Introduction to Evolution

Evolution is the process by which nature selects, from the genetic diversity of a population, those traits that would make an individual more likely to survive and reproduce in a continuously changing environment.

Over many years and many generations the full diversity of life on earth is expressed.

Evolution is one of the most fundamental organizing principles of the biological sciences and as such is the single most dominant theme in biology today.

Evolution stresses the relatedness of all life rather than its differences

→ it provides a framework (=unifying principle) for the way that we study and understand the living world

→ it’s a way of bringing together many diverse aspects of life’s tremendous complexity

Adaptation vs Evolution

One of the “characteristics of life” is that organisms adapt to their environment as it changes from year to year

eg. same species of plant adapts to dryer conditions in one part of its range and wet conditions in another

The Theory of Evolution by Natural Selection

The theory of evolution was developed by Charles Darwin, in the mid 1800’s, after a lifetime of travel, observation, experimentation and discussion.

In his 3 year voyage on the Beagle, he collected and catalogued 1000’s of plants and animals and made numerous observations.

Darwin collected copious notes on species variations and their relationship to fossil forms.

He also studied breeds of domesticated animals and plants and pondered how we could produce such variations by selective breeding.

eg. Dogs today consist of >300 breeds
→ all were created by humans within the last 200 years

eg. cats, cattle, sheep
eg. corn, brassicas

= human directed “evolution”: humans did the selecting instead of nature

If humans can do it in 100′x or 1000′s of years surely nature can do it given Millions of years.

Many of Darwin’s ideas were stimulated by an explosion of new scientific information.

eg. same species of plant or insect may have 1 generation in northern part of its range or 2, even 3, generations in the southern part of its range

eg. virtually every bacterial pathogen has become at least somewhat resistant to antibiotics over the past 60 years

Over time, these populations may change in their appearance and other visible characteristics and will surely change in their genetic structure.

eg. many unrelated species often adapt in similar was when subjected to the same environmental conditions

Over long periods of time these changes could be significantly different from what you started with.

Yet, no one has ever witnessed the origin of a major new animal or plant group

→ takes 10,000′s or millions of years

We do however have an increasing amount of fossil data that shows the evolution of one species from another, step by step.

And today with molecular techniques we can actually observe and measure the rate of evolution in many species today.

There is no controversy surrounding evolution within the scientific community itself;

The “controversy” is fabricated by those who seek to inject nonscientific beliefs into a very powerful scientific concept.

eg. in Darwin’s time scientists were beginning to realize that the world was much older than previously thought

a. before Darwin the accepted age of the earth was determined by James Ussher (1581-1656) & John Lightfoot (1602-1675)

Made assumption that the Bible was the only reliable source of chronological information for the time covered in biblical writings

Arrived at the calculation that the earth was created on Sunday, October 24, 4004 BC

Lightfoot, making additional assumptions put the time at 9:00 am

So the earth was believed to be ~6000 years old

b. In the next century, Comte de Buffon (1707-1788);

“Histoire Naturelle”, 1749) believed he could get an estimate of the age of the earth based on its rate of heat loss

He calculated the age of the earth as 74,832 yrs (and the origin of life at 40,000 yrs)

He also recognized 6 geological periods

Much of western science at this time was still dominated by Church beliefs and he was heavily pressured by the Church to reconsider his calculations

His solution: “This is what one might think if one did not know what genesis says”
c. by Darwin’s time geologists were beginning to realize that the earth was 100’s of millions or even billions of years old
eg. paleontologists were learning that fossils were representatives of previous forms of life from the ancient past
much earlier, fossils were thought of as “sports of nature”
by 1700’s most scientists believe that fossils were of organic origin
but most were explained in terms of the Biblical flood
as geologists were realizing the extreme age of the earth that that would mean that fossils trapped in these ancient layers were also millions of years old
eg. previous biologists had already suggested that
all species are interrelated
species change through time
and the environment is a factor in that change
Jean Baptiste de Lamark (1809) produced the first “evolutionary tree” to illustrate “change through time”
but he could not offer a reliable explanation or “mechanism” for how these processes could occur
took another 50-60 yrs before hereditary information was added to Darwin’s original theory
→ made it even more powerful
d. each species produces more offspring than will survive into maturity
eg. if not, 1 bacterial cell → 36 hours would cover earth 3-4 ft deep
eg. fruit fly → in 7 months would produce enough offspring to equal the mass of the earth
e. those individuals whose variations best fit their environment will be more likely to survive and reproduce
fitness = ability to reproduce
organisms with less favorable variations will be less likely to survive
→ There is a “struggle for existence”
→ with “survival of the fittest”
f. by a process of natural selection, evolution sorts through these numerous variations within a population and "chooses" the most fit combination as the environment slowly changes and certain variations are selected over 100’s or 1000’s of generations new forms will arise

Additional evidence supporting evolutionary theory
1. today the layers of rock can be accurately dated by strata and by radioactive decay methods
we can see that species have been altered over geologic time
the fossil record shows clearly that all organisms did not appear at the same time
many that once existed have become extinct
~99% of all life that ever existed on earth is now extinct
the fossil record also shows there has been an orderly sequence species change and replacement over billions of years from the simplest forms of live to the most complex:

<table>
<thead>
<tr>
<th>Time (MY)</th>
<th>Species Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.5</td>
<td>Bacteria</td>
</tr>
<tr>
<td>1.5</td>
<td>Eucaryotes</td>
</tr>
<tr>
<td>500</td>
<td>Animals</td>
</tr>
<tr>
<td>400</td>
<td>Plants</td>
</tr>
<tr>
<td>190</td>
<td>Flowering plants</td>
</tr>
</tbody>
</table>

The Theory of Evolution by Natural Selection
at its core is a relatively simple idea:

a. all living things consist of a unique combination of chemicals organized in unique ways

→ variations occur in every species
no two individuals of a species are alike

b. species’ populations are able to adapt to gradually changing environments
the same species in different parts of the world have different tolerances and slightly different characteristics to survive the local conditions in which it lives
eg. live oak in Austin, vs live oak in Baton Rouge
eg. flower and gardening catalogues vs local growers
still they are the same species:
they interbreed naturally where they come into contact

c. Most of these variations have a genetic basis
→ they can be passed on to their offspring
Darwin was not aware of Mendel’s work, He didn’t know HOW traits were passed on, just observed that some were
2. also, we have found fossils of many "intermediate forms" between major groups in the fossil record:
   - eg. between fish and amphobians
   - eg. between dinosaurs and birds
   - eg. evolutionary stages of the horse, elephant, etc
   - eg. human ancestors

   in a few cases we have essentially every major step in the evolutionary process from one species to another
   - eg. 1 snail species into 2 in So American Lake sediment (year by year evolution)

3. we have learned the science of genetics and can explain how mutations occur and how they are passed on (this process was completely unknown to Darwin)

4. In modern times we have added a massive amount of **molecular evidence** that supports evolutionary theory

   similarities and differences in biochemistry correlates with assumed evolutionary relationships

   the more closely related an animal is the more similar its biochemistry:
   - eg. DNA
   - eg antibodies
   - eg. protein structure

   - eg. nematode worm shares 40% of its DNA with us
   - eg. chimpanzees and humans share 98% of their DNA
   - eg. all humans share 99% of our DNA
   - eg. closer relatives 99.5%

   we can even quantify the degree of difference and the evolutionary timelines for virtually all forms of life

   virtually everything we know about the natural world
   - biology
   - geology
   - chemistry
   - physics
   - astronomy

   contribute to our current understanding of the process of evolution

   65 MY modern plants, primates
   15 MY hominids