iCyPhy

The Coevolution of Humans and Machines

Edward A. Lee

UC Berkeley

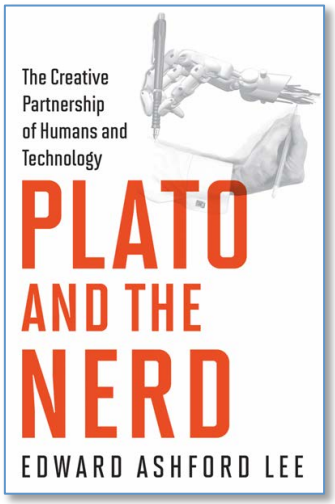
Invited talk in "Penser les technosciences" series,

LAAS, Toulouse, Feb. 5, 2020

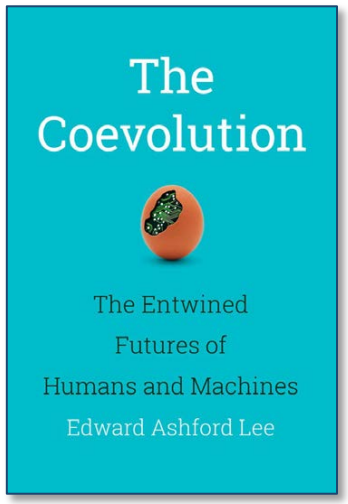
University of California at Berkeley

The (Very Short) Summary

We humans have less control than we think over technology development.



MIT Press, 2017



MIT Press, 2020

Implications: Policy is more important and more difficult to make effective than it might seem.

A Scenario: "Information Apocalypse"

- Assumption: All information on the Internet is "true."
- Fact: Information flux today vastly exceeds individual human capacity to absorb it.
- Fact: Individualized information flows, regulated by software, compete for attention.
- Result: "Islands of disjoint truths."
- *Is this the result of deliberate technology design?*

Digital Creationism: The Hypothesis that Technology is Top-Down Intelligent Design

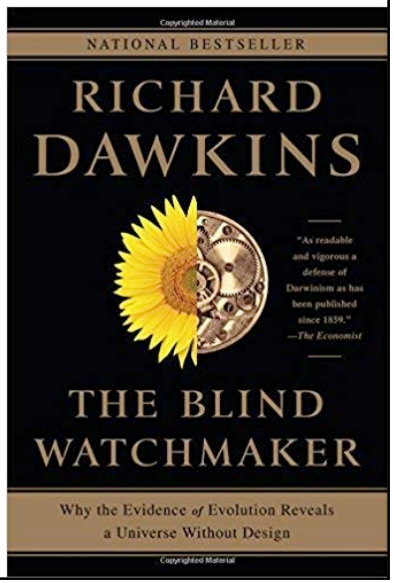
"Every boat is copied from another boat ... Let's reason as follows in the manner of Darwin. It is clear that a very badly made boat will end up at the bottom after one or two voyages and thus never be copied. ... One could then say, with complete rigor, that it is the sea herself who fashions the boats, choosing those which function and destroying the others."

French philosopher Alain

An Alternative to Digital Creationism: Darwinian Evolution

Donan.raven [CC BY-SA 3.0]

Evolutionary processes are capable of much more complex and sophisticated design than top-down intelligent design.

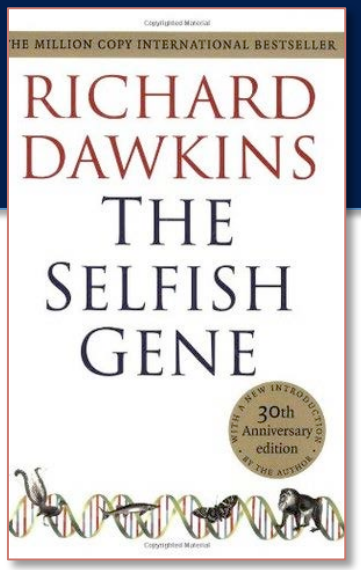


Eggs and Chickens

Richard Dawkins

Lee, Berkeley

"A chicken is an egg's way of making another egg."



Is a human a computer's way of making another computer?

Or is it a *Coevolution*?

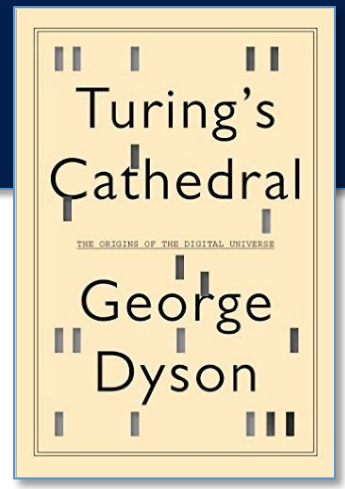
Google's million-plus servers are a "collective, metazoan organism."

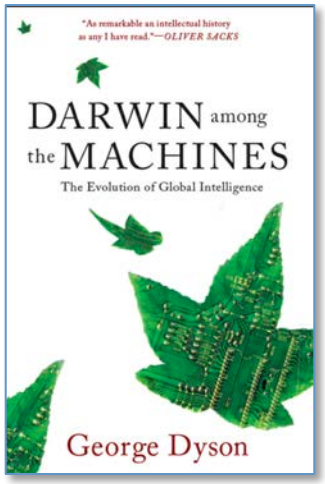
"The companies and individuals who nurture [the servers] are ever more richly rewarded in return"

"Unemployment is pandemic among those not working on behalf of the machines."

"The Big Computer [is] doing everything in its power to make life as comfortable as possible for its human symbionts."

(Dyson, 2012, p. 308,313,325)

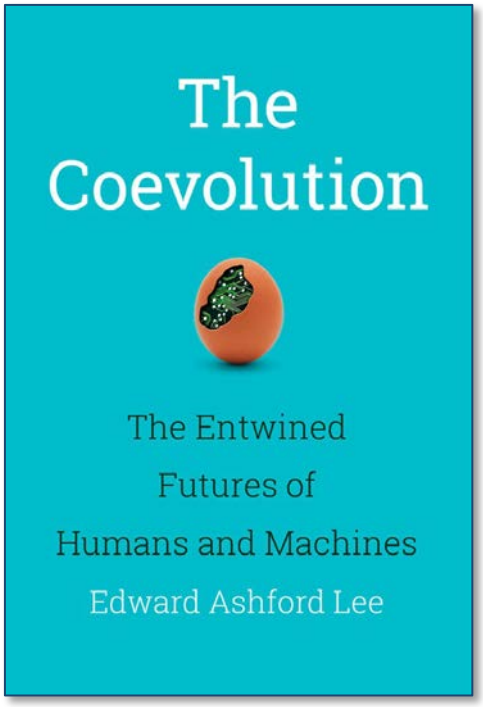




The Human Role in Technology Development

"We are the sources of mutation in a Darwinian coevolution."

"We do not like seeing our mental cognitive processes as themselves cogs in a relentless purposeless evolution. But is this what they are?"

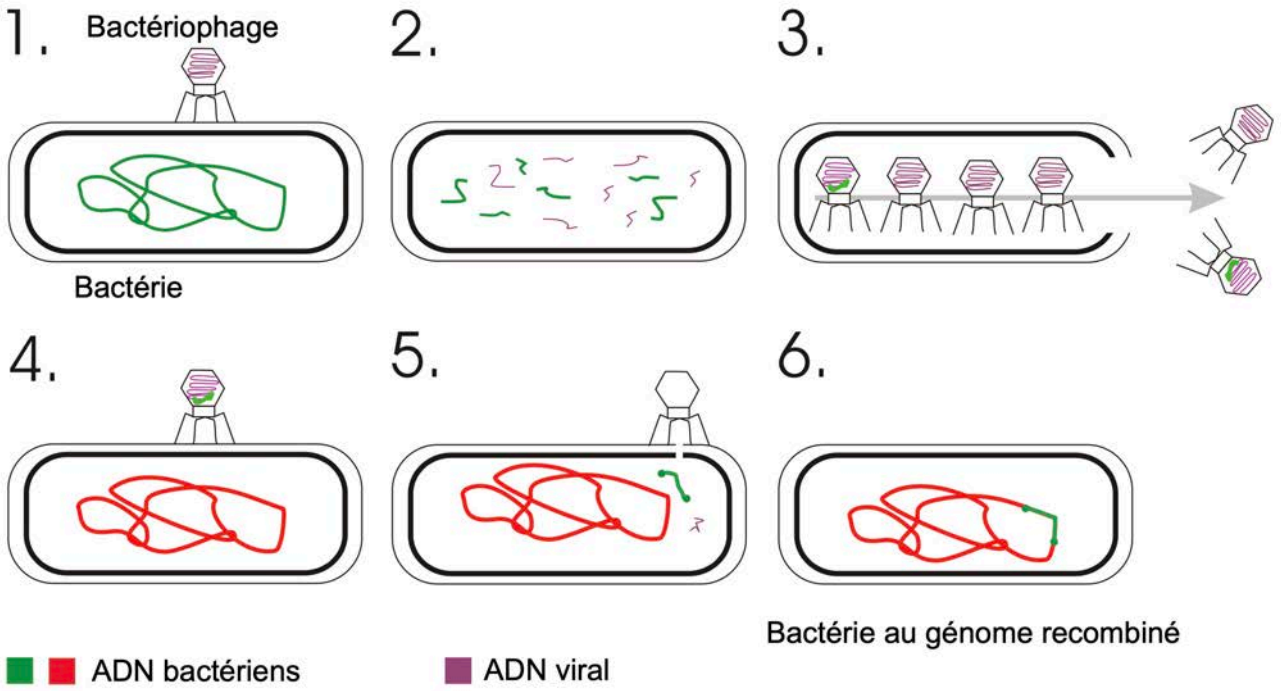


MIT Press, 2020

Mutation is Not as Random as We Used to Think.

HGT: Horizontal Gene Transfer:

A key factor in the evolution of antibiotic-resistant bacteria.

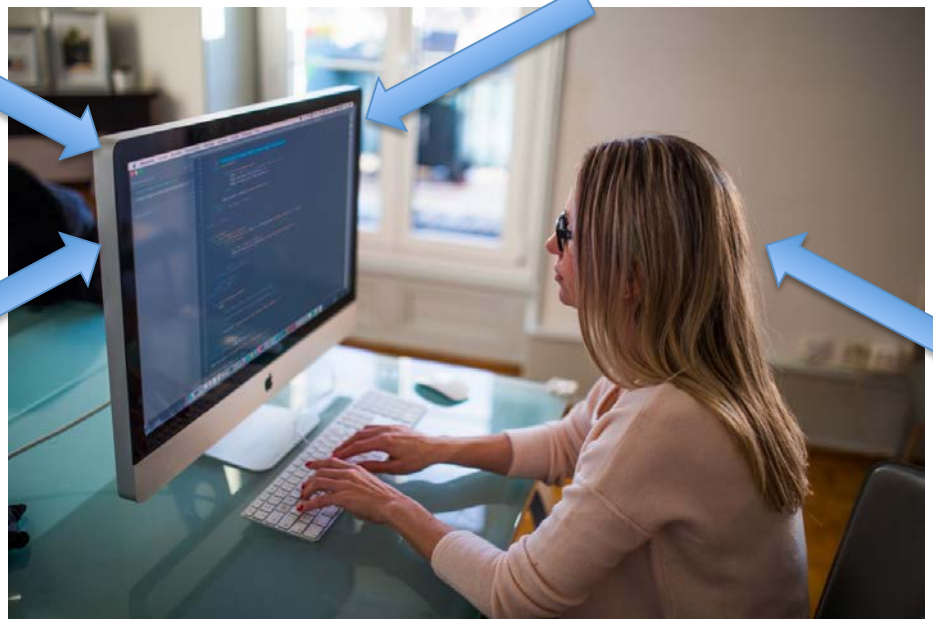


Public domain

Humans As Sources of Mutation
Horizontal Code Transfer (HCT)

GitHub

stackoverflow



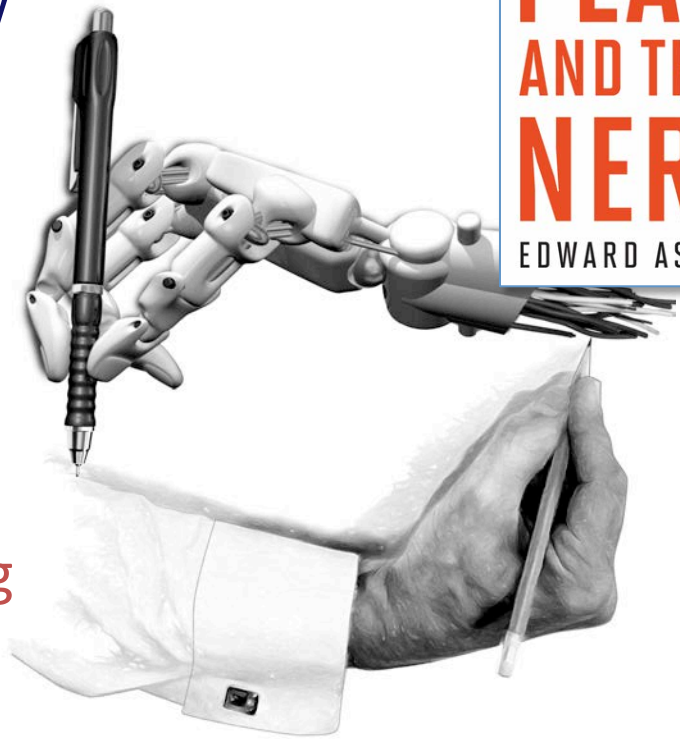
STL
Java Library
Python Modules
JS Modules

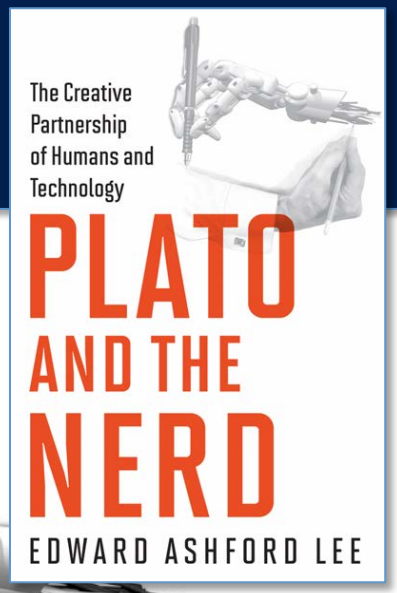
Virus?

An Alternative to Digital Creationism: Symbiotic Coevolution

"Are we playing God, creating a new life form in our own image, or are we being played by a Darwinian evolution of a symbiotic new species?"

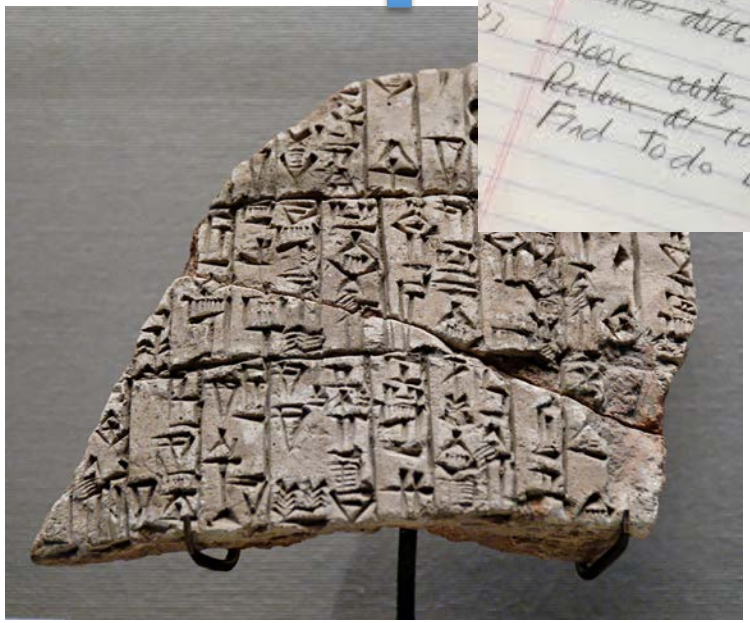
"Are humans the purveyors of the 'noisy channel' of mutation, facilitating sex between software beings by recombining and mutating programs into new ones?"

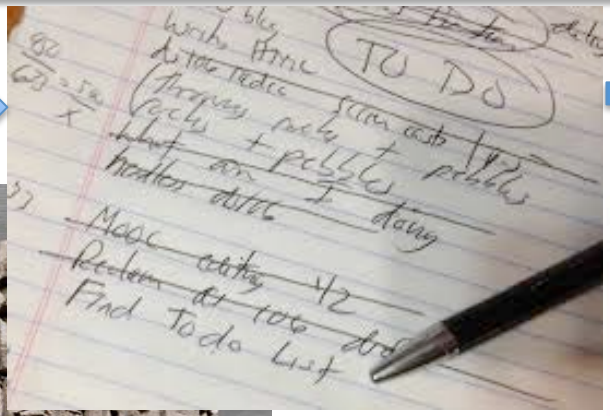




MIT Press
2017

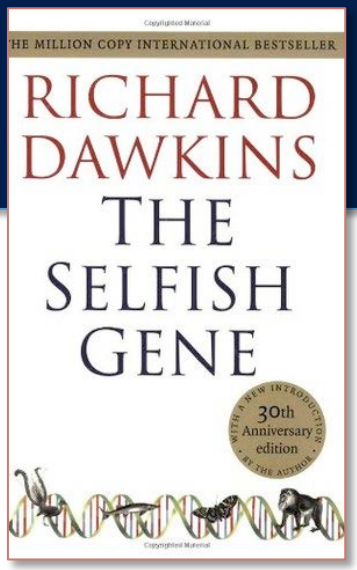
The Human Side of This Coevolution





Intellectual Prosthetics

?



Human culture and cognition ("memes" per Dawkins) are coevolving with technology.

Our biology is starting to also.

Lee, Berkeley

Symbiosis

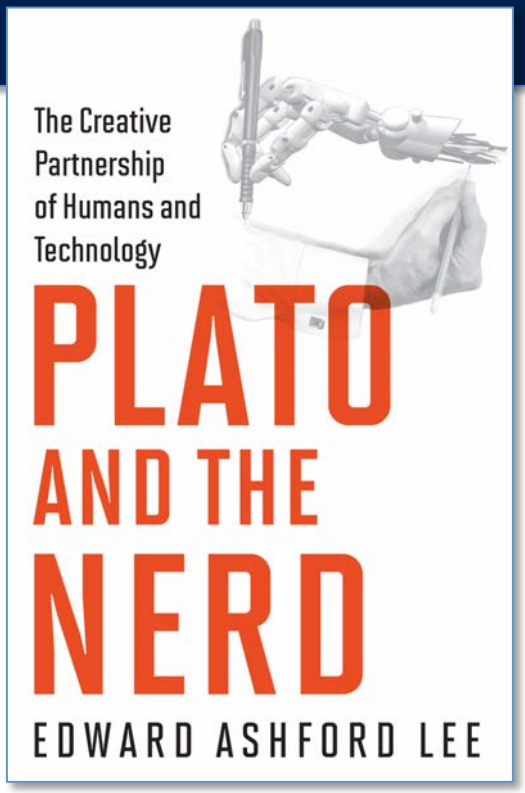
"If computers and software form organisms, then they depend on us for their procreation. We provide the husbandry and serve as midwives.

…

The machines make the humans more effective at the very husbandry that spreads the software species.

….

the software survives and evolves only if the company survives and evolves, and vice versa."



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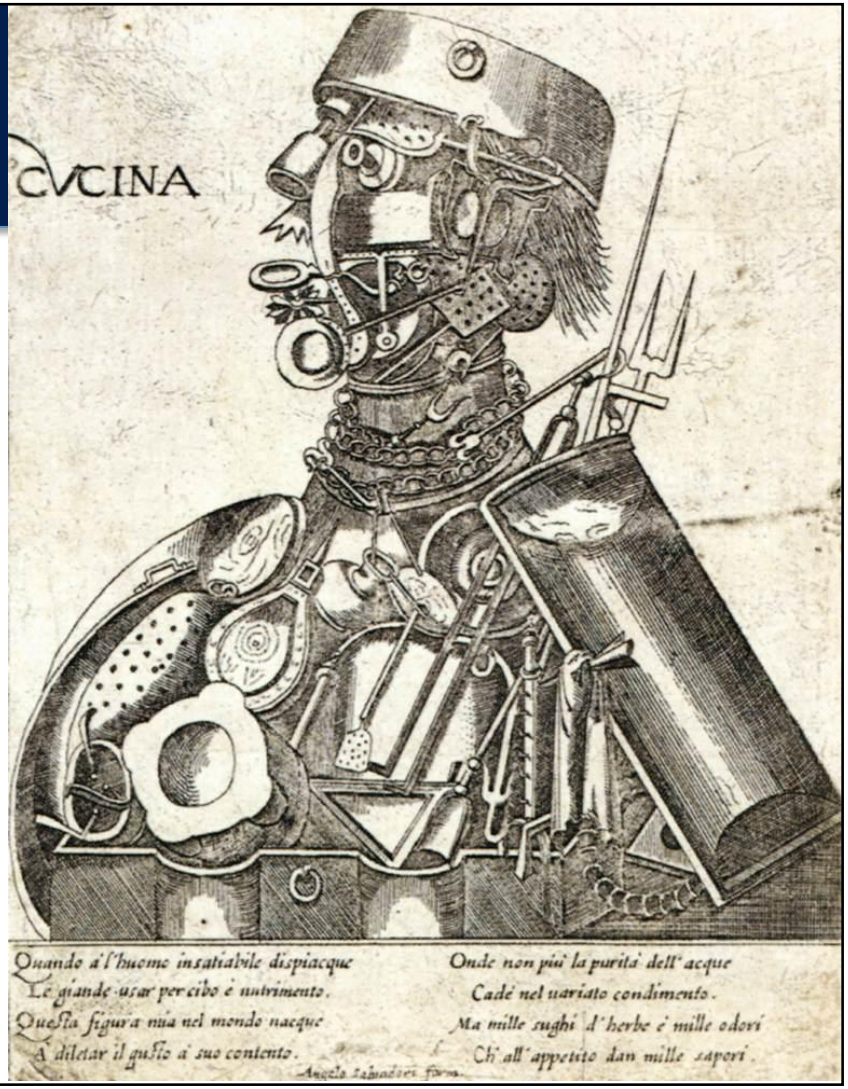
Will We Become Cyborgs?

We are already integrating technology into our biology and our cognition.



By Unknown Master, Italian (1570s)
Web Gallery of Art, Public Domain

Obligate Endosymbiosis

Lynn Margulis (1938-2011)
[Photo by Jpedreira, CC BY-SA 2.5]

Lee, Berkeley

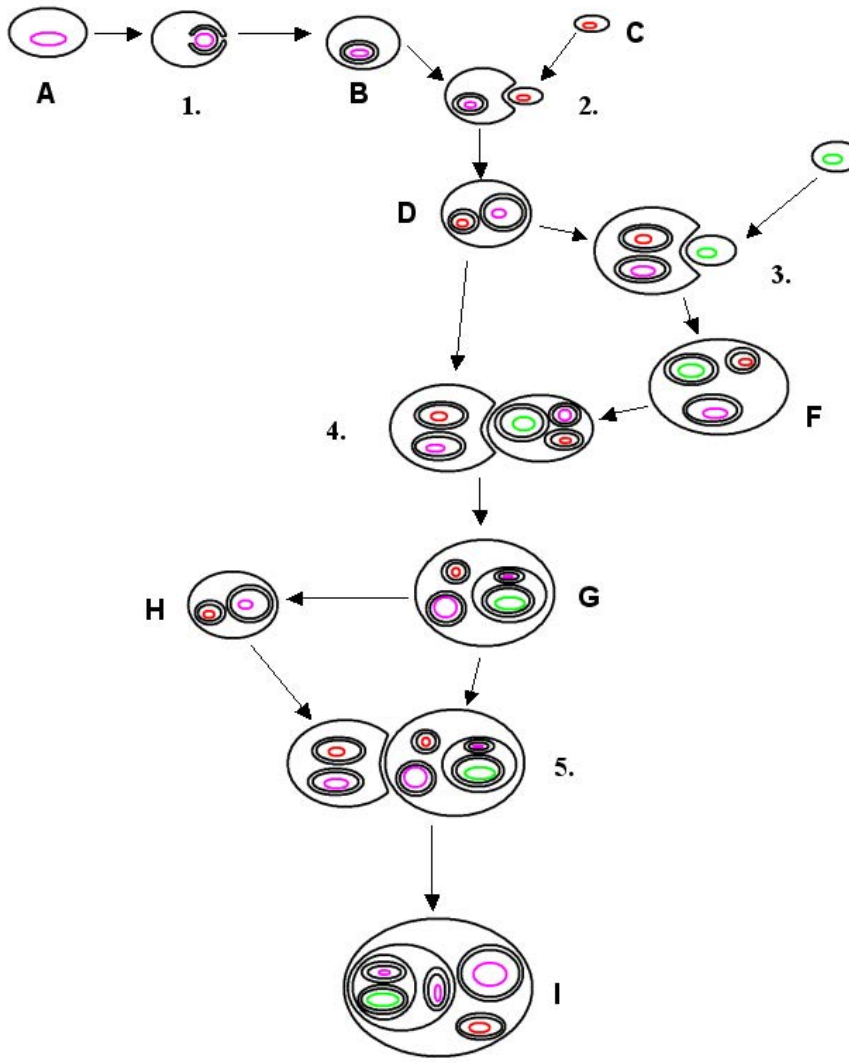
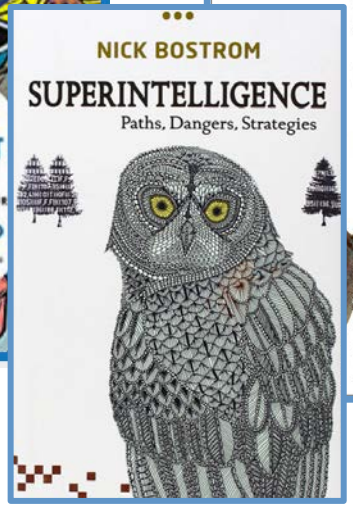
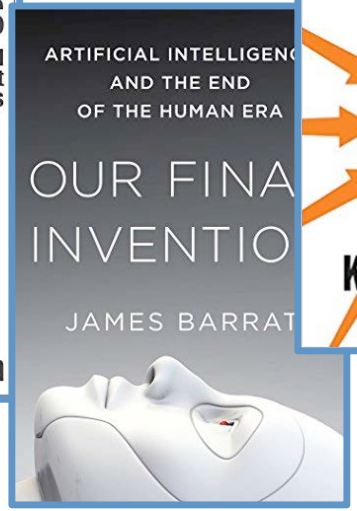


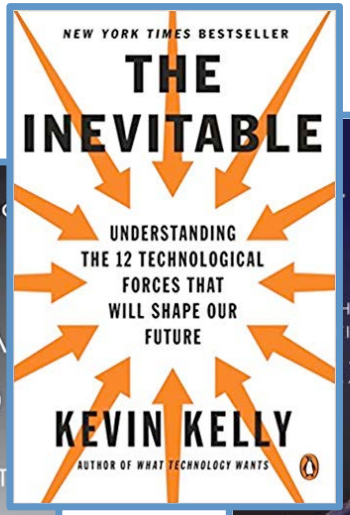
Diagram CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=475082

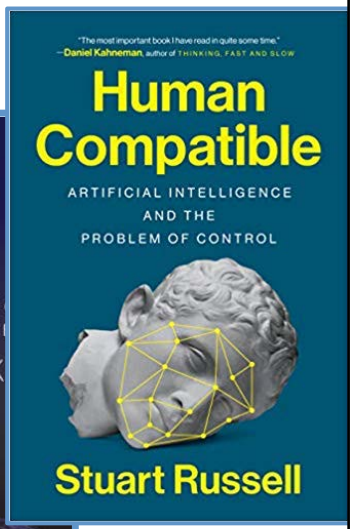
Hype and Fear About AI

Is AI an *existential threat* to humanity?









Three Questions About AIs

1. Are we going to lose control of them?
2. Are they alive?
3. Are they going to match and exceed us?

A Prerequisite to Losing Control?

Can we teach computers to program?

–Maarten van Steen, March 19, 2019

Can computers teach humans to program?

–Edward Lee, March 20, 2019

Computers Already Teach Humans to Program

Eclipse

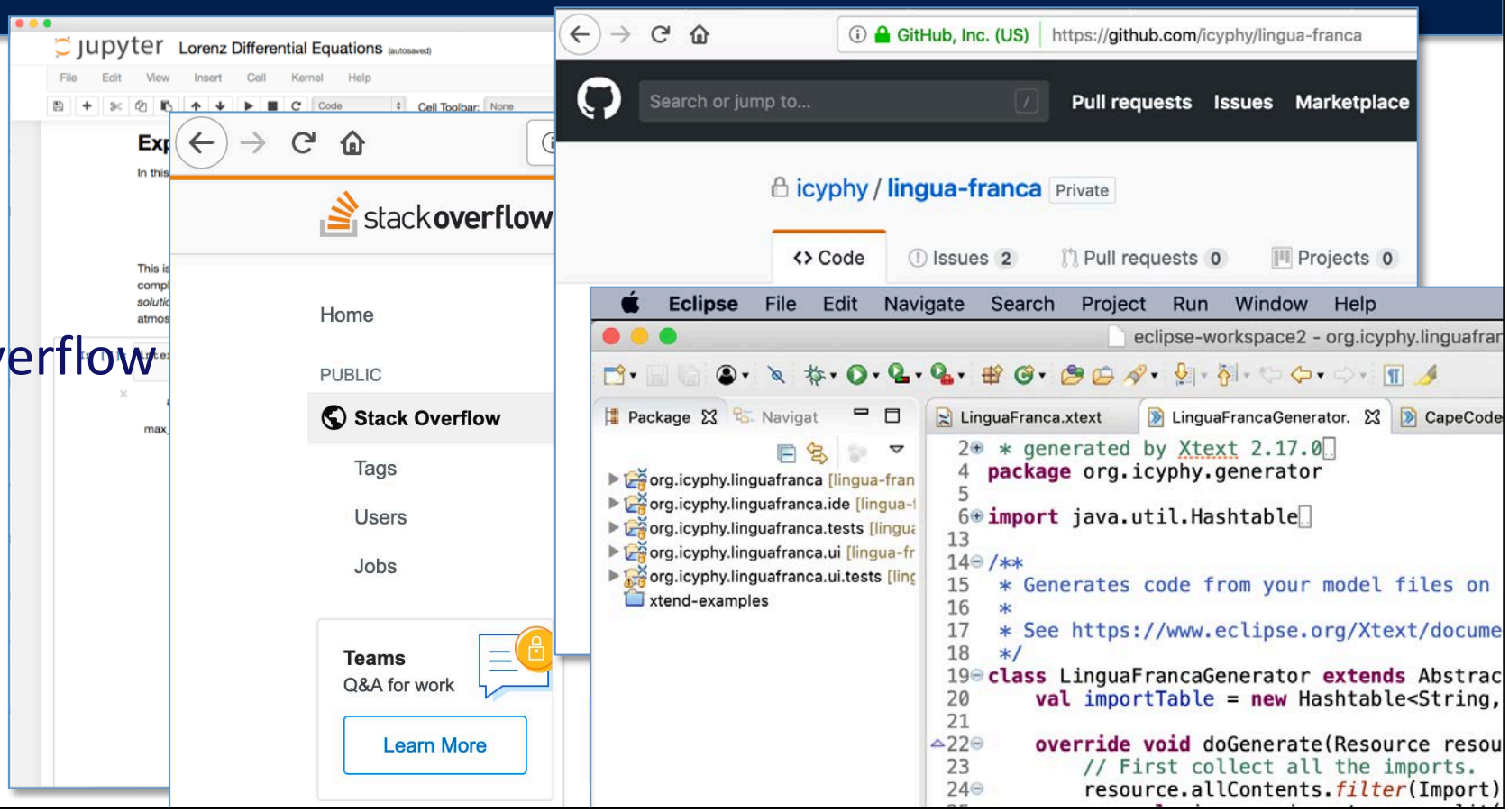
Jupyter

Github

Stack Overflow

Google

…



Lee, Berkeley

Are Humans in Control of AI?

Are we going to lose control of them?

No.

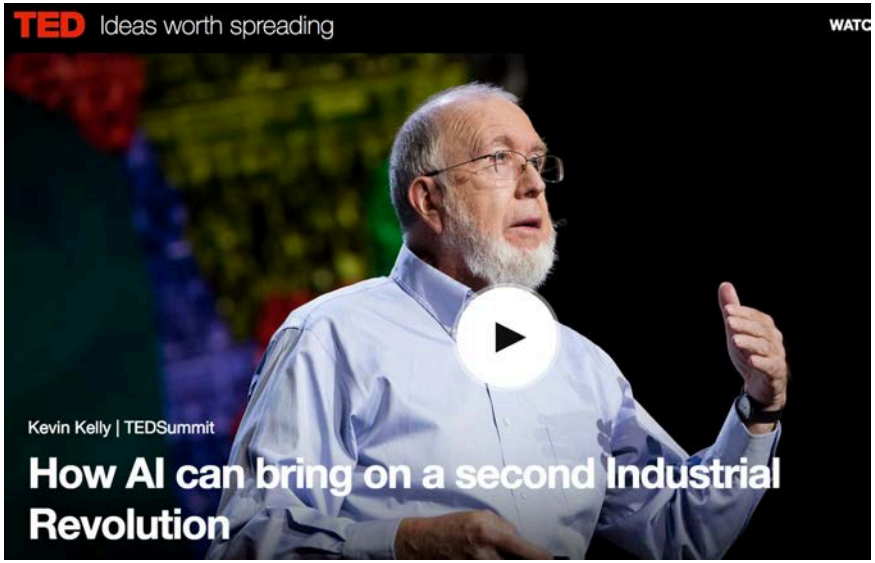
We never were in control, so we can't lose control.

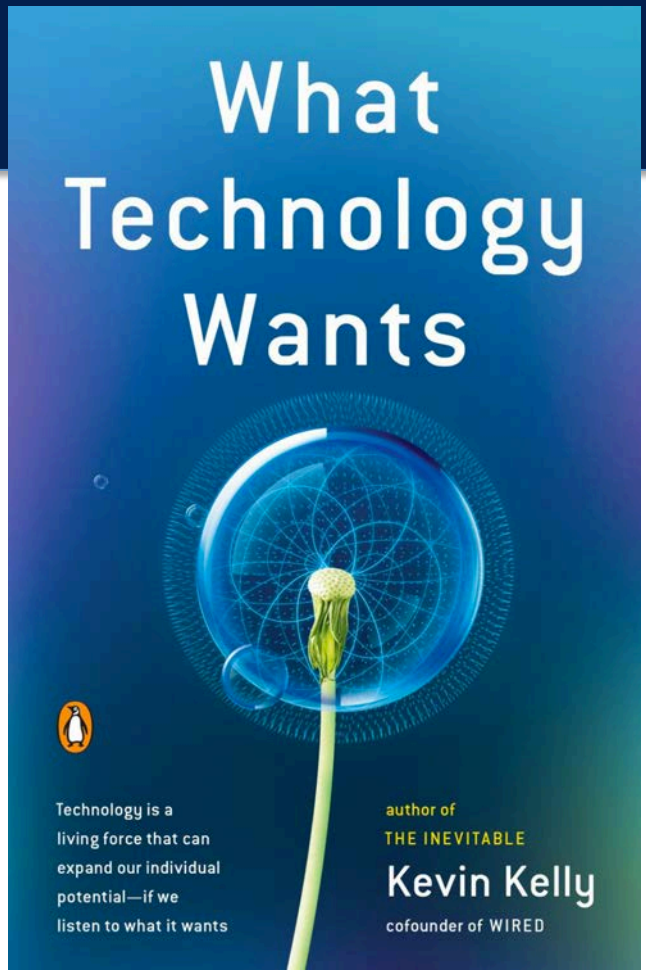
Three Questions

1. Are we going to lose control of them?
2. Are they alive?
3. Are they going to match and exceed us?

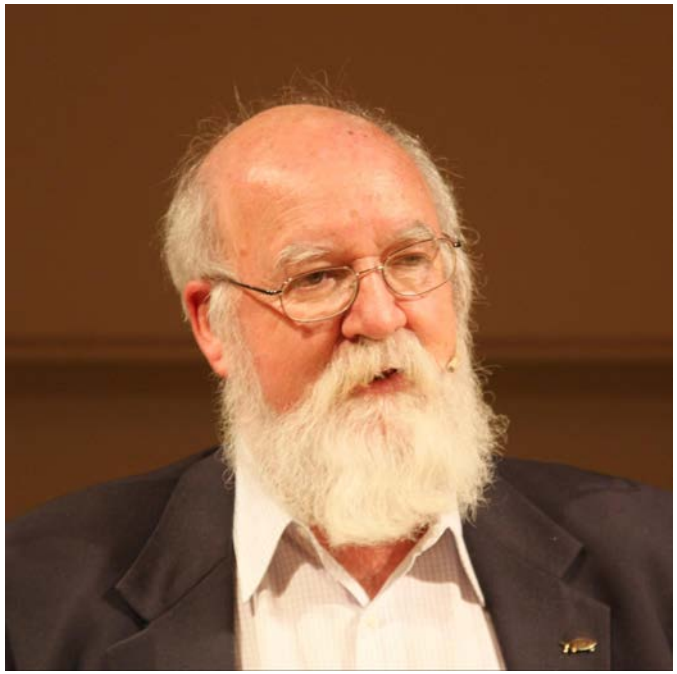
The Technium

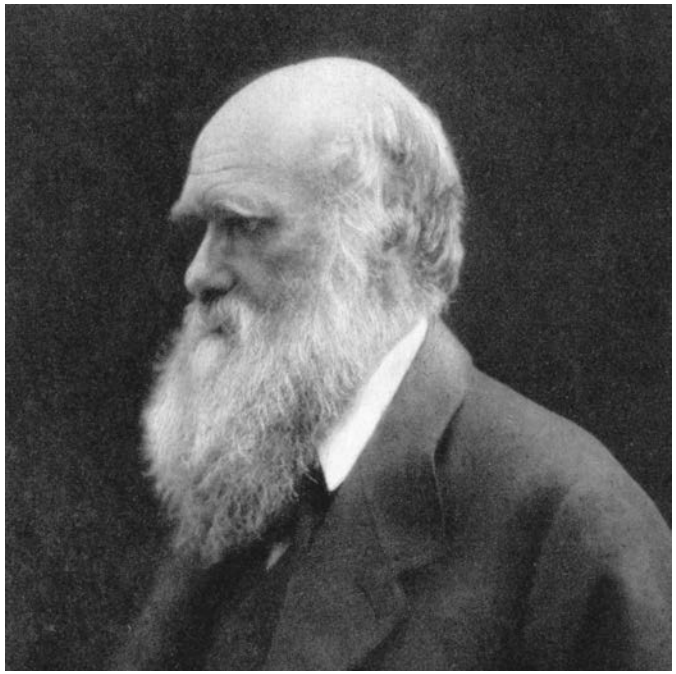
Kevin Kelly, talks about the “technium” as the 7th kingdom of life.





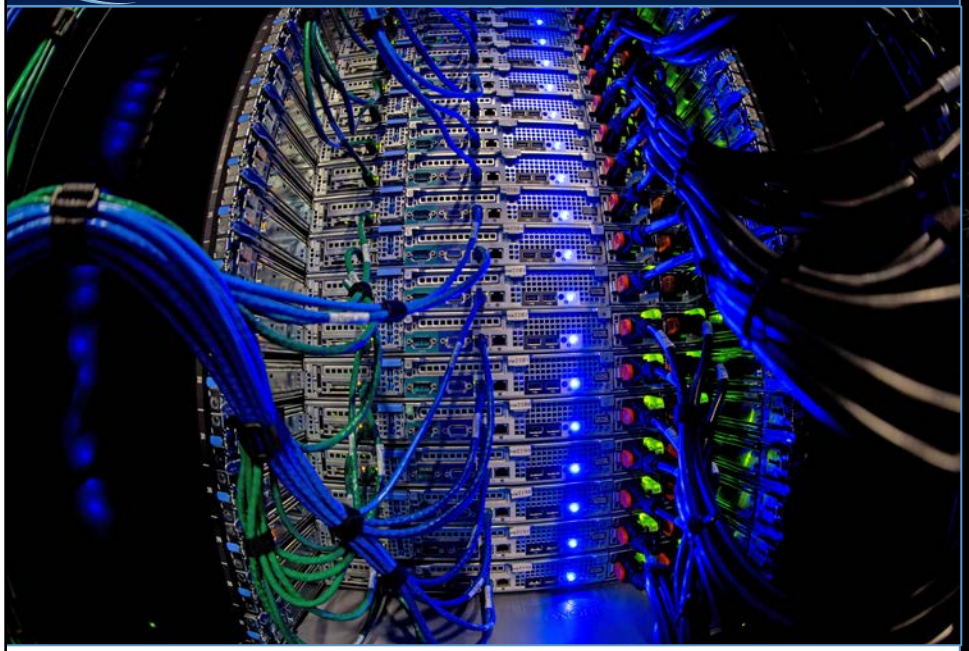
Daniel Dennett on Life



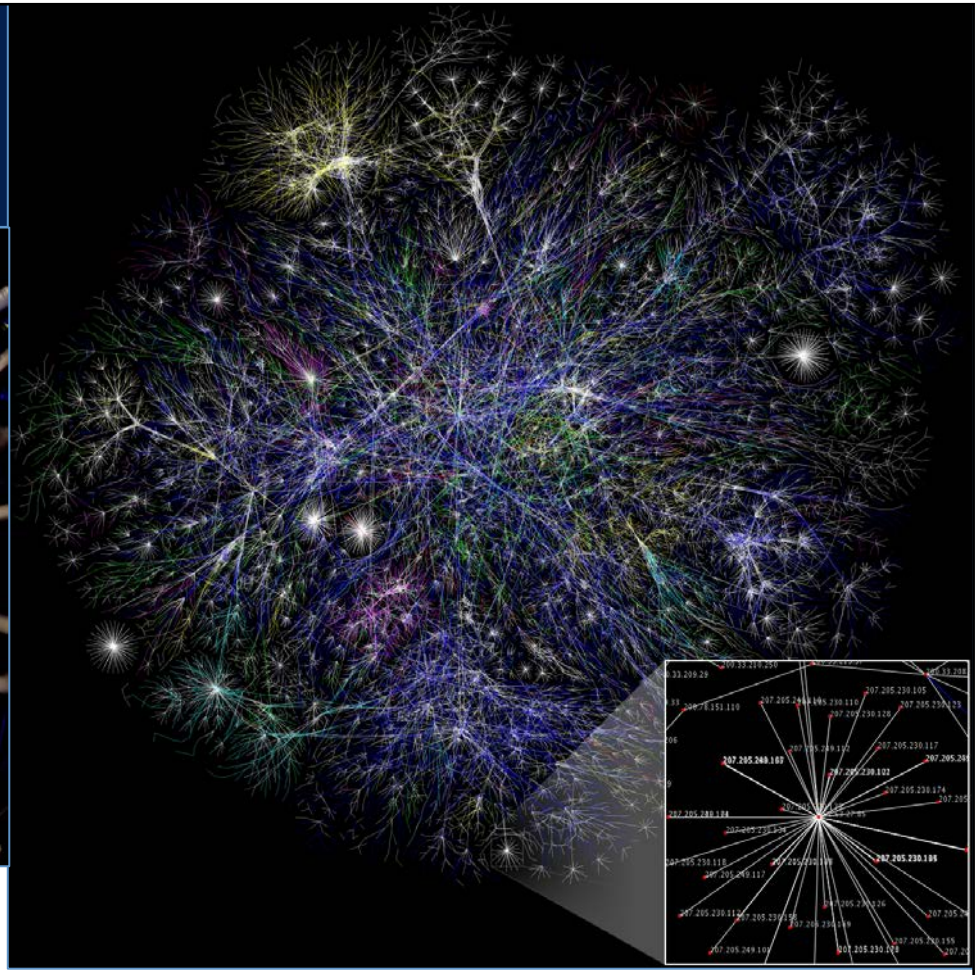


"It ain't the meat, it's the motion."

Is It Alive?



Wikipedia Servers
[Victor Grigas/Wikimedia Foundation CC BY-SA 3.0]

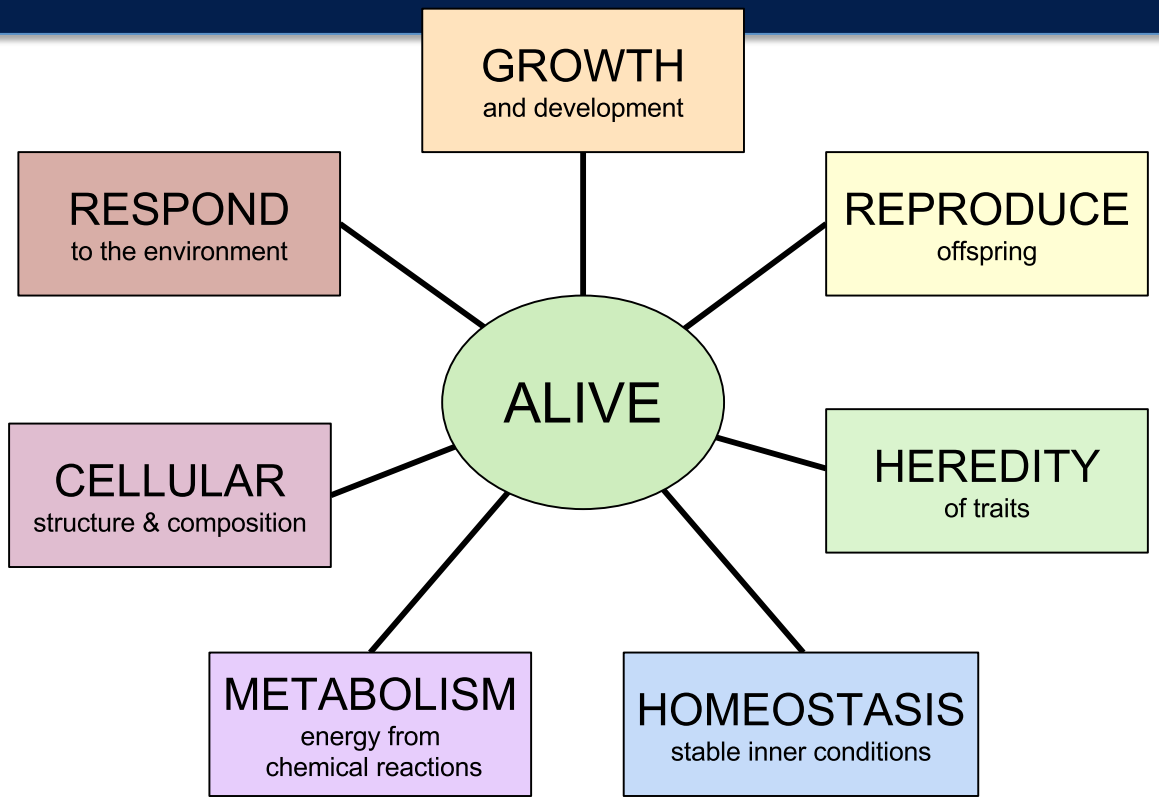


View of the Internet
[The Opte Project, via Wikimedia Commons CC BY 2.5]

What does it mean to be alive?

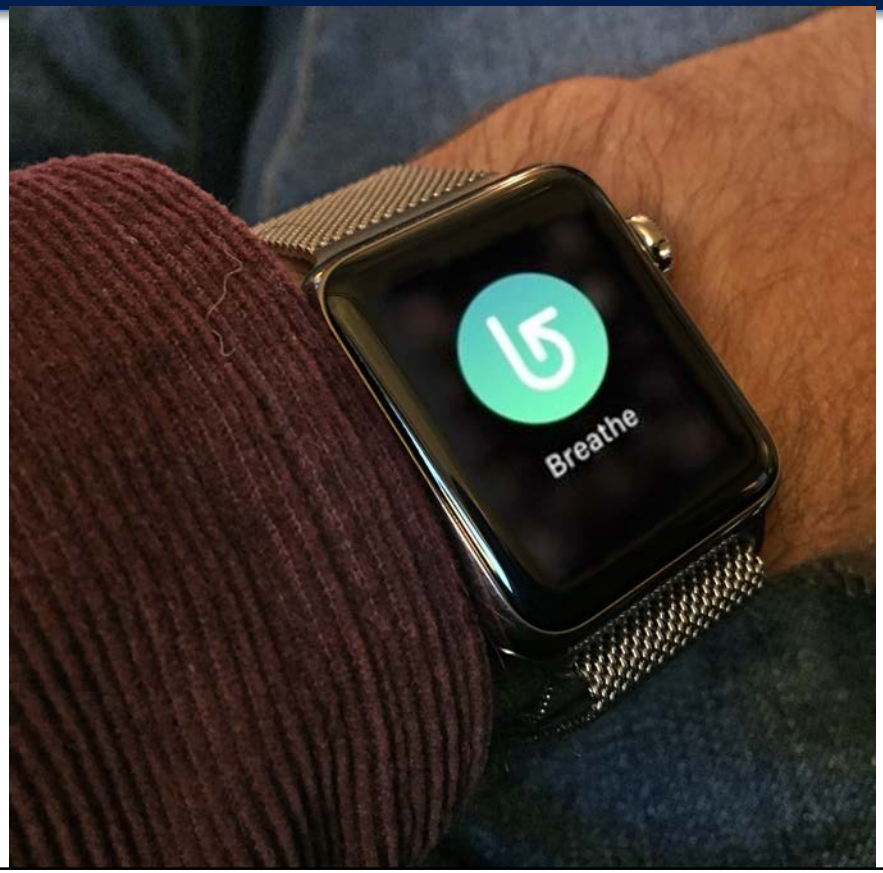
Wikipedia is arguably a “living digital being” (LDB, or “eldebee”).

It has all of these properties.



[After Chris Packard, CC BY-SA 4.0]

Reproduction? Heredity? Mutation?



Sterile Workers and a Queen Bee

[Photo by Max Pixel, released to public domain - CC0]

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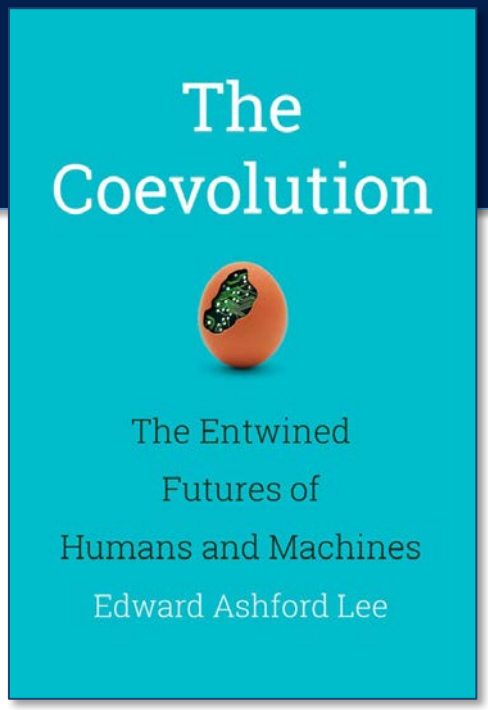
So, Are They Alive?

This depends on what you mean by “alive,” but there is no doubt they share many features with biological beings.

And more importantly, their relationship with us is much like a biological symbiosis.



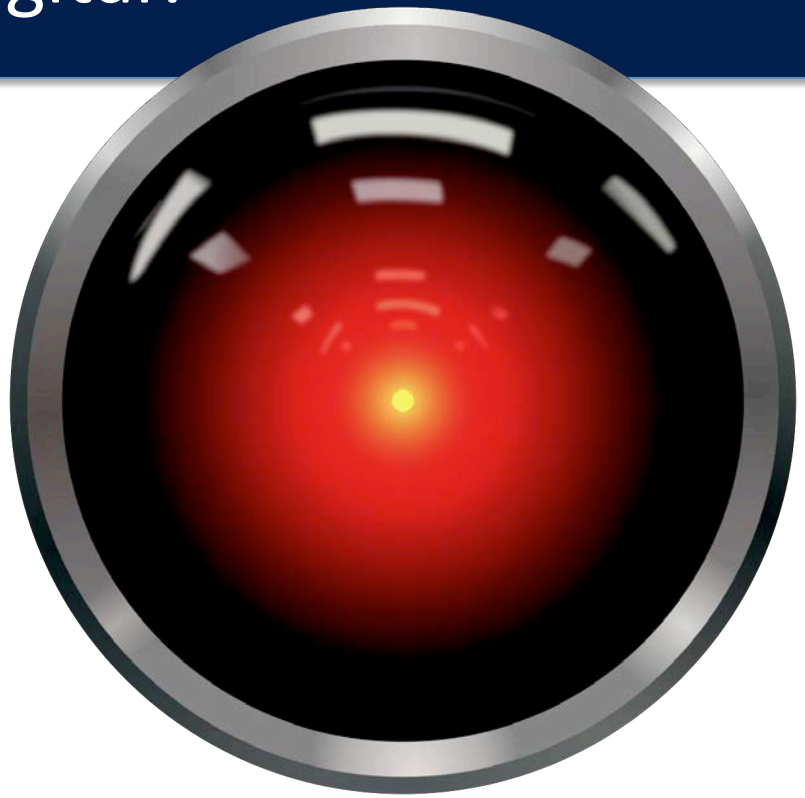
MIT Press, 2020

Three Questions

1. Are we going to lose control of them?
2. Are they alive?
3. Are they going to match and exceed us?

Computers already exceed us in many dimensions.
So the interesting question is: will they match us?

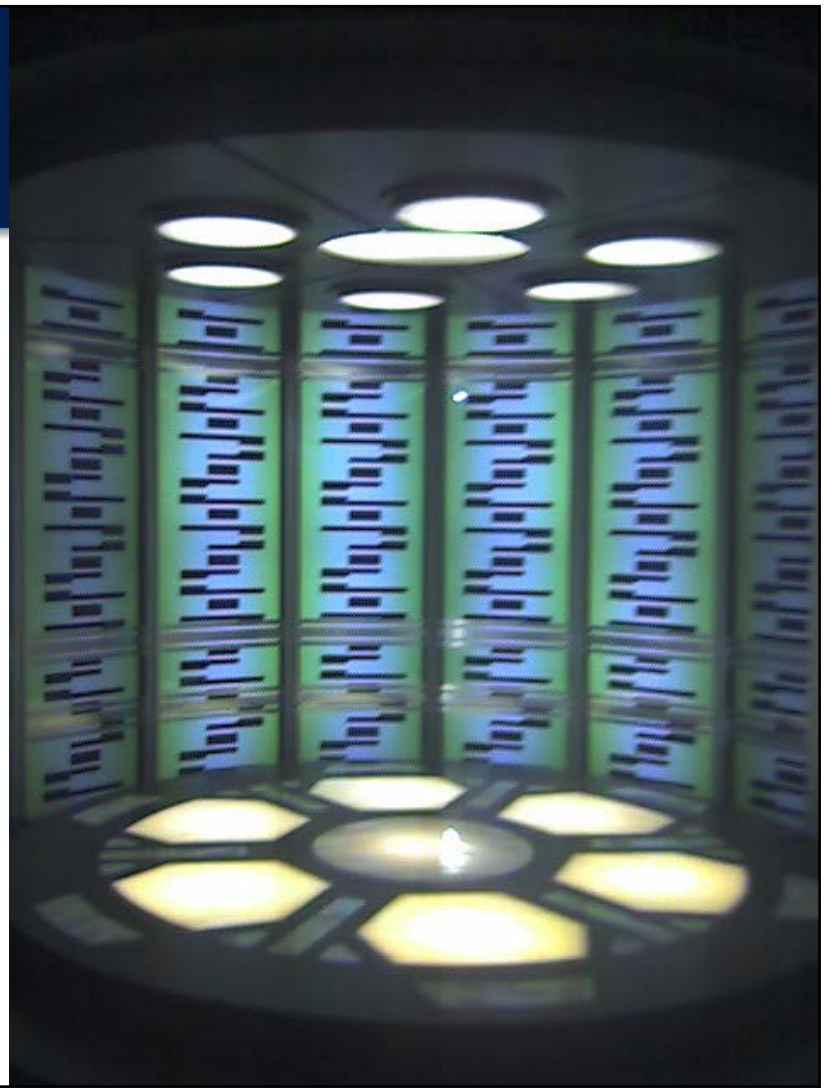
Are We Digital?



HAL, the computer in Stanley Kubrick's 1968 movie, *2001: A Space Odyssey*

Freeing the Mind From Matter

- Uploading?
- Teleportation?
- Are we really software and data?



Teleportation and Uploading

What happens to "I"?

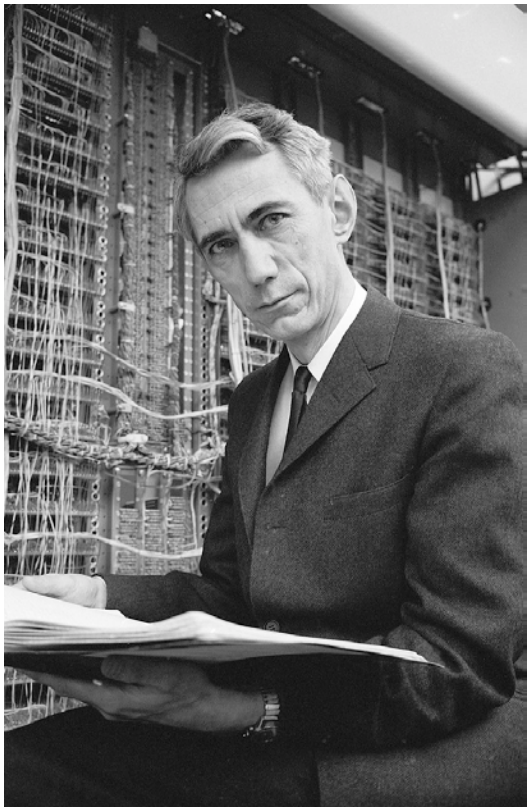
- Is the reconstruction the same "I"?
  - How can we tell?
- What if the original is not destroyed?
  - Two "I"s?
- What if a backup copy is later instantiated?
  - Two "I"s of different ages?

The Sense of Self
Per Three Philosophers

What happens to "I"?

- Derek Parfit:
  - The notion of "I" makes no sense.
- Daniel Dennett:
  - "I" is a fiction, an illusion, a social construction.
- Douglas Hoftstadter
  - "I" can be in two places at once.

A Simpler Answer: “I” Is Not Digital



Claude Shannon

Shannon showed in 1948 a noisy channel can, in principle, perfectly convey a finite number of bits (the “channel capacity”).

The converse is even more important: A noisy channel *cannot* convey *more* than a finite number of bits.

Or Maybe *Everything* is Digital?

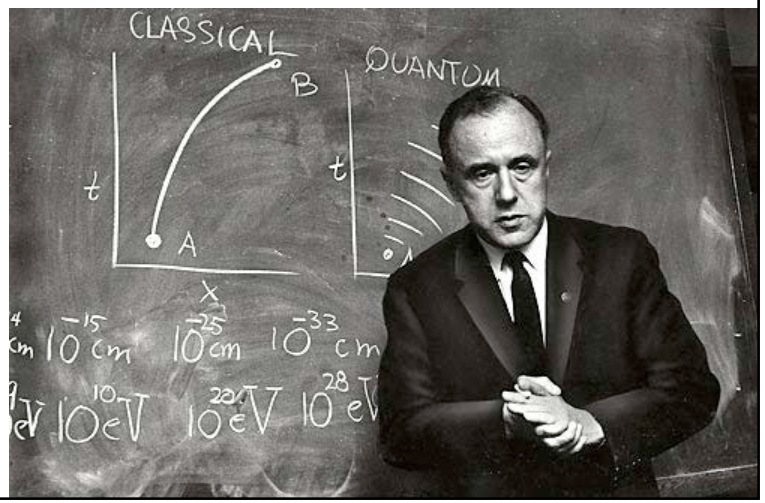
Variants of the "Digital Physics" hypothesis:

1. The number of possible states of a physical system is finite.
2. Physical processes are digital and algorithmic.
3. Every physical process is a Turing computation.
4. The physical world is a computer.
5. The physical world is a simulation.

These theses are not falsifiable by experiment, and therefore not scientific according to the philosophy of Karl Popper.

Lee, Berkeley

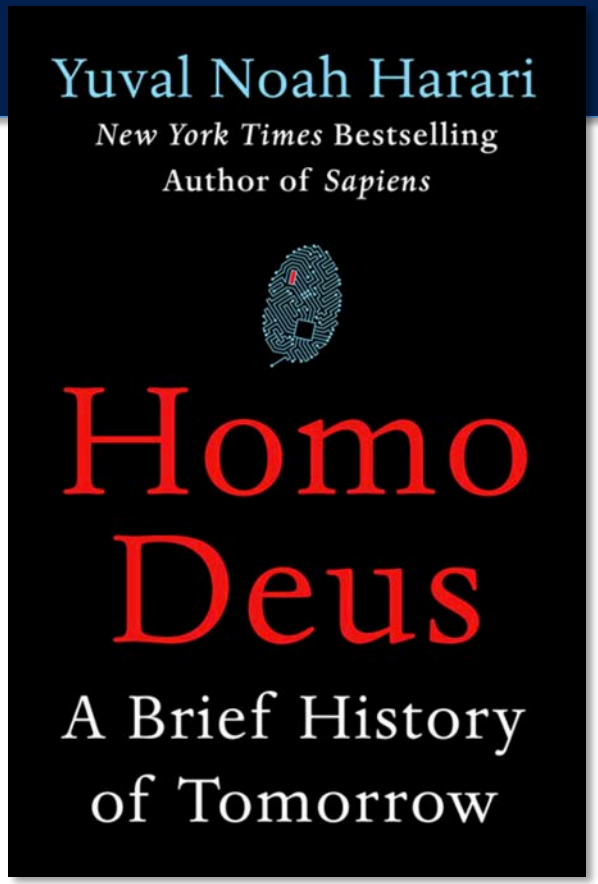
John Archibald Wheeler
"It from bit"



Dataism is a Faith not a Scientific Principle

I borrowed the term “dataism” from Yuval Noah Harari.

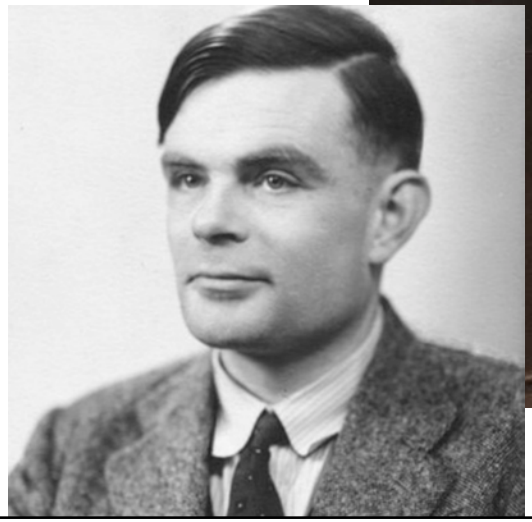
[Photo By Daniel Naber −CC BY-SA 4.0]



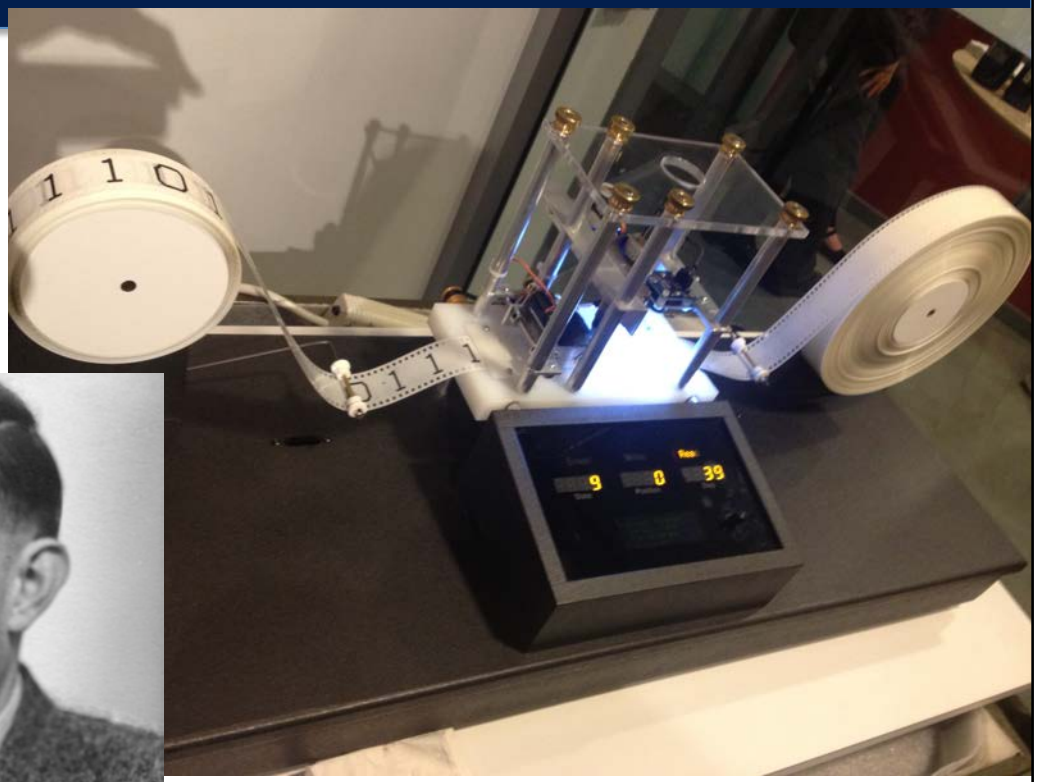
The “Universal Machine” Fallacy

Turing machines:

- Algorithmic
- Digital
- Terminating

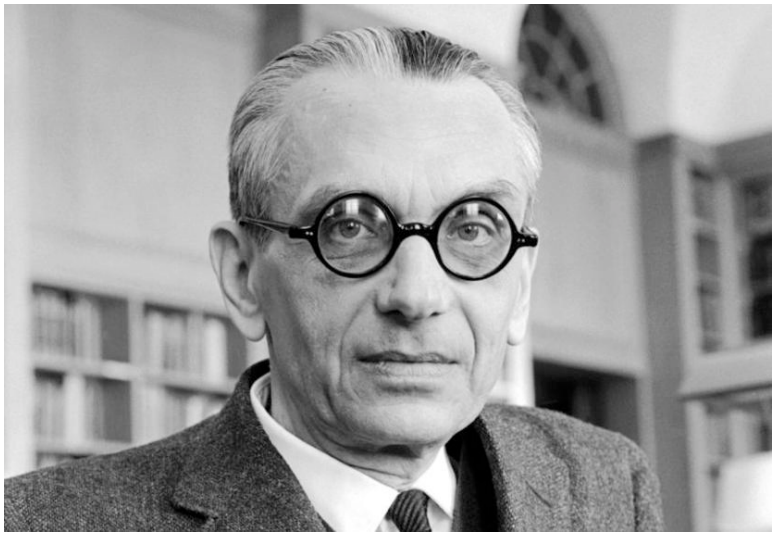


Alan Turing



Machine designed by Mike Davey
[Photo by GabrielF, CC BY-SA 3.0]

No Universal Machine Has Yet Been Invented

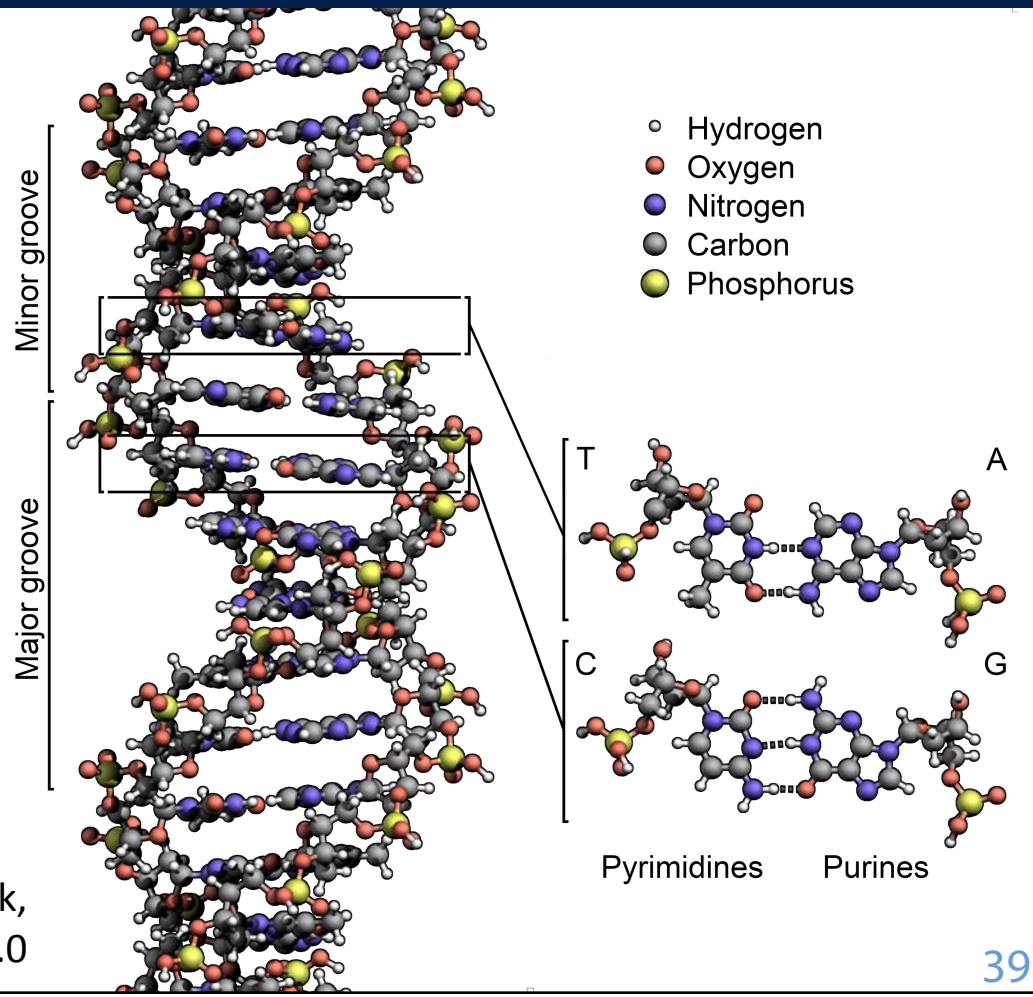


Kurt Gödel

If one is ever invented, it will not be, at its essence, a discrete, algorithmic, terminating process.

The DNA Fallacy

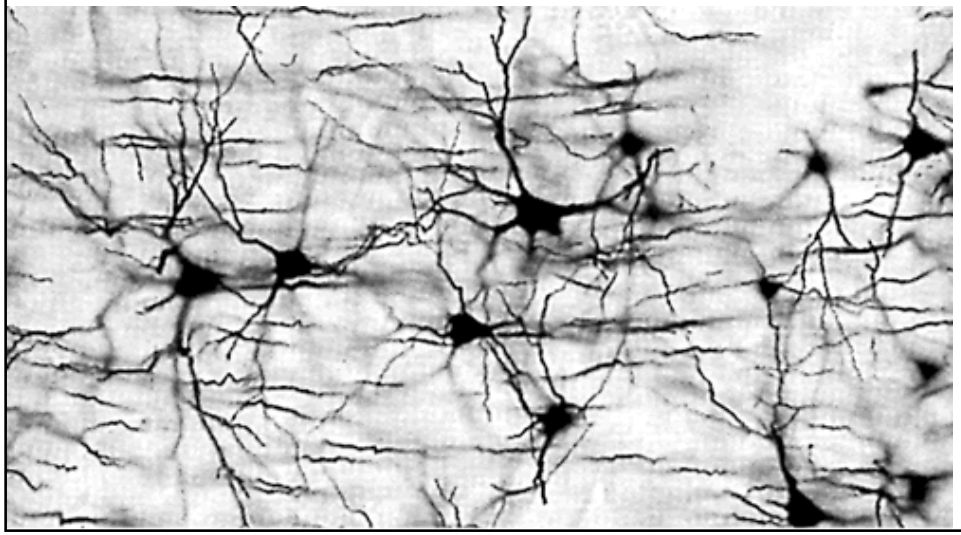
Every human alive today is the endpoint of continuous, unbroken, biological process dating back about four billion years.



By Zephyris - Own work, CC BY-SA 3.0

The Connectomics Fallacy

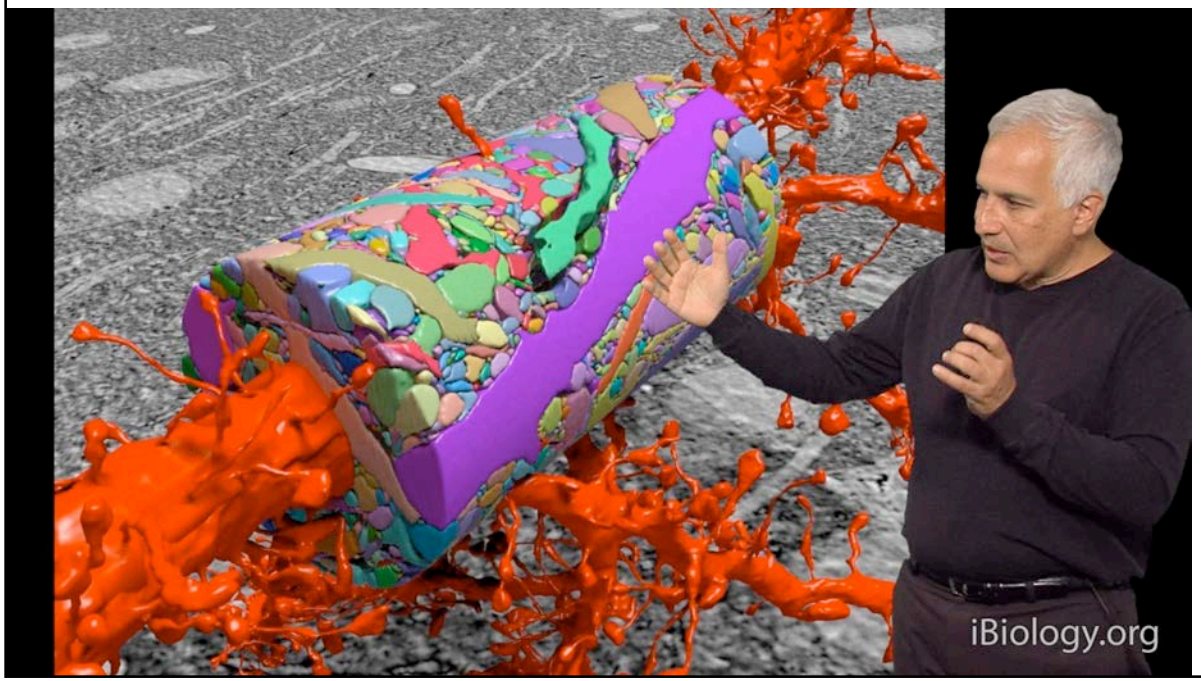
- Neurons fire discretely. (McCulloch and Pitts, 1940s)
- Neurons combine to realize logic functions.
- Logic functions can be realized on other hardware (Putnam, 1960s).
- Connections will reveal brain function (Lichtman, 2000s).



Camillo Golgi's method (1870s) gives a misleading picture of the brain.

Connectomics:
A More Complete Picture of the Brain

Can we understand brain function by studying the wiring diagram, even in principle?



Jeff Lichtman,
Harvard

If Cognition is not a Digital, Algorithmic Process, then…

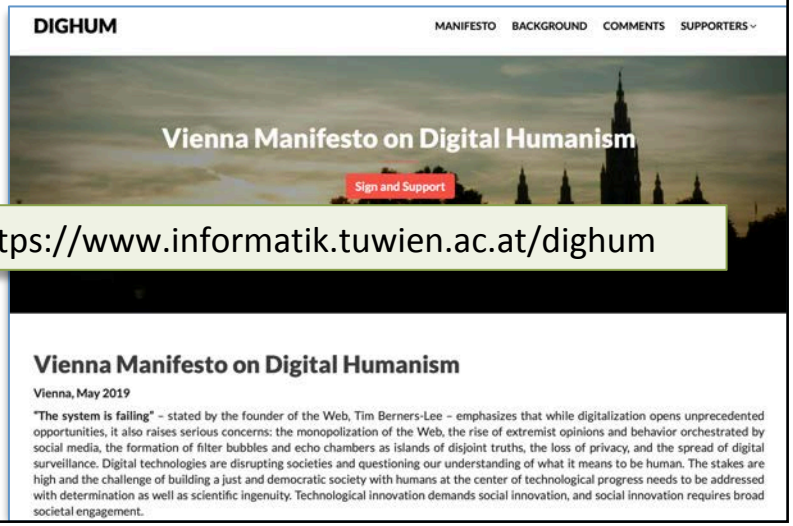
"Your mind is entirely your own."

And we have not yet invented the technology to make cognitive AIs.

Digital Humanism

- A call to action
- A rejection of naïve approaches
- A call to a multidisciplinary approach
  - Humanists
  - Scientists
  - Politicians
  - Technologists
- A call for humility

Hannes Werthner, lead author of the Vienna Manifesto on Digital Humanism.

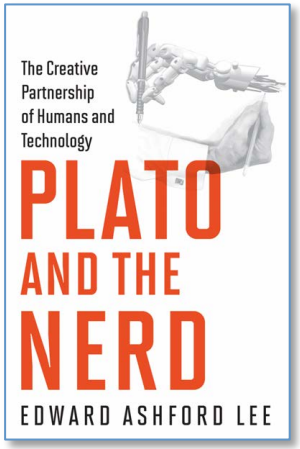


https://www.informatik.tuwien.ac.at/dighum

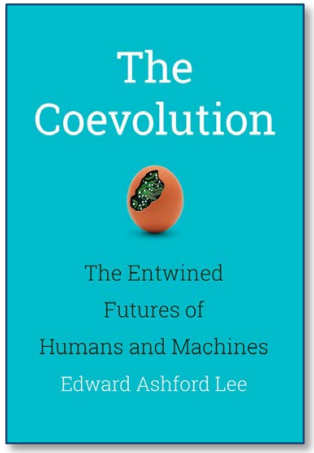
Lee, Berkeley

Conclusion

We *nudge* rather than *control* technology development, and we change as technology changes. Only with a deeper understanding of these coevolutionary processes can we have any hope of effective policies that ensure that technology serves humanity.



MIT Press, 2017



MIT Press, 2020