BMEG 350 – Lecture 1
The human body as an integrated system

Dr. Pawel Kudzia

January 9th, 2024

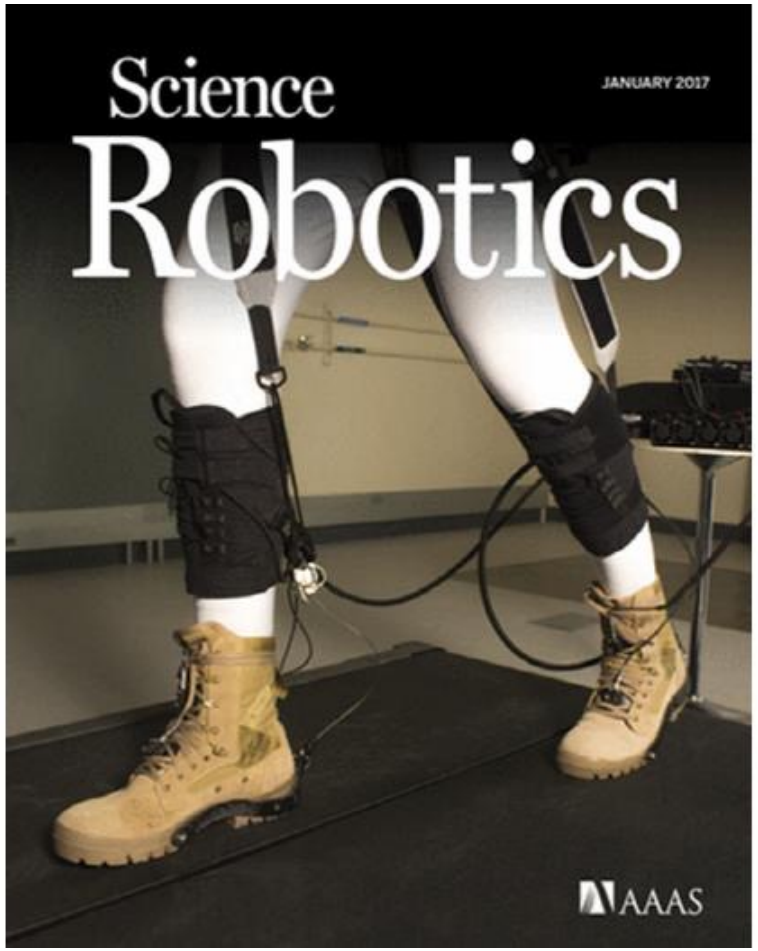
Who am I | Pawel Kudzia, PhD

Passionate engineer

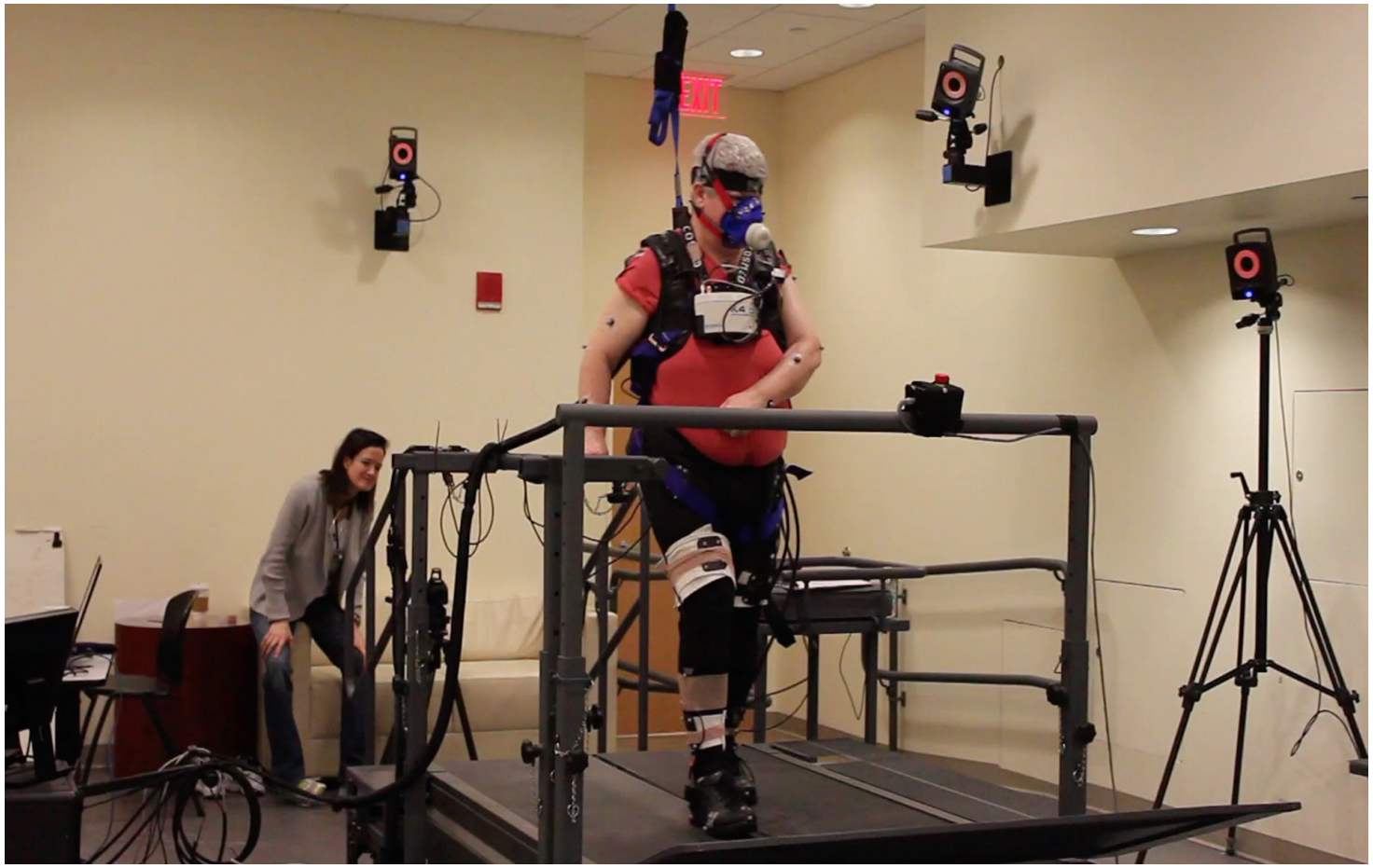
Biomechanics enthusiast

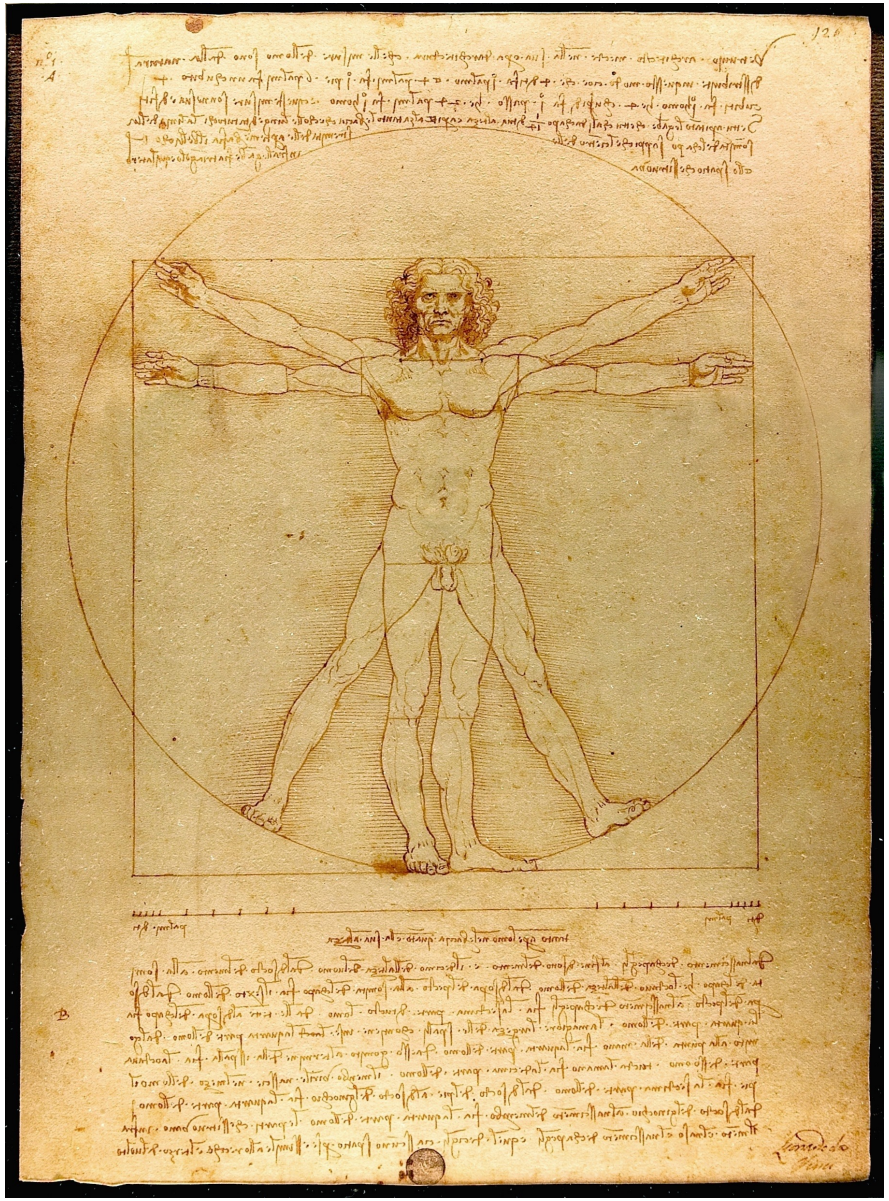
Robotics

Excited to work with you and be a resource to you

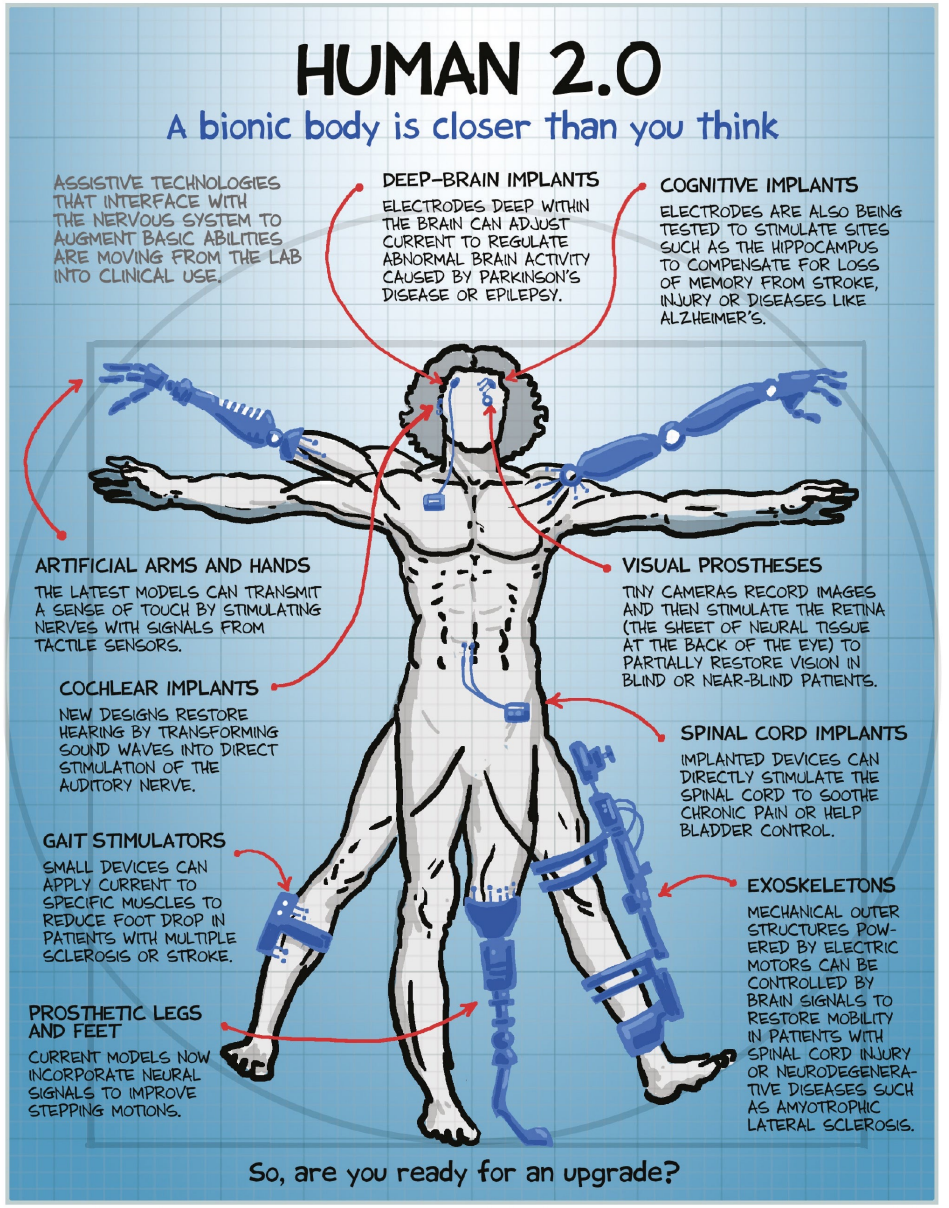


Engineering to augment and restore





https://en.wikipedia.org/wiki/Vitruvian_Man



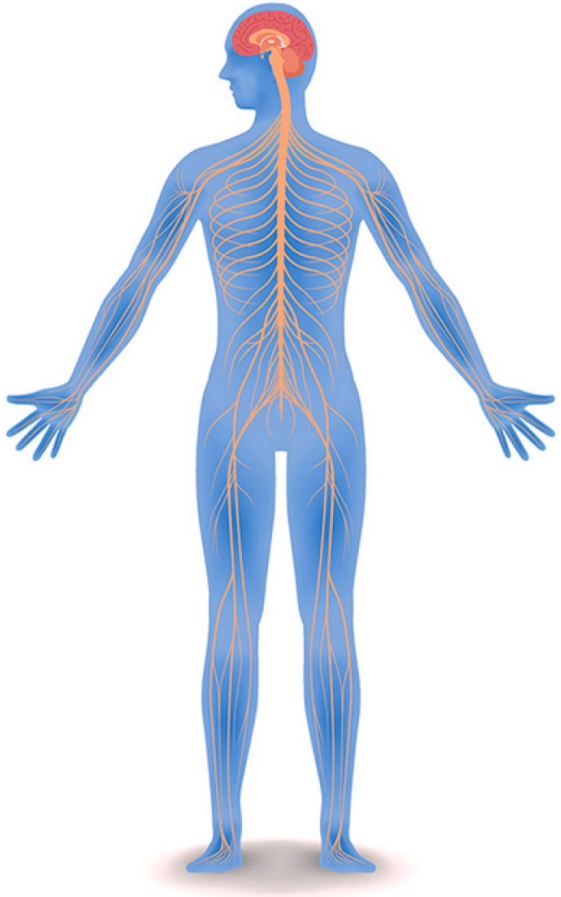
https://www.scientificamerican.com/article/human-2-0-tech-upgrades-for-the-nervous-system-cartoon/

Why is it important for engineers to learn about anatomy and physiology?

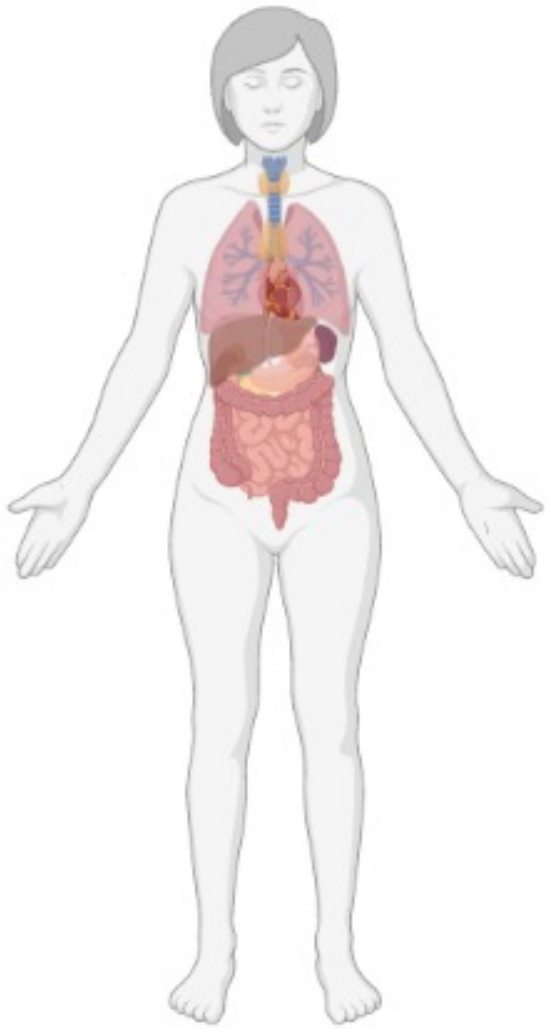
As our understanding of the human body grows, so does our ability to help repair/fix/augment or enhance it

Diagnosis, treatment, and enhancement

Holistic understanding



Body Systems

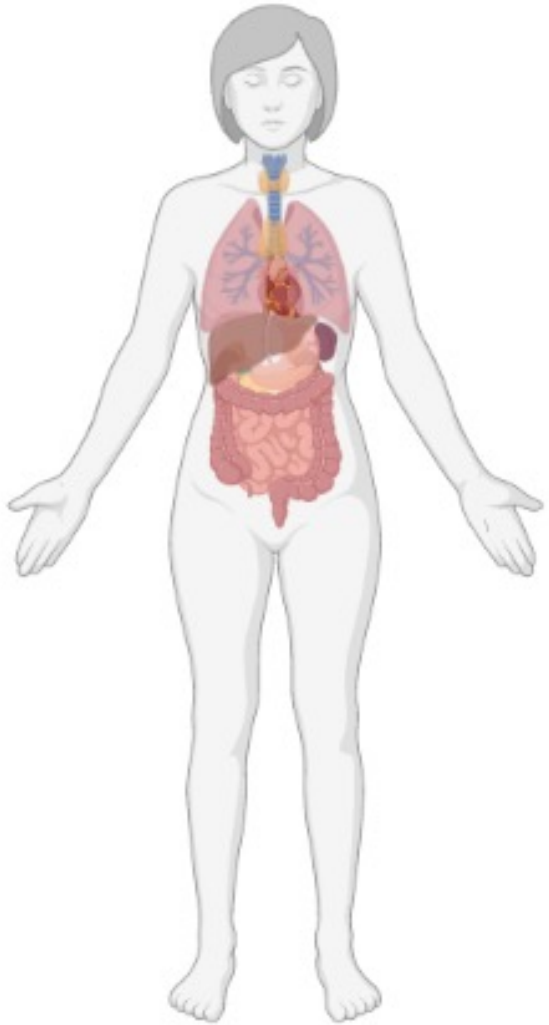


- 11 body systems “designed” to serve specific functions, but which are also integrated

Skeletal System	Muscular System	Nervous System
Endocrine System	Respiratory System	Cardiovascular System
Digestive System (GI)	Urinary System (Renal)	Reproductive System
Immune System	Integumentary System	

Created with BioRender.com

Body Systems



- Will cover systems in blue throughout the term

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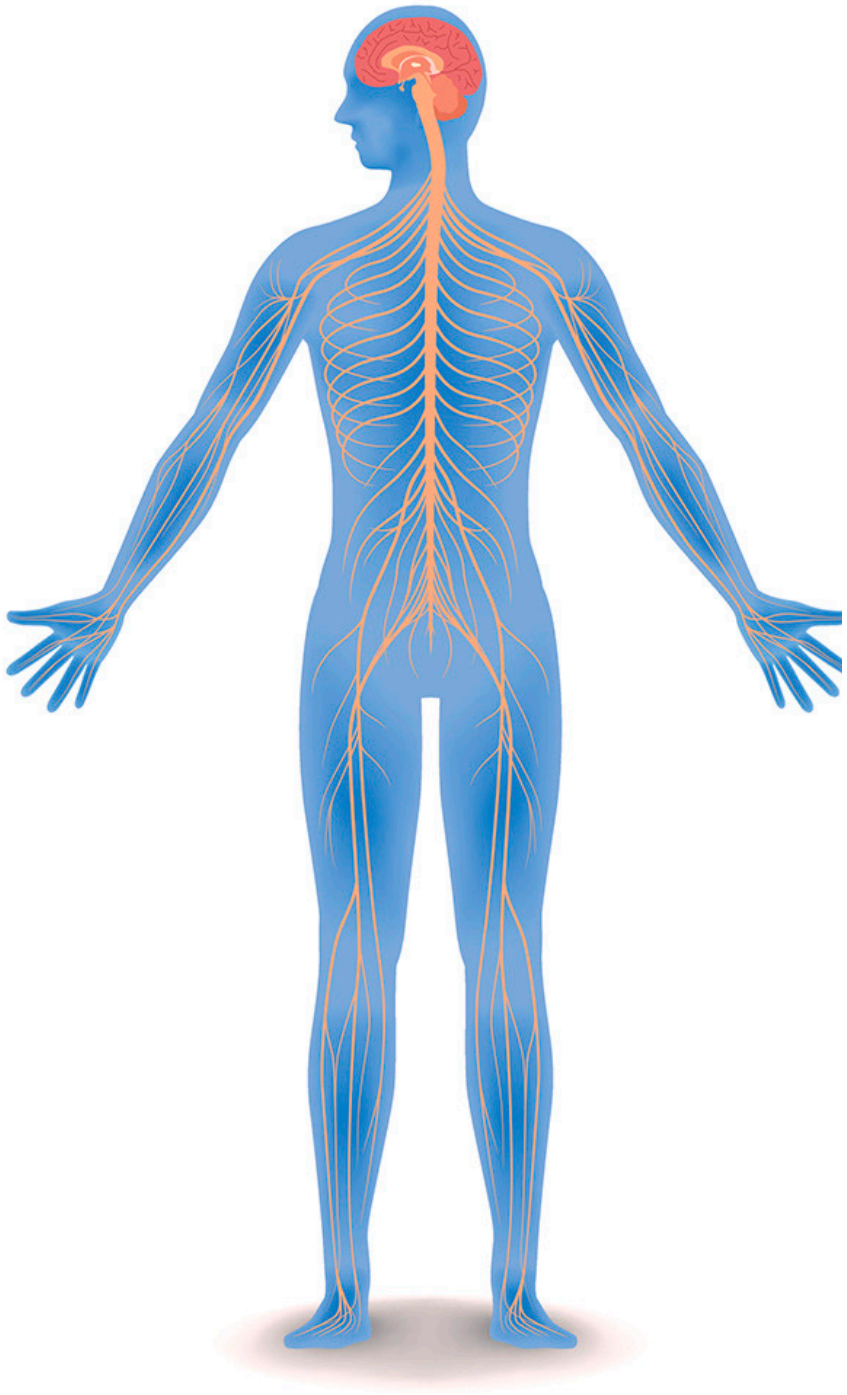
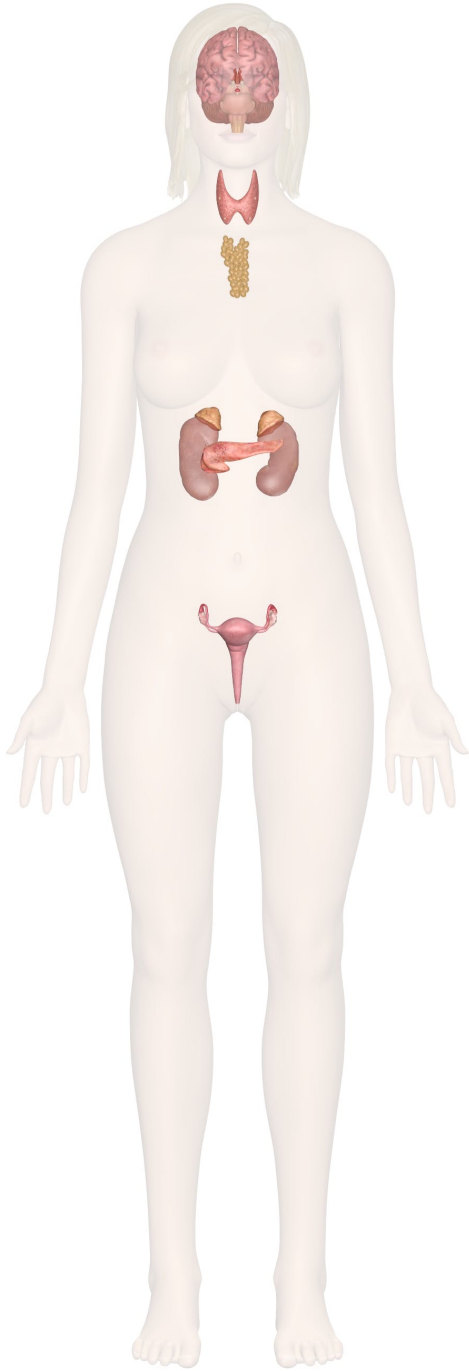
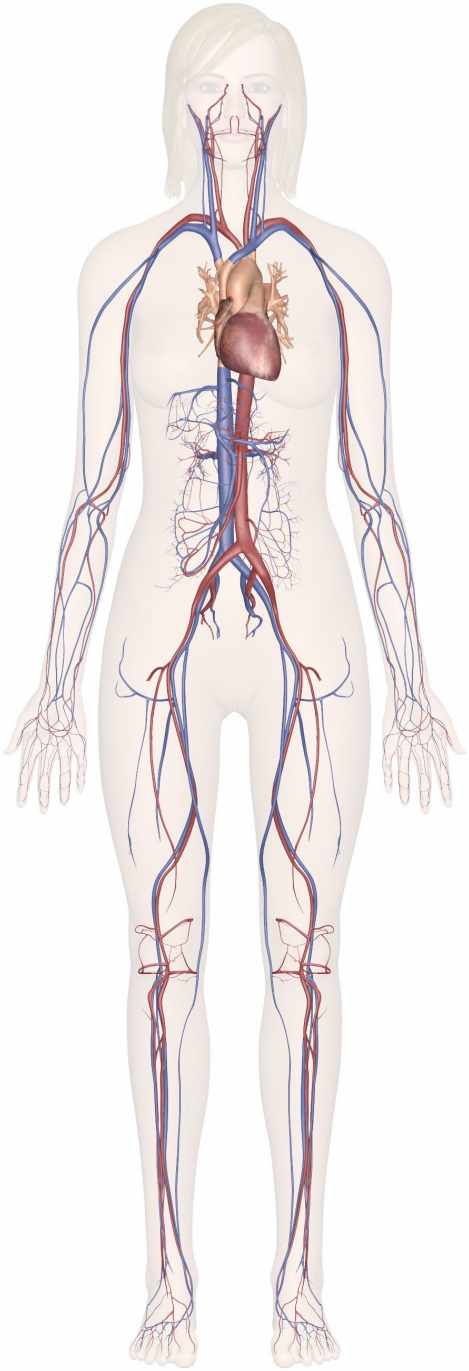
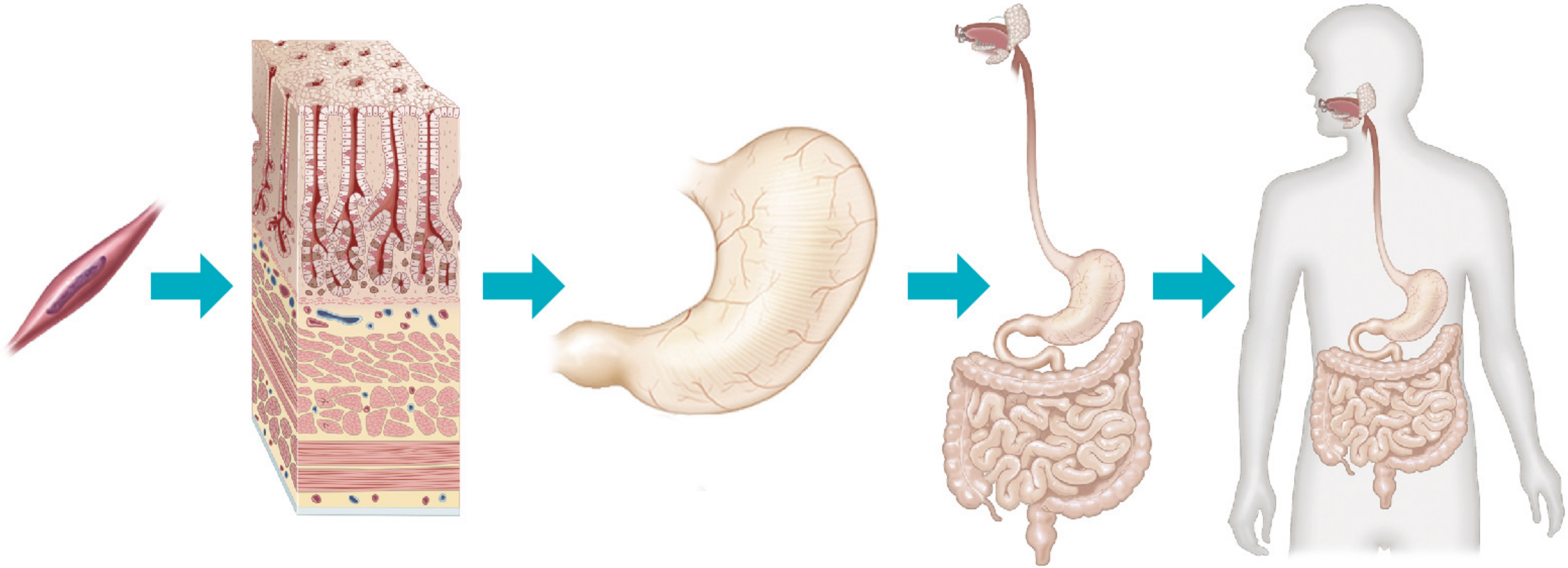






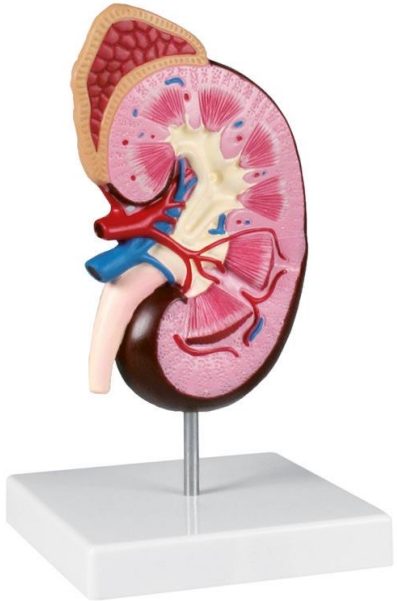
How is the human body organized?

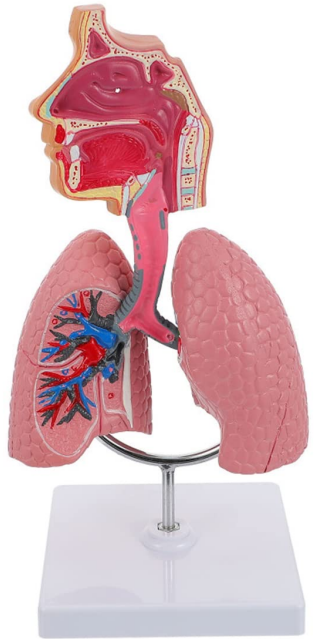


https://www.britannica.com/science/human-body

Engineering Group* Project

Choose a tissue / system of the body to repair, replace or augment from one of the systems being discussed in the class. This could be to fix an impairment or defect caused by injury or disease, or to enhance/augment biological function.





*Teams of 3, self-assigned; **Up to concept selection

Engineering Group* Project

- Identify the problem and the physiological system it affects.
- Research the state-of-the-art in biomedical approaches
- Design** a novel biomedical approach to solve the problem.
- Consider the requirements, concerns and ethical implications for the designed approach.
- Pitch the design and receive peer feedback.

*Teams of 3, self-assigned; **Up to concept selection

Project deliverables

Problem identification (10% of grade)

Understand the field (summary of the state of the art) 2 page limit excluding references

Deadline: Wed, Jan 31st, 11:59 pm

Reports should include a statement of contribution for each team member (not included in page limit)

Project deliverables

Design Requirements concerns and ethical implications
(10% of grade)

2 page limit excluding references

Deadline: Feb 28th, 11:59 pm

Reports should include a statement of contribution for each team member (not included in page limit)

Project deliverables

Video Submission

(18% of grade)

5 minute video.

Deadline: April 3rd 11:59pm

Project deliverables

Peer evaluation (2%)

Each student in the class will be assigned 3 other team videos to evaluate using a rubric

Deadline: April 12th 11:59pm

Major life processes for an organism

Build up (anabolism) and breakdown (catabolism) of different components that create structure, enable function, and generate energy

Metabolism

Responsiveness

Detect and respond to changes in the environment

Movement at different scales (within a cell, cells, organs, organ systems, whole body)

Movement

Growth

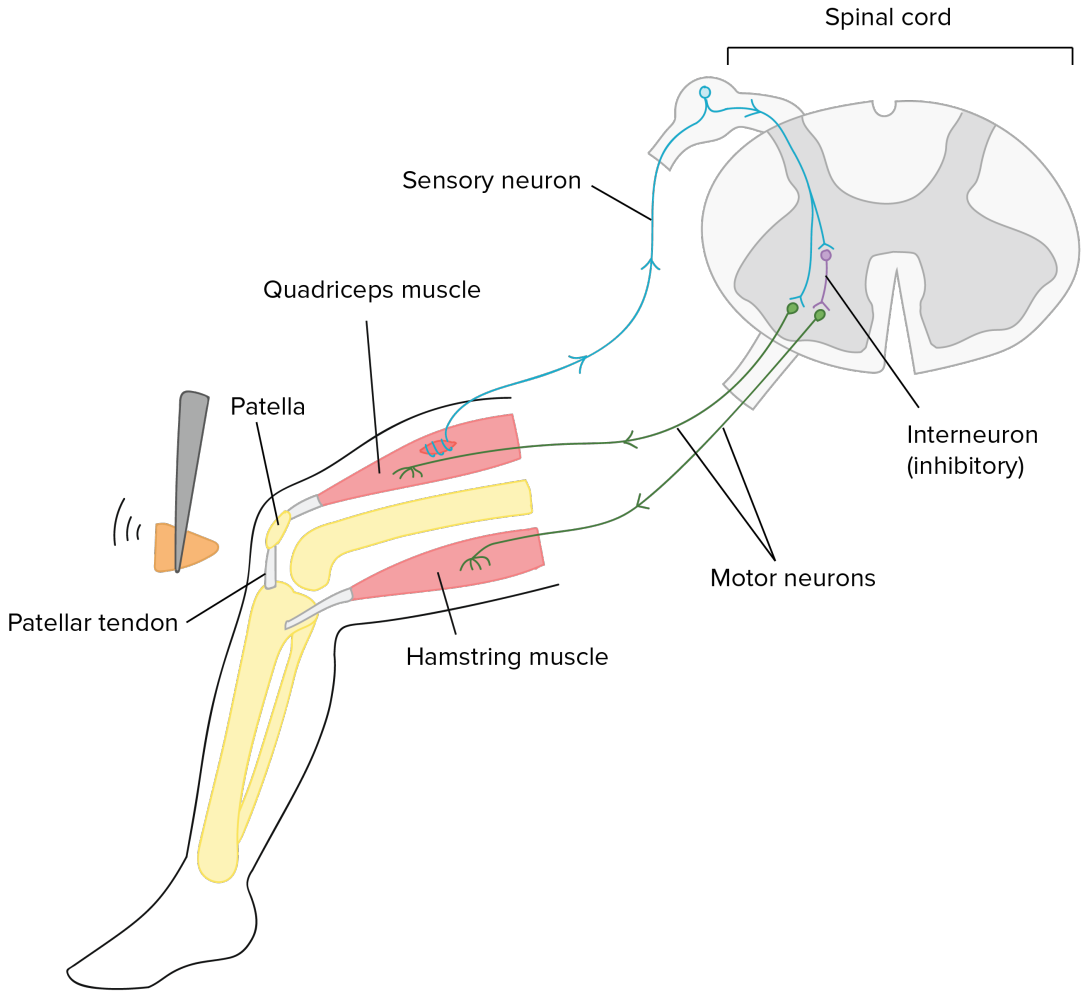
Increases in size, cell size and number, extracellular space

- Differentiation (specialization) of stem cells
- Development from an embryo

Differentiation

Reproduction

- To produce a new individual (organism)
- Create new cells for growth or repair

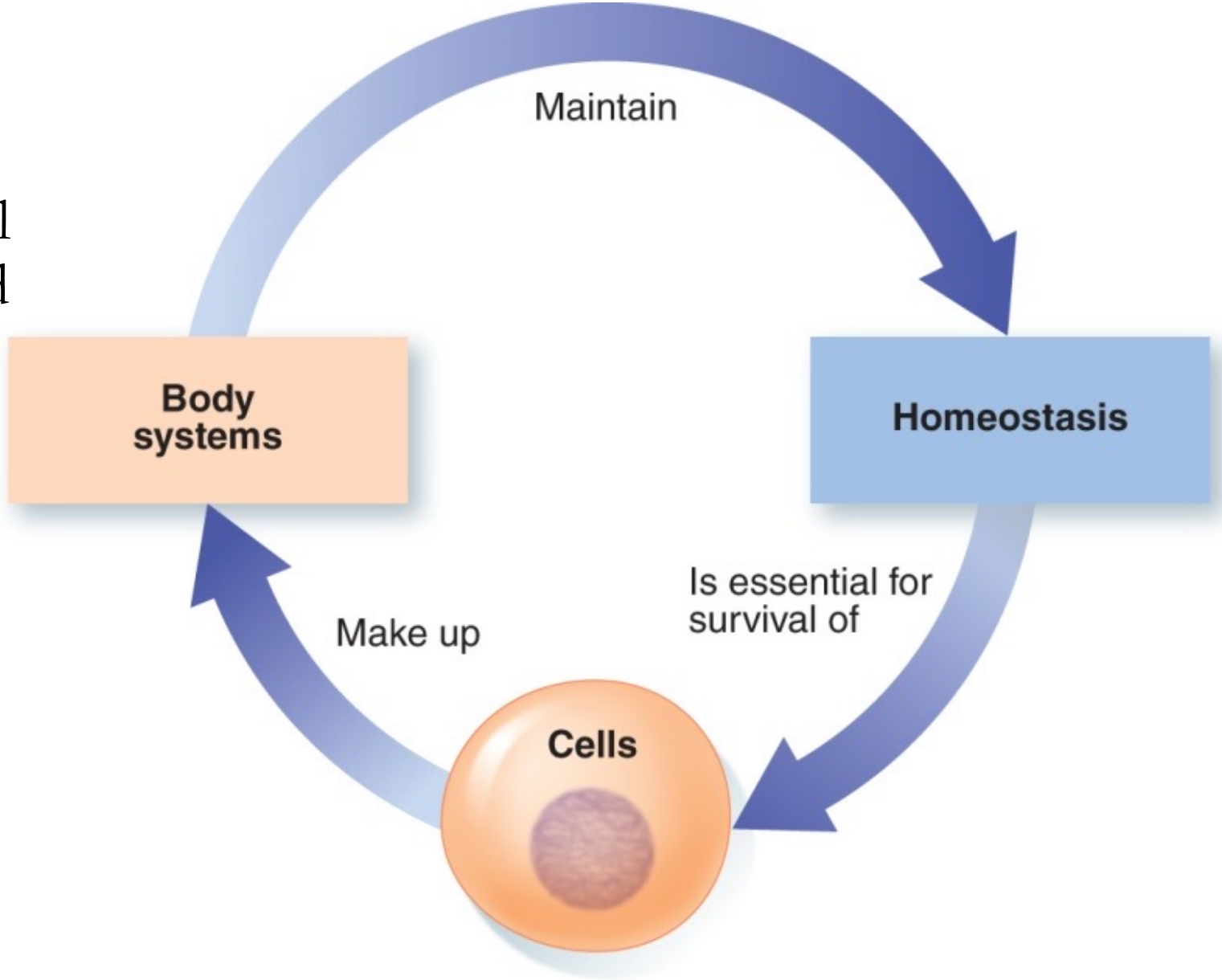


Viewing the human body through the lens of an engineer, it's fascinating to consider the body as a system that uses various controllers or 'algorithms' to adjust and regulate its internal processes.

Homeostasis

- Ability of an organism or cell to maintain a stable/balanced internal environment

- Homeostasis encompasses a wide range of physiological processes that regulate internal conditions like temperature, pH balance, hydration, electrolyte levels, and more.

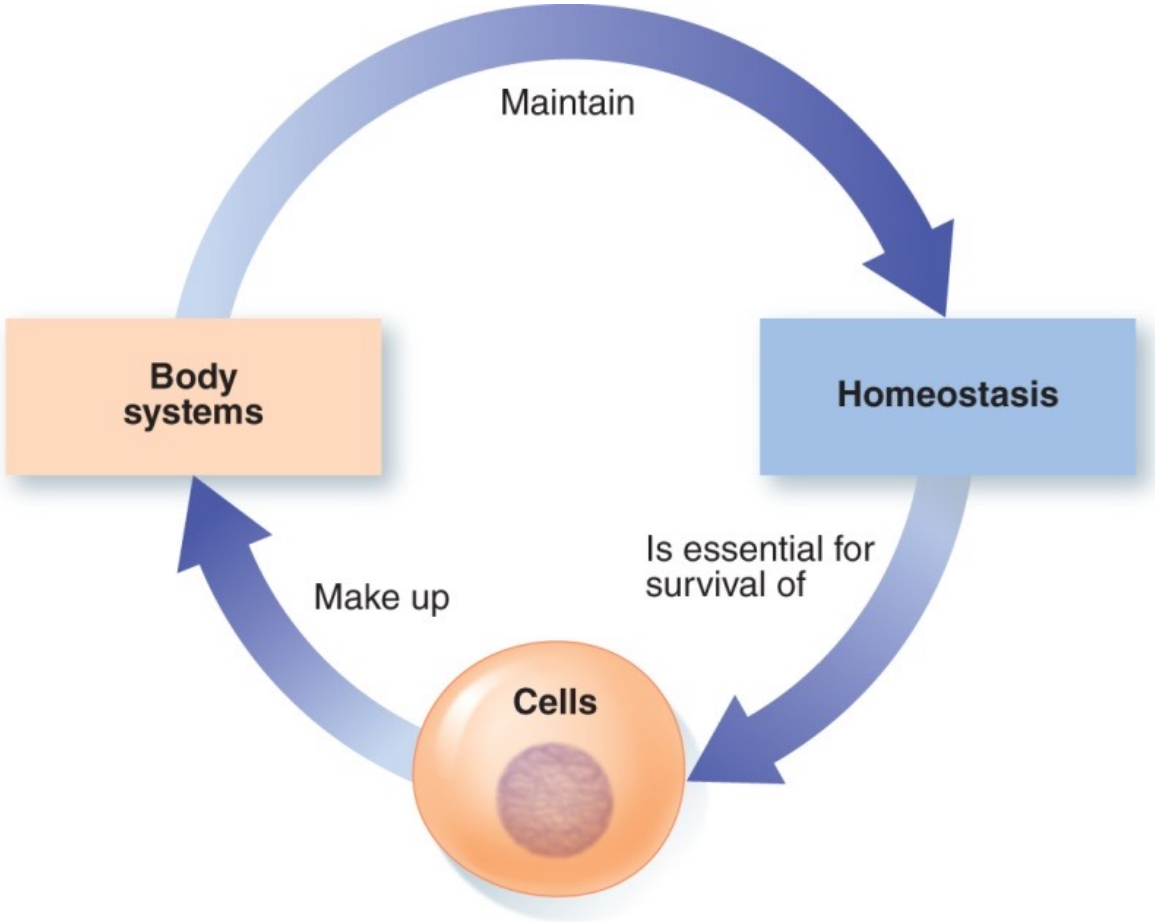


From Sherwood and Ward, *Human Physiology: From Cells to Systems, 4th Edition*, Nelson, 2018

Homeostasis
An engineering control system?

In order to maintain homeostasis, a control system must be able to

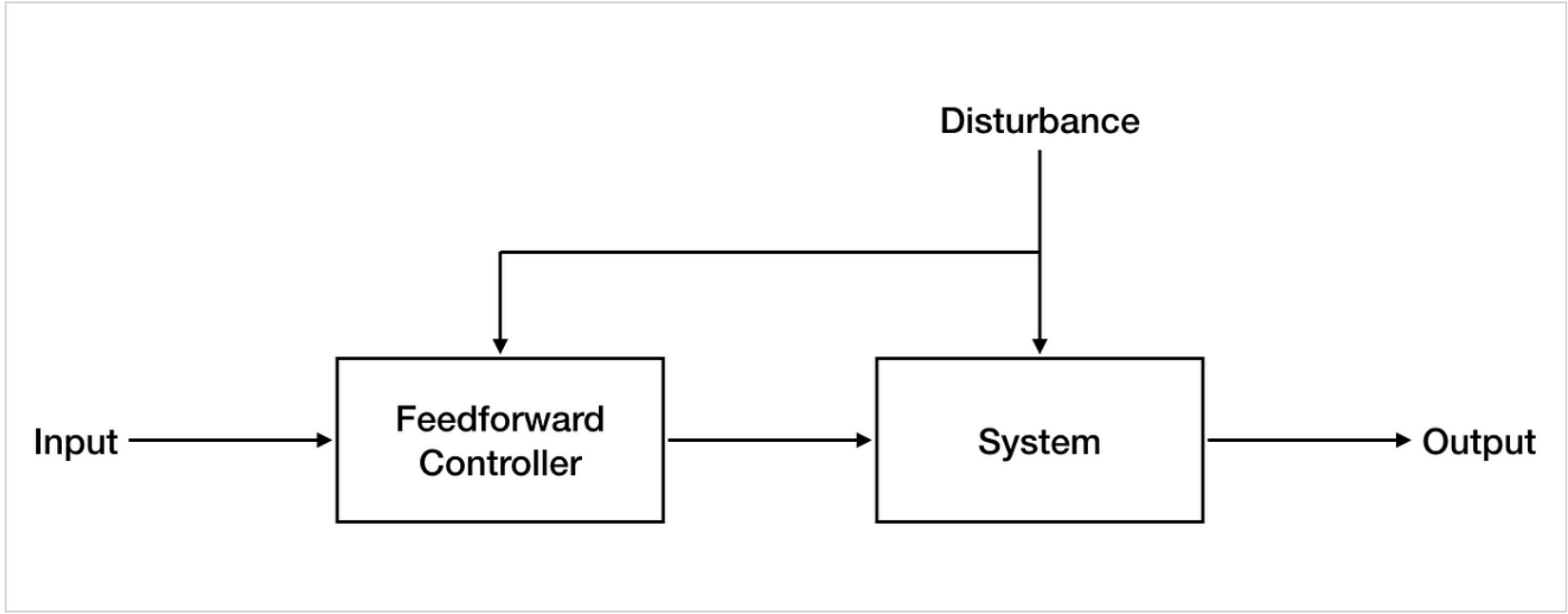
- Detect deviations from normal in the internal environment that need to be held within narrow limits (sensor)
- Integrate this information with other relevant information (control centre)
- Make appropriate adjustments in order to restore a factor to its desired value (effector)



https://en.wikipedia.org/wiki/Control_theory

Homeostasis
An engineering control system?

Lets consider Feedforward control first. Recap:

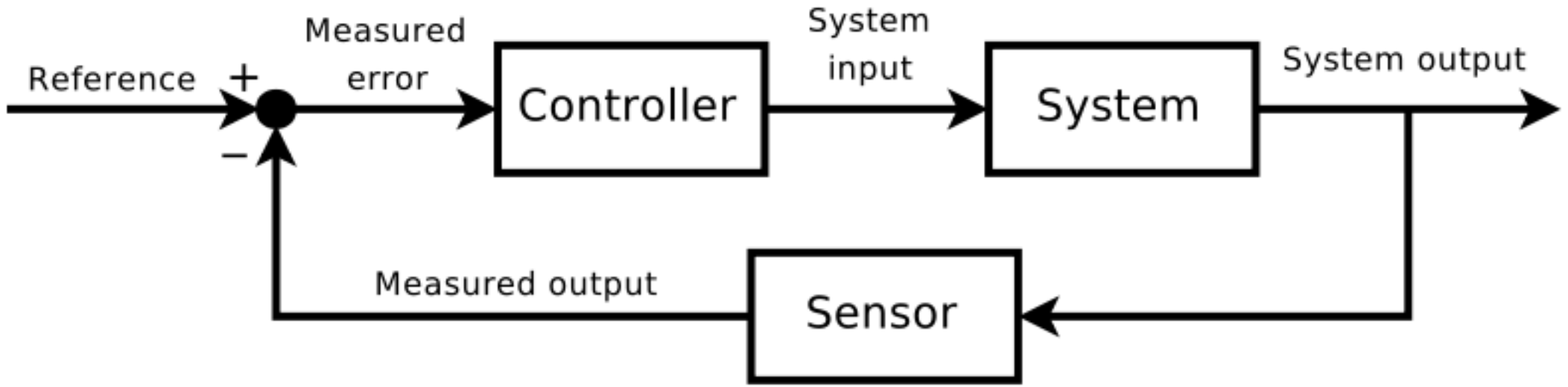


Example of feedforward control

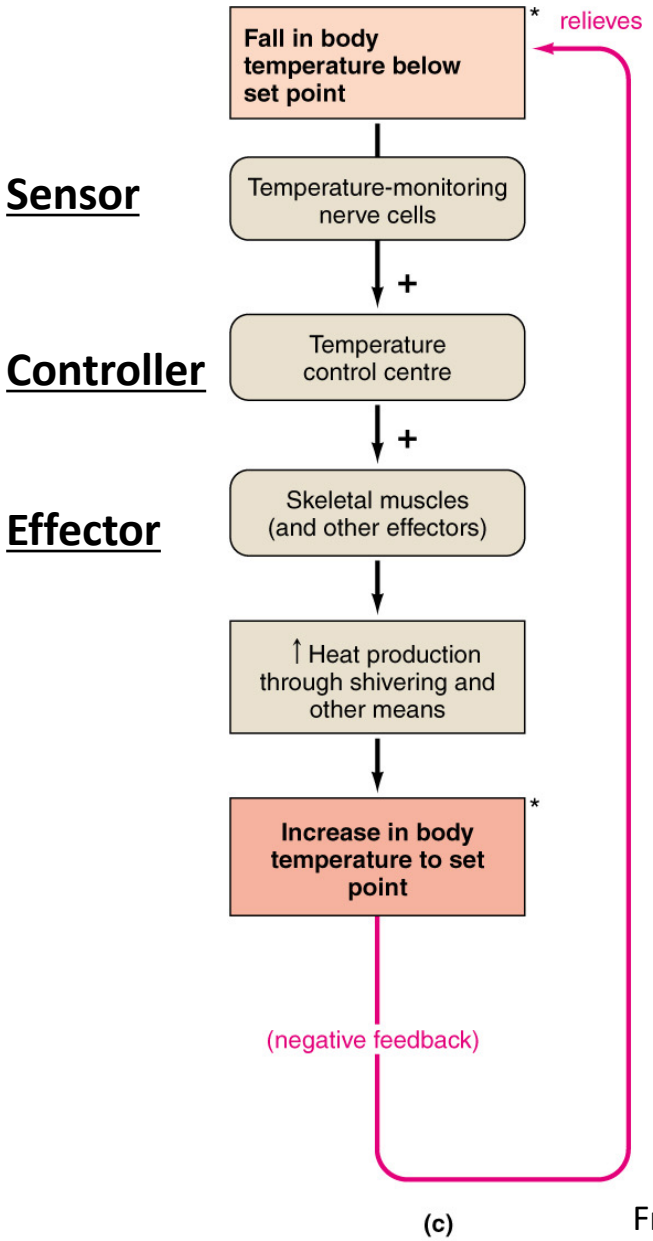
- The sight of food activates the salivary glands to release saliva in advance, preparing the digestive system for the incoming food. This pre-emptive response exemplifies a feedforward control system, where the body anticipates a future need - in this case, digestion - and takes early action to facilitate the process efficiently.
- In this example, the body's response (salivation) is triggered not by the actual process of eating but by the anticipation of it. This is a classic case of feedforward control, where the system prepares for a future event based on cues or signals, in this instance, the visual stimulus of seeing food.

Homeostasis
An engineering control system?

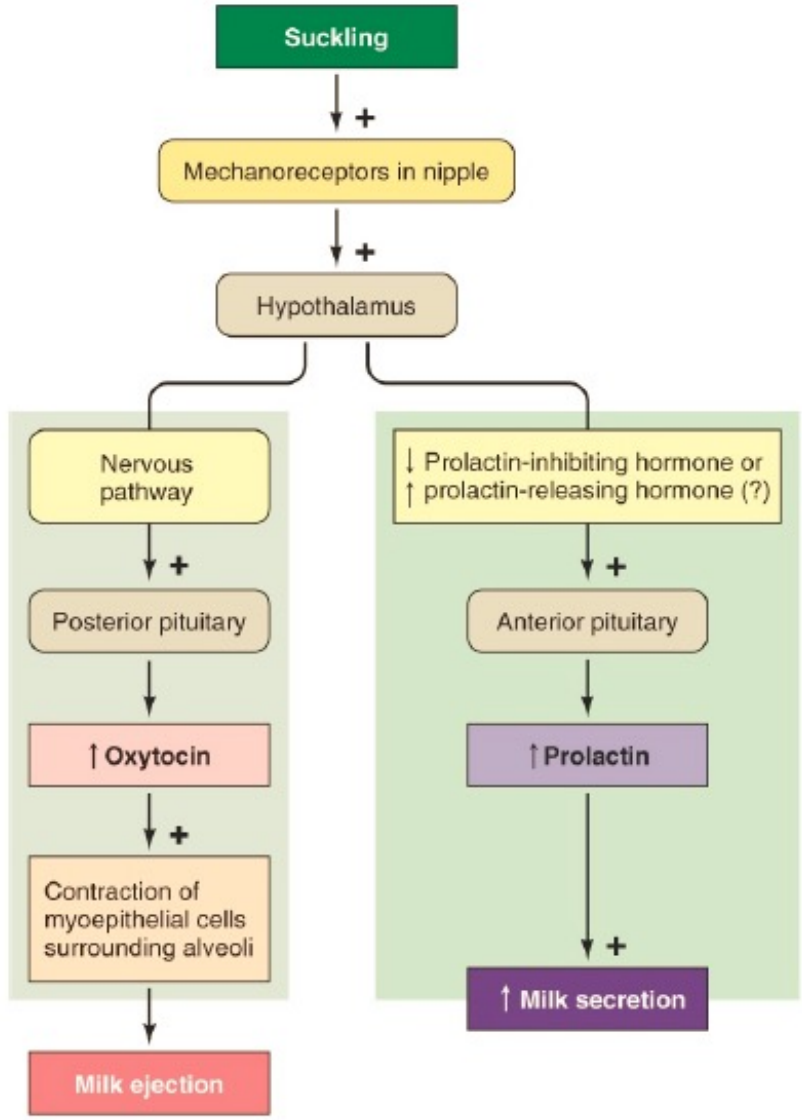
Homeostasis is more like a feedback controller



Negative Feedback



Positive Feedback



From Sherwood and Ward, *Human Physiology: From Cells to Systems, 4th Edition*, Nelson, 2018

Muscle and its importance in the control system