Bot 100 – Lecture notes, 17 Jan 2017 (this lecture delivered in lab!)

Welcome!

I. Course overview, syllabus and website – as described.

Course website: biosbcc.net/kay

II. Characteristics of life / living things

Despite the ignorant (!) claim that plants are uninteresting and don't really "do anything", they do a great deal and exhibit all the characteristics of living things: (As in future lecture notes: You need to know bolded terms/concepts on this list for quizzes and exams.)

1) Order – basis of which is cells (*we'll discuss these in our next lecture!!*).
   Entropy – a measure of disorder. Any system, including the universe, will tend towards maximum entropy (as stated in the 2nd law of thermodynamics). This is fancy talk that conveys the message that systems want to 'fall apart', such that their physical constituents are dispersed randomly in space (we invoked the example of your bedroom or the hideous refrigerator you share with your housemates – yuk!). Living beings must combat this tendency, and thereby maintain their body shape and function – that is to say – maintain order. Such order is typically absent from non-living systems.
2) Regulation – maintain the order (mentioned in #1) – life exists within ranges of temperature, hydration, and concentrations of materials in solution within cells.
3) Exchange matter and energy – organisms require energy to maintain order and to function (see item #1!!). Via photosynthesis, plants convert the energy in sunlight into chemical energy that you, I and, all other non-plants depend upon for our existence – this conversion of light energy to chemical energy drives almost all life on Earth! Feeling peppy? Thank a plant…!!
4) Growth and development – Basis of growth, development, and reproduction is cell division (we'll get to cell division later in the course…).
5) Respond to the environment – environmental stimuli
6) Reproduction – Organisms reproduce their own kind (species). Key points for now:
   - **Sexual reproduction** – Creation of genetically unique offspring from two parents (much, much more vocabulary to come later in the class!).
     In nature: sexual reproduction is critical because it generates the genetic variability in populations that is necessary for natural selection – and thus evolution (see below!)
     In plant breeding/agriculture: Sexual reproduction generates genetic variability that can give rise to new varieties of plants, some of which might be commercially important due to desirable features (fruits, flowers, disease resistance, etc…).
   - **Asexual reproduction** – Creation of offspring from a single parent. Parent and offspring are genetically identical (with rare exceptions…!)
     In nature: Important because plants can't always find a sexual partner! Thus, asexual reproduction helps short- to medium-term persistence of a plant's genes…(but long-term persistence usually requires sex and evolution…)
     In plant breeding/agriculture: Asexual reproduction is critical because plants with a desirable feature (fruit, flower, etc) can be cloned (literally) and the desirable feature is reliably duplicated in the offspring. Almost all fruit you eat is from cloned trees/plants.

Examples from lecture: Hass avocado and Cavendish banana. The fruits of Hass avocados and Cavendish bananas, as we know them today, were originally "bred into existence" by plant breeders that were cross-breeding (sexually crossing/reproducing) plants. The original plants were then cloned many many thousands of times, such that, in each case, ALL HASS AVOCADO and ALL CAVENDISH BANANA trees are clones (asexually reproduced from) individual mother trees! The downside of this approach: since clones are genetically identical, that are all susceptible to disease. For example, the Cavendish may be headed for commercial extinction, or at least a much reduced place in the banana market, due to a new fungus that is lethal to Cavendish clones. Look for new bananas to hit the market in coming years.

- In both sexual and asexual reproduction, inherited information coded for by DNA is passed to offspring
- Plant sex! Plant sexual reproduction is often very novel and interesting…ooooh yeah… - we'll take a closer look at this throughout the semester…

7) **Evolution** –Descent with modification. Change within a species through time as new generations inherit certain characteristics from previous generations (yep – you guessed it - that info is passed along in DNA!)

Species: A group of organisms capable of interbreeding and producing fertile offspring.

[video: *Plants(0:10-3:55)*, from the BBC series *Life* with David Attenborough]

(So, is it true that plants don't "do anything?". Well, In addition to "doing" all the "things" listed above, plants provide many services for Earthlings, including humans: photosynthesis, food production, timber products, and medicine, to name a few. We'll study all this and more!)

III. Evolution, adaptation, and natural selection

Evolution is something that we will revisit in this class frequently. The fact that organisms change through time is a **unifying principle** of botany and biology in general (i.e., it is present in, and fundamental to understanding, all topics and subjects in biology).

At the conceptual core of evolution is another unifying principle: **adaptive trait**

Adaptive trait (aka adaptation): An inherited characteristic that increases an organism's ability to survive and reproduce (the "meaning of life" !!!).

Selective pressure: Any cause that reduces an organisms ability to survive and reproduce (e.g., predators, difficulty securing food/water, disease, drought, freezing, etc…).

- Adaptive traits, in essence, are inherited characteristics that allow organisms to overcome selective pressures.
- It is conceptually accurate, therefore, to think of adaptive traits as evolutionary "solutions" to selective pressures. Throughout the semester, we will think about the selective pressures and adaptations present in plants – this mindset is foundational and a fun element of botany and biology!

Natural selection: A process in which individuals with certain inherited traits (i.e., adaptive traits) are more likely to survive and reproduce (in biology, survival and reproduction is the "meaning of life"!!!) than individuals without those traits.

- Organisms with adaptive traits survive reproduce at a higher rate, and thus the inherited adaptive traits that are passed on to their offspring become more common in the general population – thereby driving evolutionary change.
- Natural selection is the mechanism that drives evolution. Charles Darwin's greatest (but not his only!) contribution to science.

For natural selection to work, a few conditions must be present:

1) Genetic (i.e., coded in DNA) variation among individuals in a population
   Q: Where does this genetic variation come from?
   A: 1) Sexual reproduction (this is why sex is important!); 2) random mutations to DNA
2) Struggle for existence (life is hard and not everybody is able to survive!) due to **selective pressures** that exist
3) Differential survival and reproduction based upon genetic differences (adaptive traits are present in some individuals, but not all, and those that possess them have a higher rate of survival and reproduction…such that the traits become more common in the species or population over time!)

Adaptations increase an organism's ability to survive and reproduce by providing some important service or function. Often, the function or service that a particular adaptation provides is evident in its form (e.g., shape, size, color, etc). This gives rise to the expression: **"Form equals function"**.

The concept that "form equals function" is another anchor point for Bot 100 – and we will examine the function and evolutionary context for a great number of adaptations that range in size from large (flowers on trees) to small (molecules). In fact – it's what we focus on this week in lab.

Most importantly, the principles of evolution via natural selection, as well as adaptive traits provide a necessary and critical context for any biological science. ALL subjects, structures, and processes in biology are meaningful only when considered in their evolutionary context.

Examples from lecture: giraffe necks, tongues. *Acacia* spines.

{Video: desert pocket mouse and natural selection:
http://www.hhmi.org/biointeractive/making-fittest-natural-selection-and-adaptation
0:00 – 3:20}

Darwinian natural selection vs. Lamarckism

Lamarckism: traits acquired during an organism's life can be passed along to offspring (e.g., a giraffe's neck stretches and elongates in an effort to reach tall branches – and this longer neck is then passed along to offspring. We know this to be false, of course….)

Darwin: adaptive traits are inherited from parents. Organisms with adaptive traits have a higher rate of survival and reproduction.

Concluding key point about natural selection:
1) Adaptive traits are inherited, not acquired during life of an organism (latter = Lamarckism!)
2) A single individual does not evolve. Evolution via natural selection is an incremental process that occurs over many generations and often over long time periods (shocking exceptions of rapid evolution exist, such as bacterial resistance to antibiotics – but bacterial generation times are very short and the change still occurs over many generations.)

IN LAB – BREAK here (then continue with section IV)

IV. Botany, science and the scientific method
Due their amazing function, diversity, ecological importance, and benefit to humanity, plants are important organisms that have our full attention, and there are many fields of botany.

Botany: the science of plant life.

A brief history (do not need to know for exams):
The roots (no pun intended) of botany trace back to prehistory (before we were writing stuff down…) and human kind's attempts to identify, cultivate, and control plants for food, medicine and poisons (often referred to as herbalism).

The prehistoric roots of botany make it one of the oldest branches of science

Science: an objective process of inquiry based upon observations and testable hypotheses (guaranteed exam question!!!)

Scientific method: A way of 'doing' science by making observations and testing hypotheses. We define the Sci. method as having 5 steps:

Five steps:
1. Initial observation
2. Hypothesis
3. Prediction
4. Experiment
5. Interpret results – accept/reject hypothesis. Form new hypotheses?

(Items 3-5 are hypothesis testing)

Experimental control (aka control experiment): experiments or features in an experiment that account for alternative explanations of experimental results.

LAB activity – Eucalyptus tree bark, and oranges…both discussed in context of natural selection and scientific method