# FOLDABLE ROBOTICS

Biomechanics and Bio-inspired Locomotion

# Homework 1 Due

- 3 Late Submissions

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# Homework 2 Due

- Show and tell later

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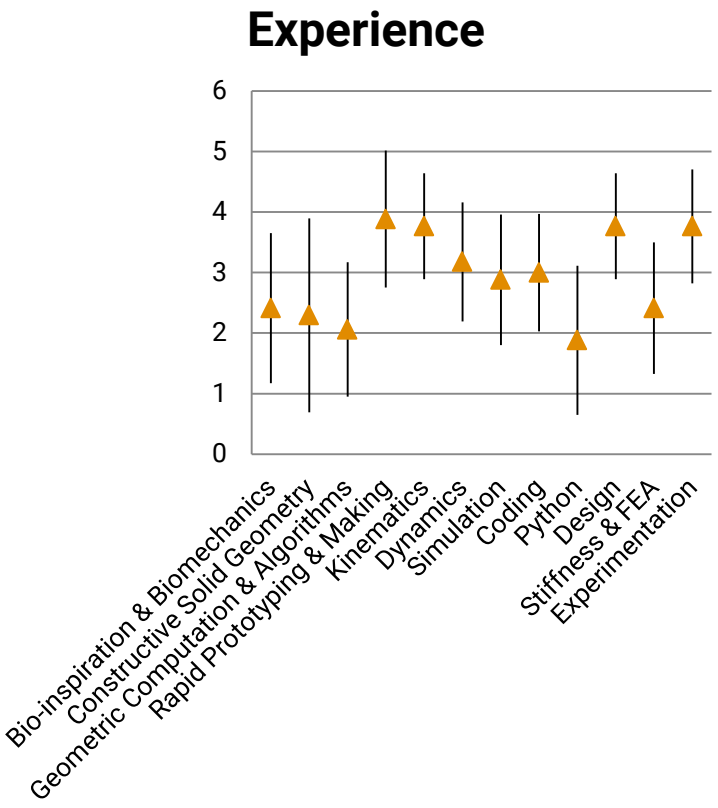
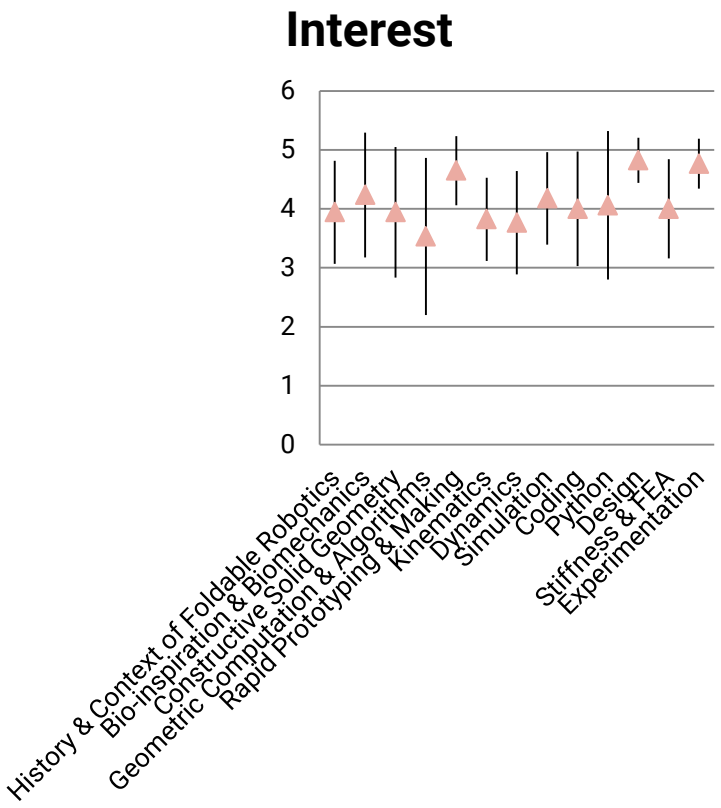
# And The Survey Says…

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# What do you want out of this class

- To be able to learn about the different types of foldable robotics and their applications.
- I would like to not only learn python but a greater understanding of robotics and fold-able robotics.
- I want to learn about foldable robotics and I want to be able to apply concepts to my future work, whatever it may be.
- experience with robotics, material option exposure and more python exposure
- Learn to apply the design ability to other feilds, specifically astronautics
- To learn about an interesting topic and gain skills that I can apply to jobs.
- I want to come out with experience which will help me get a job in a feild of robotics.
- knowledge of coding and a neat robot
- Inspiration for effective mechanism designs, manufacturing skills for flat robotics (i.e. layering of composite materials/laminating), more experience coding, possible knowledge of Popup CAD
- To be able to make foldable robotics on my own and apply the knowledge from this class to my future career.
- To better understand how to build a robot, and the programming and electrical systems that go into it.
- I would like to understand and know how to design more complex fold-able robots
- Continuing my research on the fish :-)
- To gain knowledge and experience in a new sector of engineering.
- Determine if this is a path I may be interested in for phd
- A conference paper
- Knowledge of designing and implementing foldable robotics in my research field.

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# What skills do you hope to acquire?

- to be able code and design better robots
- I would like to acquire a greater understanding of robotics as well as, a deeper and broader horizon on programming
- Anything, everything.
- more python and rapid prototyping
- design proccess, capability of foldable robots, coding in python
- Python, Simulations, and Design
- Mastering Python
- More coding
- Better understanding of Python, how to manufacture flat robots out of more materials than just laser cut plastic
- Coding, unique design skill, computation and simulation skills
- I hope to better understand how to code in Python and C++, as those were my points of struggle throughout my undergraduate degree.
- Creating computer models that predict performance of designs.
- You know!
- Better knowledge of control systems.
- Quick prototyping for robotic books
- More Python,  Dynamics analysis
- Python, Origami inspired robotics, Manufacturing skills.

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# Are there specific applications you wish to pursue with your project?

- Not at the moment
- I would like to pursue power management and distribution throughout the robotic configuration and a deep rooted language algorithm.
- Personally, I am extremely interested in prosthesis and in bio-mimcry robots.
- unsure at this time
- Not sure what applications yet
- Can't think of one yet.
- A project with purpose, it has a job and doesn't exist just for the sake of existing.
- Not at the moment but I would prefer it not to just be a robot that moves
- My MS Thesis
- I hope my project will be able to fly and become cheap mini drones.
- I want my project to come with a controller and be portable.
- I would like to be able to take any design and create a computer model that predicts the kinematics and dynamics
- SRP
- Not presently.
- Robotic books
- My research, thesis
- Energy storage mechanisms.

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# Are there specific questions this class will help you answer?

- Not at the moment
- Not right now but there is always question in the future of understanding and learning.
- I do not currently have any specific questions
- not that I am aware of
- Don't know yet
- It will help me figure out if this is a field I want to get into.
- Are there viable robotic jobs in the area when I graduate?
- how to code in an official language.
- Yes, I need to change the mechanism on my folding robot to fit smoothly and change shape with less resistance using a servomechanism design
- "I would love to know how to make a foldable robot from scratch.I would love to know the future of the field of robotics."
- I'd like to better understand how both the software and electrical systems of a robot work hand in hand.
- I would ideally like to be able to design robots that are not as straight forward as I have designed before
- No
- Not presently.
- If I should pursue his for phd study
- feasibility of using different manufacturing techniques compared to conventional techniques used
- Yes, Is there a way to store and release mechanical energy while being efficient using foldable robotics.

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# Describe your ideal project

- To solve a problem by designing a robot to function autonomously.
- Through the scope of this class I would like to create a fold-able robotic smaller then your hand which an perform on a grand scale.
- A project that allows me to work with a team to design and implement a robot that moves in a new and exciting way.
- without more exposure to foldable robots, it is unclear what would be ideal
- A project that covers each aspect of the design process to get a comprehensive overview
- An ideal project would probably be something that requires you to come up with creative solutions to solve something.
- A project that may be replicated many times and may work together to achieve a higher goal.
- designing and building something that will help those in need
- The design of a lightweight, cheap robotic swarm capable of excavating & depositing materials through a folding mechanism.
- My ideal project will be challenging but still doable. It will require group effort and it will be unique and creative.
- "I believe I will enjoy the design aspect involved in making a foldable robot. I hope to create something that is visually pleasing and portable.A maybe, simpler and smaller version of a robot that has the folding mechanisms of this thing:https://www.youtube.com/watch?v=HuC6q9kbryw"
- I would like my project to have some form of locomotion but I'm open to any different options.
- I'm working on one!
- One with enough of a challenge that it forces me to learn and adapt.
- Robotic book such as beating heart and inhaling lungs for anatomy book
- A working prototype of a laminate robot which uses faster manufacturing techniques compared to conventional techniques and enables embedding sensors and actuators in laminate mechanisms
- Creating a kangaroo like propulsion system using light weight mechanisms

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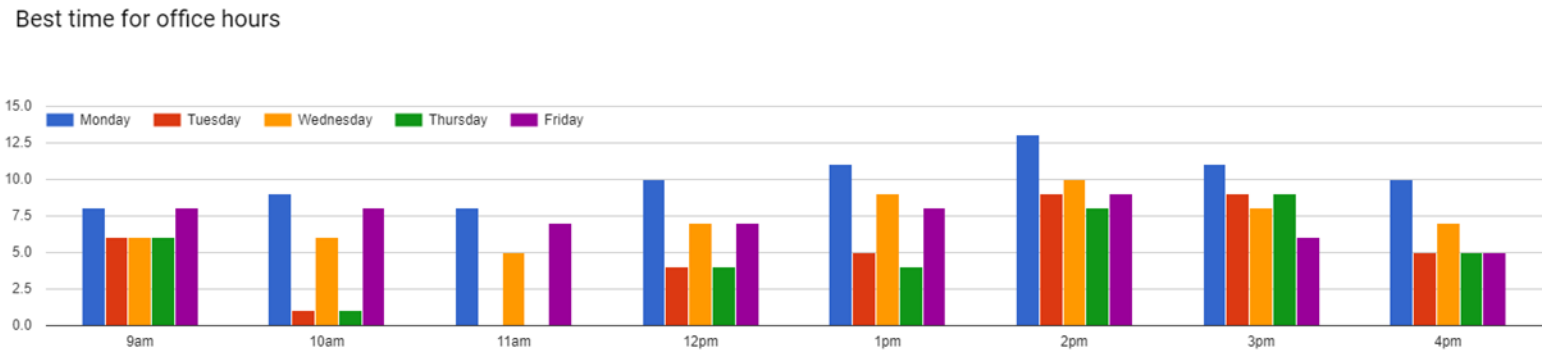
# Best Time for Office Hours

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# Bio-Inspiration

- Robotic Systems help us understand the biological world
- Can mimic biological structures
- Experiments can be designed and repeated vs. observed.
- Variation in form and function can be introduced

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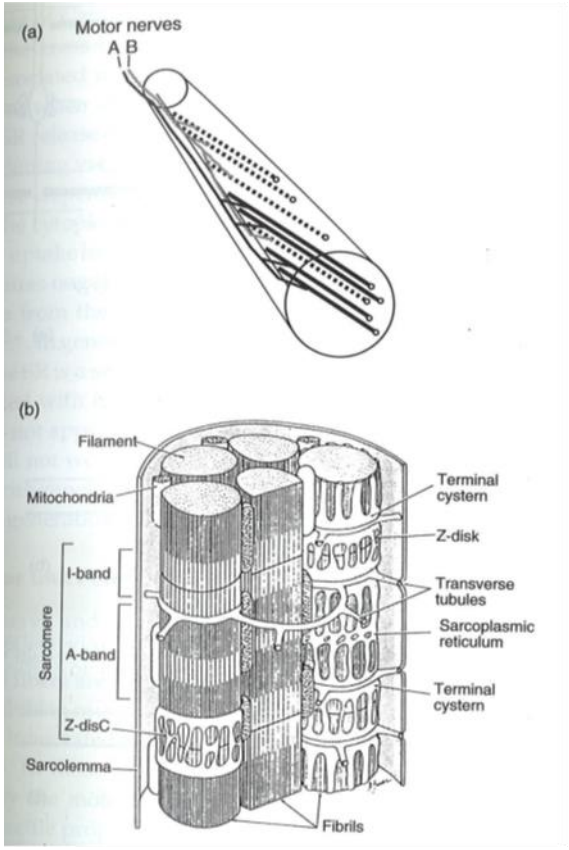
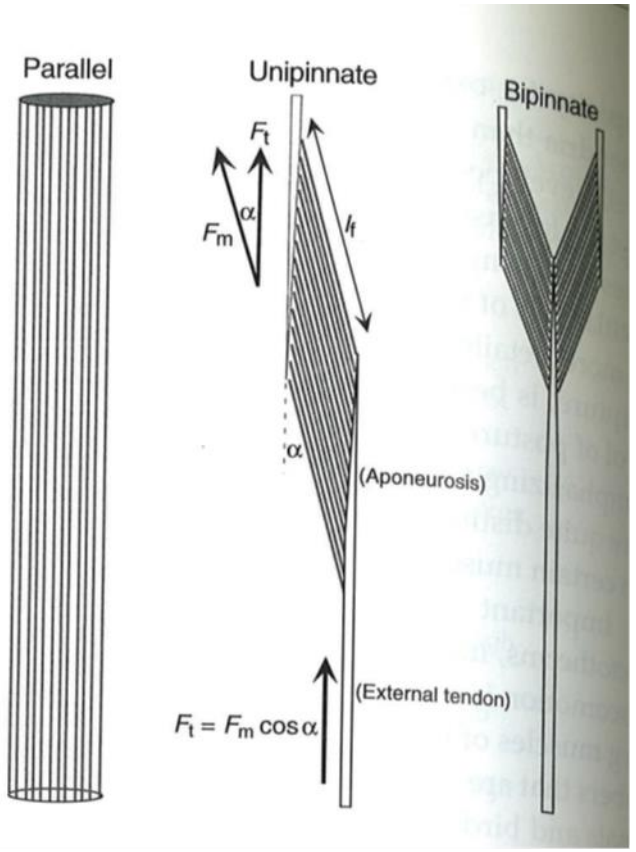
# Muscle Architecture




Biewener, Animal Locomotion

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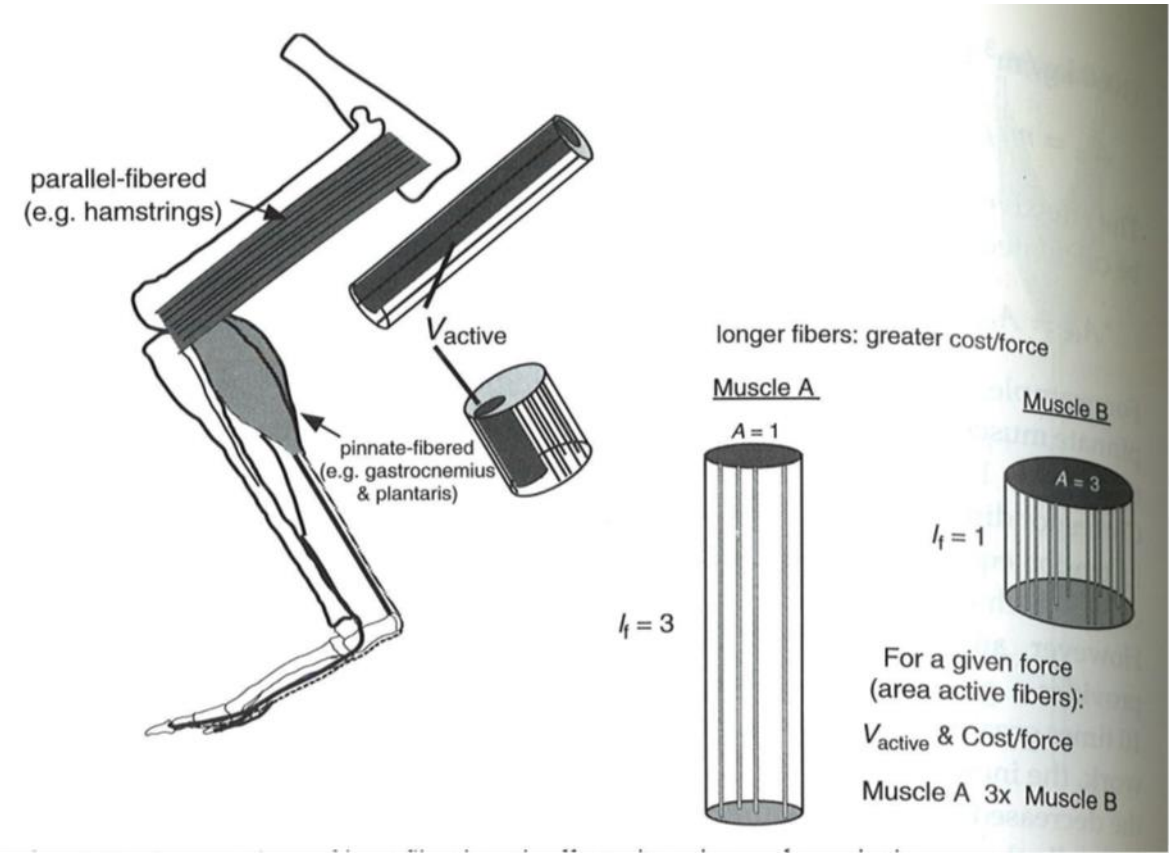
# Muscle Architecture




Biewener, Animal Locomotion

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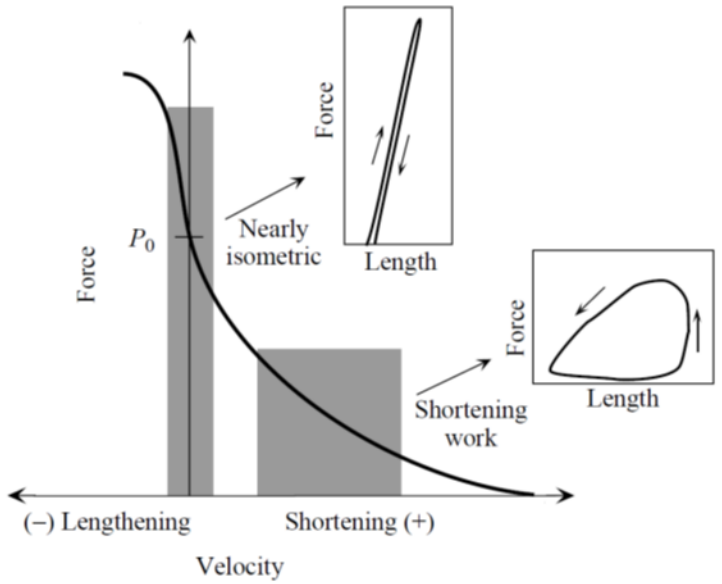
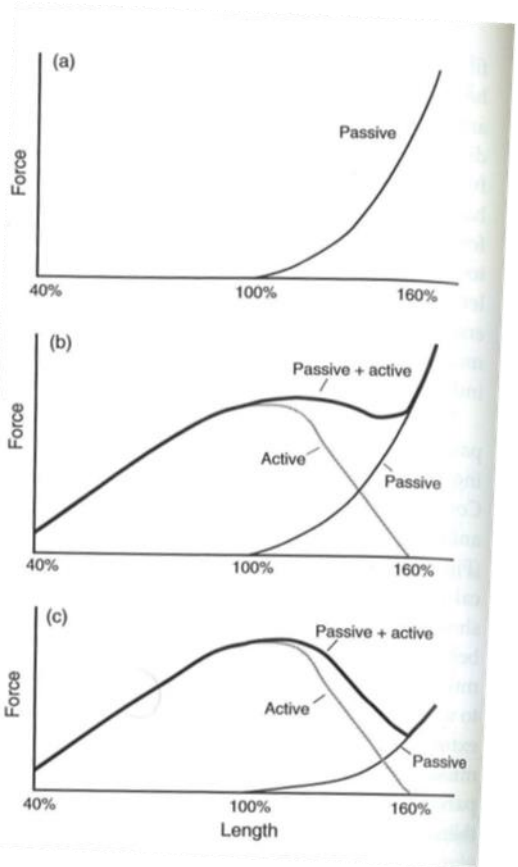
# Skeletal Muscle




A. Biewener and G. B. Gillis, "Dynamics of muscle function during locomotion: accommodating variable conditions.," *J. Exp. Biol.*, vol. 202, no. Pt 23, pp. 3387–3396, 1999.

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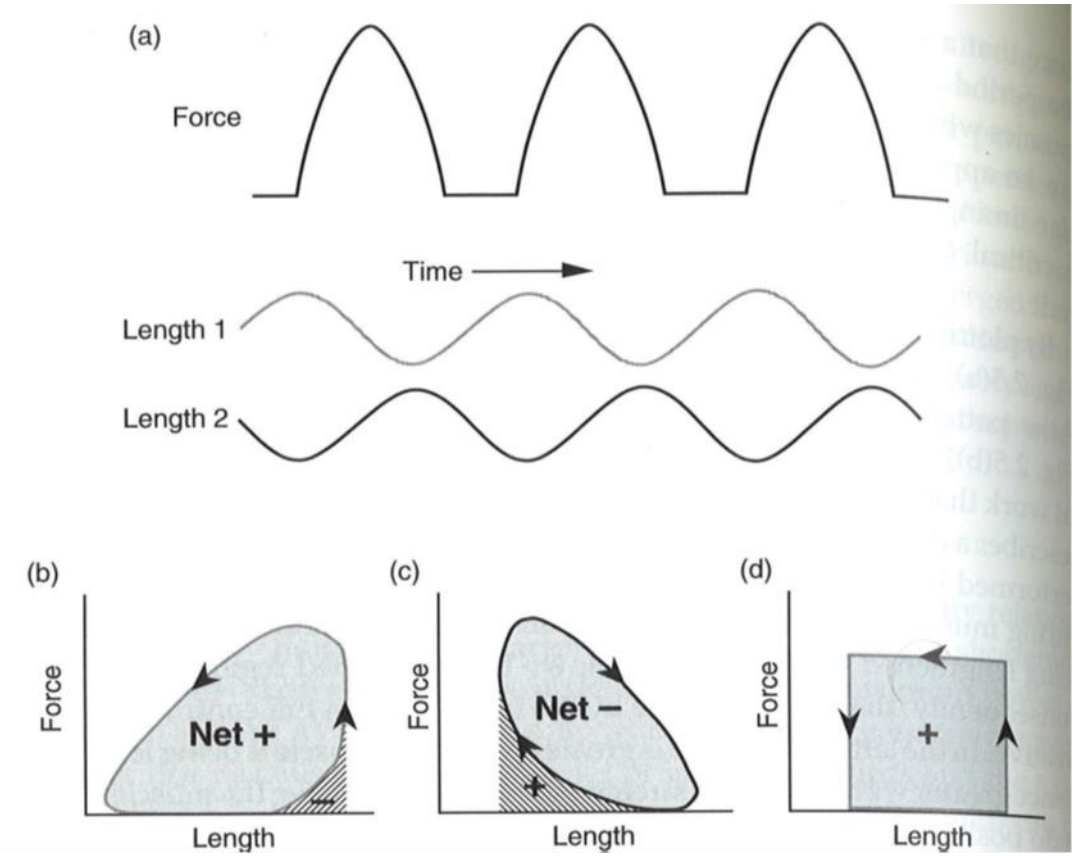
# Work Loop




Biewener, Animal Locomotion

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# Treadmill, CO2, Forces

http://www.ted.com/talks/robert_full_on_engineering_and_evolution?language=en

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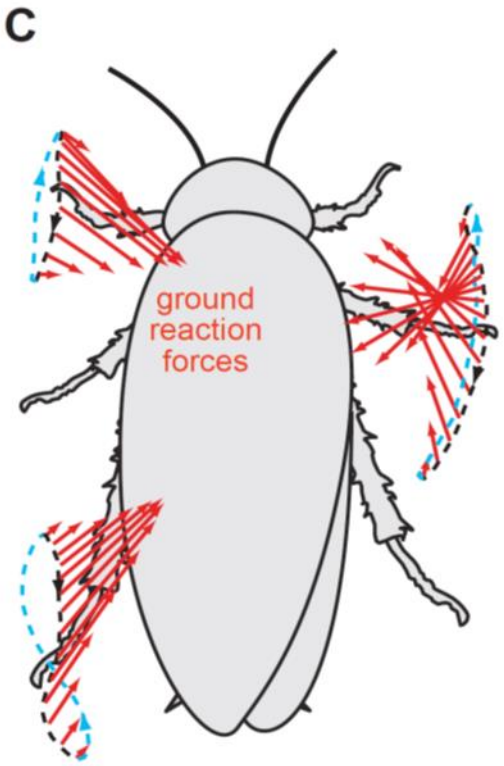
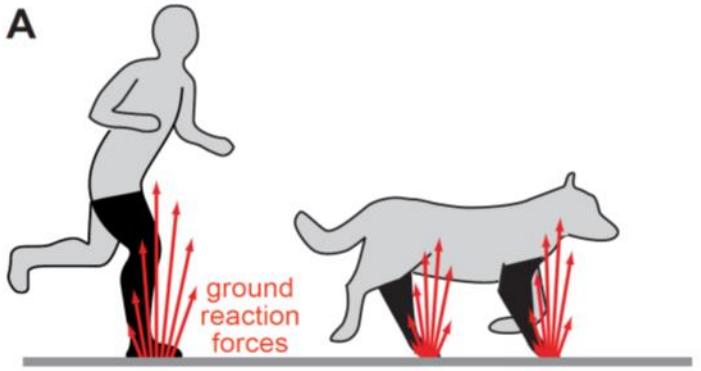
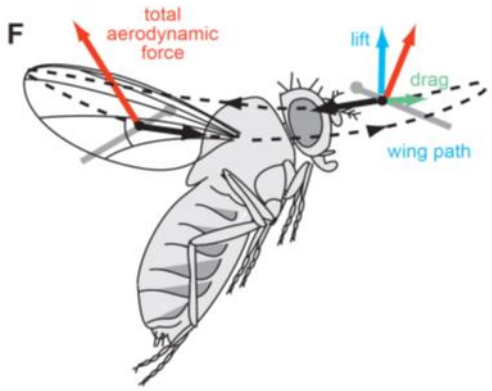
# Different Force/Motion Profiles




M. H. Dickinson, "How Animals Move: An Integrative View," *Science (80-. ).*, vol. 288, no. 5463, pp. 100–106, Apr. 2000.

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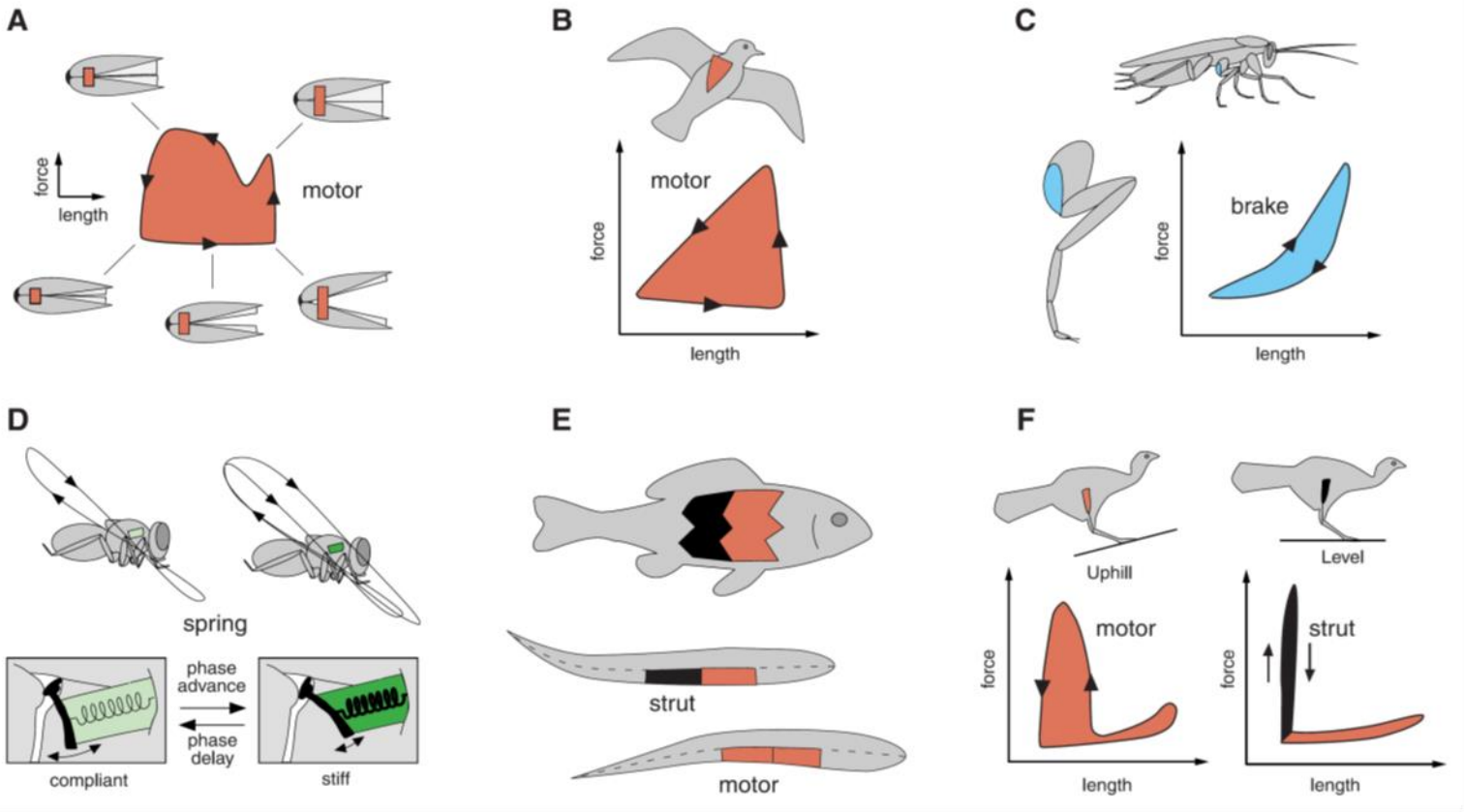
# Different Animals




M. H. Dickinson, "How Animals Move: An Integrative View," *Science (80-. ).*, vol. 288, no. 5463, pp. 100–106, Apr. 2000.

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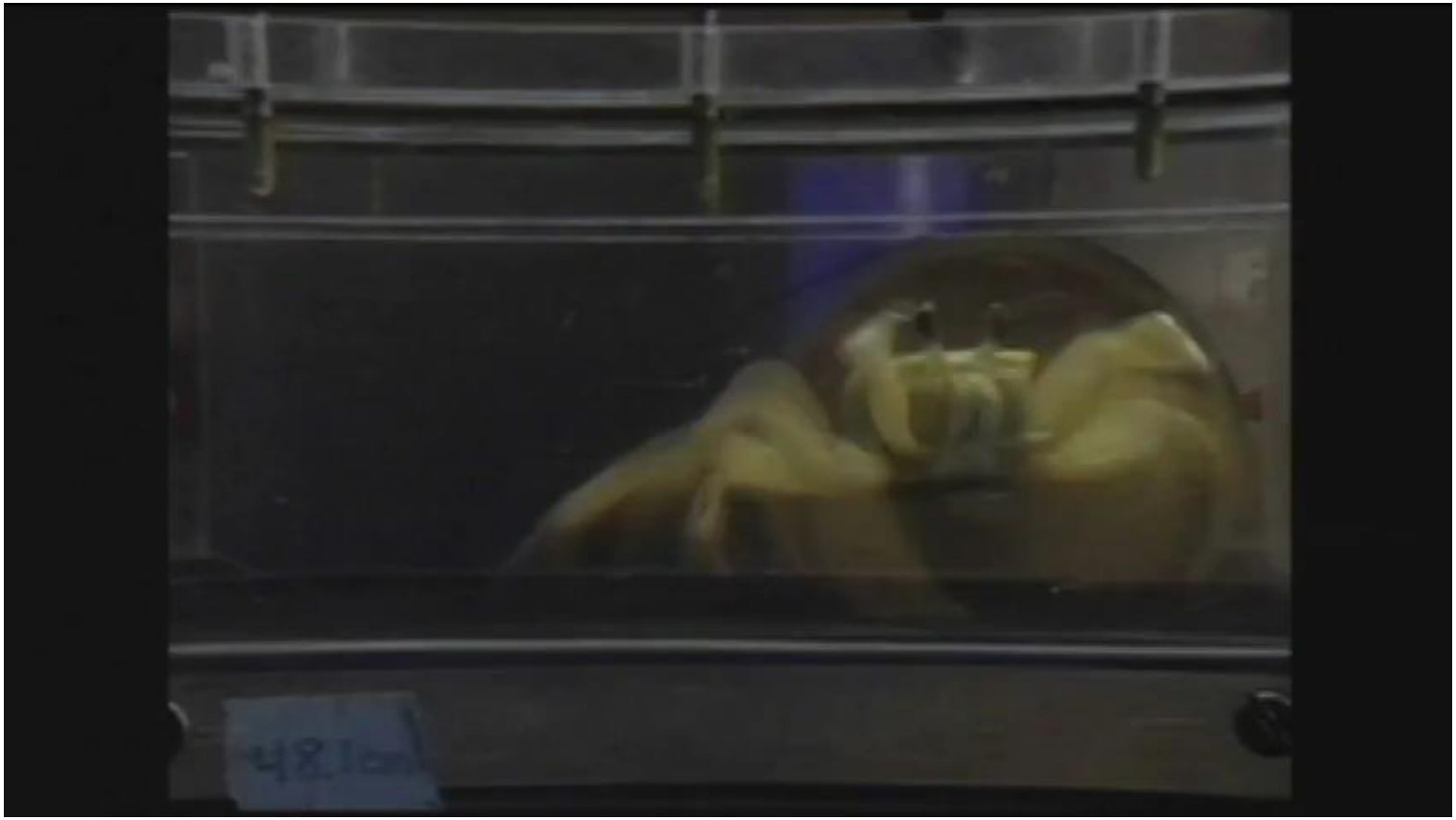
# Spring Loaded Inverted Pendulum



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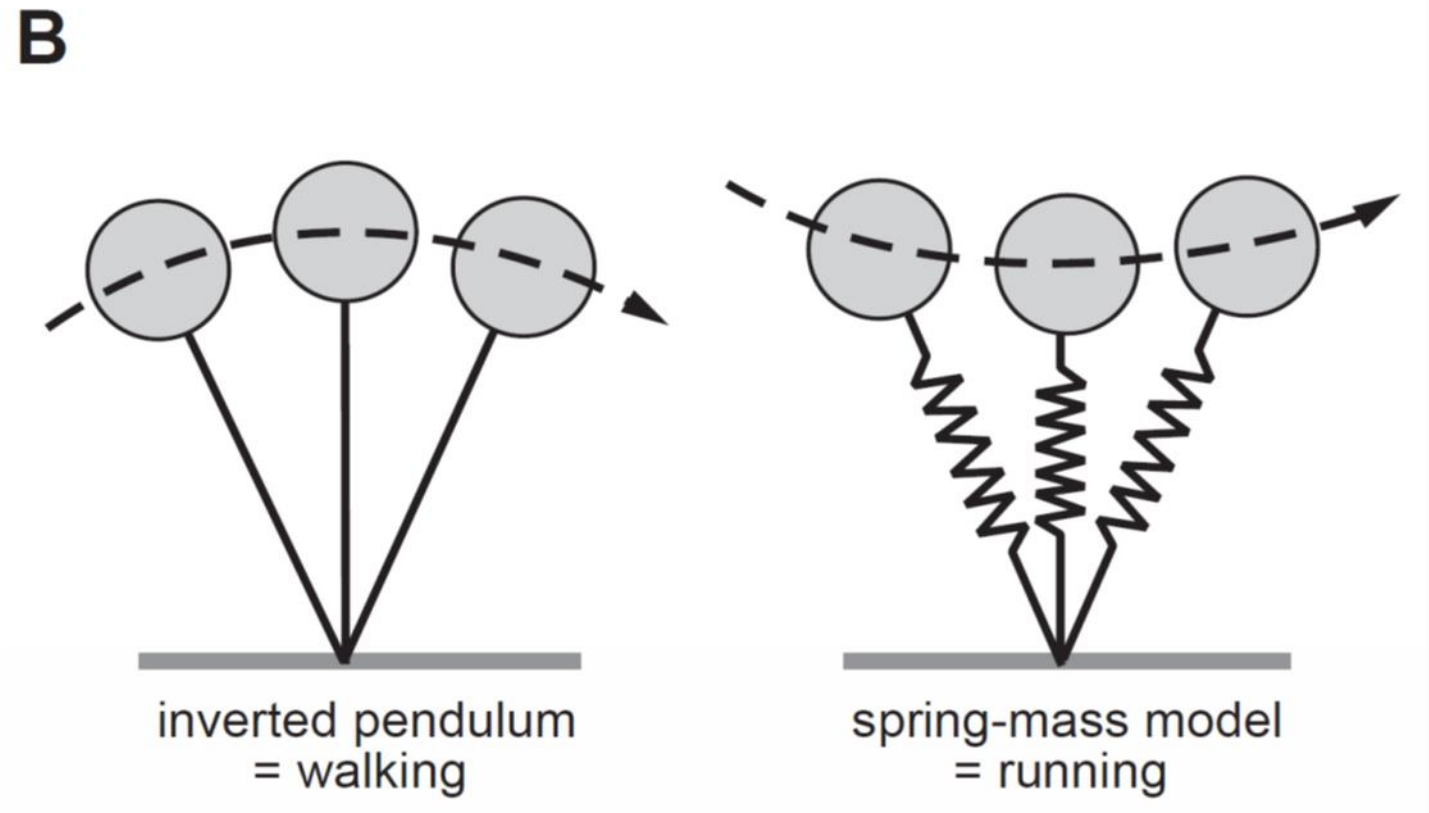
# IP vs SLIP

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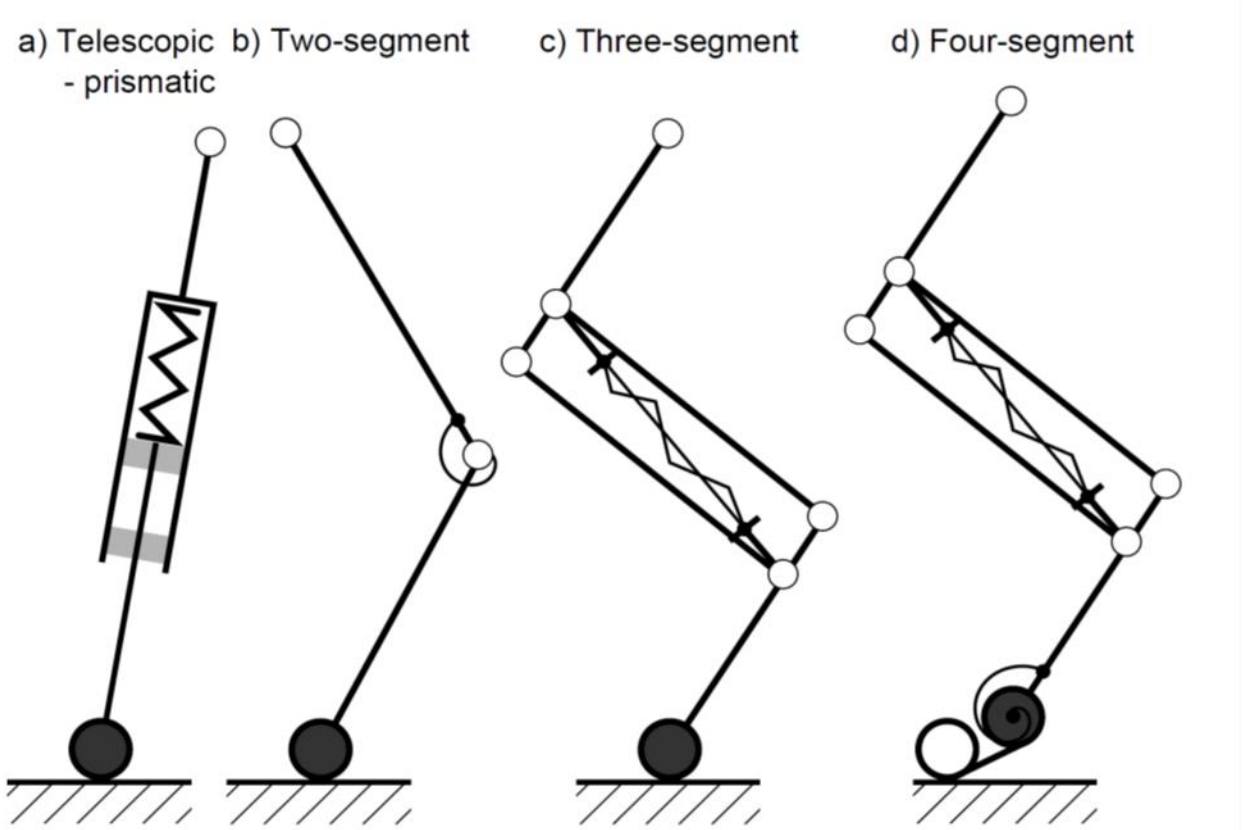
# Implementations of SLIP




A. Sprowitz, A. Tuleu, M. Vespignani, M. Ajallooeian, E. Badri, and A. J. Ijspeert, "Towards dynamic trot gait locomotion: Design, control, and experiments with Cheetah-cub, a compliant quadruped robot," *Int. J. Rob. Res.*, vol. 32, no. 8, pp. 932–950, Jul. 2013.

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# Robot Analogy


M. H. Raibert, “Legged robots,” *Artif. Intell. MIT Expand. Front.*, vol. Vol.2, no. 6, pp. 499–514, 1990.

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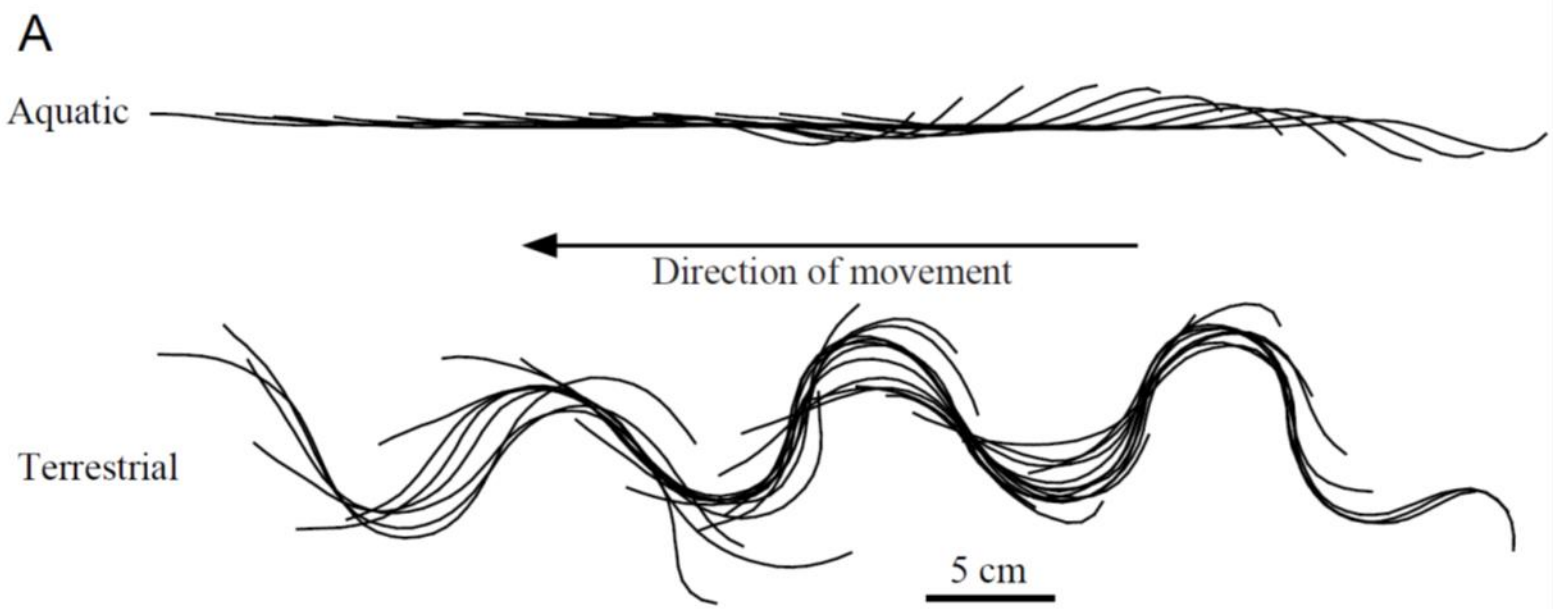
# Differences in Gait




A. Biewener and G. B. Gillis, “Dynamics of muscle function during locomotion: accommodating variable conditions.,” *J. Exp. Biol.*, vol. 202, no. Pt 23, pp. 3387–3396, 1999.

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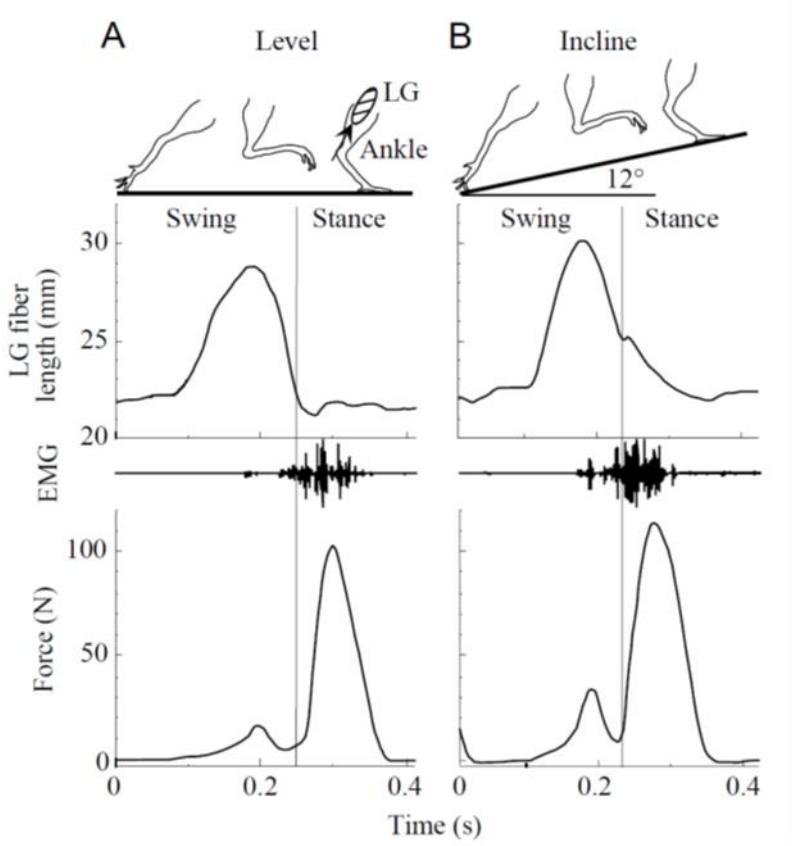
# Level vs. Incline




A. Biewener and G. B. Gillis, “Dynamics of muscle function during locomotion: accommodating variable conditions.,” *J. Exp. Biol.*, vol. 202, no. Pt 23, pp. 3387–3396, 1999.

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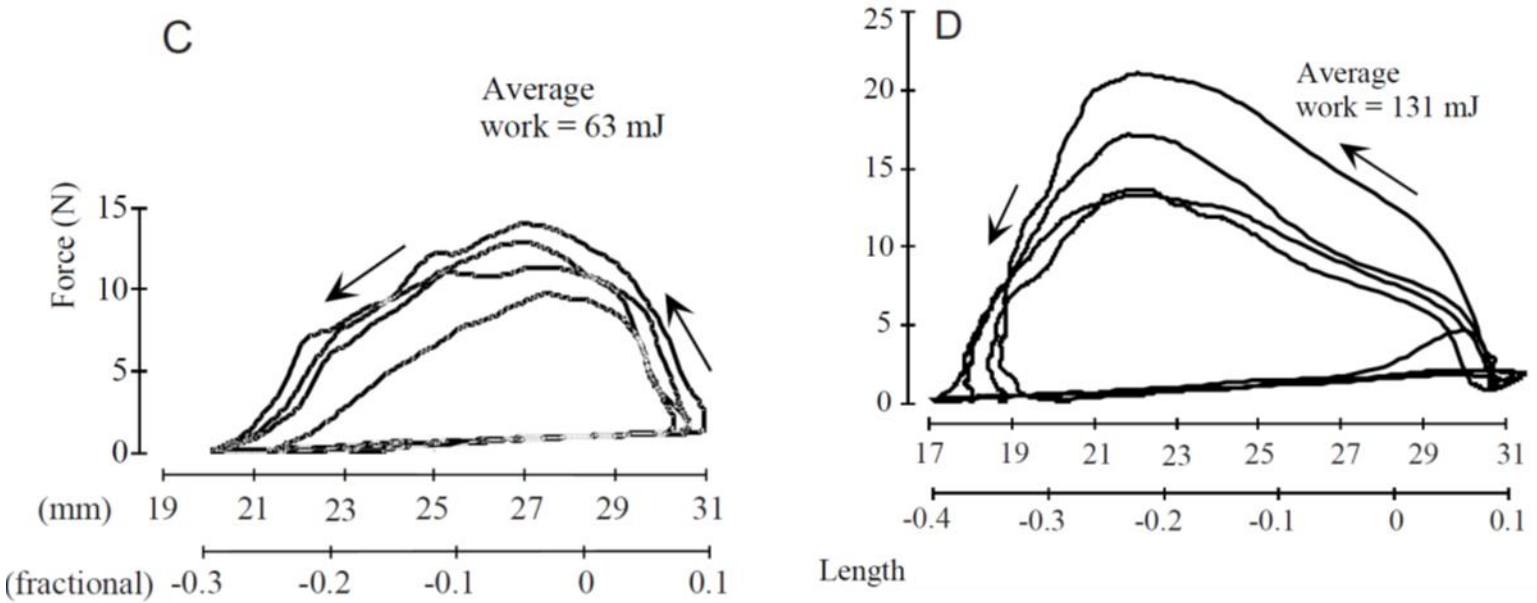
# Swimming vs. Walking




A. Biewener and G. B. Gillis, “Dynamics of muscle function during locomotion: accommodating variable conditions.,” *J. Exp. Biol.*, vol. 202, no. Pt 23, pp. 3387–3396, 1999.

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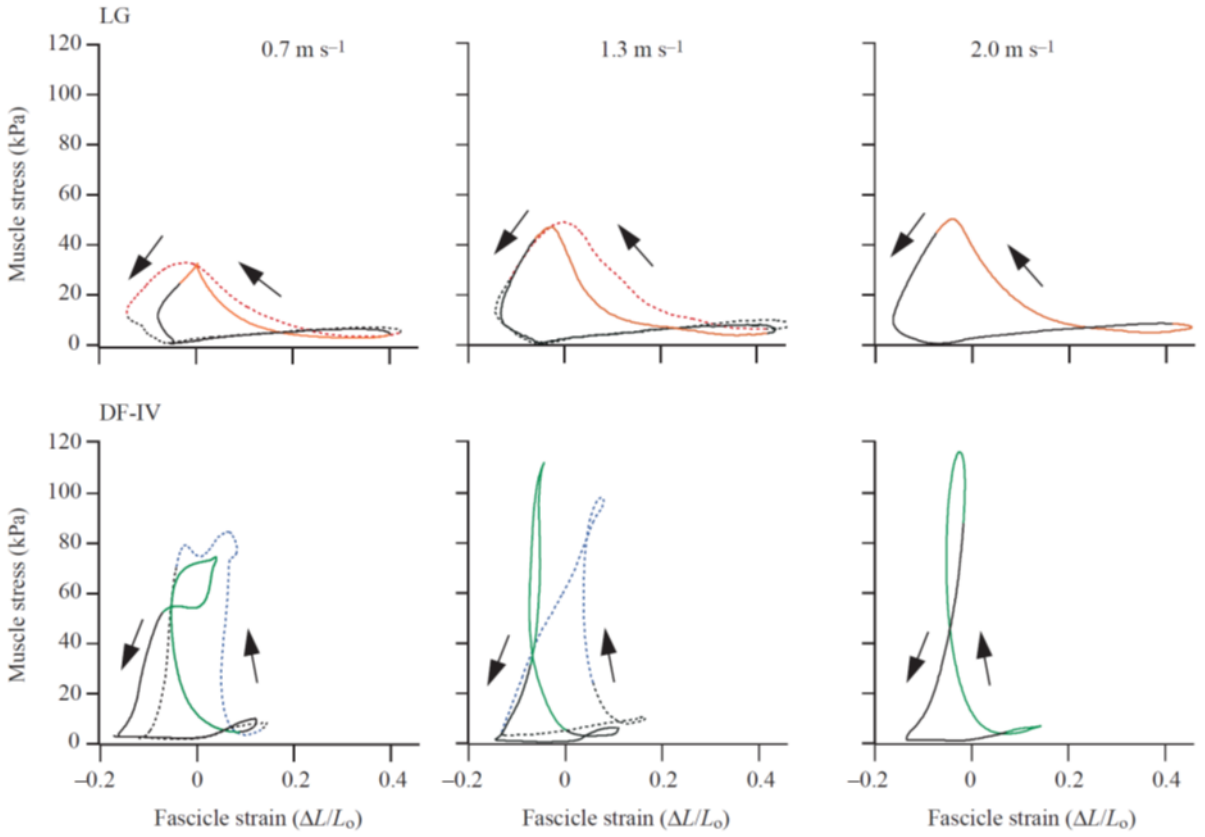
# Muscle Stress vs. Strain




M. A. Daley and A. A. Biewener, "Muscle force-length dynamics during level versus incline locomotion: a comparison of in vivo performance of two guinea fowl ankle extensors.," *J. Exp. Biol.*, vol. 206, no. Pt 17, pp. 2941–58, Sep. 2003.

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# HW 2 Show and Tell

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# PERISTALTIC LOCOMOTION

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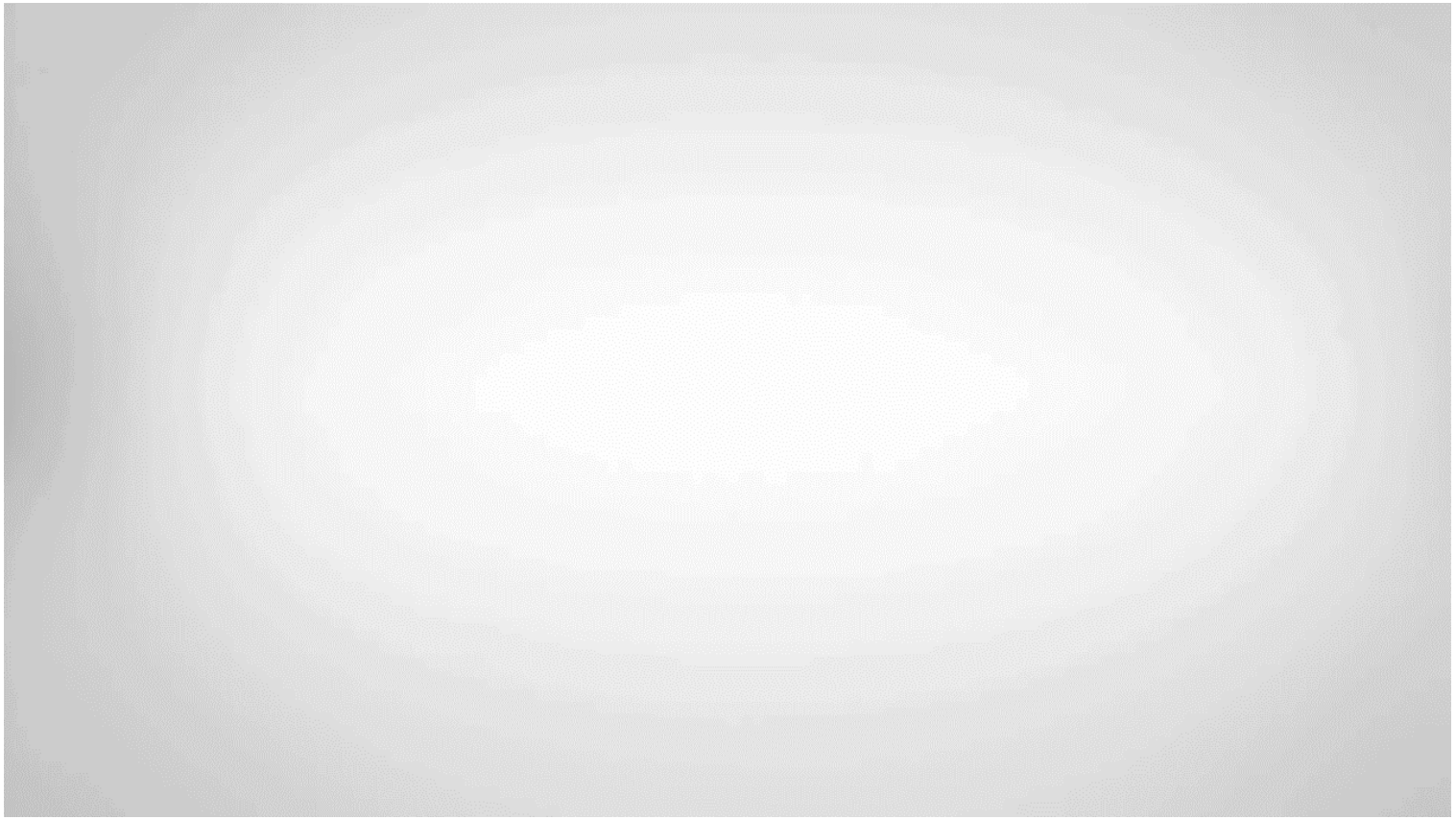
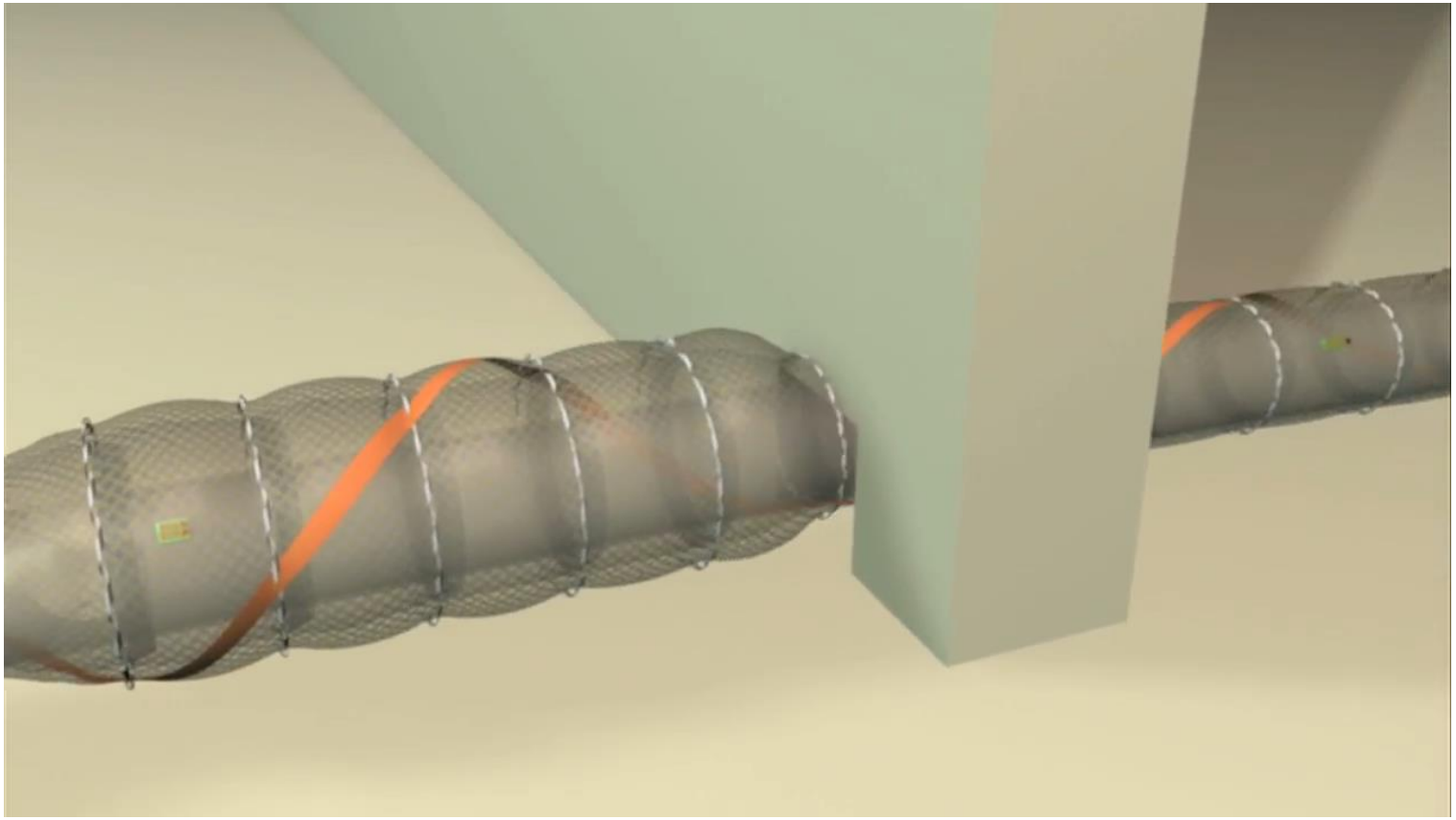
# SMA-Enabled Soft Worm



# Peristaltic Locomotion



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# UNDULATORY LOCOMOTION

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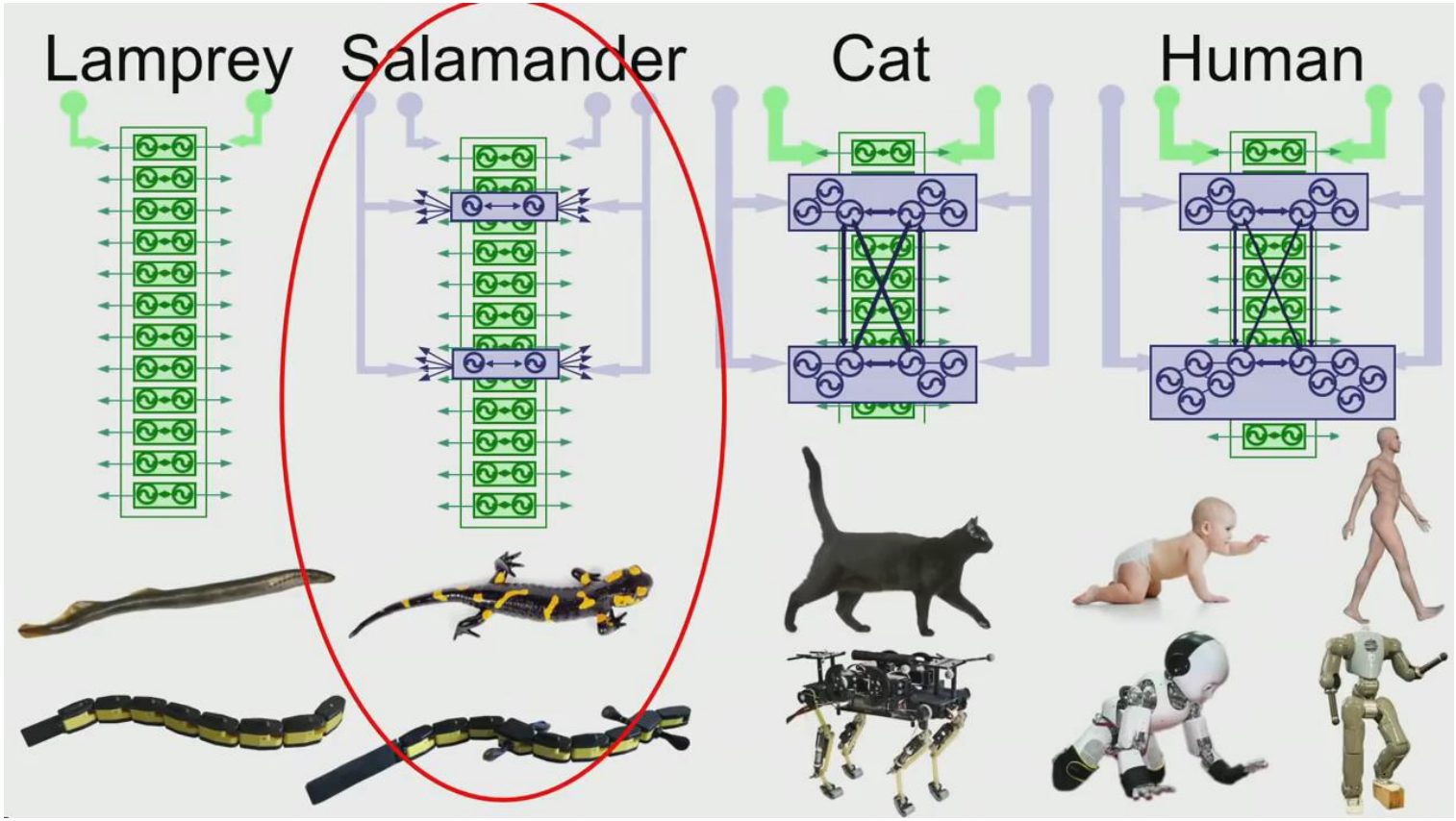
# Auke J. Ijspert

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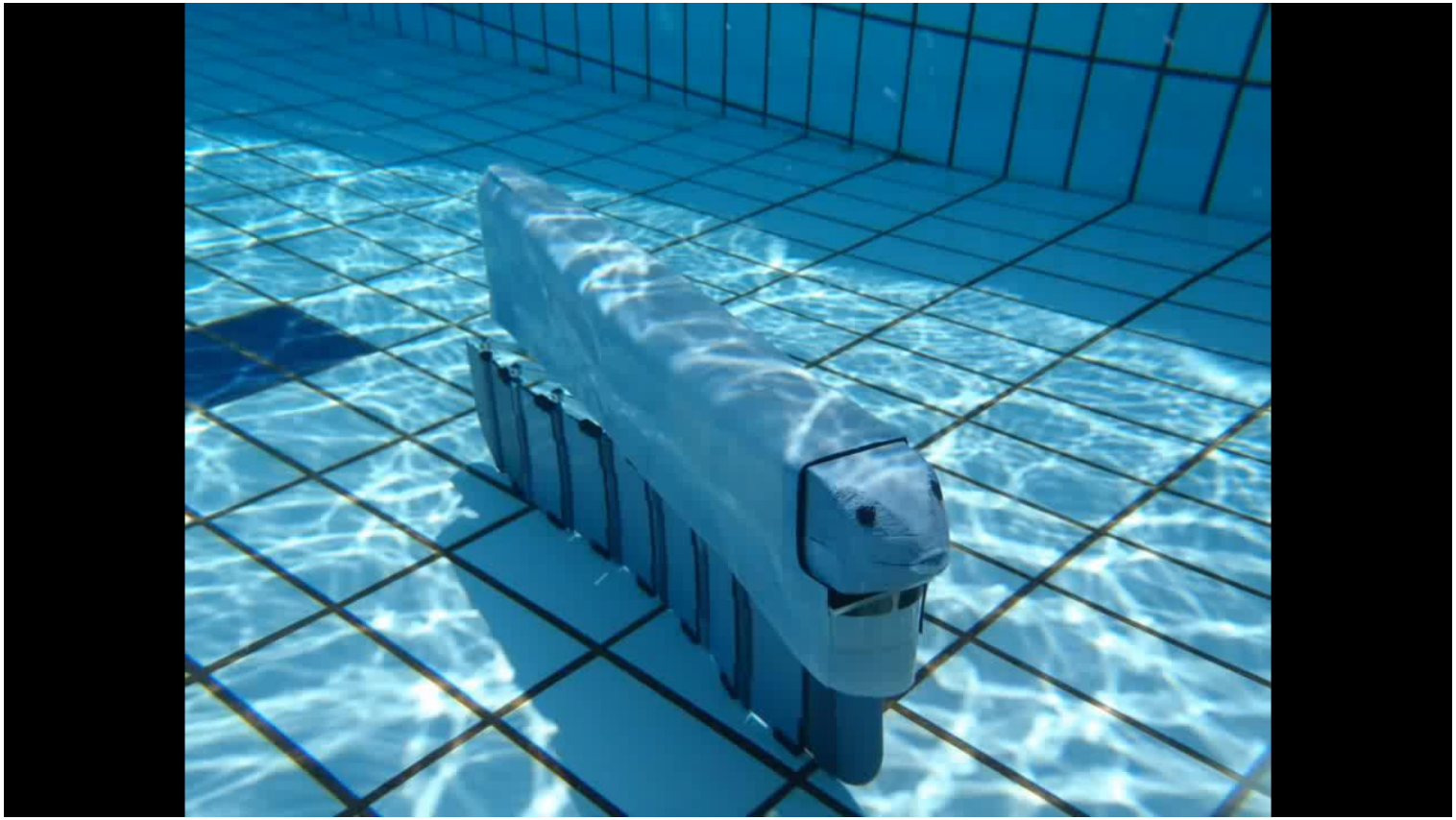
# Knifefish

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# FLAPPING WING LOCOMOTION

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# Robotic Ray

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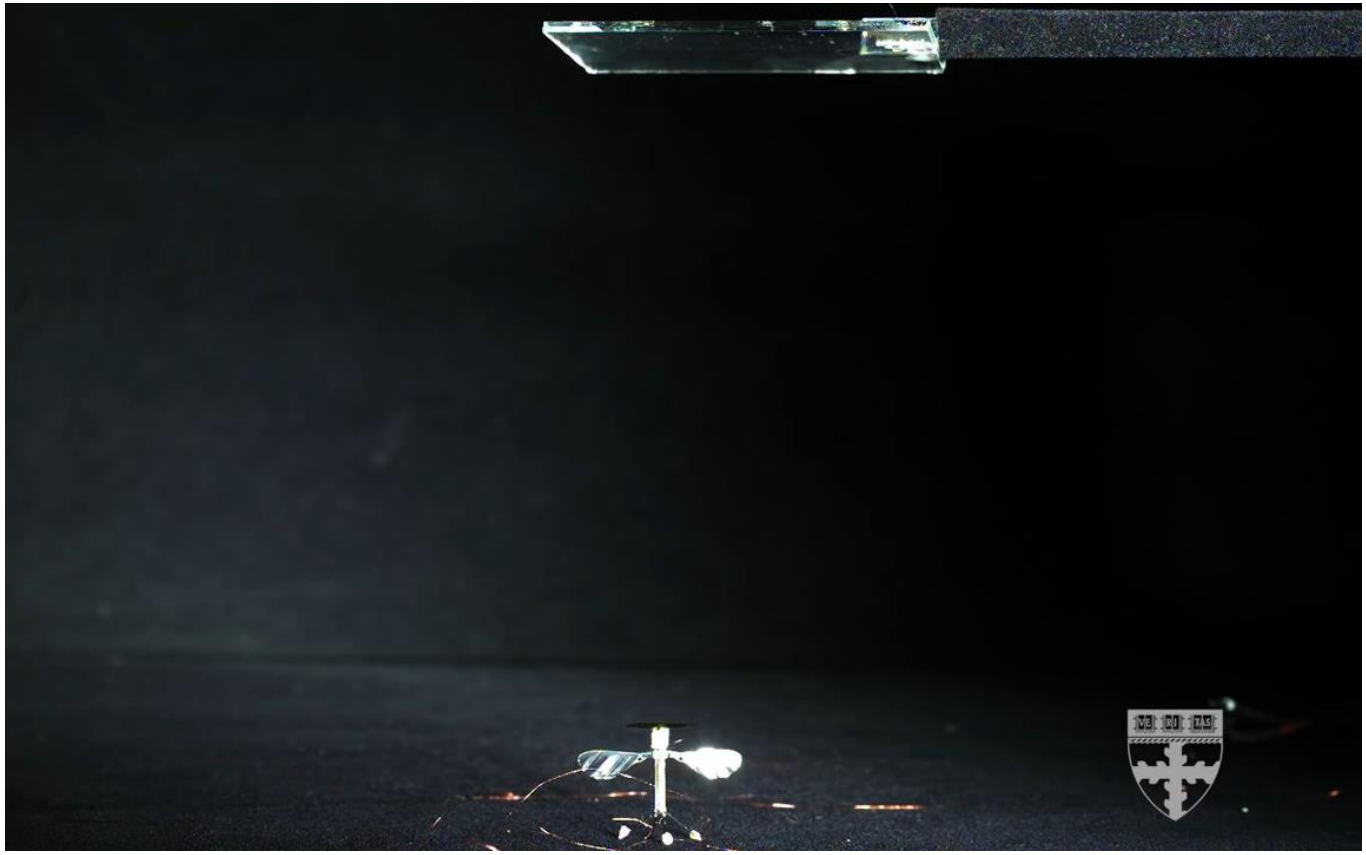
# RoboBee



# TURTLE SWIMMING

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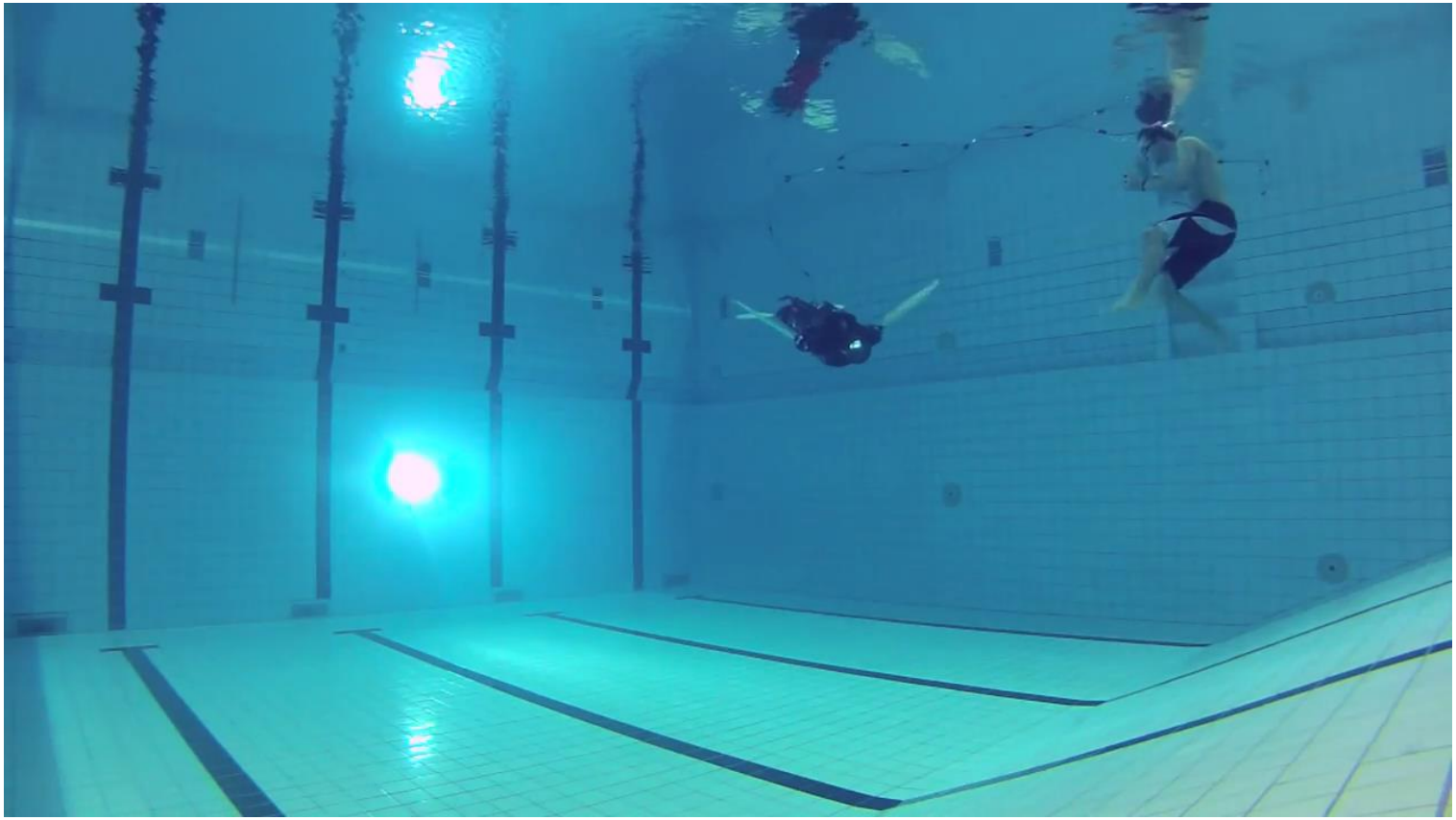
# Robotic Sea Turtle



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# U-Cat

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# TERRESTRIAL LOCOMOTION

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# Flipperbot


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# Hurtle Turtle

Created by: Tom Brewer

Advisor: Satyandra K. Gupta

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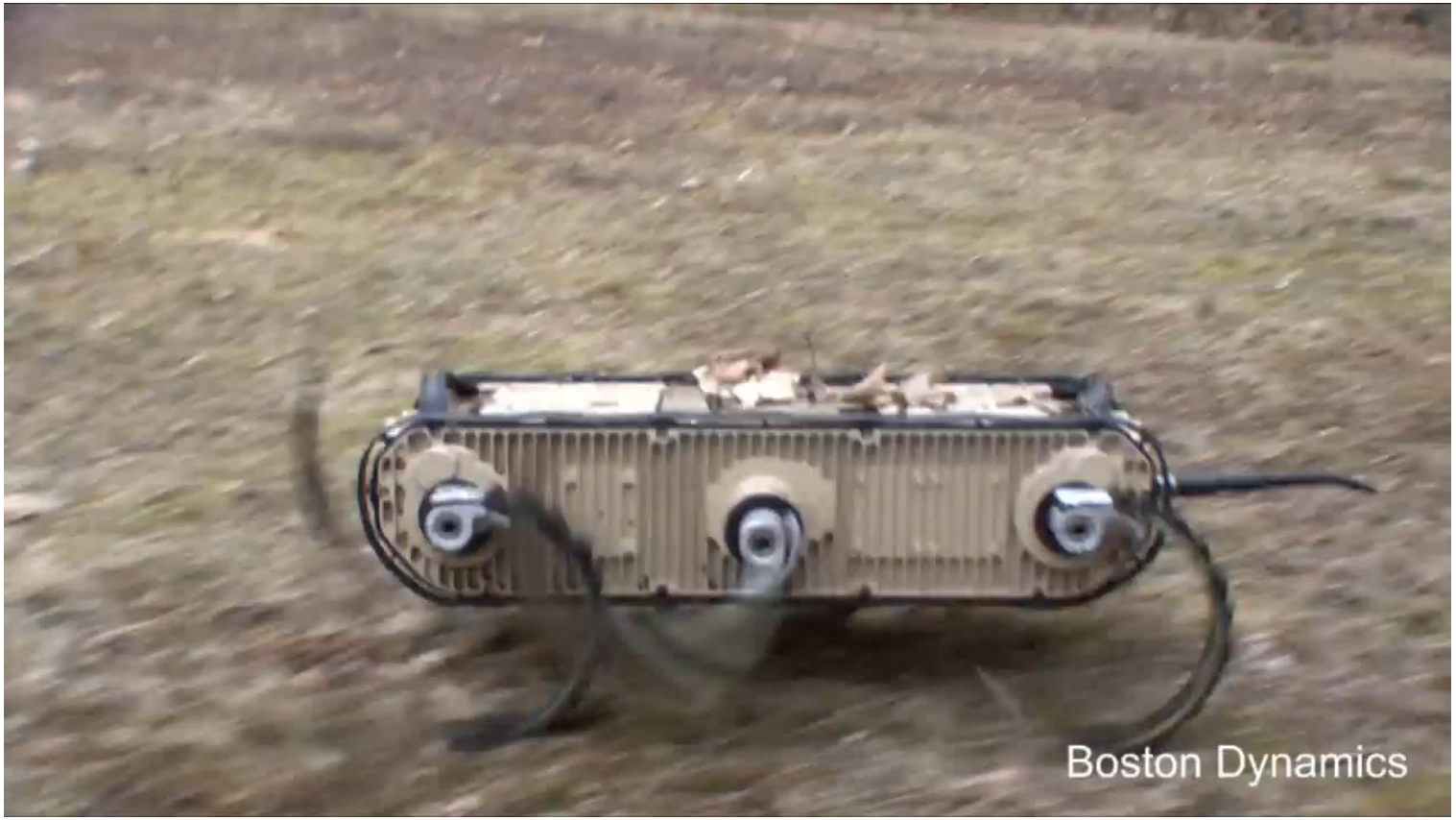
# RHEX

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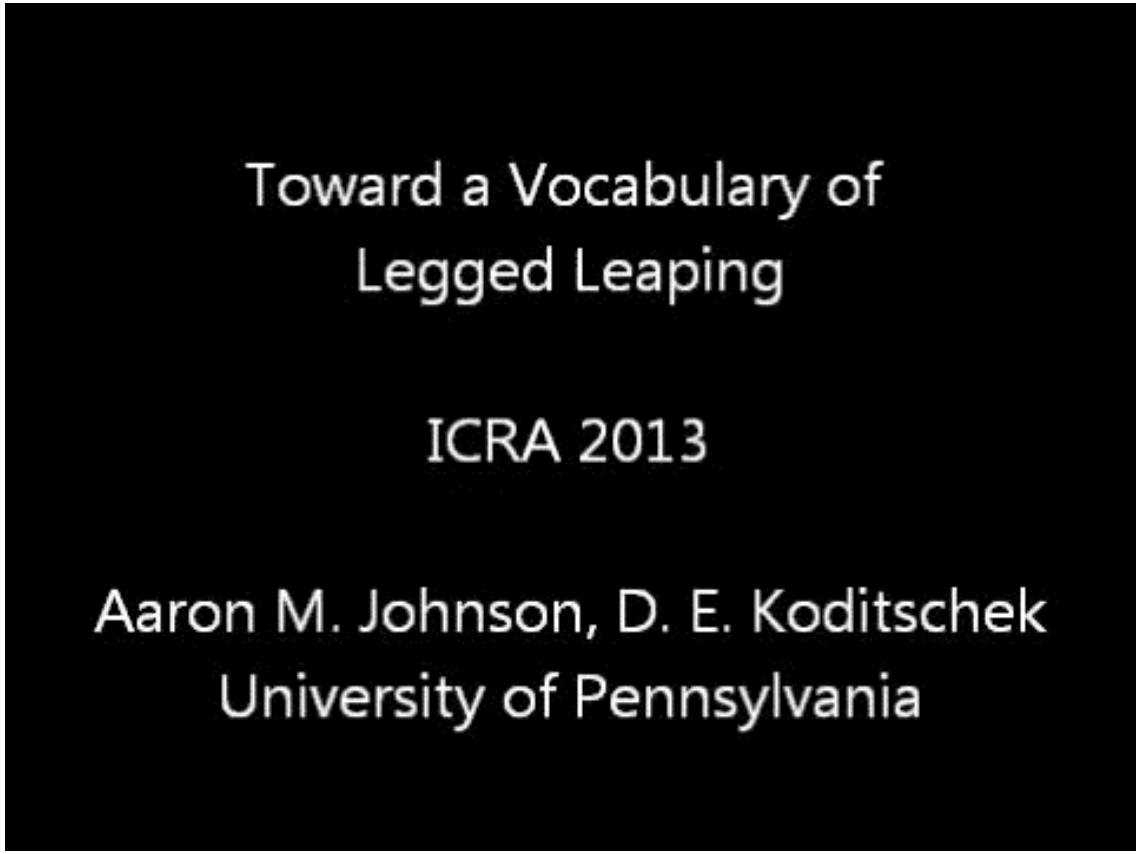
# RHEX Jumping

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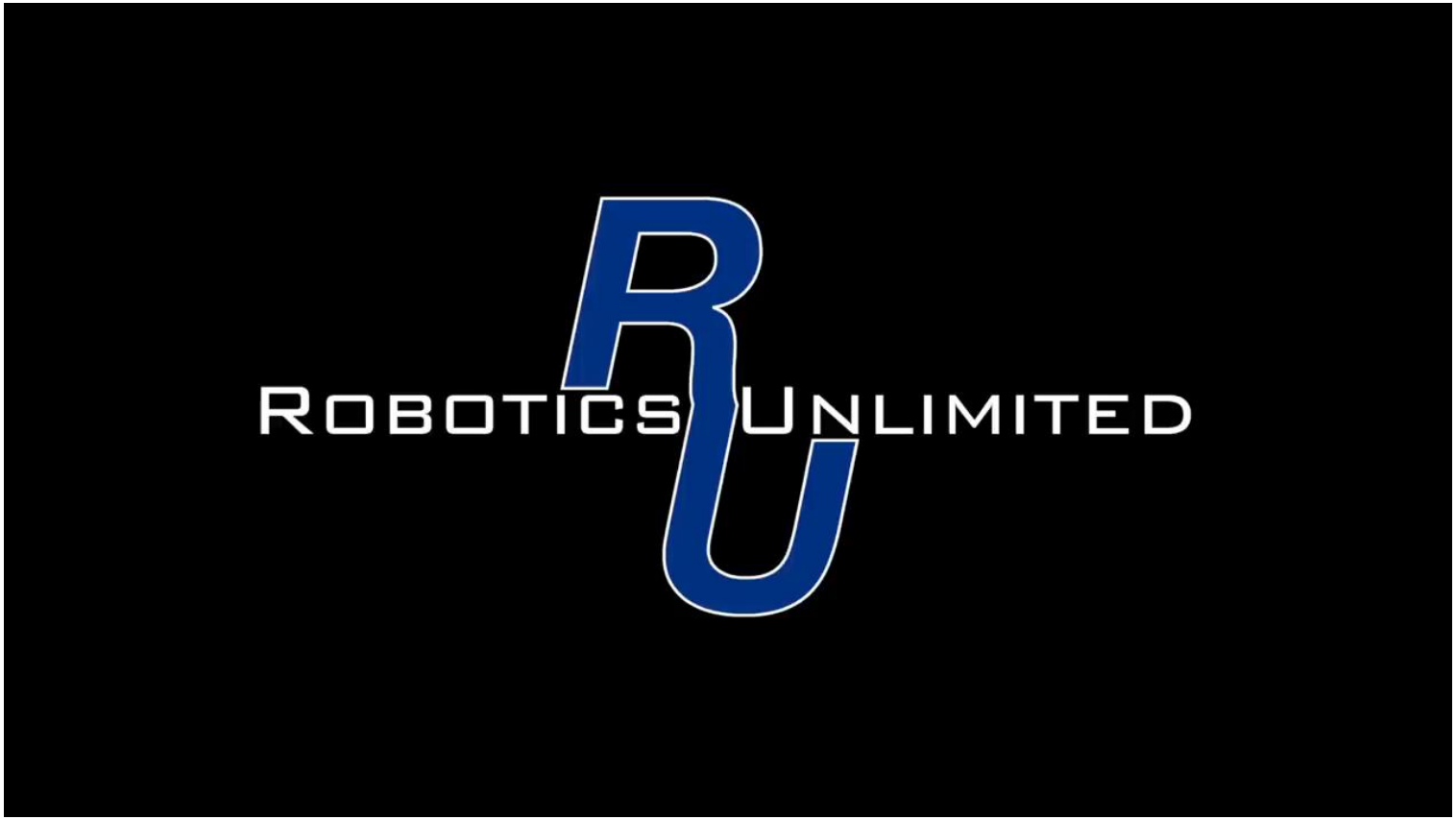
# Climbing

# Outrunner

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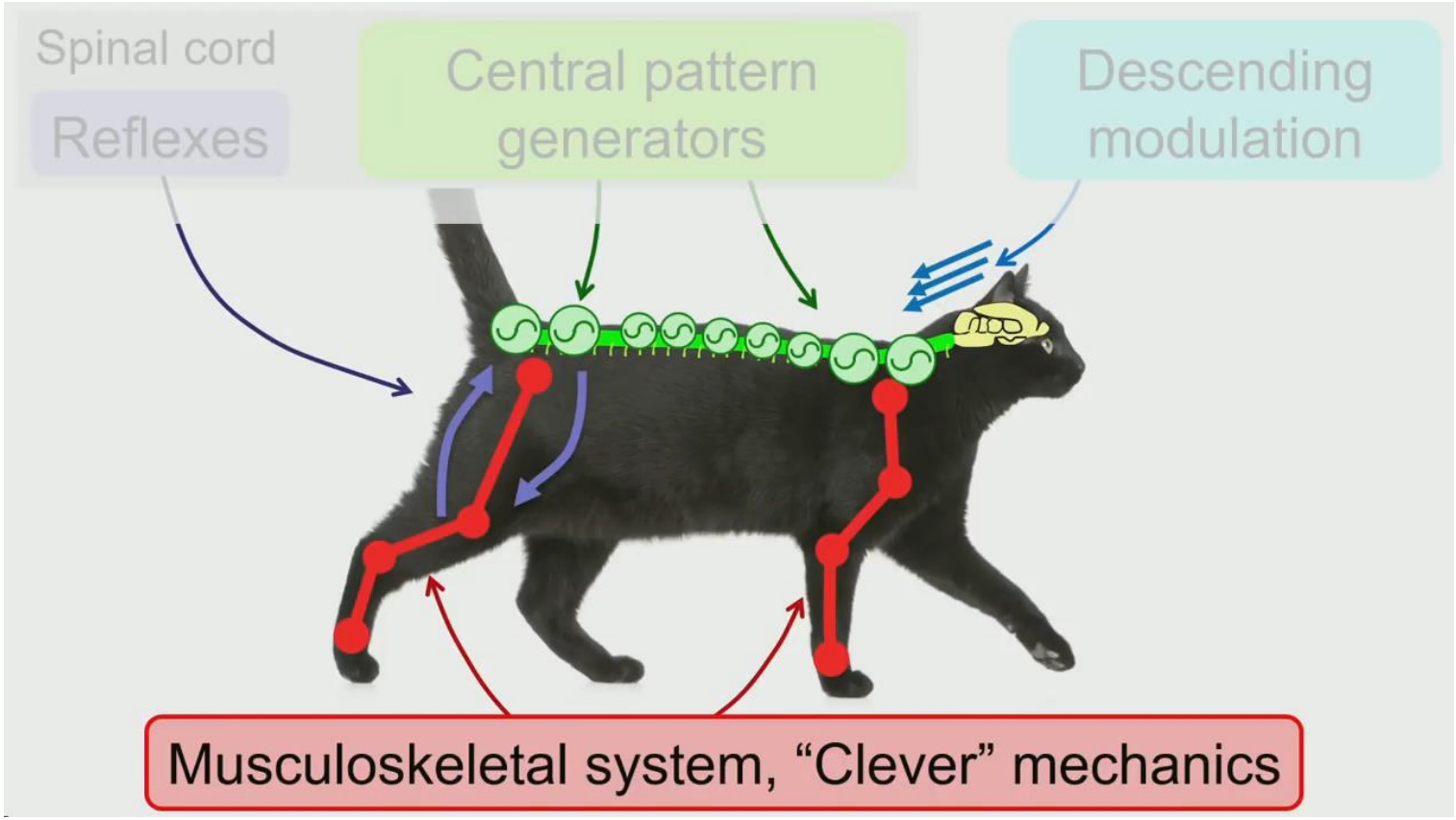
# Cheetah Cub

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# MIT Cheetah 2


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# ATRIAS


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# Cassie


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# Homework

- Install Python
  - Run Code, plot, turn in
- Research Biomechanics
  - Find references, find parameters, turn in

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