Answer key for Caitlin Conn's iBiology video "The Making of a Parasitic Plant: Parasitism as a Life Strategy"

1. What other examples can you think of for mutualism, commensalism, and parasitism?

There are countless possible answers to this question. Commonly cited examples include

- mutualism: pollinators and flowering plants; pollinators help the flowering plants reproduce, and the flowering plants provide food for the pollinators
- commensalism: commensalism is a contentious subject (regarding whether or not it truly exists), but a commonly cited example is when scavengers benefit from the leftovers of a predator's kill
- parasitism: malaria and humans; the causative protist parasite (in the *Plasmodium* genus) uses humans to progress through its life cycle, and humans get sick with malaria

2. What resources are plants competing for in this forest environment?

Plants need light (for photosynthesis), nutrients from the soil, and water. Depending on the ecosystem in which they're found, any of these resources might be in short supply, and thus plants might have to compete for them. Flowering plants also sometimes compete for access to pollinators.

3. What advantage does a parasite of a tree have over other understory plants?

Plants use photosynthesis to make their own food, and to carry out photosynthesis, plants must be able to access sufficient light. Understory plants may have difficulty accessing light if taller plants that block the sun are abundant. *Conopholis americana* does not photosynthesize; rather, it steals its food from tree hosts. Thus, *Conopholis* does not have to compete with other understory plants for access to the scarce sunlight.

4. What traits do parasitic plants share?

As explained in the video prior to the question, parasitic plants share a mechanism for invading host plant tissues (via a haustorium). Parasitic plants have also evolved ways to detect nearby hosts, either before seed germination or before development of the invasive haustorium. Some parasitic plants have convergently lost or reduced photosynthesis, as well as structures like roots and leaves.

5. Why would parasitic plants lose the ability to photosynthesize?

If parasitic plants can reliably obtain resources from a host, natural selection relaxes on the genes and structures that enable photosynthesis in the parasites. When selection relaxes, the ability to photosynthesize breaks down without negative consequences for the parasitic plants' survival and reproduction. Furthermore, carrying out photosynthesis requires energy and other resources. If parasitic plants have no need for photosynthesis, they may benefit from losing it because they don't have to expend the energy and other resources that photosynthesis requires.

6. What are the consequences of losing photosynthetic capacity?

If hosts become unavailable for some reason, nonphotosynthetic parasites will have no way to obtain photosynthetic products, and they will starve.

7. What traits would benefit an obligate holoparasite if its host was an annual crop (e.g. maize) instead of a perennial plant (e.g. oak tree)?

This question doesn't necessarily have right or wrong answers; rather, it's designed to stimulate thought among students. Some potential answers are listed below. Remember that obligate holoparasites are completely dependent upon a host for survival.

- Host range and host detection: Since crops are often rotated (i.e. a particular field might have one crop one year and something different the next), a wide host range might benefit parasites of annual crops. Along those same lines, it might be beneficial for the seeds of these parasitic plants to distinguish among different nearby crops; that way, the parasites could ensure that a suitable host is nearby before committing to the irreversible step of seed germination.
- Seed dispersal: Because trees live a long time, a parasitic plant that is attached to one may not need to disperse its seeds very far; rather, its offspring may be able to parasitize the same host plant as the parent. In contrast, because annual crops are only around for a year and may be replaced by unsuitable crop hosts the following year, parasites of annual crops may benefit from longer-range seed dispersal mechanisms.
- Overcoming host defenses: Again, because of crop rotation, as well as the development and introduction of new crop varieties, crop hosts may not have an opportunity to evolve defenses against parasitic plants. In contrast, perhaps parasites of wild plants (such as oak trees, for example) have a longer coevolutionary history with their hosts. In this latter case, their hosts may have evolved defenses, and the parasitic plants may benefit from (or even require) adaptations that enable them to overcome host defenses.

8. What environmental conditions might favor the evolution of parasitism in plants?

As with the last question, this one has no specific right or wrong answers. One might expect parasitism to evolve in resource-poor environments (so that parasites can steal from plants that successfully acquire those scarce resources rather than competing for the resources themselves). However, there is no real evidence to suggest that resource limitation has driven the evolution of parasitism in plants[1].

9. What unique challenges might parasitic plants face?

For nonparasitic plants, having few other plants nearby might be a good thing; after all, fewer plants means less competition for resources. But for parasitic plants, having few other plants around might mean that a suitable host is unlikely to be found. Especially for obligate holoparasites, not having a host plant is extremely problematic. Also, as stated above, some host plants have likely evolved defenses against parasitic plants; for instance, one facultative hemiparasite's survival rate is actually lower in the presence of hosts (but the surviving parasites grow stronger if they have a host).[2] Thus, although parasitic plants may not face as intense of competition for resources as nonparasites, they may have to overcome host defenses.

10. What traits are parasites unlikely to lose?

Evolutionary fitness depends on the transmission of an organism's genetic material to future generations. Thus, parasites are unlikely to lose structures, genes, and physiological processes

that are necessary for reproduction. For example, parasitic angiosperms are unlikely to lose flowers. Other genes and processes necessary for growth and development are also unlikely to be lost; these might include the genes and cellular machinery involved in DNA replication, cell division, and metabolism. Furthermore, parasitic plants – and especially obligate holoparasites – are unlikely to lose the structures, genes, and processes that they need in order to interact with a host.

References

1. Atsatt, P.R. (1973) Parasitic Flowering Plants: How Did They Evolve? *The American Naturalist* 107(956): 502 – 510.

2. Honaas, L.A., Jones, S., Farrell, N. Kamerow, W., Zhang, H., Vescio, K., Altman, N.S., Yoder, J.I., dePamphilis, C.W. (2019). Risk versus reward: host dependent parasite mortality rates and phenotypes in the facultative generalist *Triphysaria versicolor*. *BMC Plant Biol* **19,** 334. https://doi.org/10.1186/s12870-019-1856-1