Concept Maps to Address Misconceptions in Introductory Science Courses

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Teaching and Learning Science Concepts and Addressing Misconceptions

- Why it matters
- Which concepts
- How to address
- Improve teaching

Why

- Previous research demonstrates that one of the issues with embedded misconceptions is that students struggle with comprehension of the **relationship between abstract topics**, such as photosynthesis and respiration or pollination and double fertilization in plants.
- Concept maps have the potential to provide **scaffolding** that can address and remediate mistaken understandings.
- As teaching tools, concept maps illustrate the **relationship between concepts and vocabulary**.

Concept Maps as Learning and Assessment Tools

- Developed by Novak and Gowin (1984)
- Illustrations of the relationship between concepts can:
  - Demonstrate higher level of understanding of conceptual knowledge
  - Develop learning skills
  - Detect common misconceptions retained by students

Detecting and Addressing Misconceptions

- First detected misconceptions via previous survey (Orvis and Espinoza, 2014)
  - Used misconceptions and student responses to create assessment and study tool (assessment)
  - Also further uncovered misconceptions
    - More specific to material taught in course

Students lack understanding of **photosynthesis and respiration as two interconnected processes-**

- lack of knowledge about how photosynthesis and cellular respiration are connected;
- difficulties contextualizing photosynthesis and respiration at a biochemical level
- difficulties relating oxygen and carbon dioxide gas exchange to photosynthesis and cellular respiration;
- lack of knowledge about plants being producers of their own food (Brown & Schwartz, 2009)

Misconceptions Detected – Related to Photosynthesis and Respiration as Taught in HORT 101

- Photosynthesis gives energy
- Plants use CO_2 during respiration
- Respiration reaction is opposite to photosynthesis
- Respiration happens in the dark and photosynthesis in the light

(Orvis and Espinoza, 2014)

Implications from prior work:

- More frequent assessments help students keep up on reviewing materials and repeated exposure improves learning
- Visuals as part of activities and assessments are important
- Concept maps are a useful tool for this large science course:
  - content delivery combined with a semi-structured concept map assessment/activity to improve instruction
- Simplification of topics by instructors leads to mistakes and misconceptions – use caution

PURDUE
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Key

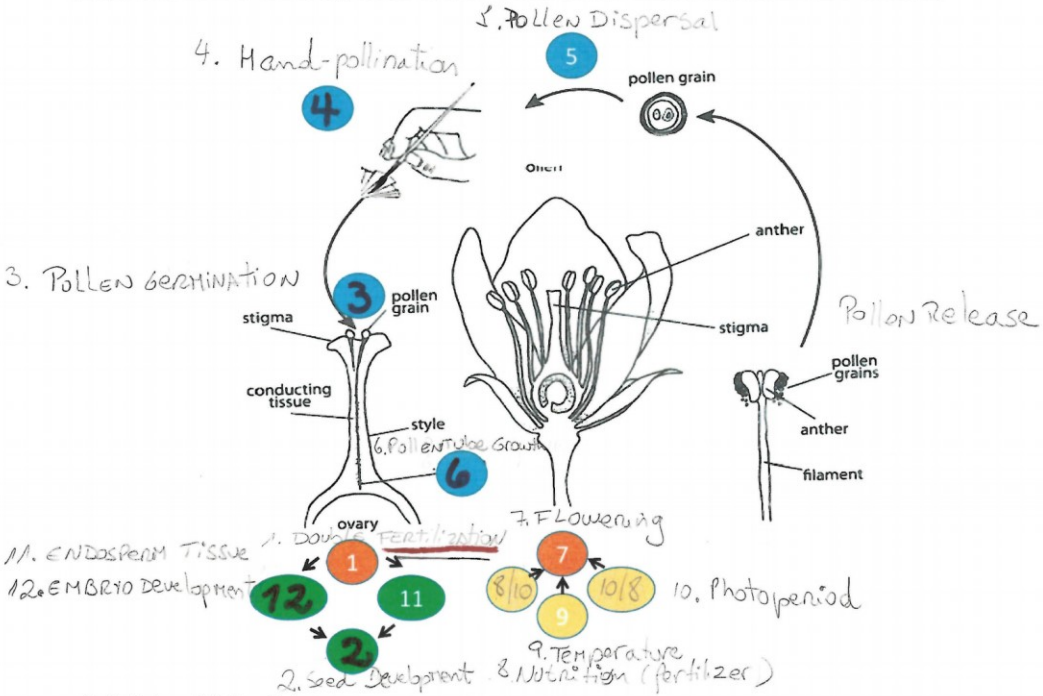
Class: Hort 10100 Fall 2016 Tuesday, September 27, 2016
Instructor: Dr. Kathryn Orvis
Graduate Researcher: Cecilia Espinoza

Lecture Activity (5): Flowering, Pollination and Seed Development

In this sheet, you can see a concept map (diagram) that represents the process of pollination which occurs after flowering and helps the seeds develop. In this activity you are asked to relate the concept of: (1) flowering to temperature, photoperiod and fertilization; (2) pollination to pollen dispersal, hand-on pollination and pollen germination; (3) seed development to double fertilization, embryo development and endosperm tissue.

Localize these concepts (**numbers**) in the diagram

1. Double fertilization	2. Seed development	3. Pollen germination	4. Hand-pollination
5. Pollen dispersal	6. Pollen tube growth	7. Flowering	8. Nutrition (fertilizer)
9. Temperature	10. Photoperiod	11. Endosperm tissue	12. Embryo development



Cecilia Espinoza & Kathryn Orvis
(Fall 2016) Adapted from: Willmer, P. (2011). *Pollination and floral ecology*. Princeton University Press.

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Class: Hort 10100 Fall 2016
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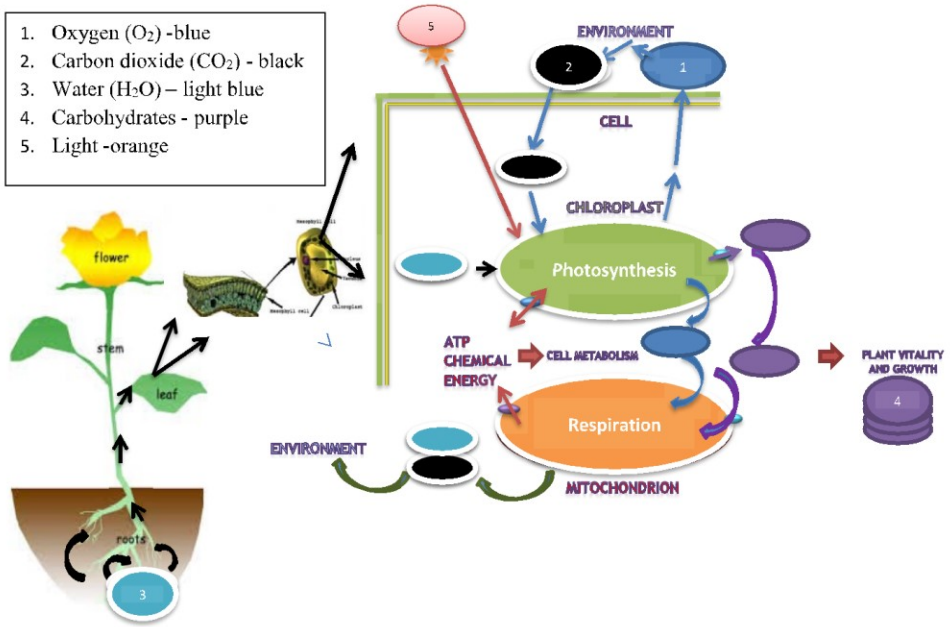
Graduate Researcher: Cecilia Espinoza ANSWER KEY

Lecture Activity:
Interpretation of a Concept Map: Photosynthesis and Respiration in a Plant Cell

In this sheet, you can see a concept map (diagram) that represents photosynthesis and respiration. Concepts maps are tools to interconnect concepts. In this activity you are asked to relate the concept of photosynthesis to oxygen (O_2), carbon dioxide (CO_2), water (H_2O), carbohydrates, and light to the processes of photosynthesis and respiration in plants. Please, complete the following diagram with the molecules in the box below. Each color means a different molecule.

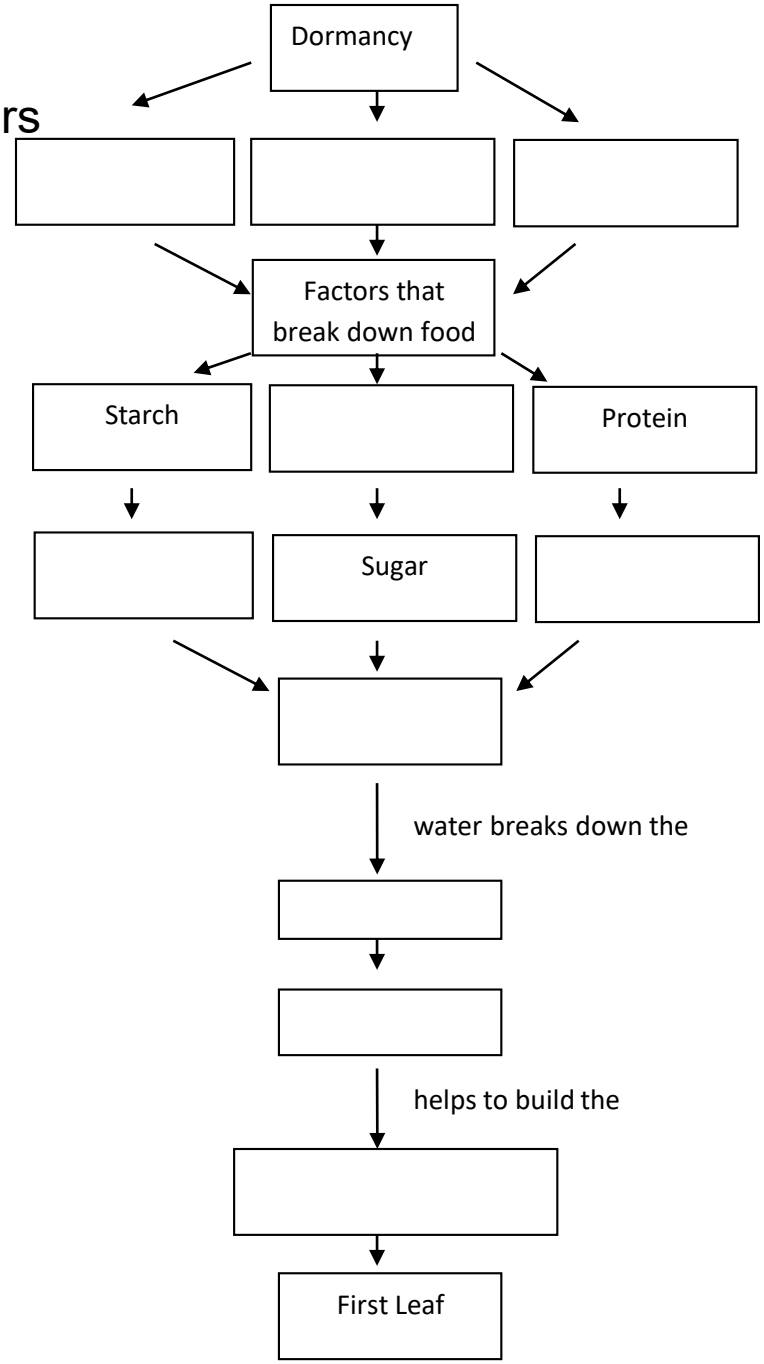
1. Oxygen (O_2) -blue
2. Carbon dioxide (CO_2) - black
3. Water (H_2O) – light blue
4. Carbohydrates - purple
5. Light -orange



Example -

Concept: Seed germination requires these factors

1. Amino acids
2. Bark
3. Endosperm
4. Flowering
5. Germination
6. Hormones
7. Imbibition
8. Lipid/Fat
9. Photosynthesis
10. Radicle
11. Respiration
12. Root
13. Seed coat
14. Sugar
15. Temperature
16. Vascular System



Methods

- Large science service course (n=140+), mixed majors and non-majors, with lab
  - Online hybrid and face to face sections
- Both sections utilized concept map activities developed by the authors
  - Activities are grounded in constructivist theory
- This study focused on implementation of activities with **hybrid** group

Results – performance measures

- Online sections show strong correlation for grades and participation in concept map activities
  - Five activities that utilized concept maps in some form (semi-structured)
  - Pearson *r* correlation between participation in online activities and final grade in course = strong
    - 0.7362 (percentage points earned activities vs total points grade percentage)
    - 0.7537 (number of activities completed vs total points grade percentage)

Results – student feedback

- Spring semester 2017, hybrid course (n=39)
- 22 responses on pollination/fertilization activity through optional (for extra credit) discussion board post
  - All state activity was helpful/useful/like it
  - Several indicate that initially the activity was confusing, however it was clarified after viewing the content video

Results - student feedback

- *So, looking at this the first time I was just so confused because this class is little difficult for me and I really don't understand anything about horticulture but going through it the second time I felt much better about what I was learning and actually started to understand a little bit.*

- *I found the activity to be useful. Try to solve it first I was very unsuccessful, but as a visual and kinesthetic learning going through the activity a second time really helped the information to stick.*

- *I did not know a lot of the answers to begin with, but I do believe I learned a lot and it helped a lot once I went over it again during the lecture.*

Conclusions

- Students indicated that the inclusion of the concept maps (semi-structured, with visuals) in the course
  - helped them conceptualize the terms they learn in lecture,
  - they appreciated being able to organize concepts and vocabulary visually.
- Overall inclusion of concept maps as learning tools in a large science course has proven to be an effective manner in which to improve student learning of complex topics.
- Lack of discussion among students a challenge for hybrid group, and instructor.

Recommendations

- Adding additional concept map activities for topics not yet covered by existing activities.
  - For example, Plant improvement, environment influences on plant growth
- Assess specific concept learning
- Improve capacity for discussion among hybrid students online
- Develop online laboratory activities that will support learning for both face to face and hybrid sections
  - For example, 3-D imaging dissection and identification of flower structure

Questions?