Animal Ecological Physiology BIOL3045/3945 Study Notes

Ecological and Evolutionary Physiology

- Physiology = provides mechanisms
- Evolution = Defines history
- Ecology = Describes patterns
  - Need to understand all of these to determine how an organism will respond to an environmental change such as climate change
  - Correlations of animal population shifts with increasing temperatures can suggest climate change is the cause however may be due to other factors such as fishing/hunting, introduced species etc.
  - Therefore, need to use experimental manipulation to explain cause and effect = experimental biology

Sources of variation

- Individuals
  - Principal target for selection - differences in individuals allows those with more preferable traits to be selected for
  - Association of traits can be used to explain function e.g. rats with faster muscle activation have lower ryanodine receptor mRNA - test to show that one causes the other
- Populations
  - Phenotypic variance = genetic effects + environmental effects + Interaction
    - Genetic effects = natural and artificial selection (populations are different in the same environment)
    - Environmental effects = deviation from genetic values (same populations change in different environments)
    - Gene-Environment interaction = response to variable environments (different populations have different responses in different environments)
- Species

Phenotypic Plasticity

- Changing phenotypes of the same organism due to different environments - differences within individuals
- When environment causes development of alternative phenotypes by a given genotype
- Every individual inherits the genetic capability to produce each of the different phenotypes however the actual phenotype depends on the particular environment it experiences
- Reaction norm = phenotypic expression of a single genotype exposed to different acute environmental conditions
- Phenotypic plasticity causes a shift in a reaction norm due to a chronic change in the environment

Mechanisms underlying phenotypic plasticity

- Development
  - Genotype stays the same but access to genes altered
  - Genetic capability maintained across generations
  - Developmental modifiers selected for
- Acclimation
  - Physiological change in response to an environmental factor
  - Reversible changes within adult phenotypes
  - Genetic capability not altered

- Selection
  - Changes in genotype
  - Genetic capability to produce phenotypes may also change
- Generalist-Specialist trade-off
- Stable environmental conditions across generation
  - Selection for phenotypes that are suited to those conditions = specialisation
- Variable environmental conditions
  - Favours phenotypes that maintain performance across a broad range of conditions = generalisation
- Trade-off
  - Maximum performance of generalists is lower than that of specialists (their reaction norm is wider but the peak is not as tall as specialists)

Thermal Adaptation

- Thermal biology = temperature influences all biological functions and temperature responses at the molecular level influence whole-animal performance and ecology
- Responses to temperature variation
  - Daily = behaviour in environment
  - Seasonal = migration
  - Years = adaptation
- Effect of temperature on organisms
  - Below optimum temp = Thermodynamics
    - Reaction rates slow down
    - Capacity limitation
  - Above optimum temp = Damage
    - Proteins denature, membranes melt
    - Critical temp = death
- Co-evolution
  - Endotherms - regulate body temp to regulate internal processes
  - Ectotherms - live in particular thermal environments where internal process are optimised

Adaptation

- Definition: Heritable changes in a phenotype that results from natural selection and increases fitness of an organism in a particular environment
- Measuring fitness = reproductive output (or proxy measures such as locomotion and metabolism)
- Natural selection acts on genetic variability in a population
  - Stabilising = decrease in genetic variance
  - Directional = shift in allele frequencies
- Adaptation of reaction norms
  - Animals distributed across different climate gradients
  - Different selection pressures in different environments creates new reaction norms - optimum temp shifts up or down shifting the reaction norm with it
  - Eventually if one species is separated in different climate gradients for long enough, reproductive isolation and occur and the species will no longer be able to mate creating 2 different species
- Reaction rate-temperature relationship
  - Slope of the relationship = E
  - Thermal specialists have high E (large slope) because small changes in temp cause large change in reaction rates
  - Thermal generalists have low E (small slope) because they can function pretty well in many temperatures so a small increase in temp only causes a slight change in reaction rate
- Genetic drift