Evolution, Natural Selection and Darwin

Charles Darwin's *On the Origin of Species by Means of Natural Selection*

- Published November 24, 1859
- Focused biologists' attention on the great diversity of organisms
- Challenged the notion that the Earth was relatively young and populated by unrelated species

The Voyage of the Beagle

- **In December 1831, Darwin left Great Britain on the *HMS Beagle* to explore the world**

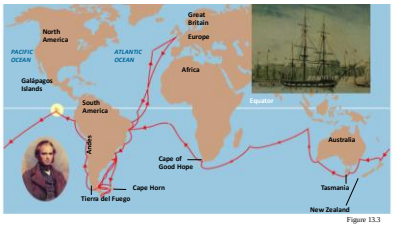
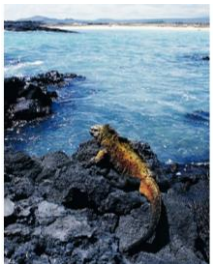


Figure 13.3

Darwin was intrigued by

- **The distribution of organisms on the Galápagos Islands**
- **Galápagos organisms resembled those in South America**



Darwin's Thoughts

- Darwin made two main points in *The Origin of Species*
  - Descended from ancestral species/organism
  - Descent with modification
    - Process: Natural selection
- Natural Selection
  - Organisms can change over generations
  - Heritable traits that increase reproduction & survival are passed down

Evolution

Biological Evolution: describes all of the changes that have transformed life on Earth from the earliest beginnings to the diversity of organisms in the world today.

Biological evolution is the unifying theme of biology.

Microevolution: occurs on small scale w/ in a single population (# of one species that live in a certain area)

Macroevolution: changes occur on a large scale over time.

The main mechanism (way it occurs) for evolution is **natural selection**.

Evolution-1

In our discussions of evolution and natural selections it is important to understand the "language" we will use. These terms will be mixed in the notes and labs. To begin with we need to know what is meant by the following:

Species: group of the same kind of organisms, that can breed w/ each other and produce fertile offspring.

Population: group of organisms (different species) of the same species living in the same area.

Heritable Trait: a trait (phenotype) that can passed down to offspring

Natural Selection 1

Natural Selection: occurs because the individual members of a population have different traits which allow them to interact with the environment either more or less effectively than the other members of the population. Natural selection results in changes in the inherited traits of a population over time. These changes often increase a species' fitness in its environment.

Natural Selection 2

Natural Selection: basically means that organisms w/in a species have mutations in their genes that cause a phenotype that makes it either:

Easier for them to feed and breed (survive)

OR

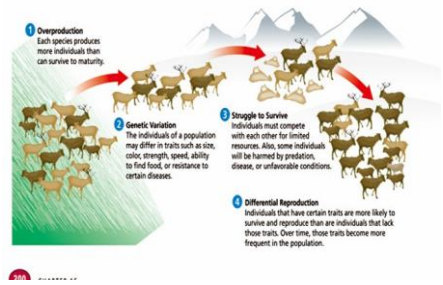
Harder for then to feed and breed

If the mutation makes it easier for them to survive they will pass those traits down to their offspring who have the same advantage, and over a long period of time the trait will become the norm in the species or population.

4 main tenants (points) of Natural selection

1. **Over production of offspring-*breed more than you need***
2. **Variation-*differences (genotype and phenotype) in population***
3. **Adaptation-*beneficial traits past down***
4. **Descent with Modification-species –*multiple species come from a common ancestor.***

Natural Selection



Overproducing of Offspring

The ability of a population to have many offspring raises the chance that some will survive but also increases the competition for resources.– The more offspring you have the better chance your species will have to continue to survive

Variation--Basically variation means differences

1. **Variation exists within the inherited traits (genes) of the individuals.**
2. **Variation exists in the phenotypes (body structures and characteristics--traits) of the individuals within every population. (difference in height with in the human population)**
3. **An organism's phenotype may influence its ability to find, obtain, or utilize its resources (food, water, shelter, and oxygen) and also might affect the organism's ability to reproduce.**

Variation--Basically variation means differences 2

4. (Phenotypic) **Variation** is controlled by the organism's **genes** (genotype) and the environment.

   Those individuals with phenotypes that do not interact well with the environment are more likely to either die or produce fewer offspring than those that can interact well with the environment.

MEANS

If the trait or traits (phenotypes) helps you, you will be able to pass it on

If the phenotype does not help you, you will either die **or** produce fewer offspring and the variation will eventually be gone

Adaptation

Occurs as traits are passed on to the next generation that increase the ability of the organism to survive

With every new generation the beneficial trait will be come more prevalent (occur in more organisms).

Other traits that make it harder to survive will become less prevalent, because these offspring will have a harder time competing with the organisms w/ the beneficial traits for resources.

Adaptation 2

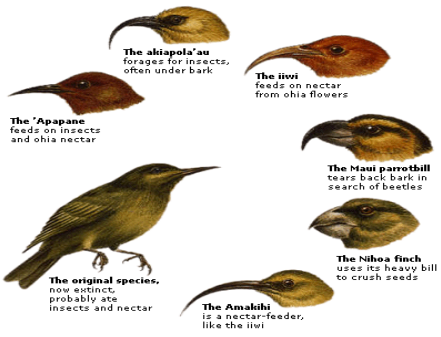
As a result, the gene pool (alleles able to be passed down) of a population can change over time.

The *fitness* is a measure how a particular trait contributes to reproductive success in a given environment fitness results from adaptations.

Natural selection has sometimes been popularized under the term *survival of the fittest*.

Descent with Modifications

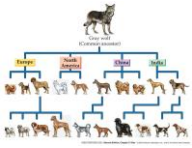
- **As the surroundings (environment) changes new phenotypes (traits) in a population (ben. Mutation)**
- **Natural selection can produce populations that have different structures, and live in different habitats from their ancestors.**
- **Each species that descends from another species will have different traits than the species it came from.**
- **Successful traits in future generations, will become the norm as long as traits are still beneficial to the habitat (environment) of the organism.**



Genetic Inheritance of Traits and DNA

All organisms come from other organisms and their traits are passed down through millions of generations. In other words: a dog that descended from a wolf will have some of the same genes and DNA as a wolf, but enough differences are their that they are separate species

A Grey Wolf's DNA is 99% identical to a Lab and a Pug



TRUTHS:

1. All life that has ever existed on earth has 2 things in common DNA and RNA (nucleic acids)
2. The processes of protein synthesis (transcription and translation) is the same in all organisms
3. All life on earth is composed of proteins that contain the **same 20 amino acids**.
4. All organisms past and present passed their genes to offspring.

These facts show that all life is genetically related to life from the past

Reproduction 1

All organisms pass down their genetic traits to offspring through reproduction.

2 Types:

Asexual: Involves only 1 parent, and produces an offspring that is identical to the parent. Offspring has genes identical to parent

Sexual: Involves 2 parents and meiosis and gamete fertilization allows offspring to have a mix of the genes of the 2 parents.

Asexual Reproduction

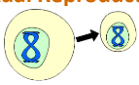
- **Genetic variability only occurs if a mutation occurs and is passed on to offspring**
- **Offspring are genetically identical to parent**
- **Can happen by cell division: binary fission (*reproduction of single-celled organisms*) or mitosis (*reproduction in multi-celled organisms*).**

Asexual Reproduction

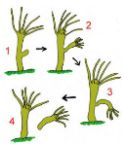
- **EX. Budding, fragmentation, and vegetative propagation.**
- **Occurs at higher rate than sex. reproduction in a stable environment because all identical offspring will have traits favorable in environment.**
- **Disadvantages: no variations except mutation, if environment changes and trait is no longer favorable population could be reduced or die off completely**

Asexual Reproduction

- Mitosis



- Budding (in hydra)



Veg Propagation (Tumeric)

EX. Ginger

Sexual Reproduction

- Fertilization results in the embryo getting 1 allele from each parent for each trait. Allows for variation of traits in offspring.– Offspring not identical to parents
- Genetic variability may also be due to crossing-over, recombination of DNA, or mutations
- Different allele combinations allow for different proteins to be made and different traits (variation).
- New allele combinations that result in beneficial traits will be passed down to subsequent generations and increase the chance that the species will survive.

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Evidence of Evolution 1

Biogeography:

The study of the locations of organisms around the world.

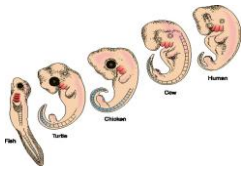
Often we see what was once a single population that was separated by geography evolve into 2 separate species with different traits adapted to their new environments.

Evidence of Evolution 1-A

Geographical Isolation: when a population or part of a population becomes separated from another part due to a change in geography, such as the separation of the ancient giant continent PANGEA in the above picture.

Evidence of Evolution 2

Embryology: the study of un-born organisms. This can be useful because many **times we can see traits in fetuses, before full development that are similar in different species, this can show the evolutionary relationship between organisms that would not be thought to be related.**



Evidence of Evolution 3

Embryos in the top line start off at the very beginning of their life looking very similar, but change dramatically before birth.

We can see an evolutionary link by examining the similarities of the embryos that can't be seen in the developed fetus or organism

Evidence of Evolution 4

Anatomy: the study of the body's structures.

***Examples* of the internal structure of organisms that appear similar can be evidence of a common ancestor.**

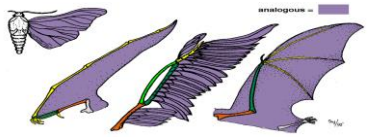
All the above are homologous structures.

Homologous structures are similar in structure but different in function. The structures evolved 1st in a common ancestor, each species has adapted new uses for them

Homologous structures are evidence of a common ancestor.

Evidence of Evolution 4-A (An. Struct.)

Analogous Structures: Are body parts (structures) in 2 or more different species *that perform the same function but evolved totally separate of each other.*
The "wings" below all evolved after the organisms split off from a common ancestor and evolved separately.



Evidence for evolution 4-B

Vestigial Structures: parts of the anatomy that are no longer functional, but are remains of an ancestral species

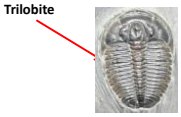
Humans have vestigial coccyx bones, remnants of our ancient ancestors' tails.

Flightless birds, such as penguins and ostriches, have vestigial flight wings. Wings no longer used for original purpose.

Evidence for evolution 5

Paleontology: the study of the *fossil record* (all known fossils), fossils which are the remains of extinct organisms, show evolutionary relationships between organisms alive now and ancestral species.
Fossils provide evidence of evolution.
Fossils in older layers are more primitive than those in the upper layers

Fossil: remains of long dead organisms preserved in rocks.



Evidence for evolution 6

Biochemistry **(the study of the chemical processes in organisms) studies genes and proteins to provide support for biological evolution.**

All life has 2 common things:

1. ***Nucleic Acids--DNA and RNA and the process by which they are made protein synthesis (Transcription and Translation)***
2. ***Proteins—All organisms have proteins made from the same 20 amino acids***

The more similar the DNA (amino acids) are the more closely related 2 organisms are related to a common ancestor

Evidence for evolution 7

Biochemistry provides evidence of evolutionary relationships among species when anatomical structures may be hard to use.
Used when species are so closely related that they do not appear to be different, or when species are so diverse that they share few similar structures.

Evidence for evolution 8

Biochemistry-Similar DNA

Human DNA: T-C-C-G-T- A-T- T-T-G-G-T-T-G-G-C-T-A-A-T

Gorilla DNA: T-C-C-G-G-G-G- A-A-G-G-T-T-G-G-T-C-C-G-G

Human DNA: T-C-C-G-T-A-T-T- T-G-G-T-T-G-G-C-T-A-A-T

Chimp DNA: T-C-C-G-G-G-G-A-A-G-G-T-T-G-G-C-T-A-A-T

Evidence for evolution 8

Biochemistry

Human DNA: T-C-C-G-T- A-T- T-T-G-G-T-T-G-G-C-T-A-A-T

Gorilla DNA: T-C-C-G-G-G-G- A-A-G-G-T-T-G-G-T-C-C-G-G

Human DNA: T-C-C-G-T-A-T-T- T-G-G-T-T-G-G-C-T-A-A-T

Chimp DNA: T-C-C-G-G-G-G-A-A-G-G-T-T-G-G-C-T-A-A-T

DNA Evidence shows that Chimps and Humans are more closely related than Gorillas and Humans

Key Terms

Species: group of the same kind of organisms, that can breed w/ each other and produce fertile offspring.

- **Share a gene pool**
- **A favorable variation in 1 individual can spread through all the members of a species in a population**

Population: group of organisms of the same species living in the same area.

Allele Frequency: the number of times (how often) an allele appears in a population

Mutation: a change in the genetic code, sometimes it is beneficial sometimes it is harmful to the individuals that have it. If beneficial it is past on to offspring.

Speciation

Speciation: the process of forming a new species from a pre-existing species.

- **Speciation often occurs when a group of the same species is isolated from the rest of its population.**
  - **The isolation can result from geographical, behavioral etc..**
  - **This results in 2 distinct gene pools.**
  - **Over time different variations occur and are favorable to the new environment natural selection occurs, and after a period of time (varies) differences between the 2 populations increase.**
  - **Eventually because different traits are favorable, a new species is related**

Speciation-2--Examples of speciation

Darwin's Finches from the Galapagos Islands: This was more than likely behavioral isolation, based on feeding. As the finch started to eat more variety the beaks began to specialize and different traits were favorable to different food sources, eventually enough differences occurred and multiple species were created.

In the case of the spotted Owl, two groups of the same populations were isolated geographically. Different traits were beneficial in the different areas. Eventually natural selection happened and 2 distinct species were formed.

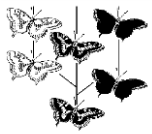
Changes in environmental conditions often are a driving force in natural selection

Evolutionary Patterns

Gradualism: Gradual changes in a species in a certain way over a very long time. ***Ex.*** *Tigers and stripes. Stripes originally occurred as a variation in solid color tigers, the strips were favorable and made it easier to hide in the grass while hunting*

Punctuated equilibrium: sudden changes in species after long periods of stability.

EX. Often caused by extreme environmental changes or catastrophe. Peppered moth changed in a few generations, due to pollution in the 19th century.



punctuated equilibrium

Evolutionary Patterns-2

Adaptive Radiation (AKA Divergent evolution): when a number of different species spin-off (diverge) from a common ancestor.

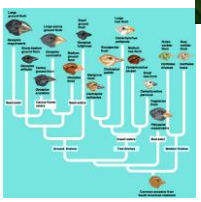
- **Occurs over many generations**
- **A variety of traits involved for survival in different environments**

Convergent Evolution: evolution in different species occurs in the same manner. Similar structures evolve in different species in different places in response to the same kind of environmental conditions. Analogous structures.

Evolutionary Patterns 3

Divergent Evolution

Finches again-Diverged from 1 species due to feeding habits



Convergent Evolution

Emerald Boa from S. American rain forest & the Green Tree Boa from Australian rainforest region evolved separately but in a similar manner due to similar environments

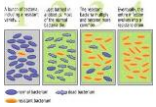
Evolutionary Patterns 4

Coevolution: When a species evolved in response to evolution in another species.

Plants and hummingbirds evolve compatible structures for pollination

Predator-Prey relationships: as the prey becomes better camouflaged, the predator adapts to become a better hunter

Another example is antibiotic resistant bacteria and viruses are also examples of a variation of co-evolution



Evolutionary Patterns-5

Extinction: elimination of a species, usually because the species can not adapt to its changing environment.

Gradual Extinction: occurs slowly over long period of time, due to other species competition, climate change, minor natural disasters.

EX. **Passenger Pigeon hunted to extinction over decades**

Mass Extinction: very sudden usually the result of major cataclysmic event such as volcanoes, meteor impact, extreme climatic shifts

EX. Permian-Triassic extinction event 90% of the life on the planet died off suddenly about 250 MYA

EX. Dinosaurs

Genetic Variability 1

Gene Variation is environmental effects & randomness ensures that that there is unique genotypes and phenotypes in the gene pool.

CALLED GENETIC VARIABILTY– Leads to evolution

Means: Allele combinations change in the individuals from 1 generation to the next

EX. (*Co-dominant situation*)

P: 5 Black(BB) 10 Black/White (Bb) 5 White (bb)

F1: 10 Black(BB) 7 Black/White (Bb) 3 White (bb)

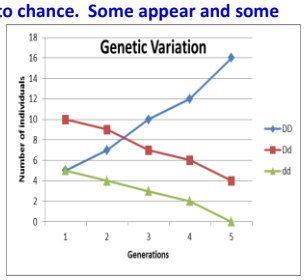
F2: 16 Black(BB) 4 Black/White (Bb) 0 White (bb)

Genetic Variability

Genetic Drift: random change in allele frequency in a population, due to chance. Some appear and some disappear.

Random and environmental pressures caused the changes seen here over generations

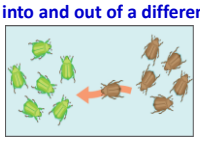
The larger the population the less effect genetic drift has on allele frequency



Genetic Variability 2

Factors that effect Genetic Variability

Gene Flow: movement of genes into and out of a population (gene pool) by movement of individuals into and out of a different species. (MIGRATION)



Gene flow can occur when an individual travels from one geographic location to another and joins a different population of the species. In the example shown here, the brown allele is introduced into the green population.

Genetic Variability 3

Factors that effect Genetic Variability

Natural Selection: allows favorable phenotypes and genotypes to become prevalent.

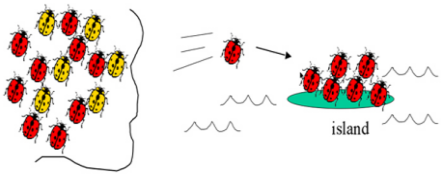
Non Random Mating: selectivity in choosing a mating partner (Colorful plumage, Size) changes the allele frequency in a population. Because certain types of phenotypes are chosen more for mating those traits will be passed down

Mutation: random mutation changes the frequency of allele occurrence in a population

Genetic Variability 4—YOU NEED TO COPY THIS

Factors that effect Genetic Variability

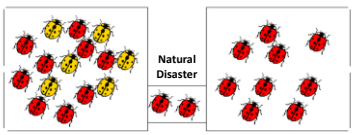
- **founder effect**: a few individuals from a population start a new population with a different allele frequency than the original population



Genetic Variability 5

Factors that effect Genetic Variability

Bottleneck Effect: is a sharp reduction in size of a population due to environmental events (natural disasters or human activities) Population drastically reduces and rebuilds with only the genes of the survivors. Limits variability.



Real Life Examples-Bottleneck

Cheetahs are sufficiently closely related to one another that transplanted skin grafts do not provoke immune responses, thus suggesting an extreme population bottleneck in the past.

Overhunting pushed the northern elephant seal to the brink of extinction by the late 19th century. Though they have made a comeback, the genetic variation within the population remains very low

Genetic Equilibrium-1

When there is no change in the allele frequency in a population (the ratios stay constant) within a species, it is called *Genetic Equilibrium* (*called Hardy-Weinberg principal*)

5 Conditions are needed for it to occur

1. **Population must be large, no genetic drift occurs**
2. **There can be no gene flow into out of population**
3. **All mating must be random**
4. **No mutations in the gene pool**
5. **No natural selection occurring**

Genetic Equilibrium-2

If you look at the figure to the right you can see the genotypic ratio of 490:420:90 does not vary over the generations.

GENETIC EQUILIBRIUM

Phylogeny-Classification-Evolutionary Relationships

Phylogeny is the evolutionary history of a group of species. Phylogenies show the evolutionary relationships between different species. Shows points at which different species "branched off". Can also show WHY the species branched off (what new trait caused the new species to diverge from the others)

The most common way to display phylogeny is with a diagram called a cladogram.

Classification-Taxonomy

Highest order classifications

Taxonomy is the classification of organisms.

Organisms are classified as follows:

Domain-Kingdom-Phylum-Class-Order-Family-Genus-Species

Did- King-Phillip-Come-Over-For-Good-Spaghetti

The 3 domains are: Archaea, Bacteria, and Eukarya.

6 kingdoms are: Eubacteria, Archae, Protista, Fungi, Plantae, and Animalia.

Leopard

Species name: *Panthera pardus*

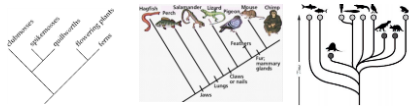
Species: *pardus*
Genus: *Panthera*
Family: Felidae
Order: Carnivora
Class: Mammalia
Phylum: Chordata
Kingdom: Animalia
Domain: Eukarya
All Domains

Cladograms

A cladogram is a diagram that shows the *evolutionary relationships* between groups of living things. Kind of like a *family tree* for species.

ALSO CALLED PHYLOGENETIC TREE

Different cladograms show different details about the relationships between the species the contain.

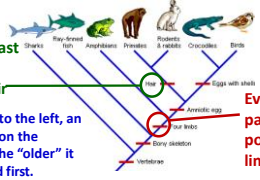


Cladograms 2

The *closer* two species are on the cladogram, the more closely they are *related*.

This means they evolved apart (split) more *recently*.

Sometimes a cladogram will also list the *characteristics* that make two groups or organisms different.

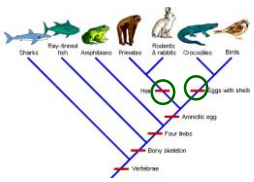


Everything past (above) this point has hair

The further to the left, an organism is on the cladogram the "older" it is, it evolved first.

Everything past this point has 4 limbs!

Cladograms 3



The hash lines that are represented w/ the lines that intersect the cladogram are called DERIVED CHARACTERS. They are evolutionary adaptation that caused speciation (splitting off of a new group)

DERIVED CHARACTERS: the newly evolved characteristic that caused they new species or group of species to form

Cladograms 4

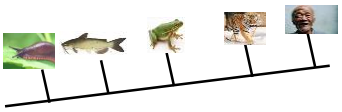
Let's make a cladogram that includes slugs, catfish, frogs, tigers, and humans

1. Make a table of some adaptations that the organisms share, and some that are unique. EX.:

	Cells	Backbone	Legs	Hair	Thumbs
Slug					
Catfish					
Frog					
Human					
Tiger					

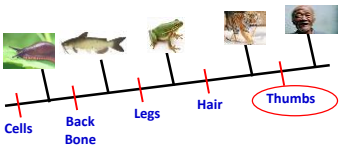
Cladograms 4-A

Draw your cladogram. Assume that organisms with less of the traits (Xs) evolved later, so they go on the right.



Cladograms 5

Now place hash lines between the organisms and then place your derived characters (traits) to show the point at which speciation occurred.

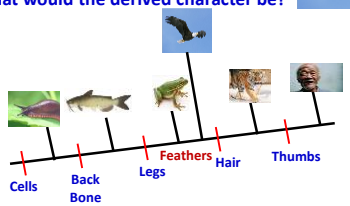


Cladograms 6

QUESTION?

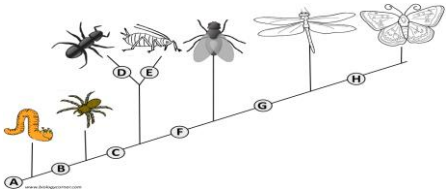
Where would the bald eagle fit in?

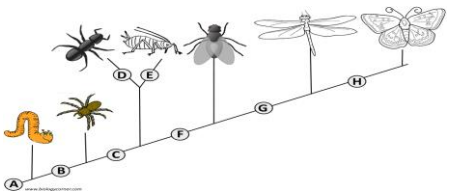
What would the derived character be?



Cladograms 7

Look at the diagram on the next slide and lets fill in the correct *derived character*, to replace the letters.





1. _____ Wings
2. _____ 6 Legs
3. _____ Segmented Body
4. _____ Double set of wings
5. _____ Cerci (abdominal appendages)
6. _____ Crushing mouthparts
7. _____ Legs
8. _____ Curly Antennae

Cladogram Practice-Write answers in notes

1. Which species is the oldest? (split first)
2. Which species is the most recently evolved?
3. Which species(s) are extinct?
4. Which species is the closest relation to species C?

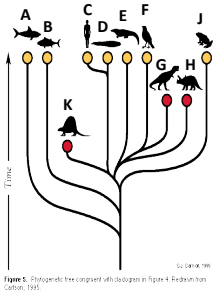
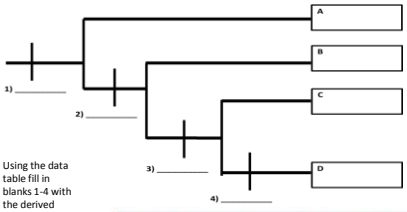


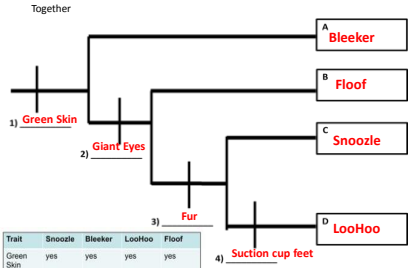
Figure 5. Phylogenetic tree congruent with cladogram in Figure 4. Redrawn from Carlton, 1995.



Using the data table fill in blanks 1-4 with the derived characters and boxes A-D with the organisms

Trait	Snoozle	Bleeker	LooHoo	Floof
Green Skin	yes	yes	yes	yes
Giant eyes	yes	no	yes	yes
Fur	yes	no	yes	no
Suction cup feet	no	no	yes	no

Together



Trait	Snoozle	Bleeker	LooHoo	Floof
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Fur	yes	no	yes	no
Suction cup feet	no	no	yes	no