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# THEORIES OF EVOLUTION PART 2: MASS EXTINCTION

## SECTION A: TYPICAL EXAM QUESTIONS

**Question 1: 6 Minutes** (*Taken from DoE Feb/March 2009 Paper 2)*

1.1 The dinosaurs became extinct nearly 65 million years ago.

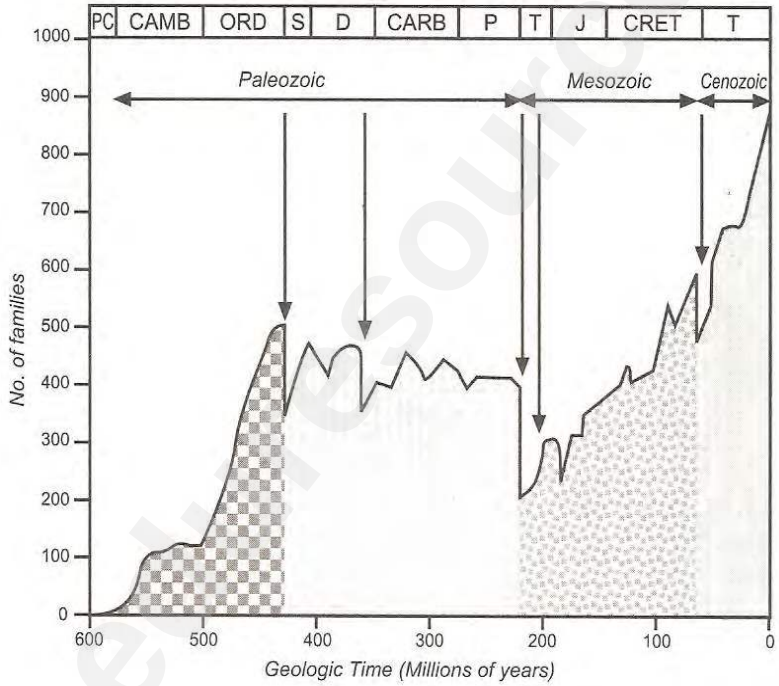
1.1.1 What evidence do scientists use to show that dinosaurs once existed on Earth? (1)

1.1.2 State how scientists have come to the conclusion that the period that dinosaurs existed was between 65 and 245 million years ago. (1)

1.2. Describe the extra-terrestrial theory that is proposed by scientists as a possible cause of the extinction of the dinosaurs. (4)

**Question 2: 14 Minutes** *(Taken from DoE Wester Cape September 2009 Paper 2)*

The graph below shows how the number of families of species has changed over time. The arrows indicate periods of mass extinctions.




| Key | | |
|---|---|---|
| PC | = | Precambrian |
| Camb | = | Cambrian |
| ORD | = | Ordovician |
| S | = | Silurian |
| D | = | Devonian |
| Carb | = | Carboniferous |
| P | = | Permian |
| T | = | Triassic |
| J | = | Jurassic |
| CRET | = | Cretaceous |
| T | = | Tertiary |



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2.1 Explain the term "mass extinction" (2)

2.2 When did the Mesozoic era start? (2)

***(HINT: Use a ruler to read information from the graph to avoid errors)***

2.3 Approximately how many families of species died out at the end of the Paleozoic era? Show ALL working. (3)

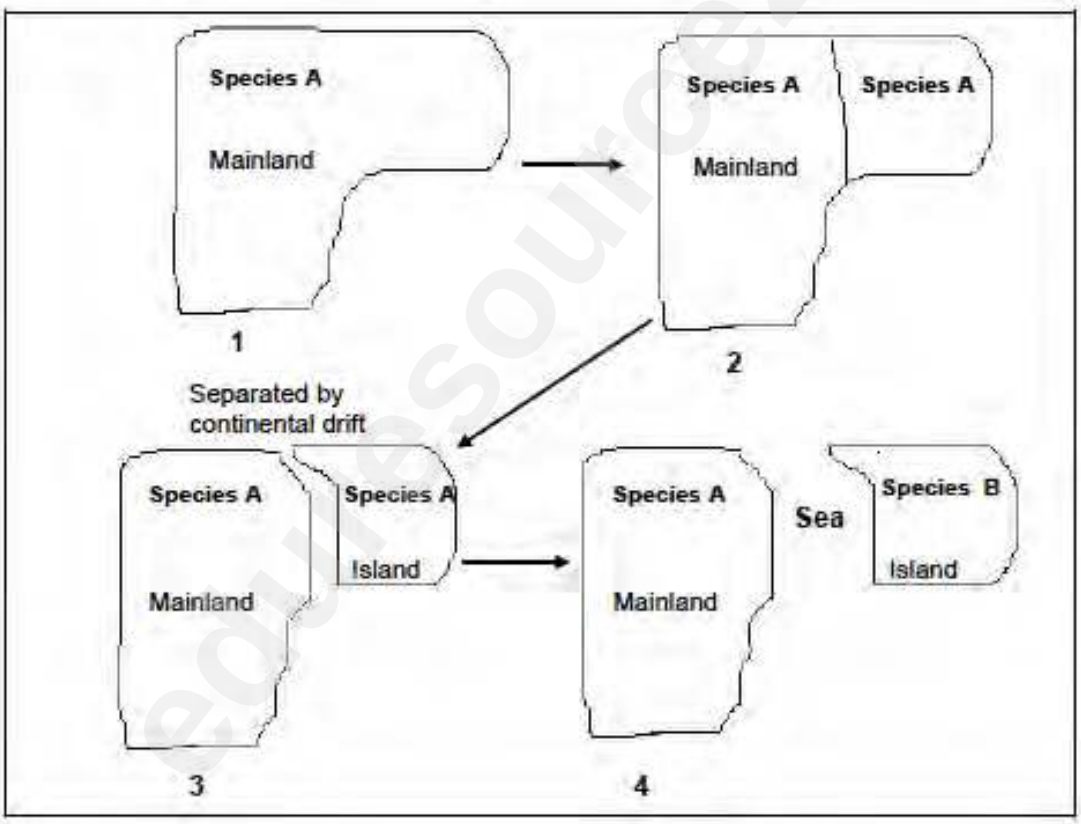
2.4 What happened to the number of families after each mass extinction? (1)

2.5 Scientists have come to the conclusion that the dinosaurs became extinct about 65 million years ago. What is currently the most accepted theory for this mass extinction? (1)

2.6 Describe the theory mentioned in QUESTION 2.5 that is proposed as a possible cause of extinction of the dinosaurs. (5)

**Question 3: 6 Minutes** *(Taken from DoE Feb/March 2010 Paper 2)*

Study the following diagrams which show different stages (1 to 4) of a process in evolution.




3.1. Name the evolutionary process that resulted from the continental drift shown. (1)

3.2. Describe how the original population of species A split to become two species as indicated in the diagrams above. (5)

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**Question 4: 8 minutes** *(Taken from various DoE exam papers)*

Various options are provided as possible answers to the following questions. Choose the answer and write only the letter (A – D) next to the question number (4.1 – 4.8).

**Learner Note**: Please do not to waste time when you answer Multi Choice questions. Read the question, cover the answers, and then underline the operative words Then think of the correct answer. Then uncover the answer options and check if your chosen answer is there. If it is, then tick next to the letter. If it is not, re-read the question and try to see exactly what is being asked. Then review the answer options again to find the correct answer. A good strategy is always to answer Section A, the Multi-choice questions, last.

4.1. Most scientists agree that the number of mass extinctions that have occurred in the history of life on Earth is …
A 3
B 7
C 6
D 5

4.2. According to the theory of continental drift, all the land masses were joined together to form one super-continent called …
A Gondwanaland.
B Pangaea.
C Eurasia.
D Laurasia.

4.3. Micro-evolution is a term that describes …
A the process by which new genera and families of organisms are formed.
B small changes that occur in the genotypes of organisms within the same species.
C changes that can be seen without a microscope.
D an increase in the size of individuals of a population over a long period of time.

4.4. According to Charles Darwin, organisms that will be most successful biologically, are those that …
A are best adapted to their environment.
B are the largest in the population.
C reproduce the slowest.
D do not change.

4.5. A consequence of an increasing human population is that …
A natural gas reserves will increase.
B raw materials will be conserved.
C more waste will be produced.
D more resources will be saved.


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4.6. Which of the following are used to explain mass extinction?

i. Ice ages
ii. Outbreeding
iii. Volcanic activity
iv. Disease

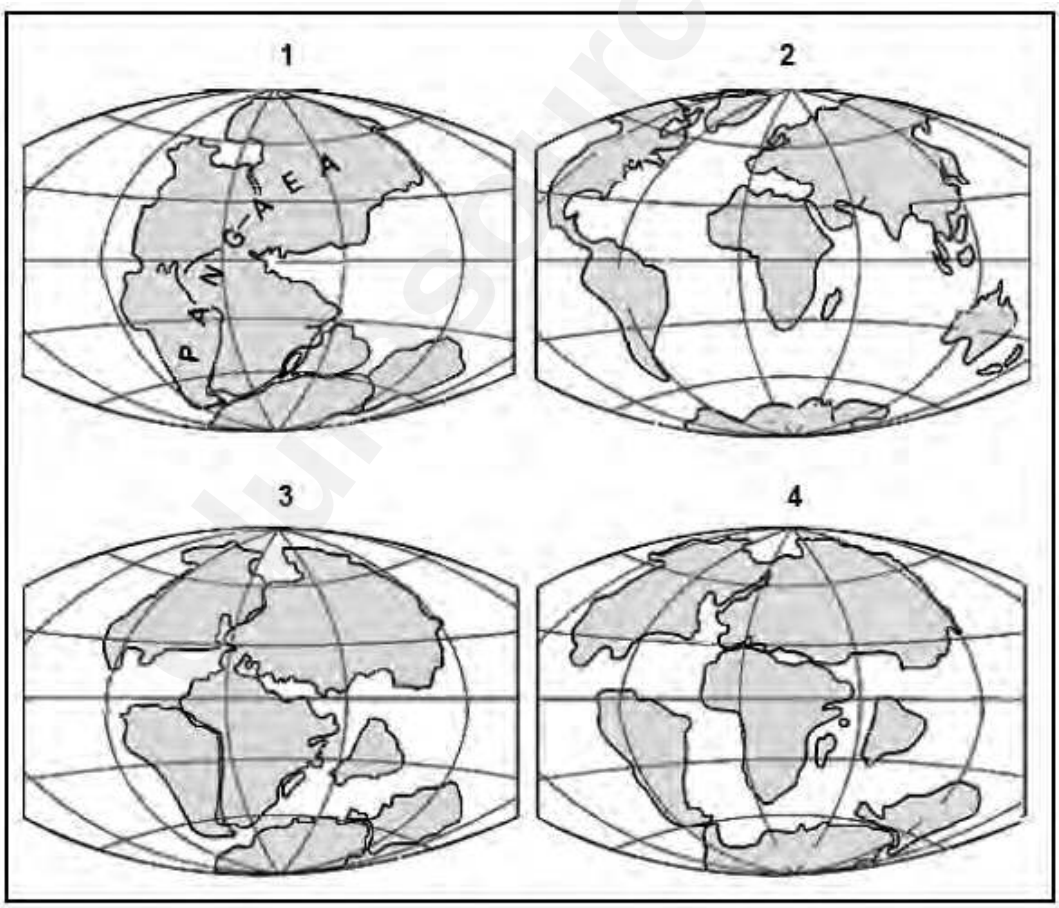
***(Hint: Tick what you think is the correct point and place a X where you think the point is not relevant. Read the question again and then select your option)***

A (i) and (ii) only
B (i), (iii) and (iv) only
C (i), (ii) and (iii) only
D (ii), (iii) and (iv) only

4.7. The evidence that related species in similar biomes across the world developed from a common ancestor, is obtained from …

A micro-evolution.
B embryology.
C biochemistry.
D biogeography.

4.8. Study the diagram below showing stages in continental drift.

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The correct sequence of events during continental drift is …
A 1, 2, 3, 4
B 1, 4, 2, 3
C 1, 3, 4, 2
D 1, 2, 4, 3 (1 x 8 = 8)

## SECTION B: SOLUTIONS AND HINTS

**Question 1:**

1.1.1 Fossil ✓evidence/Paleontological studies (1)
1.1.2 Radiometric dating ✓ of the fossils or the rocks in which the fossils were found (1)
1.2 - A comet, an asteroid or part of a star ✓ from outer space struck the Earth/Gulf of Mexico which resulted in - large clouds of dust blocking out the sun ✓
- stopped photosynthesis ✓ - global cooling ✓/dinosaurs might have been ectotherms and not able to live in the cold
- world-wide fire ✓
- monstrous tsunamis ✓

These factors caused the dinosaurs to become extinct (**any 4 = 4)**

**Question 2:**

2.1 When many species all become extinct during the same time period ✓. (2)
2.2 Accept any answer from 220 – 225 ✓million years ago ✓/mya (2)
2.3 400 ✓– 200 ✓ = 200 ✓ families of species (3)
2.4 Number of families increased ✓ (1)
2.5 Asteroid – impact theory ✓ (1)
2.6 - A comet, an asteroid or part of a star ✓ from outer space struck the Earth/Gulf of Mexico which resulted in
- large clouds of dust blocking out the sun ✓
- stopped photosynthesis ✓
- global cooling ✓/ ice age
- dinosaurs might have been ectotherms and not able to live in the cold✓
- world-wide fire ✓
- monstrous tsunamis ✓
- These factors caused the dinosaurs to become extinct **any (5)**

**Question 3:**

3.1. Speciation ✓ (1)
3.2. The population of species A has split up into two
The sea forms a physical barrier ✓ and each group adapts to the new environmental factors ✓
Each group undergoes natural selection independently ✓ and develops separately / micro-evolution
Each group may become genotypically ✓ and phenotypically different ✓
Might prevent them from interbreeding ✓when they come into contact again/become reproductively isolated leading to the formation of a new species ✓ **(any 5 = 5)**


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**Question 4:**

4.1 D
4.2 B
4.3 B
4.4 A
4.5 C
4.6 B
4.7 D
4.8 C **(1 mark each = 8)**

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## SECTION C: ADDITIONAL CONTENT NOTES

Each plant and animal species has something to contribute to life on earth and has originated from somewhere. Extinction has occurred on vast scales over the ages, caused by shifts of the continental plates, the impact of meteorites and volcanic activity. Each time a few individuals of a species survive and diversify, biological evolution occurs and ensures diversity. The organisms survive because they are able to adapt to the changing environment. **Micro-evolution** is when small changes occur in the individuals of a population. These small changes are due to mutations, natural selection, gene flow and genetic drift. **Macro-evolution** is when large scale changes in gene frequencies occur in a population, over a geological time period. Macro-evolution is, therefore, the sum total of long periods of all micro-evolution periods.

**Extinction** occurs when the species is unable to adapt to environmental changes. Fossil evidence proves that many of the organisms that lived long ago, are now extinct. In this unit, we are going to study what caused the mass extinctions.

**Continental Drift**

All organisms are adapted to their **biotic and abiotic** environment as the factors in a habitat support the organism. One can assume that if two habitats are the same, the same organisms will be found there naturally. This is not the case. Plant and animal species are **discontinuously distributed** across the world. The explanation for discontinuous distribution is based on the concept of **organisms originating in an area** and then **dispersing outwards**. However, many species are found living naturally in areas that are very far away from each other. Fossil evidence shows that distribution of species was not always as we know it today.

In 1912, **Alfred Wegener** proposed that all the different continents seemed to fit into one puzzle. He claimed that all the continents were once one huge piece of land, a supercontinent called **Pangea**. Plants and animals would have competed with one another and this led to extinction. Marine life would also have been greatly affected because there would have been a substantially shorter coastline. This **supercontinent** broke up into pieces approximately 180 million years ago, in a process called the **continental drift.** Wegener could not prove his theory, as he could not explain what would have caused the continental drift.

In 1960, scientists were able to explain the theory of continental drift. The earth's crust is composed of **seven large plates**, which float on the layer of the earth's mantle. The landmasses are located on top of these plates. The plates move by **plate tectonics**, causing the landmasses to move.

The areas where two plates meet, is characterised by much **geological activity**. This causes the formation of mountains, earthquakes and volcanoes. The Himalayas were formed when India's plate crashed into Asia's plate. When two plates move away from one another the area in between gets larger, like landmasses situated opposite each other in the Atlantic Ocean. Lava builds up between the plates, preventing the plate from moving back.


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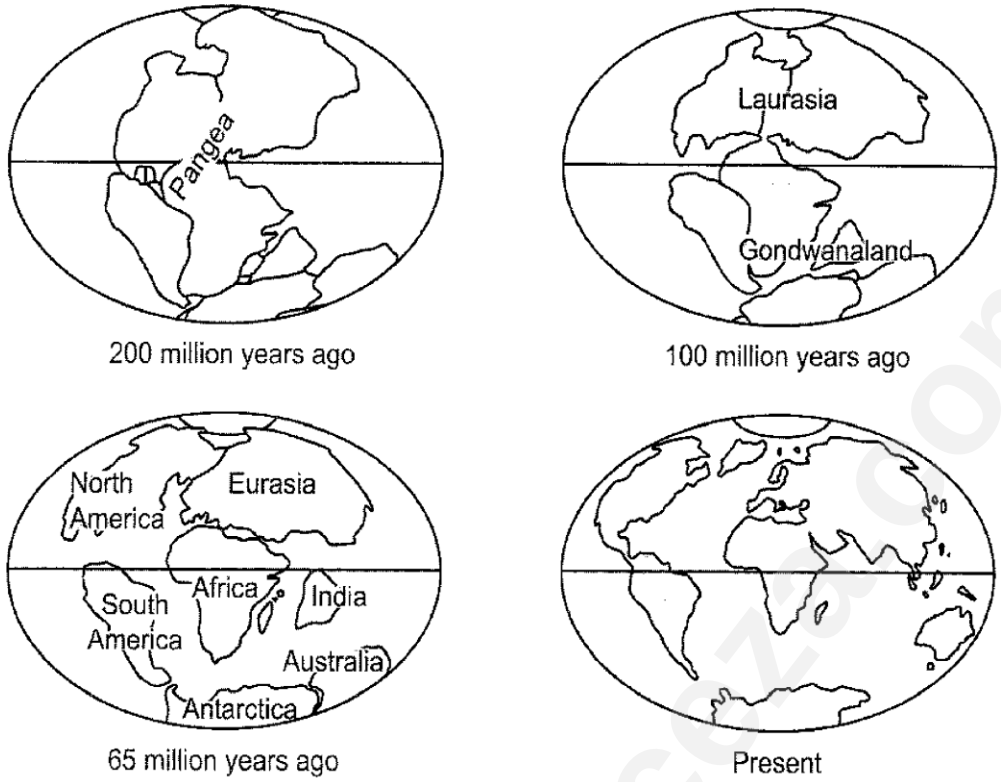


**A line diagram to show the theory of Continental drift** *(Taken from Vivlia: Grade 12 Viva Life Sciences)*

**Ice Age**

- **Atmospheric composition:** the relative amounts of water vapour, $CO_2$, methane, sulphur and various other gases in the atmosphere
- **Changes in the earth's orbit** around the sun which is known as Milankovitch cycles
- **Plate tectonics:** movement of the tectonic plates resulting in changes of the position of the continents and oceans
- **Variations in solar output** and the sun's energy
- the impact of relatively large **meteorites**
- **Eruptions** of the large volcanoes.

**Evidence to prove past ice ages occured:**

- The earliest ice age occurred about 2,5 billion years ago during the **early Proterozoic Age.**
- The next ice age occurred about 700 million years ago during the Cryogenian **Period.** It is thought that this ice age reduced the earth to a „snowball' because permanent sea ice extended to the equator.
- About 440 million years ago the last ice age occurred during the Late Ordovician **Period.**
- Finally, extensive polar ice caps formed at intervals from 350 to 260 million years ago during the Carboniferous **Period**. This ice age is associated with the Karoo Ice Age.


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**Heating and cooling of the atmosphere**

The sun provides the earth with heat. The atmosphere keeps the earth's surface at the correct temperature. High clouds increase energy reflection, while low clouds and $CO_2$ increase absorption. The rotation of the earth on its axis around the sun provides us with our seasons. Sunlight or radiant energy is made up of three parts:

- **infrared light**, which provides heat
- **visible light**, which provides light to see
- **ultraviolet light**, which is dangerous to plants and animals and causes global warming.

Pollution has a direct impact on heat reflection because the atmosphere affects the heating and cooling of the earth's surface directly.

**Chlorofluorocarbons (CFCs):**

CFCs are used in fridges, aerosol sprays and in plastic foams like polystyrene. The CFCs collect in the atmosphere and **reduce the concentration** of the ozone. The ozone forms a „blanket' about 25 km into the atmosphere and filters out much of the harmful ultraviolet rays from the sun. When the ozone is **reduced** by CFCs, more ultraviolet light is allowed through and can cause skin cancer and cataracts in the eyes. Plant growth is affected and marine plankton is damaged.

**The Greenhouse Effect:**

The atmosphere acts like a **glass box** around the earth, allowing heat and light from the sun to enter. The glass box reduces the amount of heat that is radiated from the earth's surface. This heat is radiated as **infrared energy** and causes the greenhouse effect. Some gases like water vapour, $CO_2$, methane, CFCs and nitrogen oxide absorb most of the infrared radiation. When these gases increase, it results in the greenhouse effect increasing and the atmosphere around the earth gets warmer.
When industries burn coal, oil and gas for energy, excess $CO_2$ is released into the atmosphere. If the $CO_2$ concentration becomes too high, the photosynthesis process will not be able to maintain the balance. With increased absorption of the infrared radiation, an **increase** of the earth's temperature will result. This is called **global warming**.

**The greenhouse effect and global warming:**

If the process of global warming is not slowed down or reversed:

- **Changes in the climate** as the earth's temperature increases - more condensation and cloud cover over certain regions reducing the light reaching the earth, affecting the rate of photosynthesis of plants. Will also cause a reduced rainfall, resulting in desertification.
- **Polar ice caps could melt**, causing a rise in the sea level flooding many islands and coastal cities.
- **Extremes in temperature** will cause changes in agricultural growth patterns, drought and food shortages.
- **Changes in low and high air pressure zones** will result in hurricanes and cyclones.


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## Extraterrestrial Theories

Scientific evidence shows that the universe began **10 to 15 billion** years ago, with an incredible explosion scientists call the „Big Bang'. In the process of **nucleosynthesis**, nuclear fusion occurs in stars causing elements to join together to produce heavier elements. This process generates large amounts of energy. **Visible light** is one form of this energy. The light elements like hydrogen, helium and lithium were produced during the first few minutes. When the universe cooled, protons and neutrons collided to produce **deuterium** (one proton combined with one neutron). This process continued, producing all the known elements.

After the „Big Bang', gravitation pulled clouds of gas and dust, to create giant clusters of matter. The interaction of colliding particles increased the temperature to about 15 million degrees. The electrons in the atoms were **separated** from the nuclei and created a plasma which then fused. The energy released during this process, reached the surface and stars were born. This fusion process produces enough energy to create an **inward pull of gravity**. A star's lifetime is the time it takes to exhaust all its fuel, so it is almost equal to the ratio of its mass over its luminosity (shining). The lifetime of our sun, a small star, should be about 10 billion years. It has already existed for 5 billion years.

## Meteor Collisions

Scientists collected samples from the South African and Australian formations where both sites contained **3,5-billion-year-old layers of rock** embedded with tiny spherical particles that are by-products of **meteorite** collisions. Meteors pass through the atmosphere in about one second, leaving a vacuum directly behind it. The surrounding air cannot move in fast enough to fill that hole that is created. When the meteor hits the surface, it vaporises the rock.

One evolution theory is that a huge **meteor hit the earth**. This meteor generated enormous waves, which swept across the ocean and produced tsunamis. The impact tore up the bottom of the ocean. Fossil records show that the oldest known **microbial fossils** have been found in rocks 3,4 to 3,5 billion years old. This is about the same time of the ancient meteorite collision documented. The impact of a meteor on a hot earth would send large amounts of **dust** into the atmosphere. This would cause the earth's climate **to cool** a great deal and is believed to be the cause of the **ice age** that lead to the extinction of dinosaurs.

## Diseases

Several major outbreaks of highly contagious diseases have killed millions of people over the ages. The human species survived these terrible **pandemics,** but scientists predict that we are due for another major outbreak of disease. Some of the pandemics that have posed a threat to the human race are the Black death, Spanish flu, Malaria, TB and HIV/AID.


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## SECTION D: HOMEWORK

**Learner Note**: As you attempt attempt the homework, you MUST stick to the time frames. If you get stuck refer to either the additional notes or your class teacher.

**Question 1:**
Various options are provided as possible answers to the following questions. Choose the answer and write only the letter (A – D) next to the question number.

1. Extinction occurs….
   A. When a species is unable to survive in their environment.
   B. When only a few of a species survives.
   C. When a species goes into hiding until conditions improve.
   D. The gradual depletion of a population.

2. Discontinuous distribution is…
   A. When the organisms live in one area and distribute within their environment.
   B. Organisms originate on one area and disperse outward.
   C. When organisms originate in different areas and migrate towards one another.
   D. When different species are distributed evenly among one another.

3. Pangea is said to be…
   A. The continents which made up two large masses of land.
   B. The continents, which made up one large mass of land.
   C. The seven continents that exist today.
   D. The continents, which made up three masses of land.

4. What is an Ice Age?
   A. It is when it gets cold in winter time
   B. When there is a very long period of time with very low temperatures
   C. The Artic and Antarctic poles
   D. When it takes ages to get warm

5. CFC's or Chlorofluorocarbons
   A. Collects in the atmosphere and reduces the concentration of oxygen in the atmosphere.
   B. Are poisonous when inhaled.
   C. Reflect light back into the atmosphere.
   D. Collect in the atmosphere and reduces the concentration of ozone.
6. The greenhouse effect causes…
   A. Plants to grow faster.
   B. Plants to grow slower.
   C. Global warming.
   D. Global cooling.


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7. If global warming is not slowed down is will result in…
   A. The earth's temperature increasing.
   B. The earth's temperature decreasing.
   C. The production of more bacteria and fungus.
   D. The production of more carbon dioxide.

8. The fossil records reflect that the first meteor collision occurred ….
   A. About 5 billion years ago
   B. About 8 billion years ago
   C. About 3,5 billion years ago
   D. About 2,5 Billion years ago

9. "Black Death" or the bubonic plague is spread by
   A. Mosquitoes.
   B. Rats and their fleas.
   C. Coming into contact with infected bodily fluid.
   D. Smoking.

10. Malaria is spread by…
   A. Mosquitoes.
   B. Rats and their fleas.
   C. Coming into contact with infected bodily fluid.
   D. Smoking.

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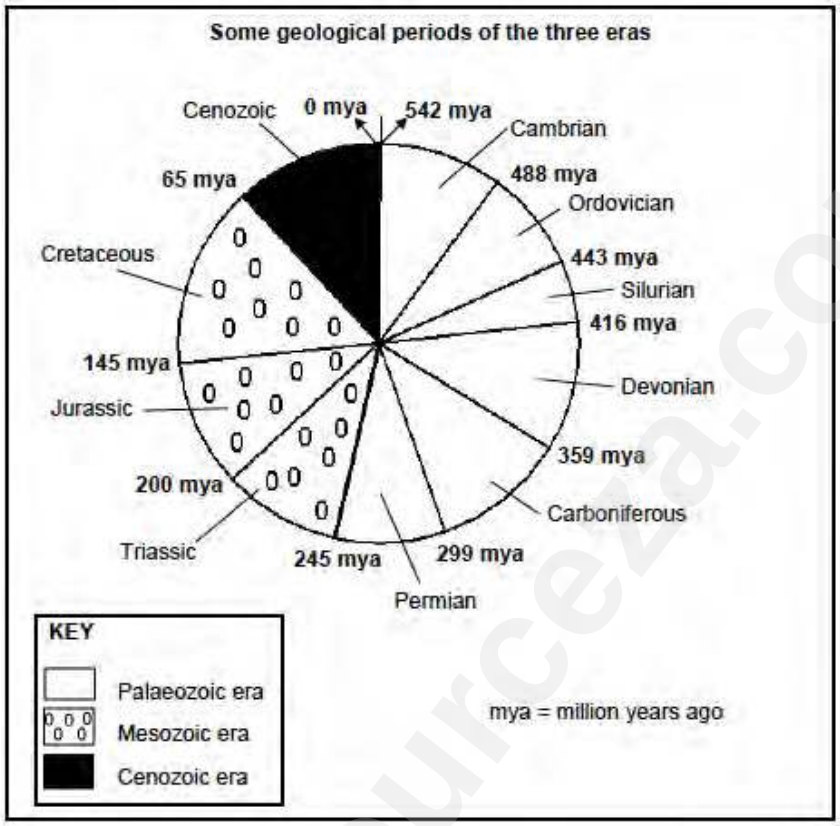
**Question 2: 13 Minutes** *(Taken from DoE Feb/March 2010 Paper 2)*

Study the pie chart on the following page which shows some geological periods of the three eras and answer the questions that follow:




2.1. Which of the three eras had the longest duration? (1)

2.2. The biggest mass-extinction took place 250 million years ago.

a) State in which era this occurred. (1)

b) State in which period this occurred. (1)

2.3. In which era did modern humans first appear on Earth? (1)

2.4. Scientists think that 'something large' from outer space struck the Earth when the Cretaceous period ended.

a) How many years ago did this 'something large' strike the Earth? (1)

b) Name a possible structure that hit the Earth at the end of the Cretaceous period. (1)

c) Describe how this structure named in QUESTION 1.5.4(b) could have caused the mass extinction of many species. (4)

2.5. The half-life of C14 is 5 730 years and the half-life of uranium is 700 million years. Explain which of C14 or uranium should be used to calculate the age of dinosaur fossils. (3)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## SECTION E: SOLUTIONS TO SESSION 21 HOMEWORK

**SESSION 21:**
**Question 1:**

1.1 Natural selection– those organisms with the most beneficial √ traits are more likely to survive and reproduce√. (2)

1.2 Organisms produce more offspring √ than can survive. These organisms compete for limited resources√
There is variation √ in populations. Organisms change over time, those living today are different to those who lived in the past√, i.e.
Change is gradual and slow, taking place over a long time√
The mechanism of evolutionary change was natural selection√
All organisms are derived from common ancestors √ by a process of branching, i.e. organisms pass genetic traits to the next generation√
**Any 6 (6)**

**Question 2:**

2.1 93 ✓% (accept 92 - 95) (1)

2.2 - As the pollution decreased ✓
- the percentage of the dark-coloured moths also decreased ✓ (2)

2.3 - The dark-coloured moths are not being camouflaged ✓/can easily be seen against the light lichen-covered bark
- and have become easier targets/prey for birds✓ (2) **[5]**

2.4 Lamarck believed that structures of individuals in a population became better✓ or less adapted✓ to the environment ✓ depending on the frequency of their use ✓ and that these adaptations could be inherited from generation to generation ✓
He suggested that change was driven by living things themselves ✓ as they strove to perfect their way of life ✓
More complex organisms developed from less complex organisms ✓
He supported the idea of common descent and linked diversity with adaptation to the environment ✓
He supported the idea of the inheritance of acquired characteristics ✓
**any (5)**


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