BIO 390 - GENETICS

EVOLUTIONARY GENETICS

OVERVIEW

- Evolution consists of continuous heritable change both within and between lines of descent.

- Mutations in DNA causing heritable variation in physiology, development, and behavior provide the raw material for evolutionary change. Natural selection is the differential reproduction of genotypes that differ in these traits.

- Both natural selection and random events contribute to evolutionary change.

- Genes have similar DNA sequences as a result of common descent, though the degree of similarity may vary considerably. Genes underlying animal development are highly conserved.

- Species consist of populations that can exchange genes.

- Acquisition of new DNA makes evolutionary novelties possible

EVOLUTION

- Darwin provided a plausible explanation for evolution: natural selection

- All living organisms are related through descent from common ancestor
  - homologous features have the same developmental origin inherited from a common ancestor
    - analogous features have independent origin
    - similarities of DNA and protein sequences allow inferences about evolutionary origin

DARWINIAN EVOLUTION

- Principle of variation. Among individual members of a population there is variation in morphology, physiology, and behavior.

- Principle of heredity. Offspring resemble their parents more than they resemble individuals to which they are unrelated.

- Principle of selection. Some variants are more successful at surviving and reproducing than other variants in a given environment. Such individuals are naturally selected.

EVOLUTIONARY HISTORY

- Phyletic evolution: change within a continuous line of descent

- Diversification: many different contemporaneous species evolved from common ancestor (branching)

- Natural selection converts heritable variation among members of a population into heritable differences among populations

HERITABILITY OF VARIATION

- For evolutionary change, phenotypic variation must be heritable

- Not all variable traits are heritable
  - e.g., metabolic responses to stress
  - e.g., behavior versus structure
  - not always easy to determine heritability

- In some cases, there is substantial genetic variability and no morphological variation
  - such characters are canalized characters
    - wild-type *Drosophila* have four scutellar bristles in a very wide range of environments
  - genetic differences revealed by stress
    - recessive mutation *scute* produces a wide variation in number of scutellar bristles

VARIATION WITHIN AND BETWEEN HUMAN POPULATIONS

- Within populations:
  - ~33% of protein-encoding loci are polymorphic
  - additional nucleotide diversity in introns, regulatory sequences, flanking sequences

- Between populations
- frequencies of alleles may vary, especially for morphological traits
- in humans, most (~85%) of total genetic variation is found *within* populations

BIOLOGICAL ISOLATING MECHANISMS

- Prevent successful reproduction between groups

- Prezygotic isolation
  - separation in times or places of sexual activity
  - behavioral or physical incompatibility
  - gametic incompatibility

- Postzygotic isolation
  - failure of hybrid to develop
  - hybrid sterility (F_1 or F_2)

ORIGIN OF NEW GENES

- Polyploidy

- Duplications
  - small sections of DNA containing one or more genes
  - duplicated sequence may diverge in function
    - e.g., hemoglobins

- Imported DNA
  - e.g., origin of chloroplasts and mitochondria through endosymbiosis
  - horizontal transfer through viruses and transposons

FUNCTIONAL CHANGE AND MUTATION

- Two extremes with regard to mutation and functional change
  - virtually all amino acids can be replaced while maintaining original function
  - single mutation may give rise to new function

- When >1 mutation is required for new function, order of mutational events may be important
  - many evolutionary failures

GENETIC EVIDENCE OF COMMON ANCESTRY

- Near universality of genetic code and conservation of translation mechanism

- Conservation of homeodomain control of development in animals

- Comparative synteny maps

- Analysis of protein and DNA sequences
  - comparative genomics and proteomics
  - conserved sequences are most informative