Discussion for Instructors

- Emphasize traits vs. adaptations and heritability
- Encourage students to make connections between prior course material and this activity.
- End with explicit discussion of values. Explain difference between instrumental, intrinsic, and relational values and ask students to identify how they value non-humans.

Evolutionary adaptations:

Adaptations arise randomly and, by chance, provide a fitness benefit that ends up being selected for via natural selection. Adaptations fall into one of three categories when they arise: structural, physiological and behavioral.

> *Structural*: a physical trait (often external, but may be internal) that helps an organism survive and/or reproduce. Examples range from the shape of a bird's beak, to the color of an animal's fur, to how organisms move through the environment (e.g. bi-pedal locomotion in humans).
>
> *Physiological*: an internal trait (and therefore cannot typically be seen) that provides a benefit in terms of the function of the living organism. Examples include haemoglobin with higher than normal binding affinity for oxygen, high efficiency kidneys, and symbiotic relationships with gut microflora.
>
> *Behavioral:* actions that an organisms takes to help them survive or reproduce. Behaviors may be innate (genetically controlled) or learned (socially transmitted or gained through experience). Learned behaviors themselves are not adaptations; <u>*the ability to learn a given behavior is the adaptation*</u>. Behavioral adaptations often interact with structural and physiological adaptations in terms of the fitness benefits a given behavior provides. For instance, organisms may structurally alter their physical appearance in order to avoid predators or find a mate. Likewise, organisms may manage physiological processes by seeking out suitable microclimates or varying their activity over the course of the day.

Traits:
Like adaptations, traits arise randomly, but traits do not necessarily provide a current adaptive or fitness benefit. Traits may have provided a fitness benefit in the past but no long do, become heritable by chance or arise as a correlated trait.

Cognitive ability:

Humans have an innate ability for complex reasoning that is often held up as a trait that sets us apart from other species. Making decisions is part of the everyday-life of many organisms and accordingly, many species have the ability to make context-specific decisions that have a meaningful impact on their fitness (see below). Not only can individuals make decisions that affect their fitness, non-humans can also make collective (group-level) decisions that affect the collective fitness of a group or population (e.g. ant societies). There is emerging evidence that many species have the anatomical adaptations that would allow them to experience something similar to what humans call "consciousness". Birds and mammals may be especially likely to experience "consciousness" and there may be non-primate mammals that are self-aware (aware that they exist and/or have a conscious). It appears increasingly likely that being self-aware is a mammalian adaptation, not a human adaptation.

Fabbro F, Aglioti SM, Bergamasco M, Clarici A, and Panksepp J. 2015. Evolutionary aspects of self- and world-consciousness in vertebrates. *Frontiers in Human Neuroscience*, 9:157, 1-16.

Condradt L and List C. 2009. Group decisions in humans and animals: a survey. *Philosophical Transactions of the Royal Society B-Biological Sciences*, 364:1518, 719-742.

Culture and innate vs. learned behaviors:

Innate (genetically controlled) adaptive behaviors can be broken into two categories: reflexes and instincts. Reflexes are often simple motorneural responses to a physical stimulus, but may be complex adaptations (e.g. mammalian diving reflex). Instincts are more complex adaptive behaviors that are often triggered by changes to the environment (e.g. procreational activities like nesting or seasonal behaviors like migration). Humans exhibit many behaviors that could be rightly called instinctual (e.g. tribal loyalty, greed, jealousy, cooperation, sexual behavior).

Learned behaviors may result from direct individual experience or from social transmission of information. Many species have the ability to learn from experience and learned behaviors often interact with innate behaviors. A classic example of the interaction between learned and innate behaviors is "imprinting". Shortly after birth many species learn to recognize their mother as the individual that tends to them (imprinting) and then innately behave toward that individual as their mother. Social transmission of information is the passing of information between individuals in a population or sub-population that may subsequently influence behavior. Humans are adept at transmitting and acting on information received from others, but this ability in and of itself is not unique to humans and is a commonly observed in social species.

Learned behaviors may result in distinct cultures where one group of the same species behaves differently than another group and those differences in behavior are maintained over generations, eventually resulting in localized adaptive changes to the genome of the species. It is commonly held that one way humans are unique compared to other species is that we possess distinct cultures and that culture can provide an adaptive benefit. It is true that culture can have an adaptive benefit in humans: when humans learned to farm and transitioned to an agrarian lifestyle, lactose tolerance beyond childhood became an adaptive benefit in cultures where animals were raised for their milk and now many people possess the genes for lactose tolerance throughout their adult life. Cultural differences in hunting style between subpopulations correspond to genetic differences between groups of killer whales, so it seems that culture as a force for adaptive change is not a uniquely human phenomenon.

Foote AD, Nagarjun V, and others. 2016. Genome-culture coevolution promotes rapid divergence of killer whale ecotypes. *Nature Communications*, 7:11693.

Cosmides L and Tooby J. 2013. Evolutionary Psychology: new perspectives on cognition and motivation. *Annual Review of Psychology*, 64, 201-229.

Laland KN, Odling-Smee J, and Myles S. 2010. How culture shaped the human genome: bringing genetics and the human sciences together. *Nature Reviews Genetics*, 11, 137-148.

Tierney AJ. 1986. The evolution of learned and innate behavior: contributions from genetics and neurobiology to a theory of behavioral evolution. *Animal learning & Behavior*, 14:4, 339-348.

Treatment and prevention of illnesses

Many organisms have developed behavioral adaptations to treat and/or prevent illnesses. In humans this behavior is learned and called the practice of medicine; in non-humans this behavior is thought to be largely innate and called zoopharmacognosy. Humans and non-humans utilize varied approaches to the treatment and prevention of illnesses but the adaptive benefit is the same: preventing untimely death and ensuring successful reproduction. Zoopharmacognosy is a relatively young (1993) sub-discipline of ecology and was initially (mid-late 1990's) very controversial due to the nature of the available evidence, but many careful studies have now been published verifying that innate (genetically linked) behaviors do exist in a number of non-human species and these behaviors do have adaptive significance. Below is a list of examples of zoopharmacognosy.

Prevention of illness:
Leaf-eating in chimpanzees to prevent parasitic infections
Ant-wiping in birds to prevent parasitic infections

Treatment of illness:
Grass-eating in dogs to induce vomiting
Consuming soil to settle stomach (geophagy; many species)

De Roode JC, Lefevre T, and Hunter MD. 2013. Self-medication in animals. *Science*, 340:6129, 150-151.

Altering physical appearance:

Humans alter their physical appearance in a number of ways. We wear clothes, make-up, uniforms, costumes, shoes; the list goes on. The adaptive significance of this behavior is varied and tied to fitness in terms of both sexual and natural selection. Alterations to physical appearance may alter fitness by making individuals more attractive as potential mates (increases ability to reproduce) or conveys information about social rank (increases ability to survive via priority access to resources). Examples from humans include fashionable clothes, expensive clothes/accessories, cosmetics or cosmetic surgery that either increases perceived beauty or decreases perceived age, and grooming or cleanliness. A non-human example of this behavior is found in female bearded vultures. Females will dye their white feathers red with iron rich soil. The darker red the female's feathers are the greater her social rank and the better access she has to mates and resources such as nesting sites and food. Fitness may also be altered via natural selection if the change in physical appearance provides a survival benefit. Examples from humans include clothes/shoes to keep warm, hats/sunblock to prevent sun burns, and camouflage clothing. This is a very common type of behavioral adaptation and there are many non-human examples where altering physical appearance confers a survival benefit.

Ruxton GD and Stevens M. 2015. The evolutionary ecology of decorating behaviour. *Biology Letters*, 11:6, 1-5. DOI: 10.1098/rsbl.2015.0325

Tool Use

The adaptive significance of tool-use in humans cannot be understated: our success as a species is intimately linked to our ability to create and use tools that increase our ability to survive. Tool-use was once thought to be a behavioral adaptation that is unique to humans, but this supposition has not stood the test of time. There are many examples of non-humans utilizing tools to increase fitness, including a recent study that observed the use of fire as a tool in a non-human.

Bonta M, Gosford R, Eussen D, Ferguson N, Loveless E, and Witwer M. 2017. Intentional fire-spreading by "firehawk" raptors in Northern Australia. *Journal of Ethnobiology*, 37:4, 700-718.

Shumaker RW, Walkup KR and Beck BB. 2011. *Animal Tool Behavior: The Use and Manufacture of Tools by Animals*. Johns Hopkins University Press, Baltimore

---

Farming and agriculture

Sometimes farming or agriculture is suggested as a uniquely human trait. In the biological literature farming and agriculture are both considered to be examples of symbiotic relationships, but agriculture signifies a more tightly evolved and specialized symbiotic relationship such that, for the species involved, the relationships may be obligate (they cannot survive without each other). There are many examples of non-humans entering into farming-like relationships with other species, but obligate relationships, non-human agriculture, has so far only been described in a handful of species including humans, termites, beetles, and ants. While humans are thought to have learned to grow crops through experience and cultural transmission of information between generations as long as 20 thousand years ago, agriculture as a set of adaptive traits shared between symbiotic species may have evolved in ants as long as 50 million years ago.

Schultz TR and Brady SG. 2008. Major evolutionary transitions in ant agriculture. *Proceedings of the national academy of sciences of the United States of America*, 105:14, 5435-5440.

Mueller UG, Gerardo NM, Aanen DK, Six DL, and Schultz TR. 2005. The evolution of agriculture in insects. *Annual review of Ecology Evolution and Systematics*, 36, 563-595.

Ecosystem Engineers and Indirect Effects

It is a commonly held belief that only humans possess the power/ability to alter the environment to their benefit and go do so on a global scale. Many species have the ability to alter their environment in order to increase their fitness and do so at varying scales. Allelopathic trees produce secondary compounds in their tissues that are not directly related to survival (i.e. not required for photosynthesis), but have an indirect adaptive benefit because they leech into the soil surrounding the plant and inhibit the growth of other species of plants nearby. Some species exert such a strong influence on their environment that we refer to them as ecosystem or ecological engineers. Beavers are a classic example of an ecosystem engineer; they take a terrestrial habitat where terrestrial species dominate and transform the landscape in an aquatic habitat dominated by aquatic species.

In the examples above there is a direct adaptive benefit to the individual/species engaging in altering the environment. It is sometimes argued that humans are unique because we alter the environment accidentally or unintentionally. While it is certainly true that humans often cause environmental “harm” by not fully thinking out the repercussions of our actions, there are many examples of “indirect effects” in ecology where one species influences another species through an indirect and sometimes unexpected pathway. Trophic cascades are a classical example whereby alterations to species abundance or diversity at one trophic level propagate up and down a food chain. Some species are particularly important to shaping biological communities through indirect effects and we call these species “keystone species”. The classic example of a keystone species is starfish in the intertidal ecosystem: starfish predation keeps the mussel population from outcompeting other species, allowing a complex and diverse ecosystem to form. Starfish did not set out to alter the ecosystem, in fact they prefer to eat mussels and would likely do well in a mussel-dominated ecosystem, but they alter ecosystem function in a dramatic way all the same.

But only humans alter the GLOBAL ecosystem accidently! Well, no. While beavers change the environment on a landscape level, earthworms can alter the environment on a continental scale by changing soil properties such that the biodiversity of tree species and their associated fauna is affected, in turn broadly altering ecological function over massive distances. Emerging evidence suggests that the daily vertical movement of microscopic zooplankton enmasse in the world's oceans can cause significant mixing, in turn affecting global ocean circulation and climatic patterns. The daily movement of zooplankton provides individuals/species with an adaptive benefit to avoid predation and the influence of this behavior on ocean currents and global climate is simply incidental. Taken to the extreme, it is thought that the evolution of unicellular photosynthetic plankton drove the accumulation of oxygen in Earth's atmosphere allowing for oxygen-breathing species to evolve; certainly the plankton did not plan that!

Houghton IA, Koseff JR, Monismith SG, and Dabiri JO. 2018. Vertically migrating swimmers generate aggregation-scale eddies in a stratified column. *Nature*, 556, 49-500.

Ferenc J. 2009. Keystone species and food webs. *Philosophical transactions of the royal society B-Biological Sciences*, 364:1524, 1733-1741.

Wright JP and Jones CG. 2006. The concept of organisms as ecosystem engineers ten years on: progress, limitations, and challenges. *Bioscience*, 56:3, 203-209.

Relational Values

Relational values may be individual or collective relative to non-human species. "Individual Identity" and "Stewardship" values are held individually. "Cultural Identity", "Social Cohesion", "Social Responsibility", and "Moral Responsibility" values are held and shared by a human collective. A human collective is scalable and may be a small community like a family or a larger group such as the people of a tribe, town, valley, shoreline, island, state, nation, or planet.

Individual Identity - Other species are important to me as a person. I am who I am because of my respect and admiration for other species. The other species around me help me to define who I am.

Stewardship - The health of other species is important to me. I value the health and well being of other species. I lead a better life when other species around me live good lives.

Cultural Identity - Other species are important to my people. As a people we need other species in order to be who we are.

Social Cohesion - I can connect with other people better when other species are present. Other species help me to develop relationships with other people.

Social Responsibility - Caring for other species allows me to care for other humans both in the present, but also in the future. Other species allow me to care for other humans.

Moral Responsibility - Caring for all species, regardless of species, is right and moral. The human species is as important as other species.

Chan KMA, Balvanera P, Benessaiah K, Chapman M, Diaz S, Gomez-Baggethun E, Gould R, Hannahs N, Jax K, Klain S, Luck GW, Martin-Lopez B, Muraca B, Norton B, Ott K, Pascual U, Satterfield T, Tadaki M, Taggart J, and Turner N. 2016. Why protect nature? Rethinking values and the environment. *PNAS*, 113:6, 1462-1465.