UNIT 4

Introduction: Clown, Fool, or Simply Well Adapted?
Living organisms are adapted to their environment
What is an adaptation?

___________________________ adaptations
___________________________ adaptations
___________________________ adaptations
___________________________ adaptations

DARWIN’S THEORY OF EVOLUTION
13.1 A sea voyage helped Darwin frame his theory of evolution
In 1859, Darwin published

How did he come up with this way of thinking?
Pre Darwinian Ideology
The Greek philosopher

In the century prior to Darwin, the study of _______________ suggested that species had changed over time
Jean Baptiste Lamarck suggested that life on Earth evolves
His mechanism included:

Mechanism didn’t truly prove evolution!
Darwin embarked on a 5 year voyage as a naturalist on the _______________
Darwin was influenced by Lyell’s _____________________
He came to realize that the Earth was very old and that, over time, present day species have arisen from ancestral species by natural processes
The primary mechanism of

13.2 Darwin proposed natural selection as the mechanism of evolution
Darwin observed that

Which enable Darwin to infer that
Darwin found convincing evidence for his ideas in the results of _______________________,
the selective breeding of domesticated plants and animals

Note these important points
Individuals do not evolve: ________________________________
Natural selection can

Evolution is not goal directed and

What evidence is used to support the Theory of Evolution?
13.3 Scientists can observe natural selection in action

13.4 The study of fossils provides strong evidence for evolution
The fossil record shows that organisms have evolved in a historical sequence
The oldest known fossils are ________________________________
The oldest eukaryotic fossils are ________________________________
Many fossils link early extinct species with species living today
A series of fossils documents the evolution of whales from a group of land mammals
13.5 A mass of other evidence reinforces the evolutionary view of life
Biogeography,

Darwin noted that animals on islands resemble species on nearby mainland more
closely than they resemble animals on similar islands close to other continents

Comparative Anatomy
Comparative anatomy is

Homology

Comparative embryology

Many vertebrates have common embryonic structures, revealing _________________
When you were an embryo, you had a tail and pharyngeal pouches (just like an
embryonic fish)
Some homologous structures are _________________ organs
For example, the pelvic and hind-leg bones of some modern whales
Molecular biology
Molecular biology:

All living things share a common DNA code for the proteins found in living cells
We share genes with bacteria, yeast, and fruit flies
13.6 Homologies indicate patterns of descent that can be shown on an evolutionary tree
Darwin was the first to represent the

These diagrams have however been slightly modified is some instances.

THE EVOLUTION OF POPULATIONS
13.7 Populations are the units of evolution
Let define some terms
A population is

Evolution is

Populations may be isolated from one another (with little ________________), or
individuals within populations may interbreed
A gene pool is

Microevolution is

Bigger Picture
Population genetics studies

The modern synthesis connects Darwin’s theory with population genetics
13.8 Mutation and sexual reproduction produce genetic variation, making evolution possible
Mutation

Not all mutations are harmful they can also be ______________________

Chromosomal duplication is an important source of ______________________
Sexual reproduction shuffles alleles to produce new combinations

Further variation arises when sperm randomly unite with eggs in fertilization

13.9 The Hardy-Weinberg equation can be used to test whether a population is evolving

Although alleles are shuffled, the frequency of

For example, if you shuffle a pack of cards, you’ll deal out different hands, but the cards and suits in the deck do not change

Therefore to test for evolution we test for ________________________________

How?

The **Hardy Weinberg principle** states

\[ p^2 + 2pq + q^2 = 100\% = 1.0 \]

Imagine that there are two alleles in a blue-footed booby population: \( W \) and \( w \)
- \( W \) is a nonwebbed booby foot
- \( w \) is a webbed booby foot

What are the possible genotypes?

Once the frequencies are calculated you can then test the same population again in the future. If the frequencies of your alleles are the __________ then there is no evolution occurring

Remember
- If a population is in Hardy-Weinberg equilibrium,

For a population to remain in Hardy-Weinberg equilibrium for a specific trait, it must satisfy five conditions:
MECHANISMS OF MICROEVOLUTION

13.11 Natural selection, genetic drift, and gene flow can alter allele frequencies in a population.
   If the five conditions for the Hardy-Weinberg equilibrium are not met in a population, the population’s gene pool may change.

Mutations

If mating is nonrandom,

Three main causes of evolutionary change

Natural selection

Consider the boobies: Would webbed or nonwebbed boobies be more successful at swimming and capturing fish?

Genetic drift

Genetic drift

In a small population, chance events may lead to the loss of genetic diversity.

The bottleneck effect

For example, the northern elephant seal was hunted to near extinction in the 1700s and 1800s.

Genetic drift produces the ______________________________ when a few individuals colonize a new habitat.

The smaller the group, the more different the gene pool of the new population will be from the gene pool of the original population.

Gene flow

Gene flow

Four moose were taken from the Canadian mainland to Newfoundland in 1904.

These two males and two females rapidly formed a large population of moose that now flourishes in Newfoundland.

13.12 Natural selection is the only mechanism that consistently leads to adaptive evolution.

An individual’s fitness is the contribution it makes to the gene pool of the next and subsequent generations.

13.13 Natural selection can alter variation in a population in three ways.

Stabilizing selection
**Directional selection**

Directional selection is common during periods of environmental ________________, or when a

**Disruptive selection**

This form of selection may occur in patchy habitats

13.14 Sexual selection may lead to phenotypic differences between males and females
In many animal species, males and females show distinctly different appearance, called

___________________________________________

___________________________________________ involves competition for mates, usually by males

In ___________________________________________ (or mate choice),

individuals of one sex (usually females) are choosy in picking their mates, often selecting flashy or colorful mates

13.17 Natural selection cannot fashion perfect organisms

Selection can only act _______________________________________

Natural selection cannot _______________________________________

Evolution is limited by historical constraints

Birds arose as the forelimb of a small dinosaur evolved into a wing

Adaptations are often compromises

Chance, natural selection and the environment interact

**THE ORIGIN OF SPECIES**

How would you define species?

14.1 The origin of species is the source of biological diversity

**Speciation**

Every time speciation occurs,

**CONCEPTS OF SPECIES**

14.2 There are several ways to define a species

**Taxonomy**
Biological Species Concept
The biological species concept

Reproductive isolation prevents

What about those organisms that:
- have the potential to interbreed, but do not do so in nature?
- do not reproduce sexually?
- exist only as fossils?

Morphological Species Concept
The morphological species concept

It can be applied to asexual organisms, fossils, and in cases when we don’t know about possible interbreeding

Ecological species concept
The ecological species concept

Consider the cichlids, which are similar in appearance but feed at different depths in the lake

Phylogenetic Species Concept
The phylogenetic species concept

Morphological or DNA similarities or differences can be used to define a species

14.3 Reproductive barriers keep species separate

Reproductive barriers serve to isolate a species gene pool and prevent interbreeding categorized as prezygotic or postzygotic,

Prezygotic Barriers
Prezygotic barriers

In __________________________________________, two species breed at different times (seasons, times of day, years)

In __________________________________________, two species live in the same general area but not in the same kind of place

In __________________________________________, there is little or no sexual attraction between species, due to specific behaviors
In __________________________, female and male sex organs are not compatible

In __________________________, female and male gametes are not compatible

**Postzygotic Barriers**

Postzygotic barriers operate *after* hybrid zygotes are formed

In *reduced* __________________________, most hybrid offspring do not survive

In *reduced* __________________________, hybrid offspring are vigorous but sterile

In __________________________, the first-generation hybrids are viable and fertile, but the offspring of the hybrids are feeble or sterile

The process of speciation depends

**MECHANISMS OF SPECIATION**

14.4 In allopatric speciation, geographic isolation leads to speciation

In **allopatric speciation**,

____________________ between populations is initially prevented by a geographic barrier

The Grand Canyon and Colorado River separate two species of antelope squirrels

14.5 In sympatric speciation, speciation takes place without geographic isolation

In **sympatric speciation**,

____________________ between populations may be reduced by factors such as polyploidy, habitat differentiation, or sexual selection

Many plant species have evolved by **polyploidy**.

A __________________________ (*4n*) plant can arise from a diploid parent

Sympatric speciation in animals more commonly occurs through habitat differentiation and sexual selection

Remember the cichlids in Lake Victoria!

14.7 Reproductive barriers may evolve as populations diverge

How do reproductive barriers arise?

Why are they important?
14.10 Adaptive radiation may occur when new opportunities arise

In **adaptive radiation**, Adaptive radiations occur

14.11 Speciation may occur rapidly or slowly

What is the total length of time between speciation events (between formation of a species and subsequent divergence of that species)?

In a survey of 84 groups of plants and animals, the time ranged from 4,000 to 40 million years

Overall, the time between speciation events averaged 6.5 million years and rarely took less than 50,000 years

Major changes over evolutionary time (like the origin of wings) represent __________

What were some of the mechanisms of macroevolution?

**PHYLOGENY AND THE TREE OF LIFE**
15.14 Phylogenies are based on homologies in fossils and living organisms

**Phylogeny**

Hypotheses about phylogenetic relationships can be developed from various lines of evidence

- The fossil record
- Homologous morphological traits, behaviors, and molecular sequences
- Analogous similarities result from ________________ in similar environments

15.15 Systematics connects classification with evolutionary history

**Systematics**

Taxonomists assign each **species**

Each taxonomic unit is a ________________

15.16 Shared characters are used to construct phylogenetic trees

A **phylogenetic tree**
15.17 An organism’s evolutionary history is documented in its genome

**Molecular systematics**

The more recently two species have branched from a common ancestor, the more similar their DNA sequences should be

15.19 Constructing the tree of life is a work in progress

An evolutionary tree for living things has been developed, using ________________ genes

Life is divided into **three domains**

Molecular and cellular evidence indicates that Bacteria and Archaea diverged very early in the evolutionary history of life

The first major split was divergence of Bacteria from other two lineages, followed by