Bio 45 – Lect. 2-01 The Basics of Cost/Benefit Thinking

I. Adaptation and the Concept of Reproductive Selfishness

A. Genetic Variants + selection among individuals + inheritance = adaptation

B. Limits on the process of adaptation

- Presence of necessary genetic variation
- Ever changing selection
- Constraints and tradeoffs
- No mechanisms for evolutionary foresight

C. Selection can be seen as competition among individuals for genetic representation in the next generation. This competition is for food, shelter, mates and resources for offspring. Competition can be:

1. indirect – each individual independently deals with selection
   - no direct interactions, e.g., best design for finding food or avoiding disease
2. direct - the interaction among individuals is the selection (see II. B)
   - exclude competitors from mates or resources, e.g., territoriality or dominance
   - eliminate competitors or their kids, e.g., sperm competition or infanticide

D. We basically assume that over time (and recognizing the limitations of adaptation (I B) that **individuals in populations will tend to be well designed to deal with the selective pressures they face** (ancestors have faced).

E. A key feature of organismal design is **reproductive selfishness**. Designs that do not increase individual fitness relative to others would not be favored in this competition for representation view of selection.

F. The paradox to solve – later in the course:

How can animals be social if they are designed to be reproductively selfish?

II. Theories about the Design of Behavioral Adaptations

A. Evolutionary view of <u>how</u> things are <u>expected</u> to work

- We shift to a more formal approach to how things <u>ought to</u> be designed -- how different designs might affect fitness? How <u>should</u> we expect selection to have designed particular behaviors?
- We assume that natural selection, given the time and genetically based variation, should produce well-designed behaviors (adaptations). We hypothesize how a well designed animal should behave in a given situation? We then test if animals do things the way we predict they should. We modify the process until we learn something - specific or general - about the behavior.
- In this course, we focus on a variety of models and theoretical concepts, look at how these models can be tested, and see how well they describe or predict what actually happens.

B. In this context we will take three views of selection (the last two will come later in the course):

1. Natural Selection = abiotic (e.g., climate)+ other species (e.g., food, predators)

   Problems: obtaining food, being safe

   Theory: Optimization Theory -- “the best way (among alternatives) to do it”

2. Natural Selection = others of the same species (mates, competitors)

   Problems: competing for resources and mates, producing offspring, communicating

   Theory: Game Theory -- “the best way depends on what others are doing”

3. Social and Sexual Selection = others of the same species (mates, competitors)

   Problems: competing for and choosing mates, parental care, cooperation and helping

   Theory: Sexual Selection and Inclusive Fitness Theories -- “the best way may differ depending on your sex, social status or relatedness”

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II. Organismal Economics - Conceptual Basis for cost/benefit thinking

A. Design and Cost/Benefit thinking.

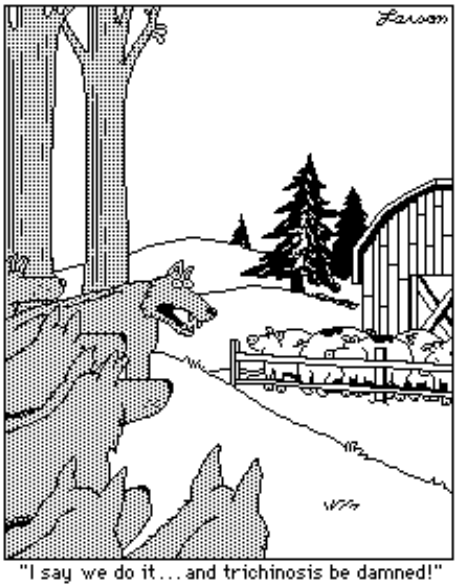
1. Any trait involves a set of costs and a set of benefits. The costs include energetic costs for producing and maintaining it as well as the constraints it puts on other aspects of the individual's phenotype and thus its overall fitness. The benefits are gains to an organisms' relative fitness due to having the trait. Thus the **net advantage** of any trait is the fitness **benefit** of that trait **minus** the **costs** to fitness of having the trait. Since costs include things like risk, they are often hard to measure – especially if costs and gains must ultimately be converted to units of relative fitness. Thus we tend to use a variety of proxies for fitness – proxies we can relate to fitness and yet more easily estimate or measure. The most important proxies are time and energy.

B. Time and Energy Budgets

1. Animals have a finite amount of time and energy during their lifetime (or at a critical period during it). They use this energy for: **Growth** (e.g., building muscle or getting big), **Reproduction** (e.g., competing for mates or making & caring for offspring), and **Maintenance** (e.g., finding & catching food, avoiding predators, or repairing damage)
2. Since total energy (time) is allocated among these three, any increase in one means the others must decrease. The "goal" is to maximize survival and reproduction relative to others. Those animals that obtain and allocate energy (time) most profitably while minimizing costs and risk will be favored by selection. The long-term result should be optimal energy budgeting (maximized "profit").
3. Time and energy are often interchangeable units– time is energy physiologically. Since we are most interested in the relative fitness of individuals with different traits, we can substitute time for energy. For example, suppose there is a basic cost (in calories) per minute of flight for bumblebees. Then two bees that differ in how long they fly before finding nectar will differ in the costs of foraging. To compare them we need only assume they have the same calorie per minute of flight costs and use the time they spend flying as the estimate of their costs.

B. Three caveats about using cost/benefit thinking – more details later

1. Our models do not <u>directly</u> test the theory of evolution by natural selection. We take it as a given. However, if we cannot make models and predictions based on this assumption that work, then we have to deal with the possibility that our assumption is wrong.
2. The best solution (design) is not necessarily the absolute best. It is, given the given specific conditions (the problem), whichever of the alternatives available works best. Remember: the best <u>available alternative</u> for a <u>given set of conditions</u>, not the best of all <u>possible</u> alternatives.
2. We assume that <u>Energy and time are good currencies to use</u> to predict long-term reproductive success or fitness. We will look at this in more detail



Cost/benefit theory about to be tested….