Evaluating competing hypotheses

- We challenge hypotheses with experiments and observation

Inheritance of acquired characteristics

- This is the idea that individuals change in response to their environment, and pass those changes on to their offspring
  - Example: giraffes reaching for food
- It is now known that while individuals do often change in response to their environment, such changes are not (usually) passed on to offspring

Inheritance of acquired characteristics vs. natural selecton

- Raise several populations of mice in the lab
- In the acquired group, every generation stretch (or chop off) their poor little tails
- In the selection group, every generation, allow mice with longer (or shorter) tails more chances to breed
- In the control group, do everything the same (including manipulations)
  -
- Measure natural tail length at the beginning of the experiment, and after 100 generations.

Goal-directed evolution

- This is the idea that organisms evolve towards specific goals
  - Complex, multicellular organisms
  - Big-brained humans
- If the organism is moving toward a goal, it should move more or less in that direction all the time

Goal-directed evolution

- There is a great deal of observational evidence against goal-directed evolution:
  - Vestigial traits
  - Bidirectional evolution
    * Finch beaks get larger, then smaller
    * Birds gain, then lose, flying ability
    * Things that become parasites may become much smaller and simpler

The good of the species

- Selection operates on individuals; individuals are not adapted to act for the good of the species
- The evolution of co-operation always involves tension between what is good for the group, and what is good for the individual
  - If 'cheating' strategies can evolve, they will
  - A **cheater** benefits from co-operation, but does not participate
- Individuals are usually selected to act for themselves, sometimes for the group, and rarely or ever for the species

Example: calculating allele frequencies

- I collect 20 peppered moths from a particular place, and find that 4 have genotype A_1A_1, 8 have genotype A_1A_2, and 8 have genotype A_2A_2.
- What is the observed frequency of each allele?
- What is the expected frequency of each genotype under the Hardy-Weinberg assumptions?
- What is the observed frequency of each genotype?

What do we mean by expected?

- If we flip a fair coin 100 times, what is the expected number of heads?
  - What if we flip it 25 times?
- We don't expect to get exactly the expected value.
- The 'expected value' is an average of what is expected under our assumptions

How do you know a coin is perfectly fair?

- You can never be sure that a coin is perfectly fair, you can only evaluate your evidence that it's more or less close to fair.
- Similarly, we never have evidence that a population is exactly in Hardy-Weinberg equilibrium, we can only evaluate our evidence that it is not in equilibrium, or our evidence that it is close to equilibrium.

Hardy-Weinberg equilibrium

- When do we expect genotype frequencies to behave like coins?
- Alleles selected at random from the previous generation:
  -
  -
- If these assumptions hold, we expect **Hardy-Weinberg equilibrium**
  - Hardy-Weinberg distribution, with no change in allele frequencies from generation to generation.

Differences from equilibrium

- If we observe large differences from the Hardy-Weinberg equilibrium, this is usually a sign that mating is not random, or that natural selection is operating
- The analysis tells us that something is going on, but not what
- Hardy-Weinberg is a **null model**: it tells us what to expect if complicating effects are absent

Reuniting — S26.4

- What happens when isolated populations come back into contact?
- Usually this happens when a geographic barrier disappears
  - a land bridge forms between an island and the continent
  - a river changes course

Fusion

- When two isolated populations come into contact, they may **fuse** – go back together
  - Adaptive differences may be small
  - Adaptive differences may be overwhelmed by gene flow

Reinforcement

- In some cases, hybrid offspring may have low fitness
  -
  -
- In these cases we expect natural selection for traits that **reinforce** the distinction between the two species
  - They avoid mating, using coloration, timing, courtship rituals

Species divergence in allopatry — S26.2

- **Allopatry** refers to organisms living apart from each other
- If two populations are isolated from each other, we would expect that they might diverge. Why?
  -
  -
    -

Mechanisms of isolation

- Isolated populations of the same species can develop if some individuals **disperse** (move) to a new area and **colonize** it (establish a new population).
- Isolated populations of the same species can develop by **vicariance** – when a population is split by a geographical or ecological barrier

Example: ratites

- The ancestors of today's ostriches, emus, etc. were isolated when the super-continent of Gondwanaland drifted apart starting about 140 million years ago

Species divergence in sympatry — S26.3

- **Sympatry** refers to organisms living in the same geographic area
- In general, it should be hard for populations of the same species living in sympatry to diverge.
  -
- Divergence by partitioning habitats — Fig 26.10
  - In some cases, gene flow will prevent divergence
- Divergence by genetic incompatibility
  - In some cases, one will drive the other extinct via competition

Monophyletic group

- A **monophyletic group** is a group *defined by* a single common ancestor
  - All descendants of the ancestor must be in the group
- Monophyletic groups can also be called **clades** or **taxa**.
- As biologists, we should try to think in terms of clades
  - Are flying vertebrates a clade?
  - What are some prominent groups that are not clades?
    -

Sister taxa

- Sister taxa can be a useful way of thinking about trees
  - two taxa that share a common node
  - You need to take the whole taxon, when appropriate
- E.g., sisters of: *Homo sapiens*; *Homo erectus*; humans?
  -

Reading phylogenetic trees

- The tree indicates the pattern of branching of **lineages** (evolving lines)
- Tips are *assumed* by the model to be monophyletic
- A tree is a model of how evolution occurred

Morphological innovation

- A new adaptive mutation can open up further possibilities for adaptation
  - **Hox gene** mutations allowed early animals to develop complex body plans
  - The arthropod body plan
    - insects, arachnids, crustaceans ...
  - The tetrapod body plan
    - reptiles, mammals ...

Hox genes — Fig 27.21

- **Hox genes** are involved in determining the identity of different body parts
- Taxa with simpler body structures tend to have fewer hox genes
  - Phylogenetic comparisons provide important evidence that hox genes were involved in evolution of complex body plans
- Evidence that new hox genes were largely created by **gene duplication** events
  - A kind of mutation; random change
  - If it persists, it was selected for

Looping

- How did we get so far?
  - Big brains, complex culture, technology, language
- Probably many of the adaptations our ancestors had set the stage for new adaptations
  - A lot of these would have "looped" through brain development
  - Bigger brains open the way for more culture, or language, or complex foraging
  - These strategies could favor even bigger brains