Lecture 13

What is Life?

Astronomy 141 – Winter 2012

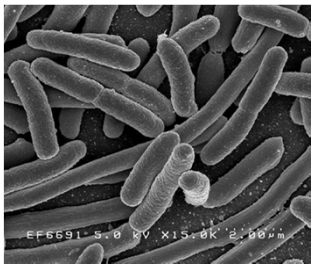
This lecture is about the biological definition of "Life".

Six basic characteristics common to all living organisms on Earth:

- Order or structure
- Ability to Reproduce
- Ability to grow and develop
- Utilize energy from their environments
- Respond to their environments
- Evolve to adapt to their environments

The distinction between life and non-life is not always so obvious…

Ebola virus



E. coli bacteria

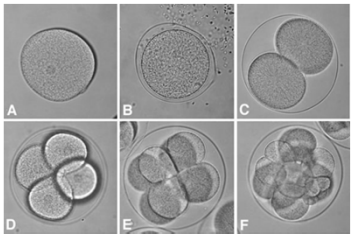
Biologists have identified six basic properties shared by all forms of life on Earth.

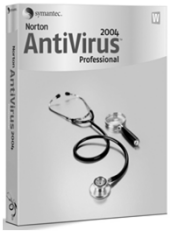
1. Order or Structure
2. Reproduction
3. Growth and Development
4. Energy Utilization
5. Response to Environment
6. Evolutionary Adaptation

1. Order: The molecules making up living things are not randomly scattered but form coherent patterns.

Order is a necessary, but not a sufficient condition to be living.

2. Reproduction: Living organisms can make copies of themselves, either sexually or asexually.





Not every living being can reproduce (sterile forms)
Some non-living things can self-replicate (computer viruses).

Viruses and Prions represent borderline cases between life and non-life.

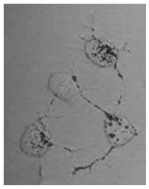
Ebola virus

Viruses cannot reproduce on their own.

They replicate by infecting living cells and hijacking their reproduction mechanisms.

Prions are infectious proteins

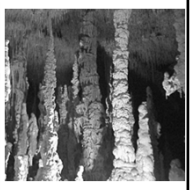
They replicate by inducing normal proteins to fold abnormally?



Prions in mouse cells

3. Growth and Development: Living organisms can increase in mass and add capabilities.

Controlled in part by heredity passed on through DNA.



All living organisms grow and develop, but not everything that grows is living (e.g., stalactites)

4. Energy Utilization: All living organisms use energy drawn from their environment (metabolism).

All living organisms use energy; but not everything that uses energy from its environment is alive (windmills)

5. Response to Environment: All living organisms sense and react to their environments.

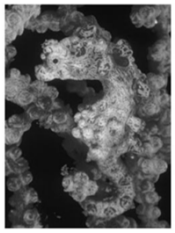
Respond to changes in temperature, sunlight, chemical environment, etc.



The usual "response" is to move…

Not everything that sense and response to its environment is living (e.g., a thermostat)

6. Evolutionary Adaptation: Living organisms evolve to better adapt to their environments.



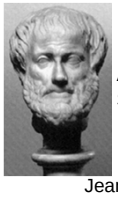
Pygmy seahorse
(camouflaged in coral)

Adaptations accrue to *populations*, not individuals, and require many successive generations.

Significant adaptations can result in the emergence of new species.

The idea of evolutionary adaptation in life is ancient.

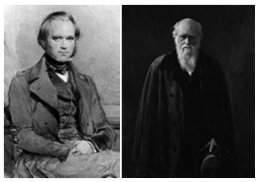
Anaximander (c. 610-547 BC)
Life arose in water and developed into more complex forms.



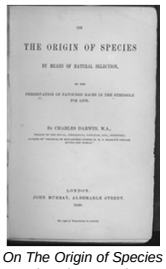
Aristotle (c 384-322 BC)
Species are fixed and unchanging.
Wrong

Jean-Baptiste Lamarck (1744-1829)
Traits acquired by an organism during its lifetime can be passed on to offspring
Wrong

Charles Darwin proposed that *Natural Selection* was the primary mechanism of evolution in 1859.



Charles Darwin (1809-1882)



On The Origin of Species
(London, 1859)

HMS *Beagle* in
Tierra del Fuego

Natural Selection is based in "two undeniable facts and an inescapable conclusion"

Fact 1:

Any population can produce more offspring than the local environment can support.

This leads to competition for resources.

Fact 2:

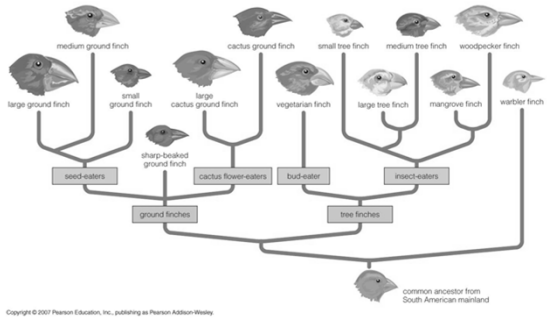
Individual offspring vary in traits passed from parents through the mechanism of heredity.

The inescapable conclusion:

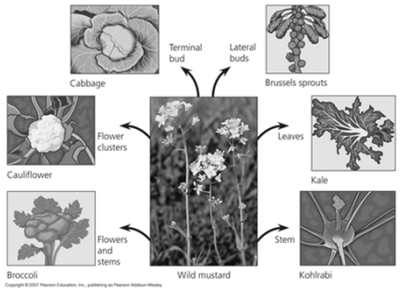
Those individuals whose traits best adapt them to survive and reproduce will pass on those favorable traits to larger numbers of offspring.

This leads naturally to the selection of favorable traits.

Evidence for Natural Selection is found throughout biology in the diversity and similarities of species.



Artificial Selection, the breeding of plants and animals for desired traits, works similarly.



The difference is that humans are the agents of selection, rather than environmental factors.

Of the six characteristics of life, the ability to reproduce and evolve are the most central.

A working definition:

A living organism is something that can reproduce and evolve to adapt to its environment.