

Evolution

“Nothing in biology makes sense except in the light of evolution”



Theodosius Dobzhansky
(1900–1975)

What Is Evolution?

In everyday life

The evolution of iMac.



What Is Evolution?

In everyday life

The evolution of iMac.



“Change over time”

What Is Evolution?

In everyday life

The evolution of iMac.



Did each individual computer change?

What Is Evolution?

In everyday life

The evolution of iMac.



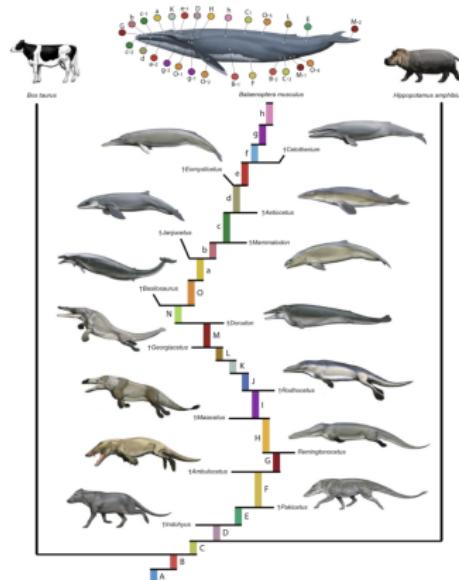
Did each individual computer change?

No, the *information* on how to build computers is what changed

What Is Evolution?

In biology

Similar to in daily life

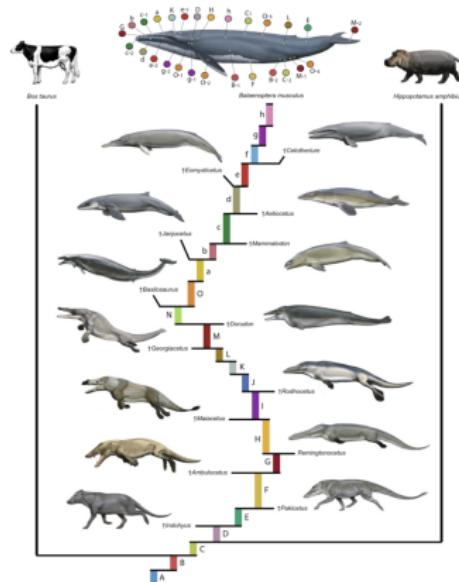


What represents the instructions/information for how to build biological organisms?

What Is Evolution?

In biology

Similar to in daily life



What represents the instructions/information for how to build biological organisms?

DNA

What Is Evolution?

In biology

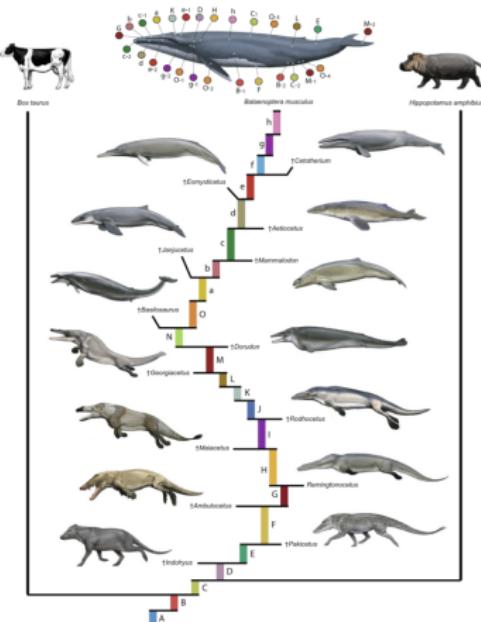
“*Heritable* change over time”

“Descent with modification”

Heritable traits are what are important for evolution

What Is Evolution?

In biology



What Is Evolution?

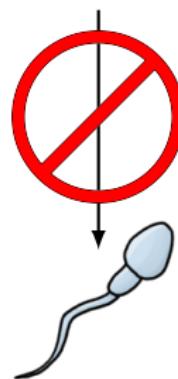
Organisms do not evolve within their lifetime (no heredity)

- “My thoughts on the relative merits of communism *vs* democracy have evolved as I’ve aged.”
- Not biological evolution, but more in the day-to-day usage

Traits that we accumulate over our lifetimes are called *acquired* traits

- We do not pass on acquired traits to our offspring (for the most part)







Heritable traits are what are important for evolution

What Causes DNA to Change Over Time?

A two-stage process:

1. The introduction of variation
2. Differential “success” of individuals with different traits

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What Causes DNA to Change Over Time?

1. Sources of variation

Are three main sources of variation:

- a. Mutations
- b. Recombination
- c. Sexual reproduction (for some species)

What Causes DNA to Change Over Time?

1. Sources of variation

a. Mutations

- DNA gets replicated prior to cell division
- During replication, errors randomly occur along the DNA sequence
 - Many neutral or nearly so (95% of human genome is non-coding)
 - Many detrimental
 - Few may be beneficial
- Only those along the **germ line** are important in evolution

Somatic *vs* Germ-line Mutations

Can divide cell lines into two types:

1. **Germ-line** cells: cells that give rise to your gametes (eggs & sperm)
2. **Somatic** cells: the rest of the cells in your body (i.e., cells that don't give rise to gametes)



Mutations in each of these cell lines have vastly different implications!

Somatic vs Germ-line Mutations

Mutations in **somatic cells** **are not** passed on to offspring

- Directly impact just your body
- Not too important for evolution (except when they kill you before you reproduce)

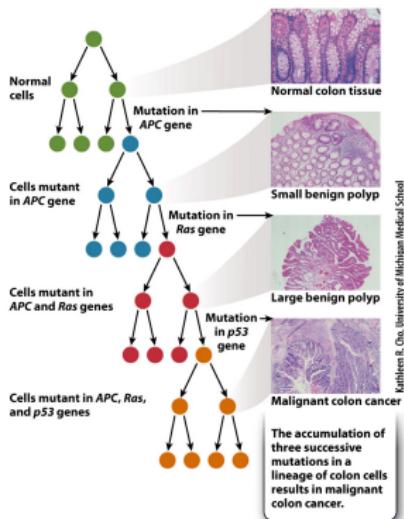


Figure 14.4
Biology: How Life Works, Second Edition
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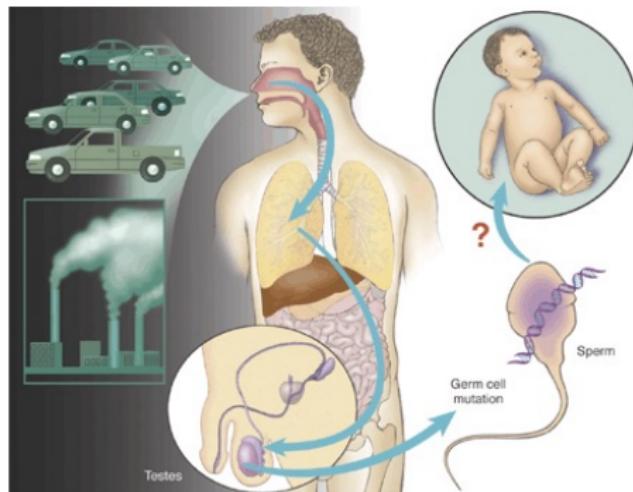


Figure 14.5
Morning glory flower. Courtesy of R. Borchelt, National Institute for Child Health and Human Development.

Somatic *vs* Germ-line Mutations

Mutations in **germ-line cells** **are** passed on to offspring

- Main types of mutation important for evolution



What Causes DNA to Change Over Time?

1. Sources of variation

Are three main sources of variation:

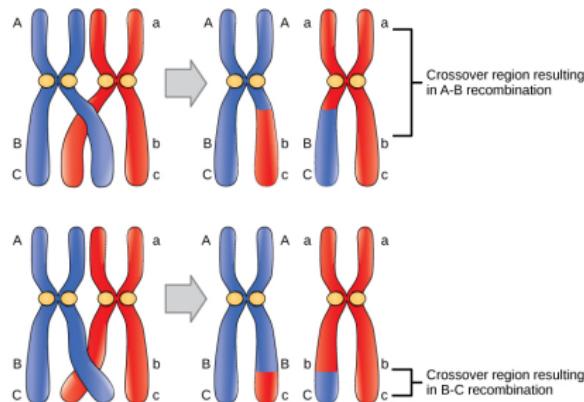
- a. Mutations
- b. Recombination
- c. Sexual reproduction (for some species)

What Causes DNA to Change Over Time?

1. Sources of variation

b. Recombination/Crossing Over

- The exchange of genetic material between homologous chromosomes during meiosis (*in-depth later*)
- Changes the *arrangement* of genetic material, but not it's *content*



What Causes DNA to Change Over Time?

1. Sources of variation

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- a. Mutations
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What Causes DNA to Change Over Time?

1. Sources of variation

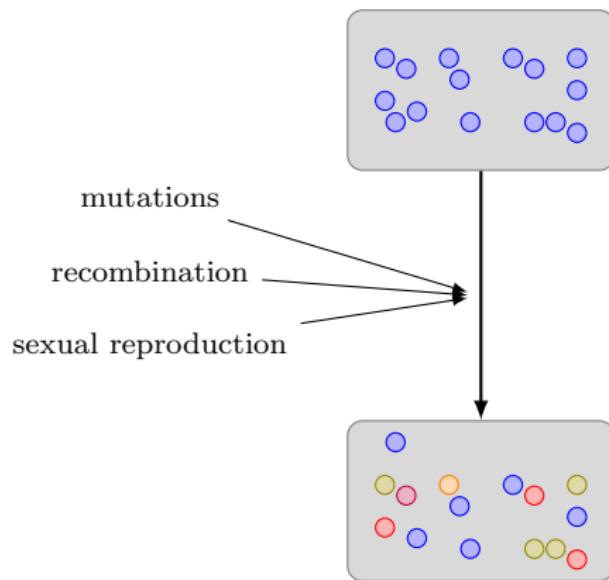
c. Sexual reproduction

- Results in new combinations of DNA sequences



What Causes DNA to Change Over Time?

1. Sources of variation



What Causes DNA to Change Over Time?

A two-stage process:

1. The introduction of variation
2. Differential “success” of individuals with different traits

What Causes DNA to Change Over Time?

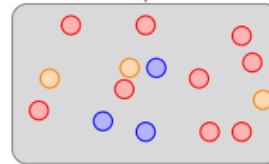
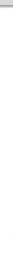
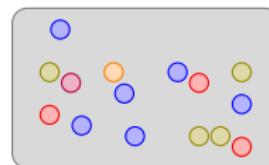
2. Differential “success” of individuals with different traits

Individuals with traits allowing them to better survive and reproduce will have more offspring

Those traits will be more common in the next generation

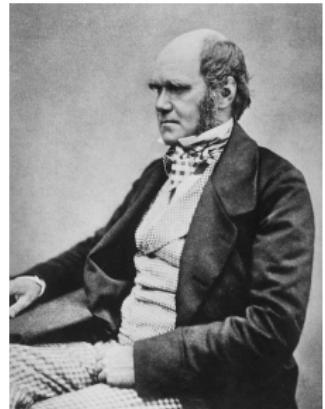
“Natural selection”

Nature is “selecting” which types are most successful



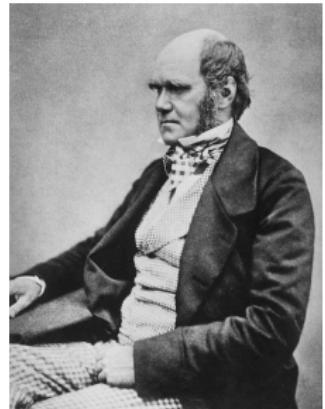
Natural Selection

1. Individuals produce more offspring than the environment can support
 2. Offspring vary in their ability to survive and reproduce
-
3. Those individuals with variations that increase their ability to survive and reproduce will produce more offspring
 4. These traits will be more prevalent in the next generation



Natural Selection

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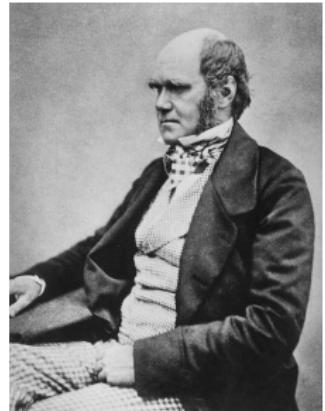


Natural Selection

Origin of Species p. 90–92

1. Individuals produce more offspring than the environment can support

...as more individuals are produced than can possibly survive, there must in every case be a struggle for existence, either one individual with another of the same species, or with individuals of distinct species, or with the physical conditions of life.



Elephants, One of the Slowest Breeders

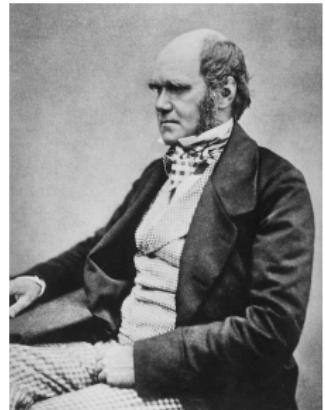


- Begins breeding when 30
- Stops reproducing at 90
- Produces 6 offspring in these 6 years

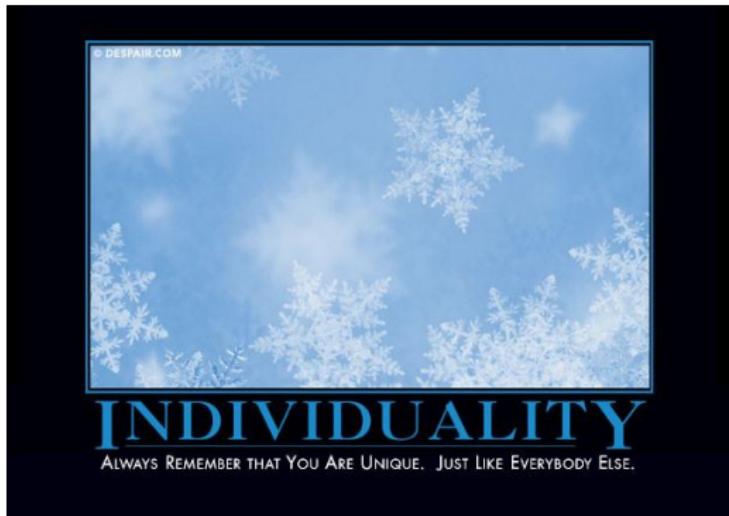
After 750 years, would be ~19 million elephants descended **from a single pair!**

Natural Selection

1. Individuals produce more offspring than the environment can support
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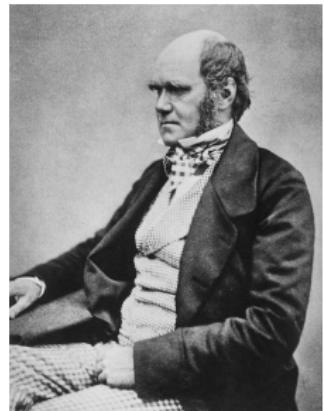


Natural Selection



Natural Selection

1. Individuals produce more offspring than the environment can support
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-
3. Those individuals with variations that increase their ability to survive and reproduce will produce more offspring
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Fitness

“Fitness” refers to the number of offspring (or really the # of genes) an individual contributes to future generations

“Survival of the fittest” is not an accurate description of evolution

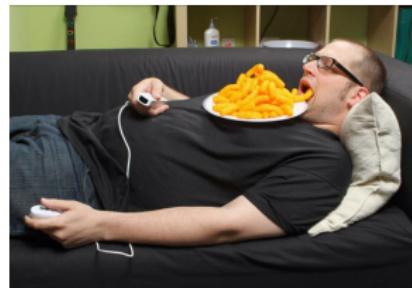
- Survival means nothing (in evolutionary terms) except for how it influences reproductive success

Two men

Man “A” is athletic, healthy, lived to be 109, had 2 kids and 4 grandkids



Man “B” is lazy, unhealthy, died at 50, had 4 kids and 8 grandkids



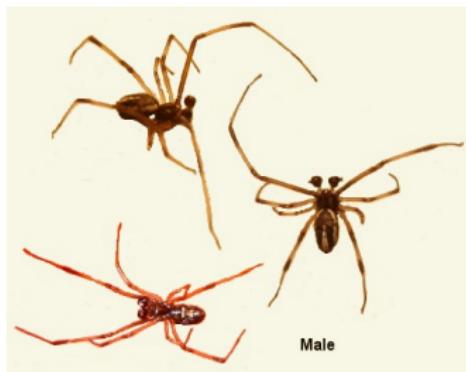
Who has higher evolutionary fitness?

Pocketmouse Example

VIDEO

Questions?

Redback Spider



Redback Spider

For this to have evolved, what predictions can you make about the biology of these spiders?

Common Misconceptions

Common Misconceptions

1. Darwin was the first to propose evolution

- Start with the “fixity of species”
- Many others thought this wasn’t so, and thought that organisms evolve

Comte de Buffon (1707–1788)

French naturalist



- Despite similar environments, different regions had distinct organisms (biogeography)
- Species both “improved” and “degenerated” after dispersing from a centre of creation

Erasmus Darwin (1731–1802)



- “All warm-blooded animals have arisen from one living filament” (1796)
- In 1802, describes the rise of life from minute organisms living in the mud to all of its modern diversity

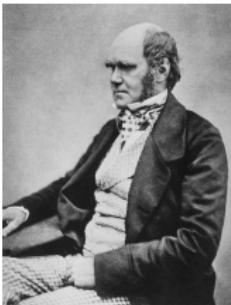
Jean-Baptiste Lamarck (1744–1829)



First comprehensive theory of evolution...now known to be incorrect

- All species (including humans) are derived from the gradual evolution of other species 
- Occurred through the inheritance of acquired traits 
- All organisms progress from simple to complex forms 

What Did Darwin Do That Was So Important?



- Published the most extensive and convincing evidence/argument for evolution - convinced the scientific community (1859)
- Developed the first (and arguably most important) accurate mechanism—**natural selection**

Common Misconceptions

1. Darwin was the first to propose evolution
2. Evolution is “only” a theory

Common Misconceptions

1. Darwin was the first to propose evolution
2. Evolution is “only” a theory
- 3. Evolution is progressive, moving towards some ultimate “goal”**

Common Misconceptions

Natural selection is just the differential fitness of individuals in the *current environment!*

- No foresight
- What is “best” will depend on specific environment (which will change over time!)
- Each stage must provide an advantage

Common Misconceptions

Humans
Mammals
Insects
Slimy things



“More evolved”
“Less evolved”

Common Misconceptions

Humans

“More evolved”

Mammals



Insects

“Less evolved”

Slimy things

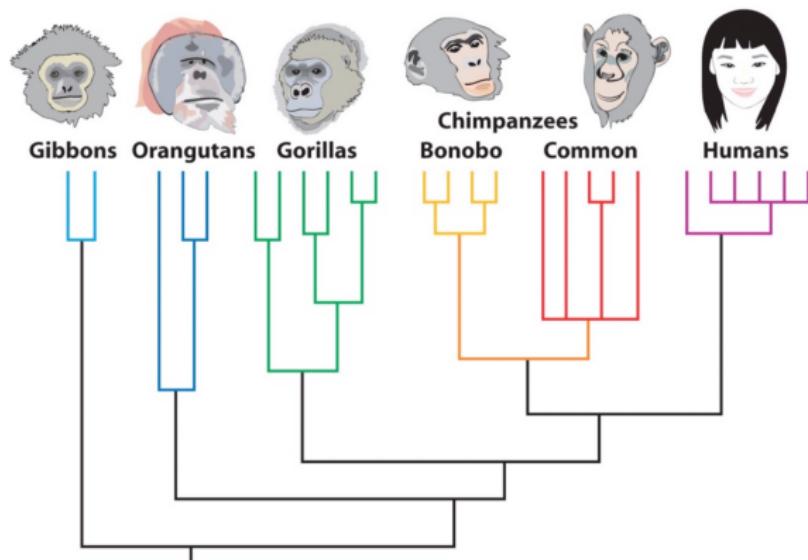
Cannot refer to “higher” and “lower” organisms

Common Misconceptions

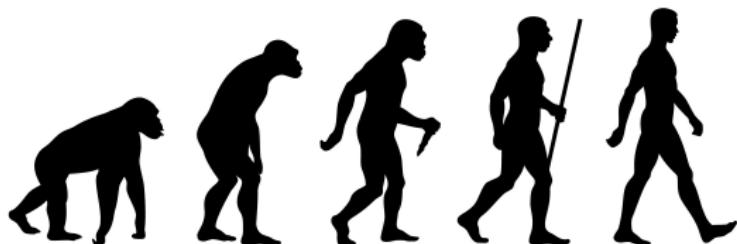
1. Darwin was the first to propose evolution
2. Evolution is “only” a theory
3. Evolution is progressive, moving towards some ultimate “goal”
- 4. Contemporary species evolved from other contemporary species**
 - “Humans evolved from chimpanzees”

Common Misconceptions

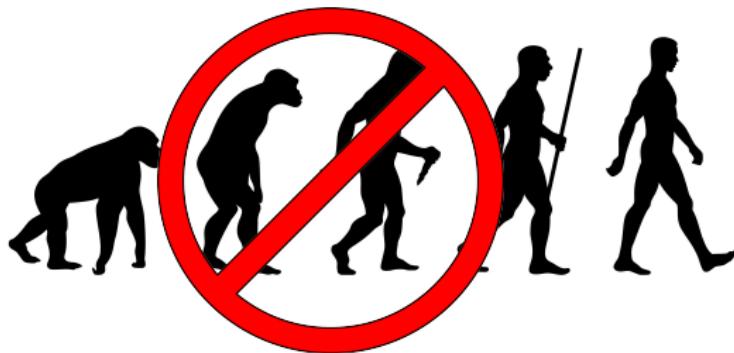
Contemporary species share a common ancestor!



Common Misconceptions



Common Misconceptions



Questions?

How We Approach Biological Questions

Proximate Causation

How something works/occurs (mechanistic).

How is this gene turned on or off?

How do individuals of this species choose a mate?

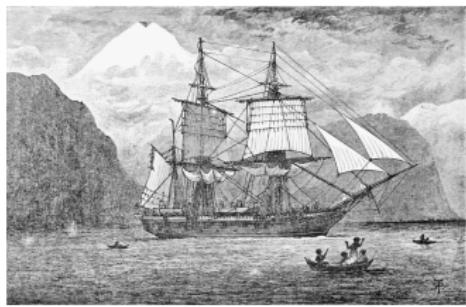
Ultimate Causation

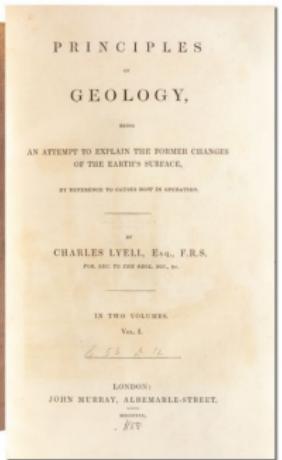
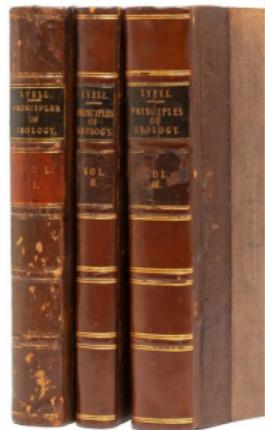
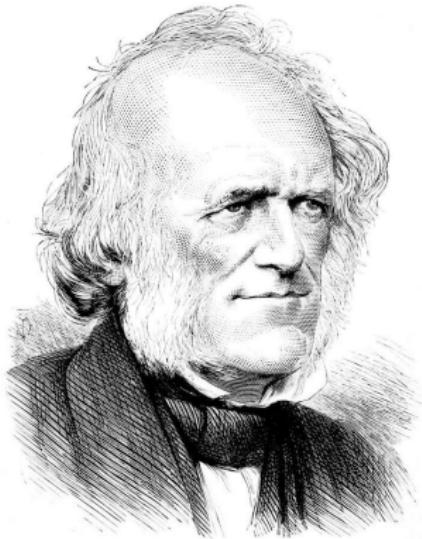
Why something works/occurs the way it does (evolutionary).

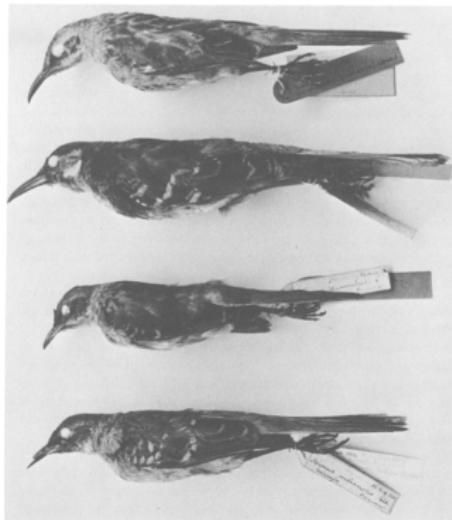
Why has this process evolved for the regulation of this gene?

Why have these mechanisms evolved by which these individuals select mates?

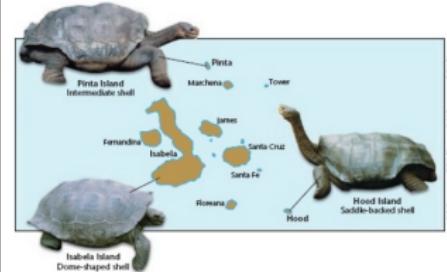
Board Work?







Galapagos Tortoises



Varieties Among Tortoises. Darwin observed that the characteristics of many animals and plants varied markedly among the different Galapagos Islands. Among the tortoises, the shape of the shell corresponds to different habitats. The Hood Island tortoise (right) has a long neck and a shell that is curved and open around the neck and legs, allowing the tortoise to reach the sparse vegetation on Hood Island. The tortoise from Isabela Island (lower left) has a domed-shaped shell and a short neck. Vegetation on this island is more abundant and closer to the ground. The tortoise from Pinta Island has a shell that is intermediate between these two forms.

