**Lecture 2: The Nature of Adaptation**

**Outline**

- Rationale
- Concepts and definitions
- Adaptation at the individual level
- Adaptation at the population level

I. Rationale

A. Understanding adaptation is fundamental to understanding fish ecology. Why?
- the environment is always changing
- you must adapt or perish
- often a balancing act!

B. Two types of adaptations
- adaptations of *individuals* through their lifetime
- adaptations of *populations* over the generations

II. Some concepts and definitions

At some level, survival may be seen as a game you are playing to win

A. The name of the game

1. Individuals: fitness = ?
   – survive long enough to leave viable offspring
2. Populations: persistence
   - keep individuals around through time

B. Selection pressures (a.k.a. selective forces, agents of natural selection)
- changes in the biotic or abiotic environment that favor a change (or an optimization)

C. Adaptation
- a change in the characters of an organism (morphology, physiology, or behavior) to cope with a selection pressure
- can result from changes in genotype (at the population level) or to phenotype (at individual level = *phenotypic plasticity*)
- *adaptive response* – the reaction of an organism or a population to a change in its environment

D. Genotype
- genetic constitution, genetic information carried on the chromosomes
- inherited from the parents
- all else equal, would produce predictable traits

E. Phenotype
- observable characters (morphology, physiology, behavior)
- produced by interaction of genotype with environment…
- especially in the developmental period

* determines fitness

II. Adaptation of individuals
- Criterion for success is fitness, which has its survival and reproductive components

A. Limits and loopholes in individual adaptation
- genotype (evolutionary history of the population) provides the ultimate constraints on the magnitude and speed of adaptation
- however, many fishes are adept at changing phenotype within these constraints

B. Some types of individual adaptations
- based on environmental cues – more later

1. Morphological
- color change to match surroundings or to attract mates
- sex reversal based on male: female ratio
- stunting to deal with competition

2. Behavioral
- learning
- aggressiveness/dominance hierarchies

3. Physiological
- maintaining homeostasis – stable internal conditions to sustain life processes
- egg resorption in stressful times

C. How does the adaptive response work?
- i.e., how are environmental cues transduced into changes?

1. The affector-receptor-transmitter-effector-output system
- see the figure
- note feedback loops and adaptive response

2. Example
- why fish don't overeat
- see figure

D. Strategies of physiological adaptation

1. Regulators

a. Pros and cons
- pro: control environment
- pro: live in wide variety of environments
- con: energetically costly

b. Example: osmosis in bony fish
- see figure
- pro: live in fresh or salt water
- con: in fresh water, must maintain large kidneys, chloride cells, secrete copious urine

2. Conformers

a. Pros and cons
- pro: energetically cheap
- con: restricts you to a limited number of environments

b. Example: osmosis in sharks
- see figure

- pro: maintain body tissues ~ salinity of seawater
- con: can only live in seawater

E. Acclimation
- adjustment to existing conditions
- note that phenotype may vary because of history of exposure to past conditions
- e.g., minnows can survive in 4C water, but a minnow moved from warm to cold water will be thermally shocked; must change its temperature gradually
- hence, environment has an effect on adaptation

III. Adaptation of populations

A. Populations adapt by producing different phenotypes, via changes in the gene pool
- changes to members increases likelihood of persistence
- relies on inheritance through generations

B. Sources of change in the gene pool (population genetics 101)

1. Mutation
- random changes to DNA during recombination and replication
- only a small portion proves selectively advantageous

2. Random genetic drift
- change of allele frequencies over time in small populations because of sampling
  - random sampling of breeders
  - random sampling of gametes

3. Migration
- genetically effective migration = movement from birth population to another, followed by successful reproduction
- can add variation to a gene pool that has lost variation due to drift

4. Selection
- directed changes to the gene pool because of selective forces
- see the figure

C. Partitioning of genetic diversity
- overall variation = within populations + between populations

D. Strategies for apportioning genetic diversity

1. Type I: high genotypic diversity, low phenotypic plasticity
- many genotypes available for different selective regimes
- high specificity and fitness for one environment
- e.g., brook trout

2. Type II: low genotypic diversity, high phenotypic plasticity
- less variation at the individual level
- more generality and individual adaptibility
- e.g., common carp
- deal well with human world

IV. The Coho salmon example
- see figure

- note interplay of factors

V. Conclusions

A. Adaptation vs. adaptationism
- not all traits observed are adaptive!

1. Convergence and homology
   - some traits are adapted independently to common environment
   - others may be evolutionary baggage

2. Evolutionary tradeoffs
   - adaptation may work well for one challenge but not another
   - tradeoffs may make some traits maladaptive in some contexts

B. Interactions between individual and population adaptation – not always a win-win
- what's good for individuals may not be good for populations, and vice versa
- e.g., altruism, aggression

C. The speed of adaptation

1. Individual vs. population
   - individual – faster, but more limited in scope
   - population – slower, but scope may become broad

2. Limits
   - see figure