Lecture Eighteen

What is life?

1. Who cares?

Although many biologists wonder about the nature of life, they don't need to define 'life' to do biology. The question really does matter, however, to biologists looking for the origin of life, extraterrestrial life, artificial life or synthetic life. Note that the real question here concerns the *nature of the phenomenon*, not the *meaning of the term*.

2. Signs of life

"For many years a physiological definition of life was popular. Life was defined as any system capable of performing a number of such functions as eating, metabolizing, excreting, breathing, moving, growing, reproducing, and being responsive to external stimuli" (Sagan 1970, p. 303).

But…

- Many non-living systems satisfy one or more of the criteria.
- Many living systems fail to satisfy one or more of the criteria.
- The criteria are highly disparate.
  → These problems don't make physiological checklists useless, but they do motivate the search for a more fundamental 'mark of the living'.

3. The '*n* = 1' problem

To distinguish between the 'essential' and 'accidental' properties of a natural kind, it helps to have a sample size greater than one. But all known examples of living things are thought to share a common ancestor. This makes it hard to distinguish essential properties from historical accidents.

- DNA—essential or historically contingent?
- Carbon—essential or historically contingent?
- Water—essential or historically contingent?

The problem is particularly acute because, to ever achieve '$n > 1$', we'd need to be able to settle the question of whether a purported simulated/synthetic/extraterrestrial life-form was indeed a life-form. But that's the question that motivated our inquiry in the first place!

4. The NASA 'working definition'

"Life is a self-sustained chemical system capable of undergoing Darwinian evolution" (see Mullen 2013).

- What is it for a system to be "capable of undergoing Darwinian evolution"? Joyce: "you can't have Darwinian evolution without self-replication or reproduction. You can't have

it without mutability, heritability, and variation of form and function. And metabolism is in there too."

- What is it for a system to be "self-sustained"? Joyce: "all of the information necessary for the system to undergo Darwinian evolution must be part of the system".

Some concerns…

- Darwinian evolution happens to populations or lineages (typically over long timescales), not to individual living things.
- Does life have to be chemically realized?
- Is Darwinian evolution the only game in town?

→ The '*n* = 1' problem raises its head. OK, this is only a "working definition"—but it's still a problem if it lumbers us with a parochial, geocentric conception of life.

References and suggested reading (* denotes particularly important readings)

Bedau MA (1998) Four puzzles about life. *Artificial Life* 4:125-140

Cleland CE, Chyba C (2002) Defining 'life'. *Origins of Life and Evolution of Biospheres* 32:387-393

*Mullen L (2013) Forming a definition for life: interview with Gerald Joyce. *Astrobiology Magazine*, 25/07/13 [http://tinyurl.com/pux3kyt]

Ruiz-Mirazo K, Peteró J, Moreno A (2004) A universal definition of life: autonomy and open-ended evolution. *Origins of Life and Evolution of Biospheres* 34:323-346

*Sagan C (1970) Life. *Encyclopaedia Britannica (1970 edition)*, pp. 985-1002

Sagan C (1974) The origin of life in a cosmic context. *Origins of Life and Evolution of Biospheres* 497-505

All of these articles (except the Joyce interview and Sagan 1974) can be found in Bedau and Cleland (eds) *The Nature of Life: Classical and Contemporary Perspectives from Philosophy and Science* (2010, CUP).