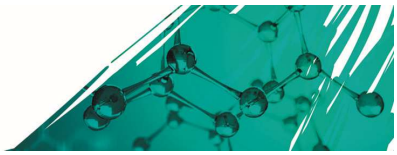


Unit 10: Climate Change

Delivery guidance

This unit covers the principles, historical evidence and present-day understanding of the Earth's atmosphere.

Approaching the unit

Young people worldwide are concerned about climate change because they are likely to experience the consequences during their lifetimes.

The three learning aims require learners to develop an understanding of:

- the Earth's past and current atmosphere.
- the evidence for atmospheric change related to 'greenhouse gases'
- various strategies that may help address climate change.

Delivery methods for this unit could include:

- learner research, using textbooks, journals, scientific magazines and the internet
- tutor presentations and explanations of key concepts (prehistoric climate, the climate since the industrial revolution, and the main strategies of mitigation: governmental, industrial and personal lifestyles)
- 3D models of the structure of the Earth to show the crust, oceans, atmosphere, wind and ocean currents
- simulations and animations from the internet to assist understanding of the historical changes that have occurred in the atmosphere, the structure of the Earth and its atmosphere
- historical documentaries about the industrial revolution and increasing energy needs
- TV documentaries, films and newspaper articles about climate change and increasing use of fossil fuels
- scientific articles related to greenhouse gases and their effect on the atmosphere and climate change
- debates, e.g. about the use of fossil fuels versus renewable energy sources
- visits/virtual visits from speakers involved in organisations with views on climate change, or from/to a local weather centre
- visits/virtual visits to organisations/businesses involved in innovation to reduce emissions
- links with *Unit 8: Contemporary Issues in Science* if learners are following the Extended Diploma programme
- recent historical data on weather, temperature, rainfall, wind speed, etc., accessed via the internet and/or newspapers
- work placement with companies and organisations involved in green technologies, such as wind or solar power
- links with *Unit 28: Sustainable Energy*.

The evidence required for assessment is research-based; there are no assessment criteria that require evidence of learners carrying out practical work. Learners will require access to a wide range of secondary sources and data.

Climate change is not an exact science and there is much debate about the validity and reliability of the information that is presented as 'evidence'. Deciding what is 'scientific fact' and what is 'hypothesis/speculation' can make for exciting learner discussion and debate.

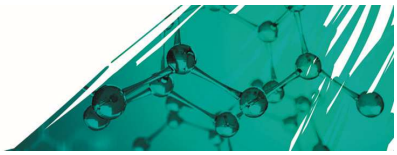
Many learners have some familiarity with the issues surrounding greenhouse gases, use of fossil fuels, renewable energy sources and links with climate change. Much of their familiarity may be the result of anecdotal and journalistic/media evidence. You must assess learners' prior knowledge and address any inaccurate beliefs or misunderstandings on a learning aim by learning aim basis.

Learning aim A requires learners to demonstrate an understanding of the fundamental aspects of the Earth's atmosphere and its history. A clear narrative of the formation of the Earth and its atmosphere is increasingly emerging thanks to advances in geology. The changes are documented in the popular scientific journals (see Resources). Learners must be able to explain the evidence and theories about the composition of the Earth's crust and the percentages of gases in the early and present-day atmosphere. The evidence for the differences must be evaluated. You could use documentary TV programmes and videos to engage learners.

For **learning aim B**, learners are required to develop an understanding of the evidence for atmospheric change related to 'greenhouse gases'. Learners will need to be able to describe and analyse the evidence about factors that cause greenhouse gases. They must describe the evidence linking industrialisation and global warming. The effects of anthropogenic activities, pre- and post-industrialisation, on climate change, and the biosphere and atmosphere, now and in the future, must be explained and compared. The influence of glacial advances and retreats, changes to the orbit of the Earth, the Milankovitch cycles, evidence from ice core drilling, ocean sediments, tree rings and coral reefs should be described. Data on carbon dioxide, methane, water vapour and nitrous oxide in the atmosphere, temperature and sea levels throughout history will be accessed and used as part of the evidence presented for assessment.

Learning aim C requires learners to describe, explain and evaluate methods that can help address climate change. Learners will investigate the measures outlined by the Intergovernmental Panel on Climate Change (IPCC) and include these in their evidence. To understand legislative approaches to climate change, centres may consider inviting local or national politicians or government officials as visiting speakers. Similar invitations may be made to environmental non-government organisations (NGOs). Learners can investigate changes that individuals can make by calculating their family's carbon footprint, and they can explore ways to reduce it – for example, by not using fossil fuel transport, reducing energy consumption by switching off lights/equipment when not in use, recycling and use of smart meters.

Learners will need to investigate industrial and scientific innovation to reduce emissions, e.g. renewable energies and increasing fuel efficiency.



Assessment model

Learning aim	Key content areas	Recommended assessment approach
A Understand the fundamental aspects of the Earth's atmosphere and its history	**A1** Evidence and theory of early atmosphere composition **A2** Changes to the atmosphere with time **A3** Development and understanding of present-day atmosphere condition	A scientific report and diagrams, including correct use of terms and numerical values. A presentation that outlines the features and numerical values associated with early gaseous composition. Diagrams for all atmospheric levels. Descriptions of volatile components and sources of early atmospheric gases and elements.
B Undertake research to develop an understanding of the evidence for atmospheric change related to 'greenhouse gases'	**B1** Evidence of atmosphere changes since the start of industrialisation **B2** Nature and causes of greenhouse gases **B3** Possible future trends of atmosphere changes and their effects	Descriptions of research that gives evidence for atmospheric change. A report on the main causes of greenhouse gases and their behaviour. Discussion on scientific evidence and suggested changes to the atmosphere over time, based on a number of viewpoints.
C Investigate the measures outlined by the Intergovernmental Panel on Climate Change (IPCC) to combat future climate change	**C1** Climate change forums and the Intergovernmental Panel on Climate Change (IPCC) **C2** Changes to industrial methods and science innovation **C3** Changes that can be made by individuals	A report on the most recent meetings of the IPCC, and other forums that address climate change. List and discuss the application of new scientific methods for industrial development that have a reduced effect on climate change. A report on what humans can change in their lives to help reduce their 'carbon footprint'.

Assessment guidance

This is an internally assessed unit with a maximum of three summative assessments – one for each learning aim. All unit content must be delivered during teaching and learning.

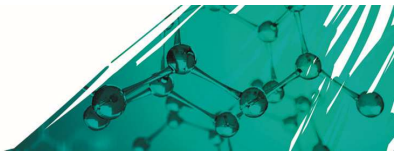
Pearson-authorised assignment briefs are available and use a holistic approach, which gives access to all assessment criteria.

The evidence presented for assessment must be produced independently to meet the targeted assessment criteria.

Learning aim A requires learners to produce evidence in the form of a scientific report and presentation of their understanding of the fundamental aspects of the earth's atmosphere and its history. Learners must be able to explain the theories about the development and composition of the early atmosphere. They must discuss the differences and changes between the early and present-day atmosphere.

For learning aim B, learners must produce a report to show evidence of their research and understanding of the evidence for atmospheric change related to 'greenhouse gases.' Learners must describe the factors that cause greenhouse gases. They must describe and analyse the evidence that links these factors to global warming, climate change and industrialisation. They will explain the possible effects of climate change on the biosphere and atmosphere, and links to anthropogenic activities on the future atmosphere. Learners must make a comparison between the effects of pre- and post-industrial activities on the Earth's surface and its atmosphere.

Learning Aim C, requires a report describing the measures outlined by the Intergovernmental Panel on Climate change (IPCC) to combat climate change and an explanation and evaluation of the methods used to address climate change



Getting started

This gives you a starting place for one way of delivering the unit, based around the recommended assessment approach in the specification.

Unit 10: Climate Change

Introduction

This unit could be linked with a major international climate-related conference such as COP (Conference of the Parties) – a UN initiative. This is an annual event held in November/December each year since 1995. These events invite young people to participate, both in person and online. If learners cannot participate directly, they could follow the conference debates and read the communiques and decisions taken.

Prior knowledge should be assessed by giving simplified unit content for learners to indicate what they are confident about, what they have heard of and what they have not heard of. This could be done on an individual learning aim basis. The delivery of the unit content can then be adapted to meet learner needs.

Learning aim A – Understand the fundamental aspects of the Earth's atmosphere and its history

Learning aim A should emphasise that the earth's atmosphere has changed considerably throughout its history. There have been periods of greater heat and cold than we have today. However, these changes usually took place much more slowly than today's anthropogenic global warming.

The activities below have been split across the unit content but there is a lot of overlap between the three sections of the learning aim content.

A1

- Hold a discussion to assess prior knowledge. Ask learners:
    - How was the Earth formed?
    - When was it formed?
    - What did it look like?
    - What was the atmosphere composed of?

  Depending on knowledge and understanding, your input and/or learner research may be required on some or all of these questions.
- Learners could access the internet and produce their own 3D model or posters of the early Earth and its atmosphere.
- Use videos, animations or simulations to help learners visualise the process and consolidate knowledge and understanding. Search the internet, using terms like 'origin and evolution of the Earth' and 'Earth timeline'.
- Have learners research articles online about the evidence for the formation of the Earth and when life first appeared. They could use the terms 'stromatolites' and 'evidence of chemical reactions and biochemical processes in rocks'. They can feed back and discuss their findings with the rest of the class.

A2

- Give a presentation/introduction to emphasise that, for most of the Earth's history, it has been much warmer than for the past three million years or so.

- Use these discussion points to assess prior knowledge:
    - What is the Earth's crust made up of?
    - When did life first appear on Earth?
    - How did this affect the atmosphere?
    - What are 'volatile compounds' and why are they important?

  Depending on knowledge and understanding, your input and/or learner research may be required on some or all of the questions.
- In groups, ask learners to research the terms 'sources' (means of adding gas to the atmosphere) or 'sinks' (removal of gas from the atmosphere) or 'residence time of atmospheric molecules'. They will prepare a short presentation to be given to the rest of the class.

A3

- Ask learners, individually or in small groups, to research the composition of gases in the present-day atmosphere, including the atmospheric layers, their altitudes and characteristics:
    - troposphere
    - stratosphere
    - mesosphere
    - thermosphere
    - exosphere.

  Have them present the findings to the rest of the class.
- In small groups, learners can produce a timeline of the development of the early atmosphere.

Learning aim B – Undertake research to develop an understanding of the evidence for atmospheric change related to 'greenhouse gases'

B1

- Introduce the learning aim by playing a song or reading a poem about greenhouse gases/global warming/climate change. These can be found on the internet by typing 'songs/poems about climate change' into a search engine.
- Have learners produce posters to describe and explain:
    - the carbon cycle
    - carbon dioxide and its change in abundance in the atmosphere
    - the importance of carbon dioxide in biological compounds
    - the importance of carbon dioxide in fossil fuels.

  Review carbon sinks (soil, plants and oceans) from learning aim A. Learners should present their posters to the rest of the class. Your input will be required to ensure full coverage of the concepts.
- Have learners use role play to explain the carbon cycle, using small balls/beans as carbon atoms and transferring them to or from parts of the carbon cycle, represented by other learners. Instructions can be found on the internet; search 'carbon cycle role play'.

- Give learners, or ask them to research for themselves, data on carbon dioxide levels in the atmosphere (troughs and peaks cycle pre-1950). They should discuss and present reasons for the increase from 180–330ppm (prior to 1950) to 300–440ppm (post-1950).
- Give an introduction about the seven cycles of glacial advances and retreats in the last 800,000 years and their impact, so that learners can carry out further research to produce an information poster. Videos are available on the internet; search using the terms, 'ice ages', 'climate cycles' and 'seven cycles of glacial advances'.
- Learners may not be aware that there have been slight changes to the orbit of the Earth, and this has affected the climate. A video from the internet can be used to introduce the 'Milankovitch cycles'. Learners will then research the concept further and present their findings to the rest of the class.
- Ask learners how we know what the atmosphere was like in the past. Through individual research they should identify ice core drilling, sediments from the ocean floor, tree rings and bands in the hard shells of coral.
- Learners should discuss the evidence from the activity suggested above using scientific research findings they have been given or found for themselves.
- Learners may be familiar with the greenhouse effect and how gases in the atmosphere affect the passage of infra-red radiation through the atmosphere. To consolidate their understanding, give learners unlabelled diagrams and ask them to add annotations to explain the concept. Some learners may prefer to create an animation on computer. The effect of increased methane levels must be included.
- Learners will need to research how temperature patterns were recorded in five of the warmest years recorded since 2010. Learners must identify how a 0.4^{O}C increase in temperature of oceans to depths of 700m over the last 50 years has influenced/contributed to the loss of ice sheets, glacial retreat, loss of snow cover and sea-levels rising by 20cm over the last 100 years. They should also look at the increase in extreme weather events (e.g. hurricane strength and abundance, increased rainfall, increase in acidity of oceans). They could use case studies of recent events locally, regionally, nationally and globally.

B2

- Ask learners to use small whiteboards to list the greenhouse gases – carbon dioxide, water vapour, nitrous oxide and methane.
- Each greenhouse gas should be written on one side of a piece of card (or on a template on computer). On the other side of the card/template, learners should identify where each of the gases comes from (anthropogenic activities). The cards can be used as the basis of a quiz to check knowledge and understanding of the nature and causes of greenhouse gases.
- Alternatively, learners could produce a concept map of the greenhouse gases, where they come from (anthropogenic activities) and their possible effects.
- Learners could simulate the effect of carbon dioxide by using a sealable glass jar, vinegar, bicarbonate of soda and a thermometer. Instructions are available on the internet; search 'climate change on a bottle'.

B3

- Small groups of learners should choose, or be given, one of the below listed issues to research. They should give evidence of how it has occurred due to human and natural

activities and related atmospheric changes. The possible future effects and impact on the biosphere and atmosphere include:

- a rise in carbon dioxide level and the greenhouse effect
- variation of hot and cold areas on the Earth's surface
- increase in hot and cold weather extremes
- increase in wind speeds and hurricane-force events
- increased sea level rise from glacial and polar ice melting
- changes in plant growth (crop height, sustainability of growing crops in different parts of the world, displacement of populations from low to high altitudes due to increased rainfall and rise in sea levels).

- Each group will need to present their findings to the class.

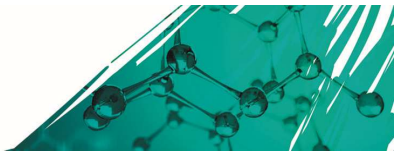
Learning aim C – Investigate the measures outlined by the Intergovernmental Panel on Climate Change (IPCC) to combat future climate change

C1

- Encourage learner engagement or even direct participation with climate change forums such as annual COP conferences.
- Ask individuals or small groups of learners to research a climate change forum and produce a presentation/leaflet/poster, to be presented and discussed with the rest of the class. Examples include:
  - Intergovernmental Panel on Climate Change (IPCC)
  - United Nations Framework Convention on Climate Change (UNFCCC)
  - Conference of the Parties (COP)
  - Paris Agreement 2016
  - Youth Climate Summative initiative
  - G8 summits.
- It may be possible to arrange a visit from one of these groups or from a local environmental group or local council/government, to discuss how climate change is being addressed.

Lead a discussion about how scientific data and scientific agreement is reached, or not, from all the studies and evidence that is being collected and presented about the main causes of current climate change. **C2**

- Use a song or poem from the internet to remind learners of the main greenhouse gas emitters covered in learning aim B2 (production of electricity and heat, transport, manufacturing, agriculture). Some learners may wish to produce their own.
- Ask learners to choose, or give them, alternative energy sources/innovations to research, describe and explain how they can reduce emissions and help prevent future climate change. They should evaluate the advantages and disadvantages of:
  - solar panels
  - wind turbines
  - geothermal power
  - hydroelectric power



- hydrokinetic power (movement of water in rivers, tides and waves)
- nuclear power
- increasing fuel efficiency in transportation
- use of electric and hydrogen fuel cells.

- Hold a tutor-led discussion about geoengineering solutions for reducing global warming. These potential solutions are controversial and include proposals to chemically remove carbon dioxide from the atmosphere more efficiently than photosynthesis.
- Ask learners to choose a business/government department and research how it is promoting sustainable energy/reduction of emissions.
- Have learners investigate ways to reduce the carbon footprint, e.g. air conditioning, paper usage, electricity, equipment reuse and recycling opportunities.
- If learners are also studying *Unit 28: Sustainable Energy*, they could seek work placement with an employer involved in sustainable energy production or utilisation.
- Information and data gathered for this unit can be used in other units, including Unit 28.
- Learners could investigate the relative contributions to anthropogenic global warming by various economic activities such as agriculture, industry, transport and domestic activities. They will need to present their findings to the rest of the class.

C3

- Have learners investigate their own/their family's carbon footprint (there are several free online calculators) and describe and explain how it could be reduced, such as:
  - limiting dependency on fossil fuel transport
  - sharing transport
  - walking/using bicycles
  - turning off equipment when not in use
  - recycling
  - use of smart meters
  - installation of solar panels and/or heat pumps.

Details of links to other BTEC units and qualifications, and to other relevant units/qualifications

This unit links to:

- Unit 8: Contemporary Issues in Science
- Unit 18: Astronomy and Space Science
- Unit 24: Pollution and Waste Management
- Unit 25: Water Quality
- Unit 26: Animal Conservation
- Unit 27: Ecosystems
- Unit 28: Sustainable Energy.

Resources

In addition to the resources listed below, publishers are likely to produce Pearson-endorsed textbooks that support this unit of the BTEC International Level 3 Qualifications in Applied Science. Check the Pearson website (http://qualifications.pearson.com/endorsed-resources) for more information as titles achieve endorsement.

Textbooks

Dunn, C, Adams, K, Holmes, D, Oakes, S, Warn, S and Witherick, M – *Edexcel A level Geography Book 1*, 3rd edition (Hodder, 2016) ISBN 9781471856549

Dunn, C, Adams, K, Holmes, D, Oakes, S, Warn, S and Witherick, M – *Edexcel A level Geography Book 2*, 3rd edition (Hodder, 2016) ISBN 9781471856532

These two books give the basic background in earth science for 16-19 year old learners.

Rholi, RV and Vega, AJ – *Climatology*, 4th edition (Jones and Bartlett, 2017) ISBN 9781284119985.

The above book is useful because it is a general primer on climatology, aimed at students in their first year at university or college. It should be accessible to 16–19-year-old learners.

Journals

New Scientist

Scientific American

National Geographic

These journals discuss the latest science discoveries, including climate science, in a manner accessible to 16–19-year-old learners.

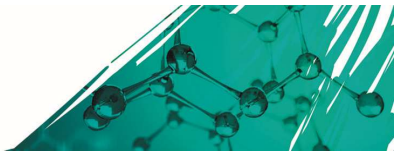
Videos

Visit the IMDb site and search for the trailers for the 2006 movie *An Inconvenient Truth* and its 2015 sequel. These trailers feature dramatic footage and an explanation of the 'Hockey Stick graph'.

Visit the ted.com website and search for a video on climate change.

Visit bing.com and search for a video by Michael Mann on climate change.

These videos are useful because they feature Jim Hansen and Michael Mann, two veteran climate scientists, discussing their climate research in the 1980s and 1990s.



Websites

Visit the NASA Astrobiology website. This links to a 2011 paper on Earth's early atmosphere, which describes how molten rock (magma) reaches the surface and releases its dissolved gases into the atmosphere.

Visit the Guardian website and search for 'climate change environment' for a biography of Svante Arrhenius of Sweden, whose calculations in 1896 gave the first indication that CO_2 levels were coordinated with atmospheric temperature.

Visit the Climate Change News website. This website is a clearing house for all things related to climate change.

Visit the Carbon Brief website and search for 'around the world in 22 carbon capture projects'. This website describes projects to remove carbon dioxide from the atmosphere, but some of the projects pump it at high pressure into oil and gas deposits to help extract more fossil fuel, which raises interesting questions about its net climate impacts.

Visit the website of the United Nations Conference of the Parties (COP), containing summaries of discussions at previous annual COP meetings from 1995.

Visit the website of the United Nations Conference of the Parties (COP) and search for 'youth CEO climate dialogue where is my money going'. This is a 44-minute video of a discussion in English by young people from around the world meeting business leaders to talk about action against climate change.

Visit the Guardian website and search for 'industries sector carbon emissions'. This is a useful 2011 article from the Guardian listing the percentage contributions to carbon emission by each industry. It identifies the main contributors.

The World Wildlife Fund offers 'Skype in the Classroom'. This enables learners to talk to experts and allows virtual field trips and access to guest speakers.

The NGSS Science and Engineering website allows access to data for learners to analyse and interpret.

Pearson is not responsible for the content of any external internet sites. It is essential for tutors to preview each website before using it in class so as to ensure that the URL is still accurate, relevant and appropriate. We suggest that tutors bookmark useful websites and consider enabling learners to access them through the school/college intranet.