

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

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 ways 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

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's 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. 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 Lamarck (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

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

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 life to the most complex:

3.5 BY bacteria
1.5 BY eucaryotes
500 MY animals
400 MY plants
190 MY 1st flowering plants

65 MY modern plants, primates
15 MY hominids

2. also, we have found fossils of many "intermediate forms" between major groups in the fossil record:

eg. between fish and amphibians

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