**Chapter 1**

**The Virus and the Whale**

Biological evolution

* Any change in the inherited traits of a population that occurs from one generation to the next

Evolution explains the diversity of life

Understanding evolution has practical implications

* How do pathogens become drug resistant?
* What is the source of new pathogens?

How do we know whales are mammals?

* Whales share **synapomorphies** with mammals
  + Mammary glands
  + Three middle ear bones
  + Hair (in developing embryos)
* Similarities with fish arose through **convergent evolution**
* Fossil whales share synapomorphies with modern cetaceans

Fossils reveal links to land mammals

* Shape of astragalus connects to artiodactyls

Fossil sequence documents transition from land to water

Documenting the transition from land to water

* Isotopic analysis of fossil teeth
* Fossil analysis of hindlimb loss

Isotopic analysis of fossil teeth

* Terrestrial animals drink freshwater; marine animals drink saltwater
* O18/O16 ratio higher in saltwater
  + Higher ratio in teeth of marine animals

Fossils document hindlimb loss

Changes in gene expression led to hindlimb loss

* Hindlimbs begin to form but do not fully develop

Research gives more clues about whale evolution

* Loss of teeth in baleen whales
* Evolution of brain size and complexity
* Whale diversity over evolutionary time

Baleen whales lost teeth

* Ancestors of all modern whales had teeth
  + Also produced small patches of baleen
* Baleen completely replaced teeth in Mysticetes
  + Genes for building teeth disabled

Brain size and complexity the result of natural selection

* Sociality promoted the evolution of large brains
  + Form lasting alliances
  + Competition for mates
  + Complex communication

2009 H1N1 Flu Outbreak

* Spread worldwide in a matter of weeks
  + First noticed in Mexico
* 16,000 deaths in U.S.
* Evolutionary biologists helped solve the mystery of its appearance

Why do new flu vaccines need to be made each year?

* Mutations may be harmful or beneficial

Viral strains with beneficial mutations increase in frequency through **natural selection**

* Viral strain no longer recognized by immune system
* Requires new vaccine

Viral **reassortment** can lead to devastating consequences

* Immune system cannot recognize distinct surface proteins
* New strains can cause significant mortality
  + Spanish flu (1918)
  + Asian Flu (1957-58)
  + Hong Kong Flu (1968-69)
* The 2009 outbreak was the result of reassortment

Common misconceptions about evolution

* Evolution is “just” a theory
  + Scientific theories backed by multiple lines of evidence
  + Provide overarching explanation for major aspects of natural world
  + Other scientific theories
  + Gravity
  + Plate tectonics
  + Germ theory
  + Evolutionary theory overwhelmingly accepted by scientists
* Evolutionary biologists understand everything about the history of life
  + Biologists continually discover new aspects of life
    - All evidence fits within context of evolution
* Evolution explains the origin of life
  + Evolution deals with how life has changed after it originated
  + Other scientific fields address the origin of life
* Evolutionary biologists search for missing links
  + Biologists expect the fossil record to be incomplete
  + Finding direct ancestors is unlikely
  + Available evidence strongly supports relationships between current and past species
  + Relationships shed light on how traits evolved
* Evolution violates the second law of thermodynamics
  + Holds that disorder increases in *closed* systems
  + Earth is not a closed system
  + Sun provides constant input of energy
* Evolution is natural selection
  + Natural selection is a *mechanism* of evolutionary change
  + Other mechanisms:
    - Genetic drift
    - Sexual selection
* Evolution is entirely random
  + Evolution includes random and non-random components
    - Mutations are random
    - Natural selection is the non-random spread of particular mutations
  + **Convergent evolution** demonstrates that evolution is non-random
    - Phenotypes are predictable when environments are similar
* Organisms evolve adaptations they “need”
  + Evolution cannot identify needs
    - Mutations do not occur because they would be adaptive in an environment
    - If beneficial mutations *happen* to occur they may increase in frequency through selection
* Evolution is a march of progress
  + Evolution is not ladder-like
    - New species result from branching events
* Evolution always moves from simple to complex
  + Evolution can also move from complex to simple
    - e.g. mitochondria evolved from free-living bacteria
* Evolution results from individuals adapting to environment
  + Evolution only works on inherited traits
    - Acquired changes are not passed to offspring
  + *Populations* evolve; individuals do not
    - Evolution results from changes in allele frequencies
* Organisms are perfectly adapted to their environment
  + Natural selection can only work with available variation
    - Constrained by physics and development
  + Many traits involved in trade-offs
    - e.g. human brain size
* Evolution happens for the good of the species
  + Evolution selects traits that are beneficial for *individuals or their genes*
    - Traits that are bad for individuals (or genes) will not be selected *even if* they are good for the species
* Evolution promotes selfishness and cruelty
  + Natural selection favors traits that increase reproductive success
    - Different conditions select for different traits
    - Cooperative traits are beneficial under some conditions
* Evolution seeks peaceful harmony in nature
  + Natural selection favors traits that increase reproductive success
    - Can result in exploitation
* Life can be divided into higher and lower forms
  + All of life is adapted to the environment in numerous ways
    - Environments differ so adaptations differ
    - One adaptation is not “superior” to another adaptation
* Evolution has produced a stable diversity of life
  + Extinction means diversity is not stable
    - 99% of all species that ever existed are extinct