Is Bioinformatics Possible?

Philosophical problems and opportunities

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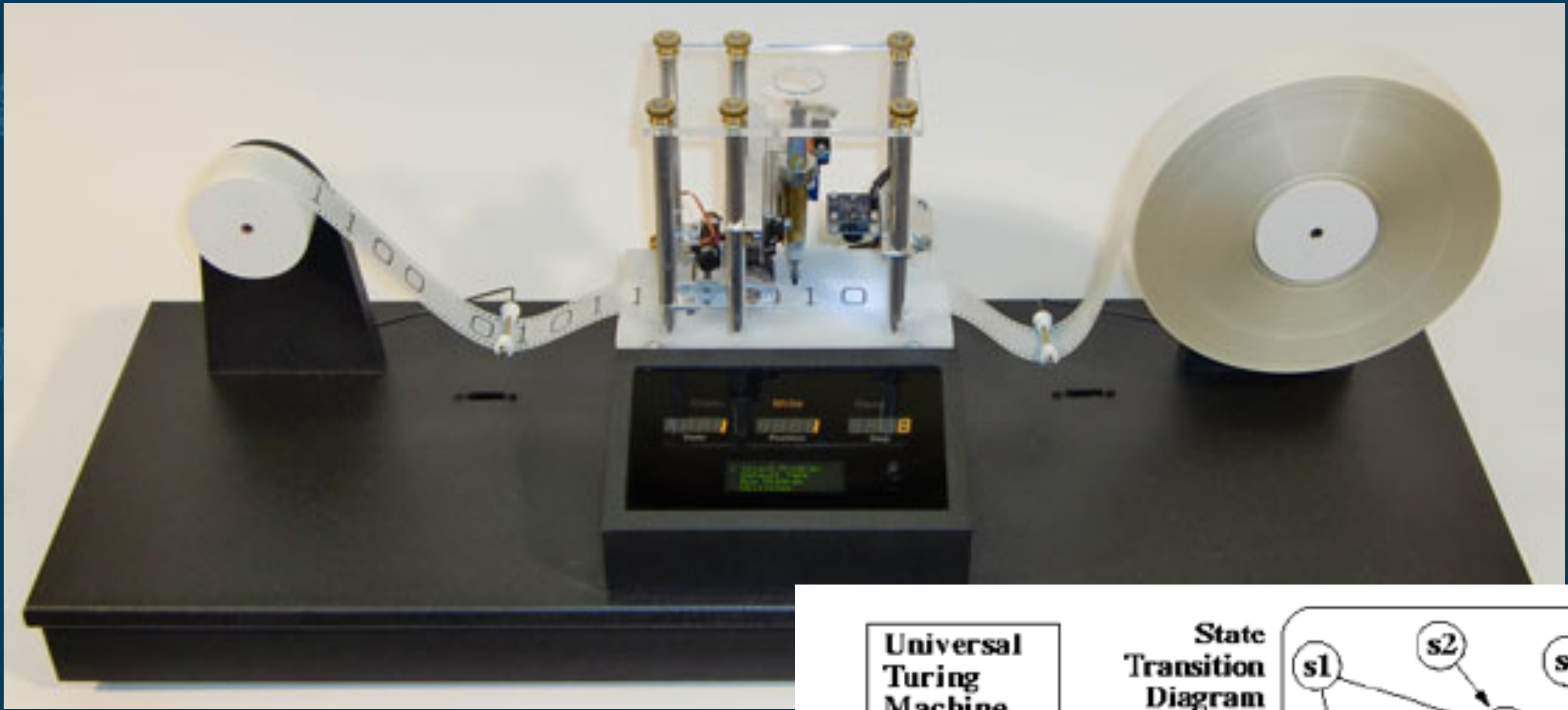
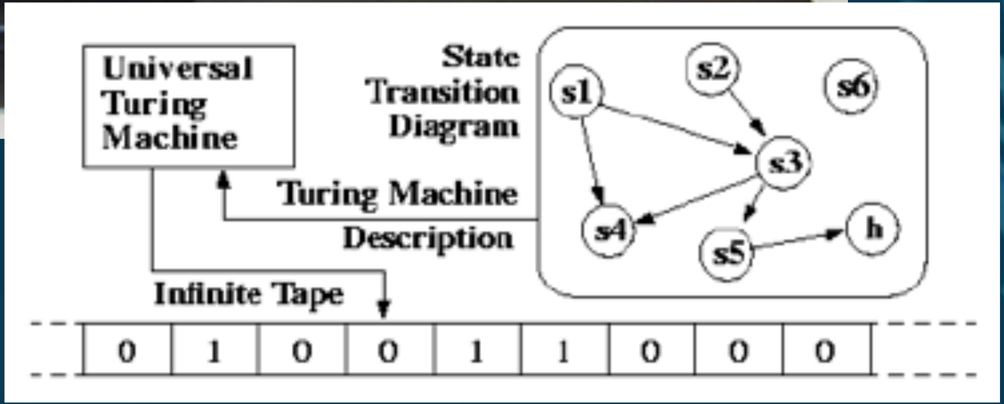
Background

PhD computer science (programming languages)

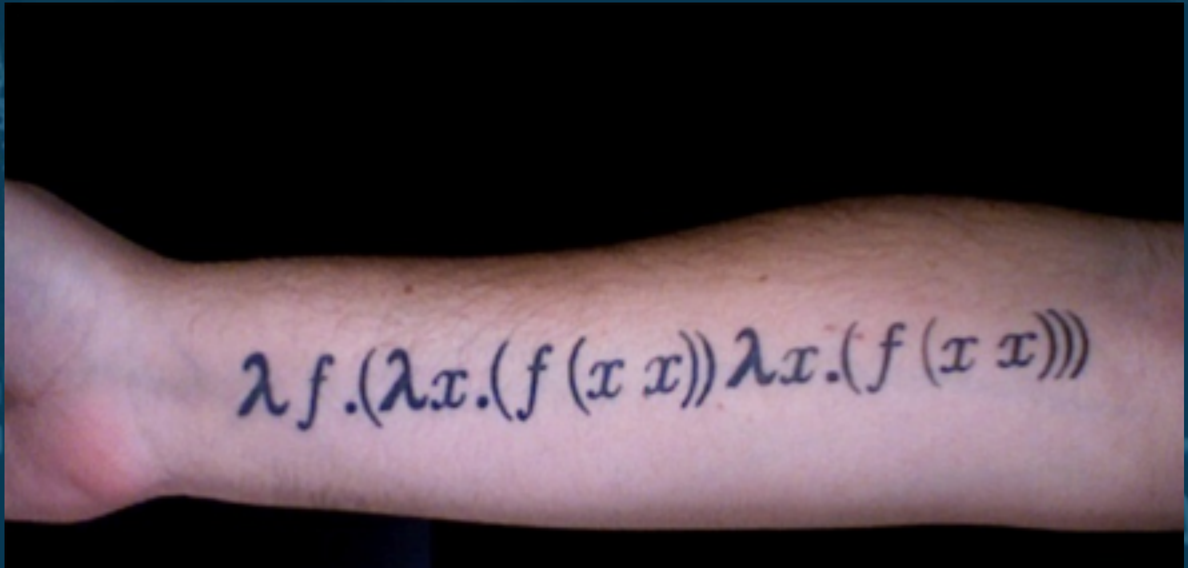
Now working with software development for toxicology/drug discovery and wheat genomics

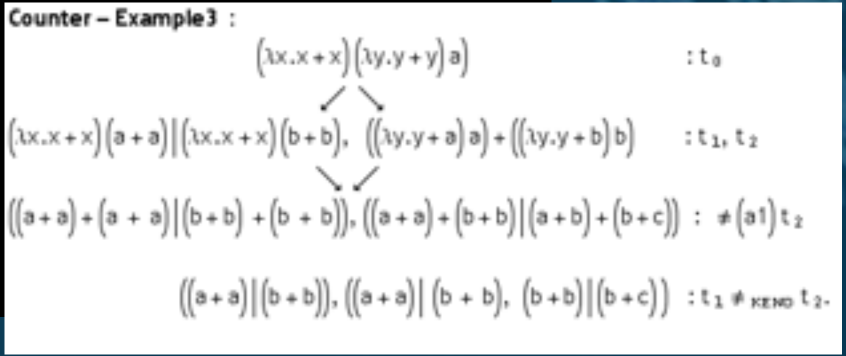




A Turing machine (Alan Turing, 1936)

Lambda calculus (Alonzo Church, 1930s)





What can computers do?

Turing machines and *lambda calculus* were shown to be exactly equivalent.

This is the *only* thing that computer science studies, and *every* digital computer is compatible with it.

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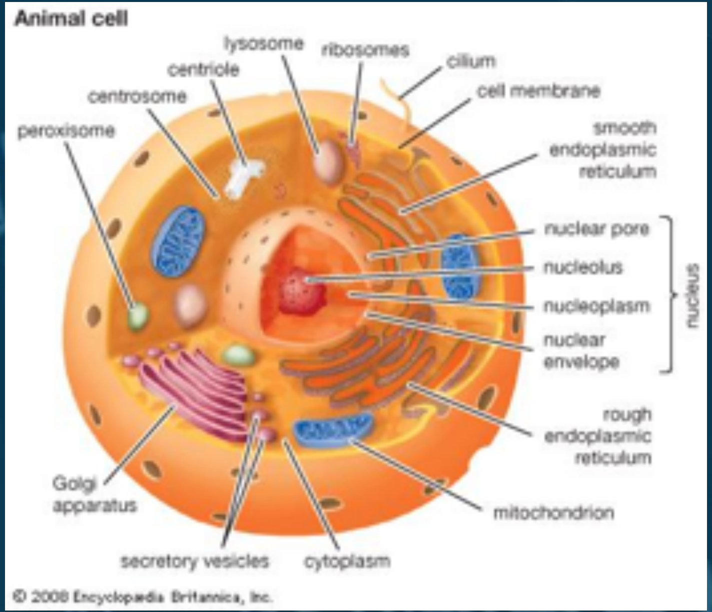
Animal cell
lysosome
ribosomes
cilium
centriole
cell membrane
centrosome
peroxisome
smooth endoplasmic reticulum
nuclear pore
nucleolus
nucleoplasm
nuclear envelope
nucleus
rough endoplasmic reticulum
Golgi apparatus
mitochondrion
secretory vesicles
cytoplasm
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What is bioinformatics doing?

- Creating *really big* databases (usually, experimental records)
- Writing *a lot* of software
  - Making predictions
  - Simulating organisms/cells/proteins/molecules
- Sending data through the internet

for the sake of...

- Clinical/industrial decision making
- Scientific discovery

The “laboratory stack”

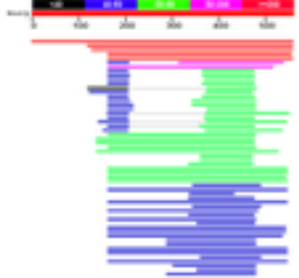
Humans, theories, intuition

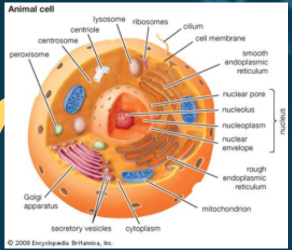
Software tools and mathematical models

Machine/assay (e.g. Illumina, GeneChip, Nanopore…)

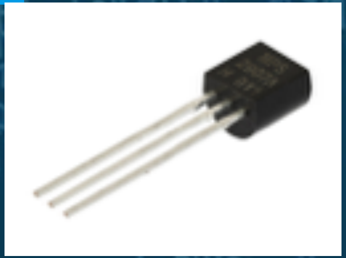
Laboratory methods

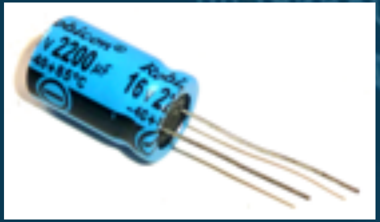
Organism/tissue/cell





The “ground” of computing





Counter – Example3 :

$$(\lambda x.x+x)\big((\lambda y.y+y)\,a\big) \quad : t_0$$

$$\swarrow \quad \searrow$$

$$(\lambda x.x+x)(a+a)\,\big|\,(\lambda x.x+x)(b+b), \quad \big((\lambda y.y+a)\,a\big)+\big((\lambda y.y+b)\,b\big) \quad : t_1, t_2$$

$$\searrow \quad \swarrow$$

$$\big((a+a)+(a+a)\,\big|\,(b+b)+(b+b)\big), \big((a+a)+(b+b)\,\big|\,(a+b)+(b+c)\big) \quad : \neq (a1)\, t_2$$

$$\big((a+a)\,\big|\,(b+b)\big), \big((a+a)\,\big|\,(b+b), (b+b)\,\big|\,(b+c)\big) \quad : t_1 \neq_{KENO} t_2.$$

Computing is constructed by humans and well understood. All high level properties can be explained in terms of the basic building blocks: digital circuits. There are no unexpected phenomena.

What is the ground of biology?

What is the smallest building block needed to construct biology? - *We don't know*, because we cannot even simulate a single cell perfectly (yet).

How deep does physics go?

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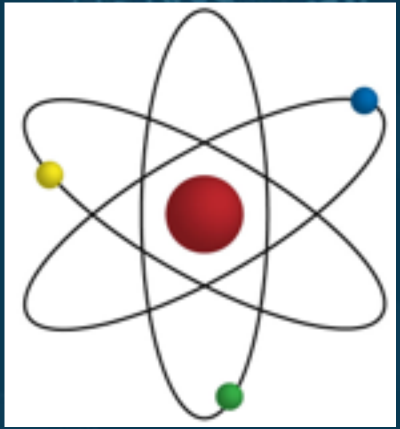
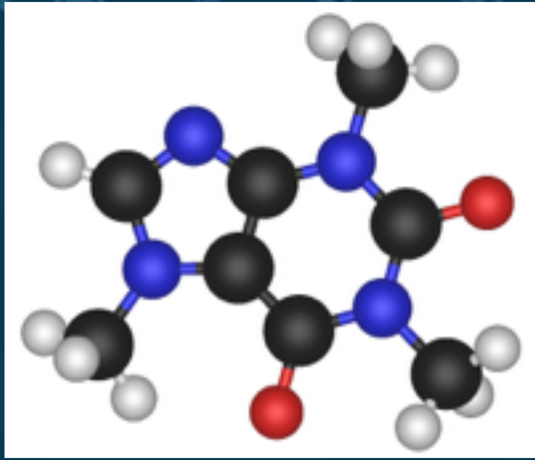




Repetition and history

Computers can always be reset to their starting state. If something goes wrong in software, we can erase the traces and start over.

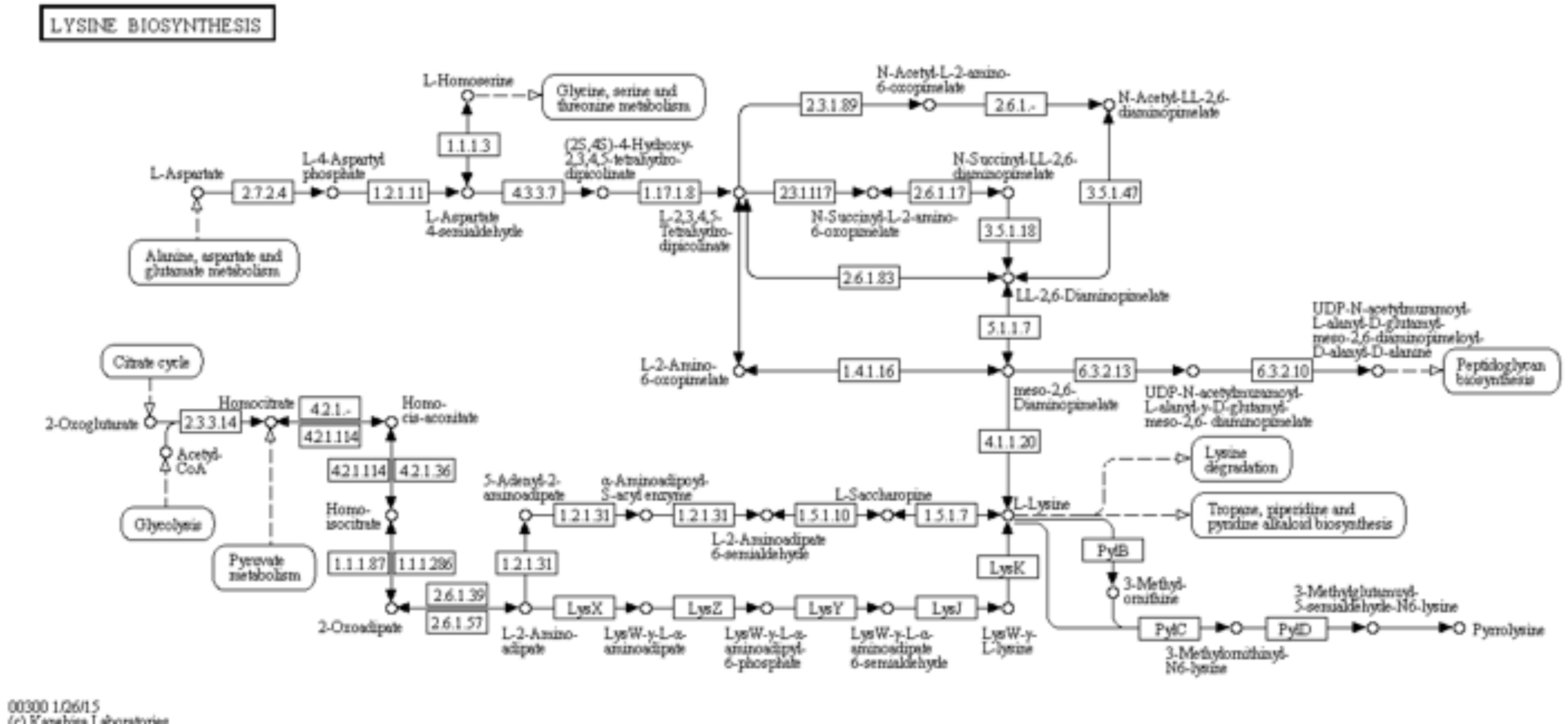
In software, *history is usually irrelevant* and *there are many paths to exactly the same state*.

Biology cannot be reset. With today's laboratory methods, we cannot fully control the state of cells (or even read the state). *History is important*.

Differences

Biology/life	**Computers/formal models**
Top-down (science constructed by humans)	Bottom-up
No well-defined ground	Well-defined ground
Many properties not known	All properties known
Impossible to “reset” or fully control state	Easy to reset
History is essential (?)	History can be made irrelevant

A metabolic pathway



Metaphors from electronics

Pathways are the circuits of DNA. DNA is the software of life."

It is tempting to think this way, but is it correct? Or wishful thinking?

Can biology really be like engineering?

Imitation/replacement as success?

Definition of success?

If a computer can replace a biological entity, and we can't tell the difference, then we have achieved perfect bioinformatics.

Control as success?

Definition of success? (This definition also involves laboratory equipment!)

If we can control a cell [/protein/organism] and place it in a fully defined state, then we have achieved perfect bioinformatics.

This implies being able to create a perfect copy of any cell, as well as of any organism...

Practices as meaning: Martin Heidegger

Heidegger gives a special ontological status to *equipment*. He calls this *readiness-to-hand* (*zuhanden*).

Biological science and bioinformatics construct more and more practices (behaviours, tools etc) that aim to present and display “the truth” of biology.

Are these activities *discovering* biology, or are they in fact *creating* biology for the first time?

A new goal for bioinformatics?

Rather than *control* or *replace* biology, we should strive to create perspectives that aid the harmonious interaction between humans and biology

Not only a scientific goal - includes metaphors and playfulness

Conclusion

Biology and computers (formal models) are radically different:

(Non-)importance of history

(Im-)possibility of full control

This produces a great tension and friction, *which is not usually discussed.*

If we acknowledge and explore this tension, we could have much better bioinformatics. (A challenge for artists!)

Thank you!

More details at my blog: http://www.monomorphic.org

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