Chapter 39: Plant Responses

OBJECTIVES:

Signal Transduction and Plant Responses

__1. Describe the signal transduction pathway.
__2. Describe the role of second messengers in the signal transduction process.
__3. Describe the two main mechanisms by which a signaling pathway can activate an enzyme.

Plant Responses to Hormones

__4. Explain how a hormone may cause its effect on plant growth and development.

Plant Responses to Light

__5. Define circadian rhythm and explain what happens when an organism is artificially maintained in a constant environment.
__6. List some common factors that affect biological clocks.
__7. Define photoperiodism.
__8. Explain how flowering might be controlled and what is necessary for flowering to occur.

Plant Responses to Environmental Stimuli Other than Light

__9. Describe how plants apparently tell up from down.
__10. Explain why roots display positive gravitropism and shoots exhibit negative gravitropism.
__11. Distinguish between thigmotropism and thigmomorphogenesis.

Plant Defense: Responses to Herbivores and Pathogens

__12. Explain how plants deter herbivores with physical and chemical defenses.

KEY TERMS:

auxins	circadian rhythm	cytokinins	ethylene
gibberellins	hormone	photoperiodism	phototropism
secondary messenger	thigmotropism	tropism	

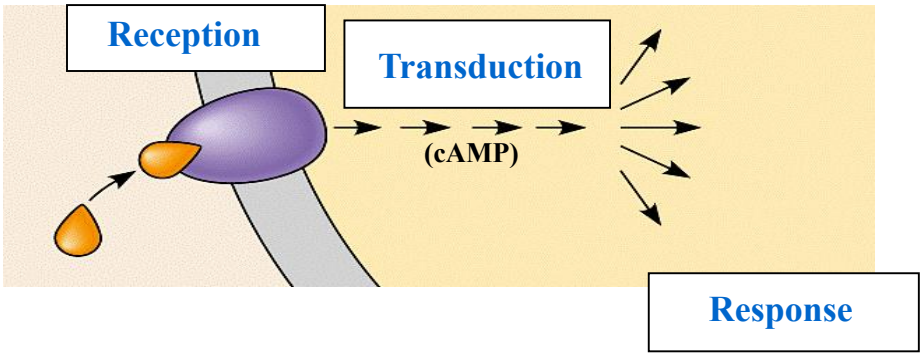
- -

WORD ROOTS:

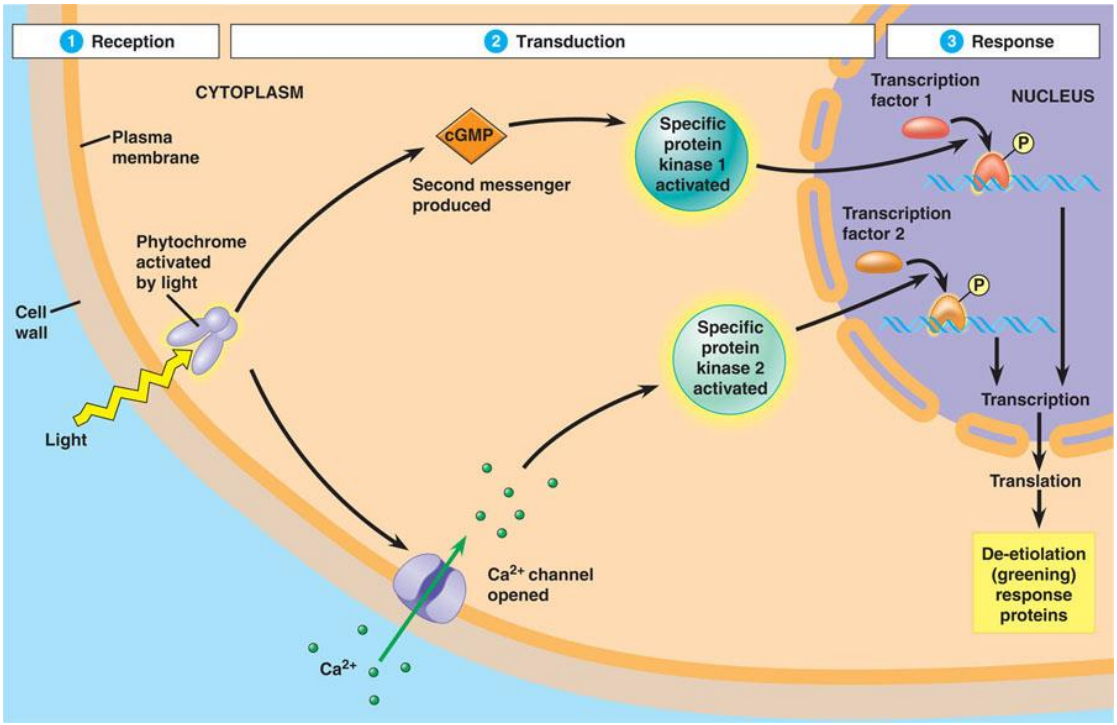
aux- = grow, enlarge (*auxins*: a class of plant hormones, including indoleacetic acid, having a variety of effects, such as phototropic response through the stimulation of cell elongation, stimulation of secondary growth, and the development of leaf traces and fruit)
circ- = a circle (*circadian rhythm*: a physiological cycle of about 24 hours, present in all eukaryotic organisms, that persists even in the absence of external cues)
photo- = light; **-trop** = turn, change (*phototropism*: growth of a plant shoot toward or away from light)
phyto- = a plant; **-alexi** to ward off (*phytoalexin*: an antibiotic, produced by plants, that destroys microorganisms or inhibits their growth)
thigmo- = a touch; **morpho-** = form; **-genesis** = origin (*thigmomorphogenesis*: a response in plants to chronic mechanical stimulation, resulting from increased ethylene production; an example is thickening stems in response to strong winds)
zea- = a grain; **-xantho** = yellow (*zeaxanthin*: a blue light photoreceptor involved in stomatal opening.

Guided Reading: Chapter 39

1. Label the diagram below to review (for the 4th time this year) the general model for a signal transduction pathway. **Animation**



(p.805) 2. Use the diagram to the right to help you describe how the signal transduction pathway and phytochromes play a role in the greening response of plants.



(photoreceptor)

Light causes phytochrome to undergo a conformational change which activates the secondary messenger cAMP (and cGMP) leading to the activation of various transcription factors (PRE and POST transcription factors may be activated) resulting in the production of greening response proteins.

(p.805) **3.** What role do second messengers play in the transduction process?

Second messengers (cyclic AMP - cAMP) are molecules that relay signals received at receptors on the cell surface to target molecules (*transcription factors*) in the nucleus

(Greek "tropos" means turn)

(p.806) **4.** Define tropism.

A tropism is a growth response that results in curvatures of whole plant organs toward (+) or away (-) from a stimulus.

(p.808) **5.** What are auxins?

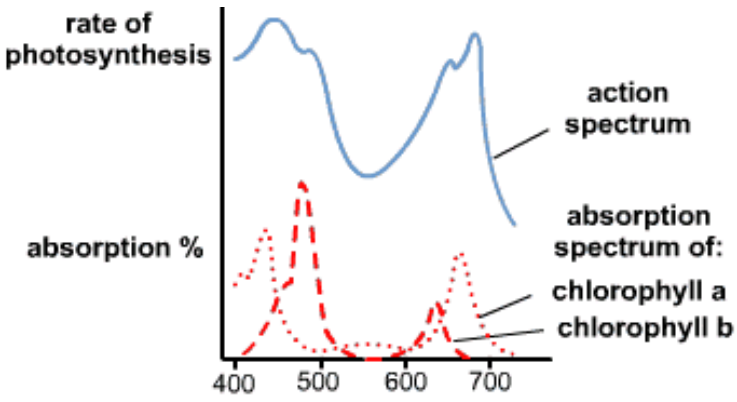
Auxins are plant hormones.

(p.808) **6.** Fill in the chart below by describing the major functions of plant hormones.

Hormone	Function(s)
Auxin	**Stimulates stem elongation.**
Cytokinins	**Stimulates cell division and differentiation.**
Gibberllins	**Promote seed germination.**
Abscisic Acid	**Closes stomata during water stress (drought).**
Ethylene*(g)*	**Promotes fruit ripening**

(p.817) **7.** Use the graph to the right to help you explain what an action spectrum is.

An action spectrum is a graph that relates a plants physiological response to a wavelength of light. An action spectrum usually coincides with the absorption spectrum of photo-reactive pigments like chlorophyll a chlorophyll b that are used to absorb light energy and use it to split water molecules during the first stage of photosynthesis.



Auxins Video

(p.820) **8.** Define **circadian rhythm** and explain what happens when an organism is artificially maintained in a constant environment.

A circadian rhythm is a natural, internal process that repeats roughly every 24 hours. When an organism is artificially maintained is a constant environment its circadian rhythms may deviate slightly from the normal 24 hour period and is no longer in sync with the outside world.

(p.821) **9.** List some common factors that affect **biological clocks**.

The most common factor that affect biological clocks is light.

(p.821) **10.** Define and give an example of **photoperiodism**.

Photoperiodism is an organisms physiological reaction to lengths of night (and day).
Examples of photoperiodism include:
(1) the shortening days of winter causes the Maryland Mammoth tobacco to flower.

(p.821) **11.** Explain how flowering might be controlled and what is necessary for flowering to occur.

Flowering might be controlled by phytochromes (photoreceptors sensitive to light) and a critical night length is necessary for flowering to occur.

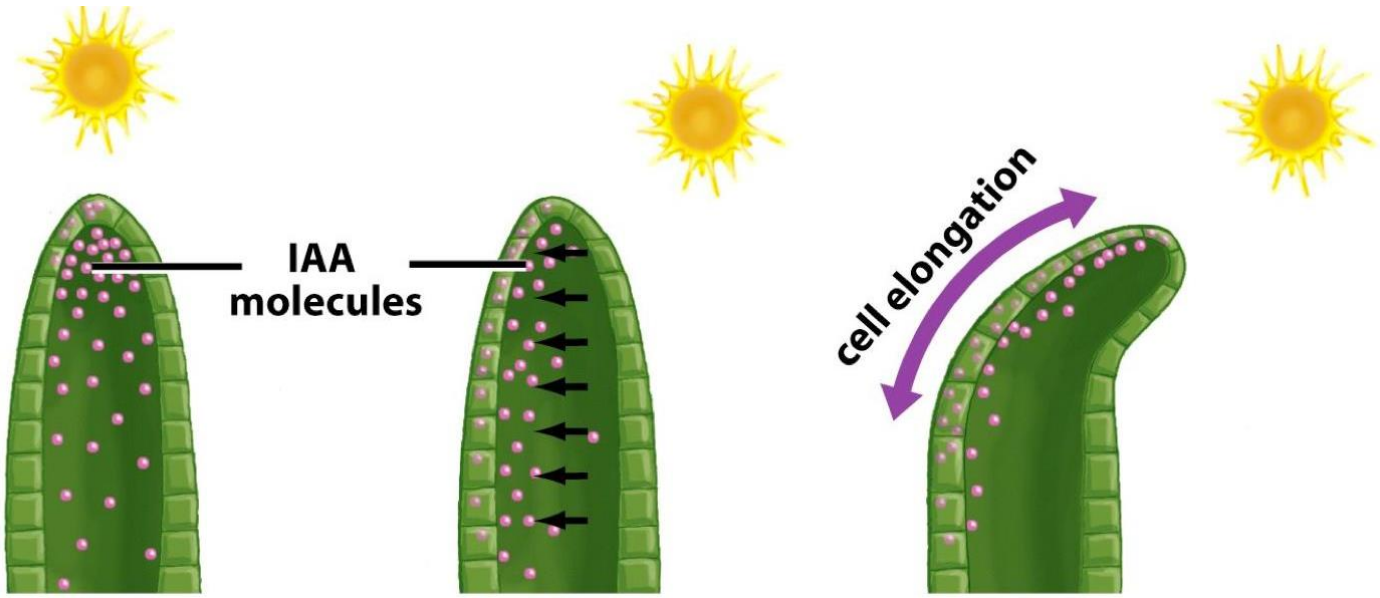
(Video: Sunflower Time Lapse)

(p.824) **12.** Describe how plants apparently tell up from down.

Many plants tell up from down by the settling of statoliths, specialized plasmids containing dense starch grains to the lower portion of cells.

(Video: Positive Phototropism in Peas)

13. Use the diagram below to help you explain how plants respond to light.



When sunlight is overhead, the auxin *indole-3-acetic acid* (IAA) is evenly distributed in the shoot (stem) of the plant.

As the sun moves, IAA molecules move to the far side or shady side of the shoot (stem) and induce the elongation of cells on that side of the plant.

Cell elongation results in the bending of the shoot (stem) toward the light.

(+ Phototropism)

UNEQUAL Auxin Distribution

(p.823) **14.** Explain why roots display *positive* **gravitropism** and shoots exhibit *negative* **gravitropisms**.

Roots display positive gravitropism ensuring that they grow into the soil and shoots exhibit negative gravitropism ensuring that they grow towards the light.

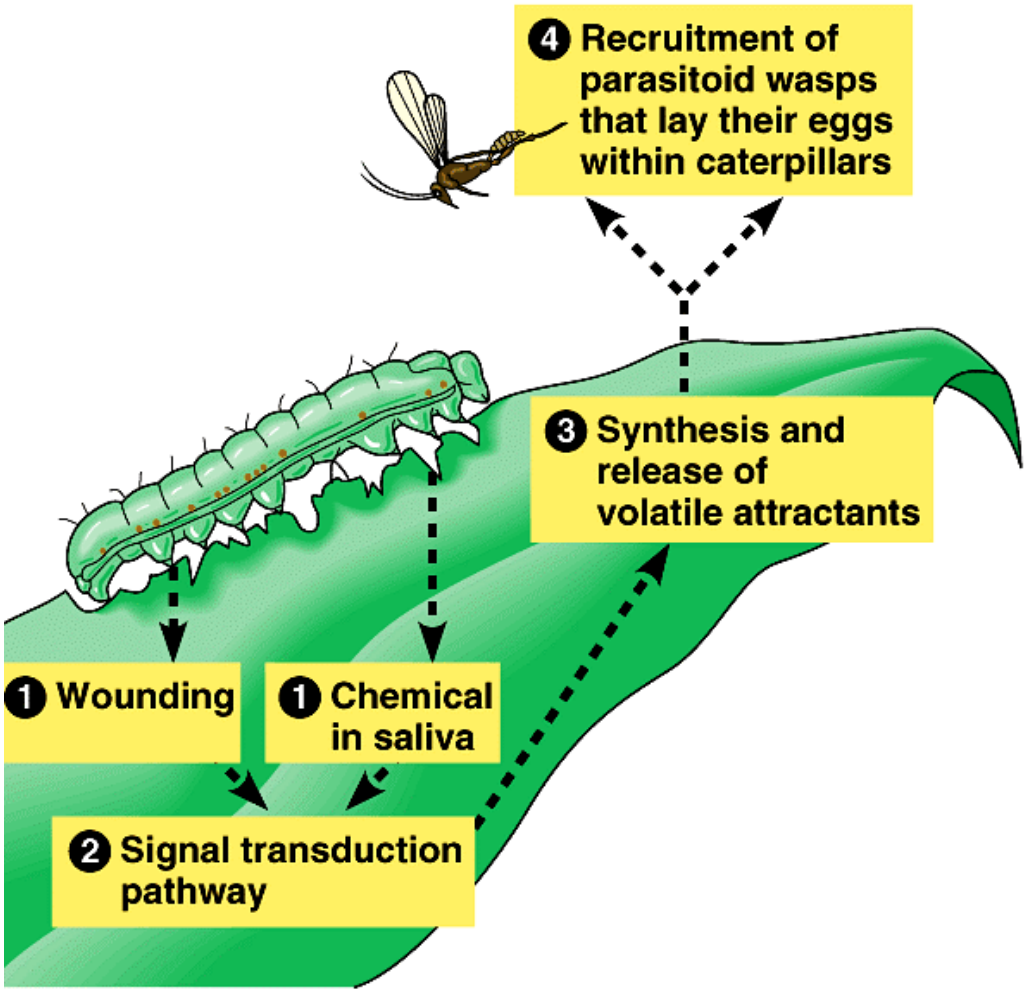
(Video: Time Lapse of Pea Shoot / Root Growth)

(Video: Time lapse fast growing corn, roots and leaves growing)

(p.823) **15.** Distinguish between **thigmotropism** and **thigmomorphogenesis**.

Thigmotropism is the change in directional growth of a plant in response to touch while thigmomorphogenesis refers to the changes in a plants form (structure) that result from mechanical perturbation or disturbance.

16. Use to diagram below to help explain how a corn leaf deters herbivores with physical and chemical defenses.



Chapter 39: Summary of Key Concepts

SIGNAL TRANSDUCTION AND PLANT RESPONSES

- Signal-transduction pathways link internal and environmental signals to cellular responses (pp. 803-806, FIGURES 39.1-39.3) Hormones and environmental stimuli interact with specific receptors, thereby activating specific signal transduction pathways and inducing cellular responses.

PLANT RESPONSES TO HORMONES

- Research on how plants grow toward light led to the discovery of plant hormones (pp. 806-807, FIGURES 39.4, 39.5) Researchers discovered auxin by identifying the compound responsible for transmitting a signal downward through coleoptiles, from the tips to-the elongating regions during phototropism.
- Plant hormones help coordinate growth, development, and responses to environmental stimuli (pp. 808-817, TABLE 39.1, FIGURES 39.6-39.16) This review cites one major function of each hormone. Produced primarily in the apical meristem of the shoot, auxin simulates cell elongation in different target tissues. Cytokinins, produced in actively growing tissues such as roots, embryos, and fruits, stimulate cell division. Gibberellins produced in roots and young leaves stimulate growth in leaves and stems. Abscisic acid maintains dormancy in seeds. Ethylene helps control fruit ripening.
  Activity39A: Leaf Abscission

PLANT RESPONSES TO LIGHT

- Blue-light photoreceptors are a heterogeneous group of pigments (pp. 817-818, FIGURE 39.17) Various blue-light photoreceptors control hypocotyl elongation, stomatal opening, and phototropism.
- Phytochromes function as photoreceptors in many plant responses to light (pp. 818-819, FIGURES 39.18-39.20) Phytochromes exist in two photoreversible states, with conversion of P_r to P_{fr} triggering many developmental responses.
- Biological clocks control circadian rhythms in plants and other eukaryotes (pp. 819-820, FIGURE 39.21) Free-running circadian cycles are approximately 24 hours long but are entrained to exactly 24 hours by the day/night cycle.
- Light entrains the biological clock (pp. 820-821) Phytochrome conversion marks sunrise and sunset, providing the clock with environmental cues.
- Photoperiodism synchronizes many plant responses to changes of season (pp. 821-823, FIGURES 39.22-39.24) Some developmental processes, including flowering in many plant species, require a certain photoperiod. For example, a critical night length sets a minimum (in short-day plants) or maximum (in long-day plants) number of hours of darkness required for flowering.
  Activity39B: Flowering Lab

PLANT RESPONSES TO ENVIRONMENTAL STIMULI OTHER THAN LIGHT

- Plants respond to environmental stimuli through a combination of developmental and physiological mechanisms (pp. 823-827, FIGURES 39.25-39.28) In addition to light, other important environmental stimuli and stresses include gravity, mechanical stimulation, water deficit, salinity, flooding, oxygen deprivation, heat, and cold.

PLANT DEFENSE: RESPONSES TO HERBIVORES AND PATHOGENS

- Plants deter herbivores with both physical and chemical defenses (pp. 827-828, FIGURE 39.29) Physical defenses include morphological adaptations such as thorns, chemical defenses such as distasteful or toxic compounds, and airborne attractants that bring animals that destroy herbivores.

How Plants Tell Time

Directions: Go to Collea's Corner to watch the above mentioned Ted-Ed video and then answers the questions below. **Video**

Background Information:

Morning glories unfurl their petals like clockwork in the early morning. A closing white waterlily signals that it's late afternoon. And moon flowers, as their name suggests, only bloom under the night sky. What gives plants this innate sense of time? Dasha Savage investigates how circadian rhythms act as an internal timekeeper for flora and fauna alike.

Taxonomy - binomial nomenclature: *Genus species*

1. Briefly describe Carolus Linnaeus' flower clock?

It was made of different plants that flower at different times of day.

2. Give 3 examples of how flowers can sense time.

- **Morning Glories unfurl their petals in the early morning.**
- **A closing White water Lily signals that it's late afternoon.**
- **Moon Flowers bloom under the night sky.**

3. What are circadian rhythms and what do they allow organisms to do?

Circadian rhythms are internal time keepers or biological clocks that allow organisms to keep track of time and pick up on environmental cues that help them adapt.

4. For plants, **light** and **temperature** are cues which trigger reactions that play out at a molecular scale.

5. **(a)** What are phytochromes? **Tiny molecules that detect light** ***(photoreceptors)*****.**

(b) What do they initiate? **A chain of chemical reactions passing a message down into the cellular nuclei where transcription factors trigger the manufacture of proteins** ***(enzyme)*****.**

(c) What do they sense? **The amount and color** ***(wavelength)*** **of light a plant receives.**

(d) What do they detect? **Colors of light of a particular wavelength.**

6. What two things do phytochromes allow a plant to discern?

- **Time** (day or night)
- **Location** (sun or shade)

7. What is starch?

Starch is polymer of glucose used for stored energy.

8. Circadian rhythms are especially important in the beginning of a plant's life. Until their phytochromes perceive the presence of light, seed sprouts grow tall and long, and do not produce any chlorophyll. As soon as they reach light, they begin to produce chlorophyll and broader leaves.
What are the advantages of producing chlorophyll only after the presence of light?

Conservation of resources (food and energy**) if light is NOT present.**

Nature: *What Plants Talk About*

When we think about plants, we don't often associate a term like "behavior" with them, but experimental plant ecologist JC Cahill wants to change that. The University of Alberta professor maintains that plants do behave and lead anything but solitary and sedentary lives. ***What Plants Talk About*** teaches us all that plants are smarter and much more interactive than we thought!

Video

Video Questions

1. Out in the field, observing pant behavior is like **watching paint dry.**,

Unless of course, you **speed things up.** ***(3:00)***

2. One of the ways plants behave is through **growth** ***(3:15)***

TROPISMS		
Stimulus	**Direction**	**Response**
Light *(photo)*	**Towards (+)**	**Positive PHOTOtropism**
	Away (-)	**Negative PHOTOtropism**
Water *(hydro)*	**Towards (+)**	**Positive HYDROtropism**
	Away (-)	**Negative HYDROtropism**
Gravity *(geo)*	**Towards (+)**	**Positive GEOtropism**
	Away (-)	**Negative GEOtropism**
Touch Pressure *(touch)*	**Towards (+)**	**Positive THIGMOtropism**
	Away (-)	**Negative THIGMOtropism**

(Video: Auxins/Tropisms)

3. Which nutrient (*organic compound*) do you think the bug provides for the Venus Fly Trap? ***(4:19)***

nitrogen = amino acids = proteins

4. As much as **80** % of a plants total mass lives below the ground. ***(5:46)***

5. What purpose do root hairs serve for the root? **increase surface area**

6. The major function of roots is to **absorption**

7. How do plants find the food they are foraging for both above and below the ground when they have no eyes, no ears and no brain? ***(8:30)***

By increasing their growth rate, roots grow toward their food as they hone in on the food source.

8. Briefly describe the experiment designed to see if the Daughter Vine can actually choose between 2 different host plants. ***(11:00)***

Independent Variable: **Two different HOST plants: wheat and tomato.**

Dependent Variable: **The number of time the Daughter Vine choose each plant.**

Controlled Variables:

What can be done to make this experiment better…more valid ***(11:50)***

Repeat the experiment - Use more plants - Modify the existing the experiment

9. What are green leaf volatiles? **Chemical scents released by leaves as they breathe.**

(Animals: *Pheromones')*

10. What did the 2nd Daughter Vine experiment reveal about how this plant detects its host? ***(12:45)***

Plants detect their host by .....

11. How does the tomato plant respond to being attacked by a daughter vine? ***(13:30)***

By releasing the chemical equivalent of a scream or an SOS.

12. List 2 ways in which the Wild Tobacco Plant responds to threats in its environment. ***(16:31)***

Wild Tobacco Plant Defense Mechanisms	
Threat	Response
Herbivores ***(plant eaters)***	**Secretes nicotine that poisons and paralyzes the invaders muscles.**
Horned-Worm Catepillar	**Releases a chemical SOS into the air (*pheromone*) that attract predators (Big Eyed Bug) to the caterpillar,**

13. How does the Wild Tobacco Plant know who is attacking it? ***(20:40)***

The Wild Tobacco Plant analyzes the saliva of the predator attacking it.

14. What is a tricone and how do Tobacco Plants use them to protect themselves? ***(22:00)***

Tricones are sweet, tasty treats produced by the Wild Tobacco Plant that caterpillars like but get cause a bad case of body order shorty after eating that attract predators.

15. Who is the Wild Tobaccos Plant best friend? ***(22:30)*** **The mother of the caterpillars - The Hawk Moth**

16. When does the Wild Tobacco Plant bloom and why is this a good thing? ***(23:00)***

The Wild Tobacco Plant blooms at dusk which is the perfect time for nocturnal pollinators like the Hawk Moth which fertilize the Wild Tobacco Plant BUT lay eggs that turn into the caterpillars that eat it.

17. How does the Wild Tobacco Plant prevent itself from being pollenated by the Hawk Moth? ***(24:18)***

The Wild Tobacco Plant prevent itself from being pollenated by the Hawk Moth by blooming at dawn, changing the biochemistry of its nectar and shape of flower and thus attracting different pollinators.

18. In the table below, list the biochemical, physiological and behavioral changes that take place in the Wild Tobacco Plant that allow it to communicate with and be pollenated by the Humming Bird. ***(25:00)***

Changes in the Wild Tobacco Plant to Attract Humming Birds	
Biochemical	**Changing the chemical makeup of its nectar and green leaf volatiles. (*pheromones*).**
Physiological	**Changing the shape and color of its flower.**
Behavioral	**Changing its blooming time from dusk to dawn.**

19. Why is being fertilized by a Humming Bird better for the Wild Tobacco Plant? ***(25:45)***

Being fertilized by a Humming Bird better it avoids a whole host of predetors (herbivores).

20. Why is continuously yelling for pollinators an evolutionary advantage (*adaptation*) for the Wild Tobacco Plant? ***(27:00)***

The continuous yelling for predators increases the plants reproductive success.

21. Spotted Knap Weed is an **invasive** species from **Eastern Europe**. ***(28:20)***

22. What ***biological control*** has the rancher utilized to combat the spread of Spotted Knap Weed? ***(29:55)***

Sheep

23. How does the Spotted Knap Weed capture and hold huge pieces of territory? ***(32:49)***

Spotted Knap Weed capture and hold huge pieces of territory by having its roots release chemicals that kill off native grasses.

24. Spotted Knap Weed is waging **chemical** warfare with its neighbors. ***(34:15)***

25. Wild Lupin plants are immune to the chemical warfare of the Spotted Knap Weed and, in fact, release their own chemical called oxalic acid that not only protects itself, but also protects the plants around it from the Spotted Knap Weed. ***(35:00)***

26. What is the dominant form of social interacting between plants?

The dominant form of social interacting between plants is Kin-Recognition,

27. What 2 things do animals use **Kin-Recognition** for? ***(37:30)***

a) To recognize relatives and avoid mating with them.

b) To benefit relatives in social interactions - give off warning calls when predators are near.

28. Why is mating with a relative a bad thing (*genetically speaking*)?

Increases the chances of homozygous recessive disorders.

29. What is **altruistic behavior** (***altruism***)?

Altruism is the selfless concern for the well-being of others.

30. How did the Sea Rocket siblings exhibit altruistic behavior? ***(40:00)***

Sea Rocket siblings exhibit altruistic behavior by having lower root allocation (decrease root growth) when growing near siblings.

31. Altruism can be defined as - doing a benefit to others at some cost to yourself.

(40:23)

32. Douglas Fir trees can live up to 1000 years. (***43:30)***

33. The gills of fungi are filled with tiny spores used in reproduction. (***43:50)***

34. The tree provides the fungi with _____**(PGA - Glucose) carbon-based sugar**_____ and the fungi provide the trees with _____**nutrients**_____ ***(47:17).*** This is symbiotic relationship is an example of _____**mutualism**_____.

35. Why was C14 used in the tree communication experiment?

C14 is a radioactive isotope of C12 and used by the plant for photosynthesis and can also can be tracked using a Geiger Counter.

36. What did the C14 experiment reveal about who benefits the most from this carbon (*food*) sharing network? ***(50:00)***

The youngest, most vulnerable tress benefits the most from this carbon (food) sharing network?

37. List 4 different examples (from the film) of how different species in an ecosystem interact with one another.

(**1**)

(2)

(3)

(4)

38. List 2 behaviors that some plants exhibit, which are what we perceive as very animal like behaviors.

(**1**)

(2)