IPS-141
Sensory and Physiological Ecology of Plants

1: Introduction

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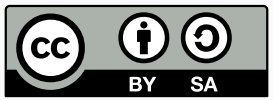


Outline

Introductions

Course organization

Motivation

Why *sensory and physiological ecology*?

About the course

Introductions

Let’s introduce ourselves 

- Name
- Subject of study and background
- Are you interested in the subject of the course?
- What do you expect to learn?
- Anything else relevant

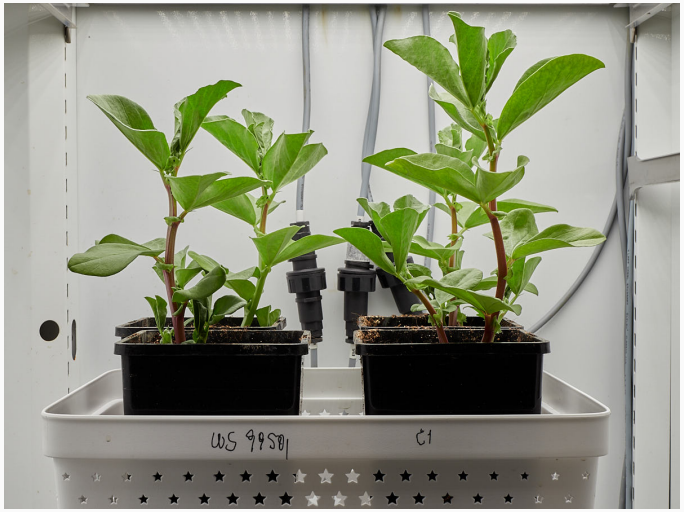
Course organization

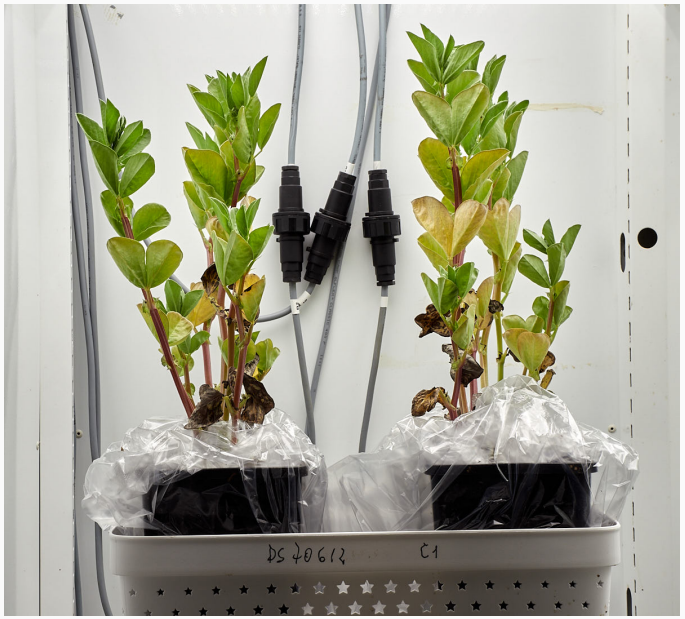
Zoom and Moodle

- Due to COVID our learning space is virtual.
- Let's all together keep interaction active.
- Short lectures interspersed with discussion in groups.
- Feel free to ask any questions or challenge what I present.
- Photo in profile/video and Zoom recordings.
- Moodle: https://moodle.helsinki.fi/index.php?id=48992

Motivation

Vicia faba and “drought” × genotype





Vegetation

A systems view of the living world

- Many interactions ⇒ structural complexity
- Many feedback loops ⇒ complex dynamics
- Complexity ⇒ emergent properties
- …emergent properties cannot be predicted directly
- cellular processes are not enough predict plant responses
- individual plant responses are not enough to predict community behaviour/crop performance
- Can you think of specific examples?
- *We will focus on the role interactions and how plants exploit them and the connection between interactions and evolution*

Some of the recent advances in plant researcch

- Synchronization of behaviour among individual plants
- Anticipatory responses to future conditions
- Strategies such as risk avoidance and bet-hedging vs. tolerance
- Role of correlations in the environment in plant responses
- “Darwinian agriculture”
- Implications of complexity of regulation for genetic manipulation
- Big data, machine learning…

Why *sensory and physiological ecology*?

Changing perspective in Biology +

Era: Industrial revolution Organisms studied as mechanical machines. Chemistry and Physics provide mechanisms.

Era: Information revolution Organisms viewed as processors of information. We add a new layer of explanation on top of earlier ones.

Animals vs. plants The role of information in animals was recognized earlier than in plants.

Examples?

Physiology vs. ecology (typical definitions)

Plant physiology is the study of the function, or physiology, of plants. Fundamental processes such as photosynthesis, respiration, plant nutrition, water relations, and development are studied by plant physiologists.

Plant ecology is the study of the factors affecting the distribution and abundance of plants. It aims to show how pattern and structure at different levels of organization are influenced by abiotic factors (e.g. climate and soil) and biotic interactions (e.g. competition, facilitation, symbiosis and parasitism)

Physiological ecology and Stress physiology

- Viewpoint: plants as "victims" of the environment.
- *Physiological ecology* $\approx$ *ecophysiology* seeks to describe the **physiological mechanisms** that underlie ecological observations.
- *Stress physiology* differs only by its focus on extreme environmental conditions instead of all conditions.
- *Ecophysiologists address ecological questions about the controls over growth, reproduction, survival, abundance, and geographical distribution of plants as these processes are affected by the "mass + energy" exchange between plants and their physical, chemical, and biotic environment.*

Sensory ecology

- Viewpoint: plants as “navigators” in the environment.
- Sensory ecology studies the **mechanisms of information acquisition and emission** that underlie ecological observations.
- *Sensory ecologists address ecological questions about the controls over growth, reproduction, survival, abundance, and geographical distribution of plants as these processes are affected by the “information” exchange between plants and their physical, chemical, and biotic environment.*

Fitness and evolution

 “Nothing makes sense in Biology except in the light of evolution”

Fitness is “measured” as the success in producing viable offspring (passing genes to the next generation).

The organisms we study are the result of the *evolutionary process*. To understand why organisms have the functions, morphology, life cycle and behaviour they have, we need to take into account how these features contribute to fitness.

These functions include both sensing leading to development “decisions” and regulation of metabolism and growth supporting reproduction and/or multiplication, and thus fitness.

Wild plants vs. weeds vs. crops 10 + 5 min

- Most **crops** have been under artificial selection for a long time. Farmers and breeders have selected the most useful genotypes.

+ In addition natural selection is also active on cultivated plants, although in a managed environment. examples?

– Most crops have very low fitness in the wild. examples?

- Crop **weeds** are not subject to artificial selection, they are under natural selection but in a managed environment. examples?
- Natural selection in most populations of **wild plants** is affected by human activities. examples?

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About the course

Learning objectives (in brief)

Are that at the end of this course:

- Learn the language of sensory and physiological ecology of plants.
- Learn the basic ”workings” of plants and how they have adapted and how they can acclimate to environment.
- Learn concepts and a way of looking at plants based on the current scientific ideas.
- Learn how to find answers to questions about acclimation and adaptation of plants through experiments.
- Learn how to find, interpret and use information to solve problems and answer questions related to plant ecology.
- However, you will **not** have to memorize detailed information that is available in books, journals or the internet.

Contents of the course

More details available in Moodle. All the points listed below are discussed emphasising acclimation and adaptation.

- Introduction
- The shared environment of plants
- Sensory biology
- Adaptation and acclimation of carbon and energy metabolism
- Adaptation and acclimation of water uptake and loss
- Adaptation and acclimation to mineral nutrient supply
- Adaption and acclimation of morphology and anatomy
- Plasticity in a changing or artificial habitat

Understanding vs. memorization

Teaching and learning

- The role of examples (in this course and elsewhere) is to make a concept tangible…
- …easier to grasp than a purely abstract idea.
- When studying focus on the concepts…
- …once you grasp a concept, or learn the idea…
- …you will be able to find or make up another suitable example when needed.

Examples

- I will use examples from both wild species and cultivated species. Mostly higher plants from terrestrial environments.
- In recent years physiological research has made frequent use of *Arabidopsis thaliana*.
- *Arabidopsis thaliana* is a useful model, but the variation in the plant kingdom is enormous: in size, shape, function, growth rate, and lifespan.
- This variation is the result, at least in part, of variation in past and current growth environments.
- Natural selection is constrained by evolutionary history.
- Random events also play a role, especially in small populations.

References

References


Capra, F. and P. L. Luisi (2014). *The Systems View of Life*. Cambridge University Press. 514 pp. ISBN: 1316616436.


Chamovitz, D. (2017). *What a Plant Knows: A Field Guide to the Senses: Updated and Expanded Edition*. Farrar Straus & Giroux. 224 pp. ISBN: 0374537127.


Denison, R. F. (2012). *Darwinian agriculture: how understanding evolution can improve agriculture*. Princeton University Press. ISBN: 9781400842810.


Dusenbery, D. B. (1992). *Sensory Ecology: How Organisms Acquire and Respond to Information*. New York: W. H. Freeman and Co. Ltd., p. 558. ISBN: 0-7167-2333-6.

References ii

- Karban, R. (2015). *Plant sensing and communication*. Chicago: The University of Chicago Press. ISBN: 022626470X.
- Keddy, P. A. (2017). *Plant Ecology*. Cambridge University Press. 624 pp. ISBN: 1107114233.
- Lambers, H. and R. S. Oliveira (2019). *Plant Physiological Ecology*. Springer. ISBN: 978-3-030-29638-4. DOI: 10.1007/978-3-030-29639-1.
- Lambers, H., T. L. Pons and F. S. Chapin III (2008). *Plant Physiological Ecology*. 2nd. Springer, p. 610. ISBN: 0387783407.
- Manetas, Y. (2012). *Alice in the Land of Plants: Biology of Plants and Their Importance for Planet Earth*. Heidelberg: Springer. ISBN: 3642283373.

References iii


Sadras, V., J. Alston, P. Aphalo, D. Connor, R. F. Denison, T. Fischer, R. Gray, P. Hayman, J. Kirkegaard, H. Kirchmann et al. (2021). “Making science more effective for agriculture”. In: *Advances in Agronomy*. Vol. 163. Elsevier. Chap. 4, pp. 153–177. DOI: 10.1016/bs.agron.2020.05.003.


Sadras, V. and D. Calderini (2014). *Crop Physiology: Applications for Genetic Improvement and Agronomy*. Academic Press. 551 pp. ISBN: 0124171044.


Taiz, L. and E. Zeiger (2014). *Plant Physiology and Development*. Macmillan Education. 700 pp. ISBN: 1605353264.