



Sheet 09 : Biodiversity in the Arctic

AV DESCRIPTION OF THE ANIMATION

Because they are the principal areas on Earth to be affected by climate change, polar regions, especially the North Pole where the effects are most noticeable, are particularly important to study.

Temperature rise has caused the Arctic pack ice to melt significantly. The thawing is now posing problems both for the local people and for the animals that live in the area.

In the taiga and tundra (the other ecosystems in the Arctic), something else is happening too: the permafrost (ground that remains frozen all year round) is thawing. In the taiga, this melting process is destabilising the conifer forests while in the tundra it is releasing huge quantities of greenhouse gases into the atmosphere.



Arctic map



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B/ LET'S TAKE A CLOSER LOOK...

1/ TWO TYPES OF ICE

There are two types of ice at the Poles: the **pack ice** and the **ice caps**.

| | Pack ice | Ice cap |
|------------------|---|---|
| Composition | <ul style="list-style-type: none"> - Giant or fragmented sheet of ice consisting of frozen seawater - Saltwater | <ul style="list-style-type: none"> - Immense glacier made up of compacted snow - Freshwater |
| Location | On the surface of the Arctic and Southern Oceans | - Cover land masses |
| Situation | - Float on the water | - Cover large areas of land and can even cover a whole continent |
| Dimension | - Melts in summer and forms during the wintertime, except where it is very cold (close to the North Pole, for example) and where it is present throughout the year. | - Its area can increase or decrease gradually, year after year, depending mainly on the temperature and the amount of snowfall. In Antarctica, the average thickness of the ice cap is 2600 metres. In some places, it can reach as much as 4000 metres thick! |
| Special features | - Since 1960, there has been a 30% decrease in the total area of Arctic pack ice. | <ul style="list-style-type: none"> - It is more difficult to evaluate the extent to which an ice cap melts because it is very thick. However, the Greenland ice cap has clearly started to melt over the past few years. For the time being, the Antarctic ice caps are more stable, although it is also showing signs of melting in some places. The melting of the ice caps results in a corresponding sea level rise. - The technique of drilling ice cores out of the ice cap enables scientists to analyse the various layers of ice and to see how the climate has evolved over thousands of years (as far back as 800,000 years in the Antarctic). |

2/ CAUSES FOR THE MELTING PACK ICE

A natural phenomenon: albedo

Albedo is the reflective power of a given surface. The ocean albedo accentuates the rise in water

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temperature, causing the pack ice to melt. How? First of all, the rise in temperature causes the pack ice to retreat. Because the albedo of the pack ice is very high, the ice reflects back most of the sun's rays. In contrast, the sea albedo is very low and absorbs between 90 and 95% of the heat from the sun's rays. This means that the remaining pack ice will melt faster as the sea is heated by the sun's rays and warms up the pack ice.

So, how do we explain this difference between ocean albedo and ice albedo? The difference in their level of reflection is caused by their difference in colour.

| Snow / Pack ice | Ocean |
|--|---|
| Light-coloured surface | Dark-coloured surface |
| <u>High albedo</u> : reflects between 30 and 90% of the sun's rays. | <u>Low albedo</u> : reflects between 5 and 10% of the sun's rays |
| ➔ Low capacity to absorb the sun's rays | ➔ High capacity to absorb the sun's rays |

Human responsibility

- While the difference in albedo between ice and ocean explains to some extent why the pack ice is melting, human activities are still at the root of climate change. Whether it is through using heat, getting around, feeding ourselves, generating light, etc., man emits greenhouse gases that are responsible for climate warming.

The observable effects of warming in the Arctic are the following:

- Temperatures have risen 3°C in the Arctic since the beginning of the 20th century, which represents 4 times the world average (+0.6°C). The Arctic is the region in the world most affected by climate warming.
- 30% of the total pack ice area has been lost since 1960 whereas its thickness has diminished 40% over the same period.
- The ice cap covering Greenland has also begun to thaw.

What about tomorrow?

Scientists estimate that, between now and 2100, the temperature above the Arctic Ocean will

increase between 4°C and 7°C, whereas the average temperature increase around the world should "only" be between 1.4°C and 5.8°C. The various scenarios predict that, within a few decades, the Arctic pack ice will have completely disappeared in the summertime.

3/ THE CONSEQUENCES OF CLIMATE CHANGE

The impacts on animals

The pack ice provides a real hunting ground for the polar bear. The increased rate with which it is melting means that the bear is having to swim much further than before. In fact, polar bears have to live on their fat reserves during more months than before because food has become so scarce. With the pack ice melting earlier in the year, the season during which polar bears normally hunt has also been shortened. For every week its hunting period has been shortened, the polar bear loses ten kilos of body fat. Since 1985, polar bears have lost an average of 80 kilos of their body mass. This forced dieting has caused polar bears to become more aggressive, and for the females, a lack of fat has made it more difficult for them to lactate.

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Damp environments cover an area of 2 million km² and contain approximately 50 billion tons of carbon which could potentially be converted into methane. Methane is a greenhouse gas which has 20 times the warming potential of CO₂.

Indicators foretell that the taiga's surface area will increase, causing the tundra's surface to diminish between 40 and 57% by 2100 as a result of increases in the overall temperature and carbon dioxide levels.

Other effects

Changes are also happening in the other Arctic ecosystems (taiga and tundra). The permafrost is slowly thawing. Permafrost is ground that is frozen all year round and which has been formed over a period of several thousand years.

In the taiga, the thawing permafrost is threatening the conifer forests. The trees are losing their grip in the ground because the frozen earth in which the roots are embedded is becoming softer as the ground thaws. As they lose their sturdy foundations, the conifers start to sway and end up leaning over, which explains why we call them "drunken trees".

The tundra is made up of stunted vegetation which has managed to adapt to the harsh climate. In this ecosystem, the thawing of the permafrost is causing the CO₂ and methane trapped in the ground to be. Both are greenhouse gases, and their release exacerbates current climate warming even further.

Depending on the type of climate, a different greenhouse gas is released:

1. Dry, windy climate: CO₂ (carbon dioxide) is released
2. Damp climate, low in oxygen: CH₄ (methane) is released



Tundra



Taiga

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| | Taiga | Tundra |
|-----------|---|---|
| Latitudes | Mid to high latitudes in the Northern hemisphere (from 55°N to the polar circle) Canada, Scandinavia and northern Russia | Above the Arctic Circle (66° N) |
| Features | Boreal conifer forests, Acidic soil, marsh Continental climate | Bushes and green shoots, lichen and moss, marsh Cold, windy climate (blizzards) Short summers |
| Fauna | Great grey owl, rough-legged buzzard, Siberian tit, moose, lynx, beaver, wolverine. | Snowy owl, ptarmigan, waders, swan, polar bear, wolf, arctic fox. |

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C/ GROUP ACTIVITY TO BE CONDUCTED IN THE CLASSROOM

ALBEDO EXPERIMENT

Aims

- Understanding the albedo principle
- Observing the difference in albedo from one surface to another.

Timing : 20 minutes

Equipment

- Two identical metal panes.
- Some black paint and some white paint.
- A thermal insulator such as a polystyrene or fibreglass pane.
- An electronic thermometer.
- Two beakers
- Two ice cubes of the same size/volume
- Water
- A lamp (or the sun)
- A plate
- A piece of transparent film

Step 1 : Procedure (20 minutes + time to take readings)

1. Paint the two panes: one black, the other white.
2. Place the two panes outside on the thermal insulator, sheltered from the wind and exposed to the sun or another source of light.
3. Take the temperature of each pane at regular intervals. To take the temperature, place the electronic thermometer's sensor between the sheet and the insulator.
4. Note the temperature readings in a table.

Step 2 : Observation (15 minutes)

The black pane warms up faster than the white pane.

Step 3 : Explanations (10 minutes)

In the science of climatology, this is called "**albedo**", or the ability of a surface to reflect the sun's rays. This **reflective ability** depends on various factors, including the roughness and colour of the surface.

- Snow and ice have a very high albedo. Ice reflects between 30 and 50% of the sun's rays and snow between 60 and 90%. The Polar Regions are areas that reflect the majority of light rays back into space. This helps the cold conditions that prevail in these regions to "self-maintain" themselves.

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Experiment: Under the influence of the sun's heat or that of another source of light, the panes absorb energy and heat up until they reach a stable and almost constant temperature. The temperature of the black pane (= seas, oceans) is higher, since it reflects the sun's rays to a lesser extent in comparison to the white sheet (= pack ice, snow) which reflects the majority of the heat back into space.

► The same thing applies to clothing. A person outside in the sun will be much warmer in a black T-shirt than in a white one.

D) RESOURCES / REFERENCES

- The educational dossier on "The Climate and Climate Change" (produced by the International Polar Foundation in 2003) can be downloaded from the educational website at:

www.educapoles.org

- The animation "Why is it cold at the Poles?" (explains albedo using images) can be viewed and downloaded at:

www.educapoles.org

This animation comes from the CD-ROM "The Polar regions and Climate Change" (produced by the International Polar Foundation (IPF)). The entire CD-ROM animations can be viewed at:

www.educapoles.org

- The educational pack "1 Degree More" can be ordered from:

www.wwf.fr

- The educational file "The Climate" (published by WWF Switzerland in 2004 aimed at 8 to 14-year-olds) is also for sale at the WWF France website.

- The brochure "Greenpeace Report: The Impact of Climate Change in Belgium" (produced by the team of climatologist, Jean-Pascal van Ypersele) can be downloaded from:

<http://www.astr.ucl.ac.be/users/marbaix/impacts/>

- The non-profit organisation "Cap Sciences" provides activities for understanding the effects of climate warming and particularly the melting of glaciers.

<http://www.capsciences.be>

- A lavishly captioned map entitled "Melting Ice" (produced by the United Nations Environment Programme (UNEP)):

http://www.unep.org/wed/2007/downloads/documents/Tunza%20Meltdown_FR.pdf

