Artificial Intelligence in Medicine:

Definitions, Implications, and Future Impact

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C.O.I. Disclosure

No affiliation (financial or otherwise) with pharmaceutical, medical device or medical communications organizations.

Other Industry Affiliations:

Senior Staff Research Scientist and Office Co-Lead, *DeepMind*
Vice Board Chair, *Alberta Machine Intelligence Institute*

Learning Objectives (1)

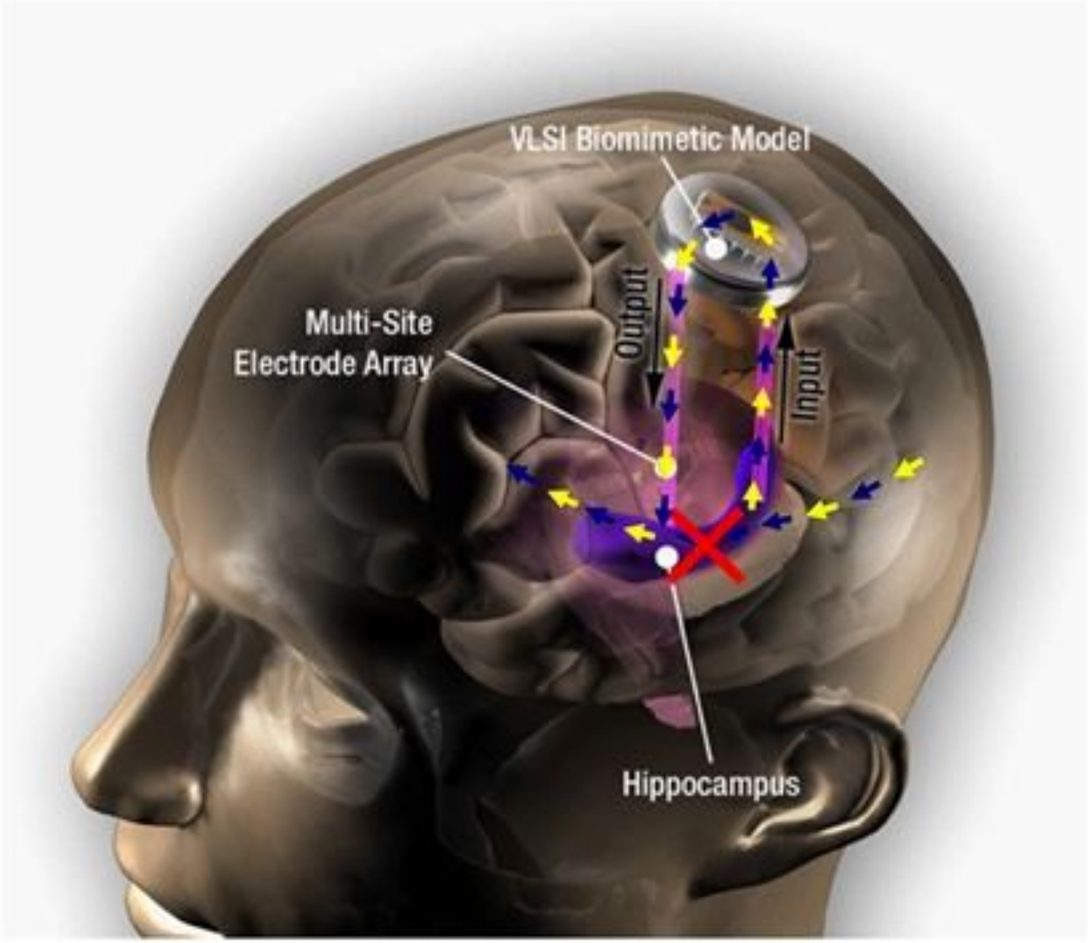
- Be able to define artificial intelligence (AI), machine learning (ML), and related concepts from the field of intelligent systems.
- Be able to describe and discuss the defining characteristics of AI and ML.
- Be able to describe and discuss how AI has been applied in medicine (specifically with regard to physiatry).

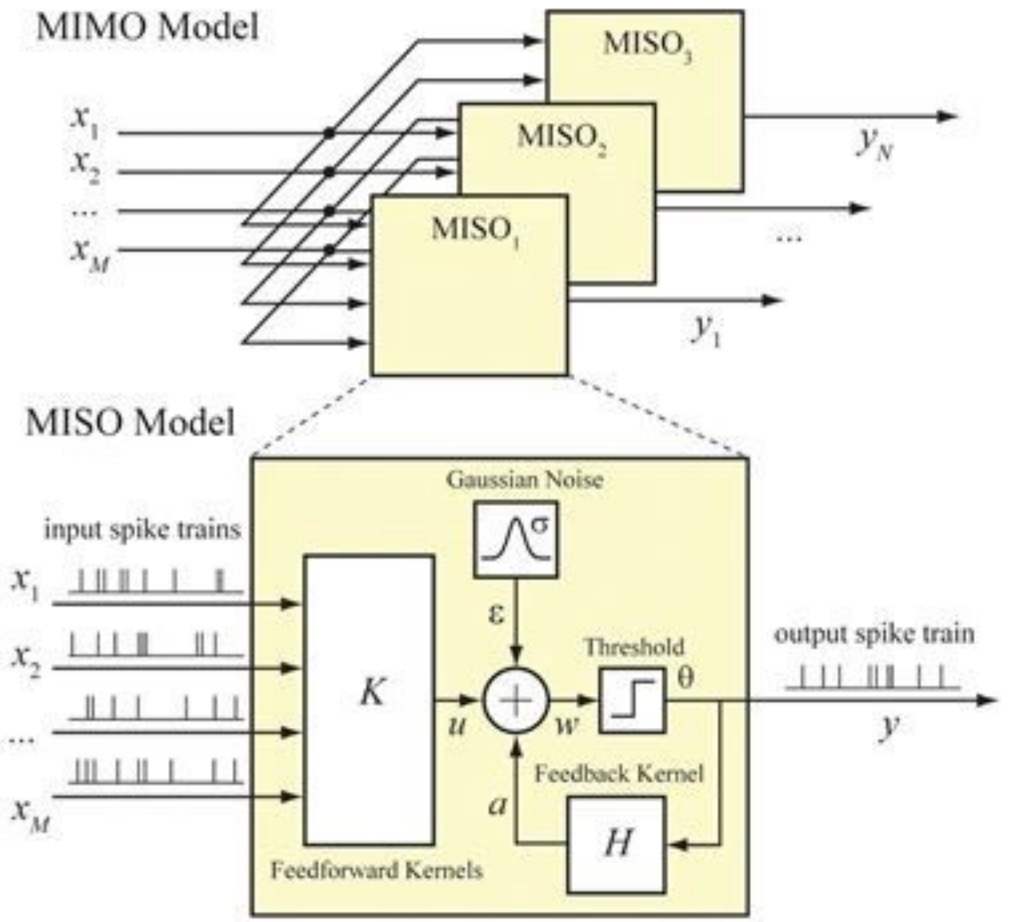
Learning Objectives (2)

- **Be able to estimate the impact emerging intelligent systems technology will have on your own life, practice, study, or work within the next 5-10 years.**

- **Be able to find and cite appropriate resources for future self-study on AI and its application within medicine.**

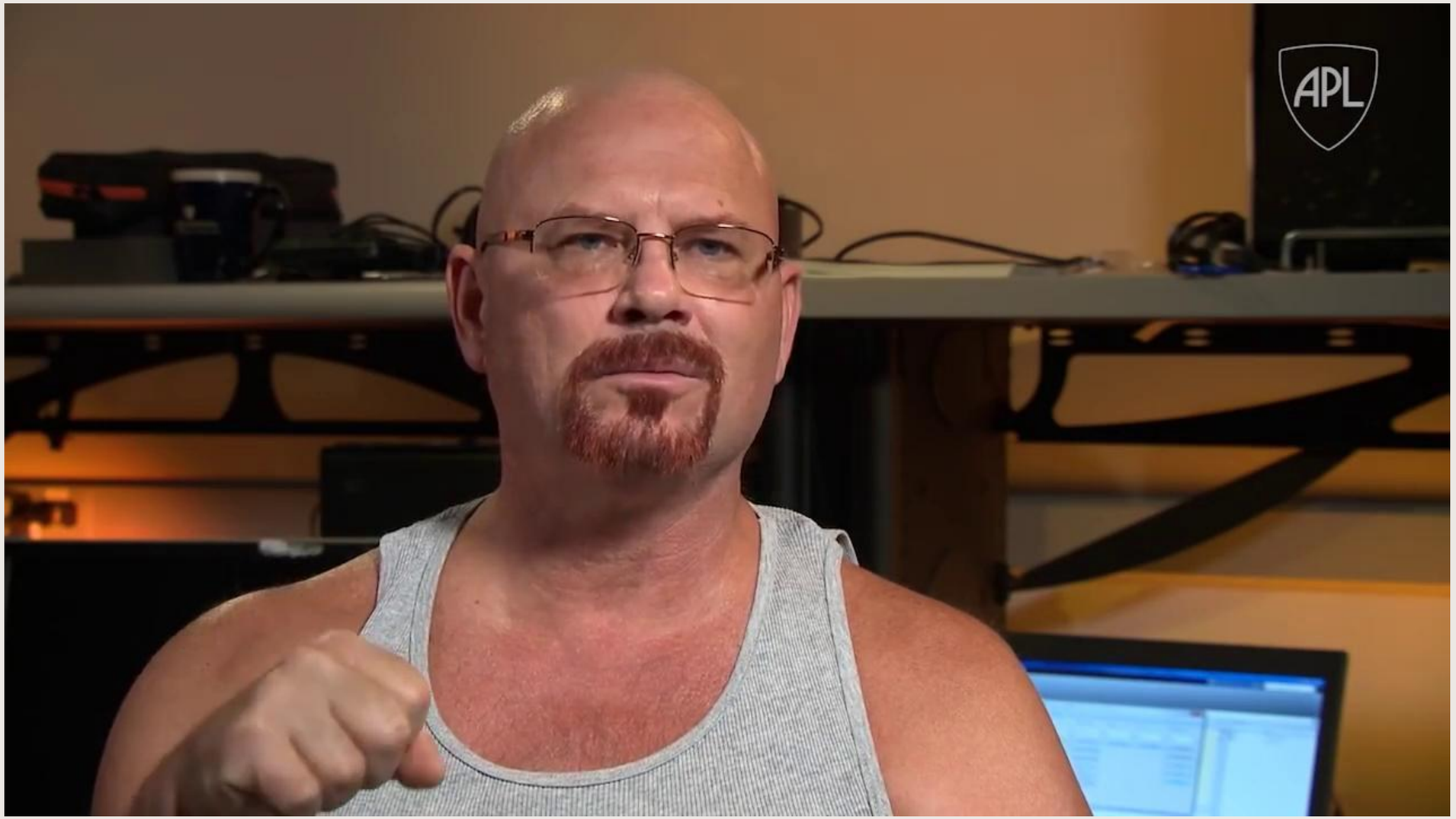
Direct brain-computer interfaces: study participant Jan Scheuermann feeding herself with a robotic limb (University of Pittsburgh / UPMC); http://www.upmc.com/media/media-kit/bci/Pages/default.aspx



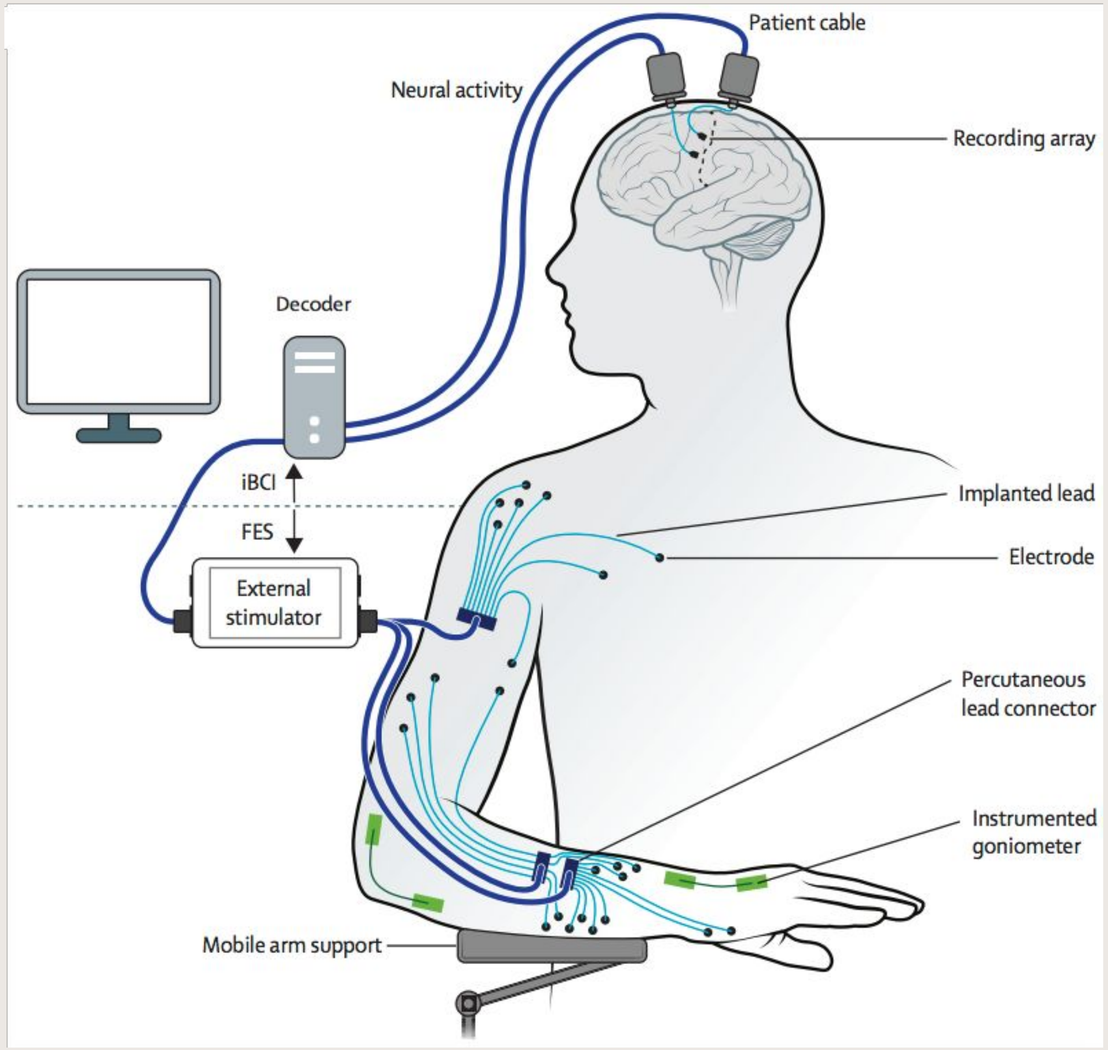


Direct brain-computer interfaces: *memory prostheses* from the Center for Neural Engineering, Viterbi School of Engineering. https://cne.usc.edu/neural-prosthesis-for-hippocampal-memory-function/ and IEEE Trans Neural Syst Rehabil Eng. 2018, 26(2):272-280.

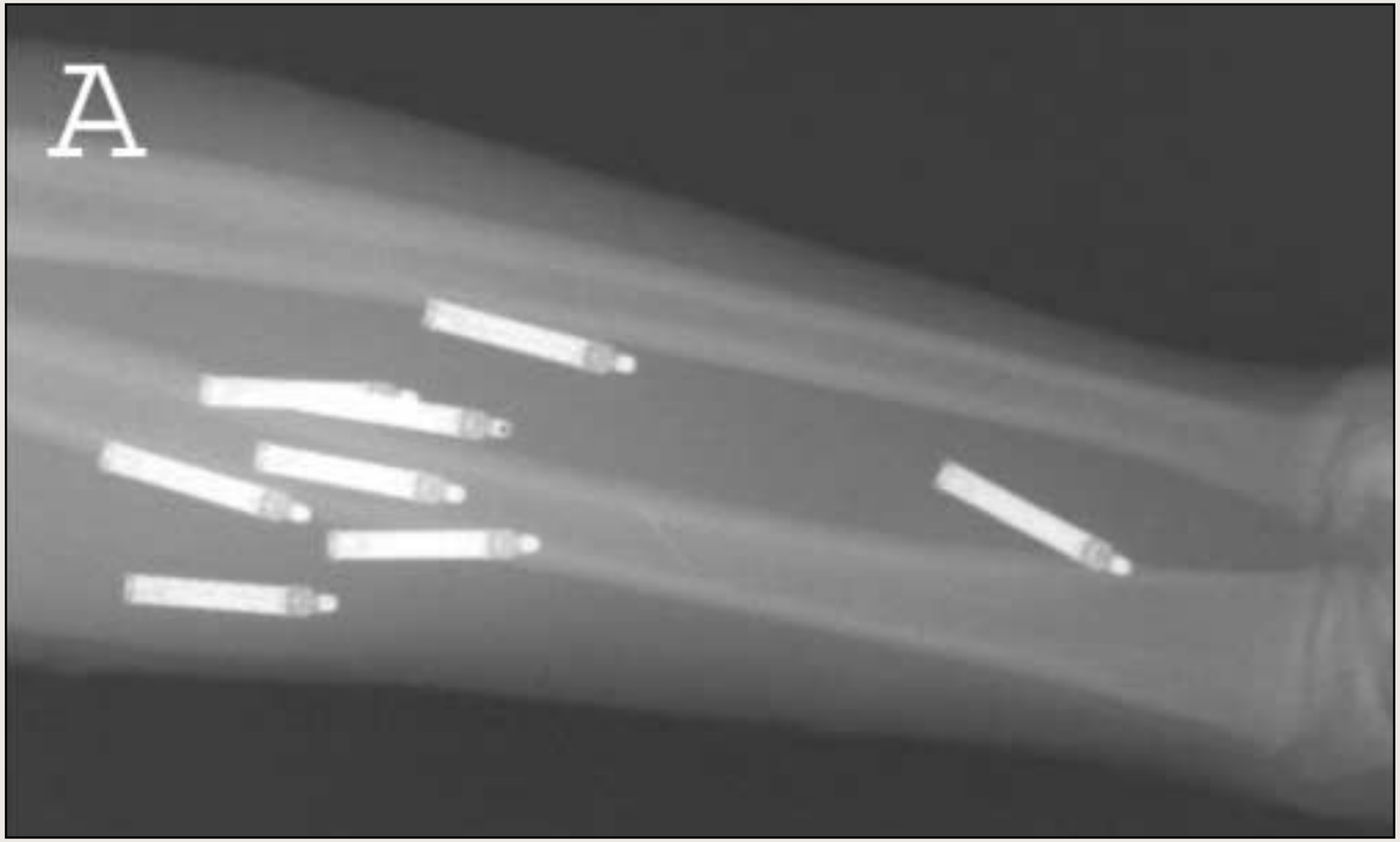
Brain-body-machine interfaces: “Amputee Makes History with APL’s Modular Prosthetic Limb” (JHU Applied Physics Laboratory); https://youtu.be/9N0ncx2jU0Q



Brain-body-machine interfaces: “APL’s Modular Prosthetic Limb Reaches New Levels of Operability” (JHU Applied Physics Laboratory); https://youtu.be/-0srXv0Qlu0



Brain-body-machine interfaces: "Restoration of reaching and grasping movements through brain-controlled muscle stimulation in a person with tetraplegia: a proof-of-concept demonstration" Ajiboye, A Bolu et al., *The Lancet*, Volume 389 , Issue 10081, 1821-1830, 2017.



Brain-body-machine interfaces: Baker et al., “Continuous Detection and Decoding of Dexterous Finger Flexions With Implantable MyoElectric Sensors,” IEEE TNSRE 18(4):424-32, 2010.

Brain-body-machine interfaces: “Brain-Machine Interface @ EPFL- Wheelchair” (École polytechnique fédérale de Lausanne); https://youtu.be/0-1sdtnuqcE

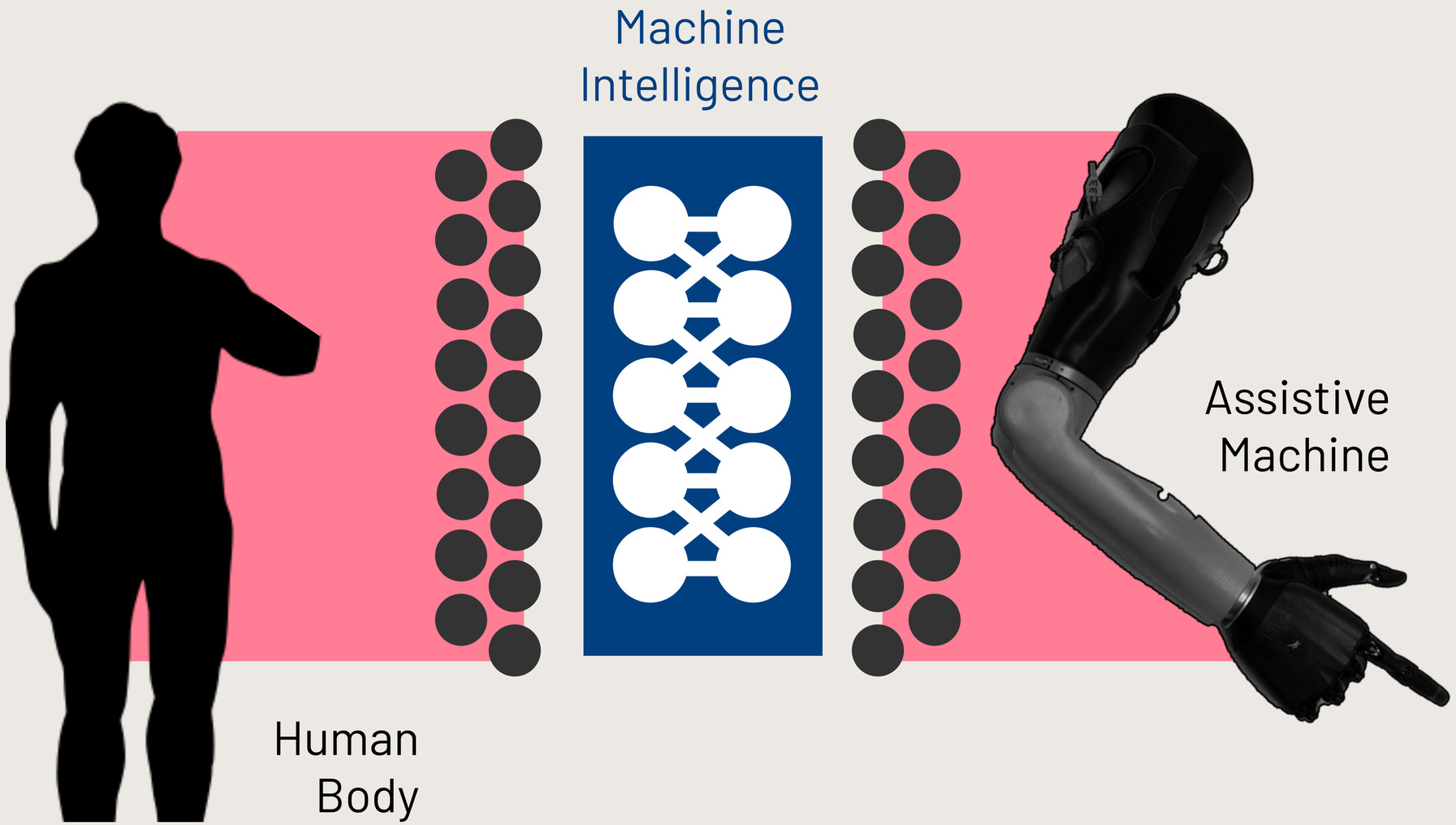
Commercially Deployed
Pattern Recognition for Prostheses

EEG

EMG

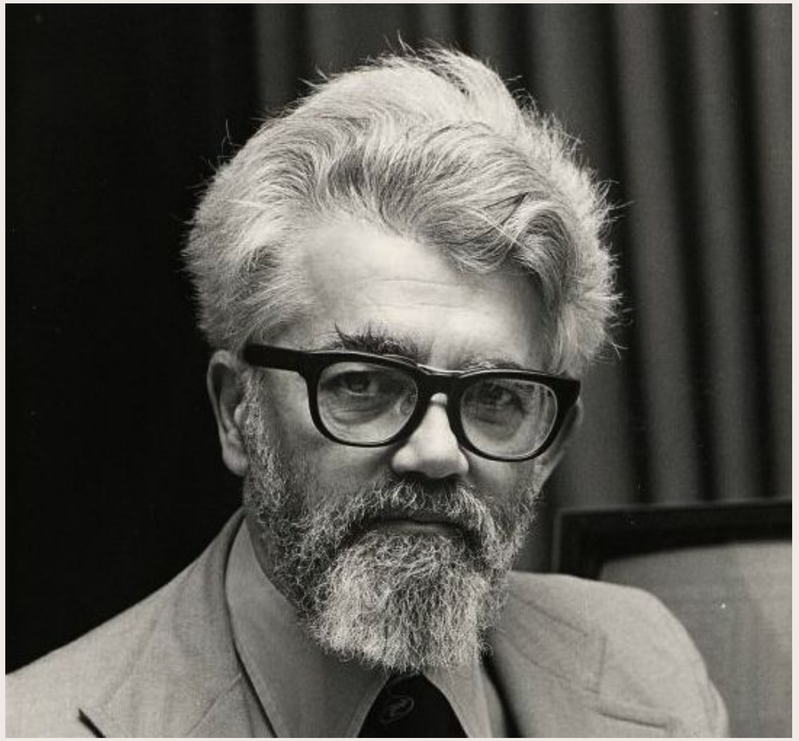
Consumer-Available BCI and BMI

These examples
all involve machine intelligence or
machine learning


Machine
Intelligence
Assistive
Machine
Human
Body

Intelligence:

“... is the computational part of the ability to achieve goals in the world.”

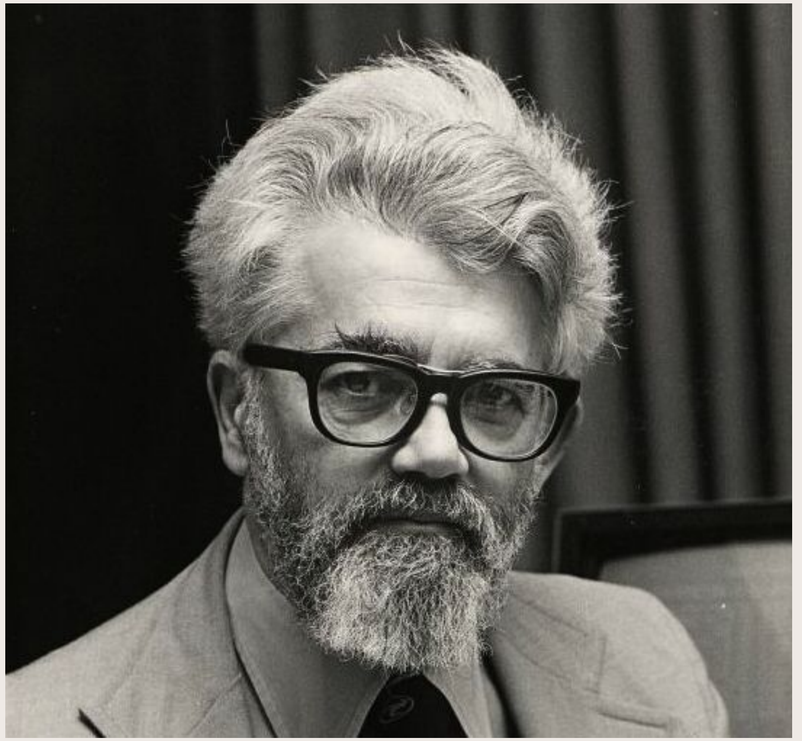


John McCarthy
(1927 – 2011)

http://jmc.stanford.edu/artificial-intelligence/index.html

Artificial Intelligence:

“... is the science and engineering of making intelligent machines, especially intelligent computer programs.”



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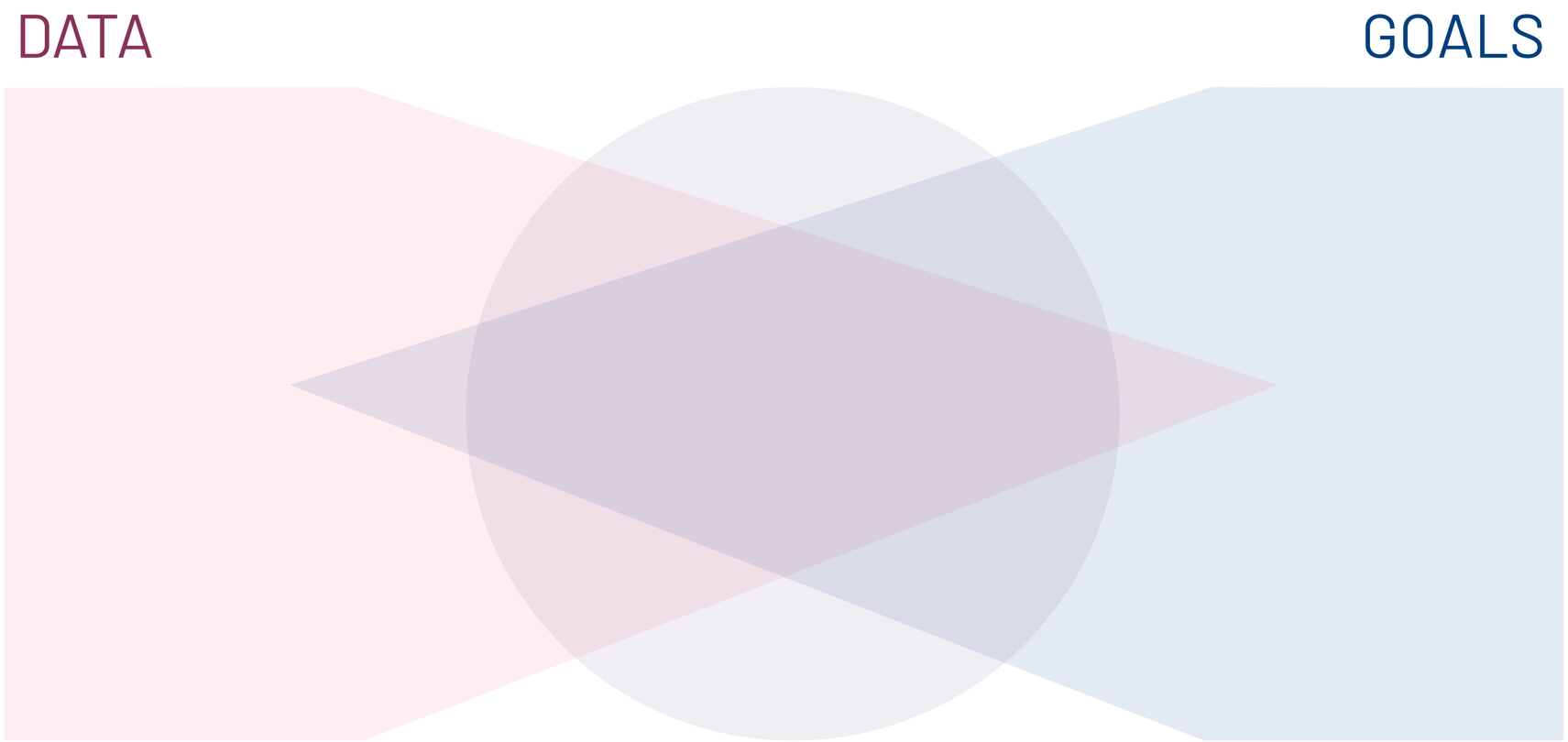
Hallmarks of Intelligence:

Artificial, Machine (and Human)



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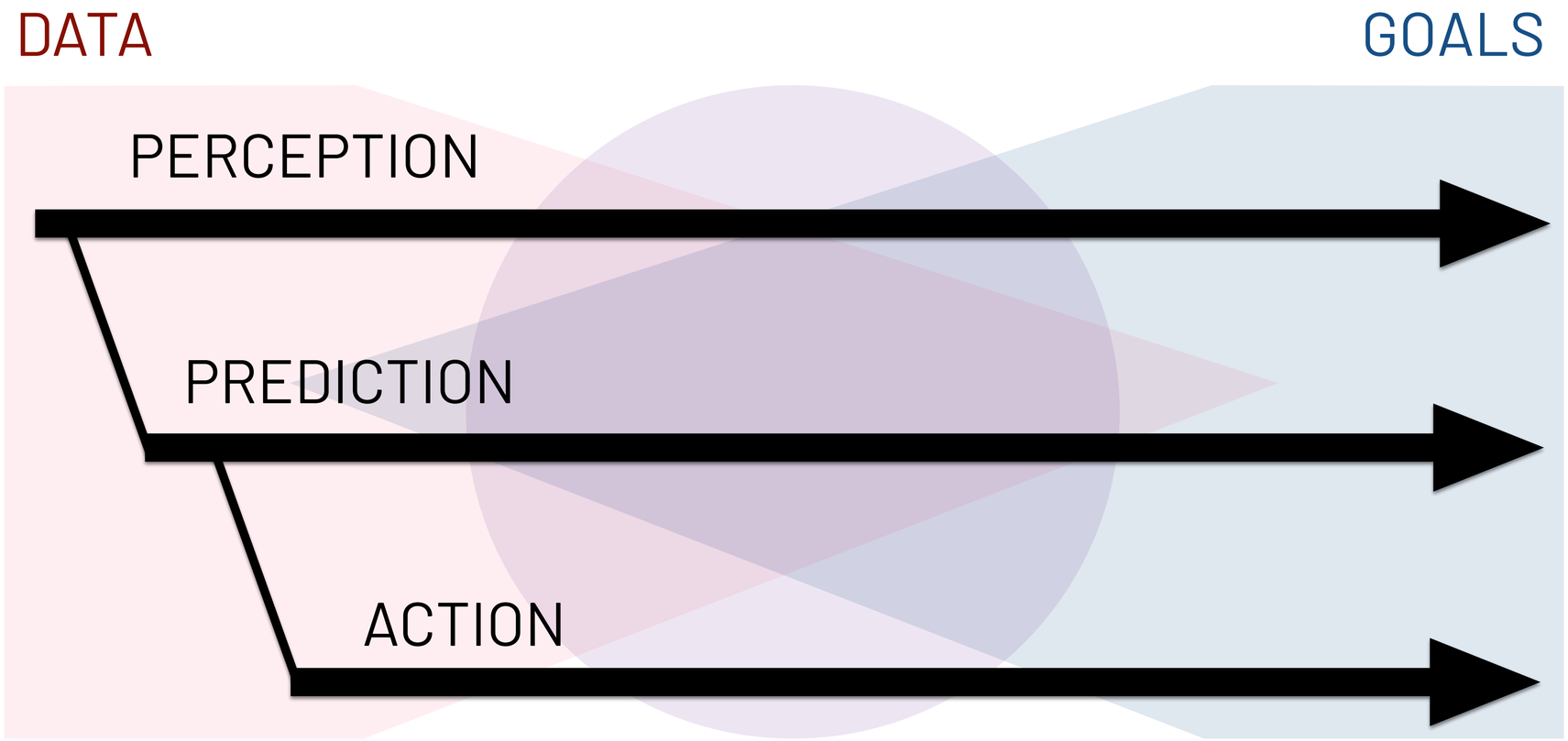

Hallmarks of Intelligence:
Artificial, Machine (and Human)

Intelligent or not?

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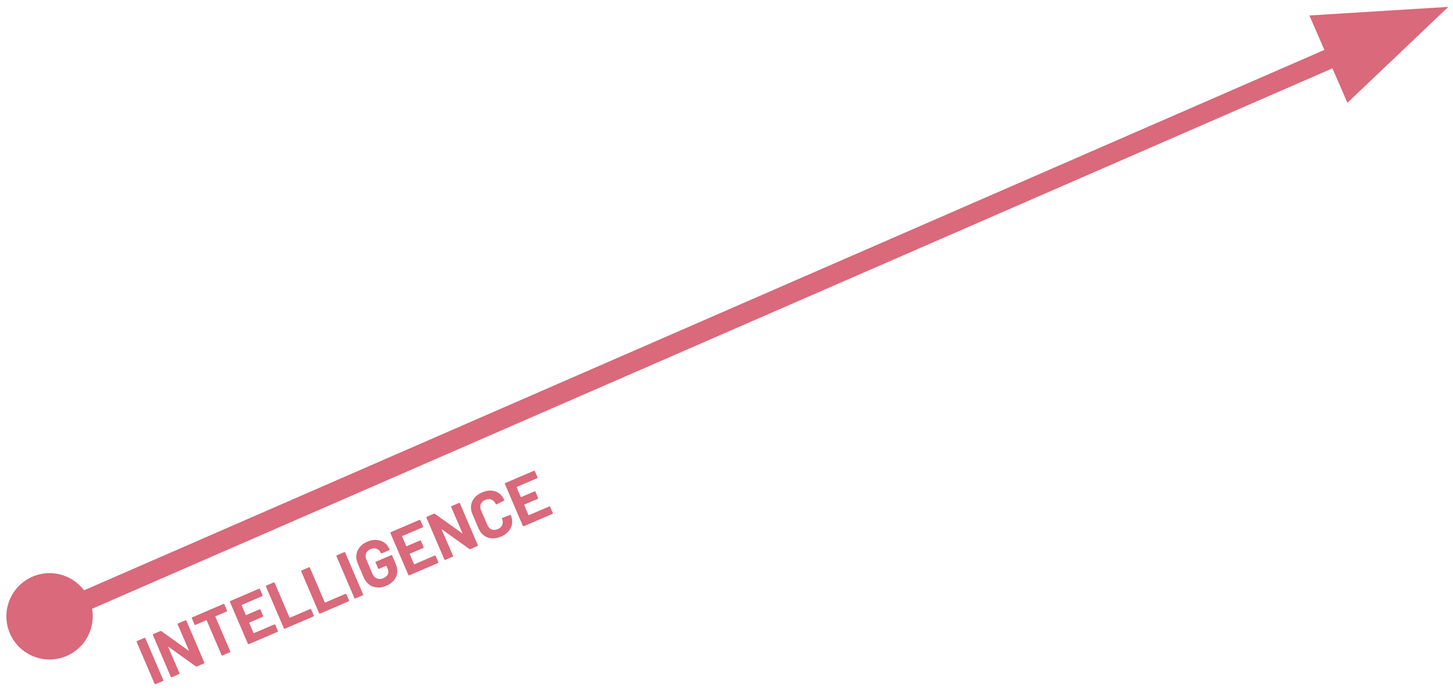
Common Misconceptions



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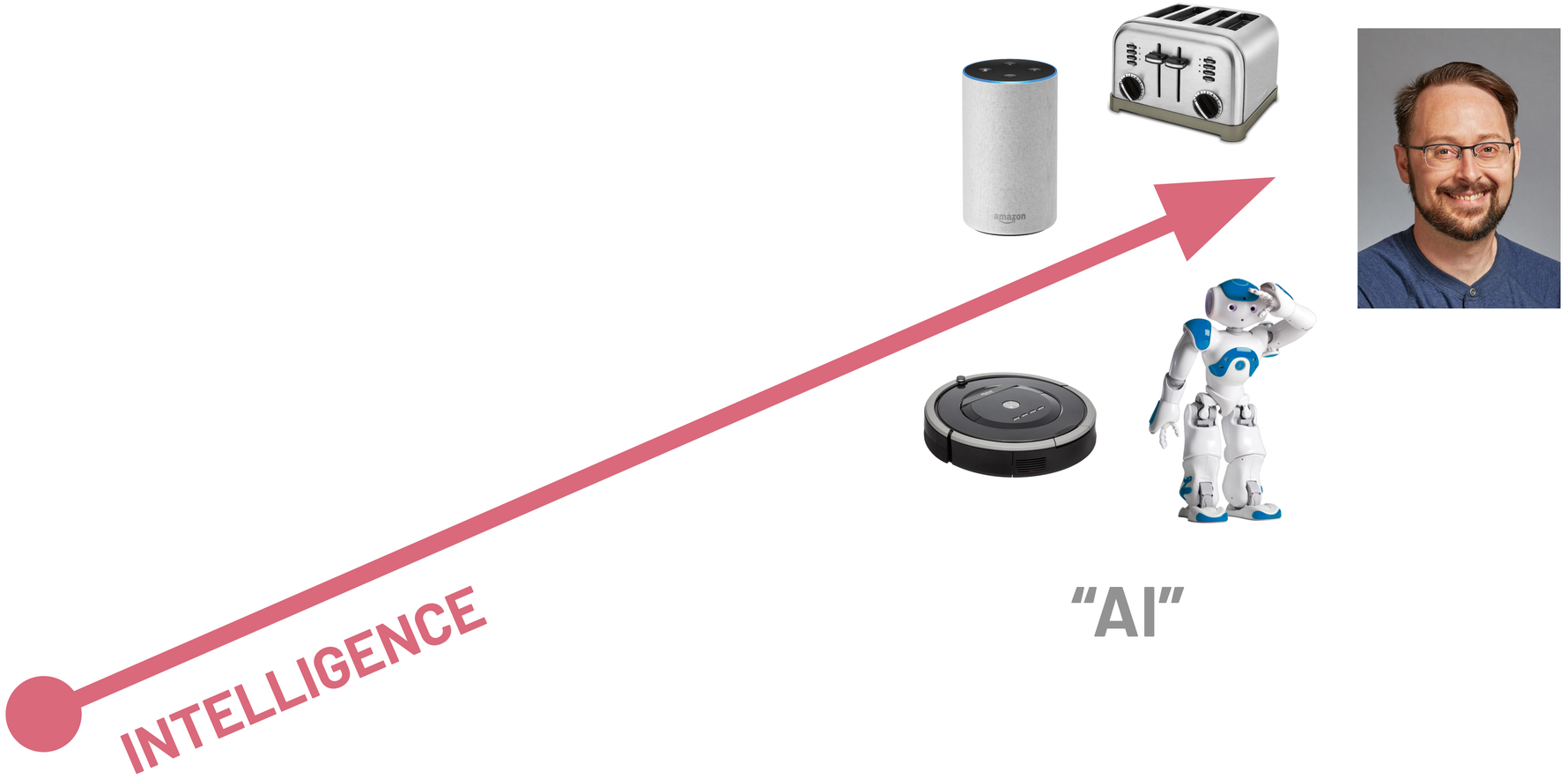

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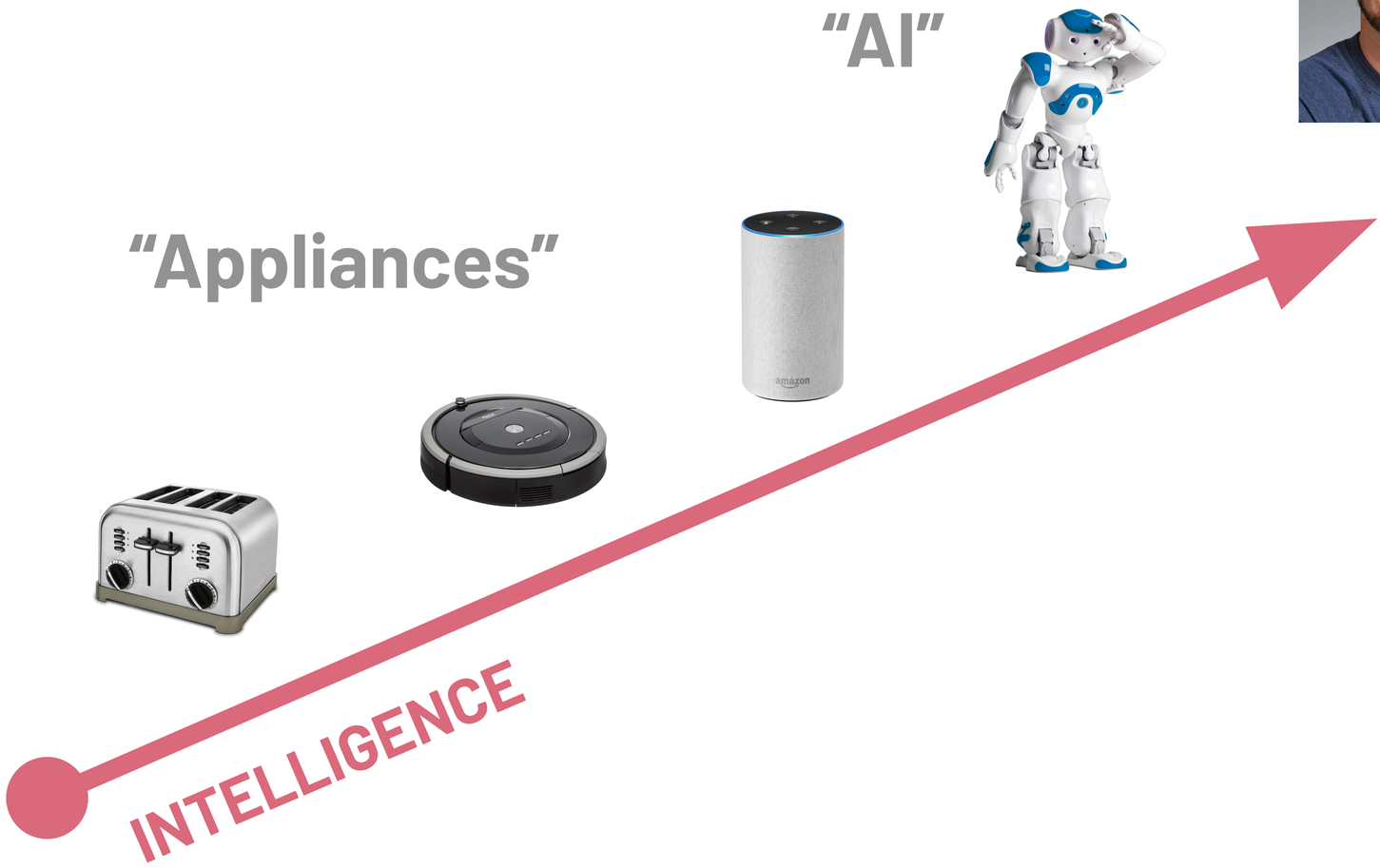
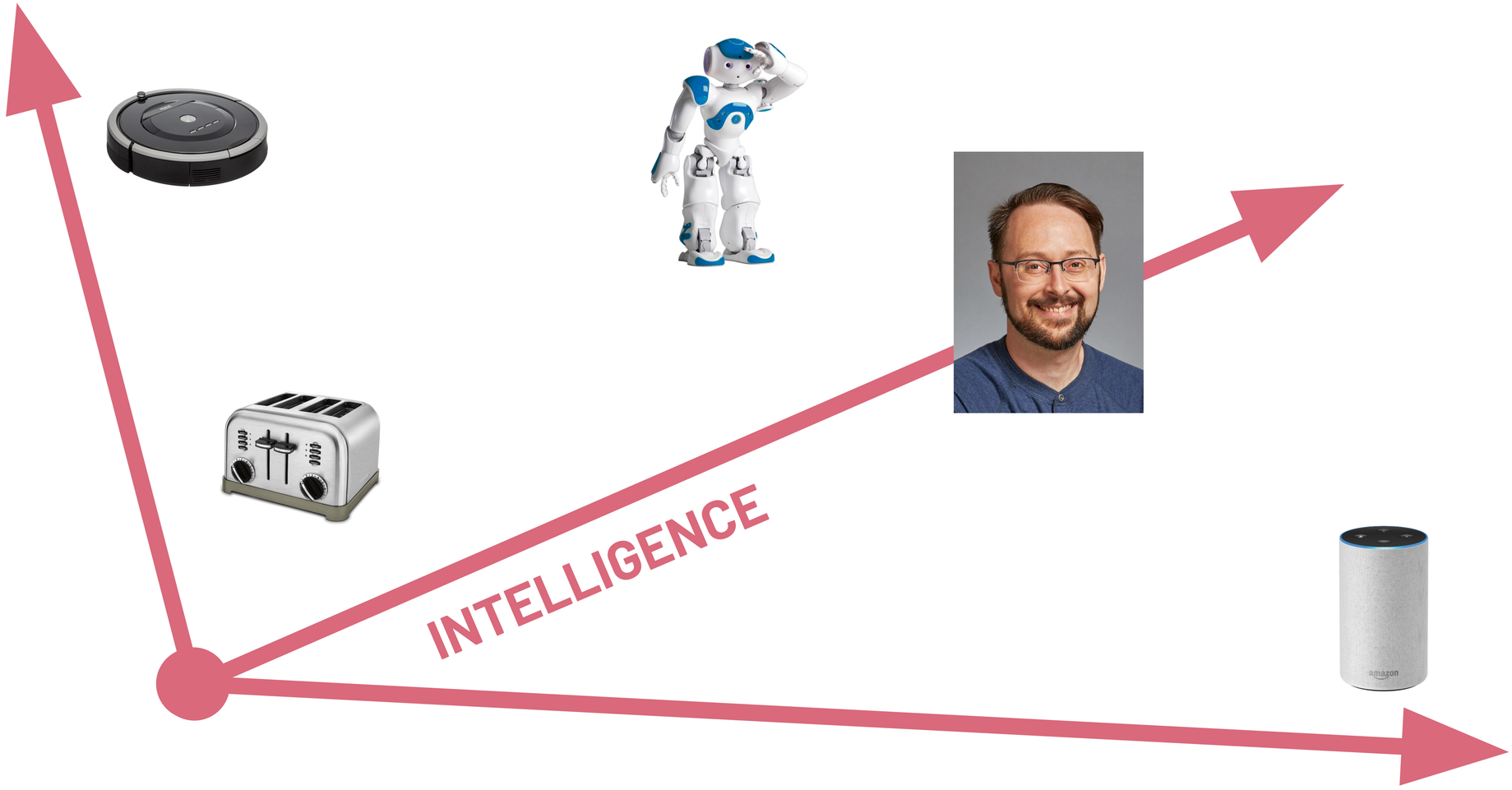


Data, Decisions, Goals

Perception, Prediction, Action



Why Machine Intelligence?

Enhanced control over a changing and increasingly complex world.

Anticipation of future events and outcomes.

General tools for solving hard problems.

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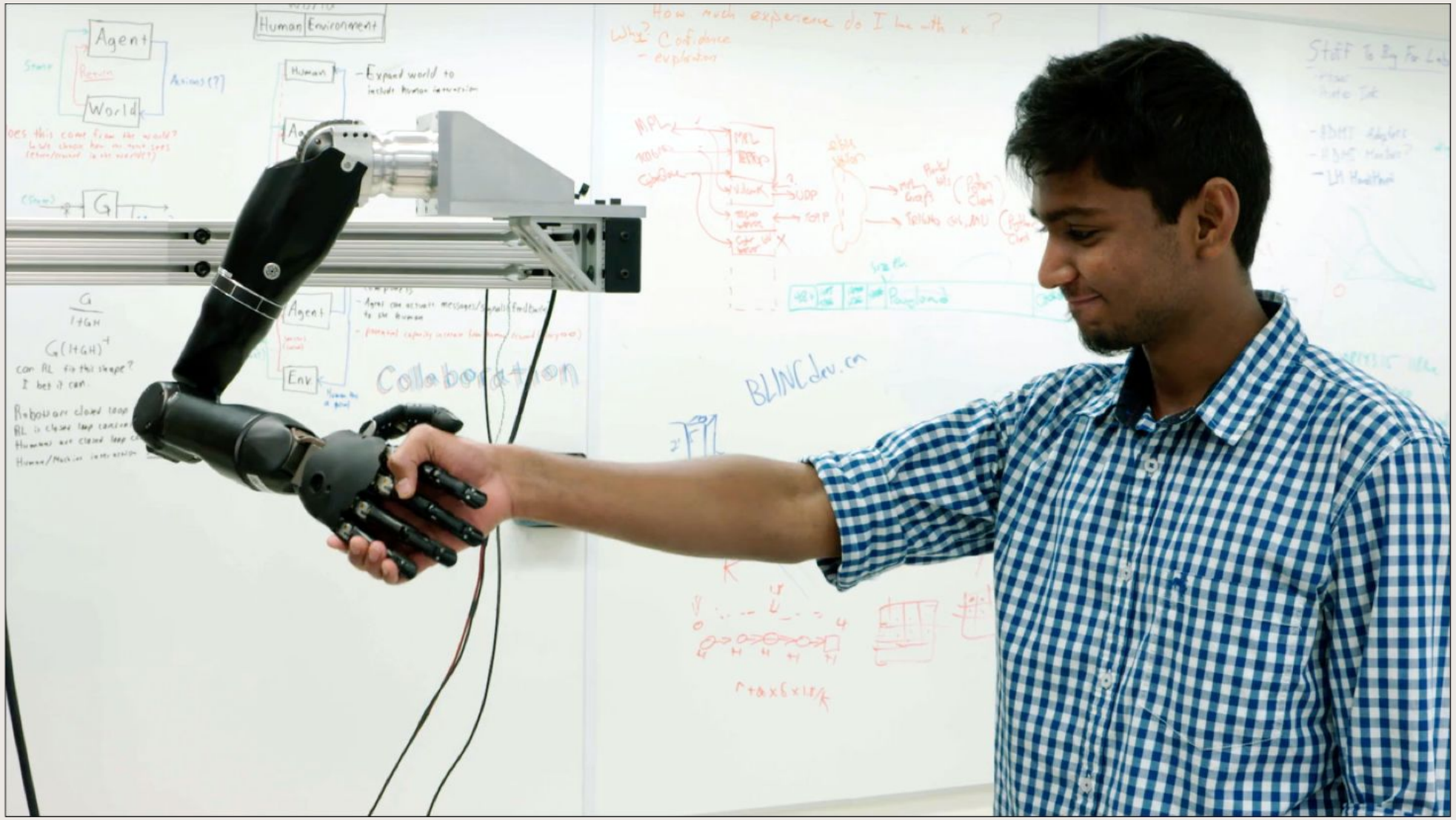
General tools for solving hard problems.

Controlling complex systems and extracting knowledge from massive amounts of data.

Examples: finance, healthcare, energy, resources, transport, information processing.



BLINC Lab / SMART Network

August 2016

Why Machine Learning?

Things are Unknown:
known ends but unclear means.

Things are Complex:
scaling up is demanding or impossible.

Things Change:
systems need to adapt!

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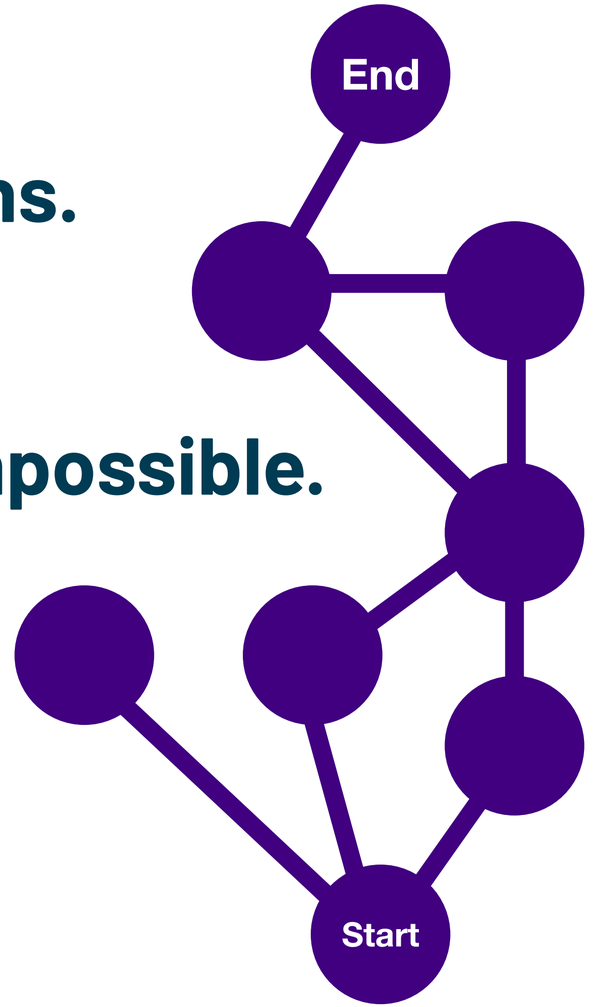

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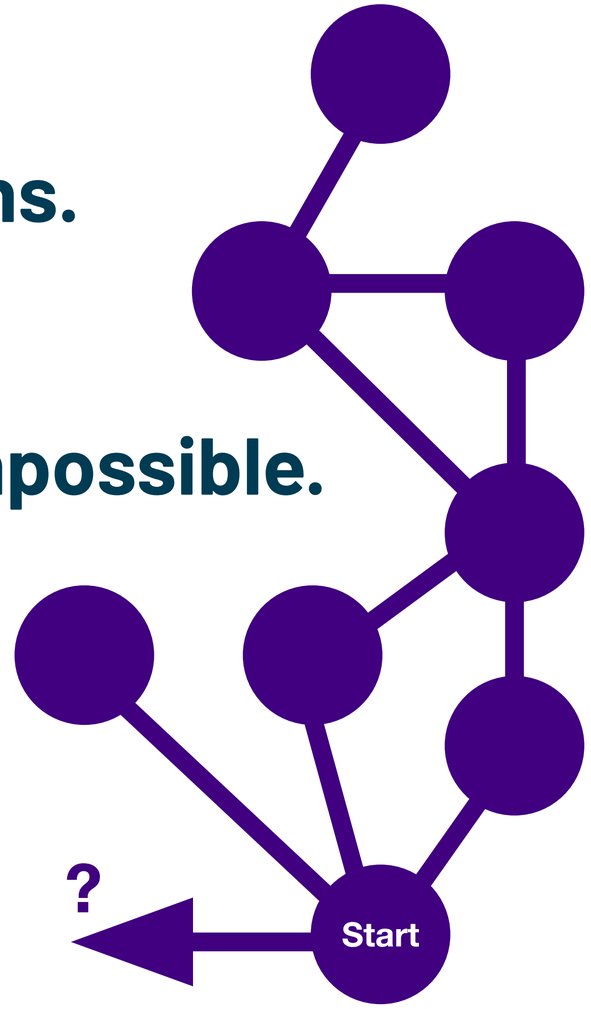
End



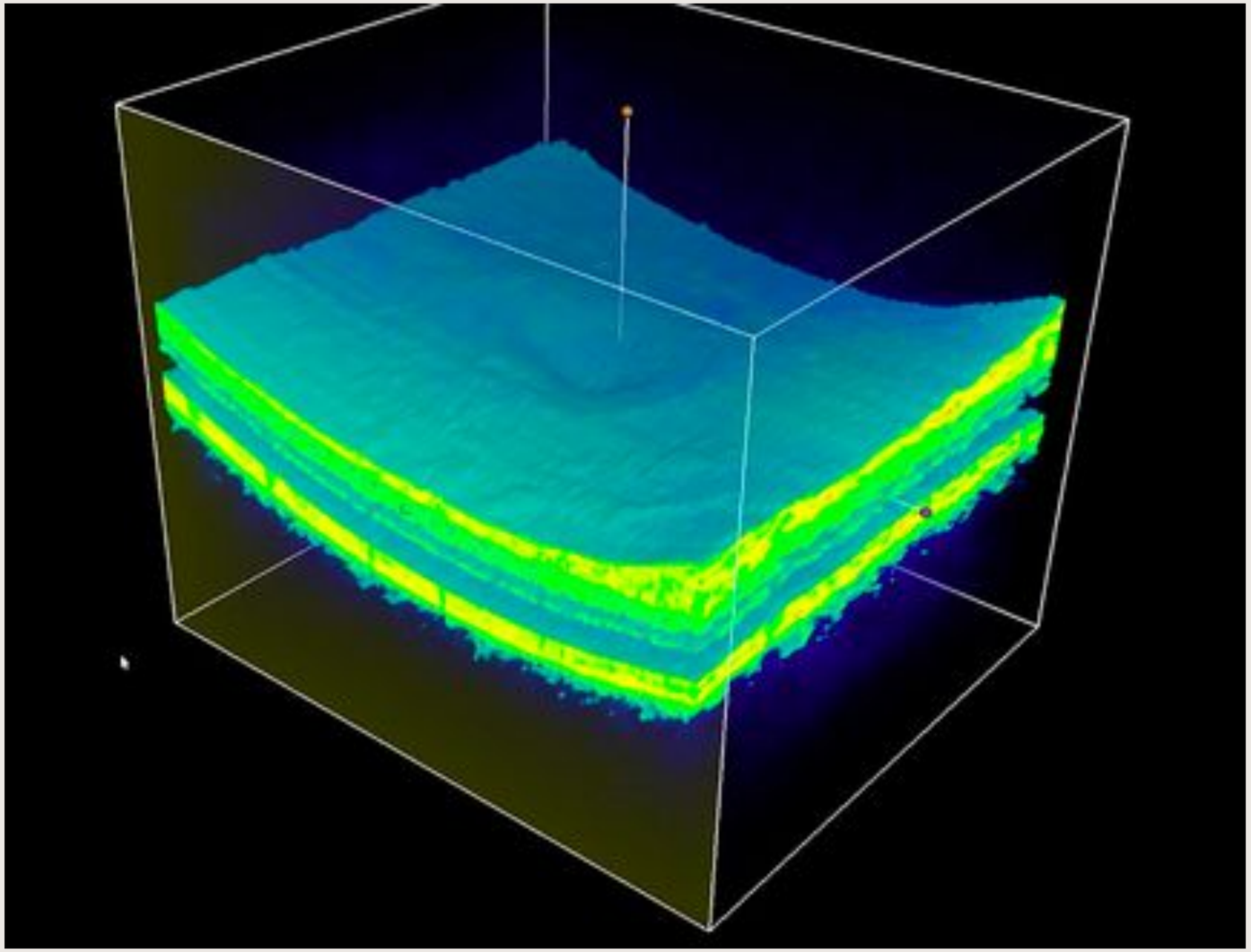
AI and ML in Medicine

1. Helping to understand patient populations (generalization);
2. Helping to understand individual patients (personalization);
3. Helping choose and improve interventions (optimization):

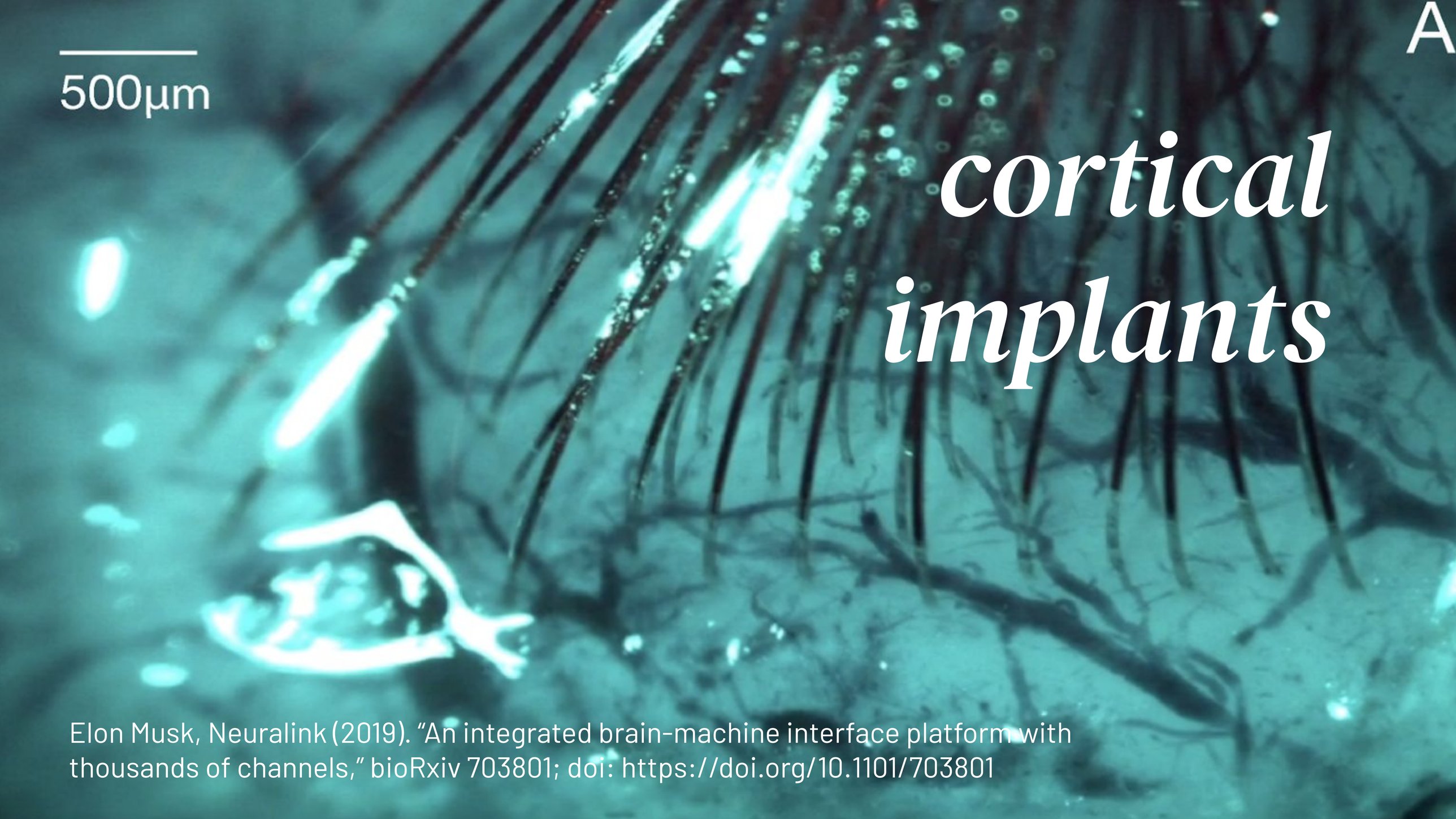
   by connecting patients to assistive devices;

   by helping deploy treatment strategies.

http://www.humanconnectomeproject.org/

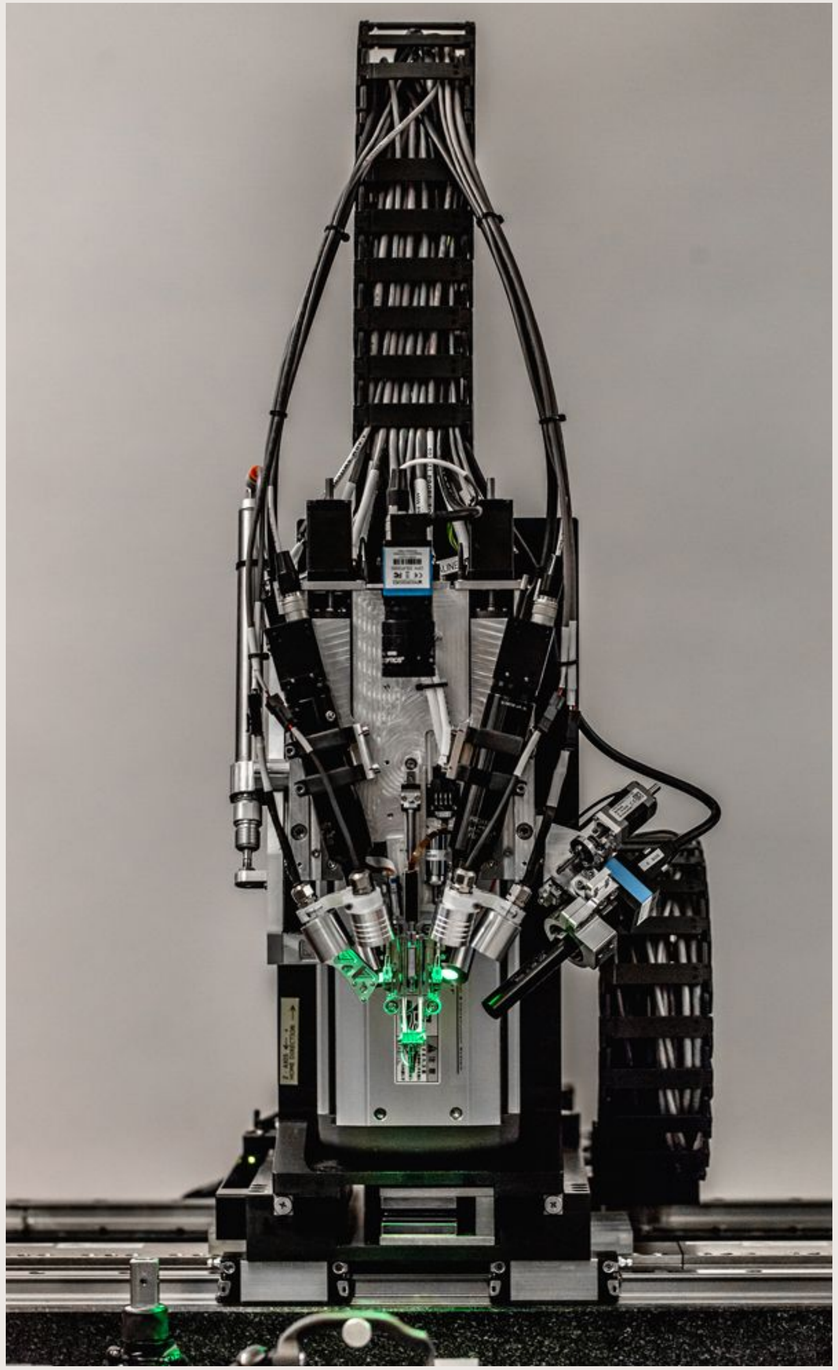


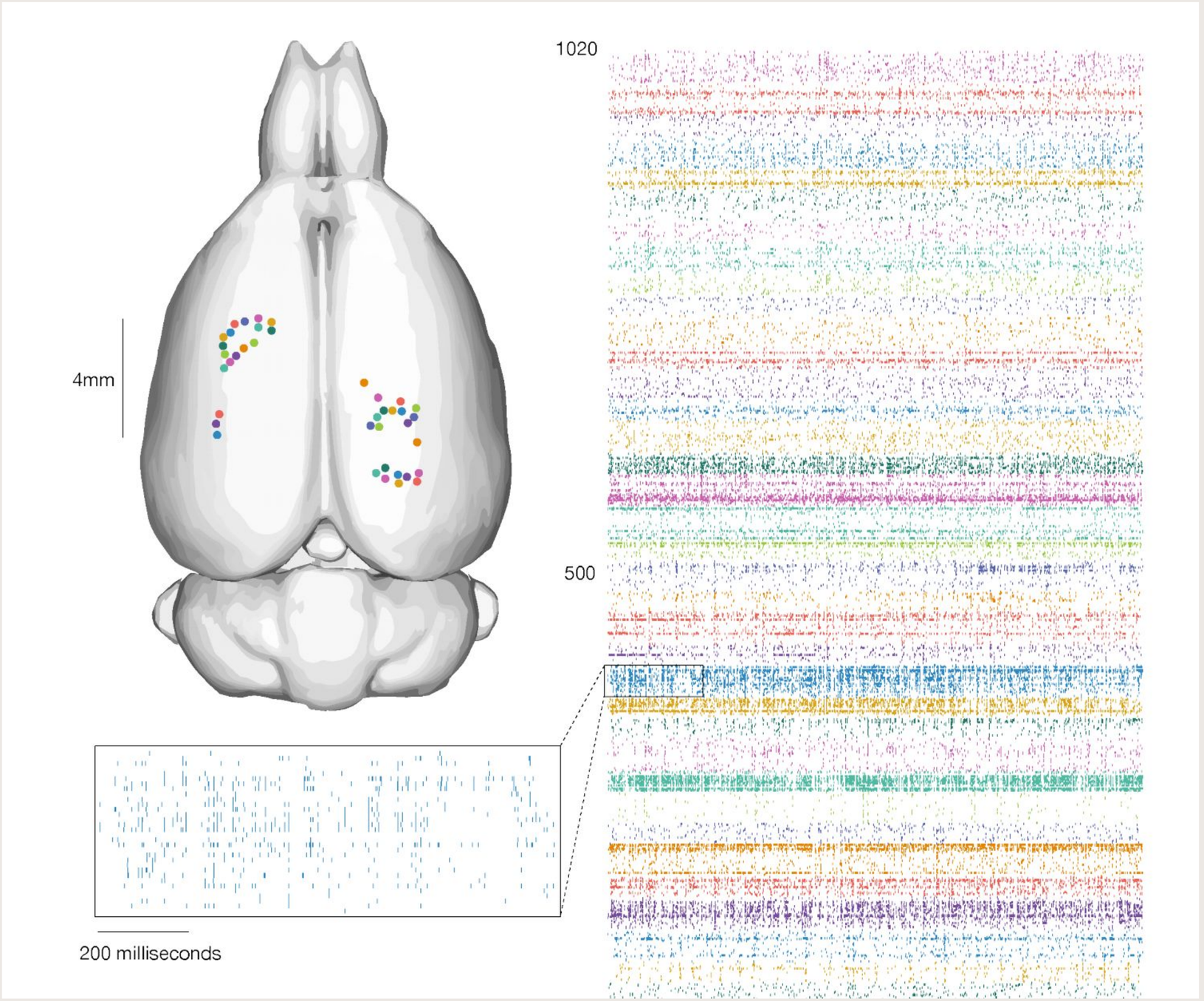
J. De Fauw et al., *Nature Medicine* 24:1342–1350 (2018)



cortical implants

Elon Musk, Neuralink (2019). “An integrated brain-machine interface platform with thousands of channels,” bioRxiv 703801; doi: https://doi.org/10.1101/703801

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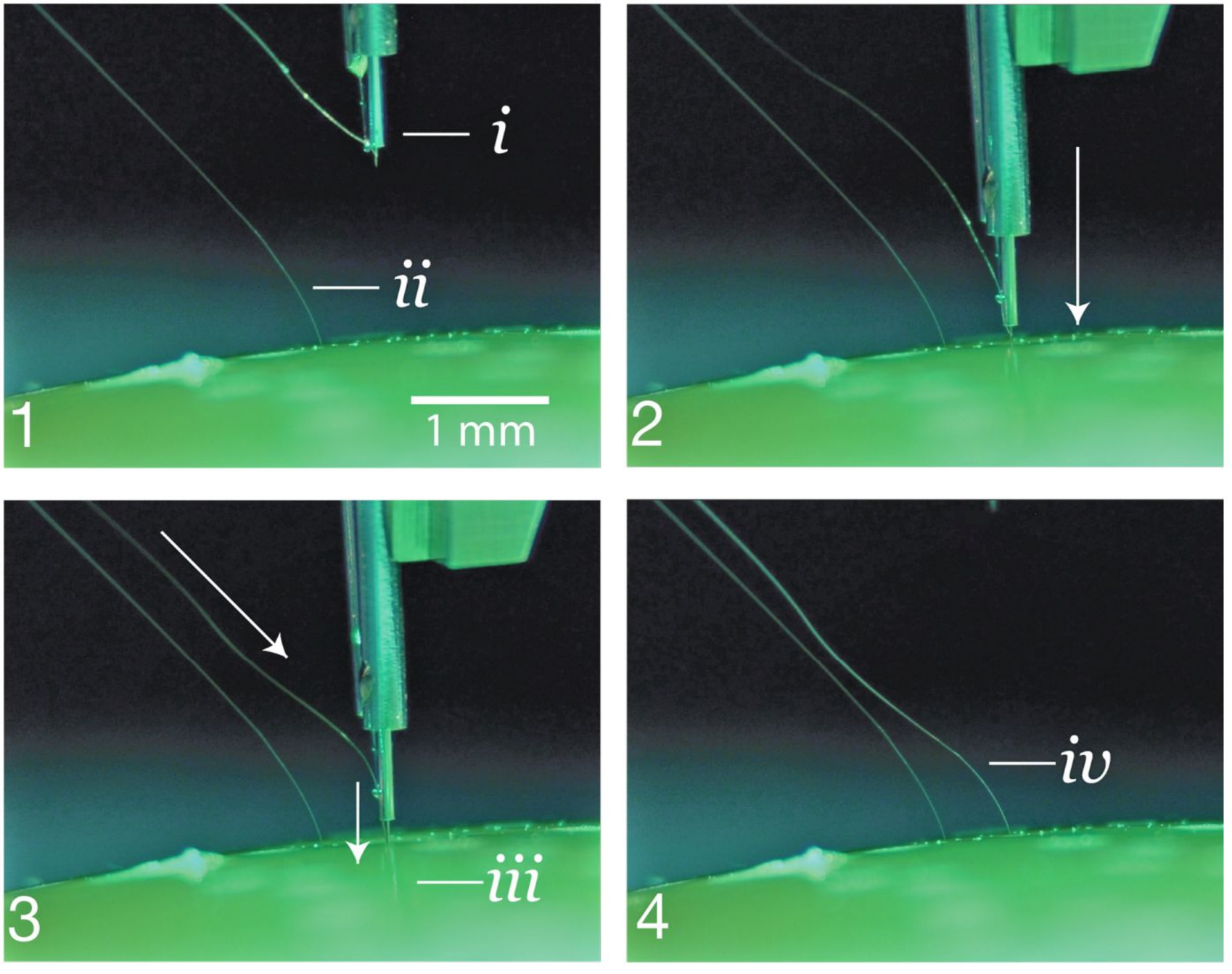
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4
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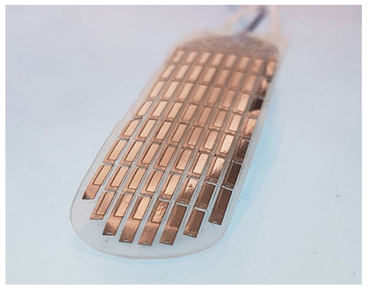
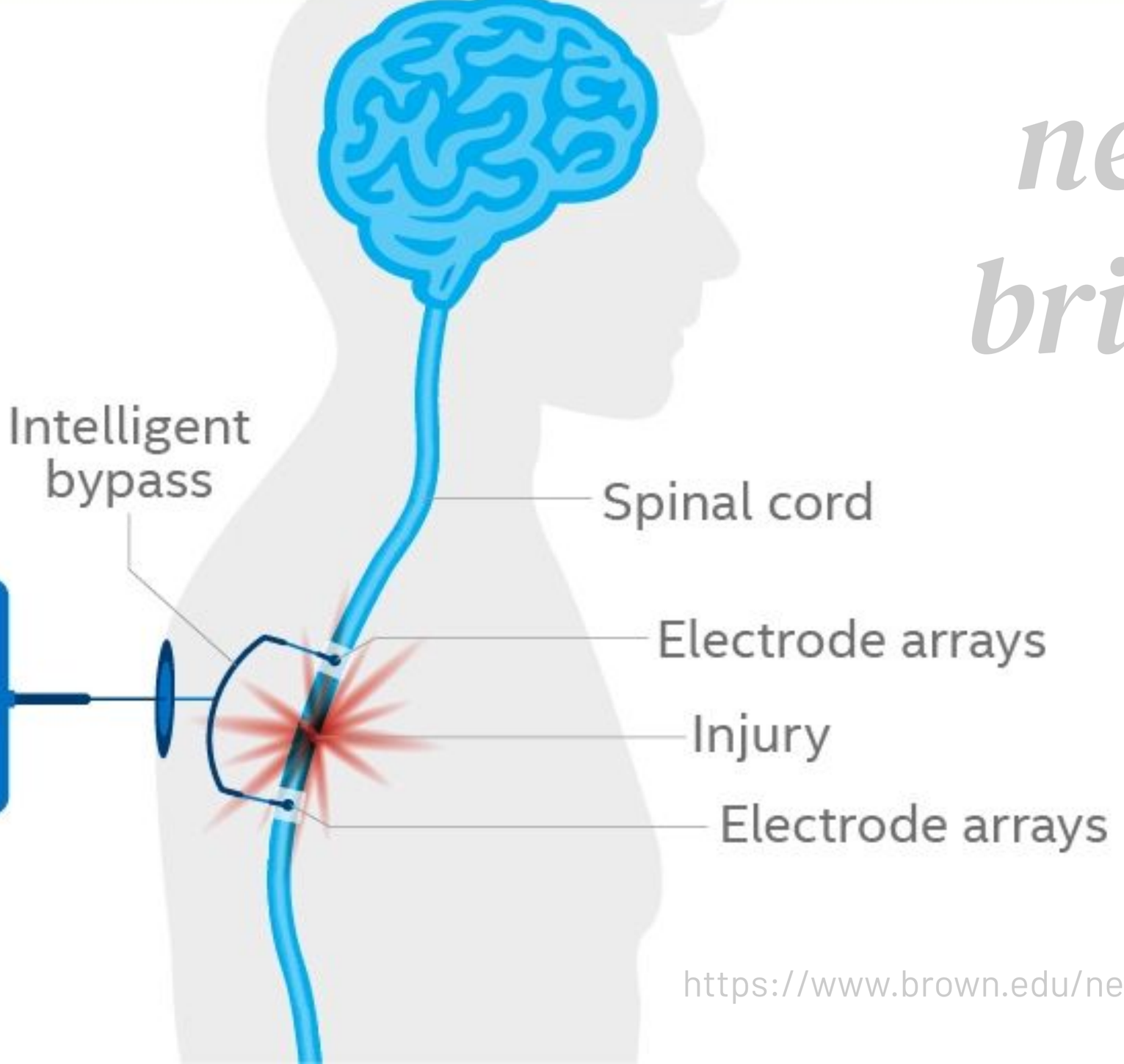
neural bridges

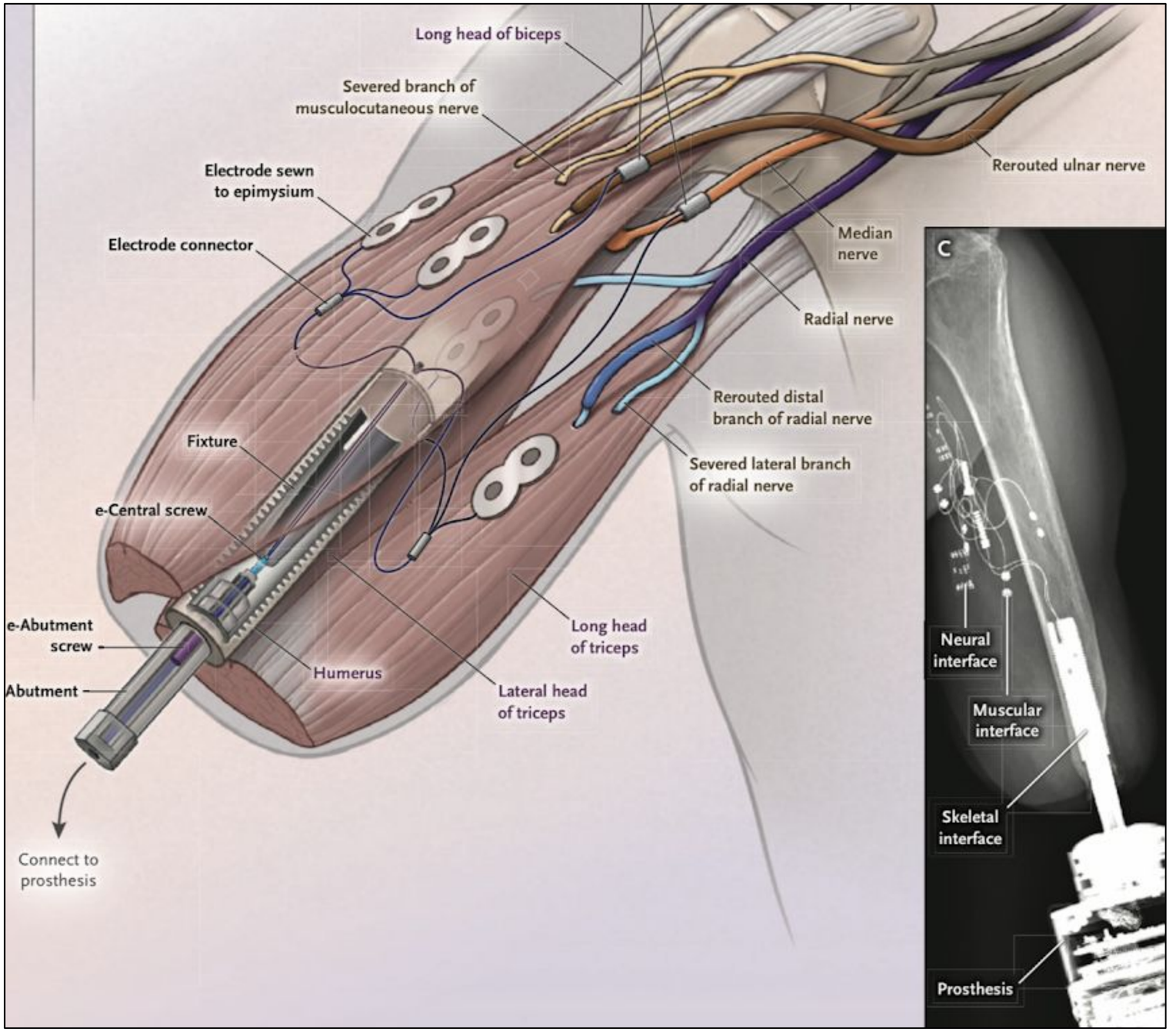




https://www.brown.edu/news/2019-10-03/isi

bone, muscle, and nerve integration

Ortiz-Catalan et al., *N Engl J Med* 2020; 382:1732-8.



avatars

e.g.: **Avatar startups:** https://www.theglobeandmail.com/business/technology/video-ultra-human-like-robots-are-at-the-cutting-edge-of-artificial/

BLINC Lab @ UofA

Dr. Jacqueline S. Hebert (Professor, Div. PM&R)

File photo by *The Canadian Press*/Amber Bracken, 2019

Looking Forward: Complex Bodies, Multidisciplinary Care

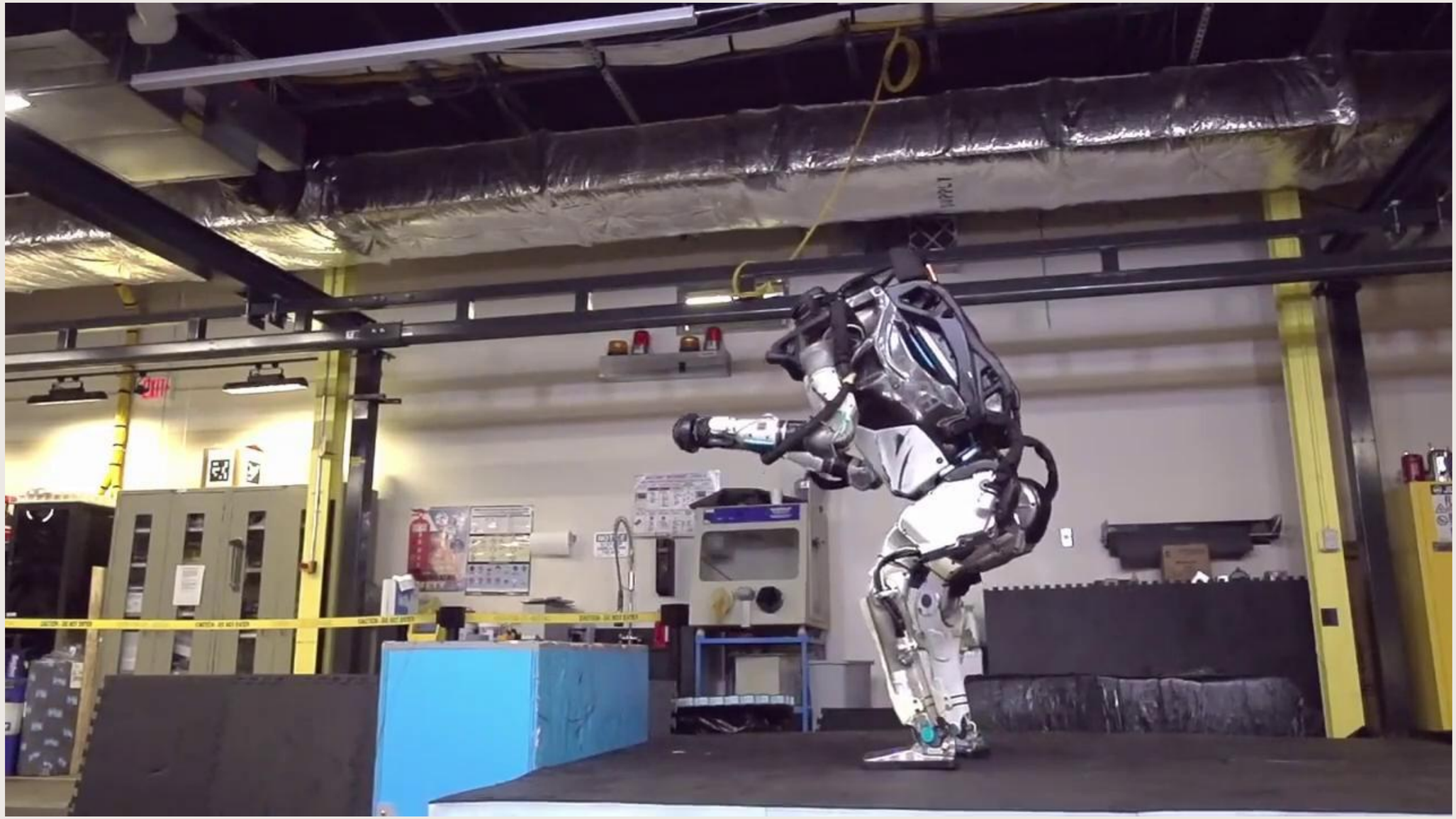
If a patient's body and mind are comprised of both biology and technology, how do we best treat the whole patient?

patients may (do) consider their technology part of themselves;

biology and technology may not be easily separable;

biological and technical care may not be easily separable;

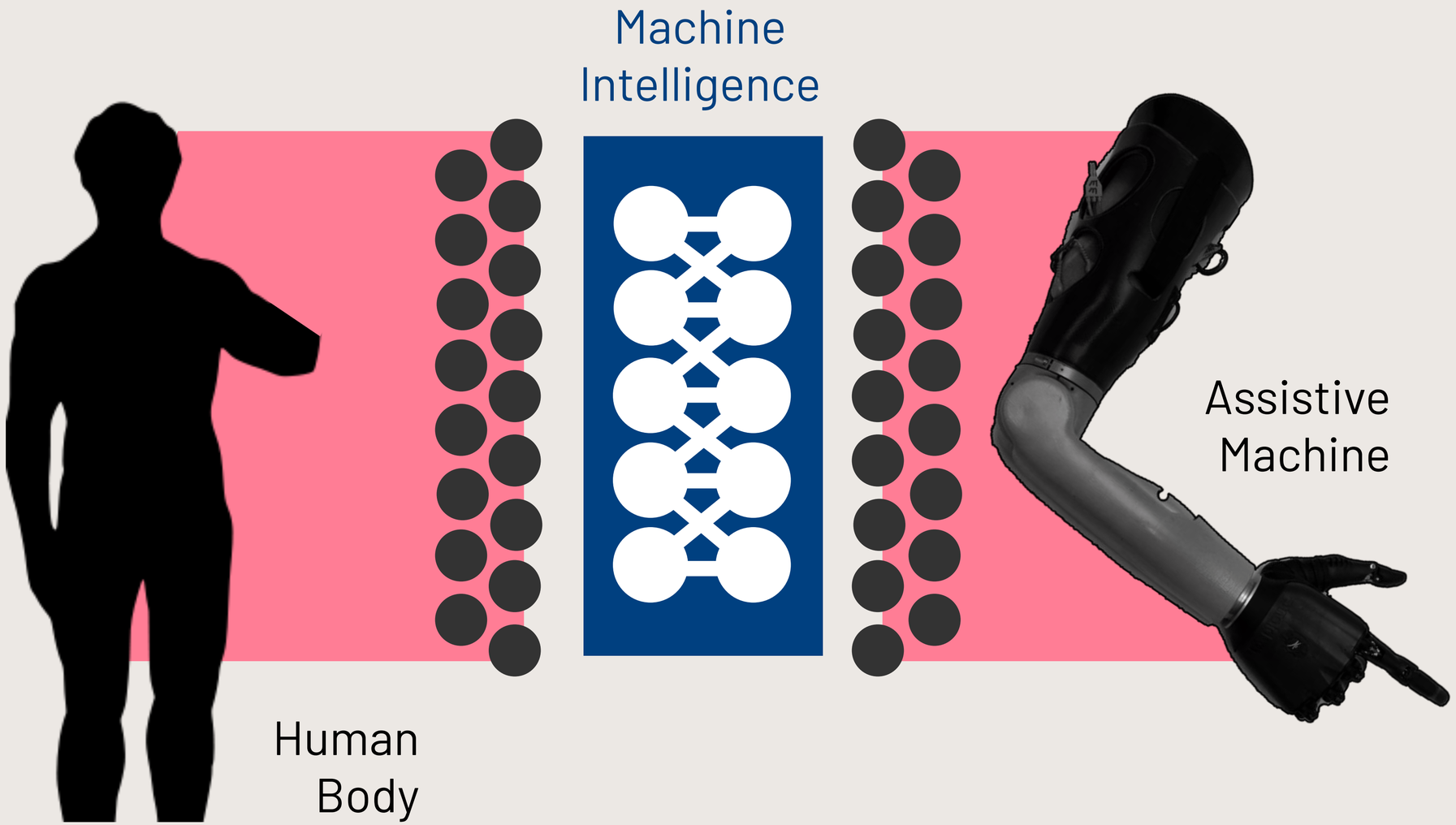
normal care may soon involve experts in *tissue*, *muscles*, *nerves*, and *bones*, alongside experts in *hardware*, *software*, and *data science*.



And in case you were wondering what the robots are up to these days...

Atlas Robot (Boston Dynamics): https://youtu.be/fRj34o4hN4I

Exoskeletons: UC Berkeley spin-off suitX exoskeleton technology; https://www.youtube.com/watch?v=l3roYI3CB2Y


Machine
Intelligence
Assistive
Machine
Human
Body

Machine
Intelligence

Human Mind:

Patient

Care Giver

Policy Maker

Thank you…

… and (hopefully) time for questions and discussion!

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BLINC
BIONIC LIMBS FOR IMPROVED NATURAL CONTROL

SMART NETWORK
Sensory Motor Adaptive Rehabilitation Technology