What are the sufficient conditions?

- Like begets like (heritability)
- Descent with modification (offspring can be different from parents)
- Because of their differences, some individuals are more successful than others at reproducing, and thus passing their traits to the next generation
What can evolve?

• Not just organisms…
• Not just life…
• Not just physical entities?
• What about?…

Evolution of…

• Pieces of computer code
  (Genetic Algorithms, Evolutionary Programming)
• Ideas & behavior patterns
  – Darwinian learning & cognition
  – Darwinian economics
    • Evolution in markets (Doyne Farmer)
  – Cultural evolution & memetics
    • Business practices (John Padgett)
    • Words (linguistic evolution)

A language phylogeny

Coming attractions…

• Dr. Lee Altenberg on:
  – Evolutionary Computation
  – Evolved art!
Another perspective: complexity and functionality

- Classic examples of complex adaptive systems include:
  - An immune system
  - A human brain
  - An economy

What are the important properties of CAS?

- What is important to understand, to predict, and to influence?
- They work!
- Functionality – where does it come from?
  - In natural, and maybe some artificial systems: Darwinian selection

Evolutionary Medicine:

The study of molecular evolution and phylogenetics can yield meaningful insights into disease evolution

Time for more?
Malign Evolution: Somatic selection and cancer

• Is ‘improvement’ always a good thing?

Selection can operate...

• Among organisms within a population
  • Among cells within an organism?
    – Are necessary conditions met?

What are the sufficient conditions?

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What if...

• Certain cells within the body get much better at surviving and reproducing.
• They cast off normal limits on cell proliferation
• Uncontrolled cell proliferation = cancer
Cancers also evolve drug resistance

• When we apply chemotherapy to a population of tumor cells, there is quite likely to be a resistant mutant somewhere in that population of billions of cells. After sensitive cells are killed, resources are freed up for rapid growth by resistant cells.
• This is the central problem in oncology.
• The reason we haven’t been able to cure cancer is that we’re selecting for resistant tumor cells.
• When we spray a field with pesticide, we select for resistant pests. It’s the same process.

Current work

• Cancer is an inevitable outcome of unrestrained somatic selection among cells.
• How is cancer ever avoided, given ongoing cell turnover & somatic mutation?
• Through cell differentiation, animal cells are compartmentalized in a way that suppresses cellular selection & adaptation. If this breaks down, cancer follows quickly

Pepper & Maley: SFI working paper – posted on CSSS wiki