General Biology 1
BIO1201
Syllabus & Textbook:
https://openlab.citytech.cuny.edu/oer-biology/lecture-schedule/

Lecturer: Michael Gotesman, PhD
Email: mgotesman@citytech.cuny.edu

Contacting Your Instructor: Do not use private email addresses (City Tech, all CUNY, or any other .edu are acceptable).

Grade Breakdown:

Lecture (60%)
Exams (4): 22.5% Each
Pop Quizzes (?): 10 % Average

Lab (40%) – Lab Instructor

Letter Grade	Numerical Ranges
A	93-100
A-	90-92.9
B+	87-89.9
B	83-86.9
B-	80-82.9
C+	77-79.9
C	70-76.9
D	60-69.9
F	59.9 and below

Bio 1201-Important Policies

- **Read your syllabus!!!** **(it's also available online)**
https://openlab.citytech.cuny.edu/oer-biology/lecture-schedule/

- Attendance required. >3 unexcused absences = F
- Two lateness = 1 absence
- You MUST take careful notes!!
  - Everything in the slides and everything I say could be on the exam.
- NO DROP EXAMS! NO CURVE! NO MAKE-UPS!

- **Policy about Tests:**
  - **Anything on PowerPoint whether it was stated in class or derived from book is fair game**

Strategies for Passing

- In-class
  - Show-up, stay awake, LISTEN !!!
  - Take careful notes, but still listen!!!
- Homework
  - Read the assigned reading BEFORE class!
  - Re-read your notes as soon as possible (that night!)
  - Make notecards (flashcards) of everything in the notes
    - It is best NOT to wait until exam time to do this!
    - Take the flashcards with you everywhere you go… in the subway, on the bus, at home, in between classes, commercial breaks…
    - But even if you DO wait until the exam, still… make the flashcards!
- Exam Studying
  - Read the notes AGAIN, then study those flashcards
  - Study the figures from the book that I used in class
  - Take the “self-quizzes” at the end of each chapter. Go find the answers
  - Only study in groups if you stay focused the whole time

FIRST ASSIGNMENT

1. **E-mail**
   - Make sure your Citytech email account is active
   - Otherwise contact the Helpdesk @5626 or email Helpdesk@citytech.cuny.edu

2. **Blackboard**
   - Get used to it ASAP!
   - Download the Handouts before each lecture
   - Check it regularly for announcements

3. **Course Website**
   - https://openlab.citytech.cuny.edu/oer-biology/

Reading List:

Week 1: Evolution 479-502 & Phylogeny 523-545

Week 2: Virus 547-573 & Prokaryotes 575-610

Week 3: Protists 611-642

Week 4: Fungi 643-673

Week 5: Seedless Plants 675-701

Week 6: Seeded Plants 643-673

Week 7: Animal Kingdom 703-730

Week 8: Animal Organization 731-754

Week 9: Circulation 1175-1199

Week 10: Immunity 1225-1258

Week 11: Digestion 967-995

Week 12: Respiration 1147-1173

Week 13: Body Fluid 1201-1223

Week 14: Nervous System 997-1037

Week 15: Reproduction 1259-1293

https://openlab.citytech.cuny.edu/oer-biology/textbook/

https://bbhosted.cuny.edu/

Classification of Living Things

Evolution, Systematics & Phylogeny

Classification of Living Things

Evolution, Systematics & Phylogeny

Outline/Overview

- Definitions: Biodiversity, Systematics, Taxonomy, Phylogeny
- Taxonomy: Taxa and the Binomial System of Nomenclature
- Phylogenetic trees: Cladistics, Maximum Likelihood & Parsimony
- Phylogeny: using Fossils and Homologies, (identifying the tricky) Analogies and Convergent Evolution, the Biochemical Data
- History of the Tree of Life: from 2 Kingdoms to 3 Domains

Biodiversity

… is the total number of species, the variability of their genes, and the communities in which they live.

- Abundance of species estimated about 15 million.
- 2 million species have been identified and named

Systematics

Systematics is the field that:

a) **describes** organisms

b) provides scientific **names** and provides **classifications** (Taxonomy)

c) **preserves** collections of the organisms,

d) provides, keys for their **identification**, and data on their distributions,

e) investigates their **evolutionary histories** (phylogeny), and

f) considers their environmental **adaptations**.

Taxonomy

- Discipline of identifying and classifying organisms according to certain rules

- Hierarchical levels (taxa) based on hypothesized evolutionary relationships

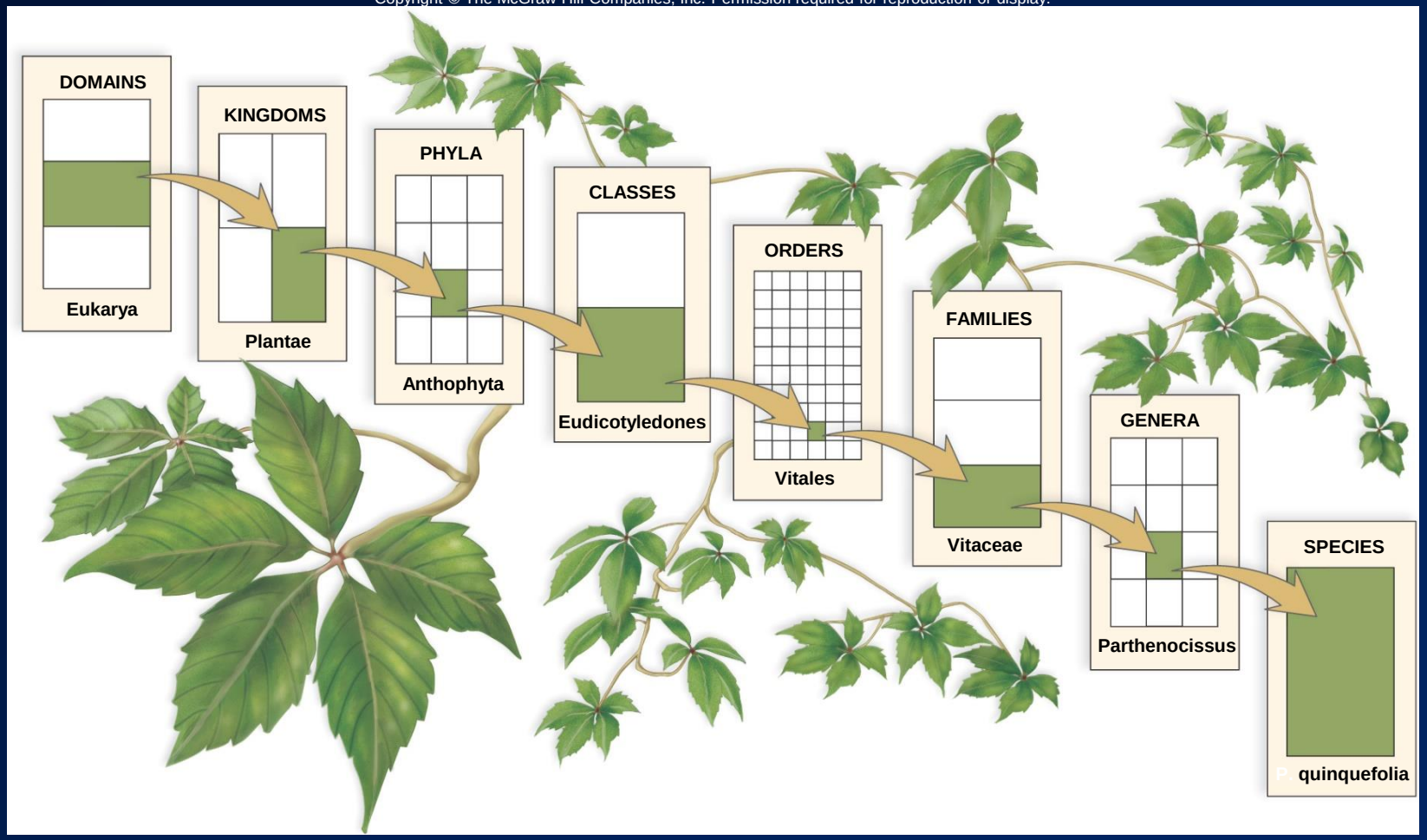
Classification Categories

- Levels are, from **least inclusive to most inclusive**
  - A level (e.g. phylum) includes more species than the level below it (e.g. class), and fewer species than the one above it (e.g. kingdom)

- Modern taxonomists use the following classification:

  - **Species – most specific**
  - **Genus** – one or more species
  - **Family** – one or more genera
  - **Order** – one or more families
  - **Class** – one or more orders
  - **Phylum** – one or more classes
  - **Kingdom** – one or more phyla
  - **Domain** – one or more kingdoms
  - Dear – Kids – Play – Chess – On – Funny – Green - Squares

Hierarchy of Taxa for *Parthenocissus quinquefolia*



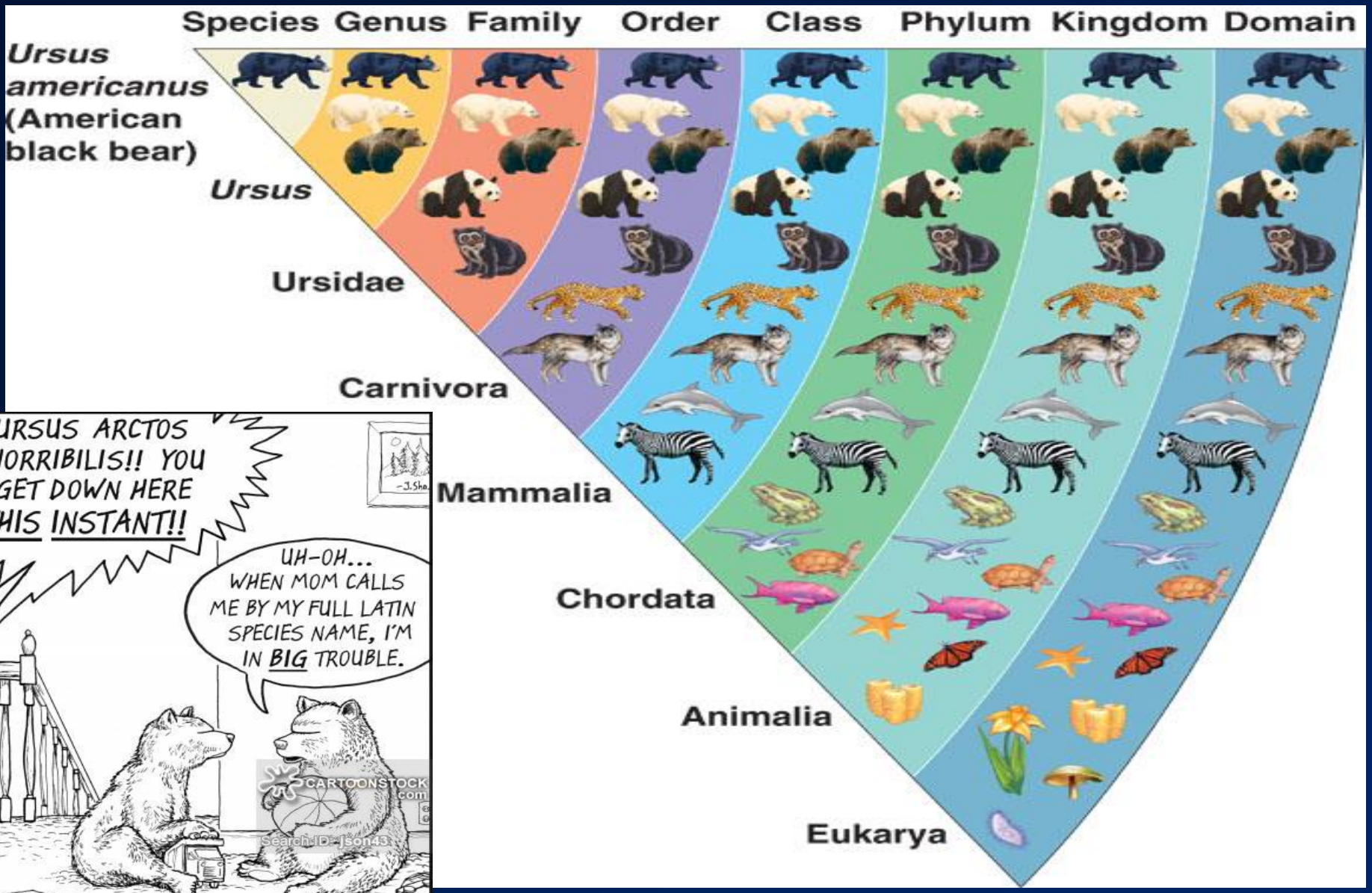
Parthenocissus quinquefolia
Virginia creeper (five-leaf ivy)

Classification Categories

- The higher the category, the more inclusive
- Organisms in the same domain have general characteristics in common
- Members of a species share quite specific characters.
  - A **character** is any structural, chromosomal, or molecular feature that distinguishes one group from another
- In most cases, classification categories can be subdivided into additional categories
  - Superorder
    - an intermediate classification rank or grouping that sit directly above an order. A superorder may contain several orders. Sharks are a good example of a superorder, grouping together eight living orders of shark, as well as, five extinct orders.
  - Order
  - Suborder
  - Infraorder

http://www.bbc.co.uk/nature/superorder

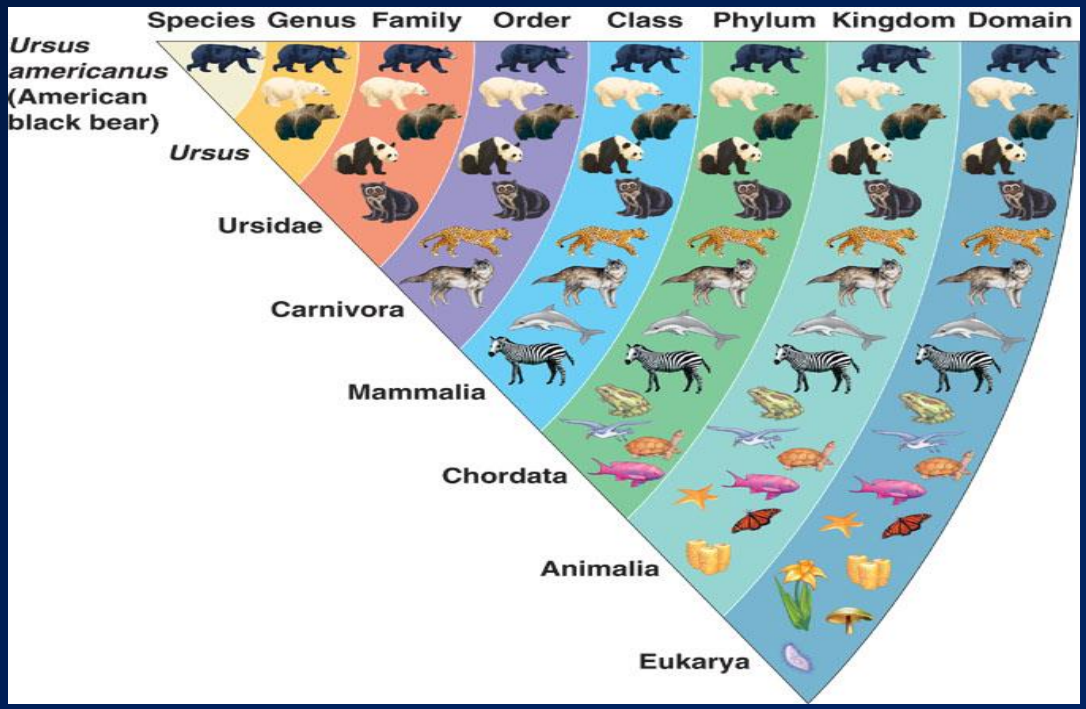
Example: Taxonomy of Bears



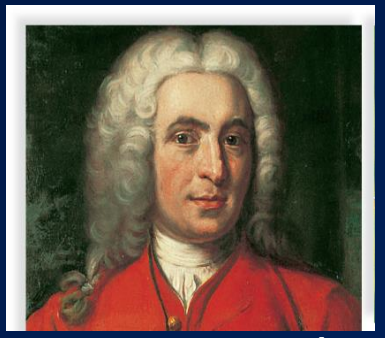
Question

If humans and black bears belong to the same class, then they must also belong to the same:

A. Order
B. Phylum
C. Family
D. Genus
E. Species



Taxonomy: Binomial System



Karl von Linné

- Mid-eighteenth century, **Linnaeus** developed the **binomial system of nomenclature** for scientific names
- Universal
- Latin-based
  - First word represents **genus** of organism e.g. *Homo*
  - Second word is **specific epithet** of a species within the genus e.g. *sapiens*
  - Always italicized as a *Genus species* (*Homo sapiens*)
  - Genus may be abbreviated *e.g*. *Escherichia Coli as E. coli*
  - Genus name can be used alone to refer to a group of related species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Levels of Classification

TABLE I.1

Levels of Classification

Category	*Human*	*Corn*
Domain	Eukarya	Eukarya
Kingdom	Animalia	Plantae
Phylum	Chordata	Anthophyta
Class	Mammalia	Monocotyledones
Order	Primates	Commelinales
Family	Hominidae	Poaceae
Genus	*Homo*	*Zea*
Species*	*H. sapiens*	*Z. mays*

*To specify an organism, you must use the full binomial name, such as *Homo sapiens*.

Binomial Nomenclature

- The genus and/or specific epithet sometimes provide descriptive information about the organism:
  - *Pluchea carolinensis* (American plucheas)
  - *Anolis carolinensis* (American anole)
  - *Gnathia marleyi* (water mite)
  - *Aptostichus barackobamai* (spider)
  - *Agathidium bushi* (beetle)
  - *Agaporomorphus colberti* (beetle)
  - *Aleiodes gaga* (wasp)
  - *Caloplaca obamae* (lichen)
  - *Etheostoma obama* (fish)

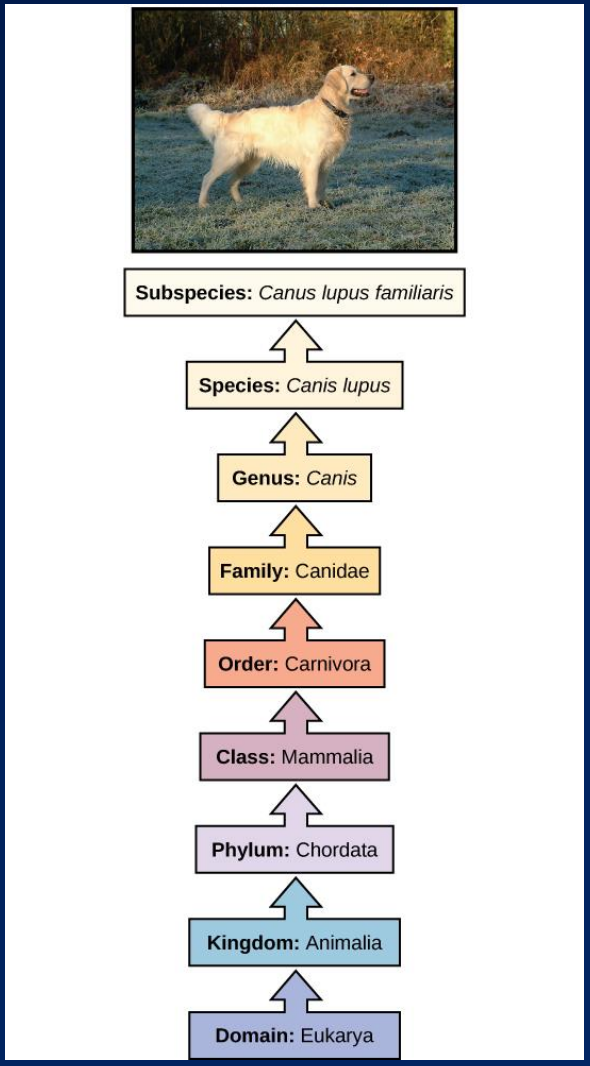
http://en.wikipedia.org/wiki/List_of_organisms_named_after_famous_people

Did you get this part?

1. Explain the binomial system of naming organisms. Why must species be designated by a complete name?

2. Why is it necessary to give organisms scientific names?

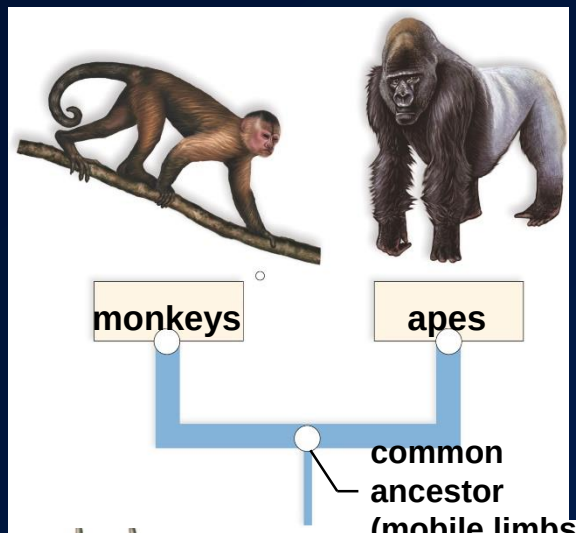
3. What are the 8 obligatory classification categories? In what way are they a hierarchy?

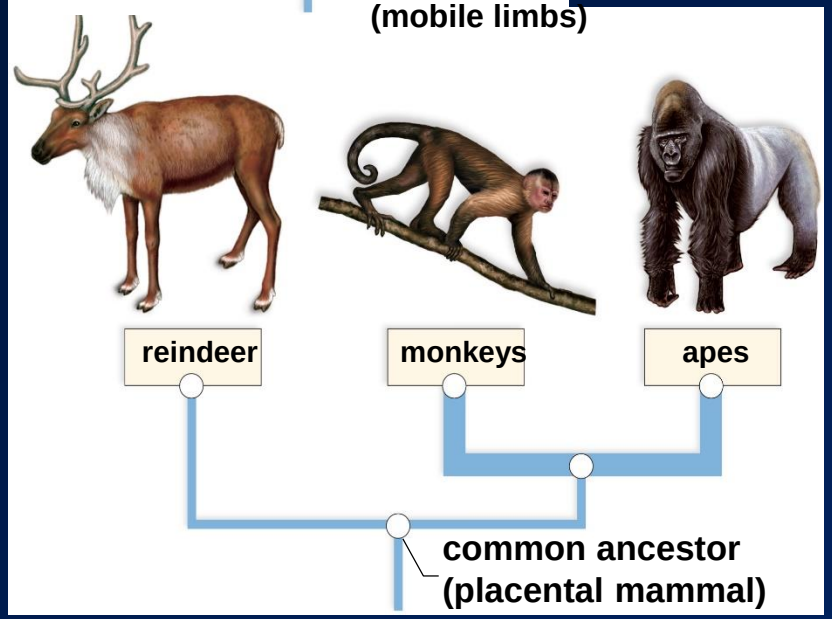


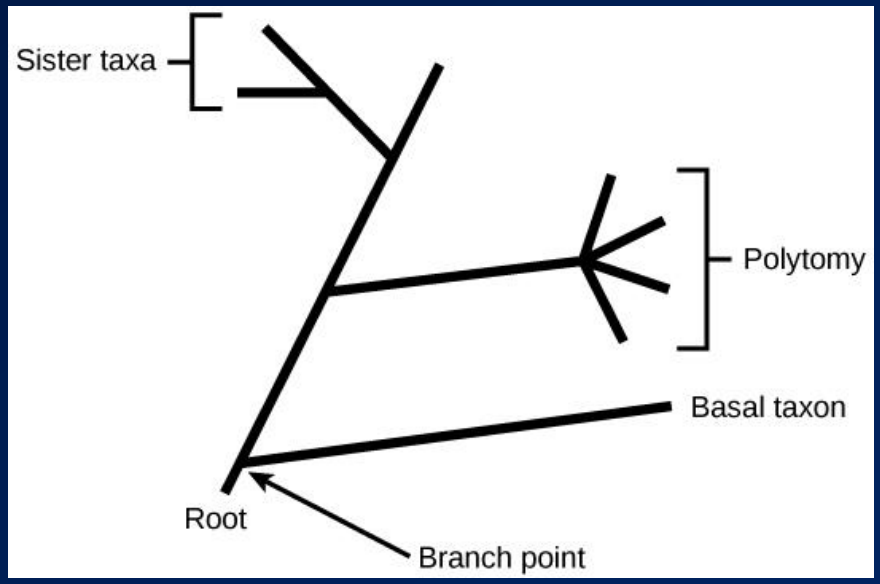
Phylogenetic Trees

- Systematics is the study of diversity of organisms using information from cellular to population levels
- One goal of systematics is to determine phylogeny = evolutionary history of a group of organisms
- Phylogeny often represented as a phylogenetic tree
  - A diagram indicating lines of descent
  - Each branching point:
    - Is a divergence from a common ancestor
    - Represents an organism that gives rise to two new groups

Classification and Phylogeny





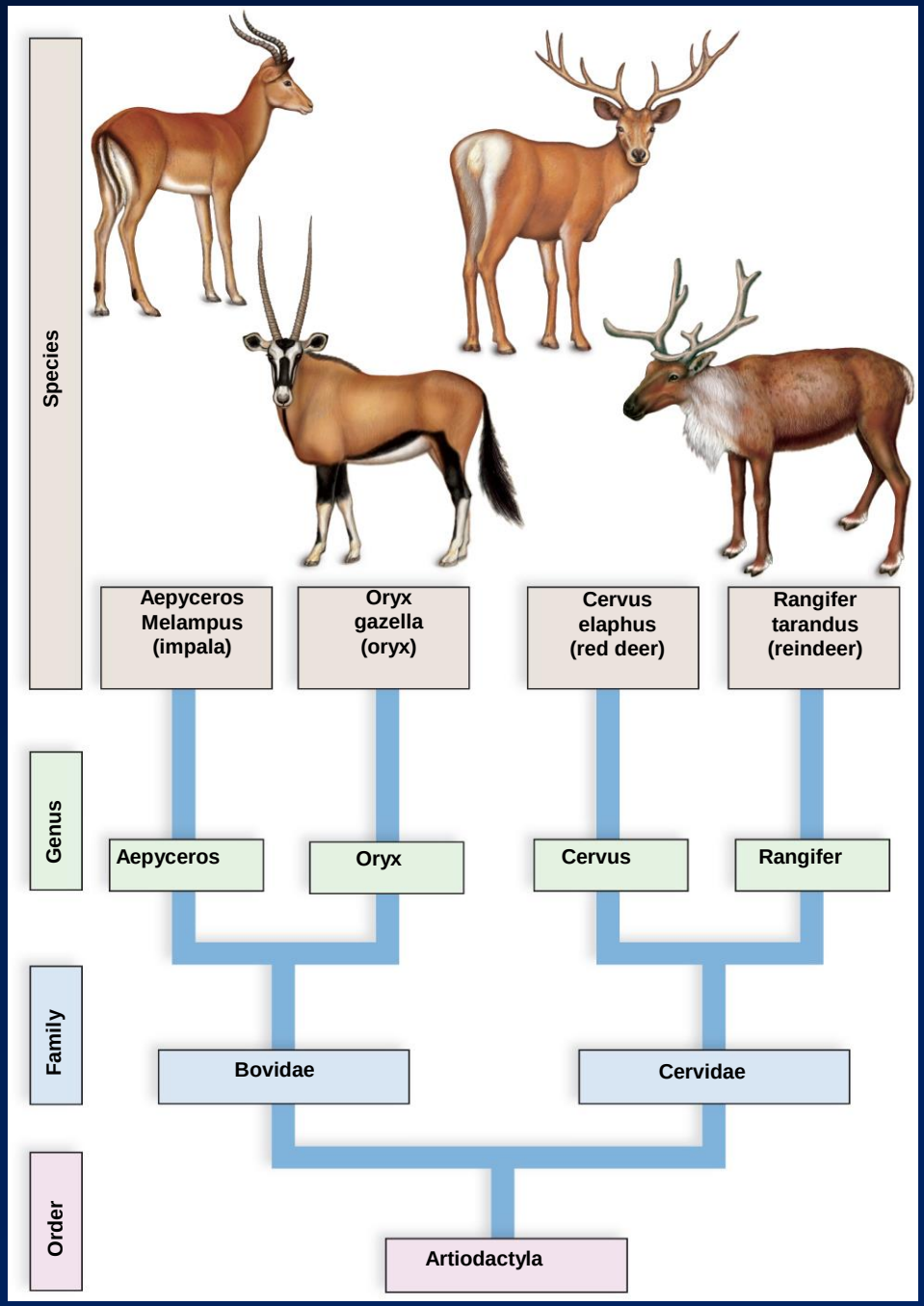


The root of a phylogenetic tree indicates that an ancestral lineage gave rise to all organisms on the tree. A branch point indicates where two lineages diverged. A lineage that evolved early and remains unbranched is a basal taxon. When two lineages stem from the same branch point, they are sister taxa. A branch with more than two lineages is a polytomy.

Classification and Phylogeny

The Bovidae are the biological family of cloven-hoofed, ruminant mammals that includes bison, African buffalo, water buffalo, antelopes, wildebeest, impala, gazelles, sheep, goats, muskoxen, and domestic cattle.

Deer are the hoofed ruminant mammals forming the family Cervidae.

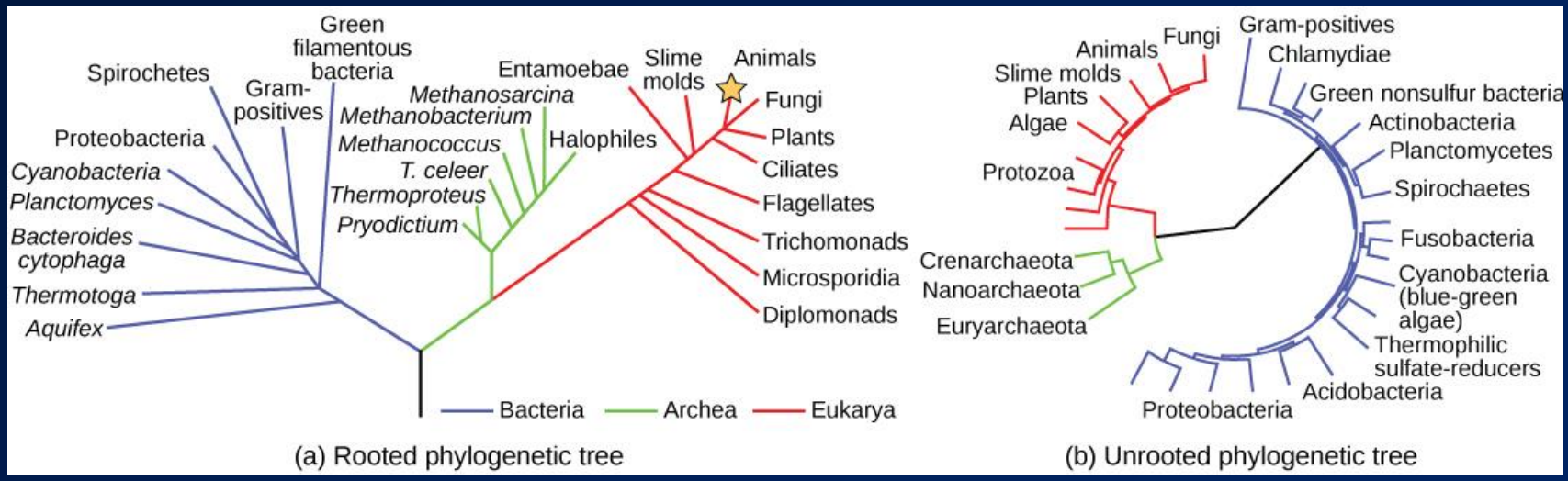


Phylogenetic Trees

- **Classification** lists the unique characters of each taxon and is intended to reflect phylogeny
  - **Primitive characters**:
    - Present in all members of a group, and
    - Present in the common ancestor
  - **Derived characters**:
    - Present in some members of a group, but
    - Absent in the common ancestor

Phylogenetic Trees

- While phylogenetic trees give *some* information about relative ages, they do ***not*** indicate ages of species
- Remember – trees are constructed to demonstrate evolutionary relationships between several species of interest… *i,e.*, there is no ONE complete tree.



Both of these phylogenetic trees shows the relationship of the three domains of life—Bacteria, Archaea, and Eukarya—but the (a) rooted tree attempts to identify when various species diverged from a common ancestor while the (b) unrooted tree does not. (credit a: modification of work by Eric Gaba)

Cladistics

- The analysis of HOW species maybe grouped into clades is called **cladistics**
- **Clade** – a group of species that includes an ancestor and ALL descendants, also called a monophyletic group
- **Cladogram** – a diagram that shows patterns of shared characteristics among taxa
  - If (and only if) the shared characteristics are *homologous* (due to common ancestry), then cladograms can be used as the basis of a phylogenetic tree

Cladistics

Clades are defined by their evolutionary novelties

- Shared primitive character a feature that is shared by a certain clade AND members of other clades
- Shared derived character a feature that is unique to a certain clade

When constructing a cladogram:

- Include an **outgroup** – a species that is closely related, but is NOT in the clade, allows to root the tree; the outgroup helps differentiate between shared derived and shared primitive characteristics
- Apply **maximum parsimony** – events occurred in the simplest, most obvious way.

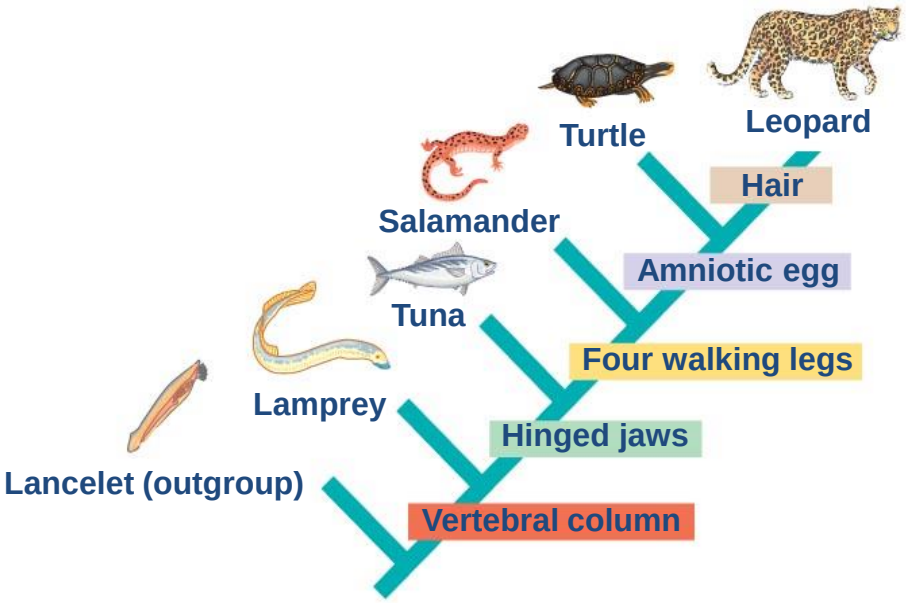
Constructing a cladogram

- Outgroup comparison assumes that **homologies** shared by the outgroup and ingroup must be primitive characters that predate the divergence of both groups from a common ancestor
- It enables us to focus on characters derived at various branch points in the evolution of a clade

TAXA

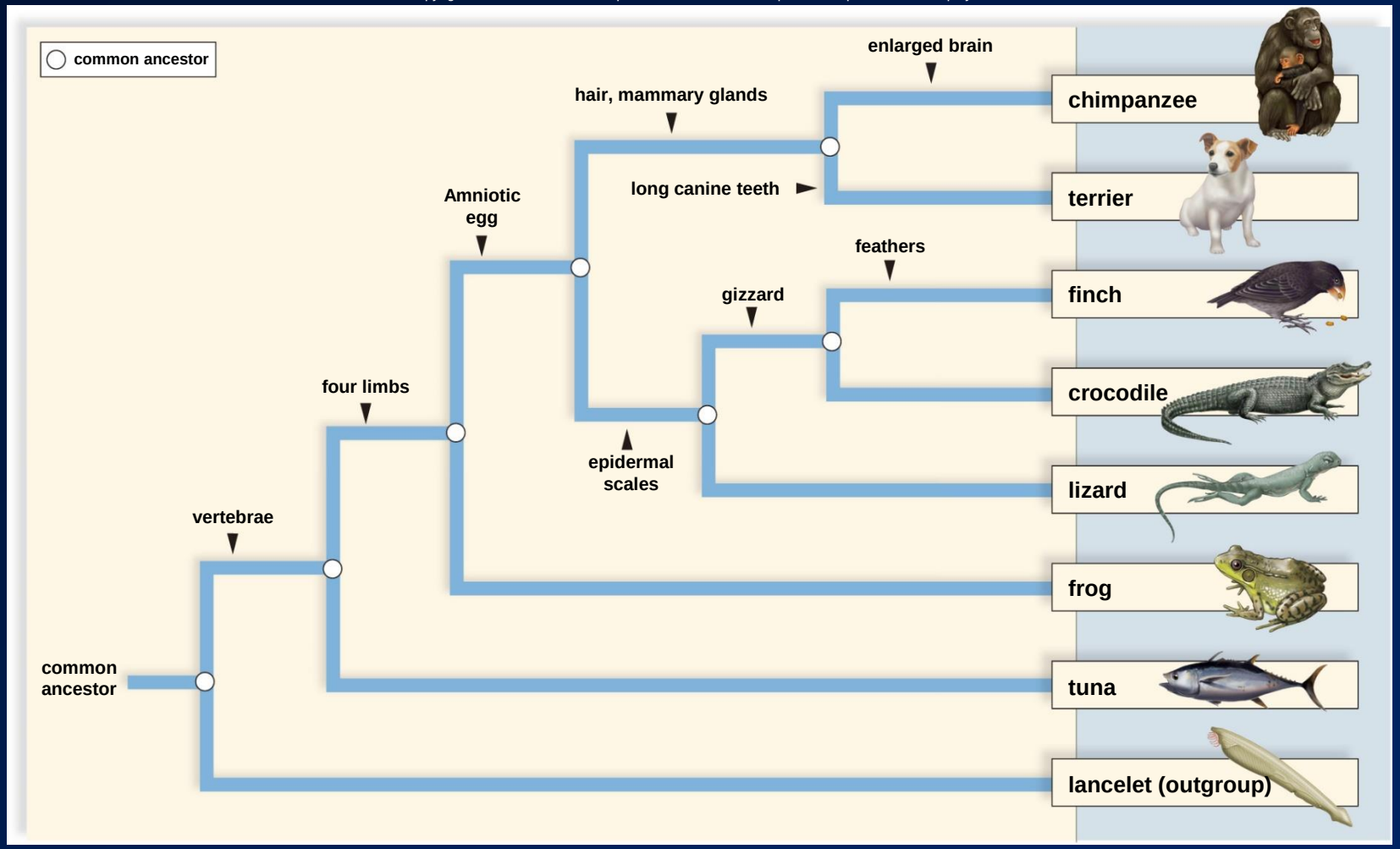
CHARACTERS	Lancelet (outgroup)	Lamprey	Tuna	Salamander	Turtle	Leopard
Hair	0	0	0	0	0	1
Amniotic (shelled) egg	0	0	0	0	1	1
Four walking legs	0	0	0	1	1	1
Hinged jaws	0	0	1	1	1	1
Vertebral column (backbone)	0	1	1	1	1	1

(a) Character table



(b) Cladogram

Constructing a Cladogram: Phylogenetic Tree



Are you following?

1. Discuss the principles of cladistics, and explain how to construct a cladogram?

2. What is a clade? With reference to the phylogenetic tree on the previous slide, why are birds in a clade with crocodiles?

3. Can you give examples of shared primitive and shared derived characters between humans, monkeys and dogs?

Questions?

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College Closed -- CC

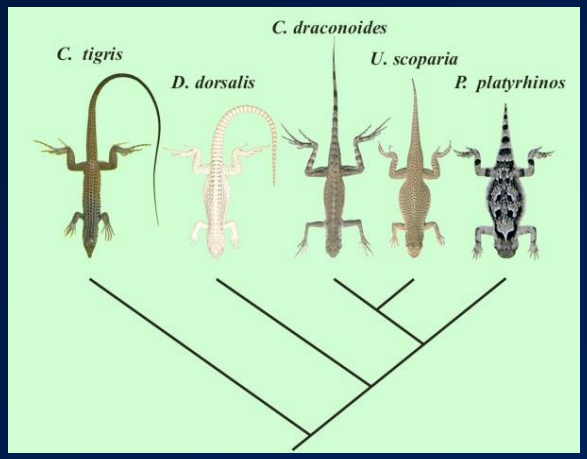
- Monday 09/03 CC, Wednesday 09/05 → Monday schedule
- M, T 09/10-11 NC (No Classes)
- T, W 09/18-19 NC (No Classes)
- M 10/22 CC
- Th –Sun 11/22-25 CC

Exam Schedule

- Exam 1: 09/26/18
- Exam 2: 10/22/18
- Exam 3: 11/19/18
- Exam 4: 12/19/18 (Final)

Phylogeny

= evolutionary history of a group of organisms.



To build phylogenetic trees, systematics gather all sorts of data:

1. Fossil record
2. Homology (*vs* analogy) & embryology
3. Biogeography (distribution of species)
4. Molecular data

Evolution

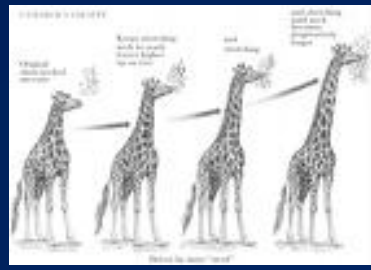
The unifying theory of biology

"*Nothing in biology makes sense, except in the light of evolution*" Theodosius Dobzhansky

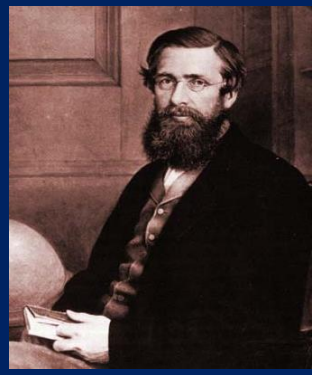
- The theory of *evolution* was formulated in the mid-1800s by Charles Darwin and Alfred Russel Wallace
  - Supported by fossil finds, geological studies, radioactive dating of rocks, genetics, molecular biology, biochemistry, and breeding experiments

Work leading up to Darwin

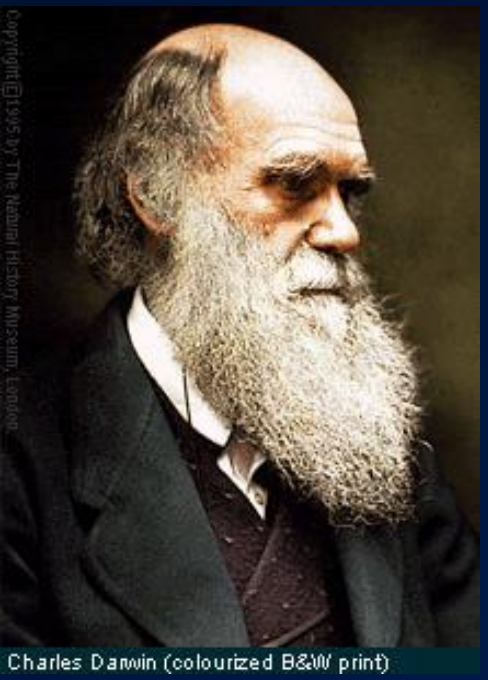
- The discovery of fossils and the notion of extinction
- Cuvier, Hutton, and Lyell – Geology
  - - Provided extensive evidence of geologic change
  - - Discovered "layers" of fossils representing different time periods
- **Thomas Robert Malthus (Early 1800) – Limited resources**
- **Jean-Baptiste Lamarck (Early 1800's)**
  - **Lamarck**'s theory of gradual change (evolution)
  - - theory of "use and disuse" leading to "inheritance of acquired characteristics

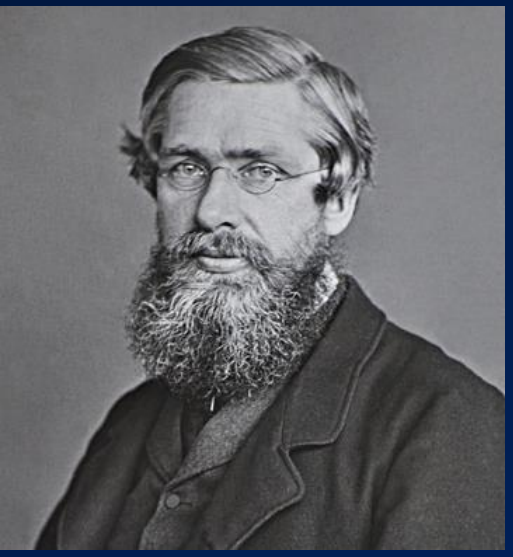


- Darwin and the voyage of the **HMS Beagle**
- Alfred Russel **Wallace** reached the same conclusions as Darwin.



Evolution


Charles Darwin (colourized B&W print)


Alfred Russell Wallace

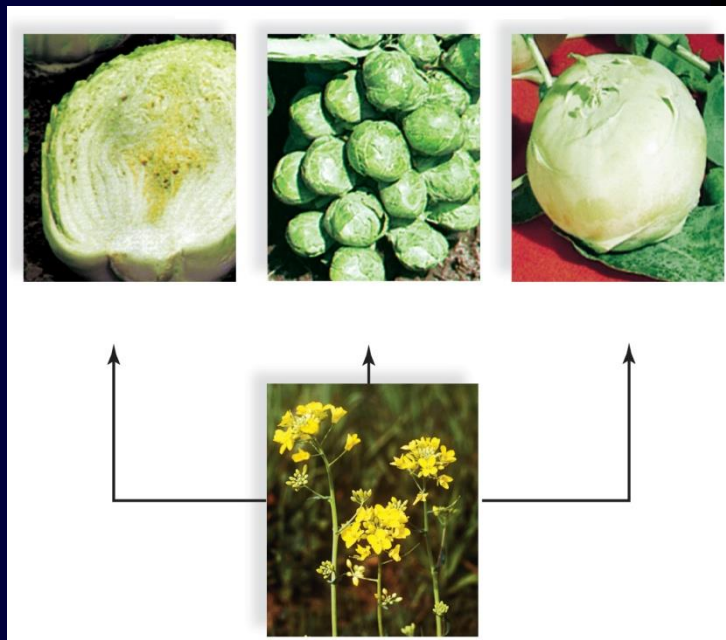
- Individuals compete for limited resources
- Individuals with traits that help them compete better tend to survive
  - ➔ Reproduce more ➔ Pass on their traits to their offsprings
    - i.e., **natural selection**

    (http://www.stuffyoushouldknow.com/podcasts/how-natural-selection-works/)
- So population changes over time
- **Evolution = change (in populations) over time**
- Interplay of the environment, genetic variation, and natural selection inevitably results in evolution: a change in the genetic makeup of species

Artificial Selection

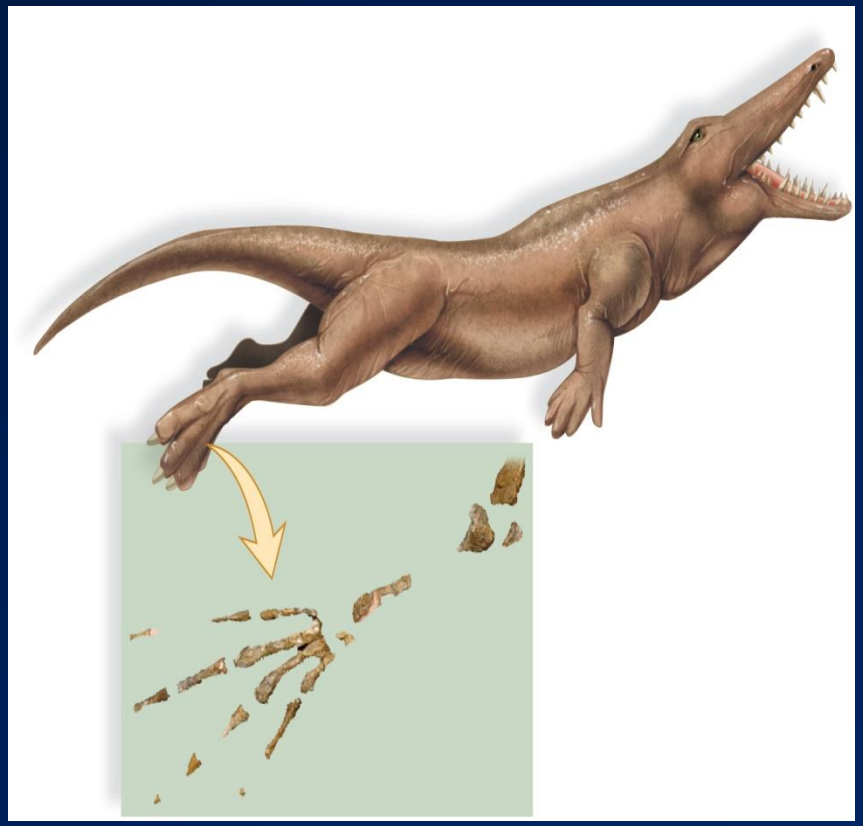
- Darwin described artificial selection as a model by which to understand natural selection.
- Following vegetables are derived from one species:
  - Chinese cabbage, brussels sprouts, and kohlrabi.
- Artificial selection of Animals
  - All dogs are descended from the gray wolf

https://www.youtube.com/watch?v=0jFGNQScRNY



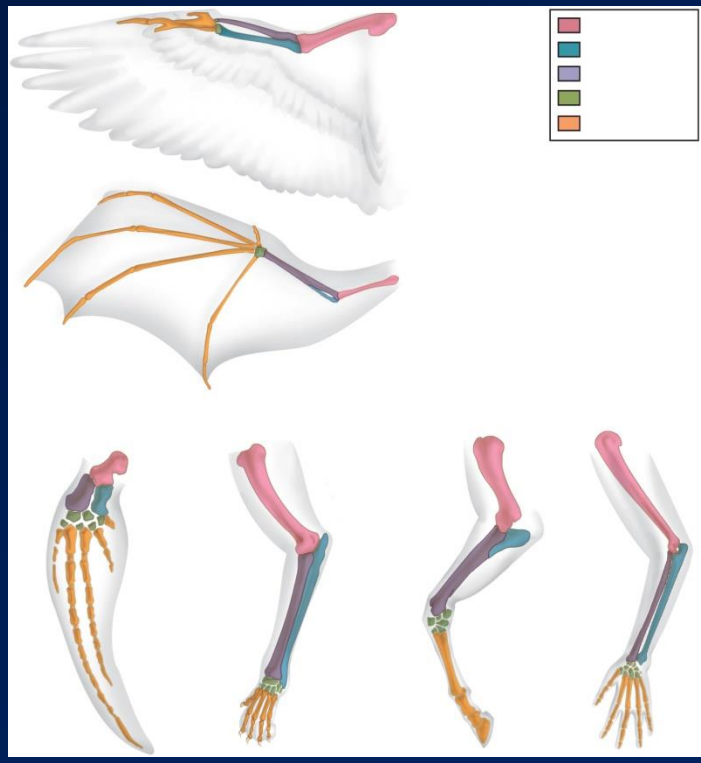
Evidence for Evolution: **Fossil Record**

- **Fossil evidence**
  - Fossils record the history of life from the past
  - Document a succession of life forms from the simple to the more complex
  - Sometimes the fossil record is complete enough to show descent from an ancestor



Homology

- **Homologous** Structures:
  - Anatomically similar b/c they are inherited from a common ancestor
  - May be functionally similar or not

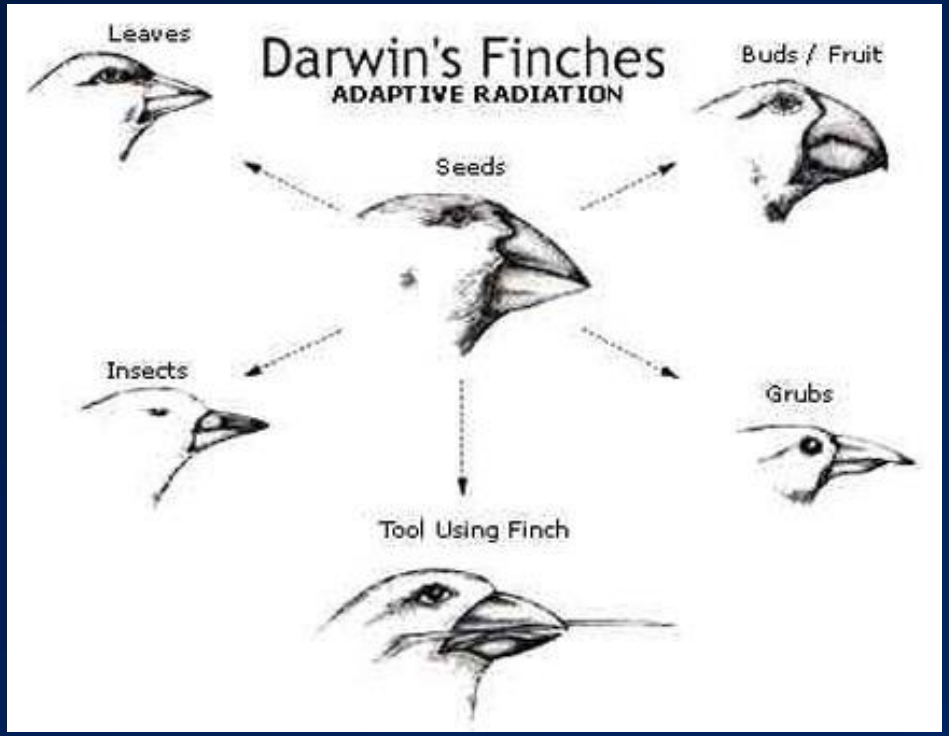


- **Analogous** Structures:
  - Serve the same function
  - Not constructed similarly
  - Do not share a common ancestor
  - E.g: wing of a bird and wing of an insect

- **Vestigial** Structures:
  - Fully-developed anatomical structures
  - Reduced or obsolete function (“left over from common ancestry)

Sorting Homology from Analogy

- **<u>Divergent Evolution</u>** – Following rapid adaptation (and speciation), two species could APPEAR very distant, but are actually closely related
  - Gene sequencing helps reveal this



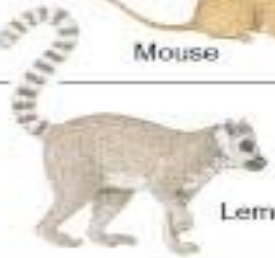
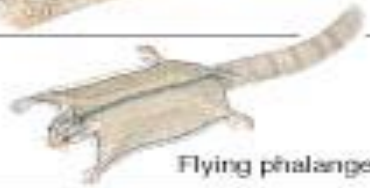
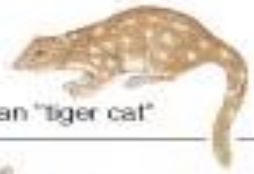
Sorting Homology from Analogy

- **Convergent Evolution** – Similarly, two distantly related species could evolve similar adaptations and thus APPEAR closely related
  - Gene sequencing helps, but also, must examine the organism as a WHOLE
  - **Homoplasy** – analogous structure (morphological or molecular)

Marsupial Australian mole

Eutherian North American mole

- **Convergent Evolution**

Niche	Placental Mammals	Australian Marsupials
Burrower	 Mole	 Marsupial mole
Anteater	 Anteater	 Numbat (anteater)
Mouse	 Mouse	 Marsupial mouse
Climber	 Lemur	 Spotted cuscus
Glider	 Flying squirrel	 Flying phalanger
Cat	 Bobcat	 Tasmanian "tiger cat"
Wolf	 Wolf	 Tasmanian wolf

Analogy or Homology?

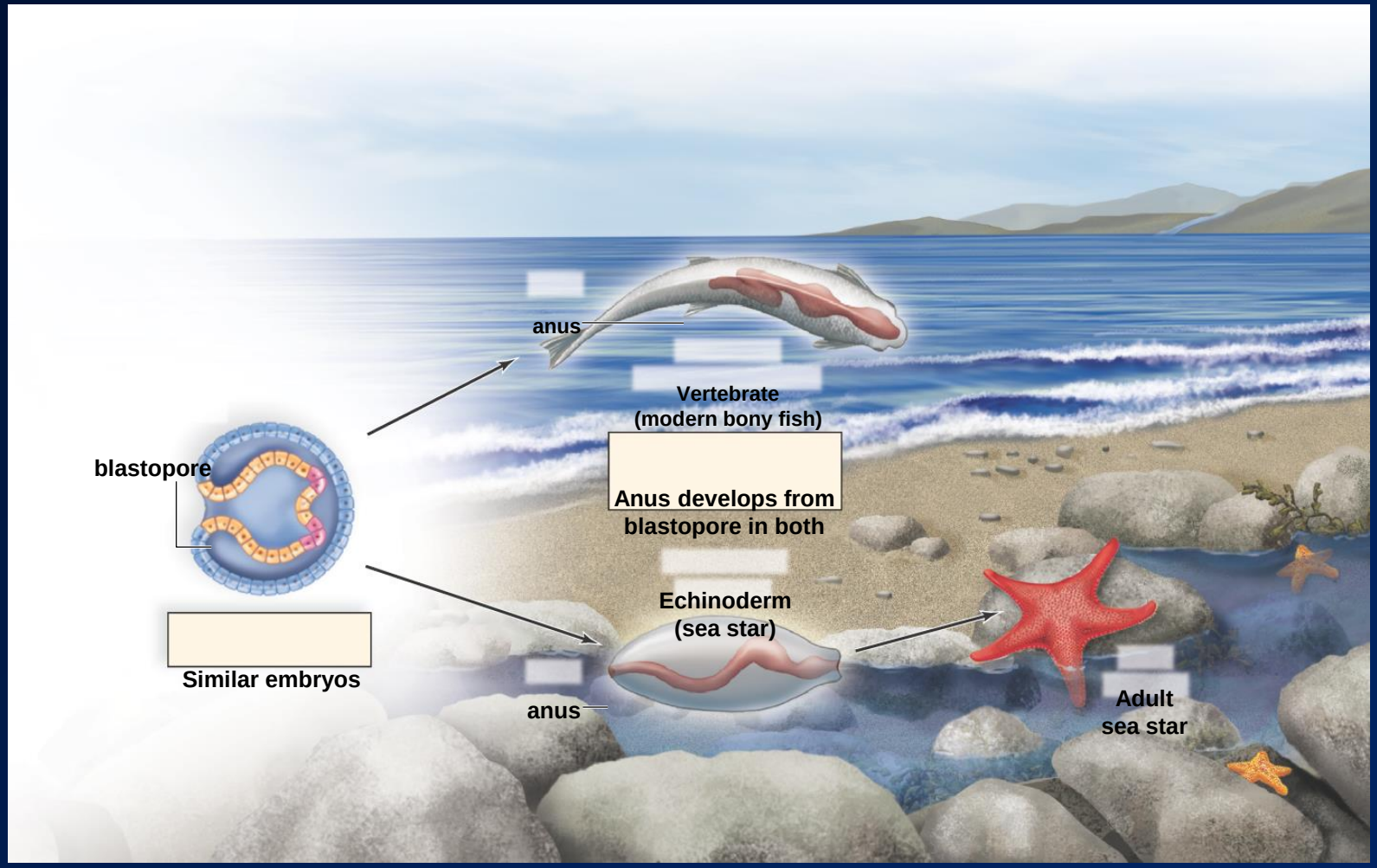
&

&

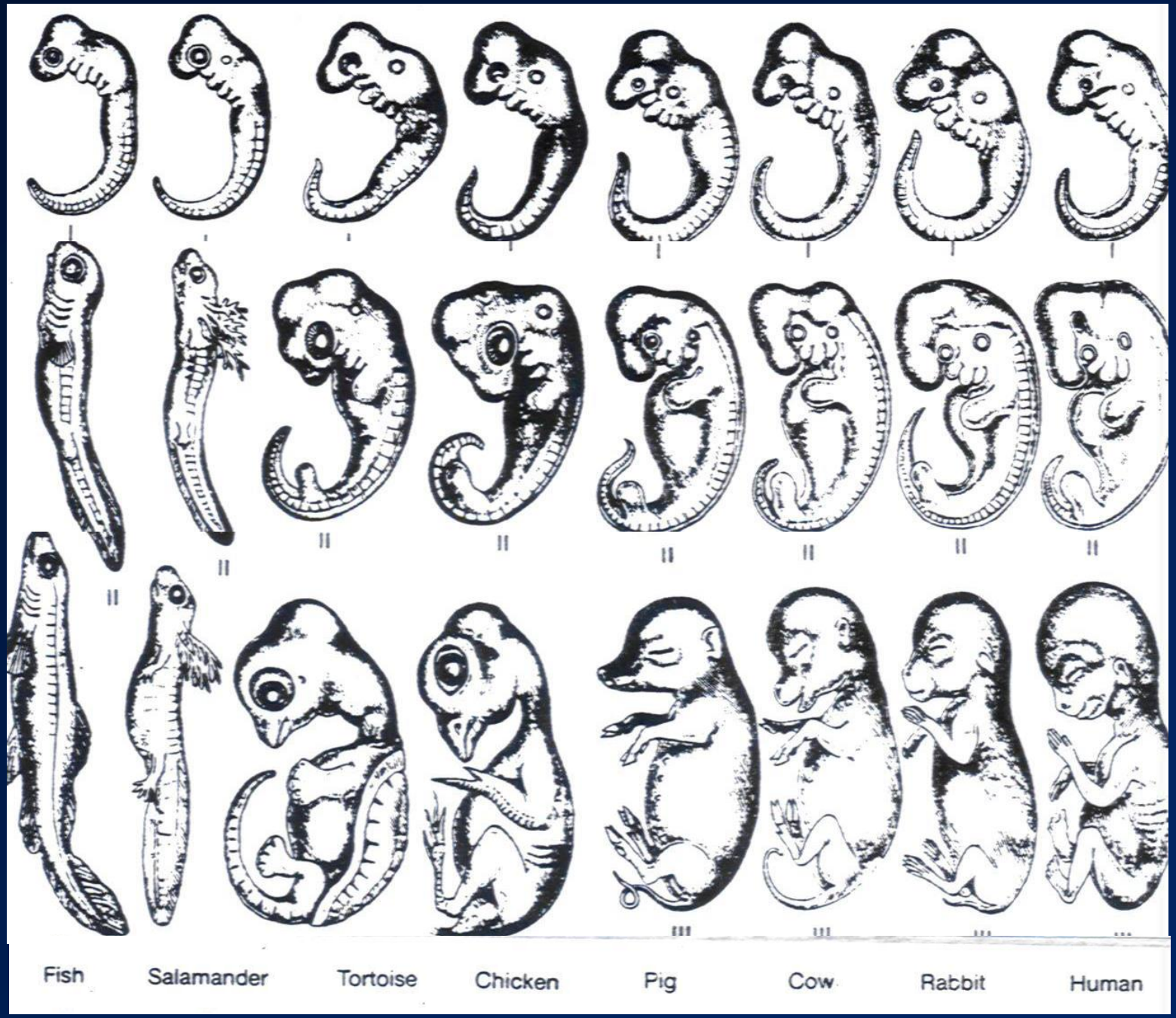
&

Homology: traits inherited by two different organisms from a common ancestor
Analogy: similarity due to convergent evolution, not common ancestry

Development Reveals Homologies

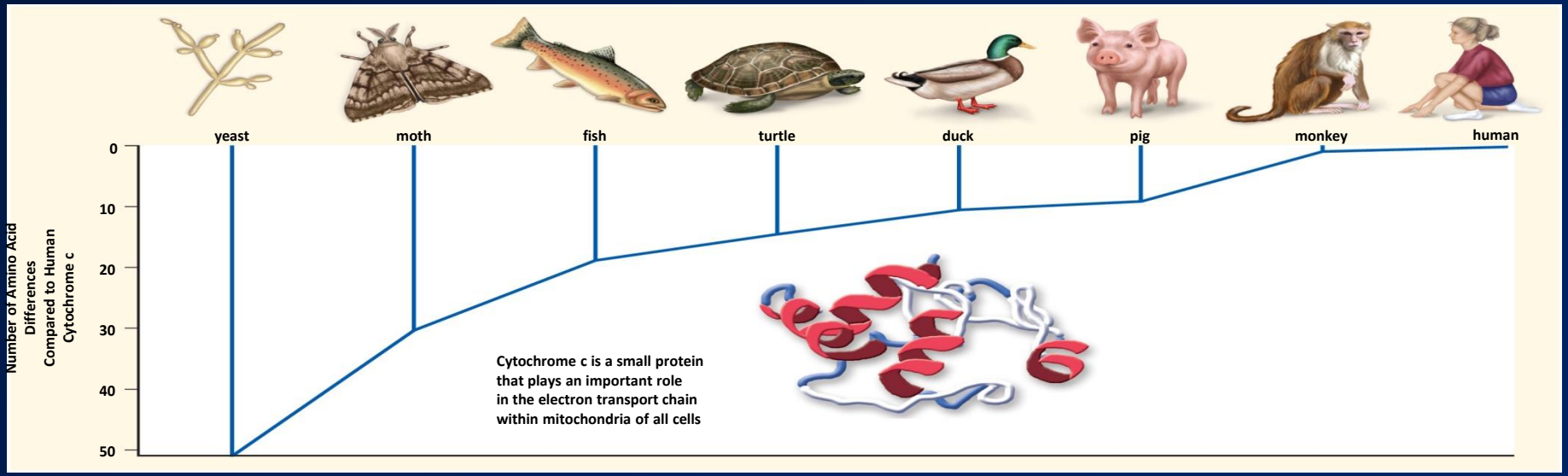


Deuterostome

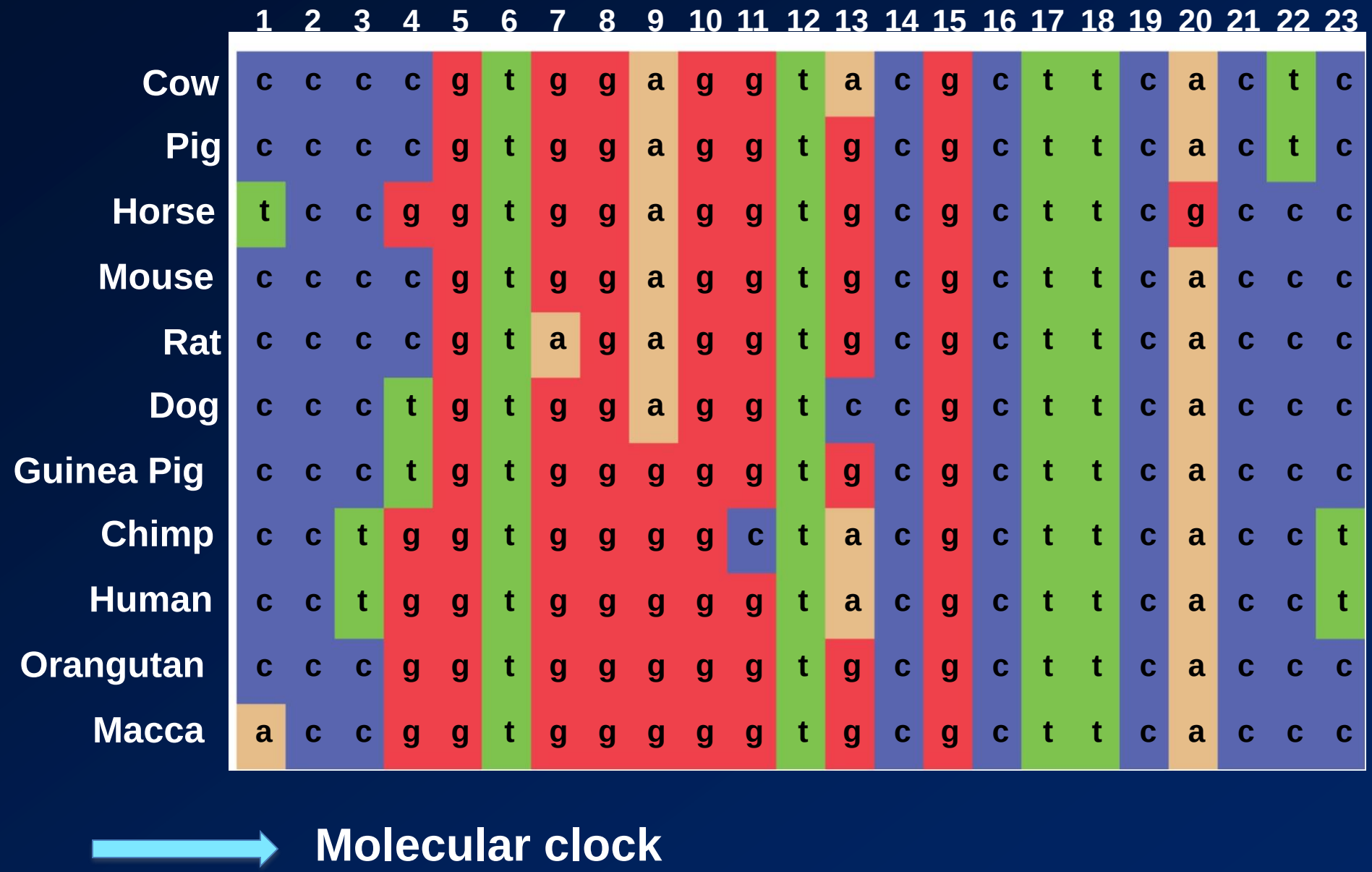

I
II
III
Fish
Salamander
Tortoise
Chicken
Pig
Cow
Rabbit
Human

Biochemical Data

- Almost all living organisms:
  - Use the same basic biochemical molecules
  - Utilize same DNA triplet code
  - Utilize same 20 amino acids in their proteins
- **DNA base-sequence differences:**
  - When very similar, suggest recent common descent
  - When more different, suggest more ancient common descent



DNA Sequence Alignment



Molecular clock

Question

Which statement represents the best explanation for the observation that the nuclear DNA of wolves and domestic dogs has a very high degree of **homology**

A. They have similar morphologies
B. They belong to the same order
C. They are both members of the family Canidae
D. They shared a common ancestor recently
E. Convergent evolution has occured

Do you remember?

1. Homologous structures are similar to each other because of _____ descent; It is sometimes difficult to decipher homologies because of _____ evolution

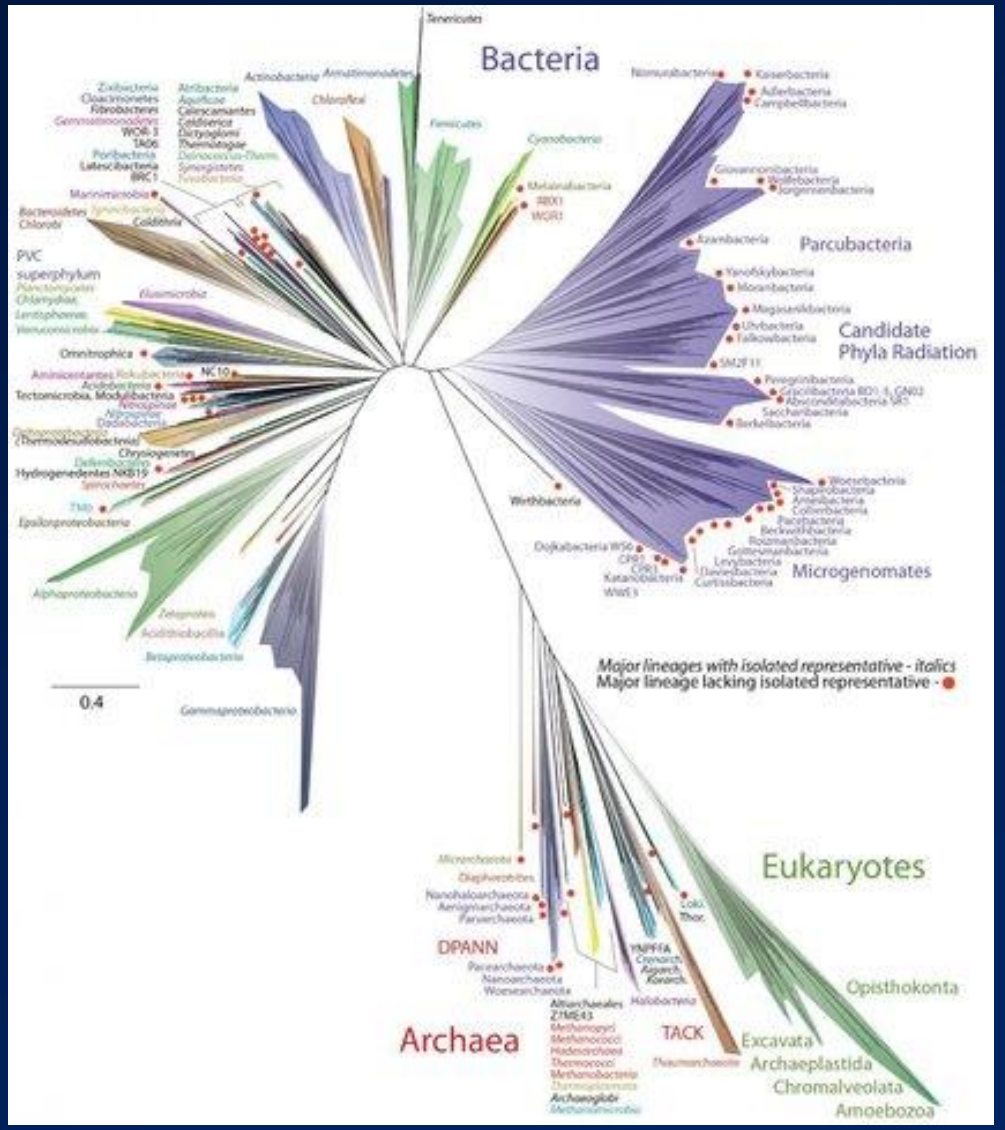
2. Analogous structures have the same _____ but do not have common_____? They cannot and should not be used to construct _____ _____.

3. Give examples of homologies, analogies, convergent and divergent evolution

4. What type of data help systematists construct phylogenetic trees?

Tree of Life Showing The Three Domains

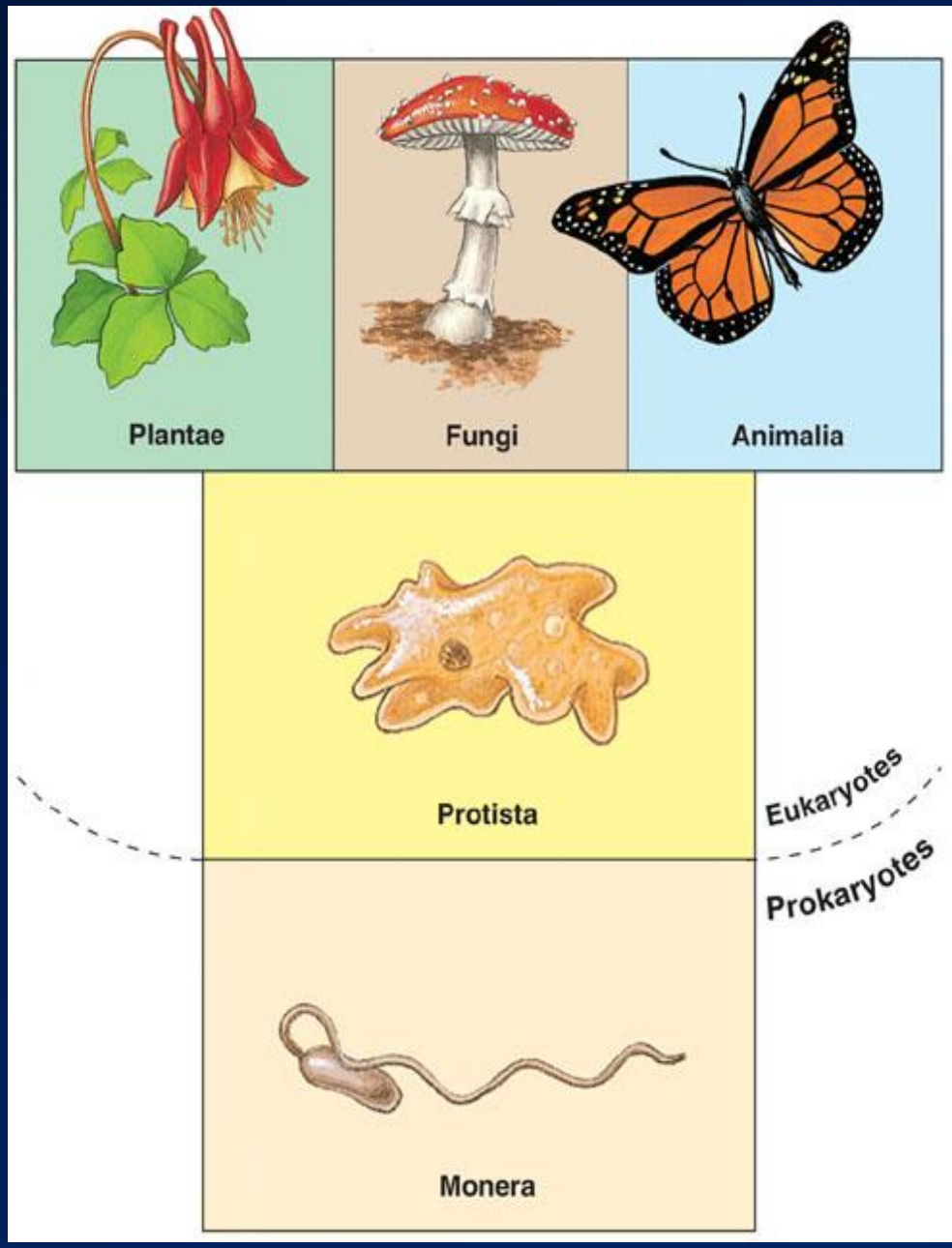
THEN (Aristotle's *Scala Naturae*)



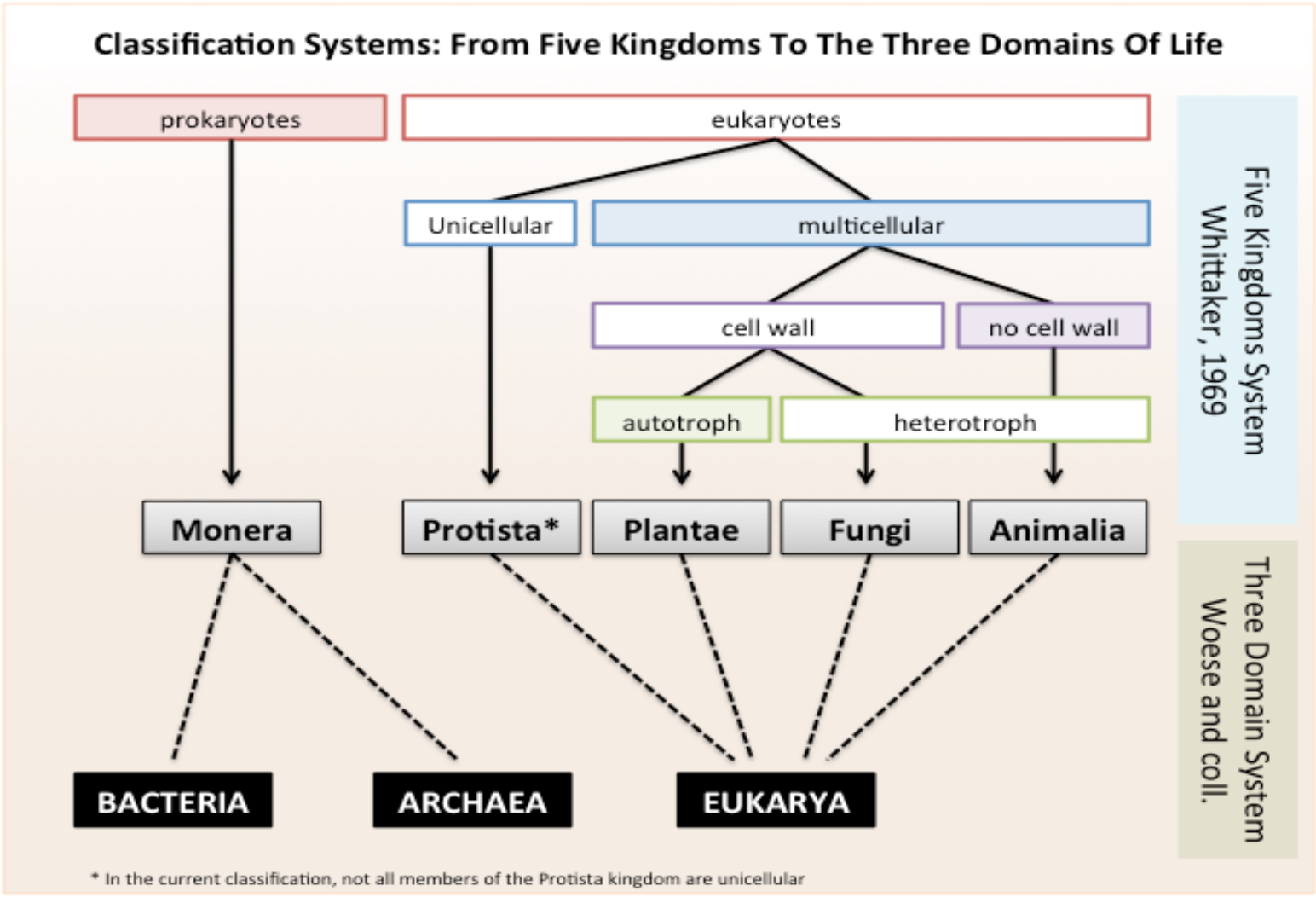
NOW (Post Darwin – http://www.nature.com/articles/nmicrobiol201648)

Reconstructing the Tree of Life

- Two kingdoms system until mid 20th century
- 1880s: Ernst Haeckel proposed third kingdom
  - Protista (unicellular microscopic organisms)
- Whittaker's five kingdoms system, 1969
- Now: Three domains system



From Five Kingdoms to Three Domains



Domains

- **Bacteria**
  - Microscopic unicellular prokaryotes
  - Kingdoms still being worked out

Escherichia coli, a bacterium

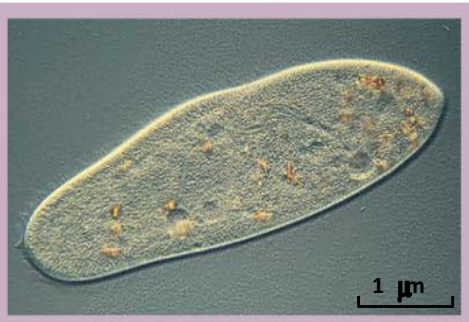
- **Archaea**
  - Bacteria-like unicellular prokaryotes
  - Extreme aquatic environments
  - Kingdoms still being worked out

Methanosarcina mazei, an archaeon

- **Eukarya**
  - Eukaryotes – Familiar organisms
  - Four kingdoms: Protista, Plantae, Fungi, Animalia

The 4 Eukaryote Kingdoms

Protists



Paramecium, a unicellular protozoan

- Algae, protozoans, slime molds, and water molds
- Complex single cell (sometimes filaments, colonies, or even multicellular)
- Absorb, photosynthesize, or ingest food

KINGDOM: Plants

Passiflora, passion flower, a flo

- Certain algae, mosses, ferns, conifers, and flowering plants
- Multicellular, usually with specialized tissues, containing complex cells
- Photosynthesize food

KINGDOM: Fungi

Coprinus, a shaggy mane mushroom

- Molds, mushrooms, yeasts, and ringworms
- Mostly multicellular filaments with specialized, complex cells
- Absorb food1

KINGDOM: Animals

Vulpes, a red fox

- Sponges, worms, insects, fishes, frogs, turtles, birds, and mammals
- Multicellular with specialized tissues containing complex cells
- Ingest food

More questions…?

1. Why was it easier to be a Bio1201 student in the 19th century?

2. Compare the five-kingdom system of classification to the three domain system

3. Contrast the characteristics of the bacteria, archaea and eukarya

4. Contrast the eukaryotic protists, fungi, plants and animals

Quiz Time

https://openlab.citytech.cuny.edu/oer-biology/lecture-schedule/