The Way We Move

The way we ALL move

BIOLOGICAL ANTHROPOLOGY

- Study of human origins and evolution

What is our place in nature?

- Who are we?
- How did we come to be this way?

Biological Anthropology

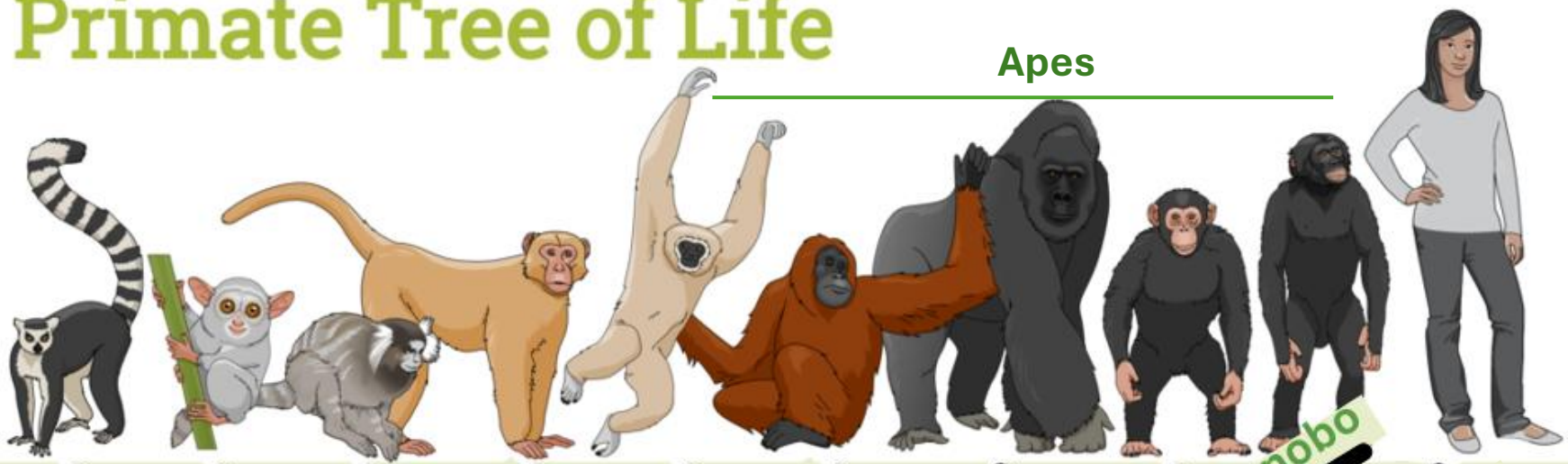
PRIMATE LOCOMOTION:

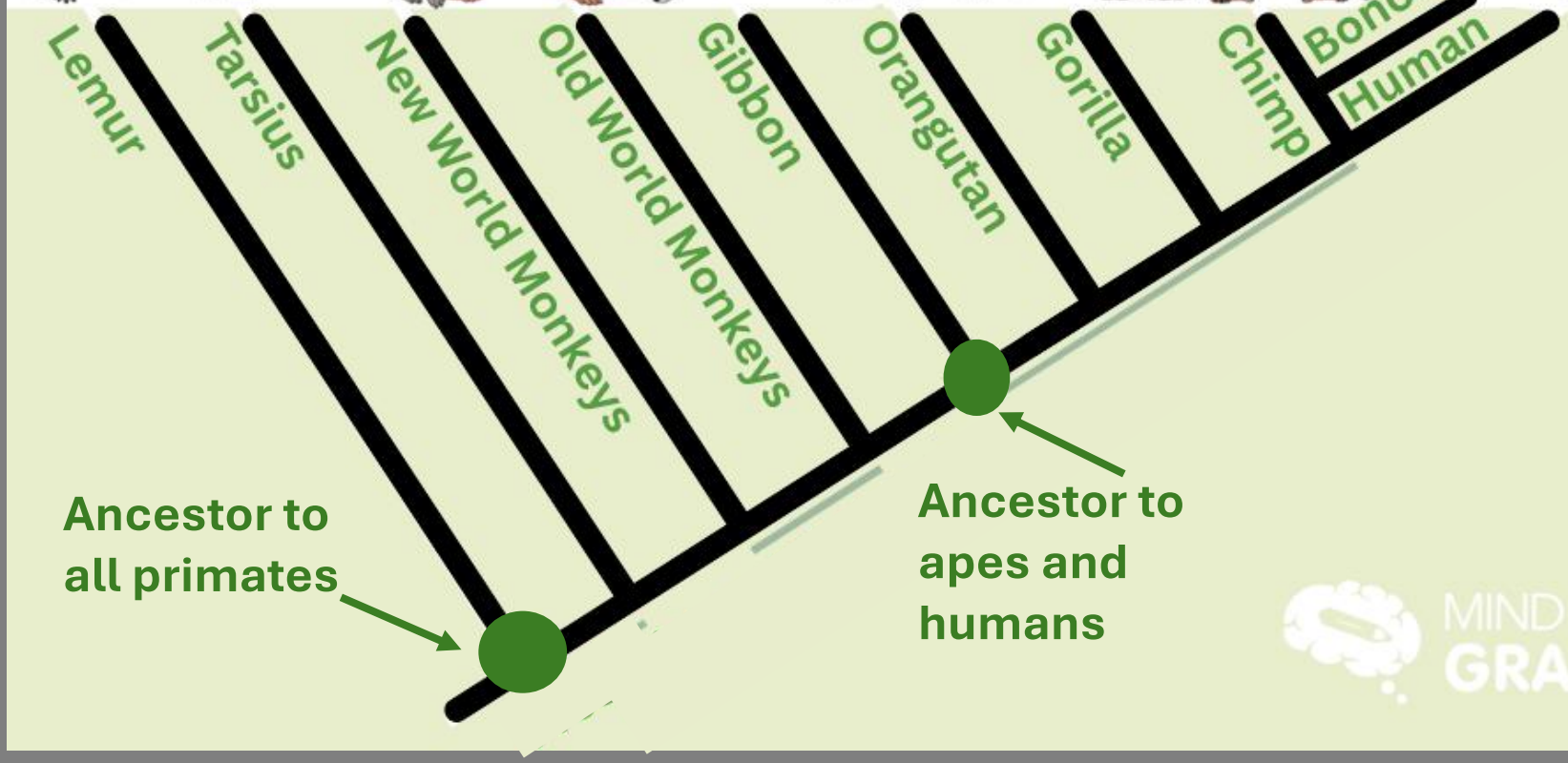
- anatomy
- function
- evolution

HUMANS ARE PRIMATES!

Humans are similar to other primates

Primate Tree of Life





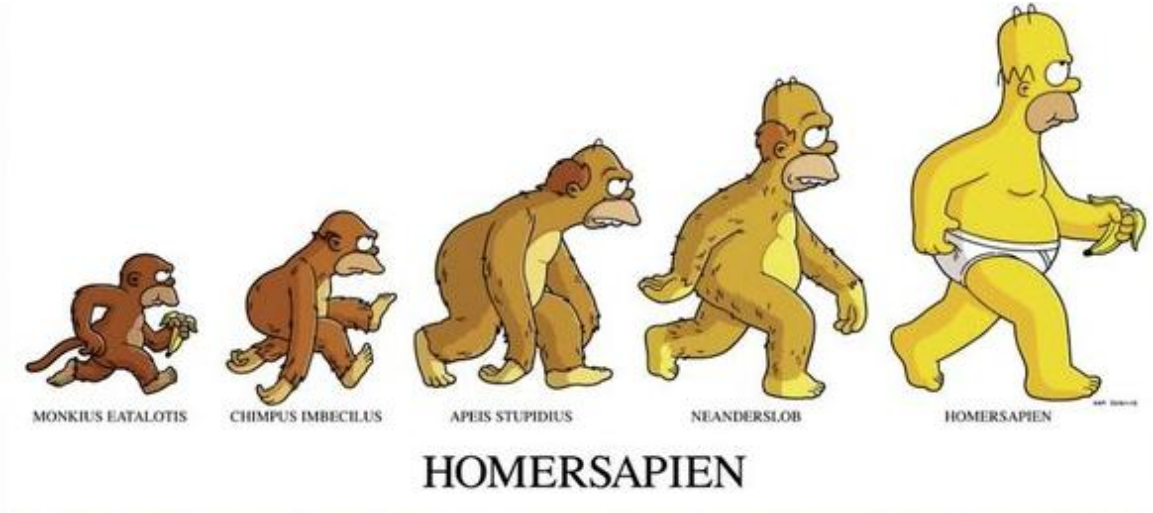
What makes us human?

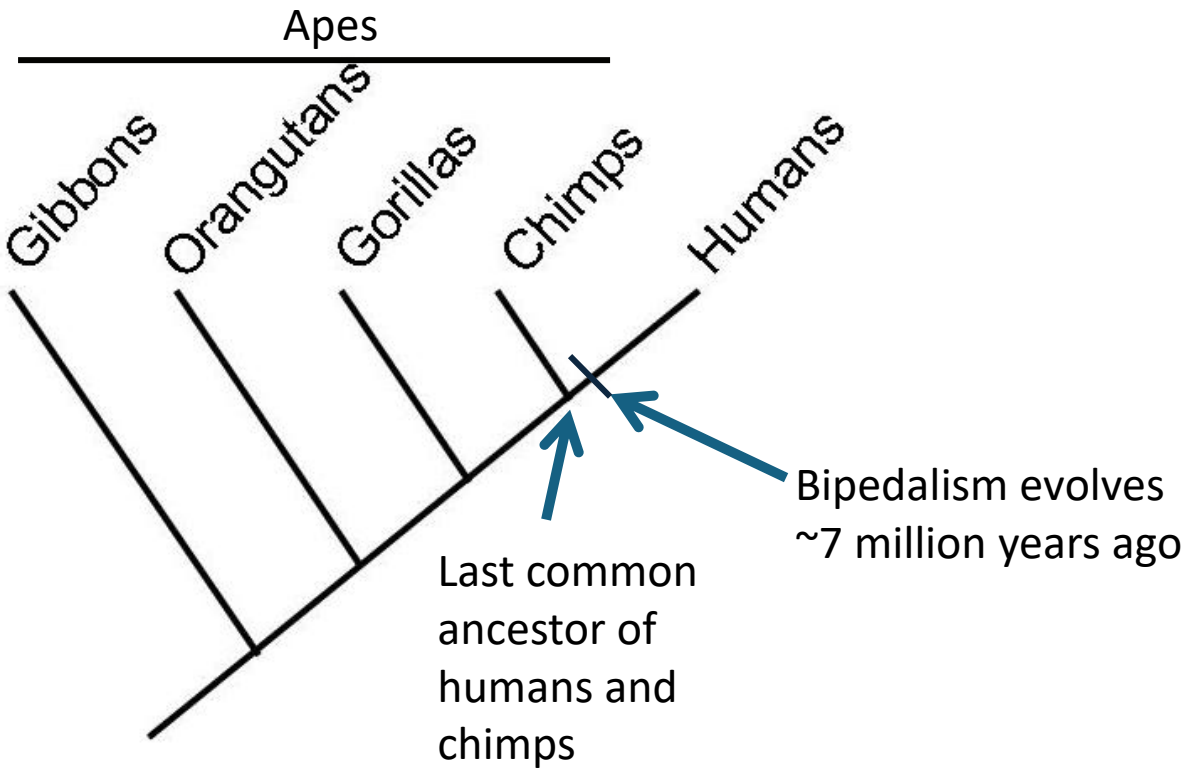
Humans are different from other primates

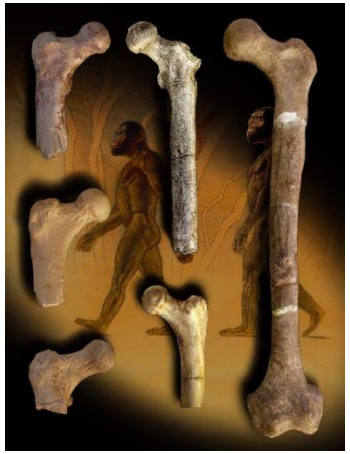
- Larger brain size
- Less body hair
- Language
- Culture
- Technology

- Locomotion: bipedalism

Evolution of bipedalism

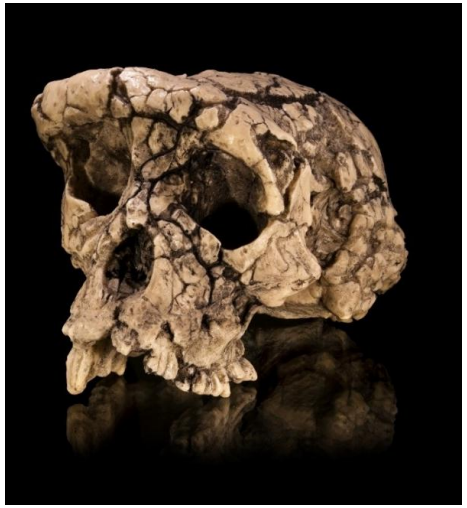






Femur of
Orrorin tugenensis
6 mya, Kenya

Oldest hominin:
Sahelanthropus tchadensis 7 mya, Chad



Tonight's main question:

How can studying primate locomotion help us understand ourselves?

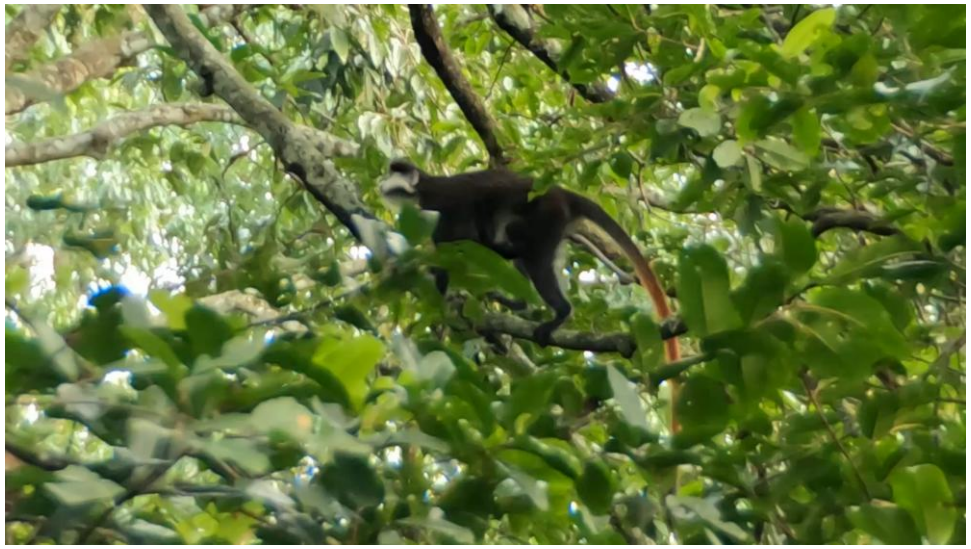
- What are the many ways primates move?
- What are some of the key moments in primate locomotor evolution?
- How does human anatomy and locomotion reflect our evolutionary history?

Primates are ARBOREAL
….they evolved to live and move in the trees

Let’s count the ways they do it…

Quadrupedalism

Moving on *top* of branches



Cercopithecus ascanius, Kibale NP, Uganda 2022

Eulemur rubriventer, Ranomafana NP, Madagascar 2022

Two kinds of leaping

HORIZONTAL LEAPING

Jumping *between* trees

VERTICAL LEAPING

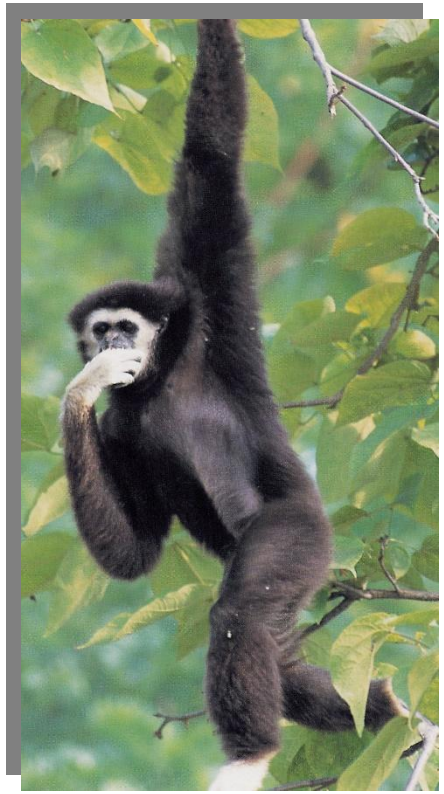
Ruffed lemur leaping

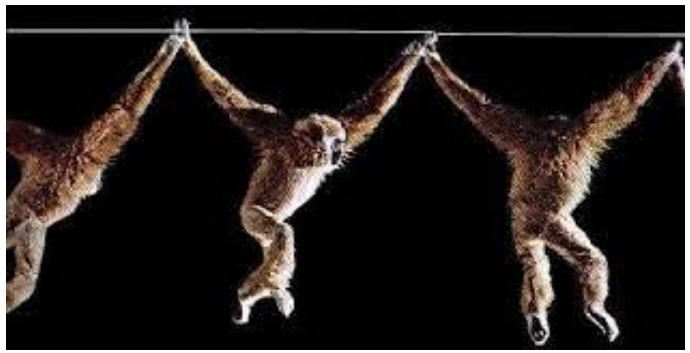
Sifaka leaping

Suspensory locomotion: moving *below* branches

- hanging
- arm-swinging
- climbing
- bridging

Orangutan





BRACHIATION

(crazy fast specialized arm-swinging)

Gibbon

Bipedalism

Ankoatsifaka Research Station YouTube channel of Dr. Rebecca Lewis, Dept of Anthropology, UT Austin **@ankoatsifaka4332**

Bipedalism

Anatomy of human bipedalism

- lower back, pelvis, hips, knees, feet

Chimpanzee (ape)

Lower back: curved

Pelvis: shortened, reoriented

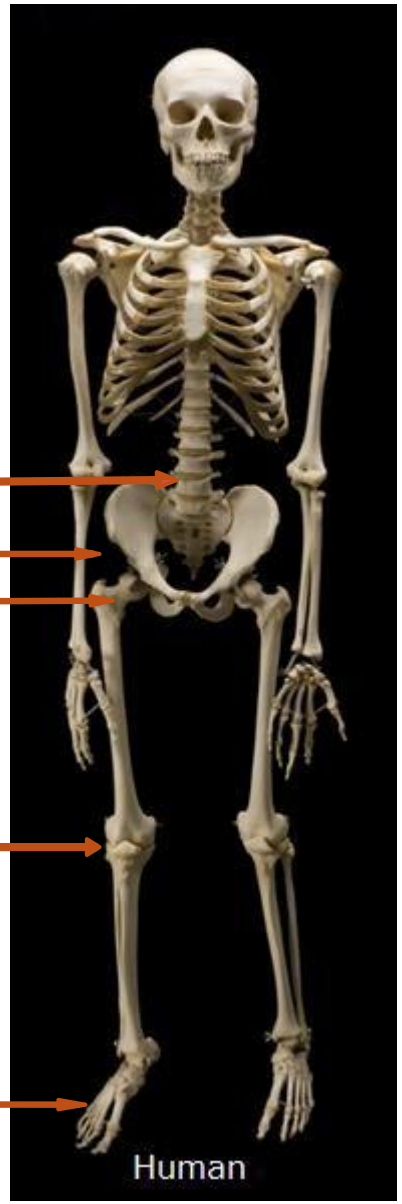
Hip joint: enlarged

Knee joint: enlarged/close to midline

Big toe: non-grasping

Foot: arched

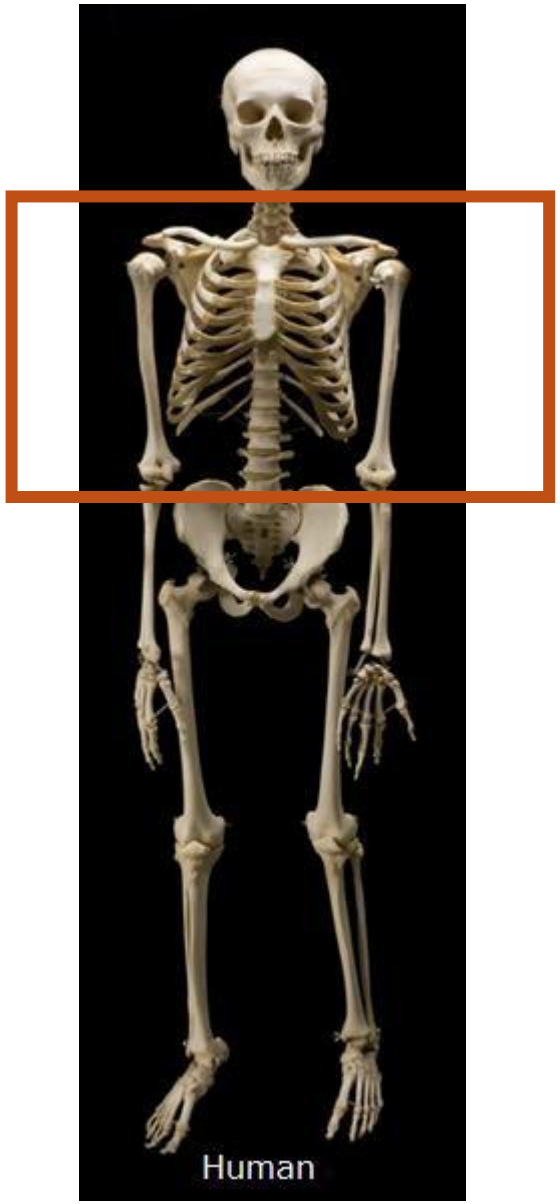
Human



But what about our upper body?

Chimpanzee (ape)

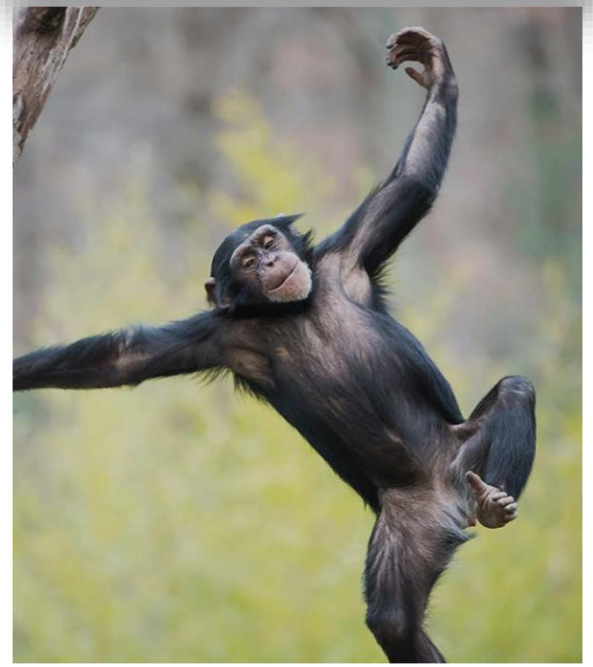
Human

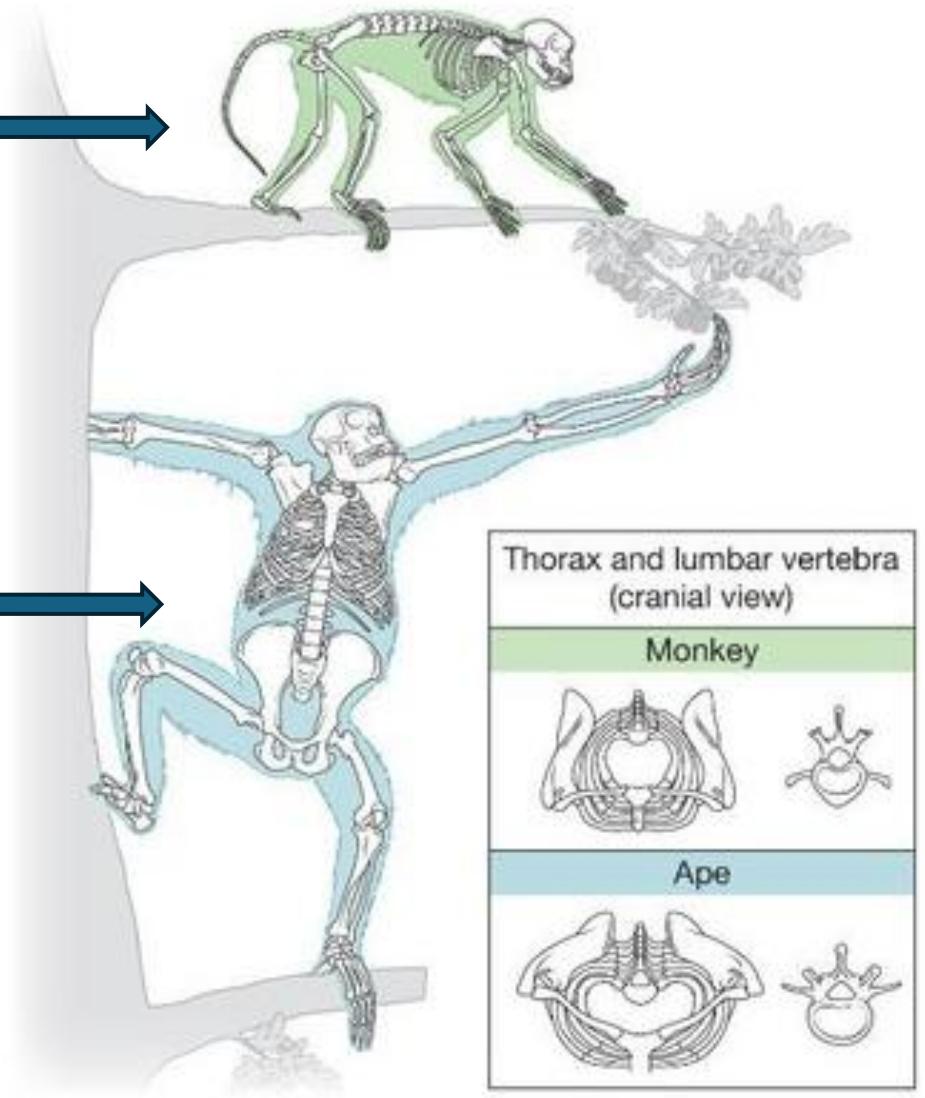


Raise your hand if you can do this!

What is this playground equipment called?

Monkeys vs Apes: Locomotor anatomy



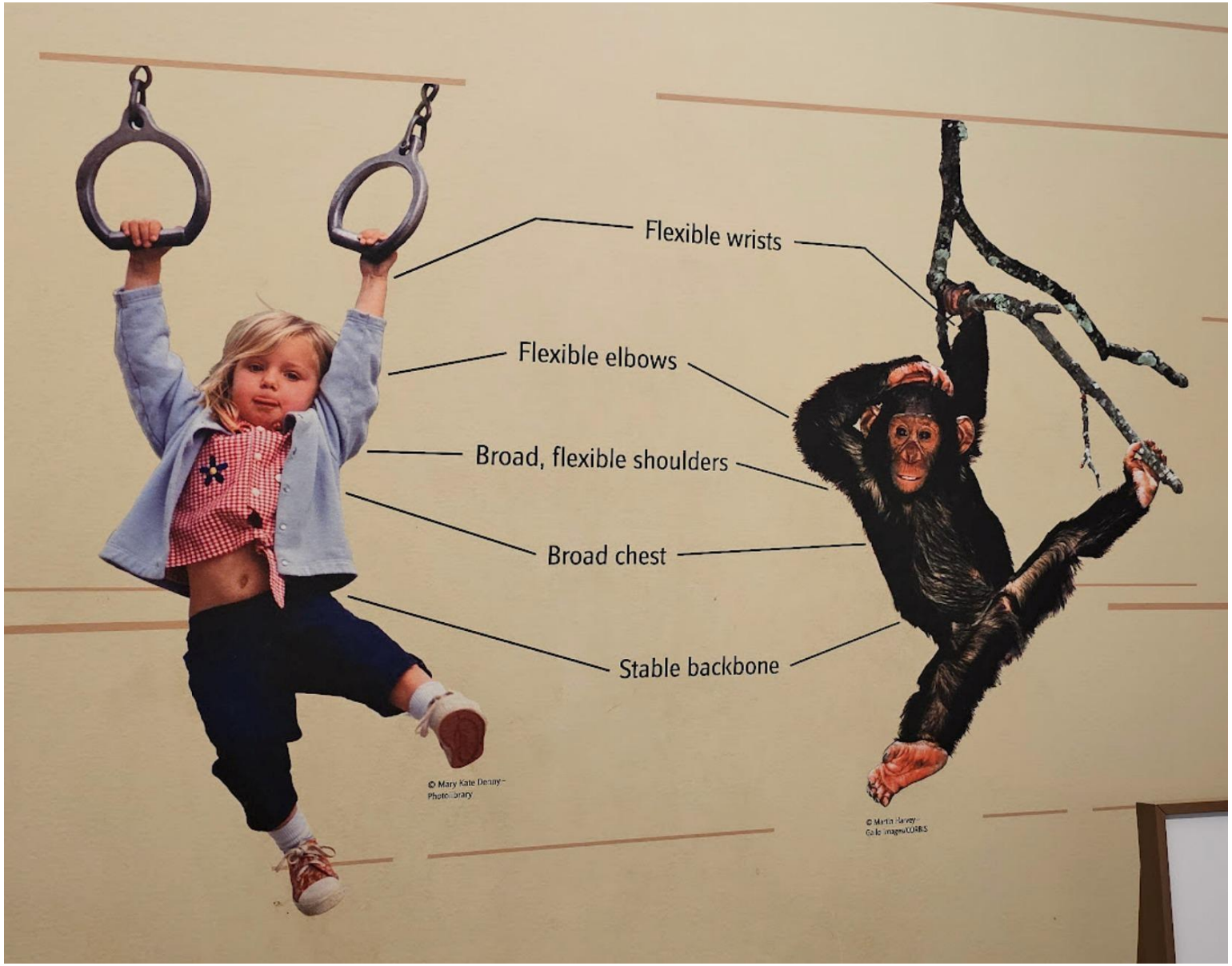


Ape anatomy:

- Broad chest and shoulders
- Long arms
- Short, upright torso
- Shoulder mobility

Almécija et al. (2021)

Humans share upper body anatomy with apes!



Oldest evidence of ape-like locomotion in a fossil ape

Morotopithecus : **20.6 million years ago, Africa**

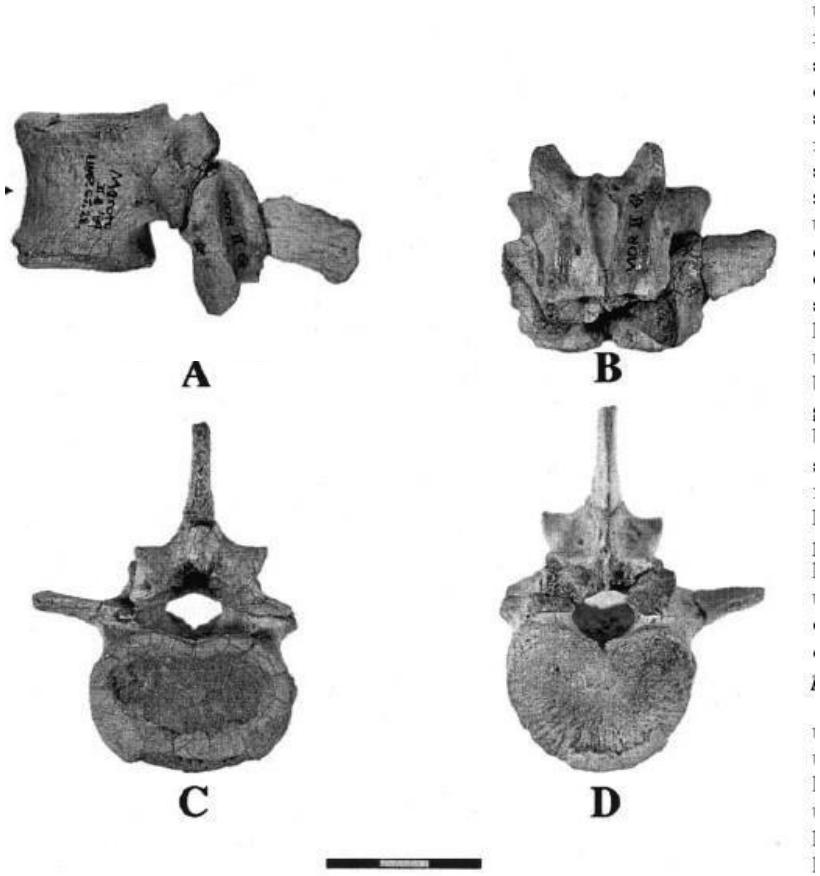
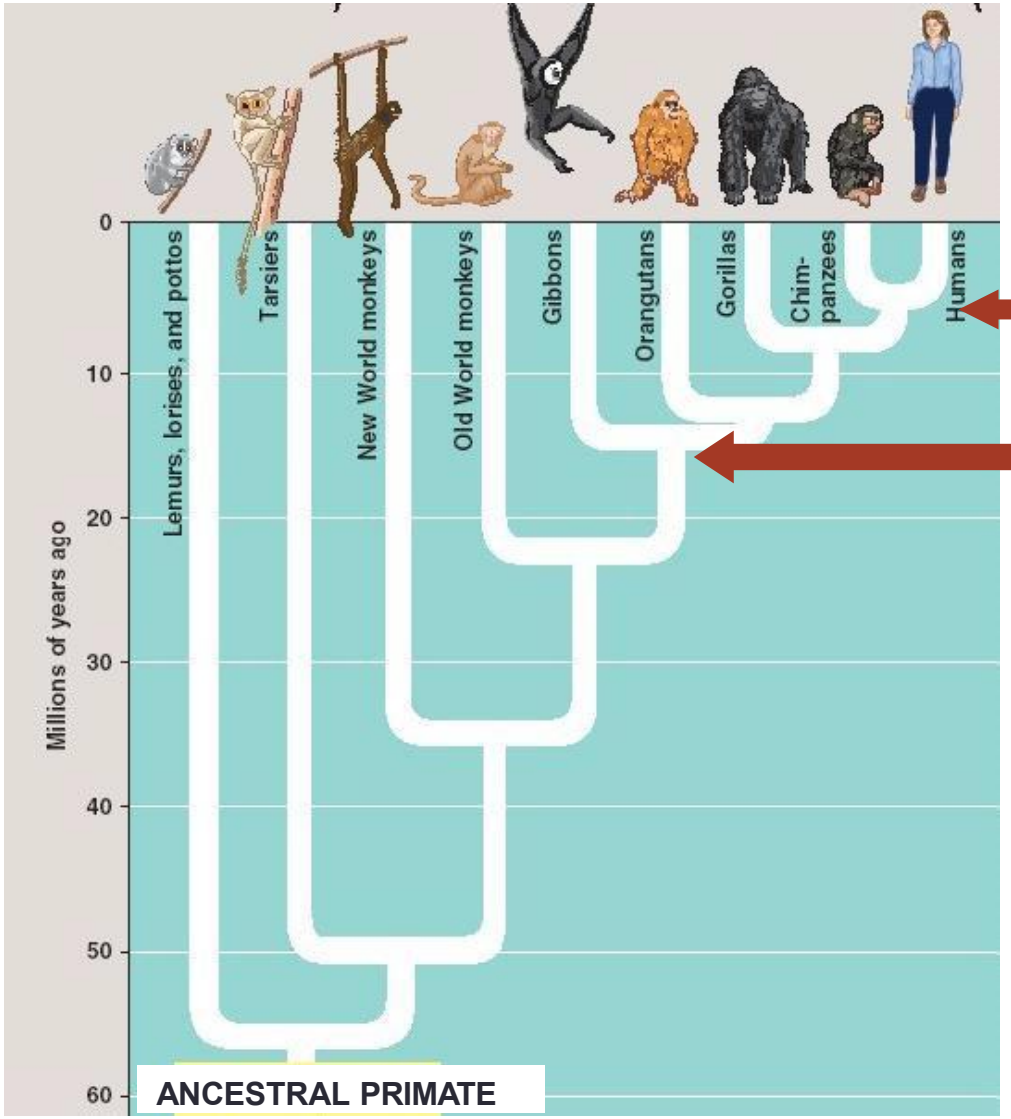


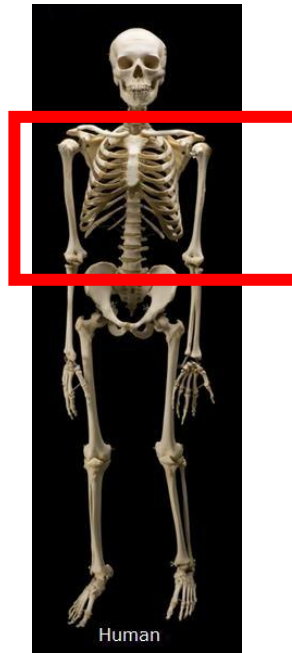
Figure 5. Lateral (A), dorsal (B), caudal (C), and cranial (D) views of lumbar vertebra UMP 67-28. Scale bar = 3 cm.

Primate perspectives on human locomotion



Bipedalism (~7 mya)

Upright posture, suspensory locomotion (~20 mya)



Primate quadrupedalism

First, can we talk about horses?

Painting from 1821

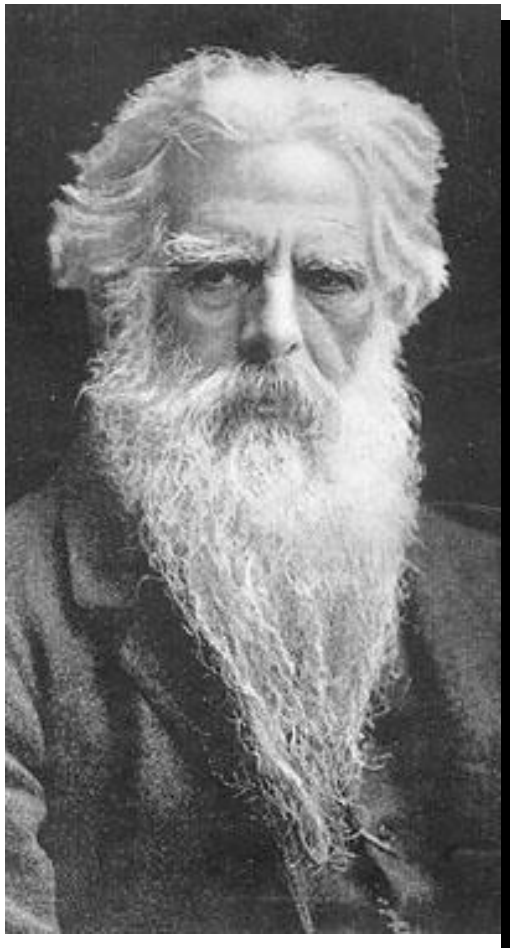
Théodore Géricault, Epsom, 1821, (Musée du Louvre)

Painting from 1821

Théodore Géricault, Epsom, 1821, (Musée du Louvre)

Actual horse

Eadweard Muybridge (1830-1904)



A work for the Art Connoisseur, the Scientist, the Artist, and the Student of Art or of Nature.

ANIMAL LOCOMOTION.

AN ELECTRO-PHOTOGRAPHIC INVESTIGATION OF CONSECUTIVE PHASES OF ANIMAL MOVEMENTS.

BY EADWEARD MUYBRIDGE.

1872–1885.

PUBLISHED UNDER THE AUSPICES OF

THE UNIVERSITY OF PENNSYLVANIA.

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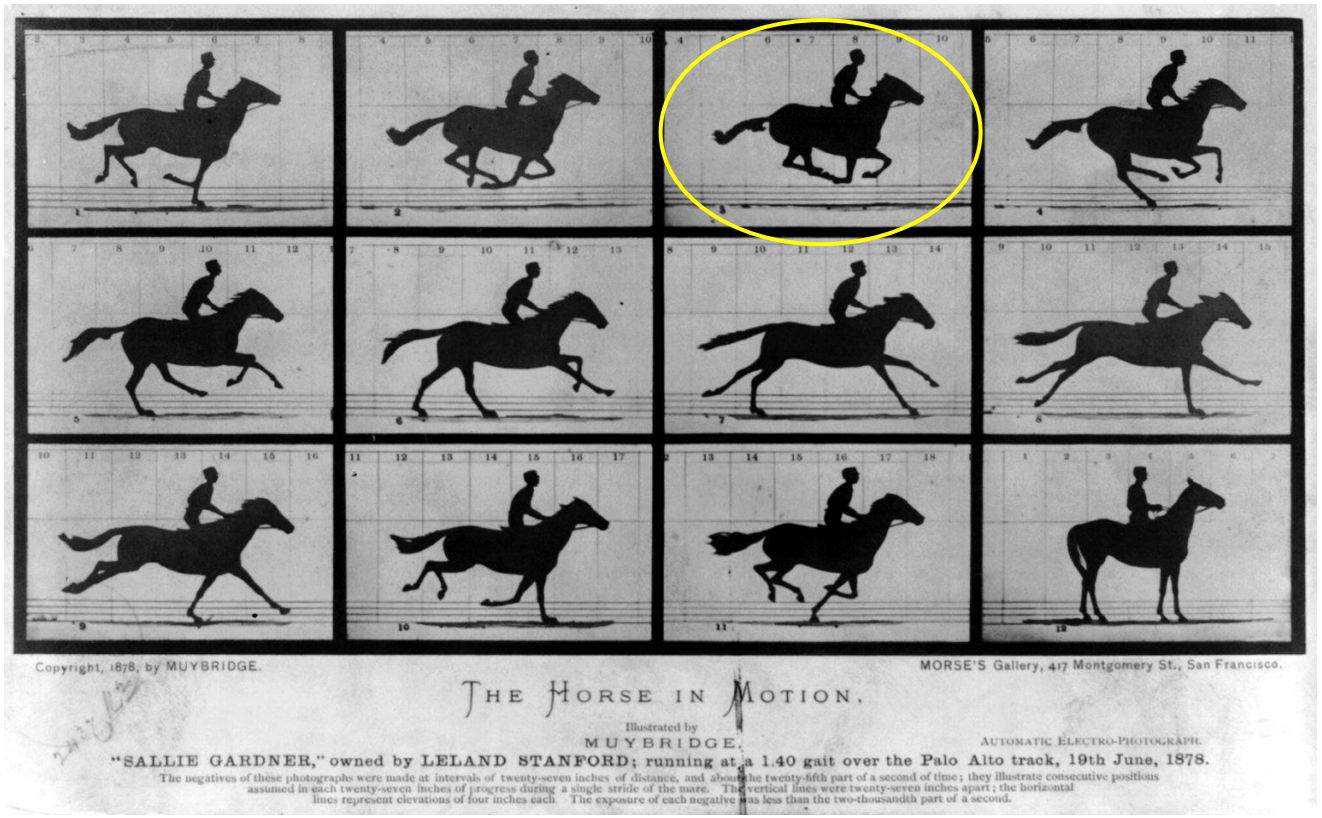
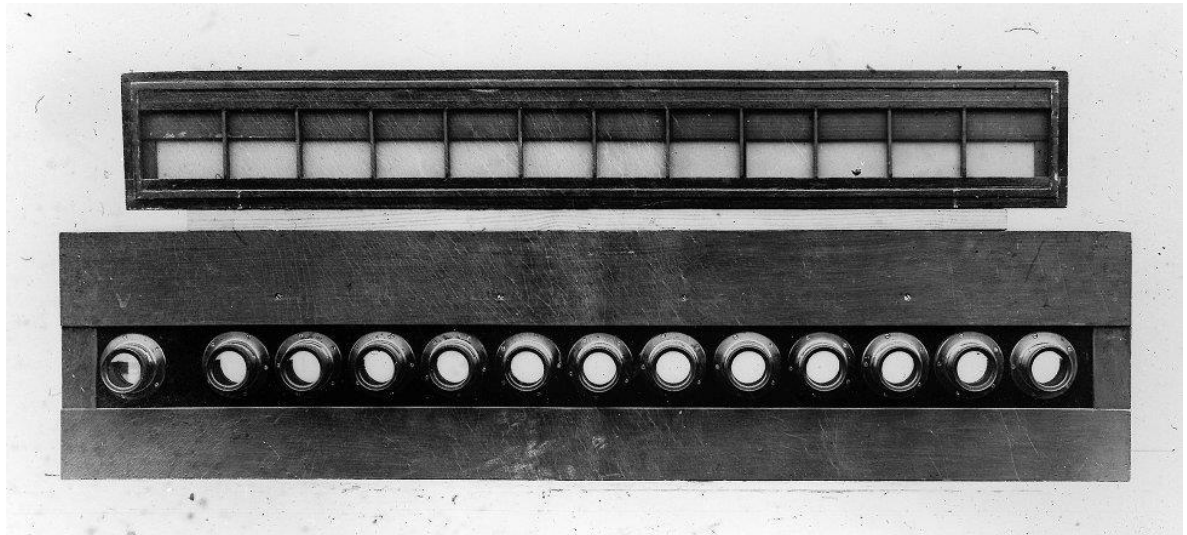
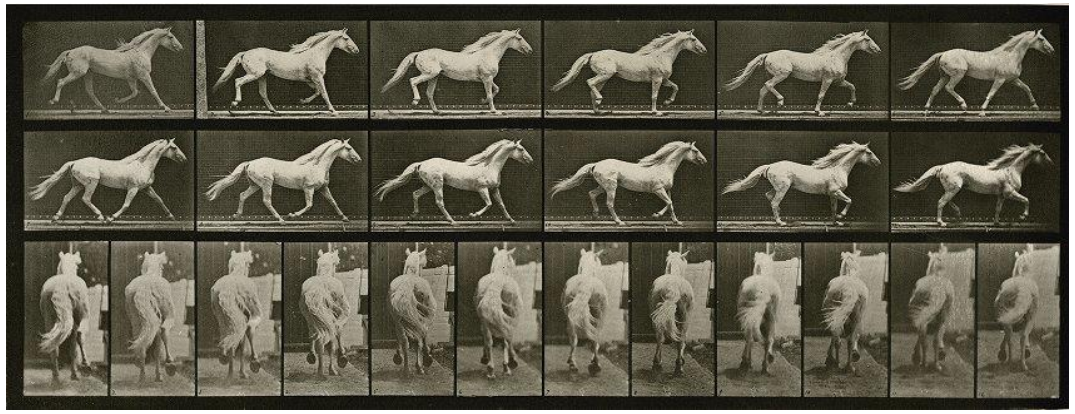
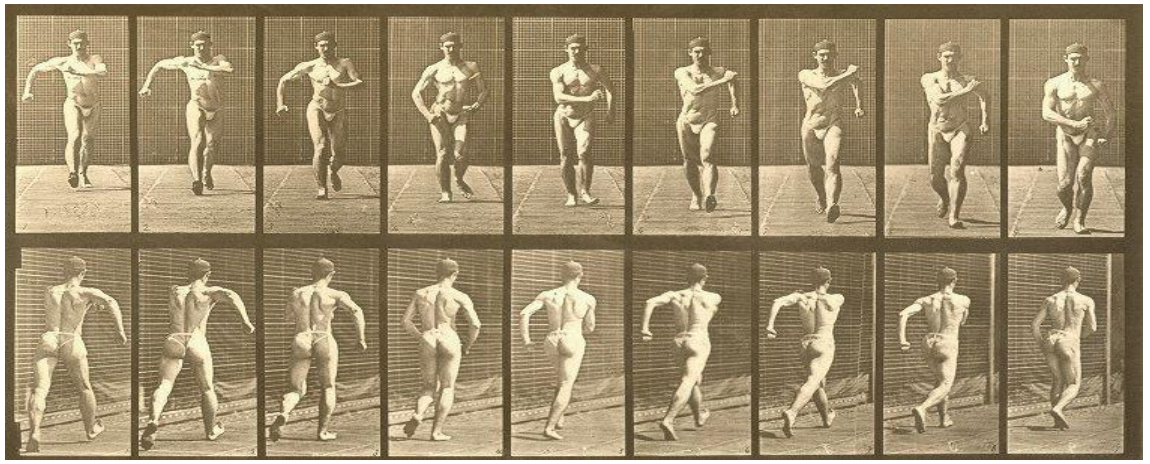
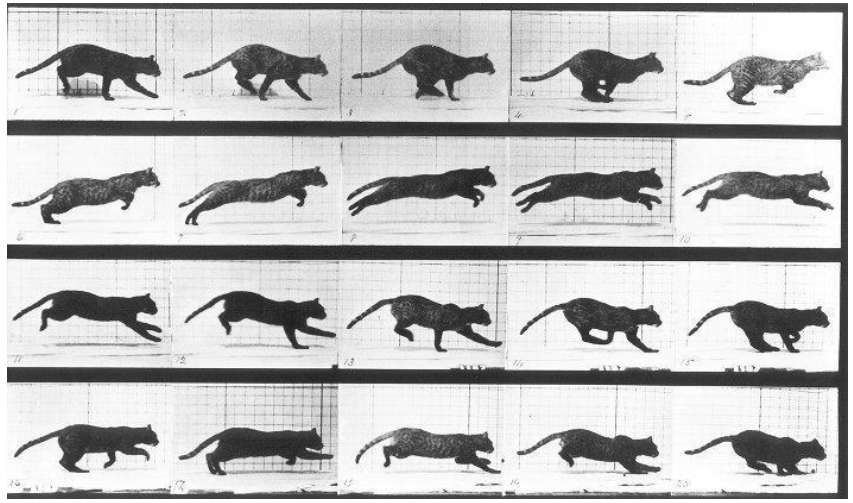
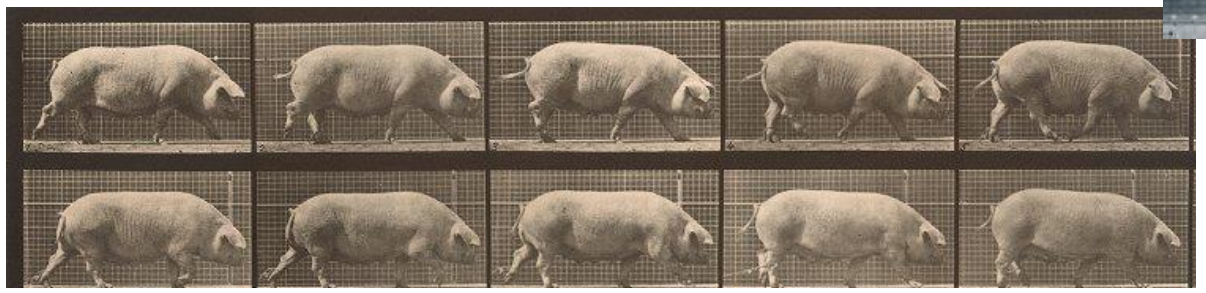

Copyright, 1878, by MUYBRIDGE.
MORSE'S Gallery, 417 Montgomery St., San Francisco.
THE HORSE IN MOTION.
Illustrated by
MUYBRIDGE.
AUTOMATIC ELECTRO-PHOTOGRAPH.
"SALLIE GARDNER," owned by LELAND STANFORD; running at a 1.40 gait over the Palo Alto track, 19th June, 1878.
The negatives of these photographs were made at intervals of twenty-seven inches of distance, and about the twenty-fifth part of a second of time; they illustrate consecutive positions assumed in each twenty-seven inches of progress during a single stride of the mare. The vertical lines were twenty-seven inches apart; the horizontal lines represent elevations of four inches each. The exposure of each negative was less than the two-thousandth part of a second.



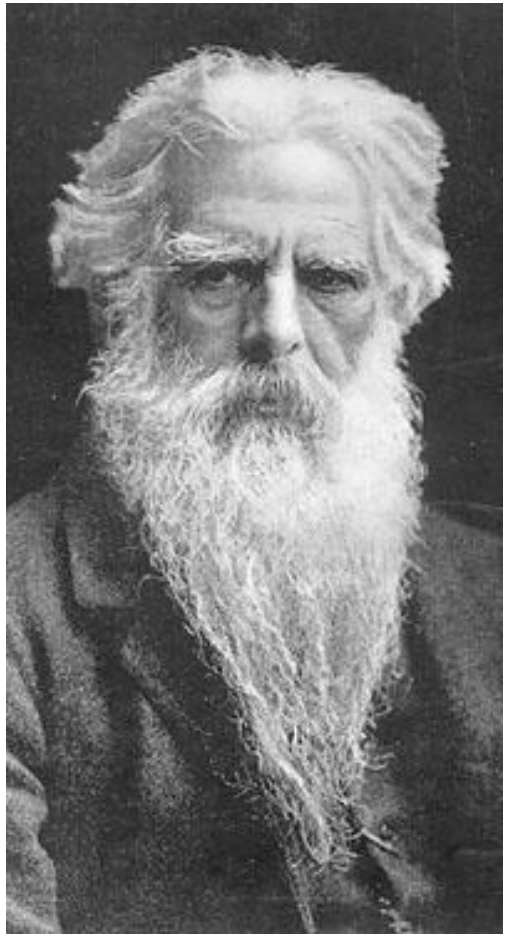


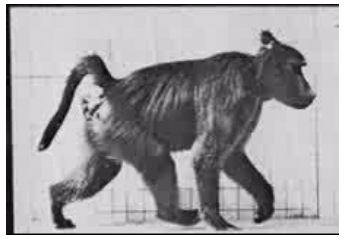




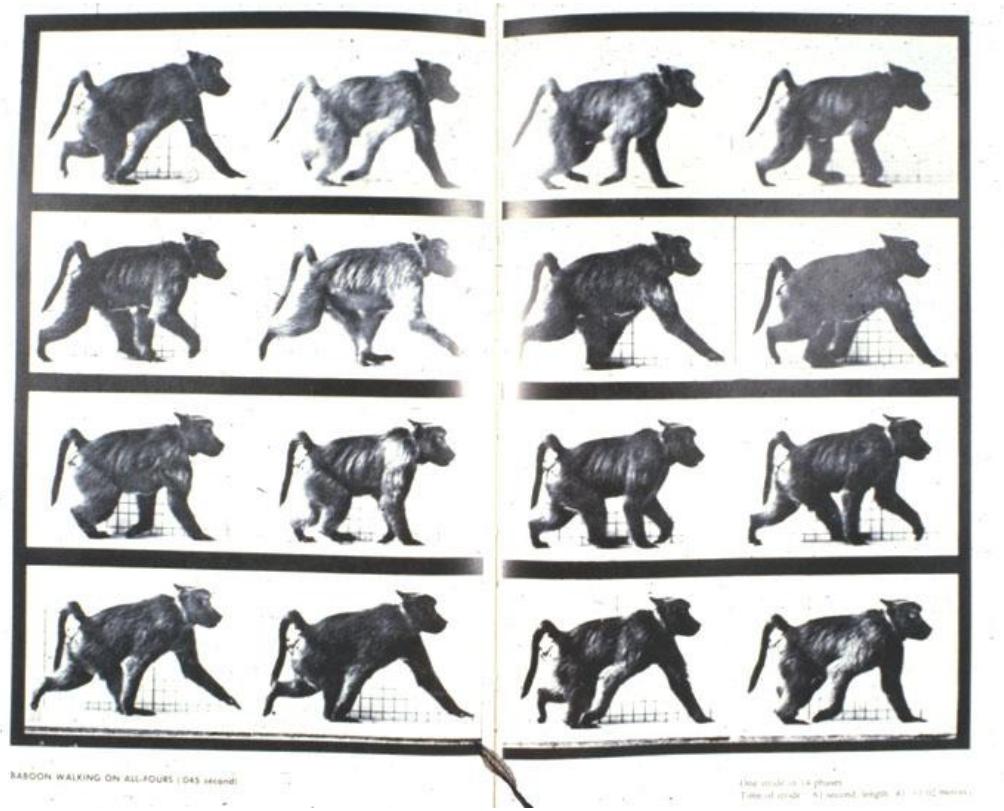


Eadweard Muybridge (1830-1904)



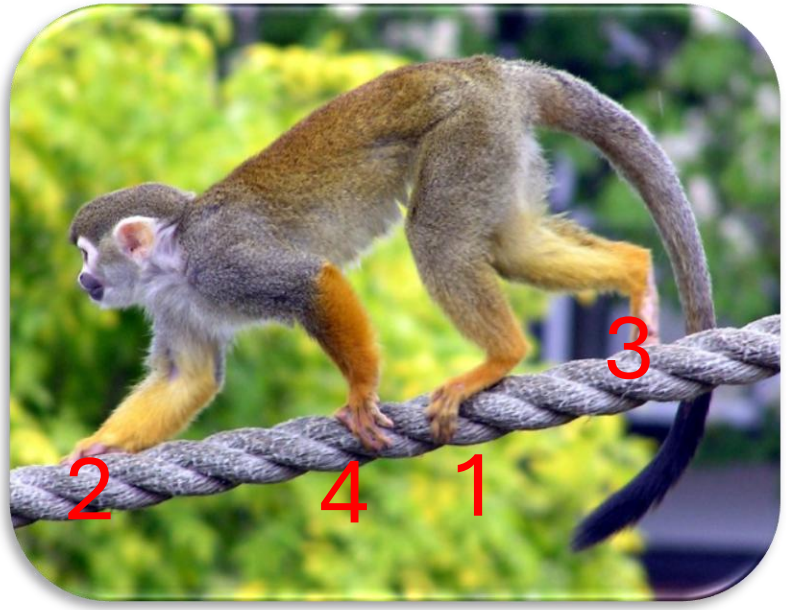


The baboon
"disregards the law governing the walk."
(Muybridge, 1887)



Primates walk in a DIAGONAL footfall sequence

Primate:
Diagonal sequence



1. Left hindlimb
2. Right forelimb
3. Right hindlimb
4. Left forelimb

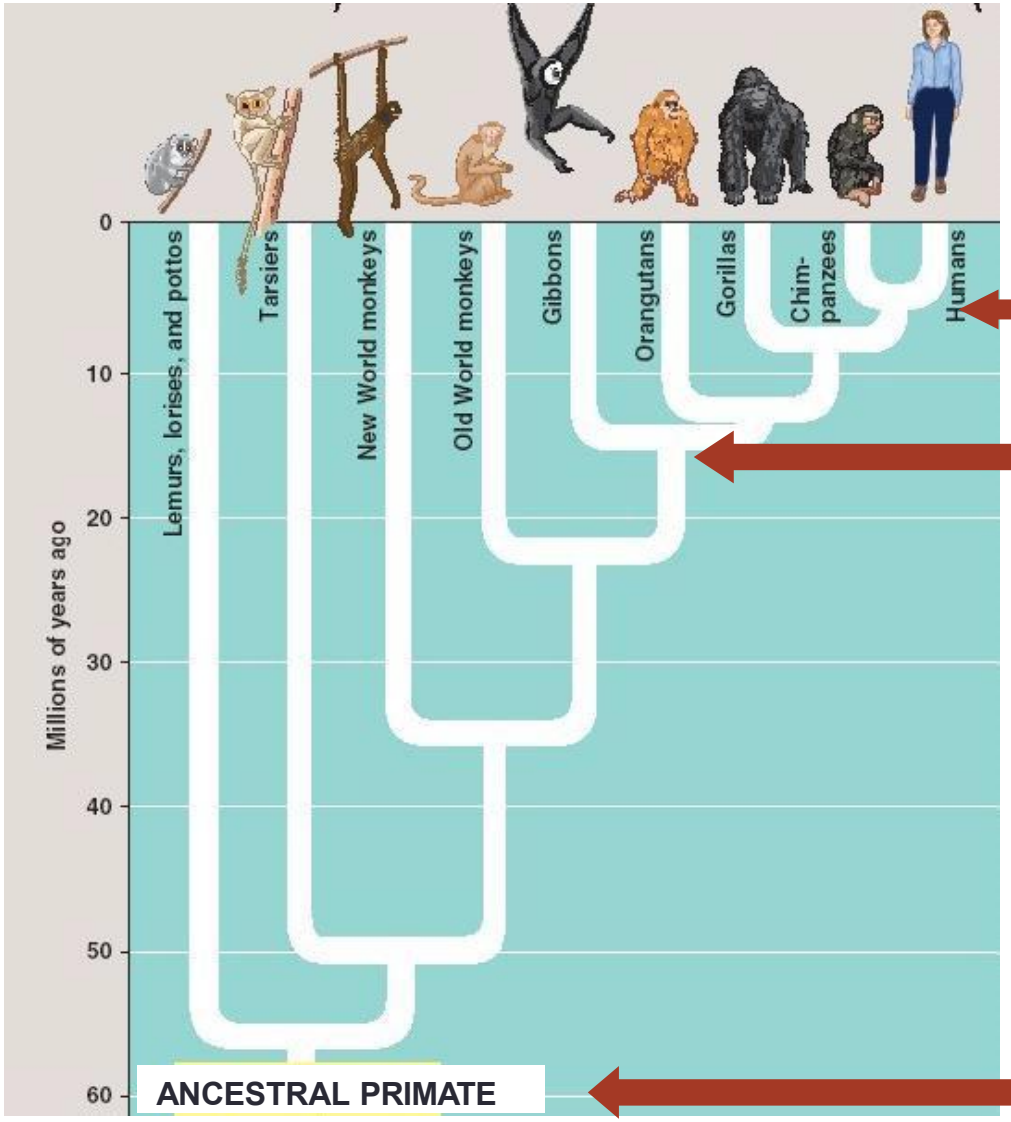
Papio anubis, Kibale NP, Uganda 2022

Almost all other mammals walk in LATERAL footfall sequence

Non-primate:
Lateral sequence

1. Left hindlimb
2. Left forelimb
3. Right hindlimb
4. Right forelimb

Primate perspectives on human locomotion



Bipedalism (~7 mya)

Upright posture, suspensory locomotion (~20 mya)

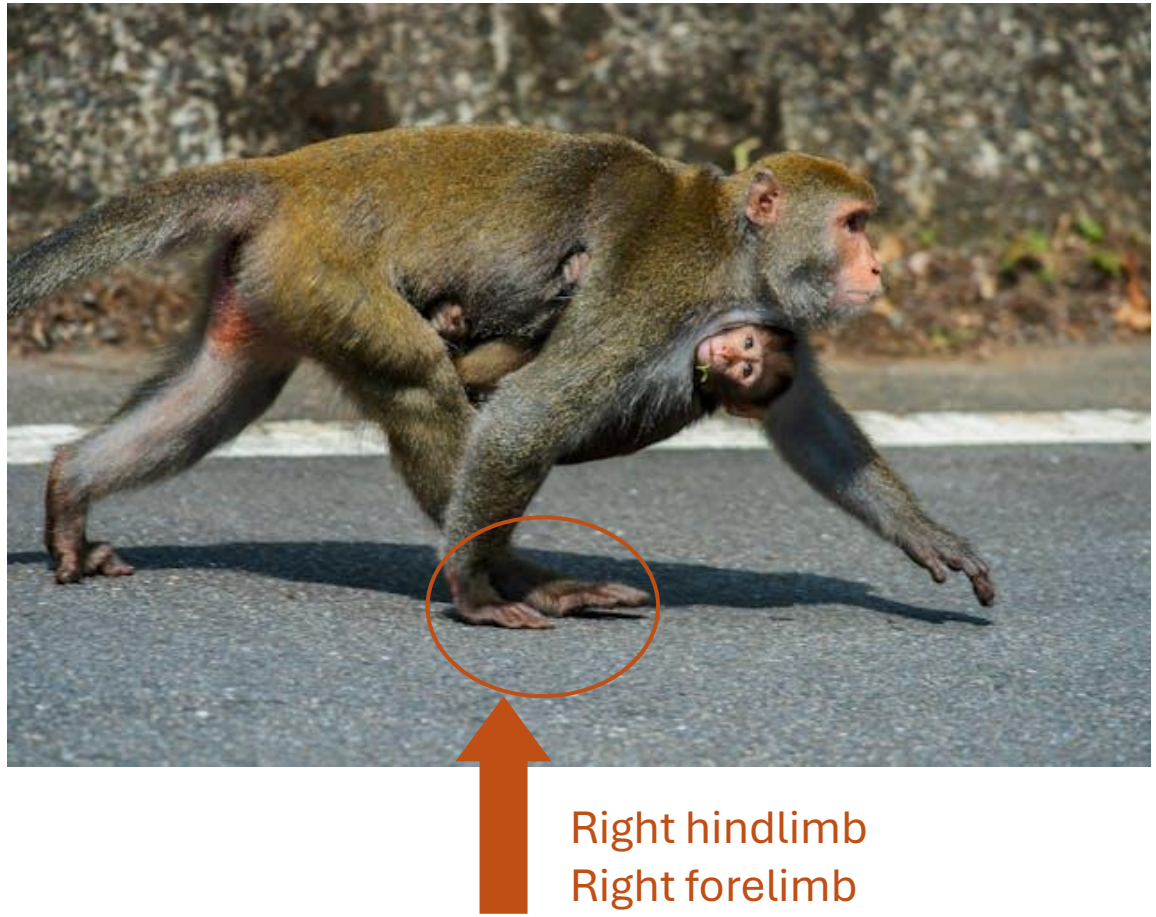
Quadrupedal ancestor of all primates (~66mya)

Research question:

Why did primates evolve diagonal sequence walking gait?

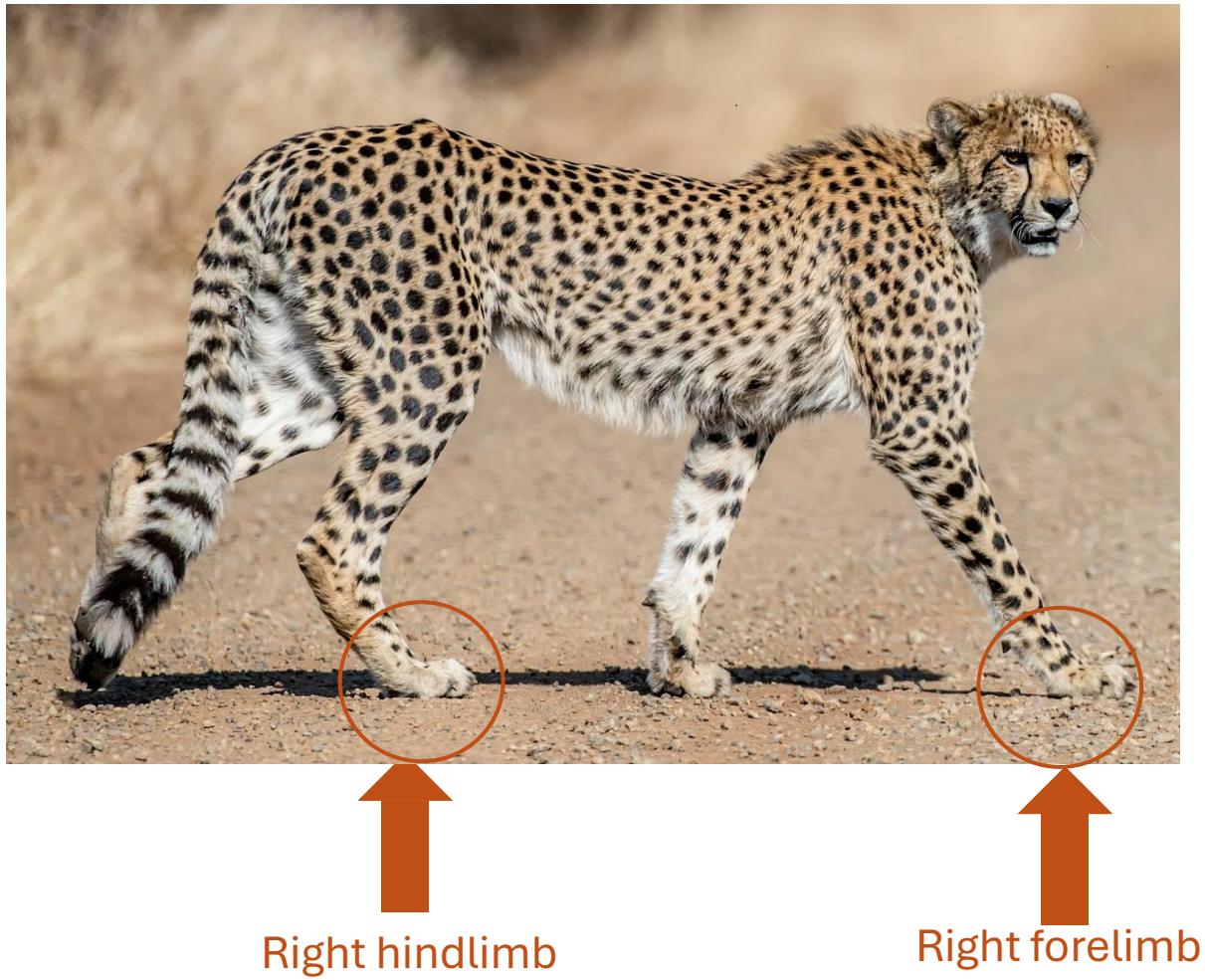
Disadvantage of diagonal sequence walking

Diagonal sequence



Interference of limbs on same side

Lateral sequence



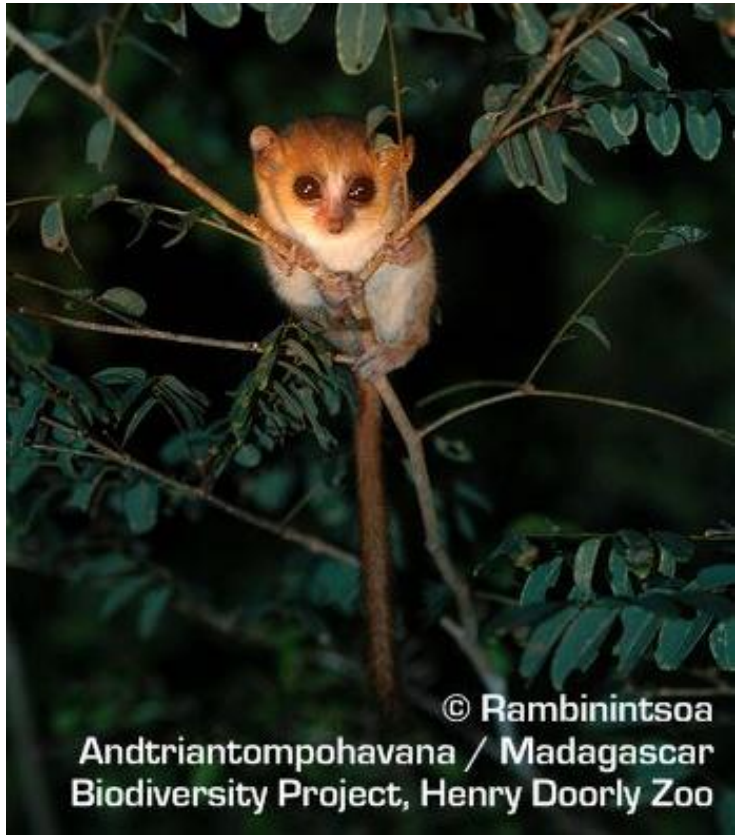
No interference

Why did primates evolve diagonal sequence walking?

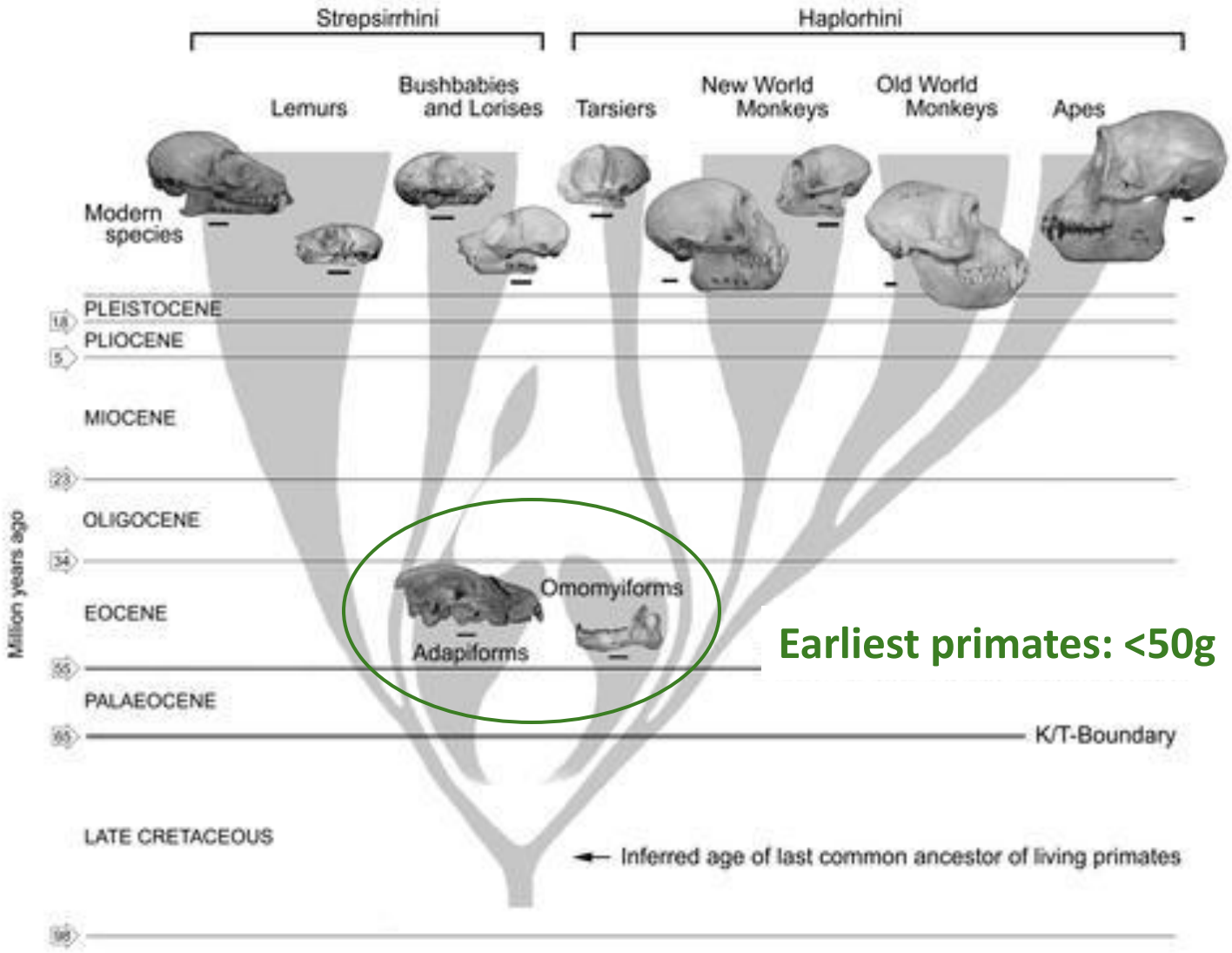
Environment of early primates: narrow, terminal branches

Did diagonal sequence walking evolve in primates as an adaptation for balancing on narrow branches?

Why does body size matter?



Earliest primate ancestors: very small body size



Earliest primates: <50g

Research question:

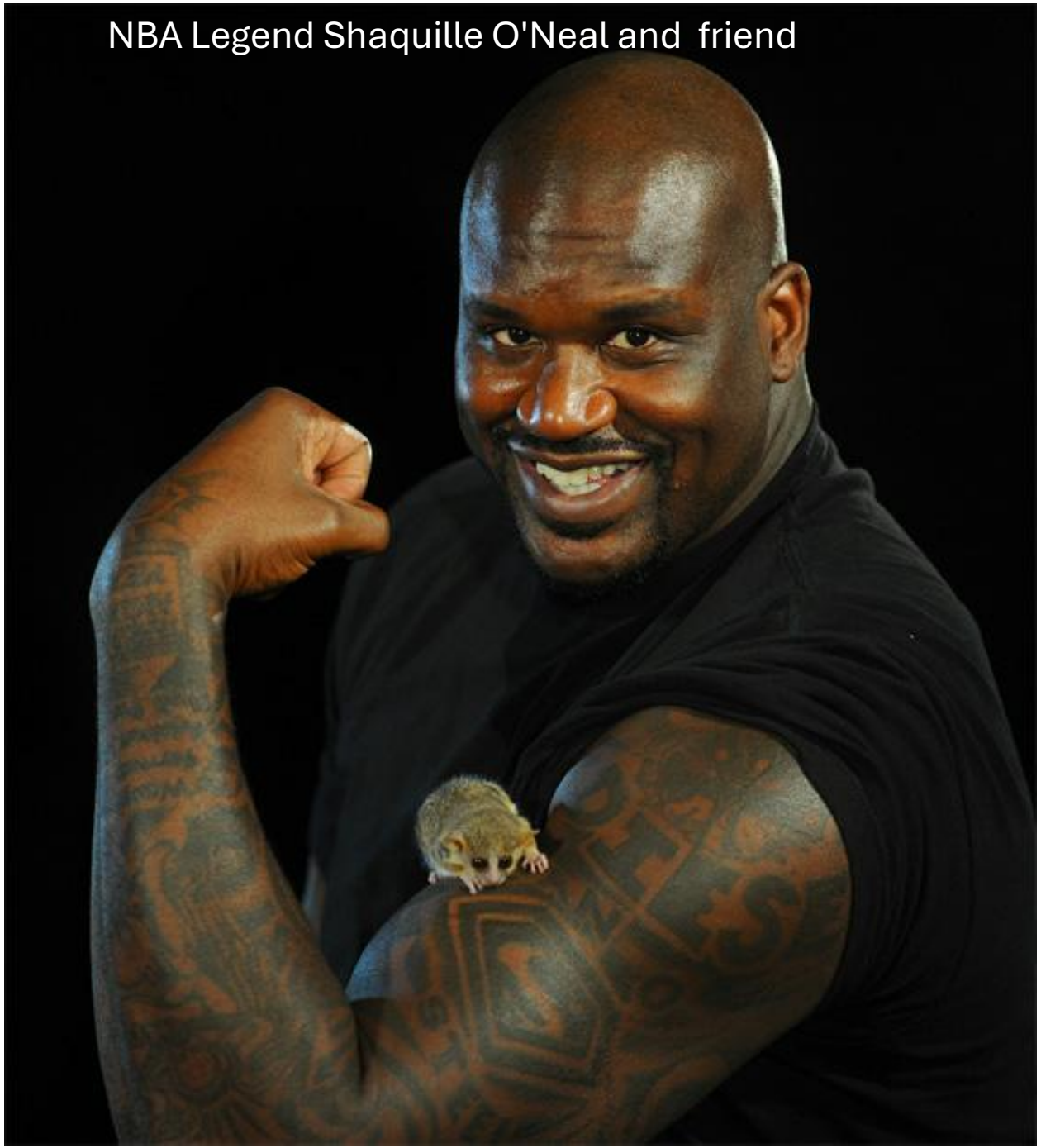
<u>If you are very small:</u>

- Is diagonal sequence necessary for balancing on narrow branches?

Let’s enlist the help of the world’s smallest primate!

Mouse lemur

Average body mass:
30-65 g

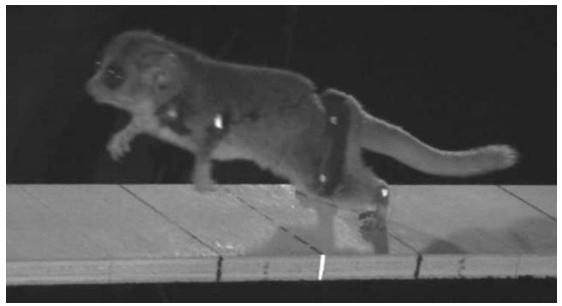


Lab studies of quadrupedal walking at small body size

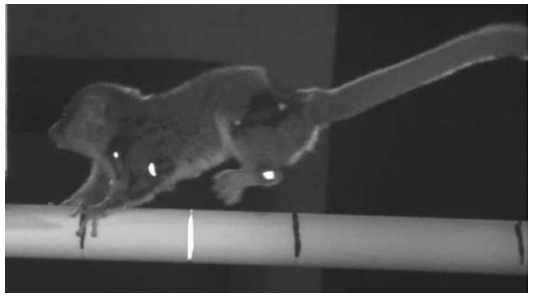
Mouse lemur

POLE DIAMETER

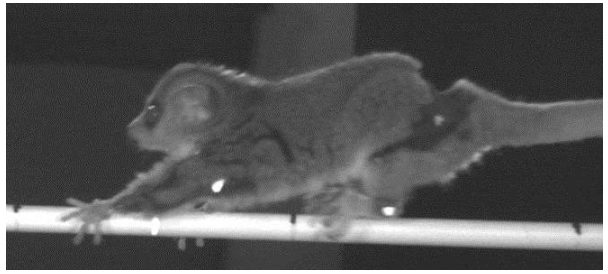
Flat board



2.5 cm pole



1 cm pole

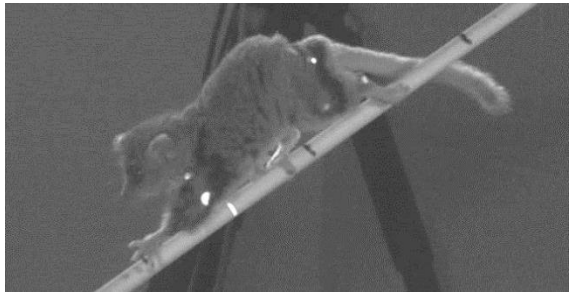


0.5 cm pole

POLE ORIENTATION

Incline

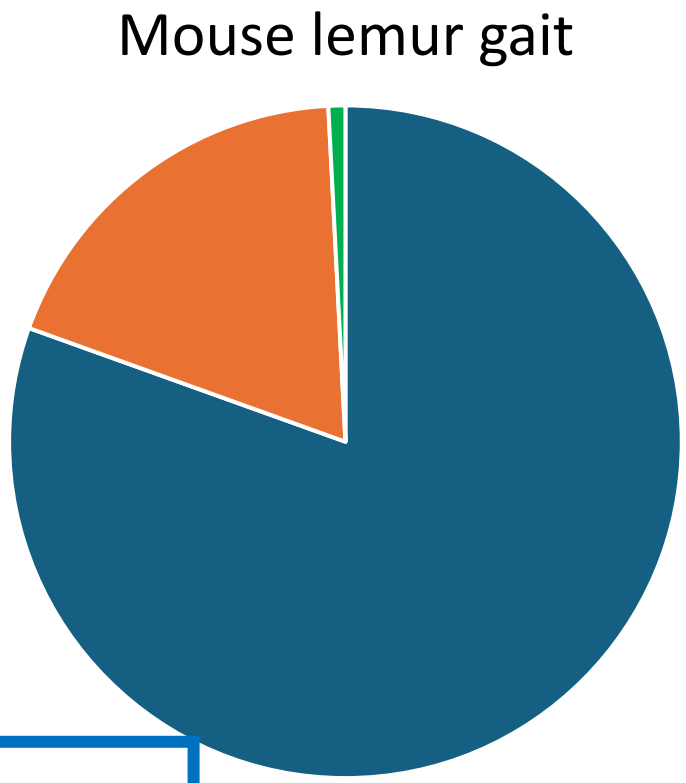
Decline

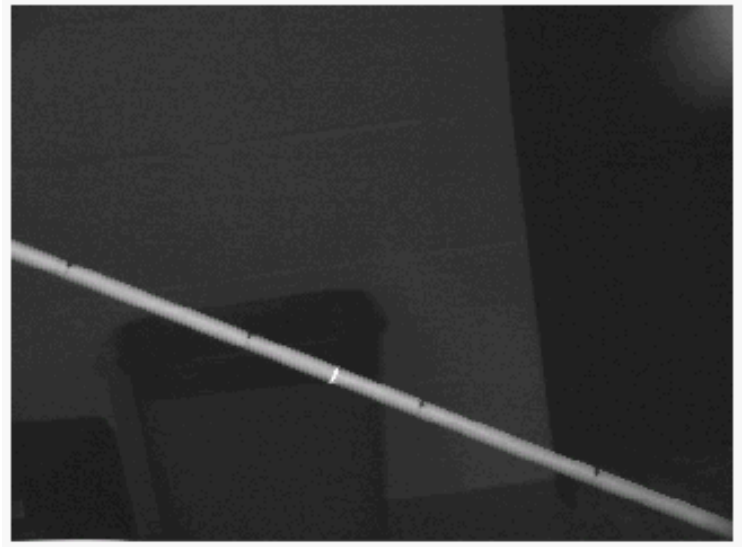


Shapiro et al., 2016 JEZ

Lab studies of quadrupedal walking at small body size

Mouse lemur





Shapiro et al., 2016 JEZ

Lab studies of quadrupedal walking at small body size

Sugar glider

Petaurus breviceps 90-130g

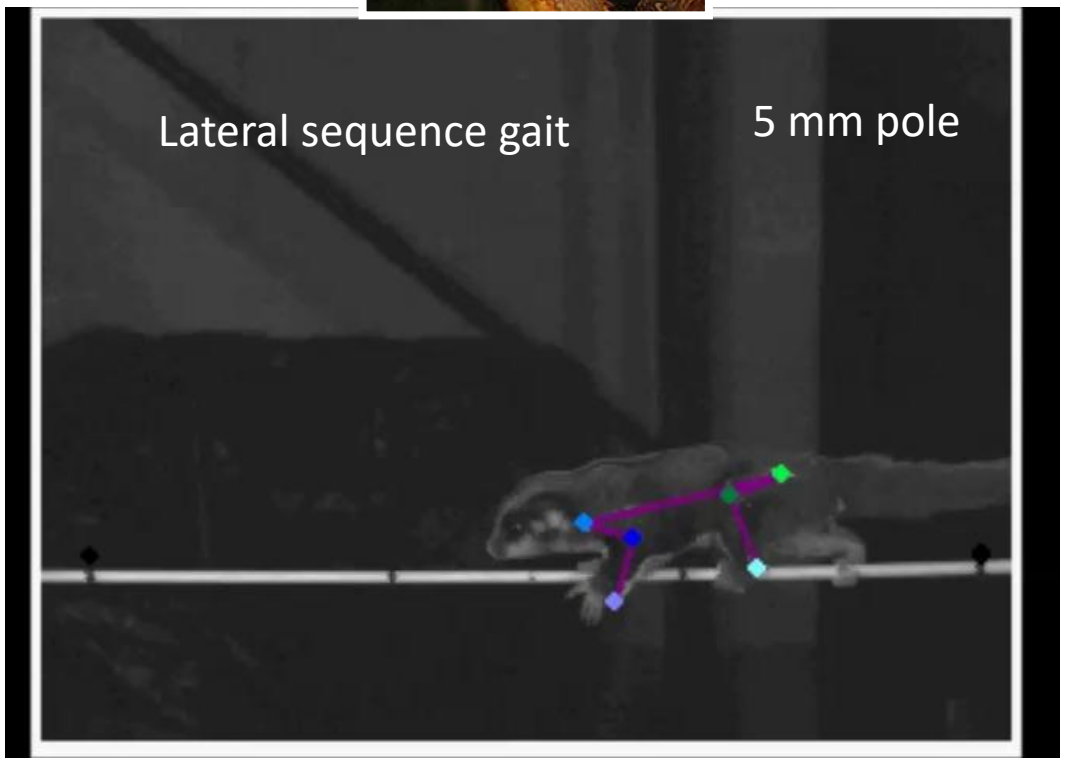
Gray short-tailed opossum

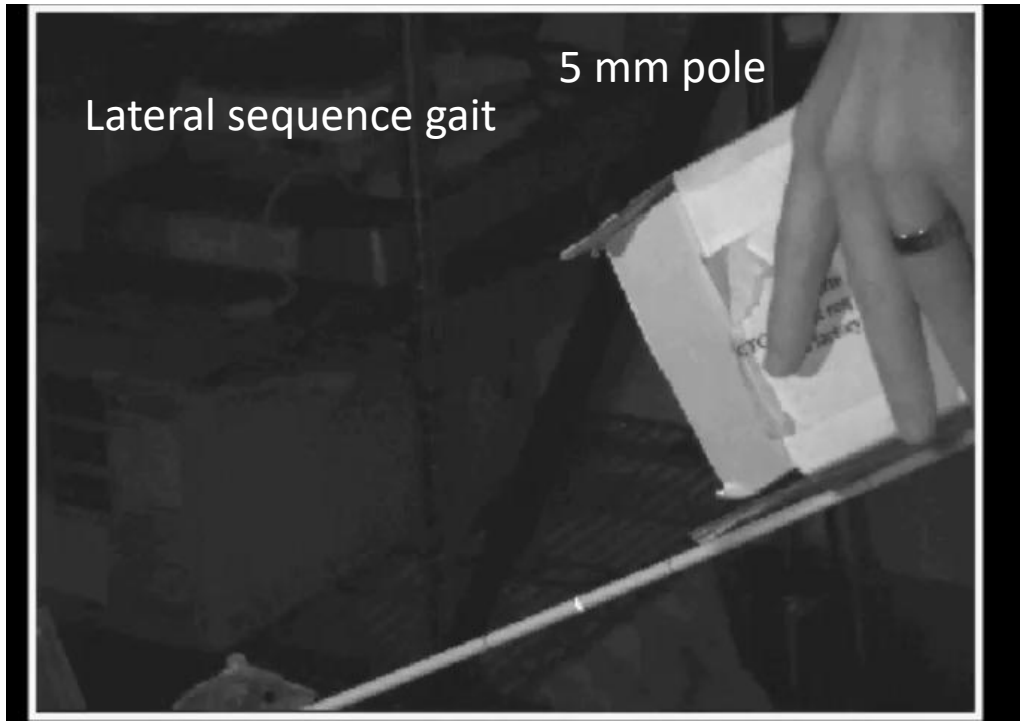
Monodelphis domestica 90-120g

Lab studies of quadrupedalism at small body size

Sugar glider

Gray short-tailed opossum





Shapiro and Young, 2010 JHE; Shapiro and Young, 2012 JEB; Shapiro et al, 2014 JHE

Results

If you are very small:

Diagonal sequence is NOT necessary for balancing on narrow branches

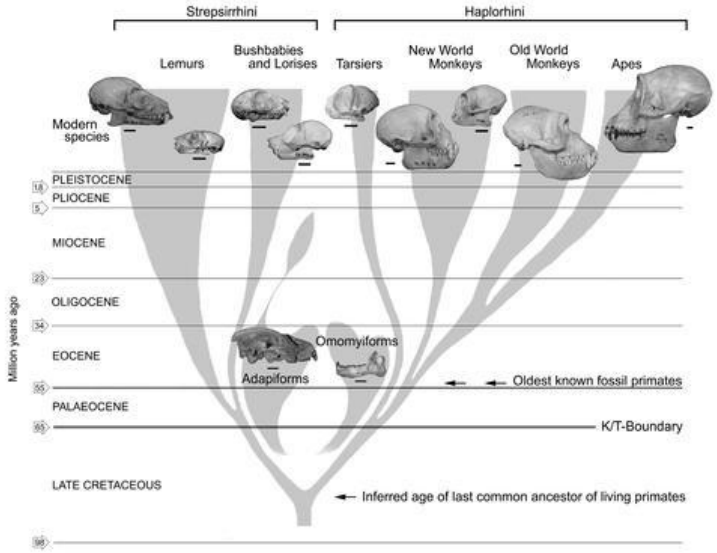
Mouse lemur: Diagonal

Sugar glider: Lateral

Opossum: Lateral

Insights on primate evolution:

Diagonal sequence walking might have evolved *after* primates increased in body size



But animals didn’t evolve to walk on poles

(but maybe will need to….?)

Out of the lab – into the wild!

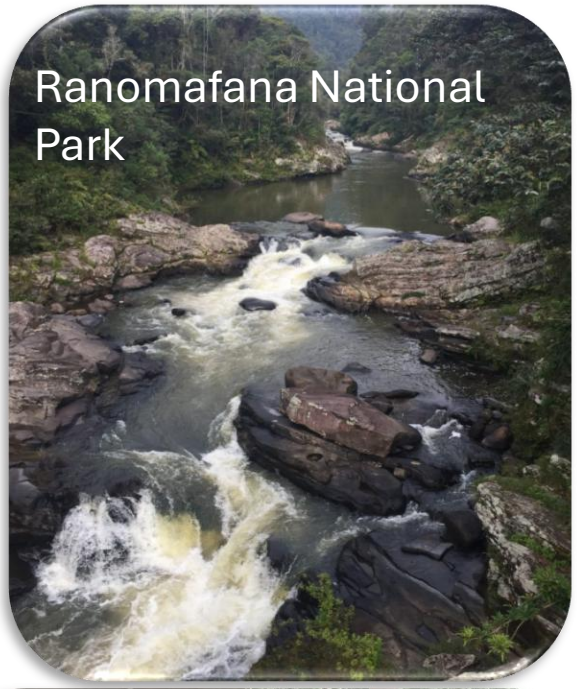
Tobin Hieronymus

Jesse Young

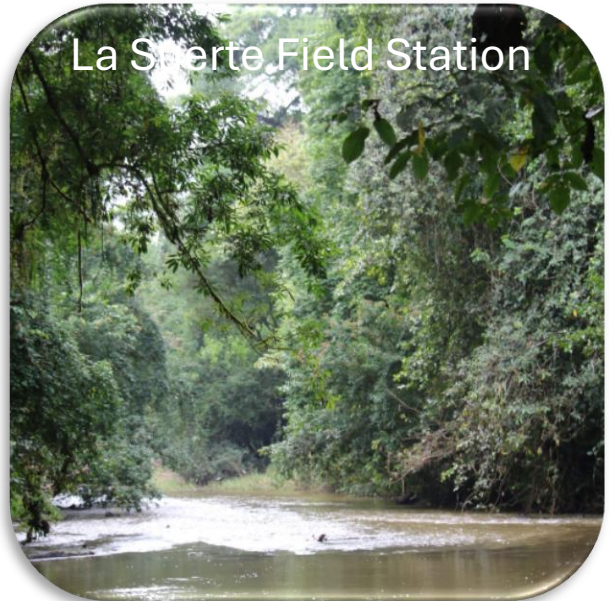
Allison McNamara
Noah Dunham

Ecuador

Madagascar



Costa Rica



Uganda

NSF

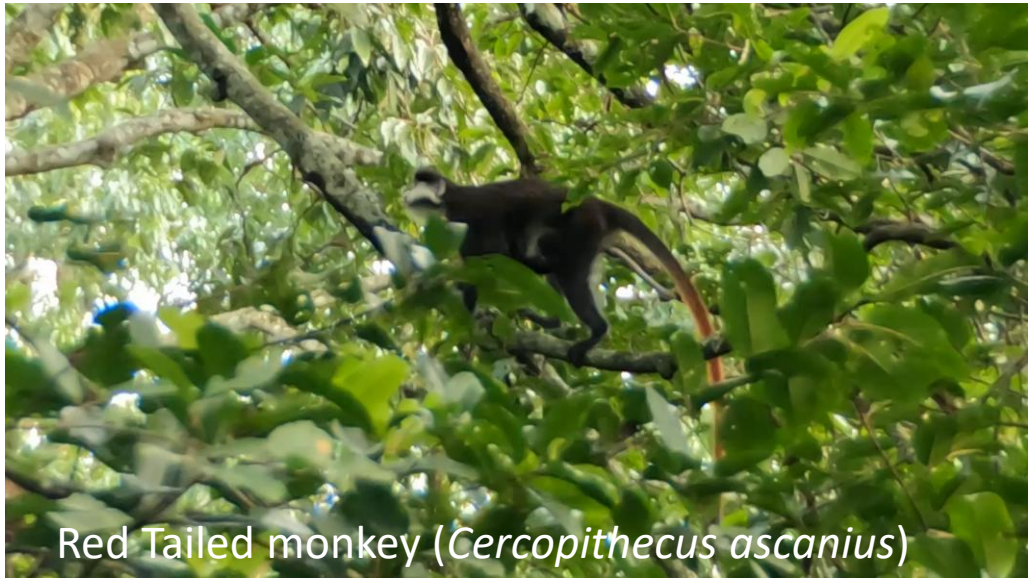
Northeast Ohio Medical University

The University of Texas at Austin

Moving around in real trees is complex!!

- Diameter
- Orientation
- Compliance
- Obstacles
- Gaps


Woolly monkey, *Lagothrix lagotricha*

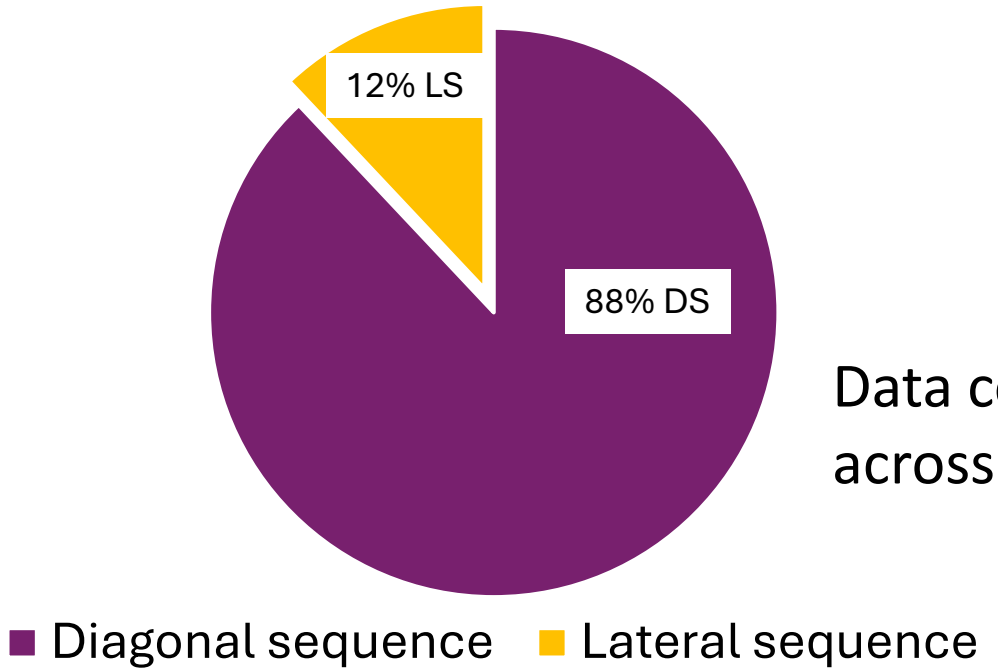

Red Tailed monkey (*Cercopithecus ascanius*)


Red-bellied lemur (*Eulemur rubriventer*)


Red Colobus (*Piliocolobus tephroceles*)

Results of field studies

- Primates are flexible, but STRONGLY prefer **diagonal sequence** walking no matter what the branch is like



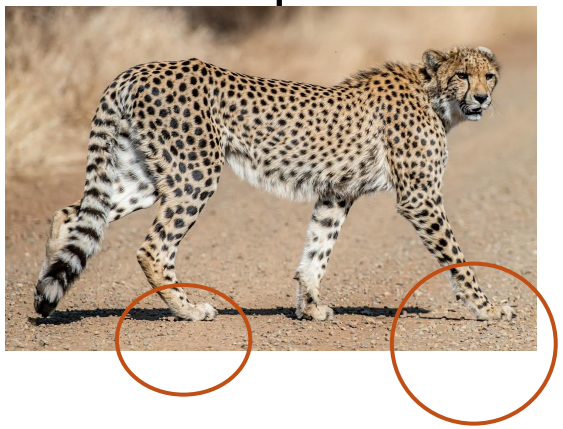
Data compiled from 997 walking strides across 10 species

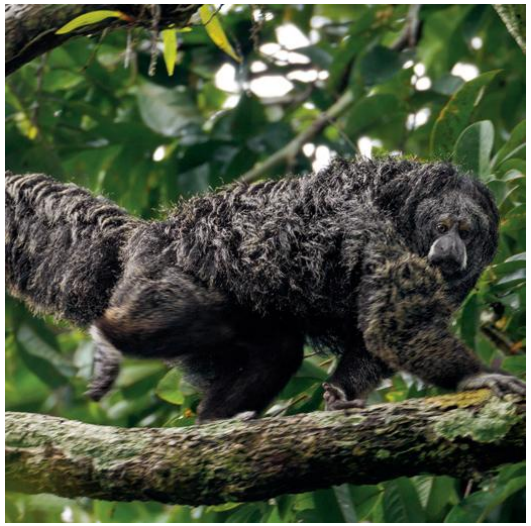
Dunham et al., 2019; Shapiro et al., 2025

Results of field studies

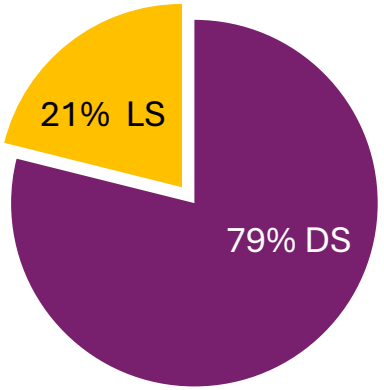
- Primates that use LS the most tend to have longer legs
- LS helps avoid limb interference

Lateral sequence



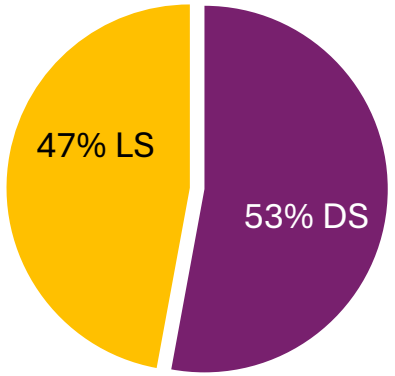


Saki monkey



Diagonal sequence Lateral sequence

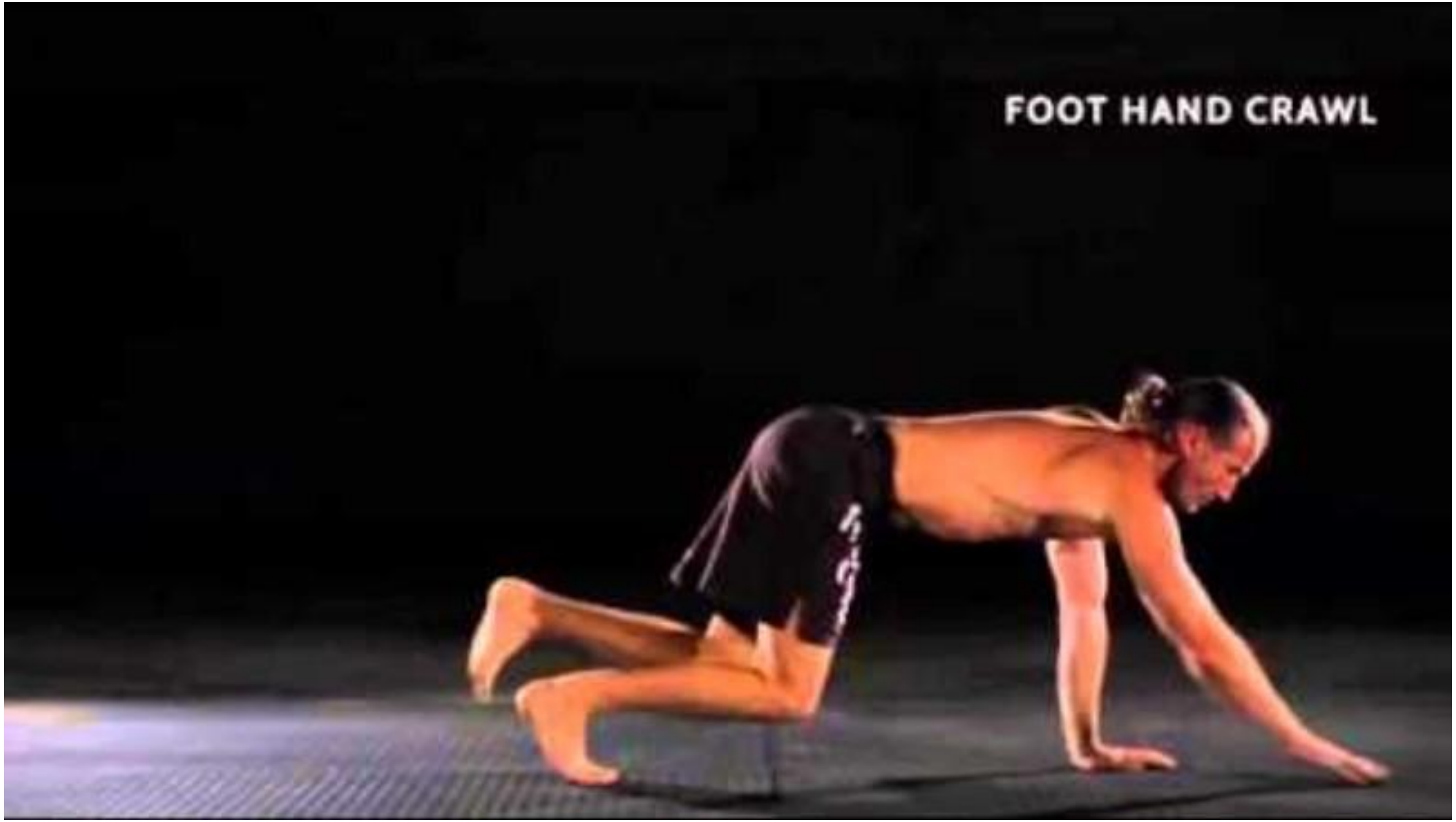
Titi monkey



Diagonal sequence Lateral sequence

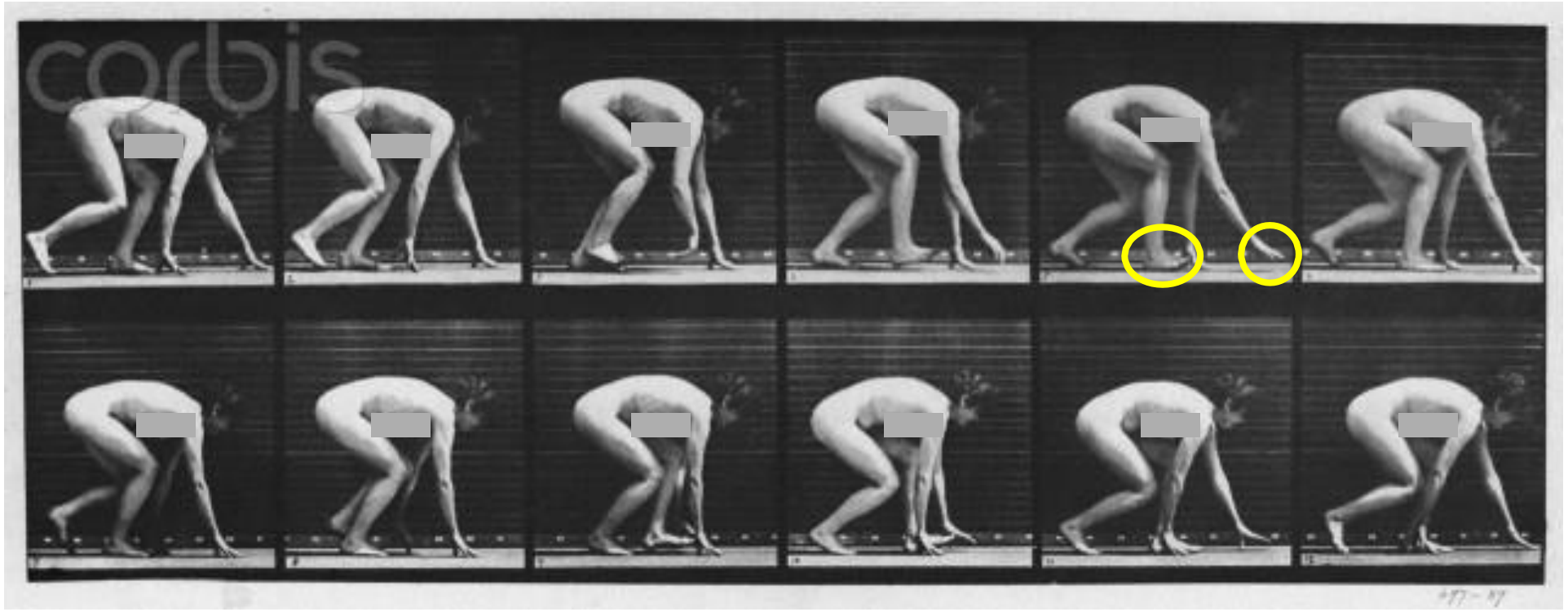
Dunham et al., 2019; Shapiro et al., 2025

What happens when WE walk on all fours??


FOOT HAND CRAWL

Why do humans use lateral sequence gait?

- Bipedal--long hind limbs! ⟶ Avoidance of limb interference



Take-home messages

- Primates have evolved many unique solutions to moving in the trees!

- Human locomotion evolved from arboreal primate ancestors who lived millions of years ago

Take-home messages

Studying locomotion in all primates helps us understand humans

Due to our bipedalism and long legs……

We are *UNLIKE* other primates when we move on all fours!

Take-home messages

Studying locomotion in all primates helps us understand humans

We are **UNIQUE** in our form of bipedalism

but we are **SIMILAR** to apes in our upper body flexibility

Thank you!

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