Teacher's guidelines

Title of the package: Written in the Arctic: paleoclimatology

Information about the package

Brief description: The package presents methods used in paleoclimatology. Key assumptions are explained, along with basic concepts and examples of use. Special ous is put on ice cores. Environmental history topic is also tackled.

How does the package relate to STEAM education: The package presents knowledge from various scientific disciplines using interactive educational materials. Their goal is to involve students in their independent search and understanding of the links existing in the natural environment, but also some elements of art (paintings and poems).

Keywords: proxy, climate change, ice cores, forams, peat, pollen, resolution, isotopes, drilling, dendrochronology

Age range: 14+

Didactical hours: 2 hours

Learning objectives:

Student:

- learns about methods used in studying paleoclimate

- learns about examples of proxies

- explores past climate change and its causes

- learns about the importance of Arctic/Antarctic traces of the past

- learns how historical events and human life conditions depend on climate

Content of the package:

Link to the package: https://cloud.graasp.eu/en/pages/61091fc89b1b9c07d3aa581e

The package is divided into 5 sections.

1. **Section "Introduction"**

Students get acquainted with a figure presenting past global climate change, along with short explanation

Quiz (5 true-false questions) to be completed based on figure watched.

ANSWER KEY:

1) YES
2) YES
3) NO
4) YES
5) NO- Before large ice sheets were formed, global ocean level was higher

ANSWER KEY

EDU-ARCTIC 2: from polar research to scientific passion – innovative nature education in Poland and Norway receives a grant of ca. 240 000 EUR received from Iceland, Liechtenstein and Norway under EEA funds. The purpose of the EDU-ARCTIC 2 project is to: enhance the knowledge about nature, geography, natural resources, political specificities concerning polar regions and increase awareness of environmental issues and climate change, increase of interest in pursuing STEM education and careers due to enhancement of knowledge about scientific research, and their place in the modern world, familiarizing young people with scientific career opportunities; introduce innovative tools by way of an e-learning portal and effective methods of teaching science in schools

What are proxies – fill in the blanks:

reconstruct, millions, record, cores, lake, measurements, CO_2 , cold

Wordsearch-students search for names of proxies (ice cores, tree rings, pollen, sediments, peat, corals, foramnifera, isotopes

A history of change – interactive online presentation (LINK:

https://media.hhmi.org/biointeractive/click/paleoc**limate/)**

Questions:

Explain how the ability to describe the pattern of ice ages over the past million years helps us to assess what is a “normal” variation in Earth’s atmosphere.

ANSWER KEY: The description of the pattern of ice ages allows the study of climatic variations over the years. This helps to understand the normal variation in the earth's atmosphere, I understand the climate established in each season and how it influenced the patterns of life and resources in the pallet. These descriptions are made using paleoclimatic instruments that observe elements such as the composition of the ice, the structure of the trees and possible fossils.

Atmospheric changes in Earth’s history have caused large temperature changes through time. Explain how knowledge of these past connections between atmosphere and climate can inform us about modern-dayclimate change.

ANSWER KEY: If we understand the processes behind limate hange by identifying trends and key factors we can predict future climate change and adapt our policies accordingly.

2. **Section „INQUIRY"**

Exercise: the student match terms and definitions. 2 definitions do not match any term.

LINK TO THE EXERCISE: https://learningapps.org/watch?v=pg7vasy9521

ANSWER KEY:

Proxy - Physical, chemical and biological materials preserved within the geologic record that can be analyzed and correlated with climate or environmental parameters in the modern world

Foramnifera- They are among the most abundant shelled organisms in many marine environments

Cosmogenic isotopes- Magnetic field limits their amount

Dendrochronology- Scientific discipline concerned with dating and interpreting past events, particularly paleoclimates and climatic trends.

Peatland- Terrestrial ecosystem in which the production of organic matter exceeds its decomposition

Exercise: “Name the frame” – match name of the proxy with appropriate image.

ANSWER KEY: 1-tree rings, 2-pollen, 3-peat

Exercise-fill in the blanks.

ANSWER KEY: gas, bubbles, spectrometers, Temperature, melting, neutrons, water, protons, hydrogen, Uranium

Exercise: drawing conclusions on past temperatures based on isotope composition is explained. Students need to put parts of sentences in correct order to complete the text.

ANSWER KEY:

During periods of warmer global temperatures there is more heat energy in the atmsophere.

This allows heavy water (H2 18O) to stay in the gaseous phase longer and travel farther from the equator before precipitating out.

Thus, during times of higher global temperatures, the ratio of heavy water to light water (H2 16 O) found in precipitation that falls at the poles changes with a higher percentage of heavy water being present.

Greenland ice core data

It is explained that in ice core samples taken at the poles, a higher ratio of heavy water to light water indicates higher average global temperatures.

Then, a set of data from an oce core is presented, along with a graph.

ANSWER KEY: the graph is correct, the average temperature is growing (see trend line), and according to data, the 18O/16O ratio is increasing overtime.

Tiny but mighty

QUIZ-the most fascinating proxies (FORAMNIFERA)- 6 true/false questions.

ANSWER KEY:

1) FALSE - they belong to PROTISTA (EUCARYOTA) - their cells have a nucleus enclosed within a nuclear envelope
2) TRUE
3) FALSE- they belong to PROTISTA (EUCARYOTA) - their cells have a nucleus enclosed within a nuclear envelope
4) TRUE
5) TRUE
6) FALSE- The ratio of isotopes of oxygen in the shells can reveal how cold the ocean was and how much ice existed at the time the shell formed. In general, the shells contain more heavy oxygen when ocean waters are cold and ice covers the Earth.

3. **Section „Research”**

Short video about Ice Core Drilling, along with explanations how ice cores need to be handled.

LINK TO VIDEO: https://www.youtube.com/watch?v=fHWnoGl79y4

After the video: 4 open-ended questions.

ANSWER KEY:

1) What makes Greenland a perfect source of ice cores?

Therecords go back as far as 130 000 yeaers ago, and drilling conditions are less severe than in the Antarctic. Each layer of snow is different in chemistry and texture, summer snow differing from winter snow. Over time, the buried snow compresses under the weight of the snow above it, forming ice. Particulates and dissolved chemicals that were captured by the falling snow become a part of the ice, as do bubbles of trapped air. Layers of ice accumulate over seasons and years, creating a record of the climate conditions at the time of formation, including snow accumulation, local temperature, the chemical composition of the atmosphere including greenhouse gas concentrations, volcanic activity, and solar activity.

2) What is the TIME RESOLUTION of data provided by ice cores?

1 year (temporal resolution)

3) Give 3 examples of information about past conditions that ice cores can deliver

Temperature, volcanic eruptions, pollution

4) Give 1 example of technical problems in working with ice cores

Because every clue in the ice, whether a grain of sea salt or an air bubble, is so miniscule and the measurements must be incredibly precise, any analysis must be done in a "clean room" setting. The researchers wear body suits and multiple layers of gloves; the room must have ultraclean filters and vents to keep the air pristine

When Antarctic was GREEN

Short video about conditions that allowed Antarctica to host palm trees about 56 million years ago.

LINK TO VIDEO: https://www.youtube.com/watch?v=cC4WiBCoVeo

The study that allowed to identify it – link: https://www.nature.com/articles/nature11300

Year without summer

LINK TO VIDEO PRESENTATION: https://view.genial.ly/60f56fe1dc97e30de4487c77/video-presentation-year-without-summer

EXCERCISE: recreating the chain of events from causes to consequences, including detailed examples and adaptations.

ANSWER KEY:

5 processes:

Extreme weather and induced extreme weather

Detailed effects: frost, hail, snowfall, wetness, floods, windstorms, tropical cyclones, droughts, (forest) fires

| first order impact

Biophysical effects

Detailed effects: primary production: biomass (food, feed, fuelwood), water availability, microorganisms

Response/adaptations: diversification of planted crops and use of parcels in di erent altitudes and exposures

| second order impact

Economic growth, human and animal health

| third order impact

Detailed effects: prices of biomass and energy, transportation, heating, epidemics and epizootic

Response/adaptation: market interventions, expansion of the road networks, harbours and canals

Demographic and social implications

Detailed effects: malnutrition, demographic growth (mortality, fertility), social conflicts

Response/adaptation: migration, public and private welfare

| fourth order impact

Cultural responses

Detailed effects: crisis interpretation, cultural memory learning processes

Response/adaptation: religious rituals, amendments (for example marriage law), adjustments, adaptations

4. **Section „Activities"**

Which proxy will bring you answers?

ANSWER KEY: From the oldest to the youngest data: foramnifera, peatland, tree rings

CRISS-CROSS puzzle

Link to activity: https://puzzel.org/pl/crossword/update?p=-MezBeL8E

ANSWER KEY:

HORIZONTAL:

3. Tree
7. proxy
8. Antarctic
9. forcing

VERTICAL

1. Isotopes
2. Peat
4. Resolution
5. Organic
6. Pollen

Find the data

Using an interactive map (https://www.ncdc.noaa.gov/data-access/paleoclimatology-data/datasets/ice-core) students must find data from Ausfonna, an ice cap located in the Svalbard Archipelago (ice core drilled in 1999).

Answer key:

What is the time period covered by data from this ice core? – 1400-1999

Explain name of the B column (d18O per mil) - do your own search

δ18O or delta-O-18 is a measure of the ratio of stable isotopes oxygen-18 (18O) and oxygen-16 (16O).

A per mil, per mille, or per mill (permil or permille) (Latin, literally meaning 'for (every) thousand') is a tenth of a percent or one part per thousand. ... A per mil is defined as: 1‰ = 10−3= 1⁄1000 = 0.001 = 0.1% 1% = 10‰

QUIZ – ANSWER KEY (baset on dataset):
1) 1646

2) 1911-1920

3) even higher d18O ratio

4) there are no trees ni the area (Svalbard), so no.

JENGA QUIZ-link: https://view.genial.ly/60f58ff00ddd920db2367bae/interactive-content-jenga-quiz-paleoclimatology

4. Section „Wrap-up"

Task: students read an (imaginary) newspaper clipping, describing a discovery of an old journal with entries referring to climate conditions in the past.

Now they need to imagine what type of proxies and data could be found for this moment in history

ANSWERS-EXAMPLES

Ice core: d18O per mil lower than records from other years

Pollen: not a lot of vegetation, mostly source etc.

Forams: N.Pachyderma-more left coiling than right coiling fossils found

Tree rings: thin tree rings, not a lot of growth in the summer

3 things to remember – suggested by students individually and/or discussed

TECHNICAL TIPS

Interactive presentation - click when suggested on the screen for further details.

Video presentation: click to stop and read carefully

Presentation and longer materials are not fully displayed on the screen - you have to scroll them using separate scroll bars (or with the mouse wheel on hover). Links to external sources are not free from personalized ads, so it is recommended to use your browser with an ad-blocking application, e.g. adblock plus.

Additional resources

Interactive presentation:

Paleoclimate: A history of Change.

https://media.hhmi.org/biointeractive/click/paleoc

Videos:

Ice Core Drilling

https://youtu.be/fHWnoGl79y4

When Antarctica was green

https://youtu.be/cC4WiBCoVeo