …
Wood structure and function

- Xylem

What does it do?

- A - Water and nutrient transport
- B - Physical support of the crown
- C - Food storage over the winter
- D - Store waste chemicals
- E - All of the above
Wood structure and function

What does it do?

• Xylem

• A - Water and nutrient transport
• B - Physical support of the crown
• C - Food storage over the winter
• D - Store waste chemicals
• E - All of the above
Wood structure and function

- Xylem
  - Water and nutrient transport
  - Physical support of the crown
  - Food storage over the winter
  - Store waste chemicals
Diagram from Kozlowski and Pallardy, 1997

Diagram showing the flow of water and nutrients through a tree.
Bur oak

Heartwood

Sapwood
~9-11 years - Sapwood
Wood structure and function

- Xylem
- Water and nutrient transport
- Physical support of the crown
- Food storage over the winter
- Store waste chemicals
Bur oak

Heartwood

Storage of waste chemicals
Annual ring formation
Annual ring formation

• Cambium – cell division
Annual ring formation

• Earlywood
Earlywood (~Springwood)
Wood (cells) produced “early” in the growing season
Large diameter, thin cell walls
Cell formation

- Earlywood
- Latewood
Cell formation

- Earlywood
- Latewood

Latewood (~Summerwood)

Wood (cells) produced “late” in the growing season

Smaller diameter, thick cell walls
Eastern white pine

Annual ring

Earlywood

Latewood

Bark

Pith
Ponderosa pine

1972 much latewood
1973

1971

1974 little latewood

Pith

Bark
Bur oak

Earlywood

Latewood
Cell types
Cell types

- Vessels
- Tracheids
- Fibers
- Parenchyma
- (Rays)
Cell types

- Vessels
- Tracheids
- Fibers
- Parenchyma
- (Rays)

Vessels, tracheids and fibers – dead at maturity.
Cell types

- Vessels
- Tracheids
- Fibers
- Parenchyma
- (Rays)

Vessels, tracheids and fibers – dead at maturity.
Parenchyma cells – alive at maturity.
Cell types

- **Tracheids** - water
- Fibers - strength
- Parenchyma - storage
- (Rays – horizontal parenchyma + tracheids)
Eastern white pine
Annual ring
Mostly tracheids
(resin canal)
Eastern white pine
Annual ring

Mostly tracheids

(From MGI). – Which is the earlywood and which is the latewood?

(resin canal)
Eastern white pine
Annual ring

Mostly tracheids
Blue spruce

Mostly tracheids
Rocky Mountain juniper

Mostly tracheids
Cell types

- Vessels
- Tracheids - water
- Fibers - strength
- Parenchyma - storage
- (Rays – horizontal parenchyma + tracheids)
Cell types

- Vessels
- Tracheids - water
- Fibers - strength
- Parenchyma - storage
- **Rays** – horizontal parenchyma + tracheids

**Rays**
Winter storage of sugar/starch
Horizontal movement of sugar, water, nutrients
Eastern white pine

Annual ring

Mostly tracheids

Ray
Blue spruce

Mostly tracheids

Rays
Cell types

- Vessels - water
- Tracheids - water
- Fibers - strength
- Parenchyma - storage
- (Rays) -
Cell types

- **Vessels** - **water**
- Tracheids - water
- Fibers - strength
- Parenchyma - storage
- (Rays) -

**Vessels** - the most important water transport cells in deciduous trees.**
Cell types

- **Vessels** - **water**
- Tracheids - water
- Fibers - strength
- Parenchyma - storage
- (Rays)

Deciduous trees – classified by timing/location of vessels in the annual ring.
Ring-porous
Russian olive

Many large earlywood vessels
Ohio buckeye
Diffuse porous
Scattered vessels
Ohio buckeye
Diffuse porous
Where are the rings?
Ohio buckeye
Diffuse porous
Where are the rings?
<table>
<thead>
<tr>
<th>Ring porous</th>
<th>Semi-ring porous/Semi-diffuse porous</th>
<th>Diffuse porous</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oak</td>
<td>Cherry</td>
<td>Basswood</td>
</tr>
<tr>
<td>Elm</td>
<td>Walnut (?)</td>
<td>Birch</td>
</tr>
<tr>
<td>Ash</td>
<td></td>
<td>Buckeye</td>
</tr>
<tr>
<td>Russian-olive</td>
<td></td>
<td>Maple</td>
</tr>
<tr>
<td>Catalpa</td>
<td></td>
<td>Poplar</td>
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<tr>
<td>Chestnut</td>
<td></td>
<td>Willow</td>
</tr>
<tr>
<td>Mulberry</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hickory</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Black locust</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Cell types

- Vessels - **water**
- Tracheids - water
- Fibers - strength
- Parenchyma - storage
- (Rays) - (storage)

Rays – storage and horizontal movement
Rays – horizontal parenchyma + tracheids

Figure from: Kozlowski and Pallardy (1997)
3 – Rays – horizontal parenchyma + tracheids
**Siberian elm root**

Note large number of rays.

**Ray cells**

Storage and horizontal movement.

**Siberian elm root**

Note large number of rays.
Bur oak stem
Note large number of rays
Bur oak stem

Note large number of rays

Ray cells
Storage and horizontal movement
Bur oak stem
Note large number of rays

Ray cells
Storage and horizontal movement

Wayne B. – Do rays extend into the phloem?
Note: Rays extend into the phloem ➔ horizontal movement of water, sugar, etc.
Sugar maple stem
Note large number of rays
Why should I care? – I
How does water move up a tree?
Why should I care? – I
How does water move up a tree?

• Tracheids and vessels – **pipes**
Why should I care? – I
How does water move up a tree?

• Tracheids and vessels – *pipes*
• Not necessarily connected end-to-end
Figure from: Kozlowski and Pallardy (1997)

Pine tracheids
Red pine
Red pine

Figure from: Kozlowski and Pallardy (1997)
Why should I care? – I

How does water move up a tree?

• Tracheids and vessels – **pipes**
• Not necessarily connected end-to-end
Why should I care? – I
How does water move up a tree?

- Tracheids and vessels – **pipes**
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Situation – spruce with branches dying in a spiral pattern up the tree
Why should I care? – I

How does water move up a tree?

- Tracheids and vessels – **pipes**
- Not necessarily connected end-to-end

**Situation** – spruce with branches dying in a spiral pattern up the tree

**Diagnosis** – herbicide or other chemical taken in by major root on one side
Why should I care? – I
How does water move up a tree?

• Tracheids and vessels – pipes
• Not necessarily connected end-to-end
• Ring-porous hardwoods:
Why should I care? – I
How does water move up a tree?

• Tracheids and vessels – pipes
• Not necessarily connected end-to-end
• Ring-porous hardwoods:
  – Really long pipes
  – Very little side-to-side water transport
Question – How far apart are DED fungicide injections?
Question – How far apart are DED fungicide injections?
Question – How far apart are DED fungicide injections?

Is it necessary to have them that close?
Roots
Roots

- Fine roots
- Coarse roots
Roots

- Fine roots – Erik L. – function?
- Coarse roots
Fine Roots
Roots

• Fine roots

• Coarse roots – Candi A. – function?
Physiology
Water leaving stomates = Transpiration
Water leaving stomates = Transpiration

Why should I care?
Why should I care?
Water loss … ➔
How to prevent it?

Water leaving stomates = Transpiration
Why should I care?
Water loss … ➔
How to prevent it?
Antitranspirants…

Water leaving stomates = Transpiration
Why should I care?
Water loss … ➔
How to prevent it?
Antitranspirants…

Antitranspirant
Thin, waxy film sprayed on
Light Energy

$\text{CO}_2 + \text{H}_2\text{O} \rightarrow$ Photosynthesis

$\rightarrow \text{O}_2$

Energy Released

Stored Energy (sugars)

Respiration

$\text{CO}_2 + \text{H}_2\text{O} \rightarrow$
**What is energy used for within a tree?**

- **CO₂**
- **Energy Released**
- **Respiration**
- **CO₂ + H₂O**
- **O₂**
- **Stored Energy (sugars)**
**What is energy used for within a tree?**

➔ Physiological Tradeoffs
Physiological Tradeoffs
Physiological Tradeoffs

• Water vs. energy
Leaf Anatomy

Top

Bottom

Stomates – pores in the leaves
Leaf Anatomy

Stomates – pores in the leaves
Leaf Anatomy

Carbon dioxide – In ➔ Photosynthesis ➔ Growth
Leaf Anatomy

Top

Bottom

Carbon dioxide – In ➜ Photosynthesis ➜ Growth

Water – Out ➜ Water loss
Leaf Anatomy

Top

Carbon dioxide – In ➔ Photosynthesis ➔ Growth

Bottom

Water – Stays in tree ➔ Water conservation
Leaf Anatomy

Top

Bottom

Carbon dioxide – Stays out
➡️ No photosynthesis
➡️ No growth

Water – Stays in tree
➡️ Water conservation
➡️ No Growth
Leaf Anatomy

Top
Carbon dioxide – Stays out
➔ No photosynthesis
➔ No growth

Bottom
Water – Stays in tree
➔ Water conservation
➔ No Growth

Tradeoff
Physiological Tradeoffs

- Water vs. energy
- Energy vs. water/nutrients
Fine Roots
What’s this fine-root structure?
What’s this fine-root structure? Mycorrhizae
Mycorrhizae
Myco = fungus
Rhizo = root
Name this type of relationship. Who gets what benefit?

**Mycorrhizae**

Myco = fungus
Rhizo = root
Physiological Tradeoffs

- Water vs. energy
- Energy vs. water/nutrients
Physiological Tradeoffs

- Water vs. energy
- Energy vs. water/nutrients
- Growth vs. defense
What happens to buds and branches when a tree gets topped?
Compartmentalization (CODIT)
Compartimentalization (CODIT)

- CODIT – Compartimentalization Of Decay In Trees
Compartmentalization

“Walling off” wounds
Compartmentalization

• Wall 1 – plugged vessels above and below wound
Compartmentalization

- Wall 1 – plugged vessels above and below wound
- Wall 2 – chemicals deposited in latewood cells
Compartmentalization

• Wall 1 – plugged vessels above and below wound
• Wall 2 – chemicals deposited in latewood cells
• Wall 3 – formed along rays
Compartmentalization

- Wall 1 – plugged vessels above and below
- Wall 2 – chemicals deposited in latewood cells
- Wall 3 – formed along rays

Reaction zone
Compartimentalization

- Wall 1 – plugged vessels above and below
- Wall 2 – chemicals deposited in latewood cells
- Wall 3 – formed along rays
- Wall 4 – new wood formed in callus
Compartmentalization

- Wall 1 – plugged vessels above and below
- Wall 2 – chemicals deposited in latewood cells
- Wall 3 – formed along rays
- Wall 4 – new wood formed in callus

Barrier zone
Compartmentalization (CODIT)

• CODIT – Compartmentalization Of Decay In Trees

• “Walls” created around wounds
Compartimentalization (CODIT)

- CODIT – Compartimentalization Of Decay In Trees
- “Walls” created around wounds
- A race – decay fungi vs. tree
Hormones …

= Plant Growth Regulators (PGRs)

• Auxins (IAA, NAA)
• Cytokinins
• (Others)
Auxins (IAA, NAA)

- Produced:
- Moves to:
- Functions to:

- Shoot tips
- (Down … )
- Apical dominance
- Rooting compounds
Apical dominance lost when shoot tips removed.
Cytokinins

- Produced:
- Moves to:
- + Functions to:

- Roots
- Growing points
- + “Growth”
  - Cell division
  - Cell expansion
  - Cell differentiation