Title: Feel the Flow From Hair to Air
-or- Transport Systems in Plants

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Abstract: So you just stick a seed in the ground, give it some water and watch it grow, right?!? That was about all I knew about plants before teaching the AICE Level Biology, and now I have to make sure my students understand transport in plants! So this year I will be adding to my incredibly boring power point lesson that I simply created from the book and standards. I will be modifying Living Trees, from Project Learning Tree, the curricula presented by Dr. Martha Monroe and creating "Feel the Flow from Hair to Air" to help students understand transport in plants. In this manner, I will be able to incorporate more of the AICE Bio standards into this living lesson, make the lesson more 'real world experience', and in the end, both the students and I will appreciate Transport Systems in Plants a little better than we did in the beginning. We will be doing both a monocot and dicot plants to show the tissue distribution differences.

Rationale: My unit on Transport Systems in Plants is BORING!!!! I have even told the students to suffer through it with me, since I do not have a background in botany and really have not studied botany since about 10th grade. Therefore, we will just sort of figure it out, make it comprehensible and then they can memorize it for the test.

Well that just changed for next year. I will keep my boring notes, but now I have a much better idea of how to make them 'come alive'. I am a very active and kinesthetic learner and teacher. If I make up dances and songs, I have an easier time remembering things. A few examples that I tell the students:

- The word enzymes sound like scissors. Remember that enzymes cut things up.
- Anna builds and the cat knocks down for anabolic and catabolic.
- PST I'm a PhD is for primary →secondary→tertiary structures of a protein are held together by peptide→ hydrogen→ disulfide bonds
- And then of course we do an alpha and beta glucose dance
- And stand up like an antibody

I am now so excited to add a living tree! Although in actuality it will be a dicotyledonous plant. My students have come to expect the unexpected from me and this is what they will get. At this writing, I am thinking of breaking it up into 3 different parts, the roots, stem and leaf. I would like this to be student driven group work and I am thinking of one poster, one clay and one living, standing model. This should hit different learning styles and have enough repetition so that the knowledge and comprehension should come very easy. Brain Rules tell us: Remember to Repeat and Repeat to Remember as essential rules for learning and gaining comprehension.

Teaching Unit: I plan on incorporating the KWL method to help gauge learning outcomes. For each chapter or unit I will be teaching this fall, I will ask the students to first use about 5 minutes to write down everything they **know (K)** about the upcoming unit. If they need a prompt for recall, they may ask a friend, but this should not take an incredible amount of time. I am also going to ask them to write down all of the pertinent learning outcomes provided by the AICE Syllabus for that unit. After that they will have to put an ** by the standards they are not confident in, this is the **W (**or what they want to learn). Since this will be written in the Hayden McNeil Scientific notebook (my Action Research Proposal from Bench to Bedside 2011), the students will hand in the carbon copy to me that class period. This twist on nominal groups, presented by Dr. Irani, will give me an incredible amount of qualitative data in a snap shot. It will help to lead my discussions, to ask certain students about comprehension, and not to go over a subject too lightly if some of them do not get it. This will help take a lot of assumptions out of my teaching.

So after I have their notes from the Transport in Plants unit, I will give a quick overview of where my power points will be going, what to look for in the chapters and then present them with their hook; ~~a~~ healthy and ~~a~~ desiccated plants, ~~dicotyledonous plant~~, ones obtained from the local nursery and allowed to grow during the school year. They will know why one is wilting, lack of water, but now they will have to piece it together. So along with my power point notes, they will have a group project. The living dicotyledonous and monocot!

Comment [DJ1]: What kind of plant? Bean?

The three parts of learning will be:

1. From the soil into the root into the stem
2. From the stem into the leaf and into the air
3. From the air into photosynthates sources into sinks

The three parts of the project will be:

1. A fully detailed drawing on a poster
2. A fully detailed 3-D clay model
3. A living plant created with their own selves as they explain their parts

I will ~~most likely~~ have ~~24~~ 35 students in 2 separate classes, so if I create teams of 4-5 students, this will guarantee participation by all group members. Since these are overachieving students, they will want to make things perfect, but I am going to put them under a very tight guideline as far as amount of time allowed. They need to be able to learn to do things on the fly, go with their gut, and not be afraid of their own brainstorms. Each team will be assigned a different project for the different parts of learning so there should be little overlap. The overlap that there is will simply contribute to better rehearsal of the information (Brain Rules). I will give them one class period and then a few days beyond that. All teams will present and with two different classes, we should have a good array of posters and clay dioramas. I can video their live presentations for posterity.

What we would call standards, AICE calls Learning Outcomes. So according the 2013 syllabus Learning Outcomes, candidates should be able to:

1. Explain the need for transport systems in multi-cellular plants and animals in terms of size and surface area to volume ratios.
2. Define the term transpiration and explain that it is an inevitable consequence of gas exchange in plants.
3. (PA) Describe the distribution of xylem and phloem tissue in roots, stems and leaves of dicotyledonous plants.
4. (PA) Describe the structure of xylem vessel elements, sieve tube elements and companion cells and be able to recognize these using the light microscope.
5. Relate the structure of xylem vessel elements, sieve tube elements and companion cells to their functions.
6. Explain the movement of water between plant cells, and between them and their environment, in terms of water potential (no calculations involving water potential will be set).
7. Describe the pathways and explain the mechanisms by which water is transported from soil to xylem and from roots to leaves.
8. Explain translocation as an energy requiring process transporting assimilates, especially sucrose between the leaves (sources) and other parts of the plant (sinks).
9. Explain the translocation of sucrose using the mass flow hypothesis.

This project really should cover a great deal of the learning outcomes, just a few of them will not be covered by this project. I am expecting a great deal of qualitative and quantitative growth in learning from this project. After their projects are finished, I am then going to ask them to complete their KWL with the **L** (what did you **Learn** from this experience) and hand in the carbon copy. I should be able to do a very easy visual judgment of growth and learning gains.

Data Collection: Aside from the KWL notes for qualitative measurement, I will give them a unit exam that will be very similar to what they will be expecting when they take the AICE exams in the spring. It will be comprised on multiple choice and short answer. However, I would also like to include an attitude judgment question using Likert scales. At the beginning of their test they will see the question, "On a scale of 1-5, how prepared are you for this test?" The last question will read, "On a scale of 1-5, how confident are you in your answers?" This will give me 2 sets of data from these questions, not only a class feel for preparation and confidence, but I can also look for growth or decline in individual confidence levels. So I will have qualitative or formative assessments, quantitative test data as a summative assessment, and an attitude assessment.

UF/ICORE Connections: ~~For this particular lesson, I will not need any of the equipment lockers directly. However, when I do order the lockers, I will be able to reference this project for greater comprehension of the labs. We will be doing the tomato wilt virus immunostrip assays, the TSWMV PCR. We can discuss where this virus is affecting the plant in a more coherent discussion. We will also be checking out the equipment locker for detecting water borne pathogen through colorimetric methods. This can lead to a discussion on how some plants are used for bioremediation of certain areas.~~

Comment [DJ2]: This feels very tangentially connected to your main lesson…I think you could do learning through disorder just the same for transport in plants as you're doing in some of your other units – how different plant diseases/pathogens impact this system. You could also bring in the info on how E. coli/salmonella get into plants via the stomata, etc. I just don't want the pathogens component to get lost in the rest of your lessons

Comment [DJ3]: Most bioremediation is with hyperaccumulation of toxic metals in the environment. Are you also thinking of wastewater used for irrigation? Or, like in wetlands, where the plants help to filter the water?

For this lesson, modifications to Project Learning Tree Activity 63 The Tree Factory will be integrated into the curriculum. Extensions to this activity will be a lab testing different plants for the Tomato Spotted Wilt Virus. The students will be using the Agdia TSWV immunostrips to test for the presence of the virus in different parts of an infected plant. This will allow for a discussion on how the virus may be present in some parts of the plant tissue, but not others.

~~For my classroom visit to UF, I am strongly considering doing the Proteomics Module Protein Extraction, Separation and Identification Lab. This complex lab will be an amazing opportunity for us to put together many parts of the curriculum and also show the students how many departments work together for the purpose of inquiry. By the point at which we travel to UF, they will have done DNA extraction, gel electrophoresis, pGlo and a few other pertinent labs. Throughout all these labs, they should be able to reference their original work with the living dicotyledonous plant.~~

New Pedagogy for this Action Proposal: In order for me to keep seeing an increase in the AICE scores and pass rate for biology, I am going to change the way I teach this year. This proposal has given me a very good idea that I can also use for my Profession Growth Plan for my district. In accordance to the BEST practices for our county, I need to have outlined both formative and summative assessments. This implementation of the KWL for each chapter will be a perfect opportunity for me to gauge both assessments for each student for each chapter. I probably would not have thought about this if it were not for the simple posters we made at ICORE, the cognitive learning styles presented and the last nominal group activity we did. Although I have engaged in numerous kinesthetic learning activities, I do not think I would have ever come up with "From Hair to Air" if it were not for Project Learning Tree.

I am also going to propose to my students the following grading opportunities. This was actually presented to me in discussion with Dr. Koaroly regarding the students in Medical School. For the projects, they will get a simply pass/fail. I am teaching an extended day of 6 AICE level courses next year and a pass/fail will take the onus off of my grading practices and the students will not have to worry about perfect work, as much as solid work. To the trash goes the rubric for group projects!

Literature Cited:

- Project Learning Tree, American Forest Foundation. www.plt.org
  - Activity 63
- Brain Rules by Dr. Medina. www.brainrules.com

Budget Justification:

- ~~www.adgia.com 50 pGLO Bacterial Transformation Kit from Biorad $111.25~~
- ~~pGLO Transformation Reagent Refill Kit $ 67.50~~
- ~~miscellaneous lab supplies to support 2 full classes tbd~~

~~$ 200.00~~

Comment [DJ4]: With plants, just like we did in ICORE, or with animal tissue?

Comment [DJ5]: Are there any other activities in the Forest Health curriculum that you can adapt for your class and your lesson goals? Those will have a much more direct link to pathogens

Comment [DJ6]: How are these at all related to your action proposal? If you're doing TSWV immunostrips, and the water-borne pathogens, as well as the proteomics lab, those need to be listed in your budget. We will likely only be able to provide the materials for the proteomics lab, and you will need to provide the materials for the immunostrip and water-borne pathogens through your mini-grant

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- TWSV immunostrips #ISK 3930010025 2x $105

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Lesson Plan

Title: Feel the Flow from Hair to Air –or- Transport Systems in Dicotyledonous Plants

Key Question: Why do some plants appear healthy and others shrivel up and die?

Science Subject: AICE Biology

Grade and Ability Level: College Level Advanced 11th and 12th grade

Science Concepts: Structure and function of xylem and phloem in multi-cellular plants for transporting water, photosynthates and ions.

Learning Styles:

- visual: posters, 3-D clay and role play
- kinesthetic: creative hands-on application and manipulation of materials
- Brain Rules: remember to repeat and repeat to remember

Vocabulary:

- Xylem: water conducting tissue of a plant consisting of Tracheids and vessels
- Phloem: photosynthate conducting tissue of a plant consisting of sieve tube elements.
- Source: origination of photosynthates
- Sinks: final destination of photosynthates such as a flower or fruit
- Photosynthates: molecules created in plants, most likely sugars that are the products of sun (photons) and carbon dioxide.
- Dicotyledonous plant: a flowering plant with two cotyledons in the seed

Lesson Summary: This lesson will help the students understand how the structural form of a plant is related to the function of its vessels. How waters and sugars are absorbed and transported in a multi-cellular plant.

Student Learning Objectives with Standards: The following learning objectives are determined by the University of Cambridge AICE curriculum. At the end of this lesson, candidates should be able to:

1. Explain the need for transport systems in multi-cellular plants and animals in terms of size and surface area to volume ratios.
2. Define the term transpiration and explain that it is an inevitable consequence of gas exchange in plants.
3. (PA) Describe the distribution of xylem and phloem tissue in roots, stems and leaves of dicotyledonous plants.
4. (PA) Describe the structure of xylem vessel elements, sieve tube elements and companion cells and be able to recognize these using the light microscope.
5. Relate the structure of xylem vessel elements, sieve tube elements and companion cells to their functions.
6. Explain the movement of water between plant cells, and between them and their environment, in terms of water potential (no calculations involving water potential will be set).
7. Describe the pathways and explain the mechanisms by which water is transported from soil to xylem and from roots to leaves.
8. Explain translocation as an energy requiring process transporting assimilates, especially sucrose between the leaves (sources) and other parts of the plant (sinks).
9. Explain the translocation of sucrose using the mass flow hypothesis.

Learning objectives will be assessed with qualitative data for a formative assessment using KWL sheets. Quantitative data will be collected with a summative assessment in which a multiple choice and short answer question test will be administered.

Materials: Class should be divided into groups of 4-5 students. Each group will be responsible for the following:

The three parts of learning will be:

1. From the soil into the root into the stem
2. From the stem into the leaf and into the air
3. From the air into photosynthates sources into sinks

The three parts of the project will be:

1. A fully detailed drawing on a poster
2. A fully detailed 3-D clay model
3. A living plant created with their own selves as they explain their parts

Therefore each group will be busy! All the students in each group should be involved in all three parts of the project. Each group should be different in matching the learning to the ~~project,~~project; however, each group needs to complete all three parts in three different ways.

- Essential materials would include:
    - Laminated paper with all the parts of a system within a plant
    - Poster paper with markers

    - Clay and pins and tags for properly marking a key explaining each part.
- Supplemental:
    - Video equipment for taping the living role play part.

Background Information:

In the world of biological sciences, it is essential that a student understands the roles that different plants play in our ecosystem. This field is called Botany, and it covers every thing from agriculture, which is growing many different types of plants for human uses, agronomy, which is more plants used for crops and feeding people or growing some type of consumables all the way to fields of wild flowers and forests of trees.
Plants make up an entire different kingdom than animals and one of the defining components is the composition of its vascular tissue. Trees are made mostly of living, functioning cells, but there is no nervous system, and no heart to pump the materials through out the organism. So instead, a plant has to depend on **xylem**, a tissue that mostly moves water up from the soil into all the different parts of a plant, and **phloem**, a tissue that moves mostly sugars and other **photosynthates** from **sources** to **sinks.**

A source in a plant refers to the place where the combination of light from the sun, triggers a reaction between water and carbon dioxide from the air to create a sugar. The chemical formula is: $6H_2O + 6CO_2 \leftarrow \rightarrow C_6H_{12}O_6 + 6O$. From a source, the sugars will be loaded into the phloem by companion cells and transported in the plant to the sink. The sink may be a flower, fruit or other fleshy part of the plant

The structure of the xylem differs greatly from the structure of the phloem. Xylem is created from dead lignified cells, where as phloem is created from living cells that lie next to companion cells. The companion cells help load the sugars into the phloem since sometimes it is against a concentration gradient.

When there is a break in the xylem or phloem, a **dicotyledonous** plant will die. The water potential gradient has been broken the cohesive and adhesive properties of water will not be enough to keep the flow through broken tissue. A plant that is not properly watered will lose its turgidity and eventually wilt, then dry up and die. The pathway of water through the plant is a continuous process and it is essential that all biology students understand the basic concept of how water and photosynthates move through a plant organism.

Advanced Preparation: The teacher will need the chapter power points for this chapter to help with pacing of the material. Also needed is a clear set of instructions:

- Students are broken into groups of 4-5
- Each student group will create one poster, one 3-D clay model and one living tissue of the dicotyledonous plant
- Each student group will create all three parts of the plant, the roots to stem, the stem to leaf and the sinks to a source.
- Each group will have the same three projects, but in a different media

- The students will need to see the Project Living Tree Activity 63 in order to get a visual on what a Living Tree looks like so that they may modify it to fit the dicot.
- A beautiful dicotyledonous plant would be a beautiful asset for the room.

Procedure and Discussion Questions with Time Estimates:

1. The students are familiar with a note taking system called KWL. Have the students write in their notebooks everything they remember about the transport system in plants. Give them the words xylem and phloem to trigger their memory. This is in their K column. 5 minutes.
2. In the next section of their notes, they are to copy the standards out of the text book that relate to transport in multi-cellular plants. When they have copied the standards, or learning outcomes, they are to put a star by the standards they have the least amount of knowledge on. They should star the standards they want to know about. 20 minutes. Have the students turn in their carbon copy of these notes.
3. Present the power point notes on the chapter. Give the students time to take notes and ask questions. 3 days.
4. The group project will actually be introduced on day 2 of the power point notes. Introduce it as follows:
    a. Students will choose their own groups to work in, from 4-5 students.
    b. Each group is to create all three sections of the plant and represent each section in a different way. They will include the xylem, phloem, sources and sinks and all the other tissues and spaces that surround the vascular bundles. No two groups will have the same sections represented the same way.
    c. The three sections and presentation media are:
        i. From the soil into the root into the stem
        ii. From the stem into the leaf and into the air
        iii. From the air into photosynthates sources into sinks
    d. The three parts of the project will be:
        i. A fully detailed drawing on a poster
        ii. A fully detailed 3-D clay model
        iii. A living plant created with their own selves as they explain their parts
5. Grading will be completely on a pass/fail for credit or no credit.
    a. Pass/fail for turning in their KW notes
    b. Pass/fail for completing all three parts of the plant in three different mediums. Make a judgment call if all the parts are there, if not send it back to the students to make corrections and get full credit.

The students will need about 4-5 days to finish. After day two of lecture notes, give them the entire day three to work in there groups. Tell them no need to be perfect and pretty, just complete and accurate.

After the lecture notes are finished, the students should present their projects to the class. This should only take one class period. Remind them there will be a test the next day.

One the last day of the unit, give the paper test.

Total time for unit: 5-7 days, depending on students pacing.