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Photocopy Master Sheets

Years 9-10

Evolution of Life

Disk filename = “18.Evolution”

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Topics Available

Year 7-8 General Science

Disk Filename	Topic Name
01.Energy	Energy
02.Forces	Forces
03.Matter	Solids, Liquids & Gases
04.Mixtures	Separating Mixtures
05.Elements	Elements & Compounds
06.Cells	Living Cells
07.Life	Living Things
08.LifeSystems	Plant & Animal Systems
09.Astronomy	Astronomy
10.Earth	The Earth
11.Ecosystems	Ecosystems

Year 9-10 General Science

Disk Filename	Topic Name
12.Waves	Wave Energy (inc. Light)
13.Motion	Forces & Motion
14.Electricity	Electricity
15.Atoms	Atoms & Elements
16.Reactions	Compounds & Reactions
17.DNA	Cell Division & DNA
18.Evolution	Evolution of Life
19.Health	Health & Reproduction
20.Universe	The Universe
21.EarthScience	Earth Science
22.Resources	Resources & Technology

Year 11-12 Science Courses

Biology
Preliminary Core
Local Ecosystem
Patterns in Nature
Life on Earth
Evolution Aust. Biota
HSC Core
Maintain. a Balance
Blueprint of Life
Search for Better Health
Options
Communication
Genetics:Code Broken?

Chemistry
Preliminary Core
Chemical Earth
Metals
Water
Energy
HSC Core
Production of Materials
Acidic Environment
Chem.Monit.&Mngment
Options
Shipwrecks, Corrosion...
Industrial Chemistry

Earth & Envir. Science
Preliminary Core
Planet Earth...
Local Environment
Water Issues
Dynamic Earth
HSC Core
Tectonic Impacts
Environs thru Time
Caring for the Country
Option
Introduced Species

Physics
Preliminary Core
World Communicates
Electrical Energy...
Moving About
Cosmic Engine
HSC Core
Space
Motors & Generators
Ideas to Implementation
Options
Quanta to Quarks
Astrophysics

All Topics Available as PHOTOCOPY MASTERS and/or KCiC

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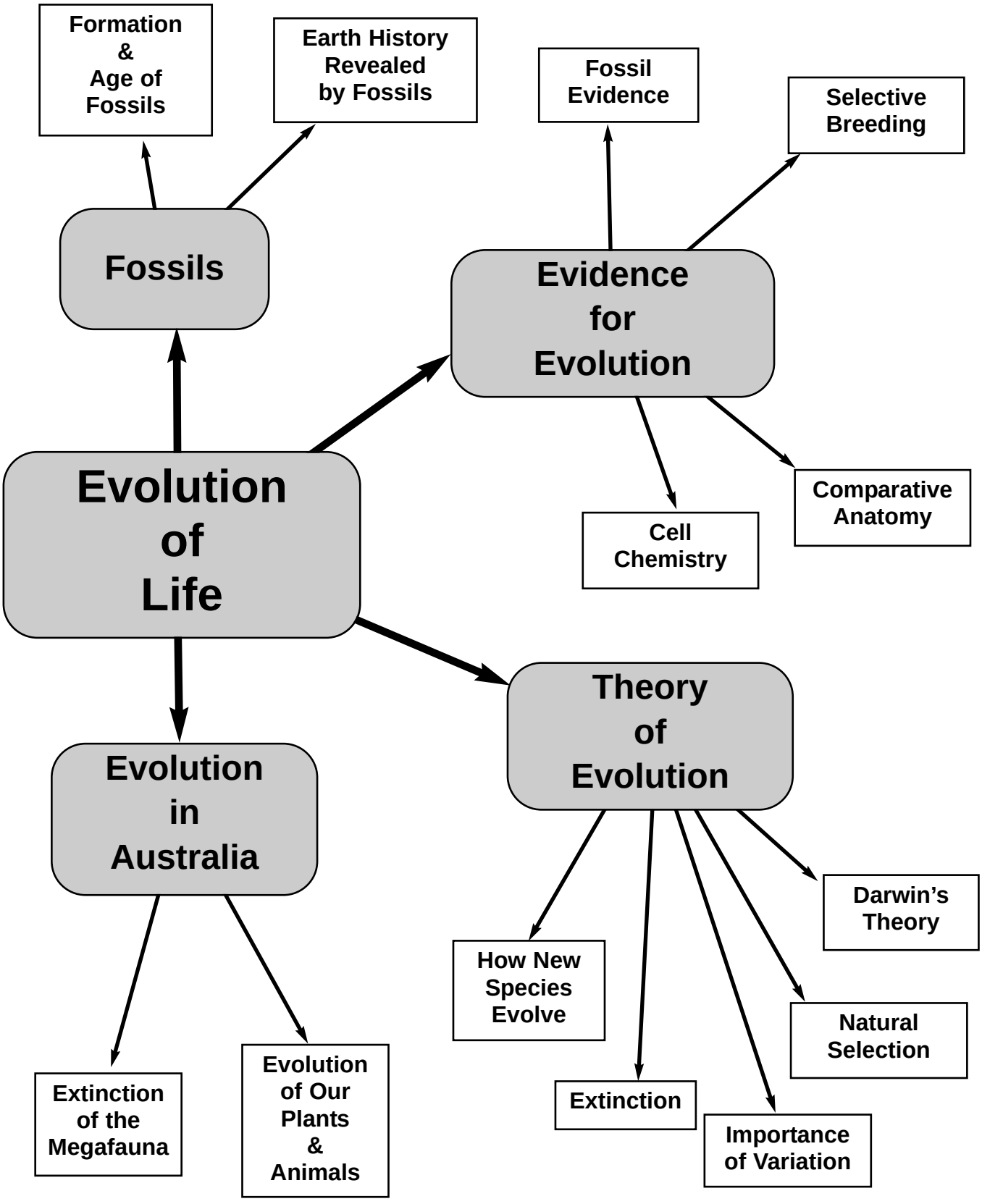
"Mind-Map" Outline of Topic

This topic belongs to the Biology branch of Science.
In fact, the Theory of Evolution is perhaps the major concept of modern Biology after Cell Theory.



Make your own "Mind-Map" TITLE PAGE.
Cut out the boxes. Sort them into an appropriate lay-out on a page of your workbook, then glue them down. Add connecting arrows and colour in.

Theory of Evolution

Evolution of Life

Formation & Age of Fossils

Fossil Evidence

How New Species Evolve

Fossils

Darwin's Theory

Importance of Variation

Earth History Revealed by Fossils

Extinction

Evidence for Evolution

Evolution in Australia

Extinction of the Megafauna

Evolution of Our Plants & Animals

Cell Chemistry

Comparative Anatomy

Selective Breeding

Natural Selection

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Fossils

A fossil is the remains, or traces, of a living thing from ages past. It could be a bone, tooth or shell. It could be an imprint or a footprint or a burrow. There is even a specialist study of fossilised dinosaur droppings!

The study of fossils is called Palaeontology. (say: pay-lee-on-tology)

Fossil Formation

Usually, when a living thing dies its remains are eaten by scavengers or they rot away as the decomposers (bacteria & fungi) do their thing.

Very, very rarely the remains are preserved as fossils.

Perhaps the remains sink to the bottom of the sea or a lake and are rapidly buried in mud following a flood. Perhaps a volcanic eruption buries and "mummifies" the remains in volcanic ash.

Either way, some traces may be preserved in rock layers.

This fossilised shell is about 200 million years old. It has been cut open to show how mineral crystals have grown in the hollow cavities. It is completely mineralised, so nothing remains of the original shell except its shape.

If the sediments containing the remains are buried and compressed, they may become *Sedimentary Rock* such as shale or limestone. This is where fossils are most commonly found.

During millions of years of burial the remains may be reduced to just a carbon imprint, or be replaced by minerals from the surrounding rock.

Much later, earth movements and erosion may expose these rocks at the surface. In many cases the fossil is then destroyed by erosion.

However, we have managed to find and study millions of fossils.

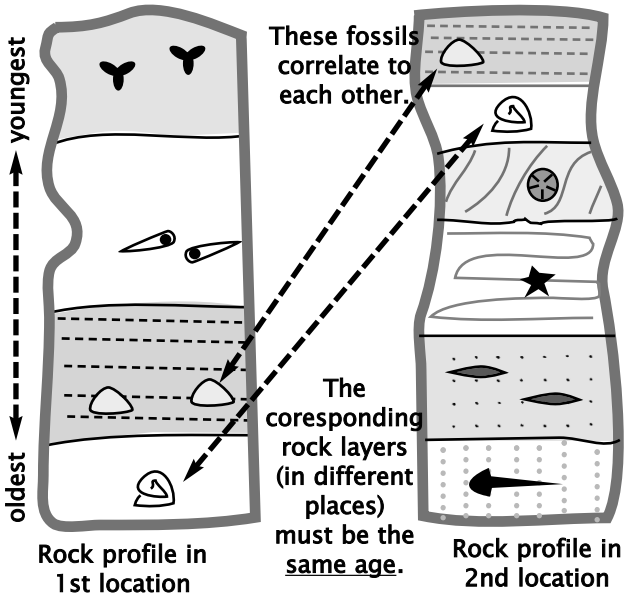
Putting Fossils in Time Order

Most fossils are buried in sediments. Fresh sediment always settles on top of older sediments. Therefore, it is a basic principle that the younger fossils are above the older ones in the sedimentary layers.

Relative Dating

By applying the principle that older fossils are lower down, the fossils in any profile of sedimentary rocks can be arranged in age order.

This idea can be extended further by correlating fossils from one area to another. From thousands of studies like this, scientists have built up a picture of the history of life on Earth.



Actual Age of Fossils

Correlating fossils gives relative ages.

Actual ages can be determined by measuring the amount of radio-activity remaining in some rocks.

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Life on Earth Has Changed

Even the earliest amateur fossil-collectors of 200 years ago noticed that the fossils they found were not the same as modern life-forms. Obviously, the living things of long ago were different to those of today.

Patterns of Change

When enough fossils had been studied and placed into relative time order, a pattern became obvious.

The younger fossils were more like modern plants and animals. Older fossils were quite unlike modern types. Really ancient fossils were all small, simple creatures only.

Rocks older than about 600 million years contain only the fossils of "mats" of microscopic cell growths and chemicals which indicate the activity of living things. Early investigators could find nothing at all in these rocks.

Geological Time

In the 19th century, palaeontologists began to <u>name</u> some periods of Earth history according to the typical fossils in rocks from each time.

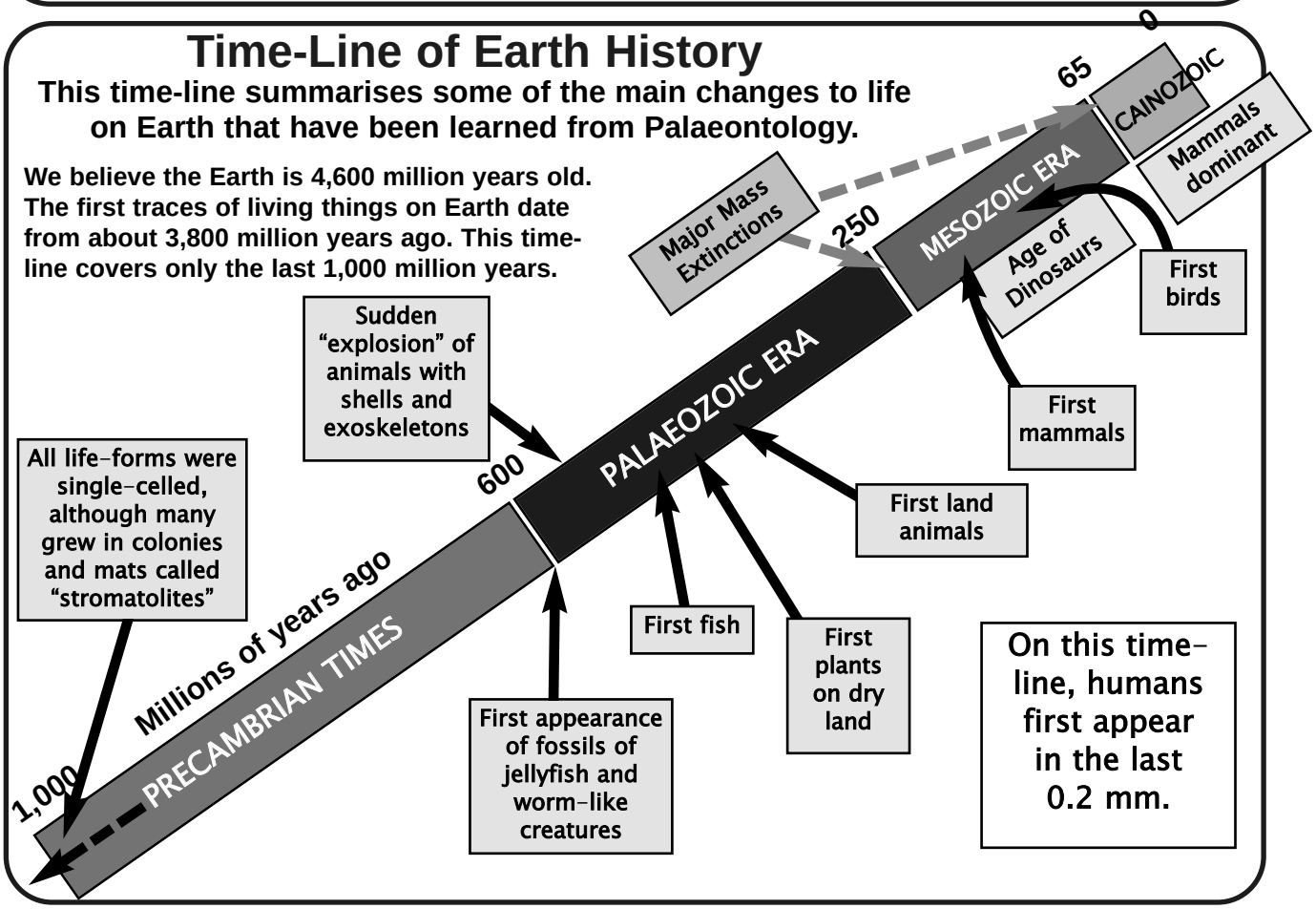
To begin with, they only had the <u>relative</u> order of things, but in mid-20th century they were able to put actual dates on the changes by using "radio-active dating" of rocks.

They noticed that at certain times in the past there seems to have been sudden <u>mass-extinctions</u> of living things, always followed by the appearance of many new types of life.

Time-Line of Earth History

This time-line summarises some of the main changes to life on Earth that have been learned from Palaeontology.

We believe the Earth is 4,600 million years old. The first traces of living things on Earth date from about 3,800 million years ago. This time-line covers only the last 1,000 million years.



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Worksheet 1
Fossils & Earth History

Student Name.....

Fill in the blank spaces.

A fossil is the a)..... or ..... of a b)..... from ages past. Fossils are usually found in c)..... rocks. They may be actual remains, such a d)..... or just an imprint or even a e)..... from an animal walking through mud.

The study of fossils is called f).....

Older fossils are always g)..... in the rock layers because younger sediments always settle h)..... This allows fossils to be placed in i)..... time order. Actual age can be measured by the j)..... in some rocks.

When fossils are arranged in time order, a pattern emerges: recent fossils are k)..... to modern living things. Older fossils are l)..... like modern life. Very old fossils are all m)..... and ..... creatures.

It seems that life began almost 4 n)..... years ago. For most of this time, all life was o).....-celled and lived in the p)..... More complex life appeared only about q)..... million years ago.

Scientists have given names to different periods of Earth history according to the different r)..... which lived then. There is evidence of sudden s)..... extinctions in the past. These are always followed by the appearance of many t)..... in the fossil record.

Worksheet 2
Relative Dating of Fossils

Student Name.....

The diagrams represent sedimentary rock profiles from 3 different areas.

1. What is the youngest fossil in each area? area 1 area 2 area 3

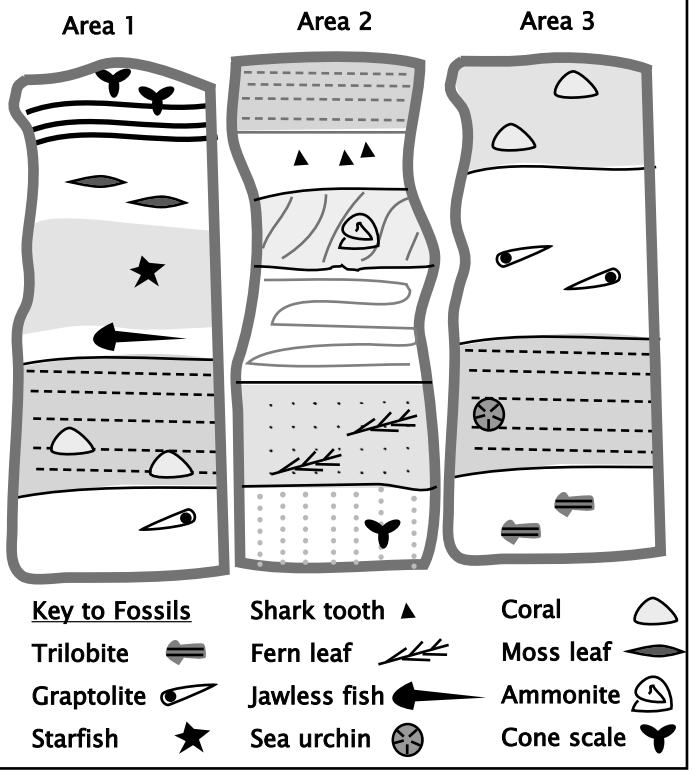
....

2. What is the oldest fossil in each area? area 1 area 2 area 3

....

3. Cut out each profile diagram and slide them vertically to correlate any fossils that match up.

4. From your correlated profiles, write the names of all the fossils in age order. Start with the oldest.



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Theory of Evolution

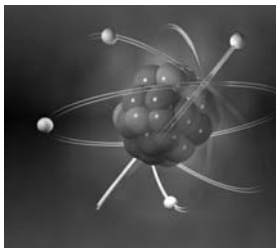
There can be no doubt that life on Earth has changed over millions of years. The changes are not random. There is a distinct pattern; from simpler life-forms towards more complex; from those unlike modern types, to creatures more and more like those alive today.

The word for a series of changes which follow a pattern is "*Evolution*".

What is a "Theory"?

Some people choose to reject the Theory of Evolution. They point out that it is "only a theory... it's not proven". They do not understand the status of a scientific theory.

In Science, a theory is an explanation for a set of observed facts. To become accepted, it must have a huge body of supporting evidence from observations and/or experiment. It is NOT just an unfounded idea.



The idea that all substances are composed of tiny particles of matter is "Atomic Theory". There is a huge body of observations and experimental results which convince scientists that Atomic Theory is fundamentally correct. There may be more to learn, but the basic idea seems accurate.

Similarly, there is "Cell Theory", Einstein's "Theory of Relativity" and the "Theory of Plate Tectonics". Each is supported by a mass of consistent, coherent, mutually-supporting facts. The Theory of Evolution fits right in with these.

Principle of "Falsification"

A basic principle of Science is that all scientific theories are subject to being proven false.

There could be thousands of facts to support a proposed explanation of things, but just one confirmed fact against it can prove it false.

It would only take one confirmed fossil in rock of the wrong age and the whole Theory of Evolution would fall over. For example, a mammal tooth in rock from when fish first appeared, or a human fossil among dinosaur bones. (Fred Flintstone perhaps?)

The fact is that millions of fossils have been studied, correlated and dated. Not one has ever been proven to be "out of place".

If that happened, scientists would be forced to drop the current theory and find a new explanation. Scientists always keep this "falsification" in mind. They might believe a theory to be a correct explanation, but are also prepared to reject it IF THE EVIDENCE PROVES IT FALSE.

So, what is the supporting evidence for Evolution?

1. The Fossil Record

This is undoubtably the most important set of facts which convince scientists that life on Earth has gone through a sequence of changes.

Simple to Complex

The earliest fossils are all single-celled organisms and the stromatolites they built. Much later simple algae, worms and jellfish appear.

Later still come fossils of shelled animals and crustaceans. Then fish, the first land plants, then insects, amphibians, reptiles, mammals, dinosaurs, flowering plants and birds... the pattern is clearly from simple towards more complex organisms.

More & More Like Modern Life

Extinct life forms from 10 million years ago are recognisably similar to modern types. Go back 100 million years and the fossils are less similar to modern life.

Keep going back and the living things are less recognisable. It seems that the pattern of changes leads directly to the modern types of life on Earth.

(Don't be fooled by that... previous stages always look "old-fashioned". In 100 million years time, human fossils will seem very primitive!)

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2. Transitional Fossils

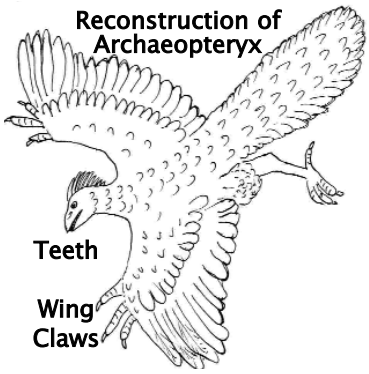
Not only does the fossil record show the overall pattern of change, but occasionally it reveals the remains of "intermediate stages" of life. These are fossils of organisms that are "in-between" in the evolution of a new type from a previously existing type of life.

Archaeopteryx (say: are-key-op-terix)

("Archae" = ancient, "pteryx" = wing)

Archaeopteryx is the most famous transitional fossil. It dates from 150 mya.

Its bones are those of a small dinosaur, but it is covered with feathers.

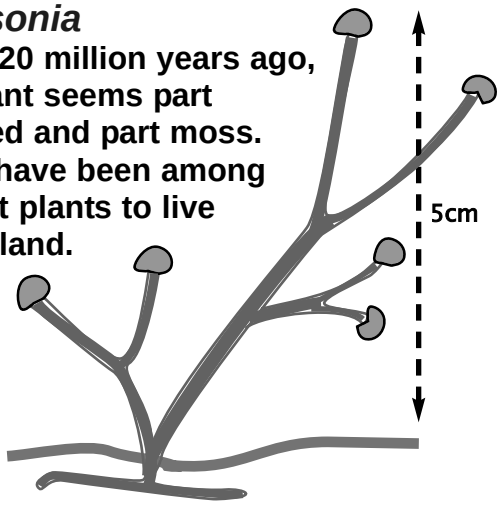


It probably could not fly well, but may have climbed trees and glided down.

This was a dinosaur - bird.

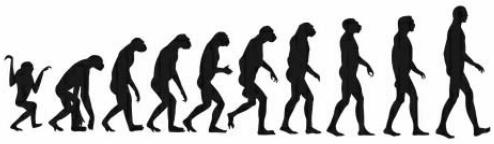
Cooksonia

From 420 million years ago, this plant seems part seaweed and part moss. It may have been among the first plants to live on dry land.



Other transitional fossils include reptiles with fur (becoming mammals?), ferns with seed cones (becoming conifers?), fish with lungs and legs (becoming amphibians?) and many more... including our own ancestors.

Transitional Fossils give us a glimpse of the changes from one type to another as evolution progressed.



3. Selective Breeding

People wonder how one organism can just "turn-into" another. No individual animal changes during its life-time. The changes occur from one generation to another, as certain features are "selected" in favour of others. Humans have been doing it to plants & animals for centuries.

Domesticated Plants & Animals

Human farmers have always chosen which seeds to keep for next year's crop, or which bull to breed with the cows.

This has drastically changed all these plants and animals. Modern wheat is nothing like the wild grass we believe it was bred from. Cabbages and cauliflowers used to be the same thing, but have been changed by selective breeding.

All breeds of dogs are descended from the wolf. Who would guess that a Dalmation and a Maltese Terrier are both wolves?!

Selective Breeding proves that a species can be changed. Humans can do it artificially, but in the wild it happens naturally.

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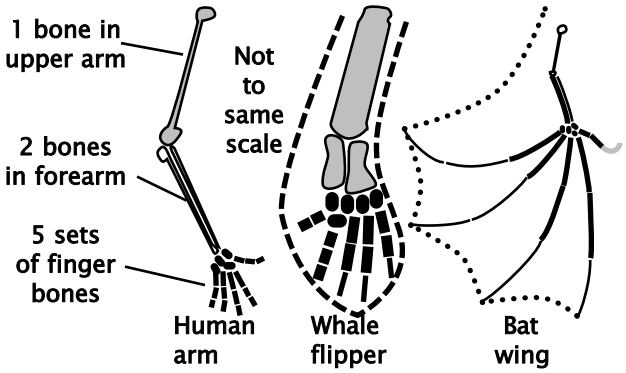
4. Comparative Anatomy

Many living organisms have basic structures which show that they have evolved from a common ancestor.

The Pentadactyl Limb

("Penta = 5, "dactyl"=finger)

Some fish, all the amphibians, reptiles, mammals and birds have the same basic bone structure in their limbs.

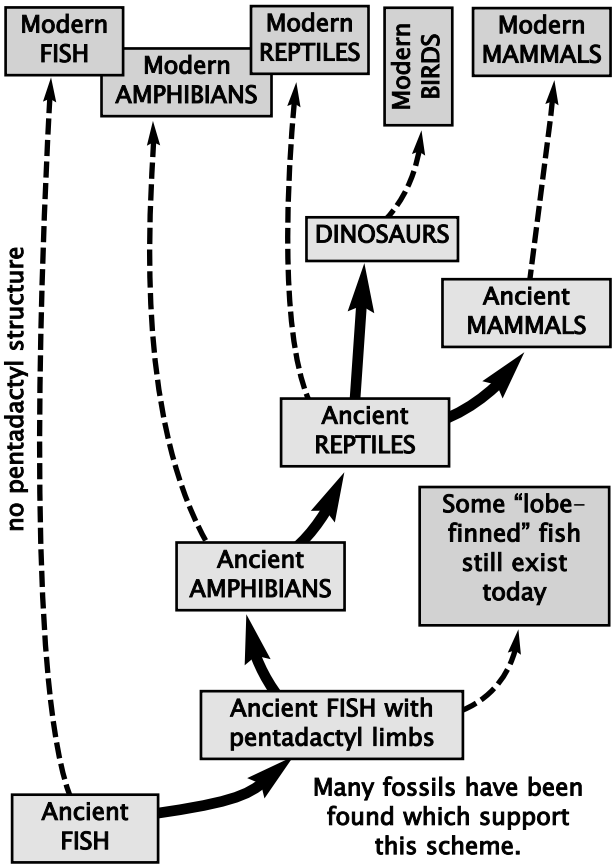


Their limbs are used in totally different ways... flying, swimming, running, grasping, digging, etc.

Why have the same bone structure?

We think it's because they have all evolved from an original ancestor which had that structure.

Evolution of Vertebrates

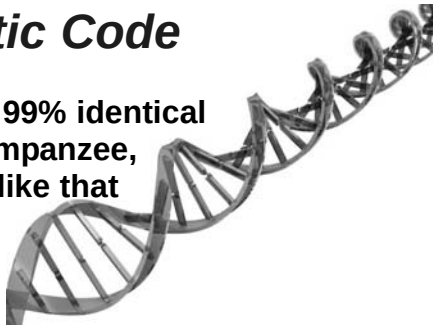


Many features of modern organisms point to evolution from a common ancestor.

5. Cell Chemistry

The structure of DNA, cell proteins & chemical pathways all point to a common ancestry.

The Genetic Code



Human DNA is 99% identical to that of a chimpanzee, but much less like that of a horse, less again for lizards, fish, insects, and so on.

Yet all these organisms use exactly the same "genetic code" in the DNA itself.

This is totally consistent with the idea of evolution from common ancestors.

Cell Chemicals & Pathways

The chemicals in living cells which control cell chemistry show the same patterns as DNA. The chemicals in a human cell and a fish, or even an insect cell are surprisingly similar.

When compared to plants, the differences become greater, and compared to certain types of bacteria the differences become huge.

Yet even there, there are some fundamental similarities. We think all life evolved from one ultimate ancestor!

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Worksheet 3
Evidence for Evolution

Student Name.....

In Science, a "theory" is an a)..... for a set of observed b)..... Every scientific theory can (in principle) be proven c)..... Evolutionary theory could be proven false by finding a d)..... which is "out of place".

The main sets of evidence supporting the idea of Evolution are:

1. <u>The fossil record</u>, which shows that life has changed from e)..... to ..... and that life-forms have become more and more similar to f).....

2. "<u>g)..... fossils</u>" such as the dinosaur-bird "h).....".

These give us a glimpse of one type of life i)..... into another.

3. <u>Selective Breeding</u> proves that a species j)..... by selection of which ones k)..... the next generation.

4. <u>l)..... Anatomy</u> often reveals evidence that different organisms evolved from a m)..... .....

5. The study of various cell n)....., such as DNA, reveals many similarities between quite different life-forms. This gives further evidence of descent from a o)..... .....

Worksheet 4
Practice Questions

Student Name.....

1. Place these Earth history events in correct time order.
Age of dinosaurs, first land plants, first birds, mammals take over, first land animals, first fish.

2.
a) Describe the animal "archaeopteryx".

b) What is the significance of fossils such as archaeopteryx?

3. Humans have carried out selective breeding on many species such as dogs. What does this prove?

4. a) What does "pentadactyl" mean?

b) The bone structure of a dog's paw, a seal's flipper and a frog's leg are all the same. What does this suggest about their evolution?

5. Descibe some chemical evidence that suggests a common ancestor for all living things.

6. A human embryo has structures that are the same as the <u>gill arches</u> in a fish. (These later develop into the bones of the inner ear.) What does this suggest?

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Evolution by Natural Selection

The Theory of Evolution is an idea which explains the FACTS of nature such as fossil sequences, cell chemistry, comparative anatomy, and so on.
The theory also contains an explanation for HOW THE CHANGES OCCUR.

Charles Darwin (English 1809-82)

In the 1830's this young naturalist travelled around the world for 5 years on a navy survey ship, HMS Beagle.

He studied thousands of plants and animals as well as rocks and fossils, especially in South America.

He became convinced that living things had changed and can change over time. He devoted the rest of his life to studying living things and developing a theory to explain how the changes could occur.

His theory was first published in 1859. It has survived the "falsification" tests of Science for 150 years, and now is backed by thousands of individual facts of evidence.

How Evolution Works

The steps of logic in Darwin's theory:

1. All organisms produce <u>more offspring</u> than can possibly survive.

2. In every species there is <u>variation</u>. Different individuals show many differences from each other.

3. Nature <u>selects</u> which individuals survive. Factors such as predators, diseases, climate, etc all contribute.

4. The survivors <u>breed</u> and <u>pass on</u> to offspring the "<u>survival characteristics</u>" which helped them to make it.

5. This may mean that each succeeding generation is <u>slightly different</u> in which variations are most common. Gradually, over generations, these <u>changes accumulate</u> as "natural selection" keeps choosing survivors. Gradually the population <u>evolves</u> into a new type, and eventually a new species.

1. Too Many Offspring

An oyster releases 2 million eggs at a time. Only 1 or 2 ever make it to maturity. Many (in fact most) plants produce thousands of seeds. Hardly any survive.

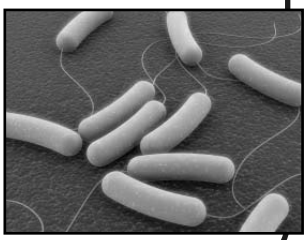
It can be shown mathematically that if every baby elephant survived to maturity and then produced 1 baby every 5 years, then the world would be completely covered with elephants within a few thousand years. Obviously, this hasn't happened. That's because they don't all survive.

Darwin's first point is well proven by many studies of survival rates in thousands of living things.

2. Variations

Zebras might all look the same to us, but every one has a different stripe pattern, a bit like our fingerprints. Some have a better sense of smell, others can run faster, another has better resistance to a disease, or can chew tougher grass.

In fact, in every species that reproduces sexually, we know that each individual is unique. Sexual reproduction keeps mixing genes from different parents together in different combinations.



Even among bacteria, differences arise due to <u>mutations</u>.

Variation is the raw material of evolution.

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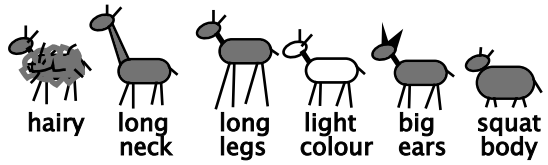
3. Natural Selection

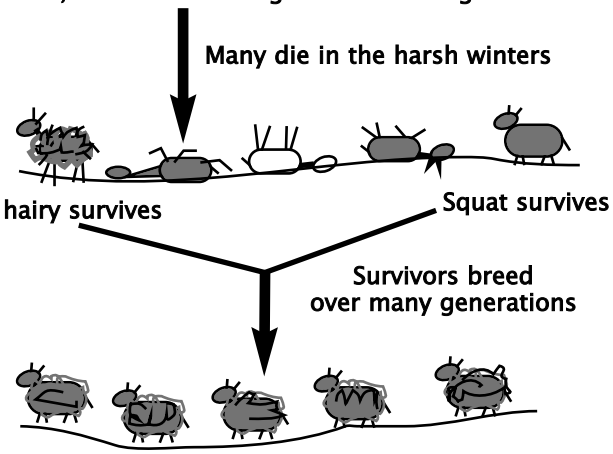
This is the key to understanding the Theory of Evolution.

HOW NATURAL SELECTION WORKS

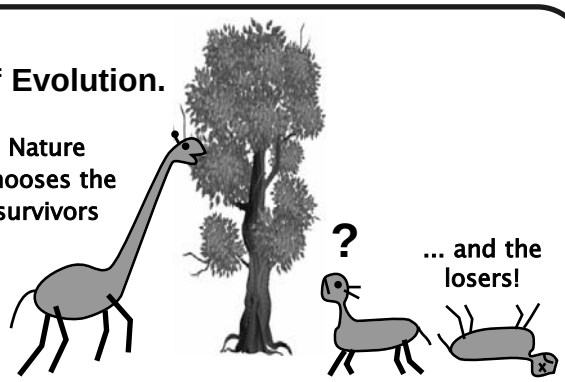
A population of a species with a lot of "variations"



Then, the climate changes... winters get colder



The survivors pass on their characteristics. Generations later, most of the population are squat and hairy. No single animal changed, but the population has changed because of which animals survived and reproduced.



What Helps Survival?

Any characteristic might be a help to survive under different conditions...

- a better immune system helps, when diseases strike...
- more inquisitive behaviour might find more food...
- more timid behaviour might avoid dangers...
- larger body size might deter predators...
- smaller body size might help hide from predators.

It is difficult to predict exactly which characteristic, or combination of characteristics, might help survival... it depends on what happens in the environment.

4. Survive to Breed

Survival isn't just about individuals having a long life. It's really about reproduction.

The survivors are ones who get to reproduce lots of offspring.

If you're dead, you cannot breed.

The survivors are the ones with slightly "better" characteristics to cope with the environment and all its challenges.

When survivors breed they pass on genetically those adaptations which helped them survive, so their many offspring have a better chance.

"Survival of the Fittest" really means reproduction by the best.

5. Population Evolves

It often seems as if evolution deliberately causes changes towards a certain goal. For example, in the ficticious example above the climate became colder and it may seem as if the species deliberately evolved to become "squat & hairy" in order to survive better in the cold.

However, the characteristics "squat" and "hairy" were already present in the population among many other "variations". They simply became more common in later generations because of natural selection.

In later generations the whole population looks different because one "type" has become predominant. Eventually it becomes a new species.

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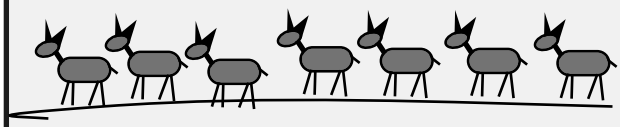
The Importance of Variations

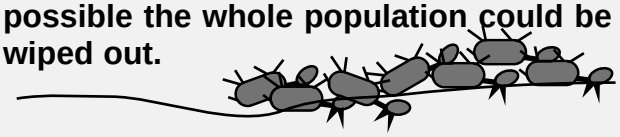
Variation Helps a Species Survive

What if all the individuals in a population were the same?



They might be "well adapted" to their environment and quite good survivors, but what if the environment changes?

What if the climate changes and winters become cold and harsh? With no "squat" or "hairy" variations, it's possible the whole population could be wiped out.



A species without variation is in danger of extinction. A larger number of variations gives a greater chance that at least some will survive and breed when the environment changes.

Where Does Variation Come From?

Sexual Reproduction **always bring together genes from 2 different parents. It mixes genes together in new combinations... variation.**

Meiosis**, the cell division which makes sperm and egg cells, also creates variations. It halves the chromosome number, but can do so in millions of different combinations of chromosomes. Every sperm or egg is different... variation.**

Mutation

Ultimately, the source of all new characteristics is the accidental changes that can occur to the DNA and create a different gene.

Most mutations are detrimental, but some simply create a new variation, neither good nor bad... until the environment changes.

Extinction

There are millions of species alive on Earth today. This is probably less than 1% of all the species which have ever lived. Therefore, extinction is the normal (and inevitable) fate of every species, sooner or later.

The Causes of Extinction

Any change to the environment might cause extinction. It could be:

- **a new deadly predator.**
- **a new competitor for food or nest sites.**
- **a disease epidemic.**
- **a loss of habitat. (Humans cause this a lot)**
- **a climate change, either natural or not.**

If a species has many variations, it has a better chance that at least some will survive and breed, possibly changing the features of the population and leading (eventually) to a new species.

Mass Extinctions

Palaeontologists have identified about 6 mass extinction episodes that have occurred within the past 500 million years.

The most recent world-wide mass extinction occurred 65 million years ago. There is evidence that a 10km meteorite from space hit the Earth.

It caused such a sudden and drastic climate change that more than half of all species were wiped out, including all the dinosaurs.

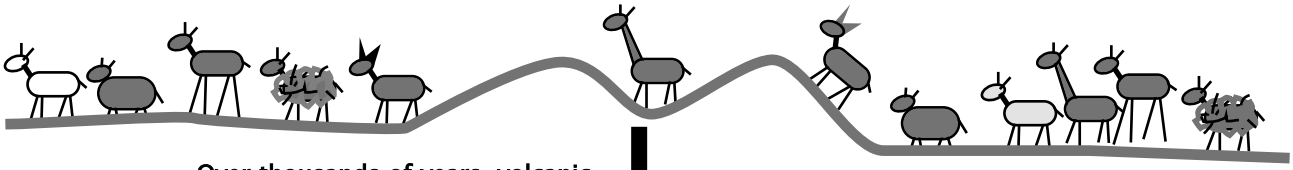
It is possible that a new mass extinction is currently underway due to human-caused Global Warming.

How One Species Evolves into Many

After every mass extinction in Earth history there has always been a recovery, with many new species "suddenly" appearing in the fossil record. How can multiple new species evolve?

This species of animals has spread out widely across a continent.

They are all one species, but have many variations among the individuals.

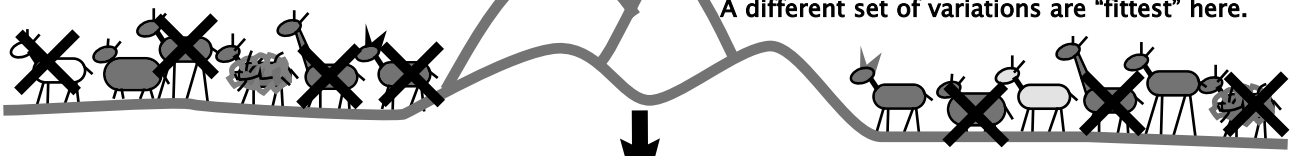


Over thousands of years, volcanic eruptions and earth movements enlarge the mountain range.

The species becomes divided into 2 groups which are <u>isolated</u> from each other and rarely meet or inter-breed.

In this region the winters have become cold. "Squat" and "hairy" have a survival advantage. Natural Selection weeds out those "less fit".

In this region a new predator has migrated in. Big ears hear it coming; long legs run away faster; lighter colour is better camouflage. A different set of variations are "fittest" here.



As always, the survivors breed.

The "survival traits" become predominant in each region over a number of generations.

Over generations, the animals in the 2 regions evolve to be quite different. Eventually they become unable to interbreed, even if they get the chance. They are now 2 different species.

The Importance of Isolation

In the ficticious example above, one original species has evolved into two different species.

The key to this was the <u>isolation</u> of one group from the other. Isolation allows <u>Natural Selection</u> to work on each group differently, according to the environment and which characteristics might help survival in each place.

Organisms can become isolated by mountain ranges, by rivers, on different islands, etc.

On his 1830's voyage, Charles Darwin was deeply impressed by the many different (but obviously related) species of birds on the different islands of the Galapagos Islands. He also noted the slightly different "sub-species" of the giant land tortoises on the islands.

Modern biologists have studied many changes to isolated groups living under different "<u>selection pressures</u>".

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Evolution in Australia

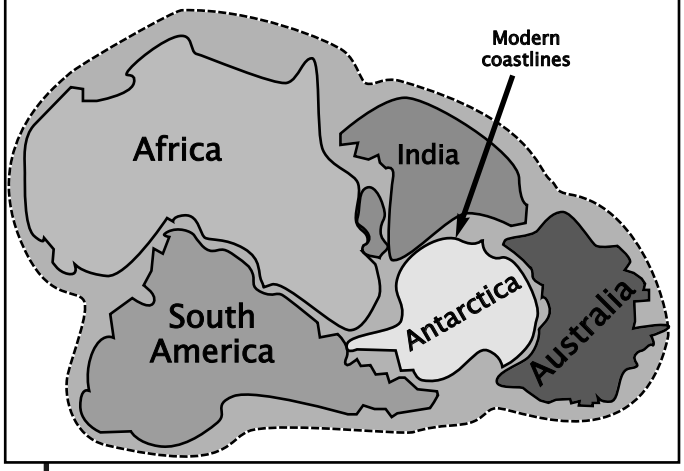
Australian native plants and animals are mostly very different to those of other continents. How can we explain that?

The Moving Continents

We believe that the crust of the Earth is made of a number of "plates" which slowly slide around, carrying the continents to new locations. This idea is covered in more detail in another topic.

There is evidence that 100 million years ago, Australia was part of a large continent called "Gondwana".

THE ANCIENT SOUTHERN CONTINENT "GONDWANA"



Gondwana gradually broke up into pieces, each of which has slowly moved away to its present-day location.

The animals and plants which lived all across Gondwana were carried away to evolve separately on each fragment.

Modern Australian plants and animals are the unique result of that separate evolution.

Australia's Climate Changes

The fossil record shows that 100 million years ago Australia was a warm, wet place, mostly covered by rainforests and populated by many dinosaurs and a few insignificant mammals and birds.

A massive and sudden climate change 65 million years ago wiped out the dinosaurs world-wide. On every continent the mammals and birds took over and rapidly evolved into many new types.

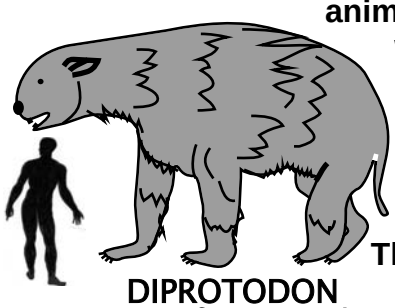
The Australian climate became very dry and so the rainforests diminished. The drought-tolerant banksias and gum trees took over. They had always been there, but in rainforest times had been rare. Now they flourished and evolved into many new types which could survive the dry, harsh climate and poor soil.

Of the original Gondwana animals, the ones that survived these climate changes best were the reptiles and the marsupials, or pouched mammals.

The marsupial method of reproduction is a "survival trait" in the harsh and unpredictable climate so they survived and evolved while many other types of mammals died out.

Australia's Megafauna

Long before the evolution of humans, there was a trend all over the world for some animals to evolve into "giant" forms. In North America there were huge mammoths, giant rhinoceros, elk and sloths.



DIPROTODON
Human figure to scale

Giants evolved in Australia as well. A 3-tonne wombat called diprotodon was the heaviest, but there was also a 3-metre tall kangaroo and a 1,000kg goanna.

These "megafauna" only became extinct after the arrival of aboriginal people. We're still not sure if the giants were hunted to extinction or wiped out by climate changes.

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Professor Tim Flannery
Australian Evolutionary & Environmental Scientist

When you study Evolution you learn about Charles Darwin, but rarely anyone else. In the 150 years since Darwin's theory was published, there have, of course, been many more great scientists who have contributed to our knowledge. In recent years, one of those great contributors has been Tim Flannery.

Scientific Achievements

Tim Flannery was educated in Melbourne, and later Sydney.

His research on the evolution of mammals in Australasia greatly enlarged our knowledge and understanding of the "Megafauna".

In the 1980's he discovered new dinosaur fossils in Victoria and was involved in the discovery of very ancient mammal fossils. His surveys of mammals in New Guinea and the Melanesian Islands discovered 16 new species.

He has contributed to well-over 100 scientific papers and written several books, some of which are recognised as important reference works.

Academic Positions

Professor Flannery was Principle Research Scientist at the Australian Museum, Sydney for 15 years. He was appointed professor at the University of Adelaide and Director of the South Australian Museum. He served as a Visiting Professor of Australian Studies at Harvard University, USA.

He is currently a professor of Environmental Sciences at Macquarie University in Sydney.

Other Achievements

In recent years Professor Flannery has become an out-spoken activist on environmental issues.

He is a leader or member of many organisations which study environmental issues, including bodies which report to and advise the governments of Queensland and South Australia.

Photo by Mark Coulson

Flannery teamed up with his friend, radio & TV personality John Doyle, to make a series of popular TV programs with an environmental theme.

In 2007 he was named "Australian of the Year" in recognition of his contributions to Science and environmental issues.

In 2009 he became Chairman of the Copenhagen Climate Council. This body promotes international action and treaties between nations to help prevent possible climate-change catastrophe.

He holds strong and often controversial opinions on many issues, from Australia being over-populated, to the future of our pastoral industry (get rid of cattle, eat kangaroos) and energy supplies (stop burning coal, go solar).

Tim Flannery is not at all like the stereotype of an "absent-minded professor". He is well-spoken, often out-spoken, perhaps a bit of an Aussie larrikin and passionate about the things that matter to him.

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Worksheet 5
Theory of Evolution

Student Name.....

A. List the 5 points of Darwin's Theory of Evolution by completing each statement.

1. All organisms produce .....

.....

2.
In every species there is .....

3. Nature (environmental factors) selects

.....

4.
The survivors .....
and pass on their .....

5.Each generation is ..... because there has been selection of who ..... As these changes accumulate, the species .....

B. List 3 "environmental factors" which might contribute to natural selection.

C. "Survival of the fittest" doesn't just mean to survive. What does it mean?

D.
i) When a species evolves, does any individual change during its life time?

ii) When do differences appear?

Worksheet 6
Evolution Questions

Student Name.....

1. a) Why is variation important in a population?

b) What might happen to a species with no variations at all?

2. a) Where do new variations originally come from?

b) How does sexual reproduction contribute to variation?

3. a) List 3 environmental changes that might result in extinction of a species.

c) What may cause a "mass extinction"?

4. Explain how one species, which is living in 2 or more isolated groups, might evolve to become several different species.

5. a) Name the large ancient continent which Australia was once part of.

b) What sort(s) of plants and animals survived most sucessfully in Aust. as the climate became drier & unpredictable?

c) What are "megafauna"? Give an example.

Topic Test
Evolution of Life

Student Name..... Score = /21

Answer all questions in the spaces provided.

1. (5 marks)
Match each description to an item from the list. To answer, write the letter (A,B,C, etc) of the list item beside the description.

Description	matches with	List Item
a) Traces of a living thing from long ago.		.....
b) When a species no longer exists.		.....
c) Fossil which is "in-between" in evolution of a new type.		.....
d) Process of environment choosing who survives or dies.		.....
e) 5-finger limb structure, common to most vertebrates.		.....

List Items Not all will be used. Some may be used more than once.

A. extinct	D. transitional
B. fossil	E. natural selection
C. pentadactyl	F. diprotodon

2. (4 marks)
a) In what general type of rock are fossils most commonly found?

b) In a particular cliff-face containing fossils, how do you tell which are older and younger?

c) When fossils representing the whole of the history of life on Earth are compared, what general pattern or trend is apparent?

d) How does modern Science explain that pattern or trend?

3. (4 marks)
a) Name a "transitional fossil", and describe it.

b) What is the significance of transitional fossils to the Theory of Evolution?

4. (2 marks)
Give an outline of a piece of evidence which suggests "descent from a common ancestor".

5. (6 marks)
a) List the 2 (unrelated) facts about living things which are the starting point for Darwin's theory.

b) Give an outline of what is meant by "natural selection".

c) It is often said that evolution is all about "survival of the fittest". What is "survival" really all about?

d) Why is it important for a species to have a lot of "variation"?

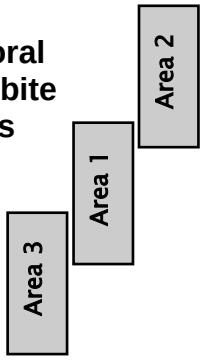
Answer Section

Worksheet 1

a) remains or trace b) living thing
c) sedimentary d) bone / shell / tooth
e) footprint f) Palaeontology
g) lower h) on top
i) relative j) radio-activity
k) more similar l) less
m) small & simple n) billion
o) single-celled p) sea
q) 600 million r) life-forms
s) mass extinctions
t) new species

Worksheet 2

1. Cone scale, shark tooth, coral
2. Graptolite, cone scale, trilobite
3.They need to be arranged as suggested by this diagram.
4. Trilobite, sea urchin, graptolite, coral, jawless fish, starfish, moss leaf, cone scale, fern leaf, ammonite, shark tooth.



Worksheet 3

a) explanation b) facts
c) false d) fossil
e) simple to complex
f) modern life-forms
g) Transitional h) archaeopteryx
i) evolving j) can be changed
k) breed l) Comparative
m) common ancestor
n) chemicals o) common ancestor

Worksheet 4

1. first fish, first land plants, first land animals, Age of dinosaurs, first birds, mammals take over

2. a) A dinosaur-bird, a dinosaur with feathers.
b) They give us a fossil glimpse of a stage in the evolution of one type of life into another.

3. It proves that a species can change when there is selection of which individuals are allowed to breed.

4. a) Literally, “5 fingers”.
b) That they all evolved from a common ancestor which had that structure.

5. All living things use the same genetic code in their DNA.

6. Common ancestry. We still retain some features of our remote ancestors.

Worksheet 5

A.
1. All organisms produce more offspring than can possibly survive.
2. In every species there is variation.
3. Nature selects which individuals survive
4. The survivors breed and pass on their survival traits.
5. Each generation is different because there has been selection of who survived to breed. As these changes accumulate, the species evolves.

B. Climate, predators, disease.

C. It means to survive and breed.

D. i) No.
ii) In the next generation, which receive a slightly different proportion of each “variation”.

Worksheet 6

1.
a) Variations increase the chance that some individuals might survive a change in the environment.
b) Without variations, all individuals could be wiped out in a changed environment, so the species becomes extinct.

2. a) Mutations
b) It mixes genes from 2 parents to produce new combinations of features.

3. a) Change of climate, a new predator, a new disease.
b) World-wide climate change is the most likely cause.

4. Each isolated group may be acted on by different environmental factors. Natural selection chooses different "survival features" in each place, so each group evolves differently. Eventually each group may become a different species.

5. a) Gondwana
b) plants = banksias and gum trees.
animals = reptiles & marsupial mammals.
c) "Giant" species of animals.
e.g. Diprotodon was a 3-tonne wombat.

Topic Test

1. a) B b) A c) D d) E e) C

2.
a) Sedimentary
b) Older fossils lower down, younger fossils above.
c) There is a trend from simple to more complex, or from less like modern types to more and more resembling modern life.
d) Life changes by a process of evolution. This constantly causes living things to change to become better able to survive their environment.

3. a) Archaeopteryx was a dinosaur-bird.
b) Transitional fossils show us a fossil glimpse of a stage in the evolution of one type into another.

4. The "pentadactyl" limb structure is common to most vertebrates even though various animals might use them as legs, flippers or wings. The same bone structure used in such different ways suggests that all types descended from a common ancestor which had that structure.

5.
a) 1. All species produce more offspring than can possibly survive.
2. All species have variations among individuals.
b) The factors of the environment ("nature") select which individuals survive and which don't.
c) Those individuals with better "survival features" are the ones who survive to breed. It's all about reproduction.
d) So that when the environment changes there is a better chance that some will survive to breed, rather than the species becoming extinct.