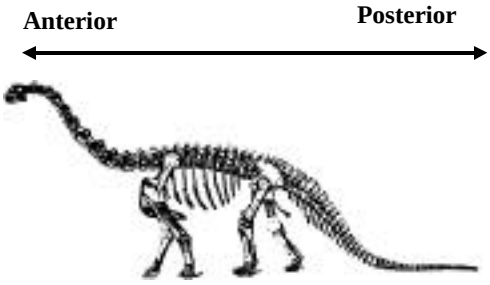
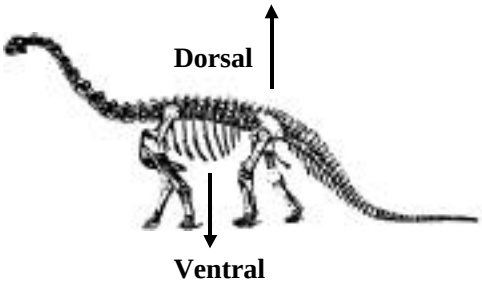
Dinosaur Anatomy & Classification

Orientation Terms – terms that are independent of the position of the skeleton.

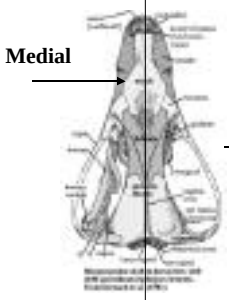
- The direction towards the head is called **anterior.** ("towards the tip of the snout") also referred to as **cranial.**
- The direction towards the tail is called **posterior.** ("towards the tip of the tail") also referred to as **caudal.**
- For example the shoulders are anterior to the hips and posterior to the skull. Nostrils are anterior to the eye sockets. The neck is posterior to the skull.



- The back side (where the spine is located) is called **dorsal.** ("toward and beyond the spine")
- The belly side is called **ventral.** ("toward and beyond the belly").
- The lower jaw is ventral to the eyes (below) and the nostrils are dorsal to the mouth (above)



- Run an imaginary plane through center of the body which runs from the tip of the snout to the tip of the tail, bisecting the body into a right and a left.
- Skeletal structures that are at the center of the plane are **Axial.** The skull, backbone and tail are the axial portion of the skeleton.
- Structures closer to the axis/center are **Medial.** (Towards the middles)
- Structures that are further away from the axis/center are **Lateral.** (Towards the sides)
- For example the shoulder blades are lateral to the ribs and the spine is medial to the ribs.



Top-down view of a skull.

- Finally, limb bones are referred to as **Proximal,** or towards the trunk of the body, or **Distal** further away from the body. For example your fingers are distal. The hip is proximal to the knee and the ankle is distal to the knee.

Posture

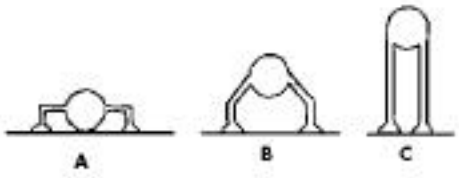
Dinosaurs are **tetrapod** vertebrates – animals with boney skeletons and four limbs. All tetrapods, including mammals, lizards, turtles, amphibians and birds, have the same general body plan, but there are variations in posture.

- Many dinosaurs were **bipeds** – habitually walked on their hind legs like modern humans and birds do.
- Others were **quadrupeds** – habitually walking on all four limbs like cats, dogs, and horses do.
- **Facilitated bipeds** usually walked on all fours but would occasionally walk on two – like bears.
- **Facilitated quadrupeds** usually walked on their rear legs, but will occasionally crawl on all fours if the occasion calls for it – like living kangaroos.

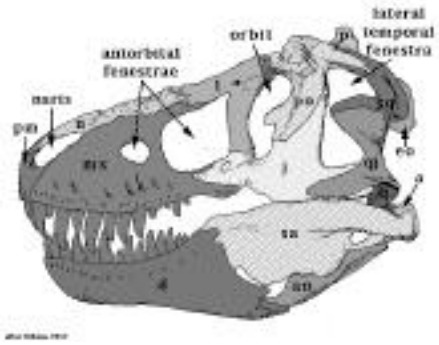
- Tetrapods that are adapted for aquatic or semi-aquatic existence, such as salamanders, display a **sprawling posture**, where the legs splay out from the body in the same plane as the torso. Walking requires a sinuous trunk motion similar to a swimming motion.

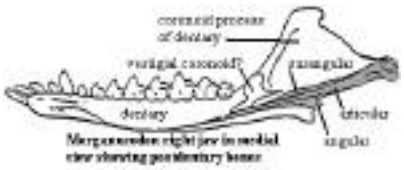
- Some tetrapods have a **semi-erect posture**, in which the legs are directed away from the body at an angle (usually about 45°). Crocodile, Komodo dragons and monitor lizards have a semi-erect posture. This posture is used by both aquatic and terrestrial animals. Locomotion is still achieved primarily by sinuous torso motion.

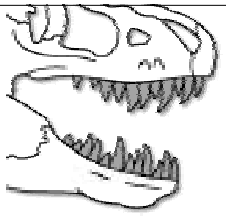
- Dinosaurs, cats dogs, horses and humans have a **fully erect** or **upright** posture. They stand and walk with their legs directly beneath their torso and are fully adapted to a terrestrial existence.



- **<u>The Skeleton</u>**
  The skeleton of a dinosaur (and all other vertebrates) is divided into a couple of different sections.
- The **skull** is composed of the
  - **cranium** (braincase, face and upper jaw) and
  - the **mandible** (lower jaw)**.**
- The **postcranium** (everything posterior to the cranium) is composed of the
  - **Axial** skeleton (spine, ribs, neck, trunk and tail) and
  - The **appendicular** skeleton (forelimbs, hindlimbs, and their **girdles** – bones that attach the limbs to the axial skeleton)





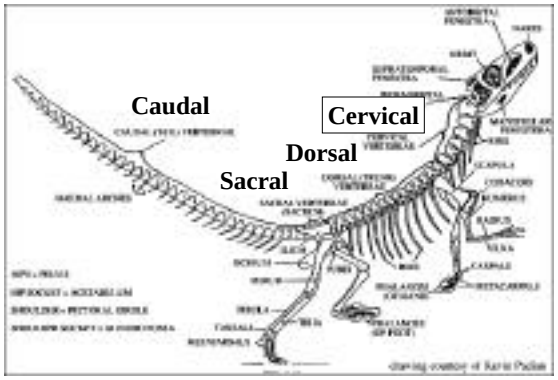


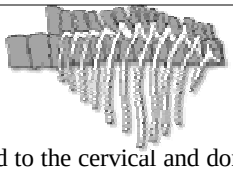
- **Teeth** are composed of soft **dentine** covered by harder **enamel.** Teeth have roots which fit into the sockets of the jaws and a **crown,** the portion above the gumline,

covered in enamel which chops, grinds, or tears food. Most types of dinosaur teeth do not show **occlusion** (when the surface of the teeth meets or touches). All of the teeth in a mouth are collectively called the **dentition**. In all toothed dinosaurs the teeth are renewed throughout life.

THE AXIAL SKELETON

- Most of the axial skeleton consists of the **vertebral column**, or backbone, which is composed of individual **vertebrae** (singular, vertebra). The vertebral column consists of the following four regions:
- **Cervical** - the neck
- **Dorsal** - the back
- **Sacral** - the hips (single unit called the sacrum)
- **Caudal** - the tail

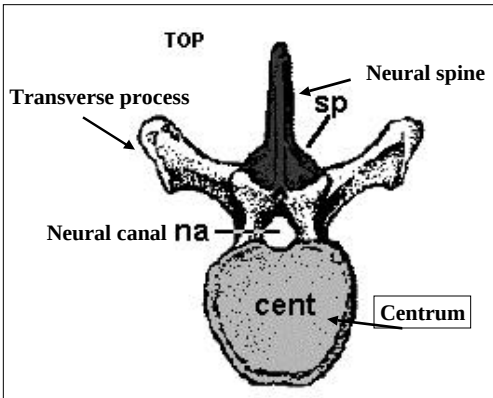




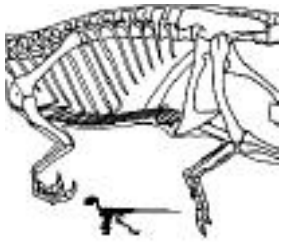
- Attached to the cervical and dorsal vertebrae are **ribs,** one on each side. Sacral ribs exist but are fused to the pelvic girdle. Instead of ribs, caudal vertebrae have **chevrons**, single bones which protect the nerves and blood vessels that run underneath the caudal centra.

Each individual vertebra contains the following sections:

- **Centrum** (pl. centra) the large spool-shaped body
- **Neural arch** an arch of bone on the dorsal surface of the centrum
- **Neural canal** the hole through which the spinal cord passes.
- **Transverse process** bony extensions off the lateral sides of the neural arch for attachment of muscles, tendons, ribs, etc.
- **Neural spine** bony extension off the dorsal surface of the neutral arch

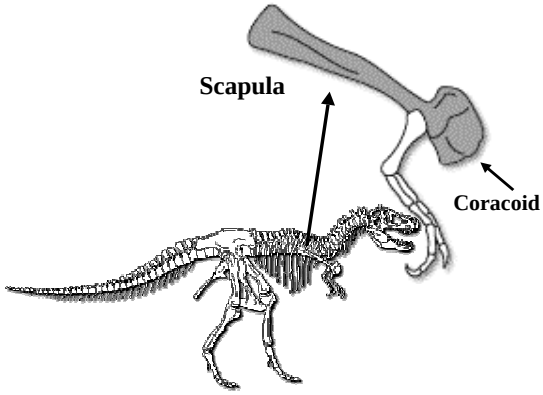


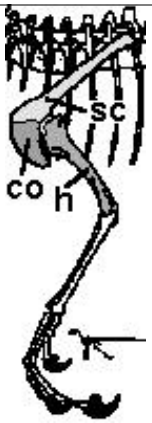
- Ventral to the guts of some dinosaurs and many other land vertebrates are **gastralia** (singular **gastralium**) or belly ribs.



THE APPENDICULAR SKELETON

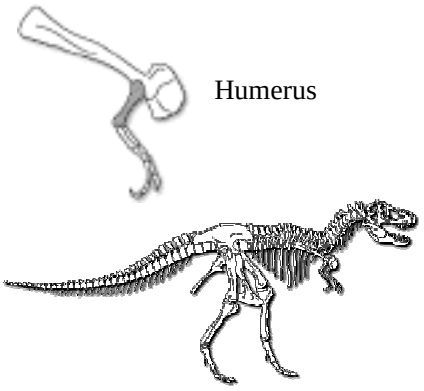
- The appendicular skeleton is composed of the limbs and their girdles.
- **The Pectoral Girdle** or Shoulder Girdle – attaches the forelimbs to the dorsal part of the axial skeleton.
- **Scapula** (pl. **scapulae**) **–** the shoulder blade (faces mostly posteriorly)
- **Coracoid** – a bone on the ventral side of the shoulder blade
- **Clavicle** – collar bone. Paired and separate in most dinosaurs, but in meat-eating dinosaurs, the clavicles are fused along the midline to form a single bone called the **furcula** (pl. **furculae**) or wishbone
- **Sternum** (pl. **sterna**) the breastbone – on the ventral surface of the chest.

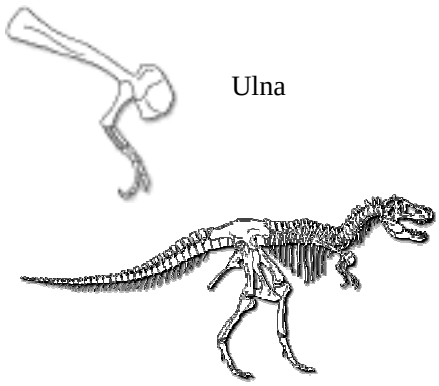


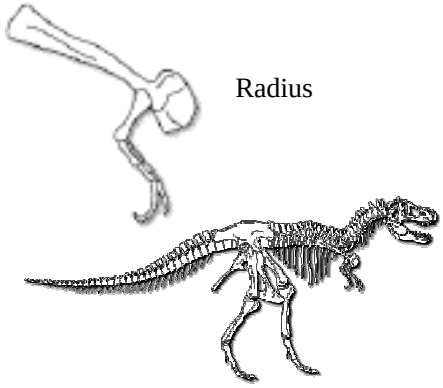


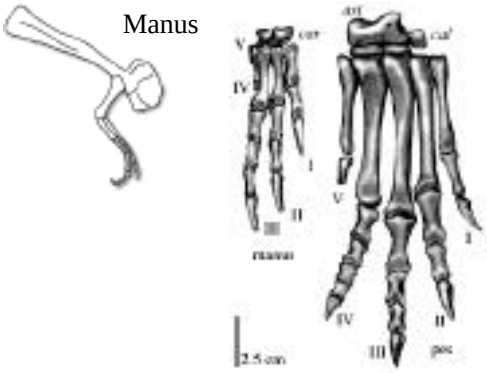
The Forelimb

- **Humerus** (pl. **humeri**) the upper arm bone which meets with the scapula and coracoid at the shoulder and the radius and ulna at the elbow
- **Ulna** (pl. **ulnae**) the (generally) larger and more posterior of the forearm bones.
- **Radius** (pl. **radii**) the smaller and more anterior of the forearm bones.
- **Manus** (pl. **manus**) the hand









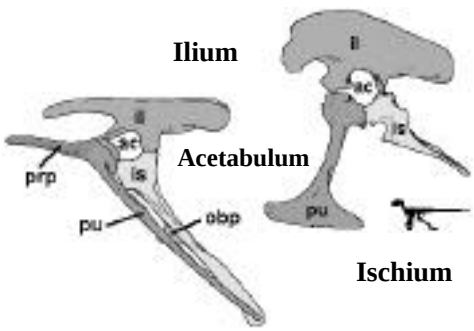
Manus (pl. **manus**) the hand, composed of

- **Carpals** – various small bones of the wrist
- **Metacarpals** – the long bones of the palm of the hand. These are numbered I – V, with I being the medialmost (attaches to the thumb) and VI being the lateralmost (attaches to the pinky). All the metacarpals as a unit are called the **metacarpus** (pl. **metacarpi**)
- **Digits** – fingers. Digits are also numbered I – V, with I being the thumb and V being the pinky. Digits are composed of individual finger bones or **phalanges** (pl. **phalanx**). The distalmost, claw or hoof bearing-phalanx is called the **ungual.**

The Pelvic Girdle attaches the hindlimbs to the sacral part of the axial skeleton (aka **pelvis** or (pl. **pelves**). The pelvic girdle is composed of three bones on each side:

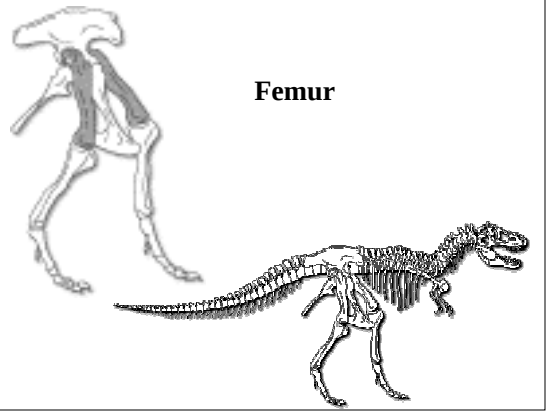
- **Ilium** (pl. **ilia**) the dorsalmost of the bones which connects directly to the sacral vertebrae.
- **Pubis** (pl. **pubes**) the lower pelvic bone that always attaches to the ilium anterior to the ischium, although the shaft of the pubis in some dinosaurs points backwards.
- **Ischium** (pl. **ischia**) the lower pelvic bone that always attaches posterior to the pubis and points posteriorly.

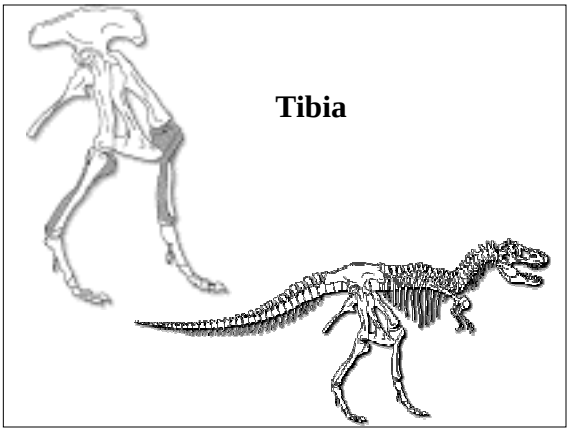
- The **Acetabulum** (pl. **acetabula**) the hip socket, where the femer fits into the pelvis. In most vertebrates there is a sheet of solid bone formed by the pelvic bones on the medial surface of the acetabulum, but dinosaurs are specialized in having a **perforate** (open) acetabulum (only a sheet of cartilage rather than bone on the medial surface).

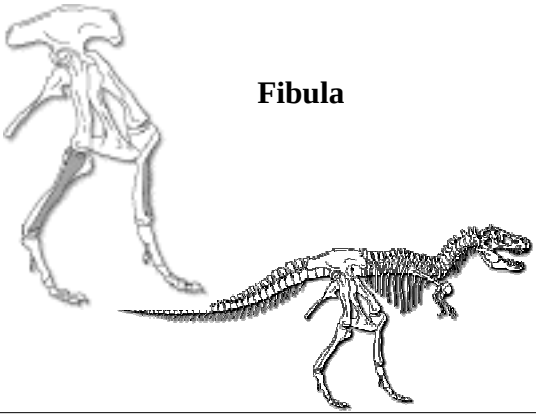


The Hindlimb is very similar to the forelimb.

- **Femur** (pl. **femora**) the thigh bone. Fits into the acetabulum by the femoral head and meets the tibia and fibula at the knee. Often the single largest bone in the body (except in small running dinosaurs were the tibia is often larger).
- **Tibia** (pl. **tibiae**) the main shin bone, generally thicker than and medial to the fibula
- **Fibula** (pl. **fibulae**) smaller than and lateral to the tibia. (There is no such thing as a "fibia")
- **Pes** (pl. **pedes**) the foot



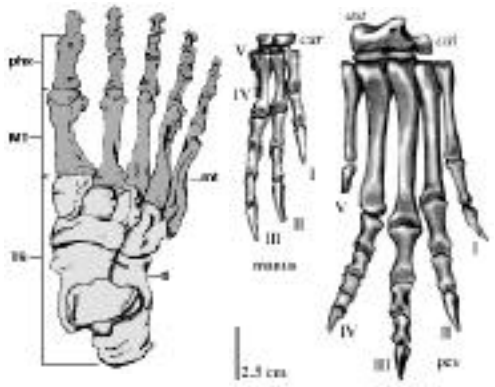




Pes (pl. **pedes**) the foot, composed of:

- **Tarsals** – various small bones of the ankle. The whole ankle is called the **tarsus** (pl. **tarsi**). Two tarsals of importance in dinosaurs are the two proximal tarsals; the **astragalus** (pl. **astragali**) and the **calcaneum** (pl. **calcanea**), which fit into the distal ends of the tibia and fibula. Incidentally dinosaurs and their closest relatives lack a heel, which is formed in other land vertebrates by a backwards extension of the calcaneum.

- **Metatarsals** – the long bones of the body of the foot. These are also numbered I-V, with I being the medialmost (attached to the big toe) and V being the lateralmost (attached to the little toe). All the metatarsals as a unit are called the **metatarsus** (pl. **metatarsi**). Unlike humans and bears, but like cats, dogs, horses and birds, dinosaurs held their metatarsi upright so that their ankles did not normally touch the ground.
- **Digits** – toes. Digits are numbered I – V as above, with I being the big toe and V being the little toe. Digits are composed of individual toe bones or **phalanges** (pl. **phalanx**).



Evolution

Jean-Baptiste Lamarck (French: late 1700s-early 1800s): predominant theory of "evolution" prior to Darwin:

- During their lifetimes, individual organisms **acquire** structures or skills useful in dealing with environment
- These acquired structures are passed on to their descendants
- Over time, the accumulation of acquired structures changes one type of organism to another
- Flaw with Lamarckian Evolution: characters acquired **during the lifetime** of an organism are **not passed on to descendants!**

During early-mid 1800s, two natural historians independently developed an alternative, and superior model: **Natural Selection**.

Two individuals were **Alfred Russell Wallace** and **Charles Darwin**:

- Both British
- Both trained in England, but traveled to far countries (Darwin to South America and Galápagos,Wallace to Amazon River basin and Malaysia)
- Independently made same basic observations and conclusions
- Mutual friends decided to present papers of both (in 1858) on their behalf, so both could get credit

- The following year (1859) Darwin published *On the Origin of Species by Means of Natural Selection*: an instant "best-seller" and source of decades of controversy.

Their basic observations:

I. Organisms in all populations possess heritable **variations** - size, color, agility, speed, digestion …

II. Some variations are more favorable then others.

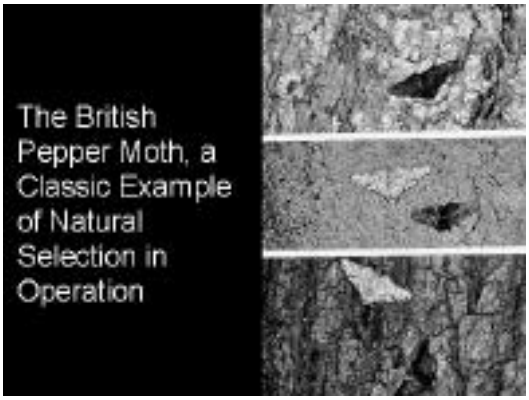
III. More young are born to every population than can POSSIBLY survive

IV. Those with favorable variations are more likely to survive and produce offspring with their favorable variation.

- Thus, IF some variation gives the individual a slight advantage (bigger, stronger, smaller, smarter, less tasty, whatever) at surviving; and IF that variation is inherited; THEN there is a somewhat better than average chance that organisms with that variation will survive to bear the next generation. Over the long expanse of geologic time, the accumulation of these variations will change the population from one form to another: the **origin of species**.

= Natural Selection

- This process is analogous to **artificial selection** (i.e., domestication), and thus called **natural selection**.
- NOTE: Natural Selection is **NOT** "survival of the fittest", as implied by your textbook
- NOTE ALSO: Darwin did not use the word "evolution" very often; instead, preferred the phrase **"descent with modification"**.



- Darwin also pointed out a subset of Natural Selection: **Sexual Selection**, where the variation is "being more sexy" (and thus have better than average chance of breeding, and thus passing on "sexiness", compared to other members of the population): peacock tails, bird song, etc.
- Sexual Selection is actually often at odds with “Natural Selection” - prettier feature can also make it easier for a predator to find/catch

Taxonomy

- the “naming of names” or the scientific practice and study of labeling and ordering like groups of organisms.
- **Taxon** (pl. **taxa**): a named group of organisms.

Carl Linné (**Linnaeus**) developed a universal set of rules in the Systema Natura ("Natural System") in 1758; later workers added and modified the system (primarily with the addition of new "ranks").

Some of the Linnean rules:

- All names are in **Latin** or **Greek**, or are modified into Latin form;
- Each name must be unique;
- All names are fit into a nested hierarchy (species into genera, genera into families, and so forth);

- In traditional Linnean taxonomy, there is a set of official ranks (from smallest to largest, species, genus, family, order, class, phylum, kingdom) (later workers added additional intermediate ranks, such as tribes, subfamilies, superfamilies, etc.);
  - The primary unit is the **species** (pl. **species**):
  - Definition of a "species" varies from biologist to biologist; some definitions ("naturally occurring interbreeding populations") cannot be tested for fossils!
  - Each species has a **type specimen** accessioned in an appropriate institution (museum, zoological or botanical garden, or other such collection);
  - Whoever describes the type specimen of a new species has the right to name that new species (following the rules below);

  - The next higher unit, the **genus** (pl. **genera**) is composed of one or more species
  - Definition of a "genus" is problematic as well, since it is composed of one or more "species";
- Each genus has a **type species**: all other species are assigned to the genus based on their similarity to the type species;

  - Linnean taxonomy has its own special set of **grammatical rules**:
- Genera have **one word** names (e.g., *Panthera*, *Homo*, *Ginkgo*, *Tyrannosaurus*);
  - The genus name is always **Capitalized** and ***italicized*** (or **underlined** if you don't have access to italics);
- Species have **two word** names, the first part of which is the same as the genus name (e.g., *Panthera leo*, *Homo sapiens*, *Ginkgo biloba*, *Tyrannosaurus rex*)

  - The genus name is **ALWAYS** capitalized, the second part ("trivial nomen") is **ALWAYS** in lower case, and the name is **ALWAYS** italicized or underlined;
    - *Tyrannosaurus rex*
  - Species names can be abbreviated by using only the first letter of the genus name, followed by a period (**NEVER** by a hyphen): *H. sapiens* and *T. rex* are correct; *H. Sapiens* or *T-Rex* are ***WRONG!!***

- Some taxon names for groups composed of multiple genera ("families" in the old sense) have special formal endings. We won't be going over those details in this class;
  - All taxon names other than species have **one word** names, which are **capitalized**; all taxon names other than genera and species are in **roman** letters (i.e., they are never italicized/underlined): Dinosauria, Tyrannosauridae, Animalia; **not** *Dinosauria*, tyrannosauridae, or animalia.

- **Rule of Priority**: whichever validly formed name for a species or genus was published **first**, even if only by days, is the name that must be used.

Systematics

- the scientific study of the diversity of organisms within and among **clades** (genetically related groups of organisms)
  - Taxonomy = naming organisms / groups
  - Systematics = identifying evolutionary significant groups

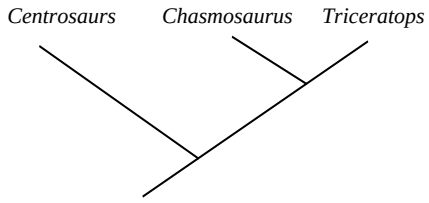
Evolutionary Systematics

- an eclectic system of classification based on morphological similarity and the Linnaean taxonomic hierarchy (K,P,C,O,F,G,S)
- It turns out that to classify organisms there need to be an unmanageable number of sub- and super- groups (superorder, suborder …)

Phylogenetic Systematics

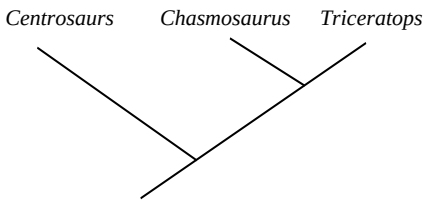
- Also known as Cladistics
- **Phylogeny**: a "family tree" of taxa
- Designed to show closeness of ancestry between groups

Chasmosaurus and *Triceratops* share a more recent common ancestor with each other than either does with *Centrosaurs*

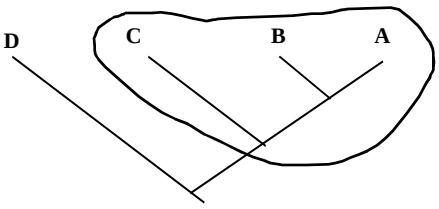


Sister Taxon - taxon which share a splitting event, like *Chasmosaurus* and *Triceratops.*

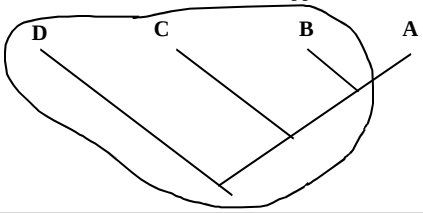
Centrosaurs is a sister group with *Chasmosaurus* plus *Triceratops.*



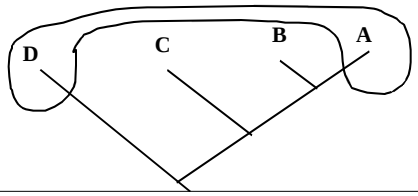
- **Monophyletic** ("single branch"): all descendants of a common ancestor
  - Most recent common ancestor of the members of a monophyletic group is also a member of that group
  - Represents a complete branch of the tree of life



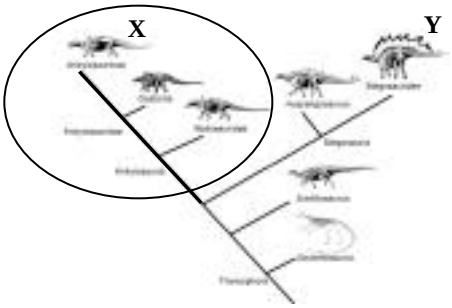
- **Paraphyletic** ("nearly a branch"): some, but not all, descendants of a common ancestor
  - Most recent common ancestor of the members of a paraphyletic group is also a member of that group
  - Represents a branch of the tree of life with one or more buds or stems clipped off



- **Polyphyletic** ("many branch"): two groups that do not share a direct common ancestor which is also part of the group
  - Most recent common ancestor of the members of a polyphyletic group is **not** also a member of that group
  - Represents two or more separate branches of the tree of life



- Stem-based taxon - "Taxon X and all organisms sharing a more recent ancestor than with Taxon Y"



- Node-based taxon - "The most common recent ancestor of Taxon X and Taxon Y, and all descendants of that ancestor"