KNES 289W
The Cybernetic Human

University of Maryland, Spring 2018
Tim Kiemel

Lecture 2, January 29

Human Movement I:
Muscles & Skeleton

Note: Updated to reflect the material we had time to cover

Reminders & Notes

Before schedule adjustment period ends, contact us about any potential scheduling conflicts, including during finals week (May 12–18)

This week:

- First Discussion on Wednesday, January 31
- Lecture on Friday, February 2
- Quiz 1 becomes available at noon Saturday, February 3 (due Thursday, February 8)

Last Time

Intro to KNES 289W

- Cybernetics and kinesiology
- Interactions among systems ⟶ movement
- Four topics
  - Human movement
  - Prostheses and exoskeletons
  - Human-machine interactions
  - Superhero kinesiology
- Overview of syllabus

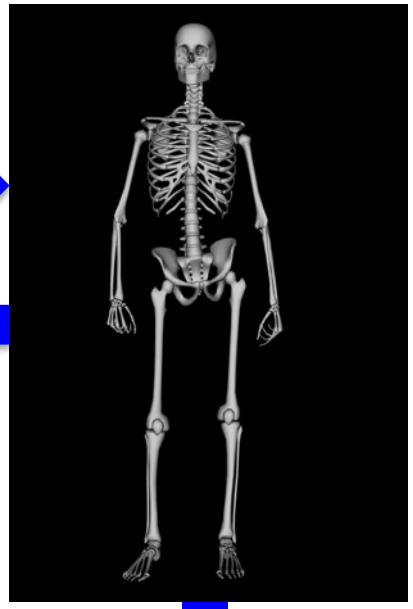
Interactions of Human Systems

This Week

Nervous & Sensory Systems

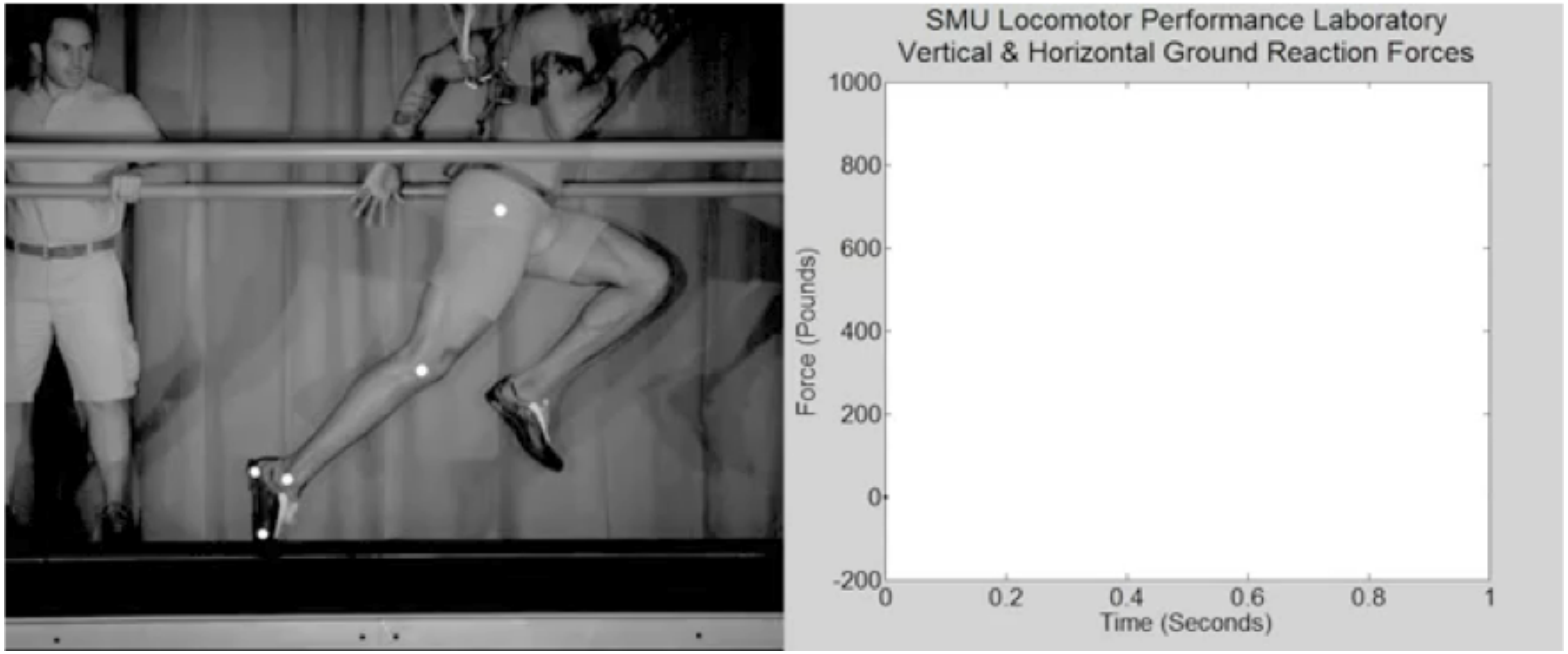
Muscles

Skeleton



Maximum Sprinting Speed

Stance and Swing Phases



Stance phase

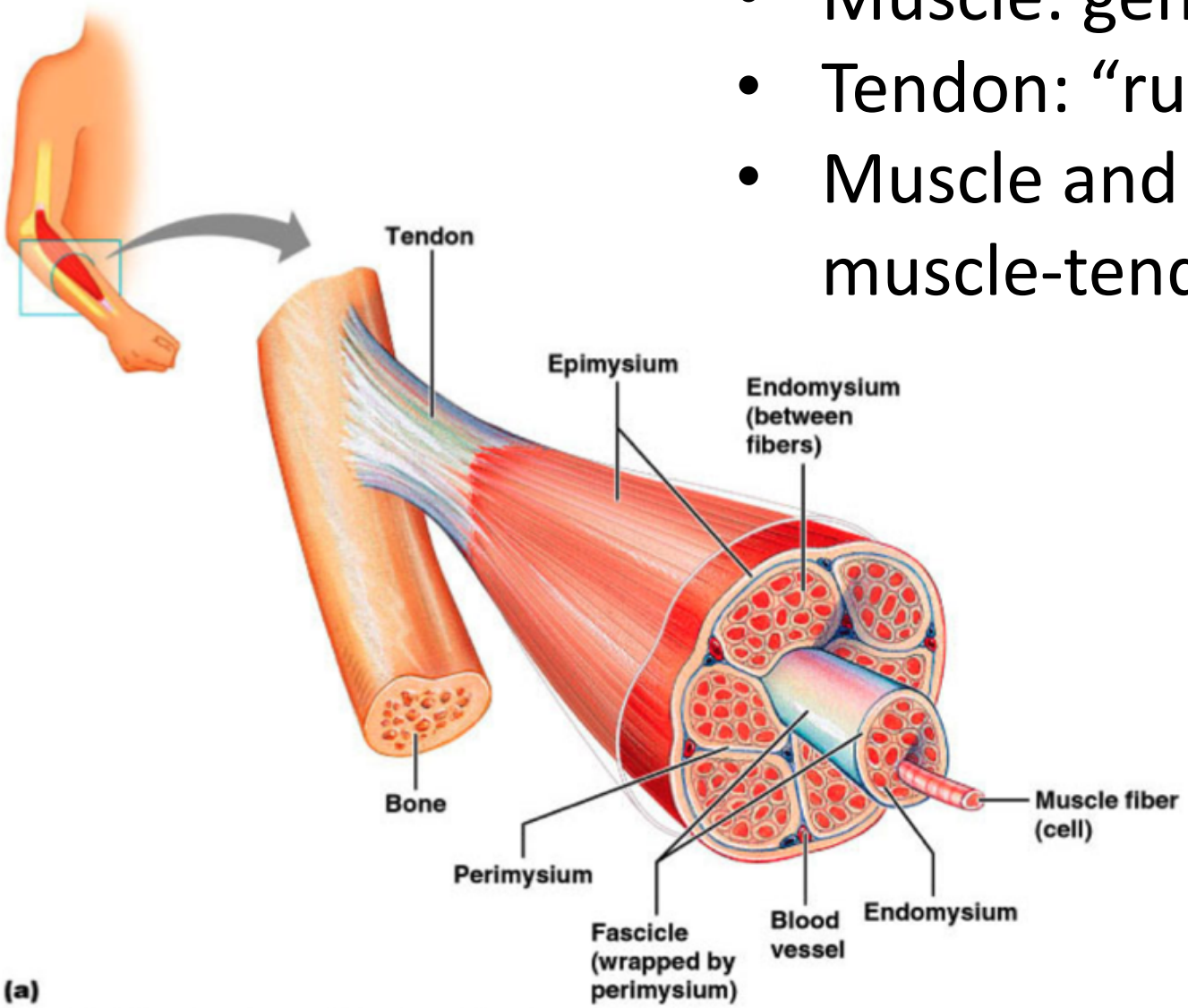
- support body weight
- accelerate body forward in late stance

Swing phase

- swing leg forward
- extend knee
- arrest motion of the knee

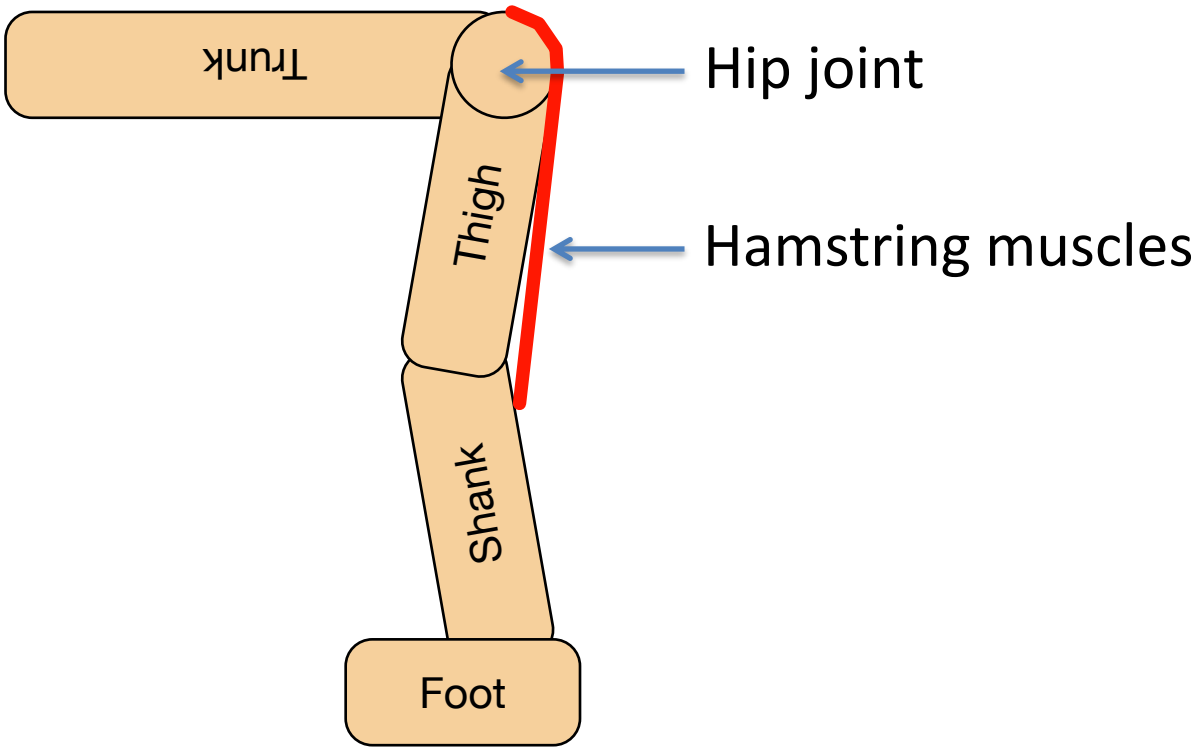
Muscle-tendon unit: What it is

- Muscle: generates force
- Tendon: “rubber band”
- Muscle and tendon: muscle-tendon unit (MTU)

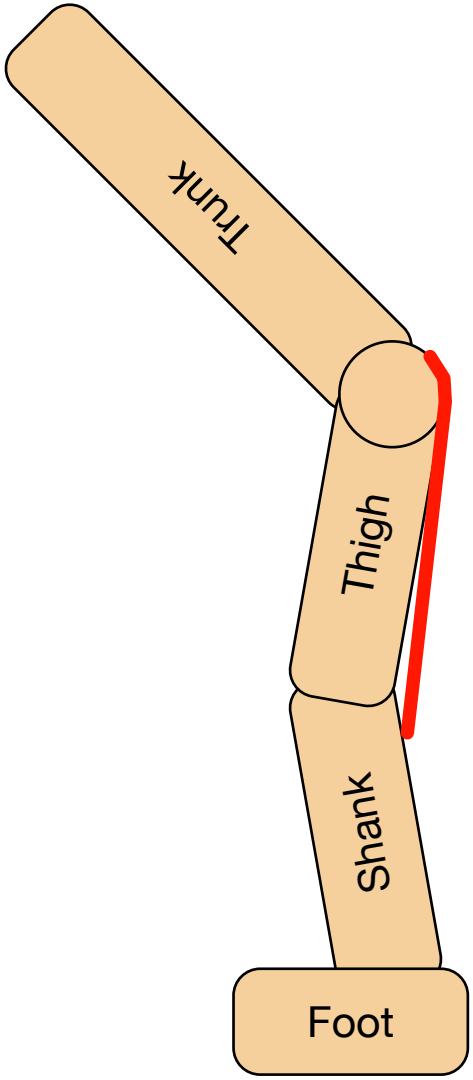


Introduction to Kinematics

Kinematics: the **description** of movement

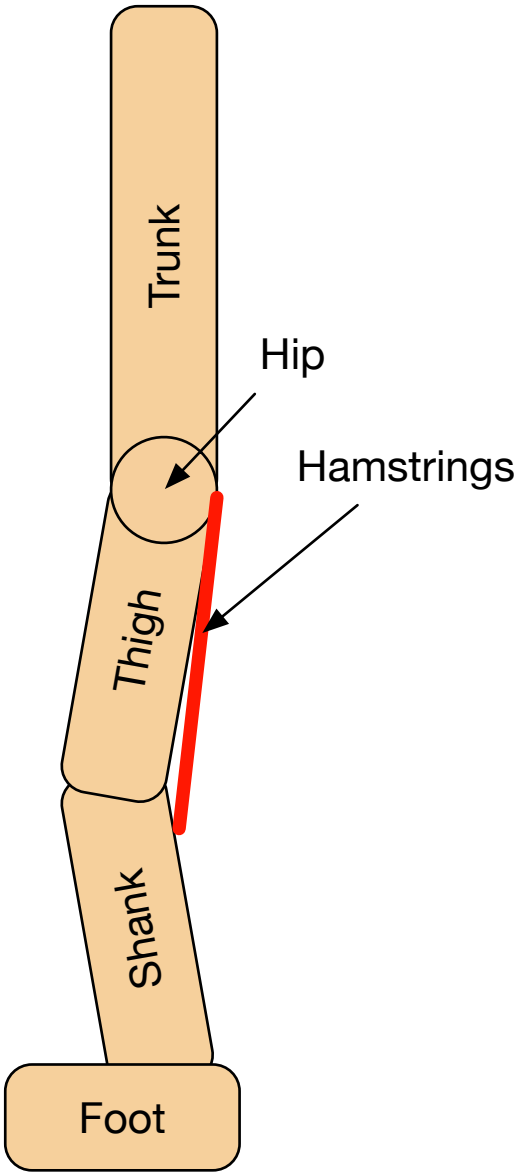


Introduction to Kinematics

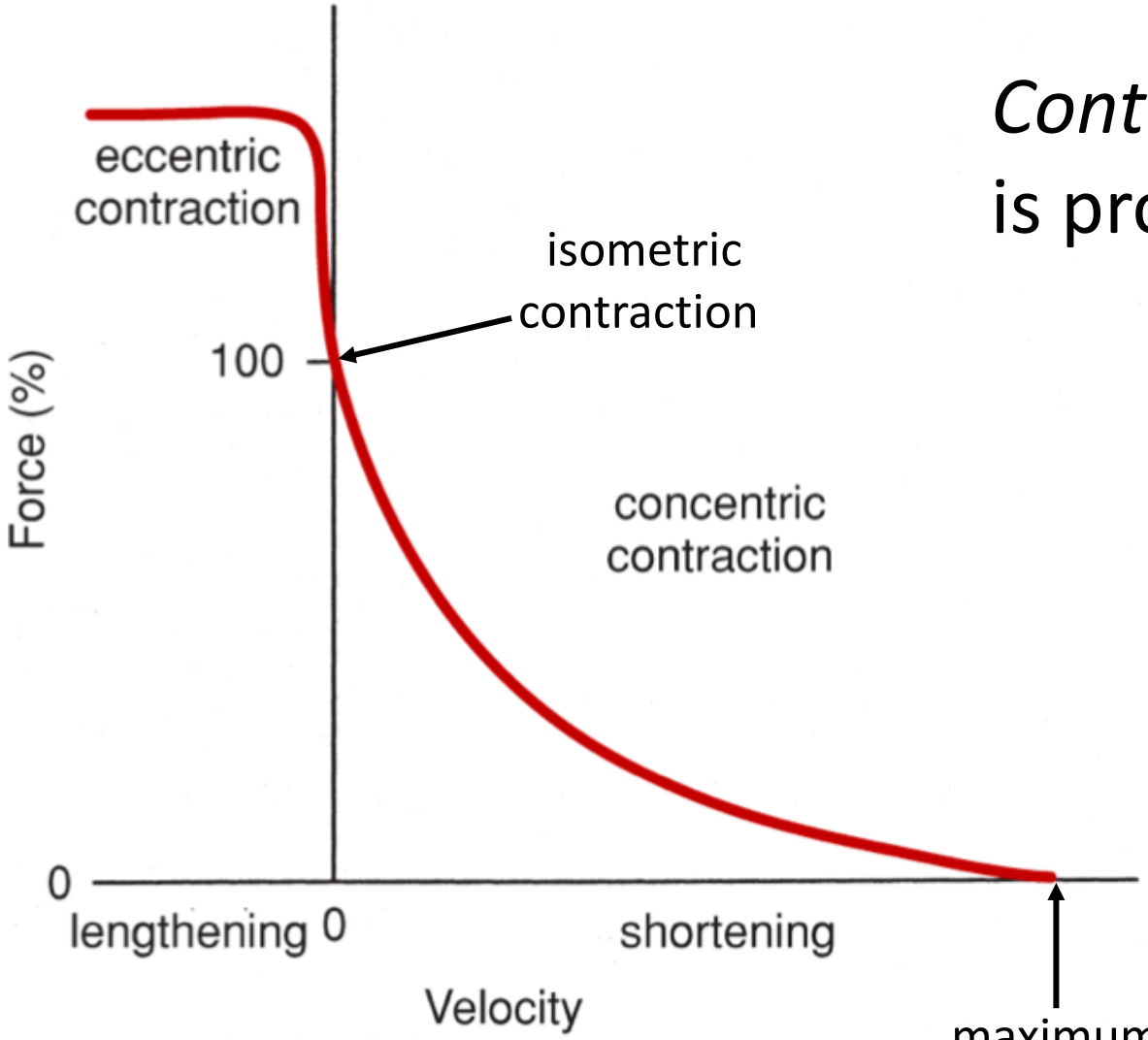


Introduction to Kinematics

Fast movements
⇒ fast changes in
MTU lengths



Force-Velocity Relationship of Muscle



Source: Pamela K. Levangie, Cynthia C. Norkin: Joint Structure and Function: A Comprehensive Analysis, Fifth Edition, www.FADavisPTCollection.com
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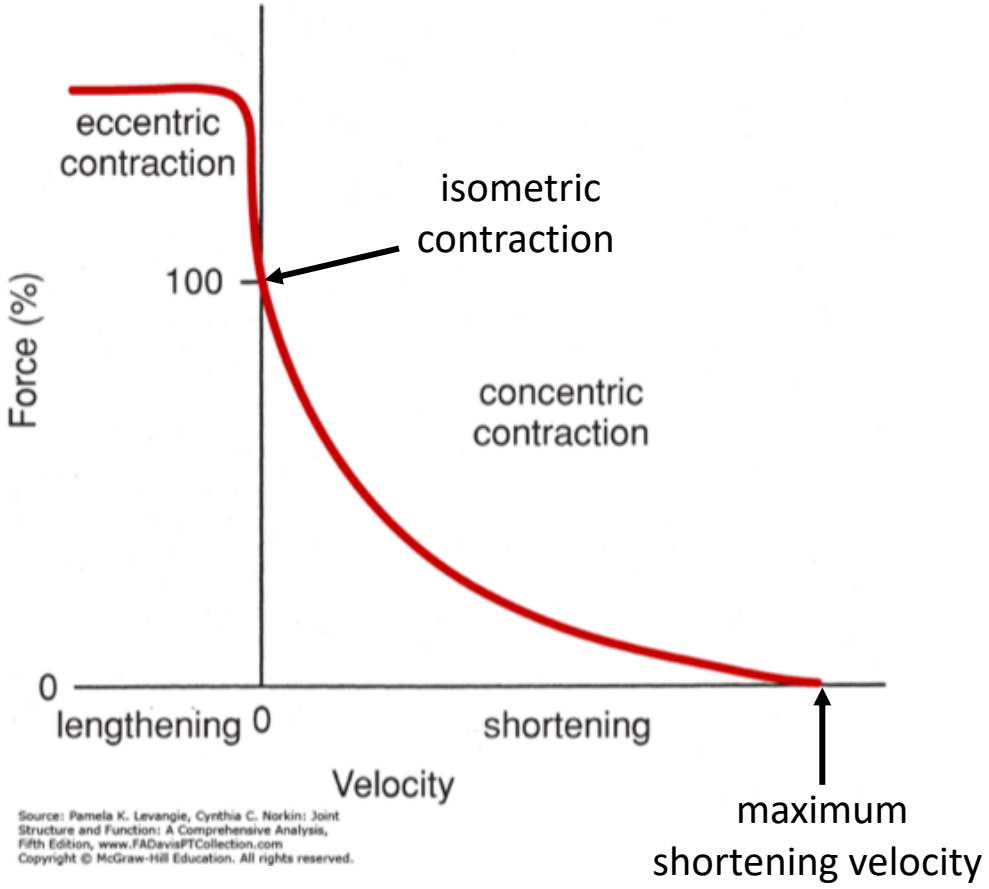
Contraction: muscle is producing force

Does Sprinting Present a Paradox?

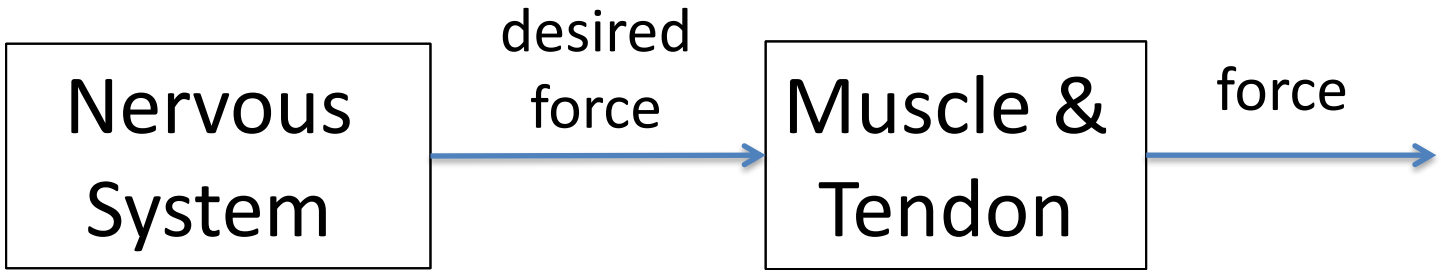
Fast movements ⇒ fast changes in MTU lengths

Muscle quickly shortens ⇒ produces weak force



Muscle-tendon unit: What it does

This simple? No!



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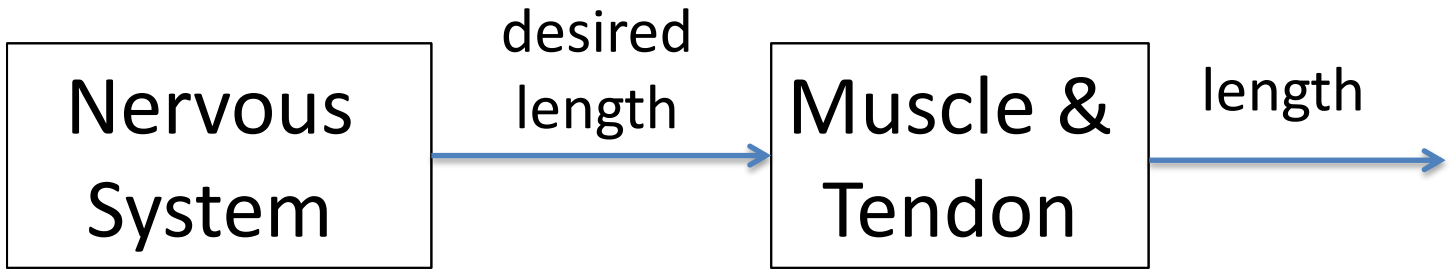
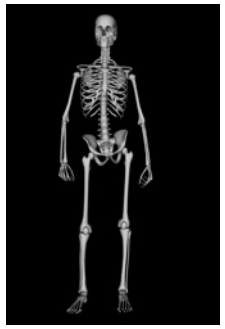


Muscle-tendon unit: What it does

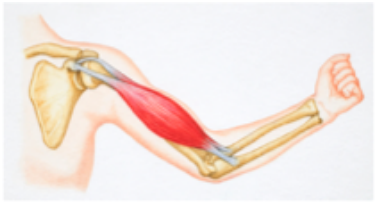
Nervous System



Skeletal System

neural command

muscle-tendon length



Muscle & Tendon

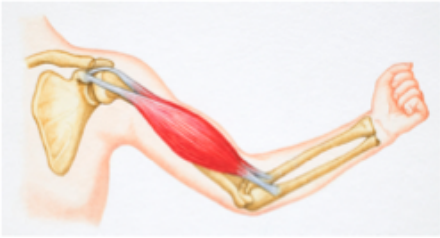
force

Muscle & tendon: *input-output system*:

History of neural command & length **up to present time**

Force **at present time**

Input-Output Systems



Muscle & tendon:

History of neural command & length **up to present time**

↓

Force **at present time**

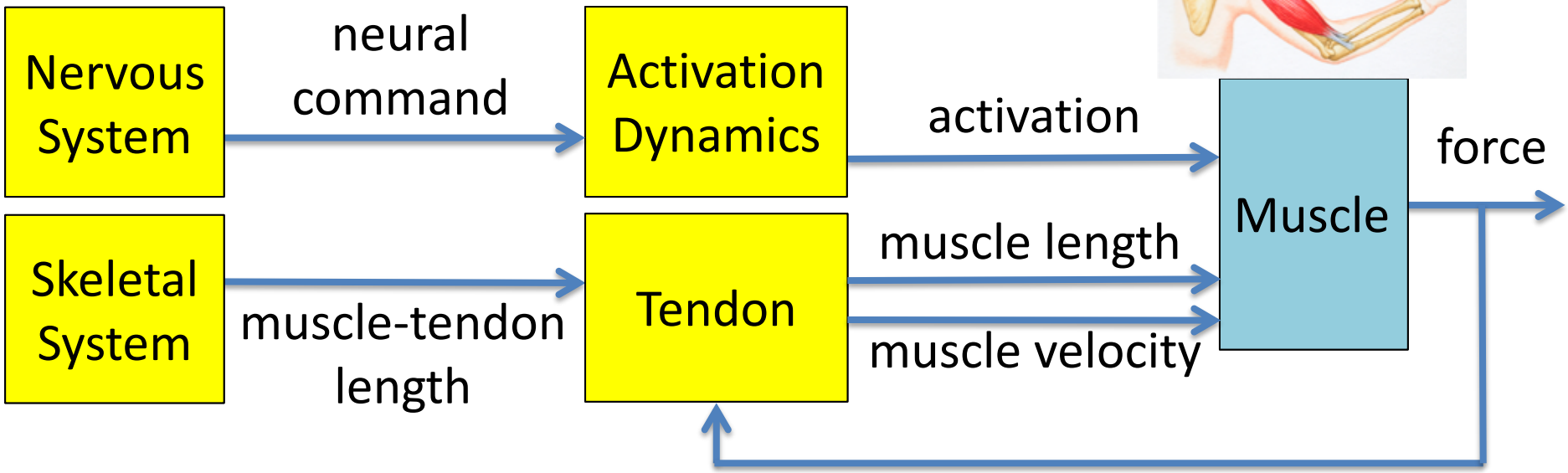
Bank account:

History of deposits & withdrawals **up to present time**

↓

Account balance **at present time**

Muscle-tendon unit: What it does

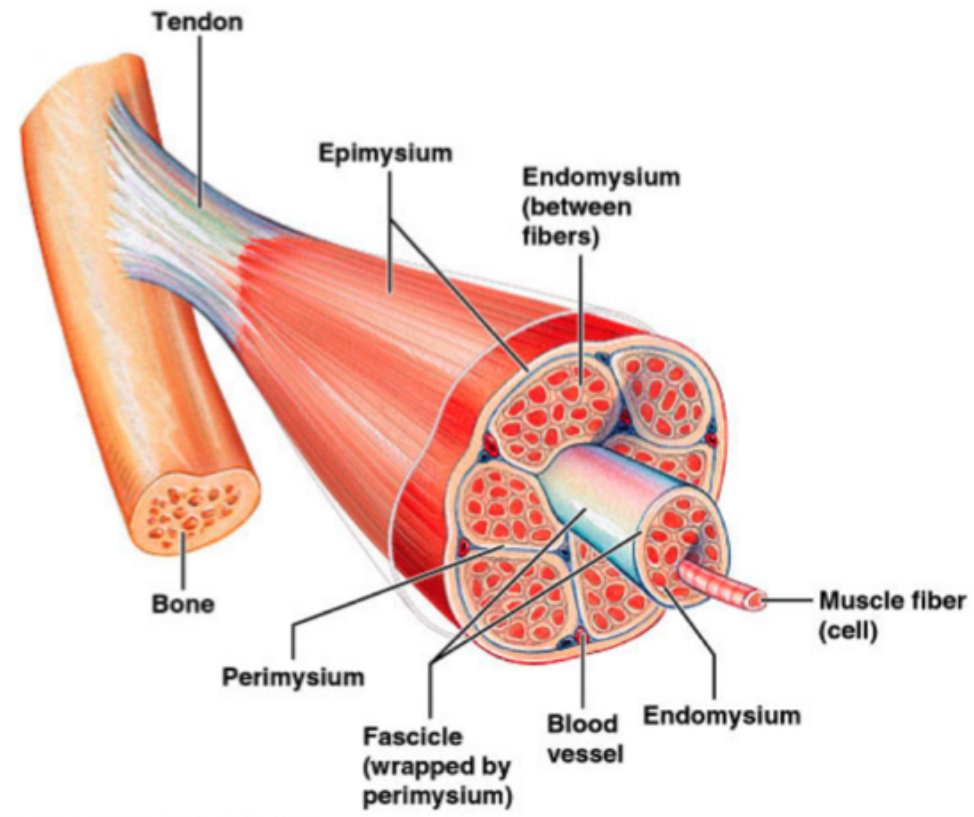


Muscle approximation: *static* input-output system:

Activation, length and velocity **at present time**

Muscle force **at present time**

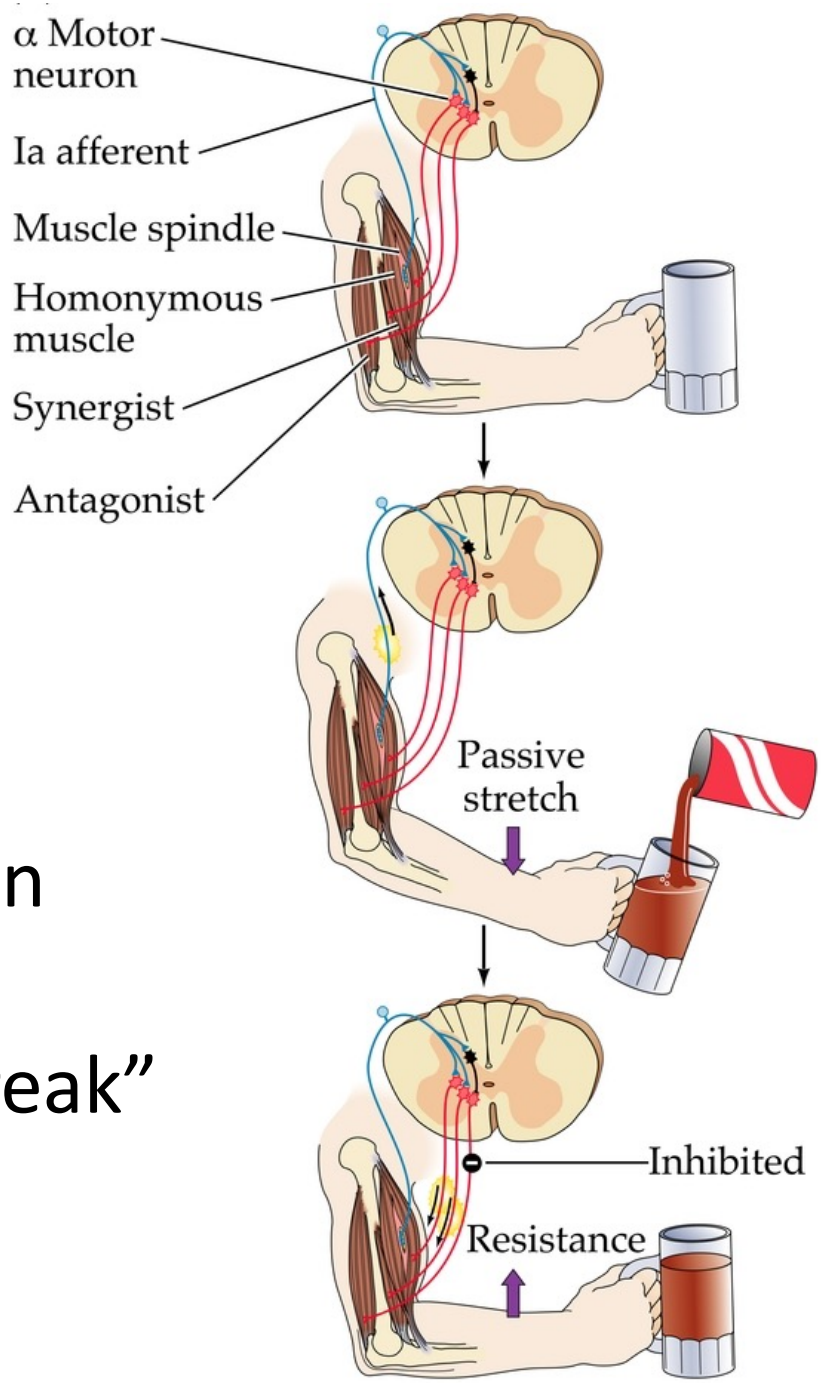
Muscle-tendon compliance



Muscle-tendon unit is *compliant*:

- External force ⇒ change in length

Muscle-Tendon Compliance



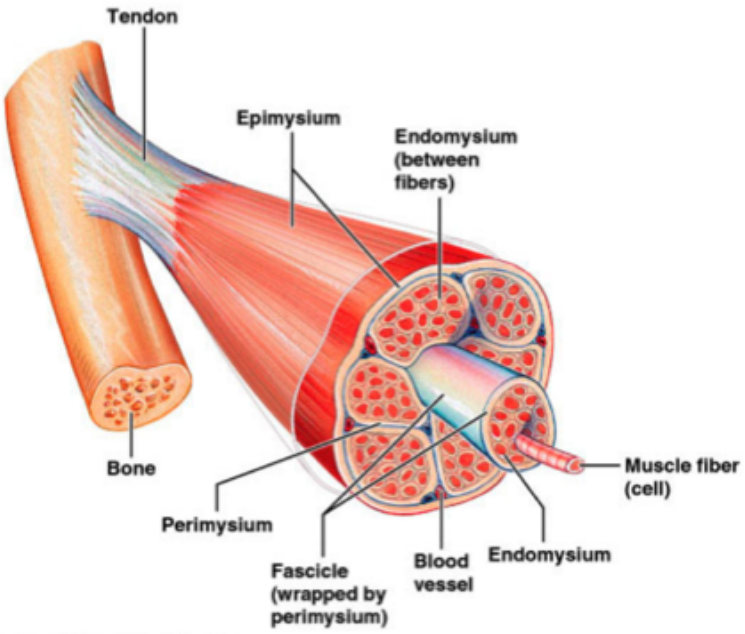
Compliance:

- External force ⇒ change in length
- Good: ”bend but don’t break”

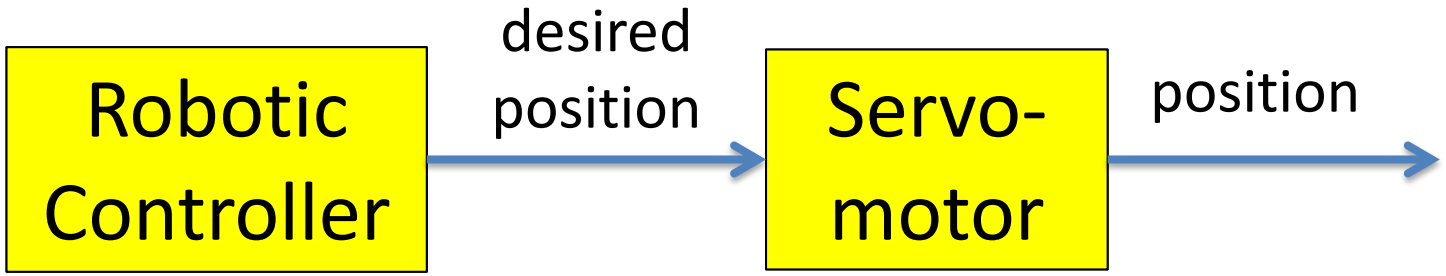
Muscle-Tendon Compliance

Compliance: External force ⇒ change in length

Compliant:



Not compliant:



Mimicking Muscle-Tendon Compliance

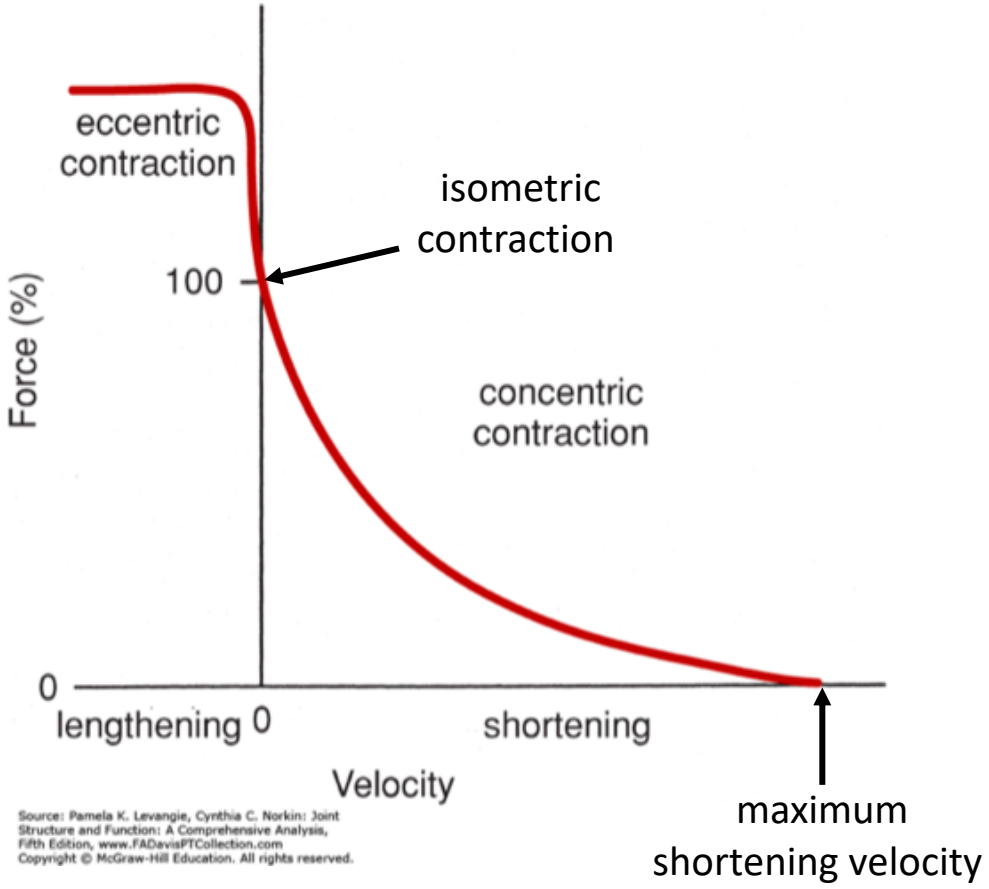
Optimal Feedback Control for Anthropomorphic Manipulators

D. Mitrovic, S. Nagashima, S. Klanke,
T. Matsubara, S. Vijayakumar

Does Sprinting Present a Paradox?

Fast movements ⇒ fast changes in MTU lengths

Muscle quickly shortens ⇒ produces weak force



Does Sprinting Present a Paradox?

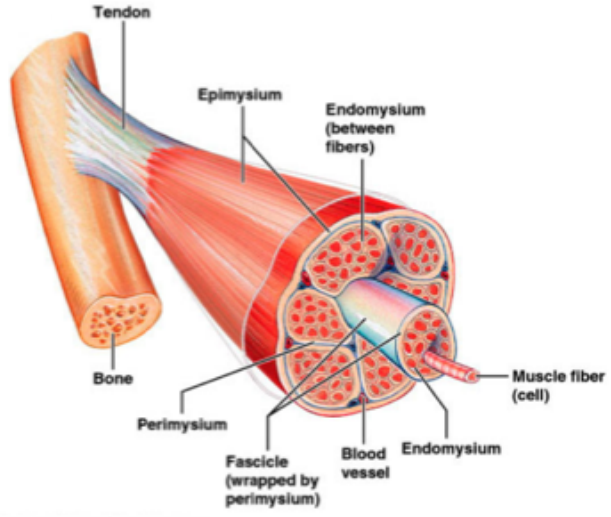
Fast movements ⇒ fast changes in MTU lengths

Muscle quickly shortens ⇒ produces weak force

So how do we run fast?

Factor 1:

- Force-velocity relationship describes **muscle**
- Does not describe the muscle-tendon unit

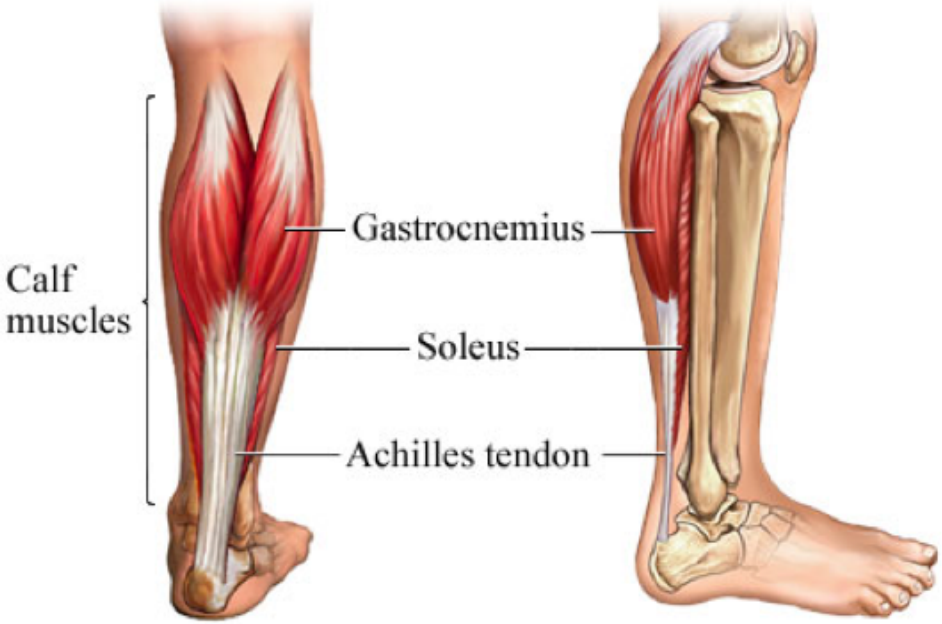


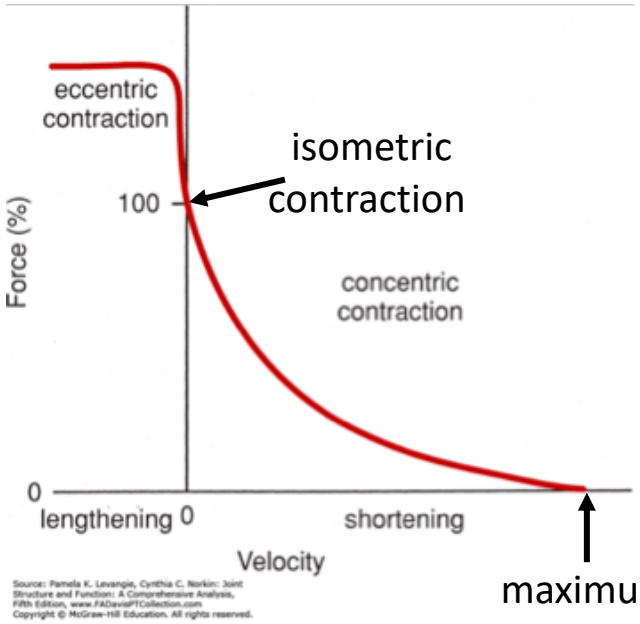
Factor 1: Tendon Length

Factor 1: Tendon Length

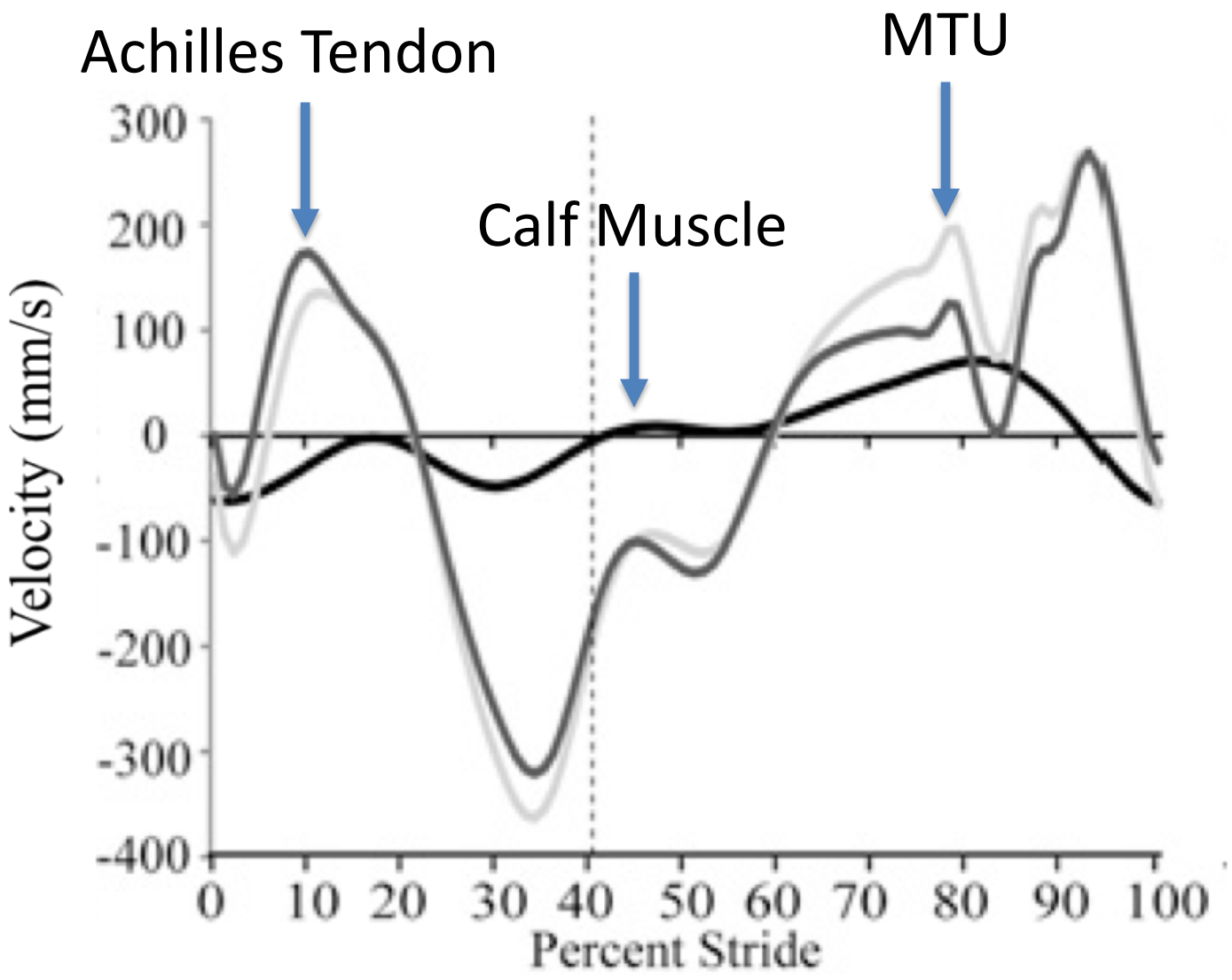
Relatively long

- Compared to muscle fibers
- Stretches as muscle force increases
- Reduces changes in muscle length





Factor 1: Tendon Length



Review

- What does muscle do from the cybernetic perspective as an input-output system?
- What does it mean that muscle and tendons are compliant? What are the implications?
- How does changes in the length of the Achilles tendon affect sprinting speed?

Next Time:

Human Movement I:
Muscles & Skeleton