ICOS | Cities

WHAT IS CO2 DOING TO OUR CLIMATE?

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Teaching material "What is CO2 doing to our climate?", Version 1, December 2023

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List of materials

- 8 planets laminated
- Chenille wire (red + yellow), sun arrow (yellow, thick paper)
- 4x tins with aluminium beads
- balloons
- baking soda
- 15x balloon clips
- 8x small jar with lid
- 2x EmpAir CO2 measuring device
- 4x large transparent glass jars
- 2x Tupperware
- 2x ice cube mould (min. 40 ice cubes)
- cloth
- Painter's tape
- 8x glass containers (2dl)
- White and black paper (160g/cm2)
- Rubber bands
- 4x thermometer (up to 100°C)
- insulating plate
- pH measuring strip
- Mineral water with a high CO2 content
- Road chalk
- 6x small jar with lid
- Small spoon and paring knife
- 4x fireproof base
- Needles dry and fresh (conifers)
- 8x magnifying glasses
- 4x Climate Fresk card set 1x laminated set

Cities are hotspots for man-made (anthropogenic) greenhouse gas emissions. Worldwide, cities emit around 2/3 of greenhouse gases and therefore play an important role in efforts to reduce emissions and implement the Paris Climate Agreement. Many cities have therefore taken measures to reduce these emissions. The city of Munich also wants to reduce greenhouse gas emissions.

The European ICOS Cities project supports cities in this endeavour by identifying, monitoring and reviewing greenhouse gas emissions (e.g. CO2 emissions).

in Europe: **pilot cities** selected

- **Paris** (a large city)
- **Munich** a medium-sized city)
- **Zurich** a smaller city)

The objectives of the ICOS Cities project are:

The measurement of greenhouse gas emissions

Developing services and models to analyse and present the observations

Raising awareness among the population

Supporting cities in the implementation of urban climate action plans

German partners of ICOS Cities are: Technical University of Munich (TUM), University of Heidelberg, University of Freiburg

Further information on ICOS Cities: https://www.icos-cp.eu/projects/icos-cities

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- Fake and facts

Climate Fresk
- Discover 42 maps
- Groups of 5-7 people
- Link causes and effects of climate change to form a puzzle

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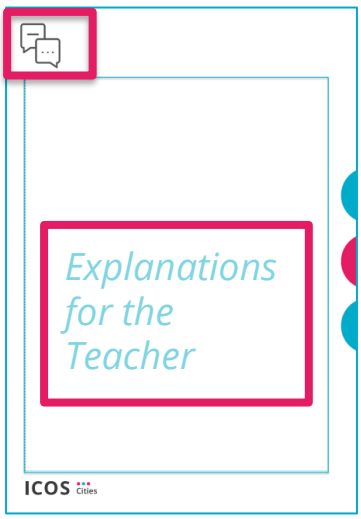
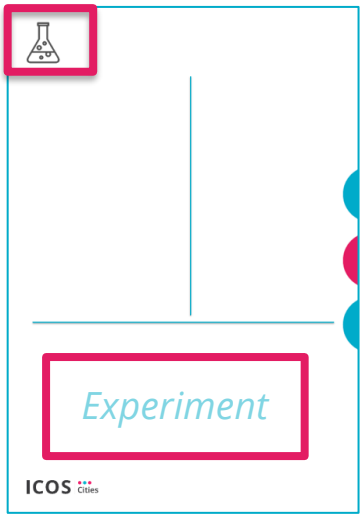
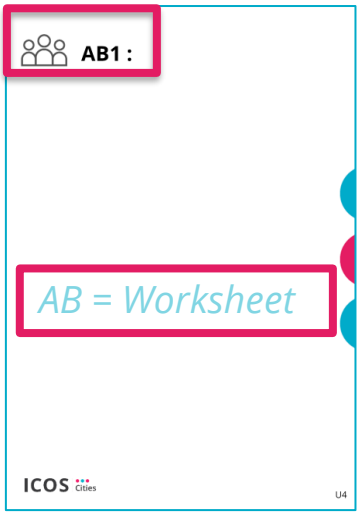
Symbols in CO2 module





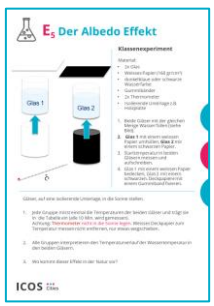


- "Pupils" is abbreviatedas SuSin the instructions .
- "**Image**" indicates the corresponding graphics card of the Climate Fresk, e.g. **image 12**

For example, set up an experimental station:

Theory sheet

+



Experiment instructions

+

matching Fresk cards

+ Material

Learning objectives

Pupils:

- understand how carbon dioxide (CO2) is produced.
- understand the connection between CO2 and global warming.
- recognise the danger of global warming.
- realise that CO2 will not disappear on its own.
- can debunk common misconceptions about the climate.
- know ways to reduce CO2.
- are committed to reducing their own CO2 footprint.

Expertise

Pupils:

the natural greenhouse effect and the greenhouse effect caused by humans using a model. explain

- can explain the causes of CO2 and relate them to global warming.
- can describe solutions for reducing CO2.
- know the term CO2 footprint and can reflect on their own.
- can describe the long-term consequences of global warming.

Lesson plan I

Preparation

- make ice cubes
- find and prepare dry pine needles and green coniferous branches
- Put plenty of sparkling mineral water in the fridge

Theory and experiments

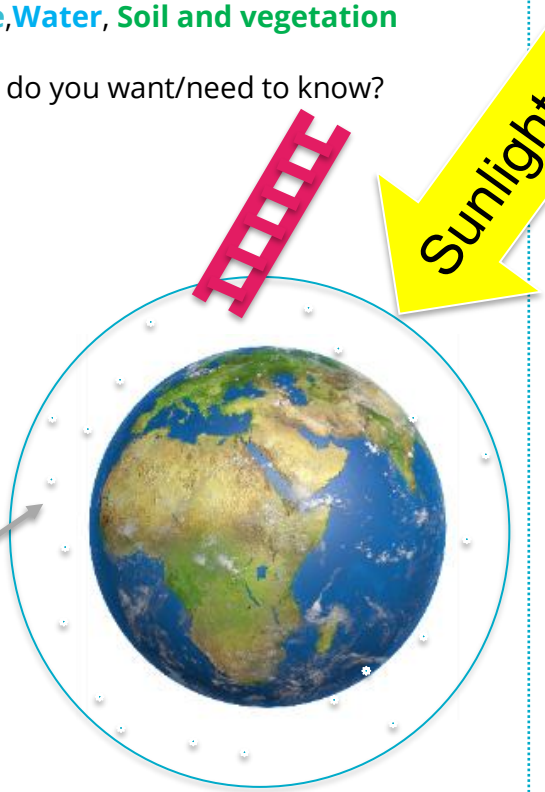
- Prepare experiment instructions with pictures, instructions and theory sheet plus material. 2 pupils per experiment group.
- Questions about experiments: where to write them down? Paper or iPad?
- **class experiments** (**E4/E5)** Set up
- **Plan 4 chapters**: **Atmosphere**, **Glaciers and ice**,**Water**, **Soil and vegetation**

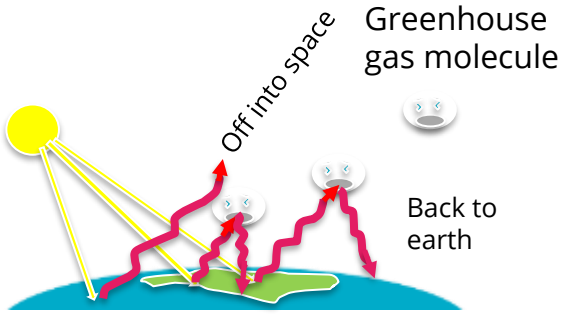
Getting started: What do you already know? What do you want/need to know?

Atmosphere

- each **planet**): Use planet model + circle with chalk = atmosphere
- **What does the atmosphere consist of?** *78% nitrogen, 21% oxygen, greenhouse gases and argon = noble gas (decay of potassium)*
- **Advantages of the atmosphere ?***protection from radiation, regulation of temperature*

  Distribute aluminium pellets = distribute greenhouse gases in the atmosphere
  These gases scatter heat radiation from the earth back to the earth.
- What is **a greenhouse**/ show the greenhouse effect using a model
- How are greenhouse gases produced?
- How do greenhouse gases affect global temperature?
- Name greenhouse gases (CO2, methane, nitrous oxide)
- How much CO2 (0.042 %) is there in the atmosphere? Show cube with number comparison

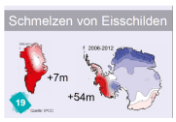




- Carry out experiments (E1a/E1b/E2/E3) Download E3 app. Take measurements together, possibly as a walk (building site, playground). Discuss measured values.
- Hierapolis history (optional)

Lesson plan II

Glaciers and ice fields



Make ice cubes (approx. 50 cubes) the day before.

Explain the difference between the Arctic (North Pole) → sea ice and the Antarctic (South Pole) → continental ice. Explain the albedo effect, analogy to white and black surfaces in everyday life (T-shirt). Discuss glacier melt in the Alps: meltwater is very important for agriculture.

Experiments **E4** and **E5** can be carried out as class experiments.

E4 Class experiment:

Pupils observe the progress of the experiment (approx. 2h) and answer questions with the support of .The teacher can accelerate the melting with a hairdryer

E5 Class experiment

Outdoors April - September or in the classroom behind the window pane. Prepare white and black covers or lids for jars. Provide 2x thermometers. Provide wooden bases for jars. Determinelocation.
Create temperature measurement series with different groups.

Water

For experiments, place highly carbonated mineral water in the fridge.

70 % of the earth is water. The oceans regulate the temperature. Figure 12 → They are a major carbon sink = absorb CO2 from the atmosphere.

Density of water is temperature-dependent → discuss.
This means that the volume increases as the temperature rises → Sea level rises. Figure 17/22

Discuss the problems of the oceans: increased water temperature, less oxygen, acidification, overfishing, plastic, chemicals...

Picture 23/24

What does the pH value indicate? How acidic or alkaline is a liquid (solution)? Example: Our skin has an acid mantle pH 5.5, stomach acid 1-1.5 = extremely acidic, vinegar approx. 2.8, soap 8-10 Measure with pH measuring strips.

Lesson plan III

Experiments:

- **E6**: measure pH. keep the mineral water cold and sealed, store the test strips in a dry environment.pictures: 17, 20, 22, 23, 24, 27

- **E7:** use street chalk, dissolves better than blackboard chalk, keep mineral water cool and sealed.
- History of Lake Nyos (optional)

Soil and vegetation

Preparation: collect dry and green needles from conifers.

Discuss soil vocabulary, address biodiversity, examples from the environment.

photosynthesis .

CO2 sink = place where CO2 can be absorbed from the atmosphere
images: 6, 8, 9, 12, 25 Discuss

Photosynthesis = sink for CO2.

Biodiversity and agriculture: discussing CO2 sinks Figure 25

- **E8**: location , carry out with magnifying glass in summer (May-Sept.) : Cool season Exp. Carry out with match in the laboratory fireproof surfaces.

Signs of climate change →

And now .....

- Compile causes and effects with pictures.
- Conduct Climate Fresk (2 teachers required per class)
- What can we do? Where are greenhouse gases produced?
- → Pictures: 1, 2, 3, 4, 5, 8
  Consequences:
  Air temperature rises and water temperature rises
  Pictures: 21, 30, 35, 36 Pictures: 17, 22, 26, 33, 34, 24

- Fake or fact?

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Weave CO2 project into various NT subjects

Biology

- Treating photosynthesis
- CO2 sinks: forests, meadows, moors
- The greenhouse in the nursery
- The greenhouse for the earth: how it is created.
- Burning pine needles (dry, fresh)
- Biodegradation by microorganisms

Chemistry

- Acid-base reactions
- pH measurement
- Produce CO2
- Measuring the pH of carbonated water
- Dissolve lime
- Chemical composition of the air in the atmosphere
- Chemical formulae of greenhouse gases

Physics

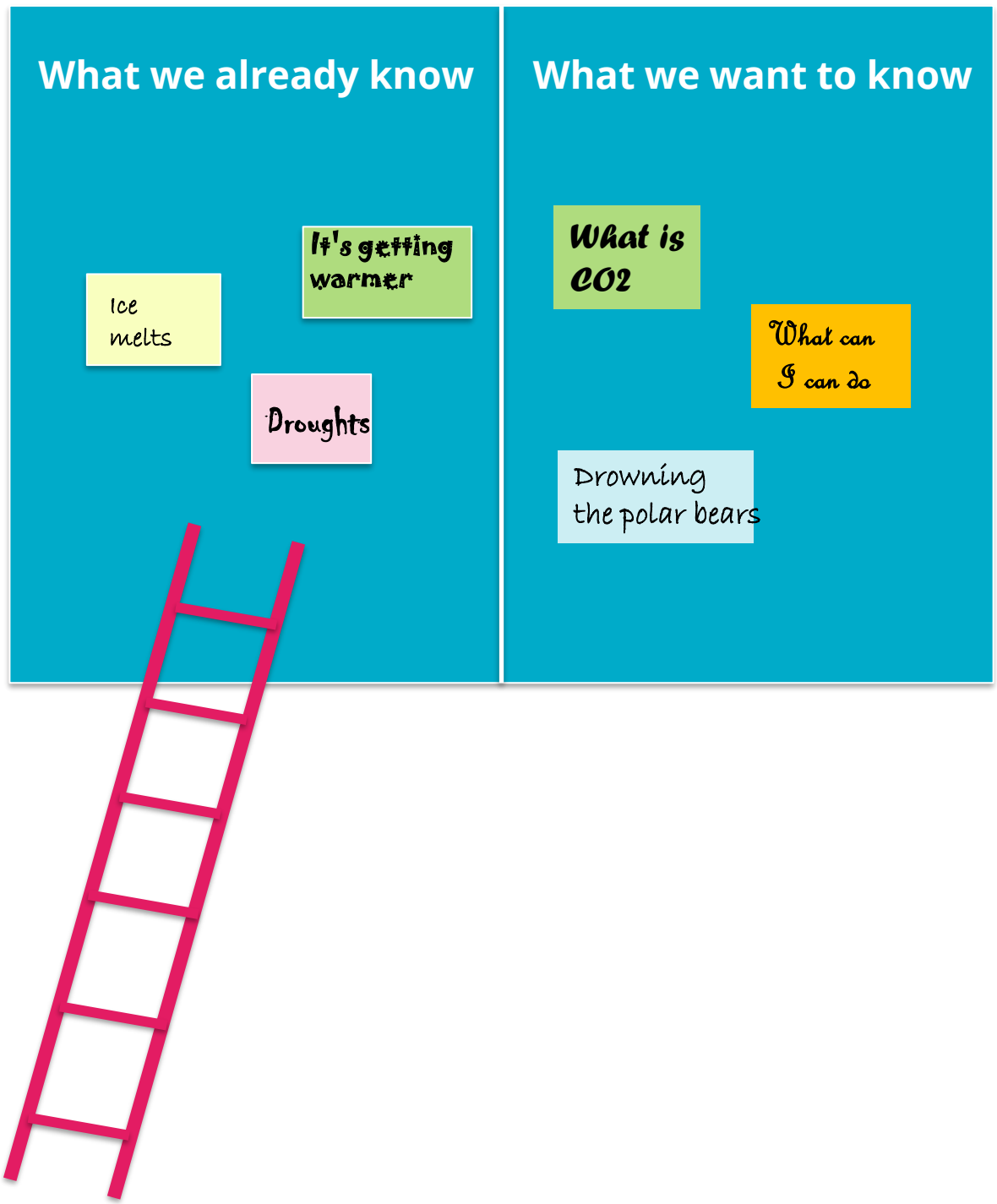
- Light is a wave
- Composition of sunlight
- Colours
- Infrared radiation
- Scattering of infrared radiation by greenhouse gases (model)
- Greenhouse gases regulate global temperature

Geography

- Structure of the atmosphere
- Greenhouse effect
- Greenhouse gases

Introduction

Gather prior knowledge:



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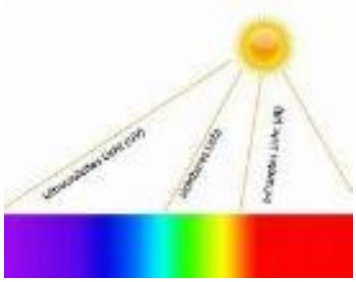
Atmosphere vocabulary

- **A**tmosphere: the Earth's atmosphere, which surrounds the planet and makes life on Earth possible.
- **C**limate: is the totality of all weather phenomena for a specific region over a longer period of time (at least 30 years). Difference between climate and weather: climate refers to long-term average values, weather describes short-term atmospheric conditions, e.g. it rains.
- **W**eather : currently perceptible condition such as wind, precipitation, temperature at a certain place, at a certain time. Normally predictable for 5-10 days.
- **C**limate warming : The current global warming or global warming (colloquially also referred to as "climate change") is the increase in the average temperature of the layers close to the earth.
- **Emission**: Emission of solid, liquid or gaseous substances, e.g. CO2.
- **G**lobal warming = warming throughout the world. This means that the average temperature increases everywhere on earth over a longer period of time.**global**does not necessarily mean that this happens evenly everywhere on earth.
- **I**nfrared radiation = heat radiation: long-wave radiation.
- **Carbon dioxide** = carbon dioxide = CO2: chemical compound between two oxygen atoms with one carbon atom O=C=O . The gas carbon dioxide is colourless, easily soluble in water, non-flammable and odourless.
- **p**pm = parts per million (1: 1,000,000)

- **The** greenhouse effect: contained in the atmosphere **greenhouse gases** absorb the heat radiation and immediately emit it in all directions. There are two forms of the greenhouse effect. The **natural greenhouse effect** (natural sources of CO2) forms the basis for life-friendly temperatures on earth.
- The **man-made greenhouse effect** is created by burning fossil fuels and causes global warming.
- **G**reenhouse gases: Gases in the air that send heat back to the earth, for example carbon dioxide CO2, methane CH4 .
- **A**nthropogenic greenhouse effect = man-made greenhouse effect caused by the burning of fossil fuels.
- **G**reenhouse gas emission = emission of greenhouse gases



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Atmosphere

Planet Earth is surrounded by a gaseous envelope called the atmosphere, which protects the Earth from dangerous radiation, ensuresthat temperatures on Earth are favourable for life and enables the water cycle and our breathing.

The atmosphere consists of 78% nitrogen (N2) and 21% oxygen (O2). Small amounts of argon (0.9%) and so-called trace gases, including greenhouse gases, are present.

the sun's rays passlargethrough the atmosphere and hit land, water or ice on Earth. These surfaces absorb the energy and heat up. Some of the heat radiates back into space through the atmosphere as thermal radiation.

Influence of greenhouse gases:

For life on earth to be possible, the temperature must not fluctuate too much. This is achieved by a balance between solar radiation and heat radiation. This balance is influenced by greenhouse gases.

The most important greenhouse gases are: water vapour H2O, carbon dioxide CO2, methane CH4 and nitrous oxide N2O.

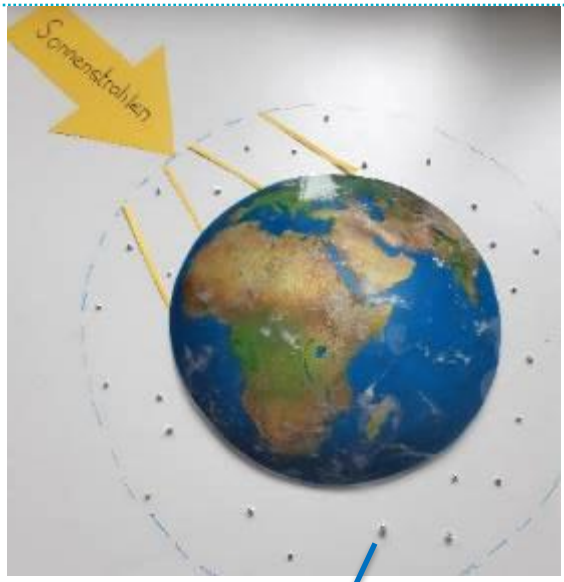
If the heat radiation emitted from the earth's surface hits the molecules of the greenhouse gases (e.g. CO2), these have the ability to send some of the heat radiation back to the earth.

The amount of greenhouse gases in the atmosphere determines how much of the heat radiation remains in the earth-atmosphere system and how much is radiated into space. Greenhouse gases therefore have a major influence on the average temperatures on earth.

What is happening today:

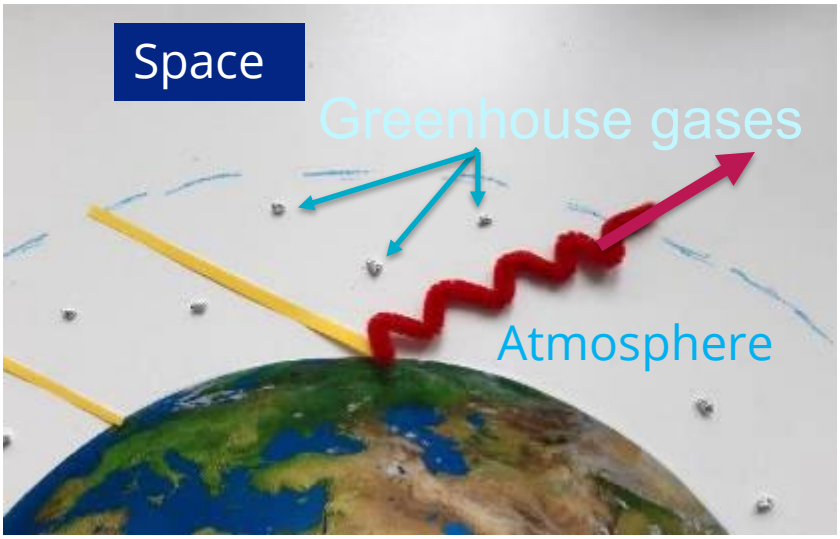
- The concentration of greenhouse gases in the atmosphere is being increased primarily by human activities. The causes are the massive burning of fossil fuels, intensive agriculture and deforestation. The ongoing increase in the amount of greenhouse gases in the atmosphere is leading to a continuous rise in the Earth's temperature and thus to climate change.

Model on the table: atmosphere with greenhouse gases



Atmosphere: 78% nitrogen N2, 21% oxygen,
0.9% noble gases, 0.04% carbon dioxide CO_2 and other greenhouse gases

The sun's rays penetrate the atmosphere and, depending on the surface properties, the earth's surface absorbs the solar energy and sends heat energy back into space.



Radiation of heat into space

The greenhouse effect

- A greenhouse is a transparent house made of glass or plastic. The glass is permeable to visible light, while heat radiation (so-called infrared light) can hardly escape. This creates a warm climate in which plants thrive faster and fruit can be harvested earlier. The temperature can be regulated by opening individual glass surfaces.

- The atmosphere has similar properties to the greenhouse in that the glass surfaces are replaced by **greenhouse gases** (molecules) such as water vapour **H2O**, carbon dioxide **CO2**, methane **CH4** and nitrous oxide **N2O**.

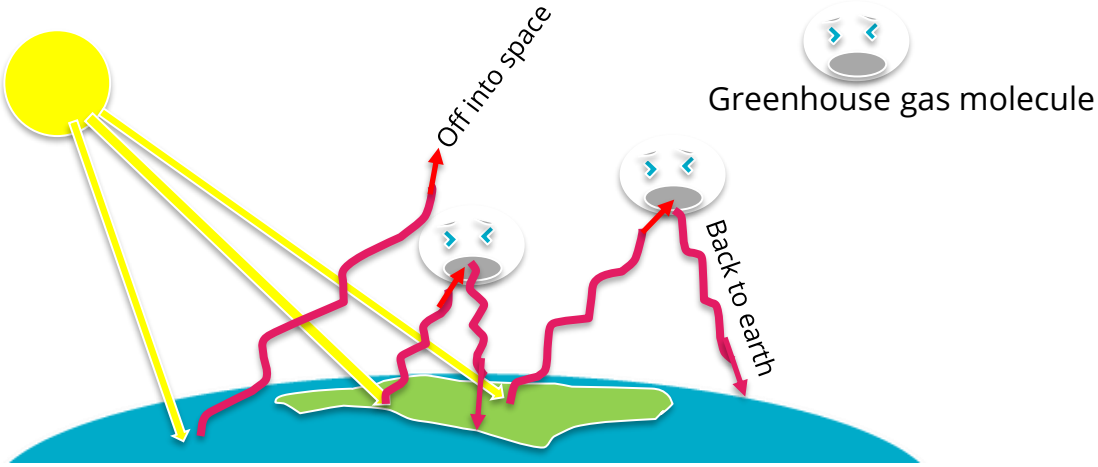
- Solar radiation penetrates the atmosphere and is converted into thermal radiation at the Earth's surface. This thermal radiation is partially scattered by greenhouse gases, which prevents the heat from being radiated into space and some of the heat remains in the atmosphere.

- A proportion of these greenhouse gases has always been present and has made "life" on Earth possible. This is called the **natural greenhouse effect**.The natural greenhouse effect is mainly caused by **water vapour**, which enters the atmosphere through evaporation, and **CO_2**, among other things, with every **exhalation** and every **natural combustion process** is formed .

- by human activities, in particular the **burning of fossil fuels** (e.g. petrol, gas, coal) . This produces huge quantities of carbon dioxide **CO2.** A greenhouse gas that retains heat radiation on the earth. As a result, our climate is warming (= global warming). This is known as the **man-made** (= anthropogenic**) greenhouse effect.**

Greenhouse gases

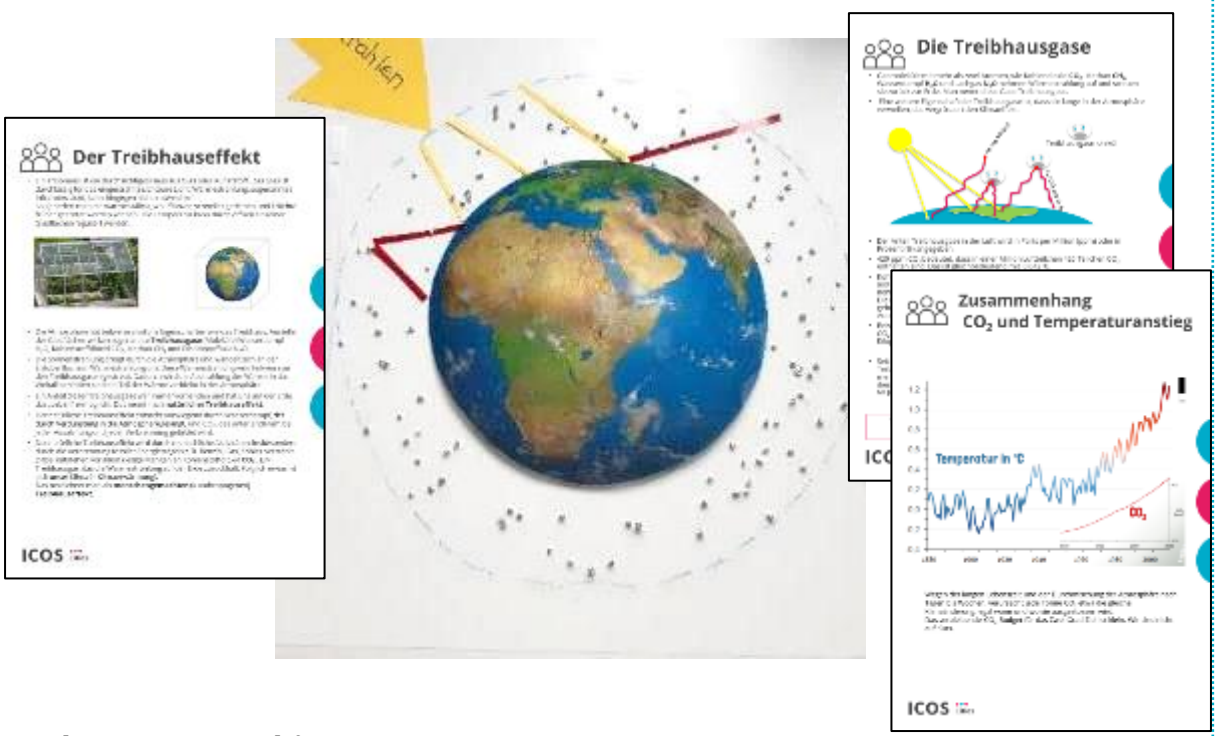
- Gas molecules with more than two atoms, such as carbon dioxide **CO2**, methane **CH4**, water vapour **H2O** and nitrous oxide **N2O** , absorb heat radiation and scatter it back to earth. These gases are called greenhouse gases.
- Another property of greenhouse gases is their long residence time in the atmosphere, which increases the climate effect.



- Coal, oil and natural gas were formed over millions of years through transformation processes from forests, plankton and plants in deep layers of the earth. This is why these energy sources are also called **fossil fuels**. At that time, the plants extracted CO2 from the atmosphere and bound it in the soil. When fossil fuels are burned, e.g. when heating or driving a car, the CO2 is released again.
- The proportion of greenhouse gases in the air is given in parts per million (ppm) or in per cent (%). 420 ppm CO2 means that one million air particles contain 420 particles of CO2, which is equivalent to 0.042 %.
- Example: If a vehicle consumes one litre of petrol, this corresponds to CO2 emissions of approx. 2.37 kilograms.
- by 43% globally 1.2 than it was 100 years ago.

Greenhouse gases are molecules that send heat back to the earth and thus drive global warming.

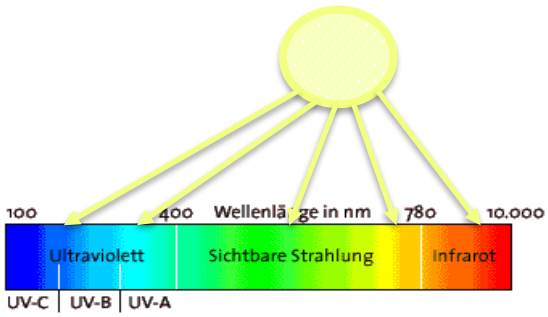
Workstation model



The sun's rays hit:

- 71% on water surfaces, with about 5% being sea ice.
- 29% on land, with 3% being glaciers.

Spectrum of the sun The greenhouse effect is about the heat radiation (infrared radiation) that is sent from the earth back into space and encounters greenhouse gas molecules



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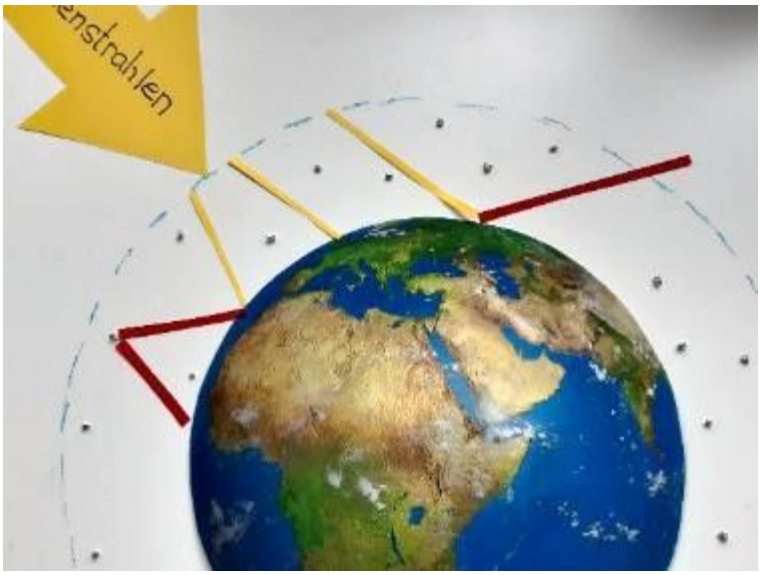
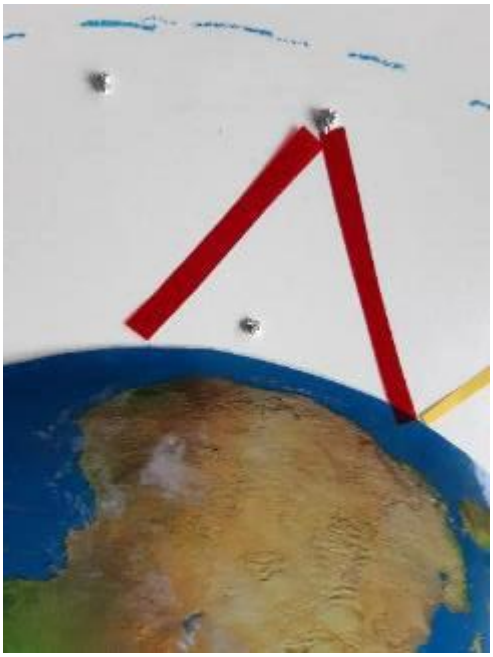
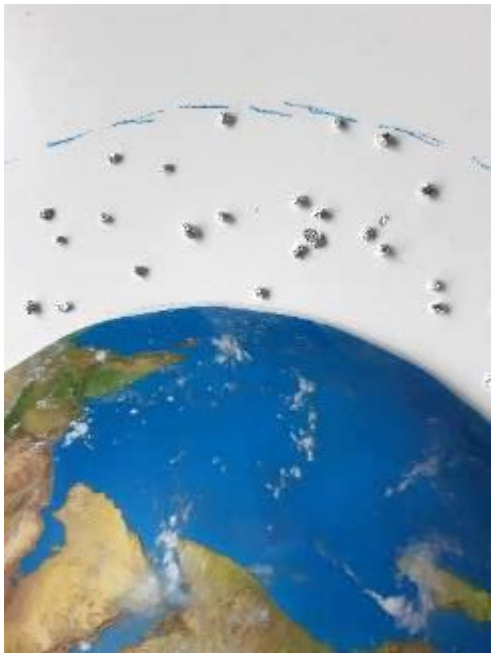
Greenhouse effect model



If the heat radiation hits a greenhouse gas molecule (in this case aluminium beads), the heat radiation is scattered back towards the earth.



Aluminium beads represent greenhouse gases in the model



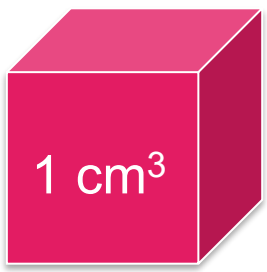
The more greenhouse gases there are in the atmosphere, the warmer the planet's climate becomes.

CO_2 Volumen

In the case of gases, one mole has a volume of 22.4 litres under standard conditions.

- 1 mol = 24.46 litres
- 1/ 24.46 mol = 1 l = 1 dm^3
- 1 mole is 6.022 * 1023 particles => 24.46 litres
- 1l → 24.6 1021 particles → 1dm3
- In 1 cm3 of air there are approx. 24.6 x 1018 particles
- of which 0.04% are CO2 i.e. 9.8 x 1015 i.e. approx. lso ca. **10^{16} Particles**

25 x 1018 air particles
25‘000‘000‘000‘000‘000‘000
25 trillion



Davon 1x 10^{16} CO_2
10‘000‘000‘000‘000‘000
10 Billiarden

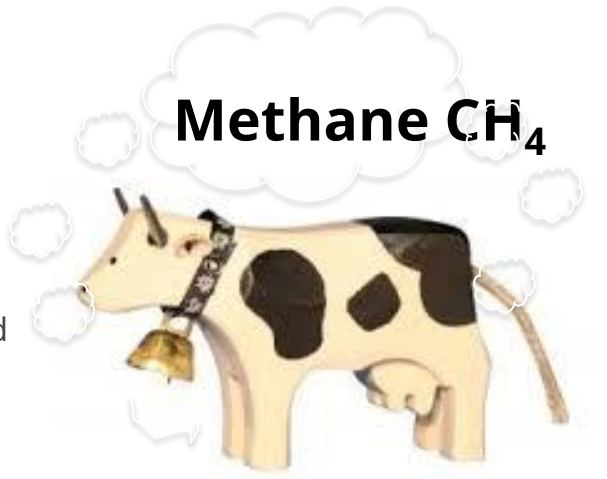
One mole has a volume of 22.4 litres.

The atomic mass of oxygen = 16 grams per mole, of carbon = 12 grams per mole →
16 + 16 + 12 = 44 g atomic mass of CO2 .

So one mole of CO2 weighs 44g = 22.4 litres
1l CO2 weighs 44/22.4 = 1.96 g → 1kg CO2 = 520 litres

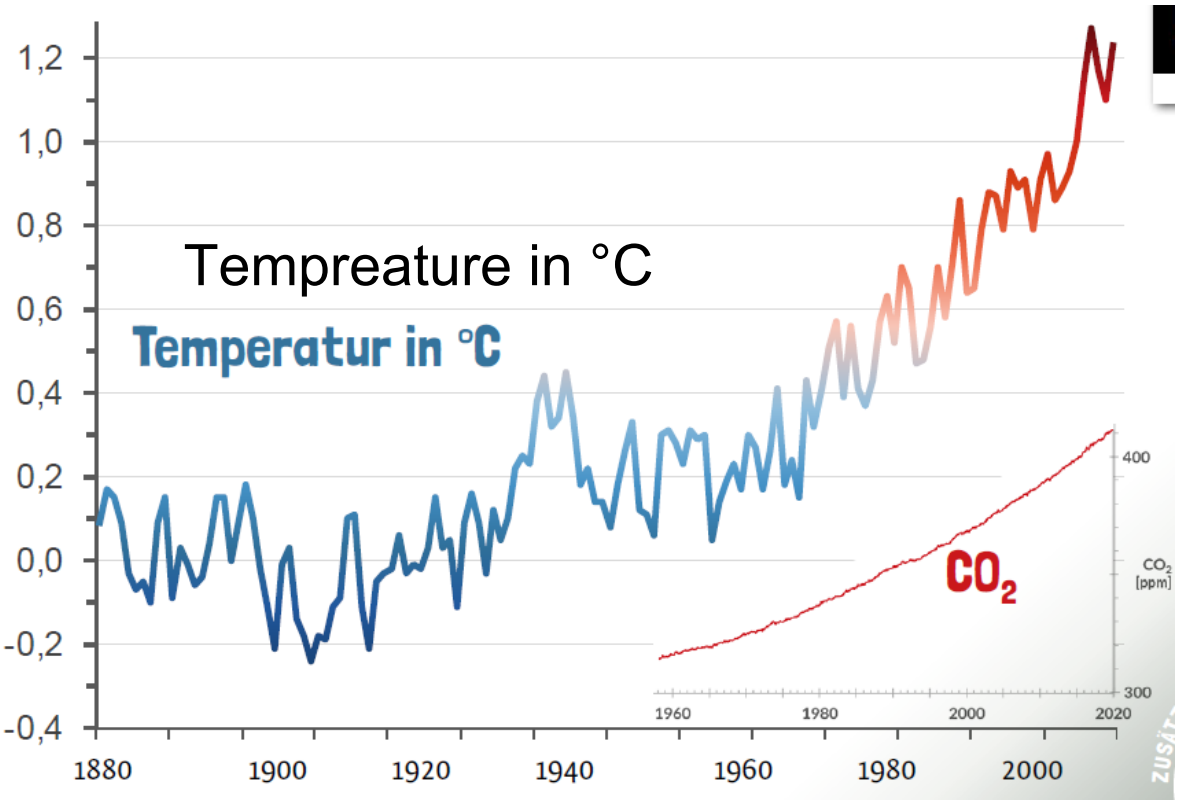
Other greenhouse gases: methane CH4 / nitrous oxide N2O

- **Methane CH4** , also known as natural gas, is **30 times more potent** a greenhouse gas than CO2.
- Methane is formed when plants are broken down in the absence of air, e.g. in a cow's stomach, in rice fields and in landfill sites
- Methane is also produced during the extraction of fossil fuels through fracking and escapes from leaking gas pipelines.
- Livestock farming accounts for 37% of methane and contributes around 20% to the man-made greenhouse effect, which has increased significantly as a result of intensive livestock farming.
- Methane molecules remain in the atmosphere for around 12 years.



- **Nitrous oxide N2O** = dinitrogen monoxide is colourless and odourless.
- Nitrous oxide is about **200 times more potent** as a greenhouse gas than CO2.
- Two thirds of nitrous oxide is produced in agriculture. If the soil is fertilised too intensively with nitrogen-containing artificial fertilisers, the plants cannot absorb enough nitrogen. The excess fertiliser is broken down by microorganisms. Among other things, this produces nitrous oxide, which contributes to global warming. Nitrous oxide contributes around 7 % to the man-made greenhouse effect. remains in the atmosphere for over 100 years

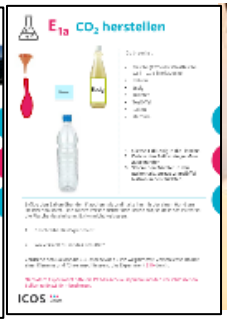
Connection between CO2 and temperature rise



Because of the long lifetime and the mixing of the atmosphere after days to weeks, every tonne of CO2 causes roughly the same climate change, no matter when and where it is emitted.
The remaining CO2 budget for the two-degree target is small and we are not on track.

Set up an experimental station

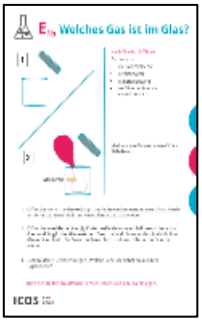
Pictures: 5, 7, 9



E1a

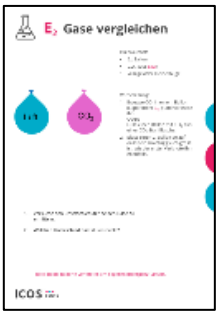
Material per station

- Vinegar
- Spoon,
- baking soda,
- balloon
- Funnel
- Measuring cup
- PET bottl



E1b

- 2 glasses
- Painter's tape
- Felt-tip pen
- Matches



E2

Fill 1 balloon with CO2 and inflate a second balloon with breathing air. Both balloons should be the same size (possibly CO2 from a pressurised cylinder). Provide only one place.

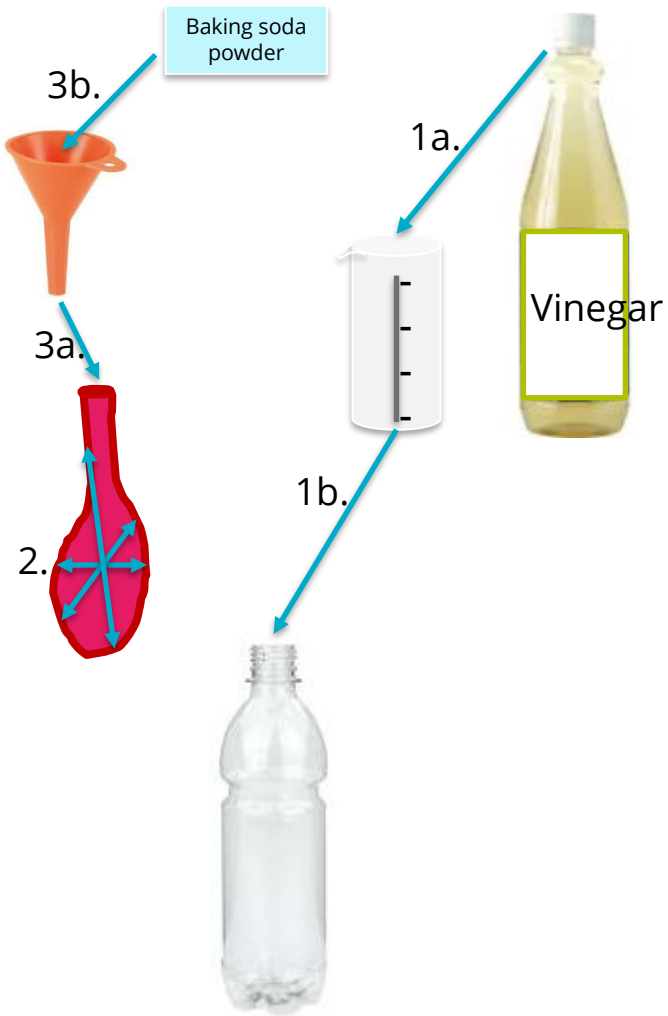
E3* CO2 measuring

device: 2 groups possible at the same time

Download app → Use mobile phone or iPad

* Additional experiment

E_{1a} CO_2 produce



You need:

- Bottle (PET or glass bottle 0.5 l - 0.75 l) with lid
- baking soda
- Vinegar
- Funnel
- Teaspoon
- Balloon
- Clamp
- Measuring jug for vinegar

1. Pour 1 dl of vinegar into the bottle using the measuring cup.
2. Stretch the balloon a few times on all sides.
3. Insert the funnel into the neck of the balloon and sprinkle 2 teaspoons of baking soda into the funnel.

Put the balloon over the neck of the bottle and hold it by the neck with your hand. A second person straightens the balloon so that the powder can trickle into the bottle. Do not let go of the balloon.

1. Wait until nothing changes and describe the experiment.

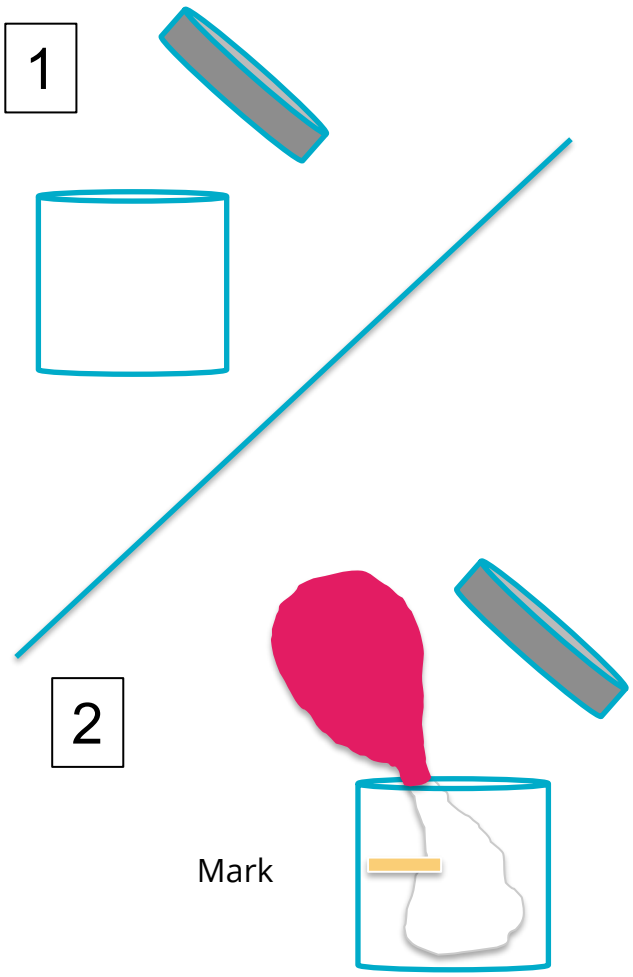
2. How do you explain the result?

Twist the neck of the balloon 2-3 times before you take it away, close it with a clamp and then carry out experiment E1b .

After the experiment, please rinse out the PET bottle and take the sealed balloon to Exp.E1b.

ICOS Cities

E_{1b} Which gas is in the jar?



Perform according to E1a

You need:

- 2x glass jar with lid
- Matches
- Painter's tape
- Filled balloon from experiment E1a

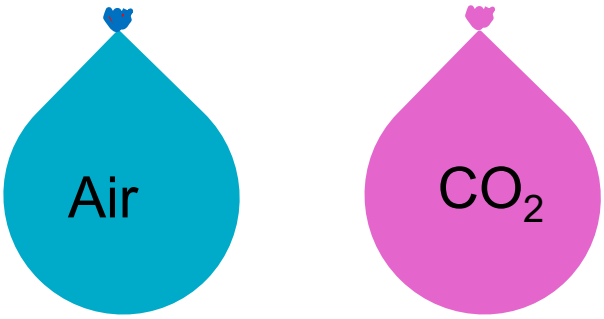
Mark a jar with a piece of adhesive tape.

1. Open the unmarked jar (**1)**and hold a lit match in it. Remove the match and close the jar again.
2. Open the **marked** jar (**2)**. Remove the clamp from the balloon and carefully let the gas flow into the jar. Then hold alit match in this jar. Remove the match and close the jar (2) again.

3. Write down your observations and what conclusions do you draw from the experiment?

Please empty the balloon at the open window and place it at E1a.

E_2 Compare gases



You need:

- 2x balloon
- CO2 (from the pressurised CO2 cylinder or from E1a)

Preparation:

1. Fill a balloon with CO2 from a pressurised CO2 cylinder. Or: Create CO2 in a balloon (experiment E1a and tie the balloon in a knot .
2. Inflate a second balloon so that its circumference is the same as the first and tie it in a knot.

1. Try to determine the difference between the two gases.
2. What difference have you discovered?

Please leave both balloons knotted at the experiment site.

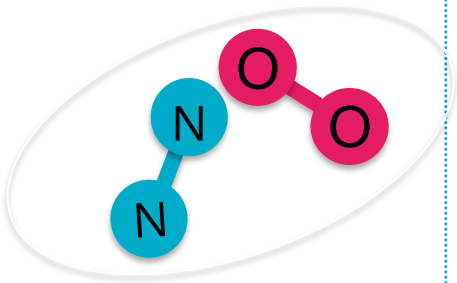
$E_{1ab/2}$ CO_2 Properties

E1a CO_2 produce

When vinegar and baking soda are mixed, carbon dioxide (CO2) and water (H2O) are produced with vigorous foaming. The gaseous CO2 rises from the bottle into the balloon, pushes the rubber envelope apart and inflates it.
The chemical formula for baking soda is NaHCO3 (sodium hydrogen carbonate) and you can imagine that CO2 can be produced from this substance.
Baking soda is also used as a leavening agent in baking. Baking powder consists of baking soda, acid and starch. The acid powder dissolves in the moist dough and reacts with the baking soda, forming small CO2 bubbles that make the dough airy.

E1b Which gas is in the jar

The 1st glass contains a normal air mixture. The match does not go out because there is enough oxygen for the flame. The 2nd glass, which was filled with the gas from the balloon from experiment E1a, contains mainly CO2 . The CO2 displaces the oxygen in the glass. The flame of the match goes out because fire needs oxygen to burn.

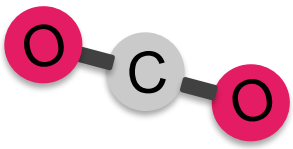


E2 Compare gases

balloon is inflated to the same size (as the CO2 balloon) with breathing air.

If you drop both balloons from the same height, the CO2 balloon reaches the ground first. This means that the CO2 gas is heavier than air. You can also feel the difference in weight if you place both balloons on your hands.

Air:
O_2 and N_2



CO_2

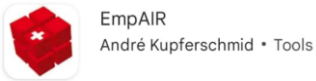
App for CO_2- Measuring device

Description:

- The EmpAir app displays the CO2 concentration, temperature and humidity, and the data can also be saved.
- The app is available for Android and iOS.
- Further information and a version for Huawei mobile phones: www.empa.ch/empair
- Grant permission for location services (Android). No location is saved by the app!

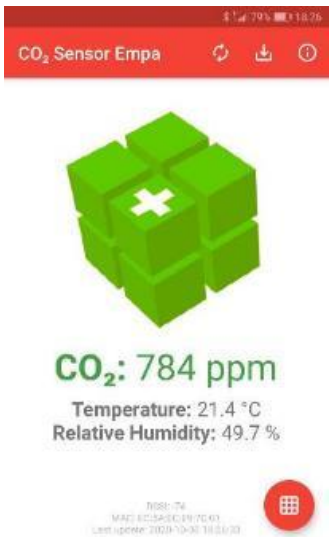
Installation instructions

- Close other active apps on your mobile phone or iPad.
- Search for EmpAir in Google Play (Android) or App Store (iOS).
- Install and start the app.

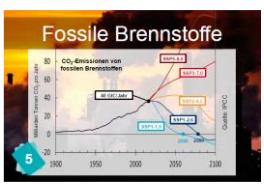


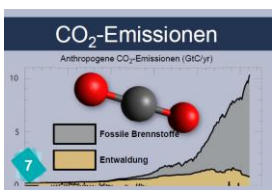
Or :

- Take your mobile phone and scan the QR code of the sensor.
- If the app cannot find a sensor: Activate the location services in general on the device (Android) - Settings > Security and location > Privacy > Location



Pictures: 5, 7





ICOS Cities

E_3 CO_2 measuring

You need:

- CO2 measuring device
- Mobile phone with app

Choose different measurement locations and give reasons for your choice.

1. Measure the CO2 value at different locations.
2. Record the measured values in a table and compare them.
3. Discuss the measured values in class.

Hierapolis

Hierapolis in modern-day Turkey was a magical place. The city near Pamukkale attracted pilgrims over 2000 years ago.

Ancient historians reported the "Gate to Hell" and the following events took place during the ceremonies at this magical place:

In the Roman temple of Pluto, an underground grotto in Hierapolis, sacrificial animals fell dead as if by magic, but nothing happened to the priests standing right next to them. At the time, people were convinced that this must have been the deadly breath of the hellhound Kerberos, who guarded the entrance to the underworld for the god Hades.
The spectators were able to watch the mystical spectacle safely from their higher rows of seats in the arena.
But there were no supernatural forces at play.
Recent studies have shown that from cracks in the ground, the early morning CO_2 why the priests deliberately scheduled the ceremonies for the early hours of the morning. Researchers have shown that the CO_2 concentration in the caves is extremely high at times (up to 53% CO_2 in the air, deadly from approx. 4%).

The priests knew when the deadly breath of Kerberos was effective and up to what height it was completely safe to stand. In the morning, this was about 40 cm above the ground. If they wanted to demonstrate their supernatural powers, they stood on stones around the sacrificial animals. However, the animals stood in the middle of the CO_2 lake, where they inhaled the deadly dose. The priests could remain in their position for about 20 to 40 minutes without being harmed.

Glaciers and ice surfaces

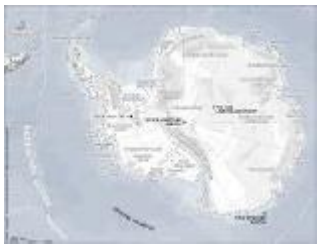
White surfaces reflect a proportion of the sun's energy. In the case of ice, this proportion is around 30 % and in the case of fresh snow up to 90 %. This means that only a small proportion of the energy is absorbed by ice and snow and the surface hardly warms up at all.

Ice and snow surfaces play an important role in the Earth's climate system. Worldwide changes in ice and snow surfaces as a result of global warming influence our climate.s

At the poles, a distinction is made between sea ice and land ice. **Sea ice** is frozen seawater, while **land ice** is glacial ice that has formed from snowfall. Most of the **Arctic** area at the North Pole) is a **sea** Arctic Ocean) around the North Pole, the northernmost point on Earth. The North Pole itself is normally covered by a thick layer of sea ice all year round. Only in summer is the Arctic Ocean partially passable for ships. Due to global warming, larger areas of ice are increasingly thawing, literally melting the ice floes from under the polar bears' paws!

Arctic region with sea routes

- The **Antarctica** area at the South Pole) is a **continent,** e.g a land mass covered by glaciers (continental ice). The glaciers consist of fresh water. Large icebergs break off at the edge of the land mass and then float in the sea. If the loss of glacier ice from Antarctica into the Southern Ocean increases due to climate change, this will contribute to rising sea levels



Continent Antarctica

What is happening today:
When white surfaces melt, water or soil surfaces appear there. These absorb more solar energy, which means that the oceans warm up more.

Melting glaciers in the Alps

The example of the Trift Glacier

2011 and 2021

- The reasons for glacier shrinkage are lower snow volumes and, above all, increasing temperatures (as a result of climate change).
- The glaciers in the Alps melt particularly quickly during summer heatwaves.
- Above 2500 metres above sea level, many soils are frozen all year round, with only a few centimetres at the surface thawing in summer. Such soils are known as permafrost. Global warming is also causing the permafrost to begin to thaw and the ground can become unstable. This can lead to landslides, mudslides and rockfalls.
- Glaciers are freshwater reserves and play an important role in the water supply.
- Freshwater is vital for all living creatures and accounts for around 3 % of the Earth's water resources.
- Most freshwater (approx. 70 %) is bound in the form of ice and snow in the polar regions and in the high mountains. Around 30 % is groundwater, i.e. below the earth's surface. Less than 1 % of freshwater is found as surface water in streams, rivers and lakes.

Albedo effect

The albedo effect describes how much solar energy is reflected by a surface (reflectivity).

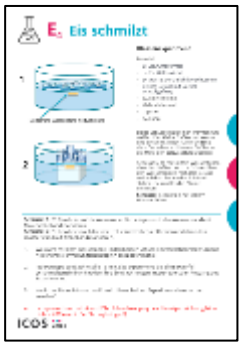
Examples:
Fresh snow has an albedo of 0.9, which means that 90% of the sun's energy is reflected.
Dark asphalt, on the other hand, has an albedo of 0.15. This means that only 15% of the solar energy is reflected. 85% is absorbed (swallowed).

- As the area of Antarctica is so large, the albedo effect has a direct influence on the warming of the entire Earth.

Snow with
Sahara dust (orange area) or soot particles (grey area)
absorbs more solar energy.

The more ice that disappears, the more solar energy is absorbed by the dark ocean or land surfaces, which in turn leads to a warming of water and air.
In addition, warm water takes up more space and thus contributes to rising sea levels - in addition to the melting of the ice masses.

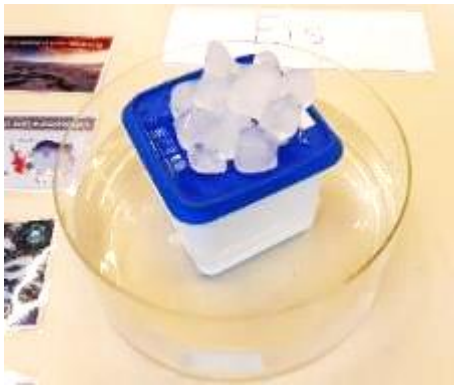
Experimental station E4



Material:

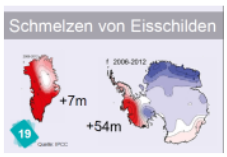
- 2 large glass jars
- Small container with lid (Tupperware)
- Ice cubes (approx. 15 -20 per container)
- Painter's tape.
- Cloth

Antarctica



glacier melt

melting of ice sheets

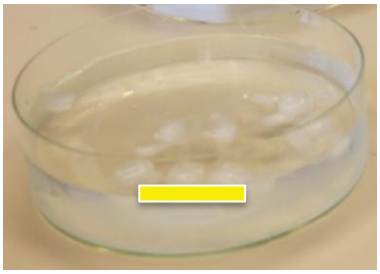


freshwater resources

Pictures:
16,19, 31

Fill a small container with water and close it with the lid. Place it in the centre of a glass bowl. Then fill the large bowl with water to approx. 2 cm below the rim of the small container. This must remain on the bottom. Then pile 15-20 ice cubes on the lid of the small container. Immediately mark the water level on the outside of the large container with painter's tape. Observe!

Arctic

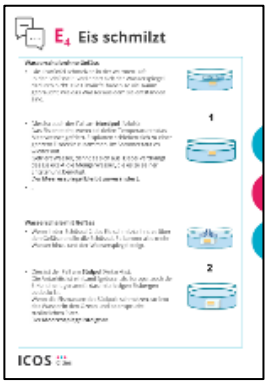


melting of sea ice

Picture:
18

Half fill a glass bowl with water.
Add 15-20 ice cubes (possibly together with pupils) to the water. Immediately mark the water level with masking tape. Observe!

Explanation:



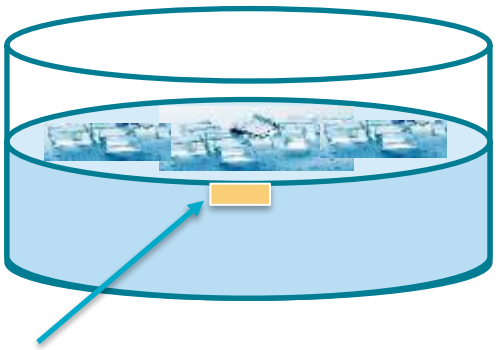
E_4 Ice melts

Class experiment

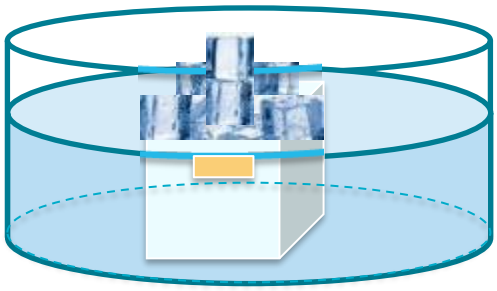
Material:

- 2x ice cube moulds
- approx. 2 x 25 ice cubes
- 2x large, transparent bowls
- small container with lid (plastic container)
- possibly small stones
- Painter's tape
- cloth
- Possibly hair dryer

1



2



Place both bowls in a warm place. Fill the small container with water (possibly with a few stones) and close it with the lid. Placethe container in the centre of **bowl 2 .**

Fill bowl 2 with cold water so that the small container is still approx. 2 cm above the water level. The container must stand on the bottom of the bowl. Fill **bowl 1** with cold water.

Bowl 1: Fill 20 ice cubes on the surface of the water and mark the water level with masking tape.
Bowl 2: Fill 20 ice cubes on the island (= lid of the container) and then mark the water level with masking tape.

1. What will happen to the water level in the two bowls? Each group writes down their guesses at the start of the experiment.

2. Each group observes the experiment every 15 minutes until all the ice cubes have melted and notes down their observations. Interprets the outcome of the experiment.

3. Where in nature could the principle of these two experiments be observed?

4. Teacher can accelerate the melting process with a hairdryer (be careful not to bring the hairdryer into contact with water!)

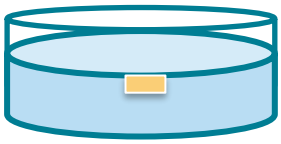
E_4 Ice melts

Water bowl without Container

- The ice cubes melt in the warm air. This does not change the water level in bowl 1. The ice cubes have displaced as much scpace as the water from which they were formed.

- This is also the case at the **North Pole** Arctic): ice is formed when seawater freezes at low temperatures. Ice sheets push together to form an entire ice sheet. It thaws again in summer., **the sea ice melts** bleibt dthe **sea level remains unchanged.**

1



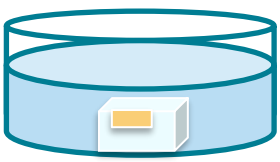
Water bowl with container

- When the ice melts in bowl 2, it runs over the edge of the container into the bowl. More water is therefore added and the water level rises. If ice cubes fall into the water, this also causes the water level to rise (additional ice).

- This is the case at the **South Pole** Antarctica) and in Greenland: Antarctica is a land (larger than Europe, also called the 6th continent) covered with huge icebergs, and Greenland is the largest island in the world, covered by an ice cap over 3 kilometres thick.

  When the ice masses at the South Pole or in Greenland melt, the water flows into the ocean and takes up additional space. This results in a rise in the water level. When **the land ice melts** the **sea level** rises.

2



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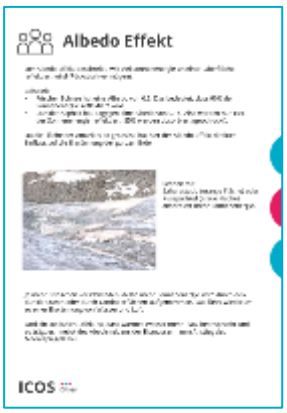
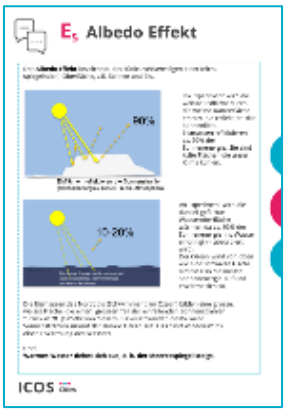
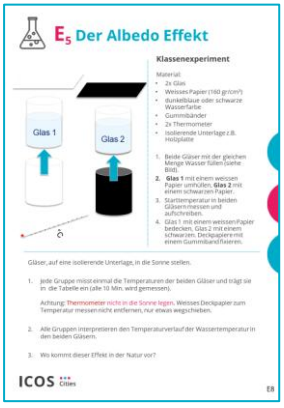
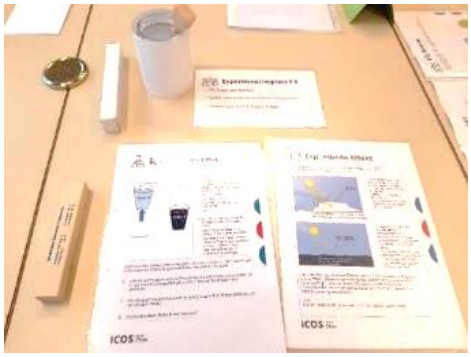
Exp. E5





No picture cards
For this experiment





Class experiment

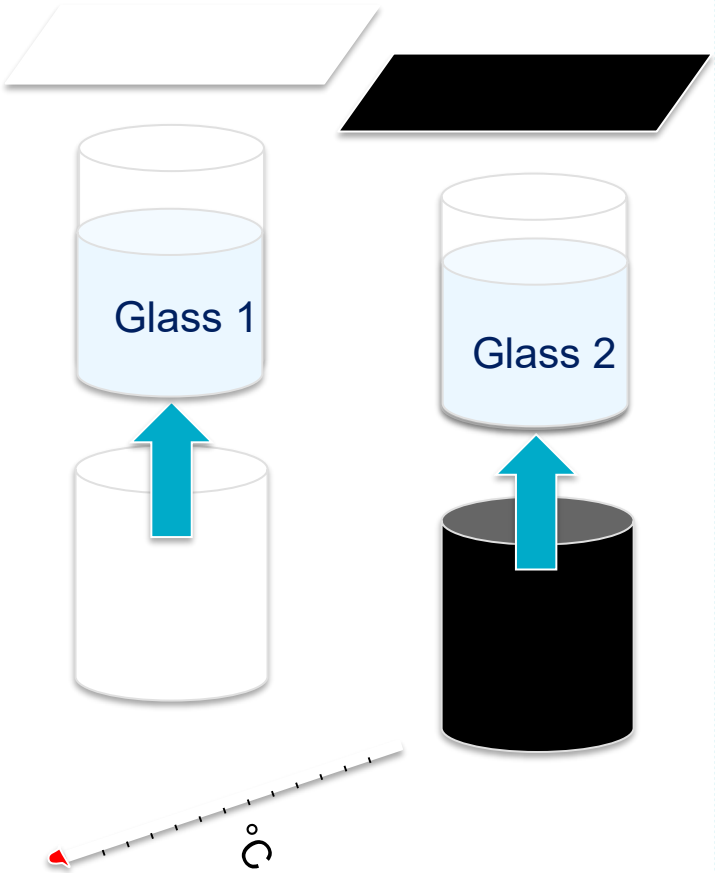
Material:

- 2x glass
- White paper (160 g/cm3)
- Dark blue or black watercolour
- rubber bands
- 2x thermometer
- Insulating base e.g. wooden board

1. Fill both glasses with the same amount of water (see picture).
2. **glass 1** with white paper, **glass 2** with black paper.
3. Measure the starting temperature in both jars and write it down.
4. Cover jar 1 with a white paper, jar 2 with a black one and fix the cover papers with a rubber band.

The black-coated glass heats up more.
Black absorbs solar energy.

E_5 The albedo effect



Class experiment

Material:

- 2x glass
- White and black paper (approx. 160 gr/cm3)
- Rubber bands
- 2x thermometer (scale up to 100°C)
- Insulating base e.g. wooden board

1. Fill both glasses with the same amount of water (see picture).
2. **glass 1** with white paper, **glass 2** with black paper.
3. Measure the starting temperature in both glasses and write it down.
4. Cover jar 1 with white paper and jar 2 with black paper.
5. Secure the cover papers with a rubber band.

Place the jars in the sun on an insulating surface.

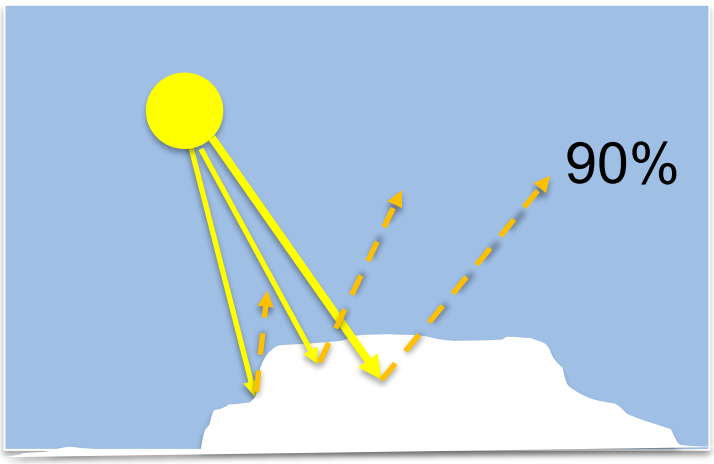
1. Each group measures the temperatures of the two glasses once and enters them in the table (measurements are taken every 10 minutes).
   Caution: thermometer in the sun. Do not remove the white cover paper to measure the temperature, just push it away a little.

1. All groups interpret the temperature curve of the water temperature in the two glasses.

2. Where does this effect occur in nature?

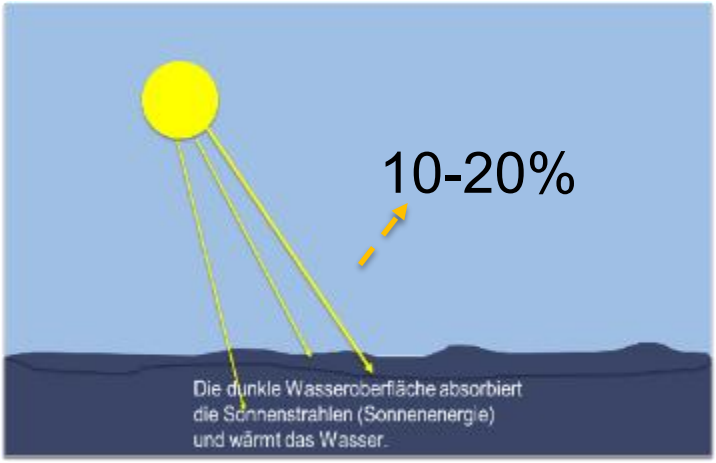
E_5 Albedo effect

The **albedo effect** refers to the reflectivity of a (non-reflective) surface, e.g. snow and ice.



Snow surfaces reflect the sun's rays (solar energy) back into the atmosphere.

In the experiment, the white ice surface is replaced by the white cardboard surface. It reflects the sunlight. Snow surfaces reflect around 90% of the sun's energy. They are cold surfaces that cool our climate.



The dark surface of the water absorbs the sun's rays (solar energy) and warms the water.

In the experiment, the dark water surface is simulated by the black cardboard, allowing a large proportion of the solar energy to penetrate the water.
From above, the ocean acts like a black surface, absorbing most of the solar energy and thus warming up.

The ice masses of the North Pole (floating in the ocean) form a large, white surface that reflects a large part of the incoming sunlight. The more of this ice disappears, the more sunlight the dark ocean absorbs. This in turn leads to a warming of the water. And: **Warm water expands, i.e. the sea level rises.**

Water

Oceans cover 2/3 of the earth's surface and provide us with oxygen, water and food and are very important for regulating heat.

The oceans absorb huge amounts of carbon. 25% of the CO2 emissions caused by humans to date (= CO2 emissions) are thus removed from the atmosphere and bound in the oceans in the long term. This is known as a carbon sink:

- Some of the CO2 dissolves in seawater , and ocean currents carry it to the bottom, where it can be stored for a long time.
- The dissolved CO2, which produces carbonic acid (H2CO3), makes the water slightly more acidic, which means that the pH value drops.
- Some of the carbon dioxide (CO2) is used by algae and seagrass for photosynthesis and growth. After dying off, they sink to the seabed and thus permanently store the CO2 in the sea.

Effects of increasing water temperature:

- Water expands with increasing temperature, which means that the water level rises (as water temperatures rise).
- The water's ability to absorb carbon dioxide decreases as the temperature of the oceans rises, meaning that more CO2 remains in the air as water temperatures rise and global warming intensifies.

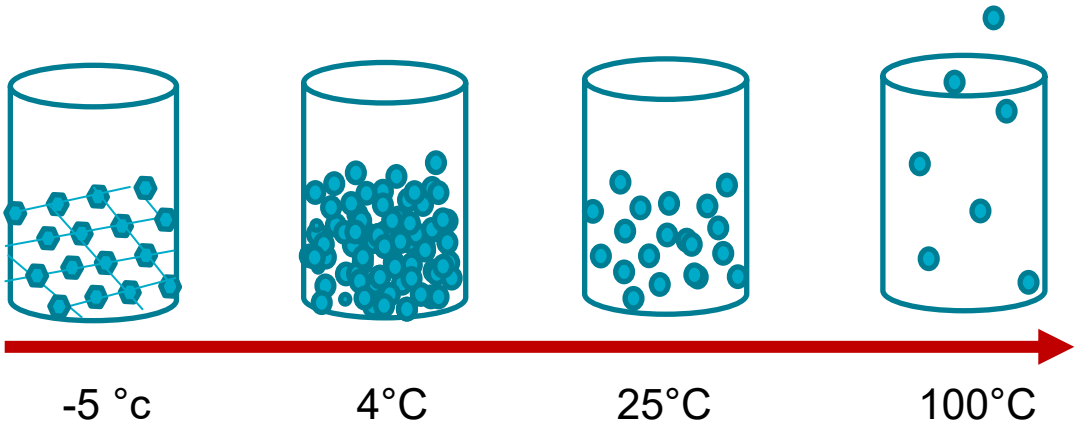
What is happening today:

- The more CO2 is dissolved in the water, the more acidic the oceans become.
- Reduction of biodiversity in the oceans:
- Animals with calcareous shells (e.g. mussels) are inhibited in their development.
- Calcifying phytoplankton (plants) lose weight.
- The oxygen content in the water decreases as temperatures rise; this can also lead to problems for the fish.

Water properties

Water takes up different amounts of space depending on the temperature. The number of particles per unit volume is called density.

Particle density of water as a function of temperature



- When **water is heated** , it expands. This means that it takes up **more space** or volume (= lower density). Example: Fill a PET bottle with water and place it in the blazing sun for 1 h. The bottle will feel harder and plumper .
- The warmer the water is, the more space it needs; the density decreases with the temperature, which means that sea levels rise as the water temperature increases.
- **Cold water** can **more oxygen** than warm water. If the temperature in the water rises, the oxygen content in it falls. Aquatic animals and plants cannot adapt as quickly and suffer massively as a result. In hot summers, this can lead to fish kills in watercourses if the fish cannot move to colder waters.
- The uppermost layers of water generally contain more oxygen than deeper layers.

Problems of the oceans

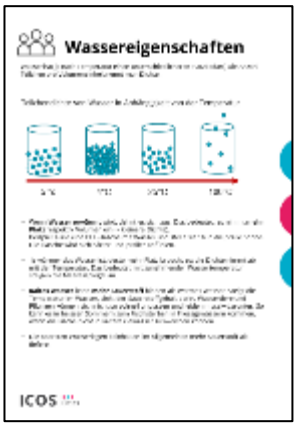
Acidification

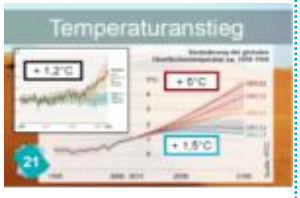
- CO_2 is almost completely dissolved in the ocean. It reacts with water and forms carbonic acid. This leads to a decrease in the pH value of the seawater. The acidification of the water attacks the calcium carbonate shells of calcifying marine animals. One possible consequence is that their shells become thinner or could dissolve.
- Calcifying phytoplankton (plants) also suffer. They lose weight and can no longer sink to the seabed after fading. As a result of sinking, carbon is bound to the seabed for thousands of years (large CO_2 sink).
- Acidification inhibits the calcification of corals, which are valuable ecosystems and protect coastal areas.

Increasing the water temperature

- Increasing the temperature is a problem for fish because they need oxygen in the water to breathe. The warmer the water is, the less oxygen can dissolve in the water, which means the fish have to breathe faster and this requires more energy.
- Corals lose their colour due to rising temperatures.
- Algae live in the tissue of the corals, which feed the corals through photosynthesis and give them their special colours. When the corals are under stress, triggered by pollution or heat, they reject the algae. As a result, only the white skeleton remains.

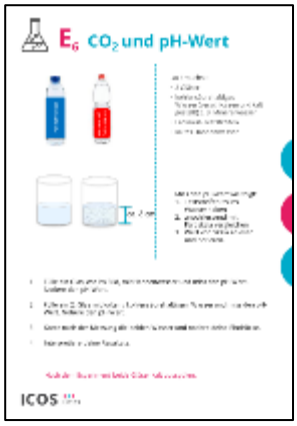
Exp. E6



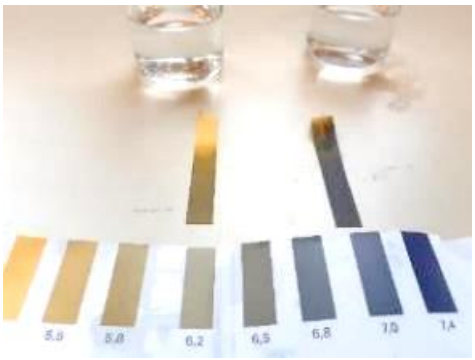


Pictures: 17, 20, 21, 23, 24, 27

Prepare a cold, sealed bottle of mineral water, test strips in a dry environment, cloth, 4-6 glasses (2 per group), pupils wash the containers after the experiment. Pupils answer questions 1-4.



Carbon dioxide (CO2) is combined with water to make the water bubble. This is done by pressing CO2 into bottles under pressure. Carbonic acid is CO2 dissolved in water.
The pH value of the water changes when CO2 is absorbed into the water. The more CO2 is absorbed, the lower the pH value, i.e. the more acidic the water is.

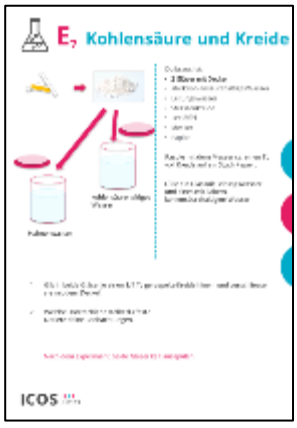


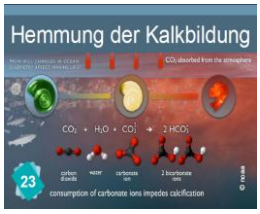
Exp. E7

Pictures: 17, 20, 21, 23, 24, 27

Provide mineral water bottle (highly carbonated) cold and sealed, test strips in a dry environment, cloth, 4-6 glasses (2 per group) Pupils wash containers after experiment. Pupils answer questions.

Inhibition of limescale formation



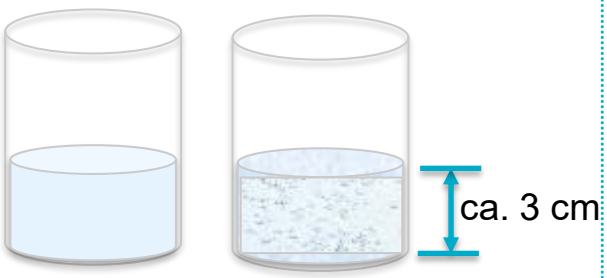


Marine biodiversity

Material:

- Use sidewalk chalk
- Knife
- Paper
- Cold mineral water
- 2 glasses per experiment station (group of 2)

E_6 CO2 and pH value



You need:

- 2 glasses
- Carbonated water (sealed and chilled) e.g. mineral water
- litmus test strips
- cold tap water

Always place the test strips in a dry place.

Measure the pH value as follows:

- Take a test strip and hold it in the water for 2 seconds.
- Then compare it with the colour scale and read the pH value

1. Fill a glass with tap water, as shown in the picture, and measure the pH value. Note the pH value.

2. Fill a 2nd glass with cold, carbonated water and immediately close the bottle again. Measure the pH value of the carbonated water and note the pH value.

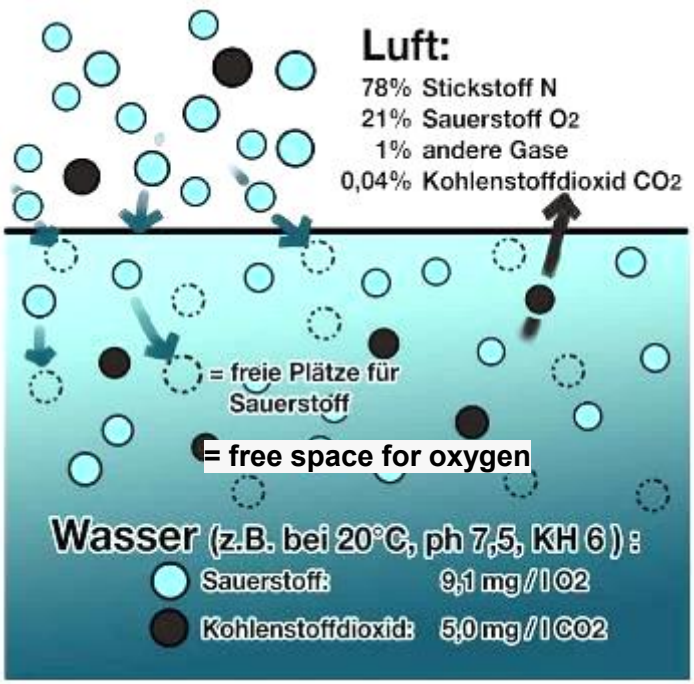
   Always store the mineral water bottle in a cool place.

1. Interpret your results.

After the experiment, please rinse both glasses in cold water.

ICOS Cities

Dissolve gases in water



Air:
78% nitrogen N
21% oxygen O^2
1% other gases
0.04% carbon dioxide CO^2

Gases such as oxygen or CO2 can dissolve in the water.

Water (e.g. at 20°C, pH 7.5, KH 6):
Oxygen: 9.1 mg/l O^2
Carbon dioxide: 5.0 mg/l CO^2

- The colder the water is, the more CO2 can dissolve in it.
- The colder the water is, the more oxygen can dissolve in it.
- The higher the temperature of the water, the faster the water particles move. This reduces the "space" for gases such as CO2 or oxygen. In warm water, the gases rise to the top and are released into the air.

  Example:
  In lakes and streams, the fish absorb the dissolved oxygen from the water through their gills. The warmer the water, the less oxygen it contains. The gill cover movements per minute are increased as the water temperature rises in order to obtain sufficient oxygen. If there is not enough oxygen dissolved in the water, at water temperatures above 25°C, fish can die in small bodies of water in summer.
- The pH value of the water changes when CO2 is absorbed into the water. The more CO2 is absorbed, the lower the pH value, i.e. the more acidic the water is.

$E_{6/7}$ CO_2 and water

CO2 can dissolve in water.

- Carbon dioxide (CO2) is combined with water to make the water bubble.
- In the experiment, you have a glass of carbonated water and a glass of tap water. The pH measurement shows that the carbonated water has a lower value, i.e. is slightly acidic. pH values below 7 are described as acidic, above 7 as alkaline.
- Tap water has a pH value of 6.8-7, depending on the region, and is therefore described as neutral. Carbonated water has a pH value of around 5.6, depending on the manufacturer, and is therefore slightly acidic.
- If you look at this phenomenon in nature, it means that the more CO2 is absorbed in the water (e.g. in the oceans), the lower the pH value, i.e. the more acidic the water is.
- The colder the water is, the more CO2 can dissolve in it.
- As the CO2 content in the atmosphere increases, more CO2 is also dissolved in the water of the oceans. This means that the oceans become more acidic, which in turn has consequences for marine life.

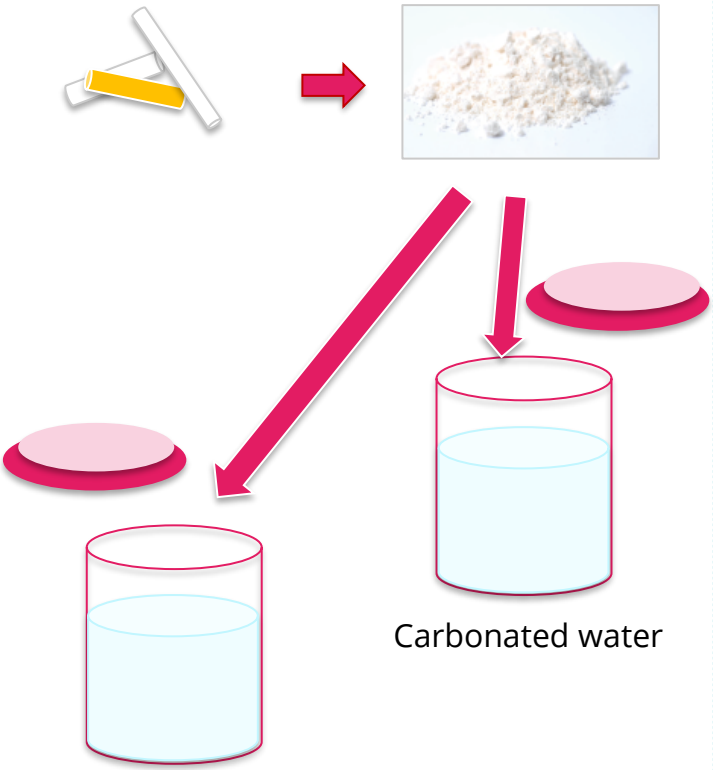
Exp. carbon dioxide and chalk

- In the experiment, the chalk (contains lime) in the mineral water is dissolved in the water, it bubbles. The liquid becomes cloudy. Then some of the chalk (the lime) that was not dissolved also sinks to the bottom and the water becomes clear again.
- In tap water, the chalk sinks to the bottom without dissolving.

Effects of the lower pH value in water in nature:

- Aquatic organisms that have calcareous shells such as mussels, crabs or corals etc. lose their strength.
- Microorganisms such as certain types of plankton, which have a calcareous shell, are damaged. Plankton is the basis of the entire food chain.
- Calcareous algae have an enormous influence on CO2 storage, as they bind a lot of CO2 with their photosynthesis.

E$_7$ Carbon dioxide and chalk



You need:

- 2 glasses with lids
- Highly carbonated water
- tap water
- Road chalk
- Teaspoon (TL)
- Paper

Use a spoon to scrape about half a teaspoonful of chalk onto a piece of paper.

Fill one glass with tap water and one with cold, carbonated water.

1. Add 1/4 teaspoon of grated chalk to each jar and seal with the lid.

2. What differences do you notice? Write down your observations.

After the experiment, rinse both glasses in cold water.

Mazuku - "Evil Wind"

One of the most beautiful crater lakes in the volcanic region of western Cameroon is Lake Nyos (photo), which the locals used to call the "good lake".

On the night of 21 August 1986, however, something horrific happened, which a local resident later described as follows: "I heard a humming and crashing sound, as if an aeroplane was going down. Half asleep, I heard my daughter snoring in a terrible way, very strange. When I went to her, I collapsed and fell down. I slept until half past four the next day. When I woke up, I found that my daughter was dead."

When Joseph Nkwain looked around the village, he found only corpses everywhere and an eerie silence. Not a bird sang, not a grasshopper chirped, not even flies buzzed. Everywhere the flowers sway forlornly in the wind, not a butterfly or bee settles on them. Nkwain rode his motorbike to a neighbouring town. He reached the village, which was a normal bustle of activity and where there was still no knowledge of any disaster in nearby Subum. He drove to the hospital and told them what had happened. Soon the whole town was buzzing with rumours.

Some policemen and a priest set off for the small village by the lake, travelling along the road that Nkwain had travelled shortly before. But not far from the lake, it occurred to the officers that whatever had killed the people and livestock might still be in the area. They stopped and decided not to continue. Only the priest insisted that they had to get to the lake, that human lives were at stake. He continued on his way alone.

There was an oppressive silence in all the villages on the lake shore. Most of the houses were locked, as if it were still night, in them motionless silence. In front of some houses - huddled together - dead families could be found. Later the priest, the Dutch missionary Father Horn, would say that it looked as if a neutron bomb had hit: "Little damage to property, but almost total destruction of life." This remark would soon pass from mouth to mouth.

Studies by European geologists come to a different conclusion: according to them, it was a huge carbon dioxide bubble that rose from an underground magma chamber. This bubble accumulated under the lake bed until it finally rose, perhaps triggered by a landslide. It burst its banks and destroyed people, livestock, birds and even insects. The catastrophe claimed at least 1765 lives, killed 3000 cattle and countless goats, sheep and chickens.

Soil and vegetation

30% of the earth's surface is land. The sun's rays hit forests, grassland, agricultural land, rocks, sand or urban areas with asphalt and concrete. Depending on the nature of the surface, more or less solar energy is absorbed.

Green plants have a particularly important function. They convert CO2 into oxygen and biomass during photosynthesis. This removes CO2 from the atmosphere and stores the carbon (C) in the plants. This carbon store is also known as a natural CO2 sink. Only around 25% of the greenhouse gases caused by humans are broken down by plants through photosynthesis.

- Der Soil is a habitat, a water reservoir and the central basis for our food production.
- Soil is the most important carbon store, with more than 70% of carbon in the soil (twice as much as in the atmosphere).
- If the surface is not covered (rock, desert, ice, asphalt and concrete), it is characterised by soils, which are usually invisible, hidden under forests and meadows.
- Natural soils form over very long periods of time.
- also have on the soil through chemical effects (fertilisation, pesticides, etc.) and cultivation.
- The water retention of the soil and plants influences the air temperature: green spaces and forests cool the air through evaporation.
- Cities with their many built-up areas heat up more than green landscapes or forests, which is why they are referred to as heat islands (hotspots).

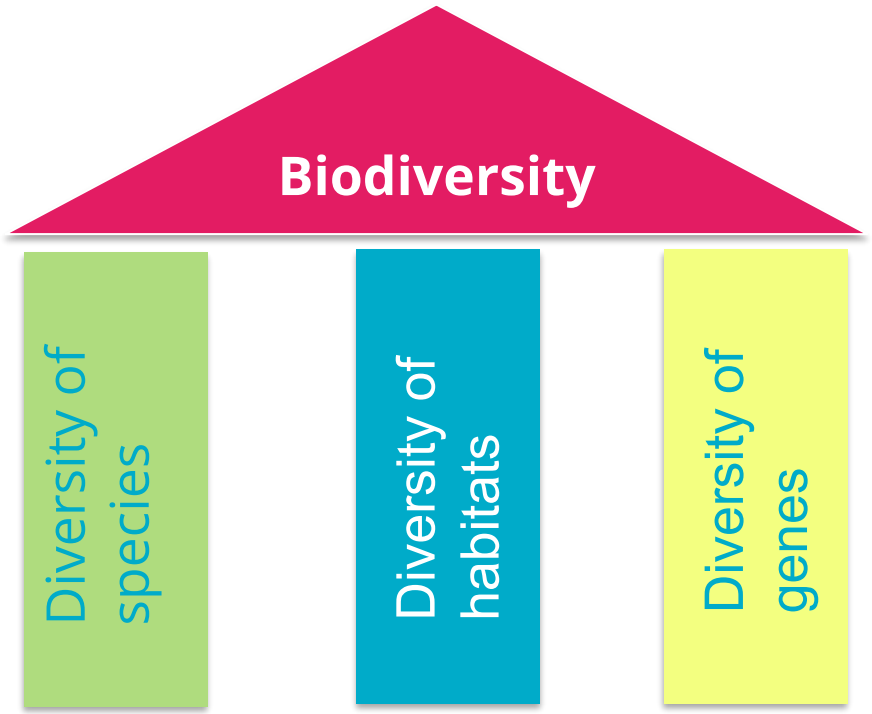
What is happening today?

- Global warming is changing the habitats of plants and animals. Many creatures are unable to adapt in such a short space of time and are disappearing. Biodiversity is decreasing.
- Entire ecosystems are changing due to the rise in temperature.
- Weather extremes lead to a decline in harvests and loss of settlement areas.
- Intensive agriculture produces additional greenhouse gases (methane, nitrous oxide).

Soil and vegetation vocabulary

- **Biodiversity** consists of three areas:

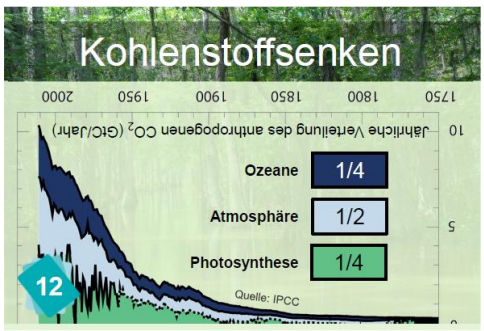
1. the diversity of plant and animal species, 2
2. genetic diversity, e.g. every person looks different,
3. the diversity of habitats (ecosystems), e.g. bodies of water, meadows, forests, etc.



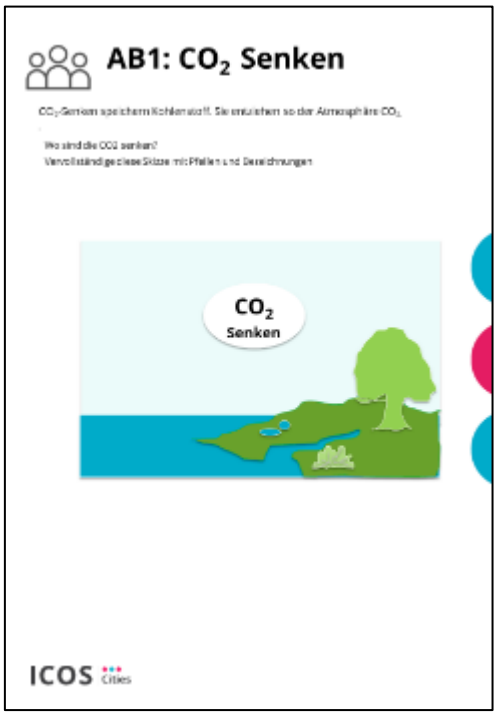
- **Biomass**: Substances that are mainly produced from plants, e.g. maize and cereal plants, straw, sugar beet, reed grass and other grasses, but also residual materials such as liquid manure and biowaste.
- An **ecosystem** is a community of living organisms in a specific habitat e.g. pond
- **Intensive agriculture:** the soil more efficiently **cultivate**, increasing the use of pesticides (weed killers, insect and fungus killers) and fertilisers, keeping more animals per area both on pasture and in stables (intensive livestock farming).
- **Settlement area**: Built-up areas where people live.

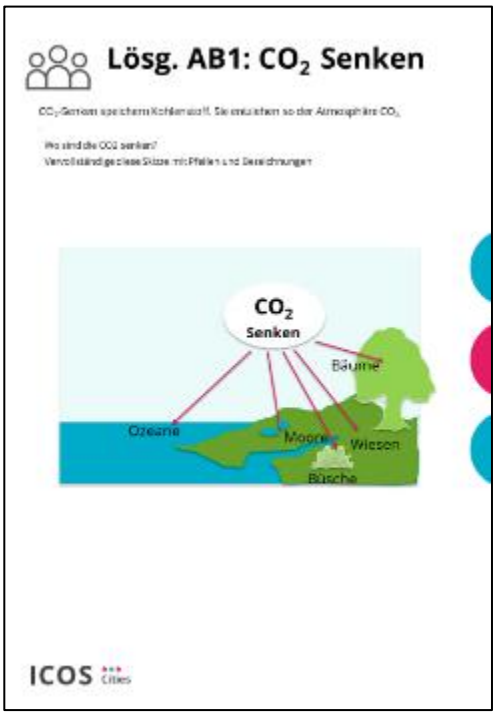
CO_2-Reducing

A carbon reducing is a natural place that temporarily absorbs and stores more carbon than it releases.



carbon sinks





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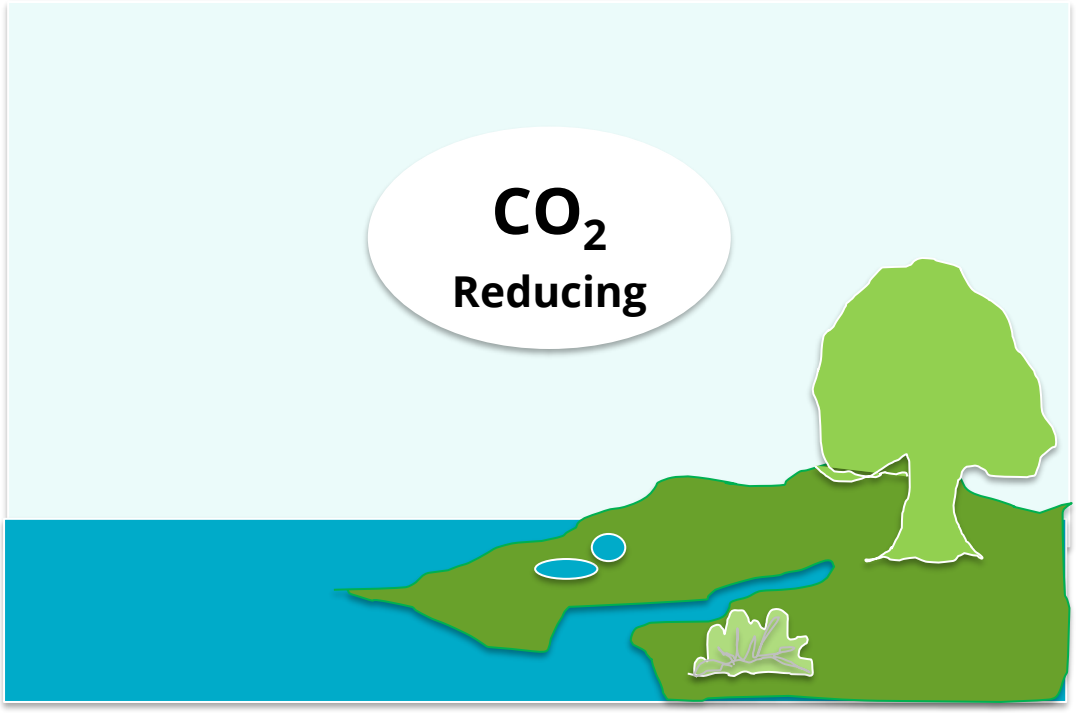
AB1: CO_2 Reducing

CO_2-Reducing saves Carbon. They extract CO2 from the atmosphere.

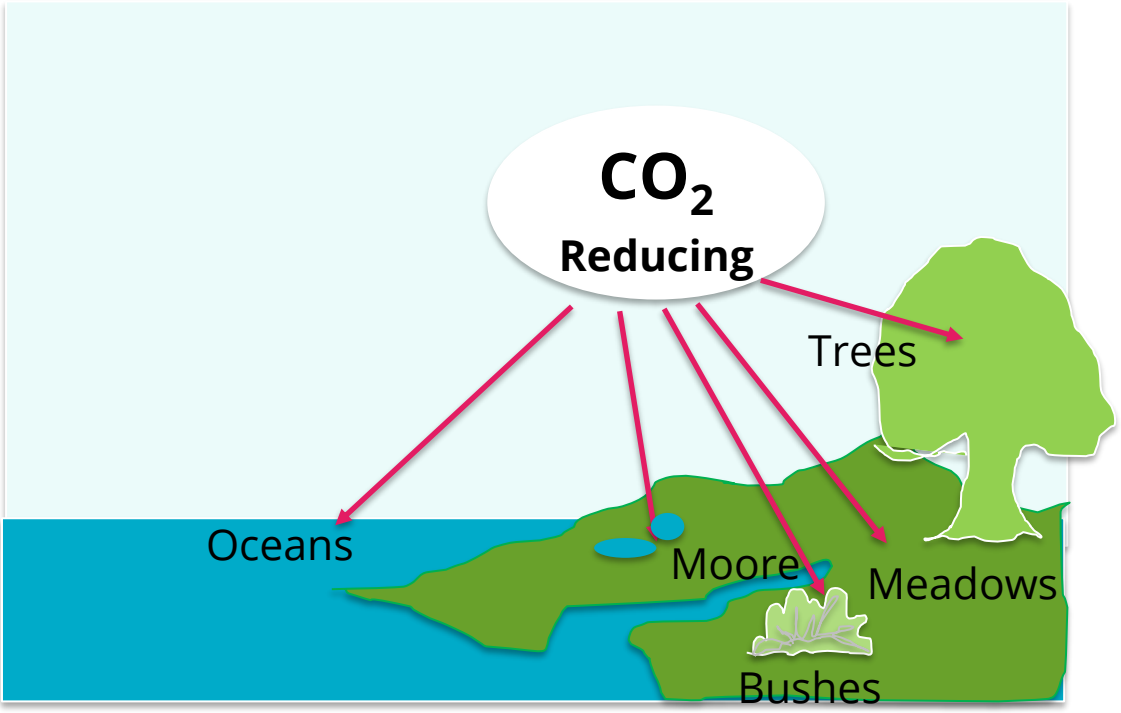
Where are the CO2 sinks?
Select the corresponding locations in the picture.
Name them and connect them with→ **CO_2 Reducing**



Solution. AB1: CO_2 Reducing

CO_2-Reducing saves Carbon. They extract CO2 from the atmosphere.

Where are the CO2 sinks?
Select the corresponding locations in the picture.
Name them and connect them with→ **CO_2 Reducing**



E8 Dryness

Collect dry and juicy green needles from conifers/shrubs.

In the summer months (May-Sept. in full sunlight) the needles can be ignited with a magnifying glass.

Material per workstation:

- Magnifying glass or matches
- Containers with dry and green needles.
- Refractory bases

Pictures:
6, 8, 9, 12, 25

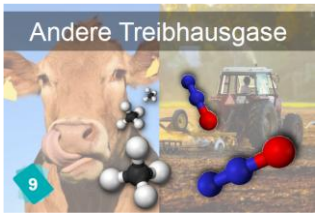
forest fires

droughts

deforestation

Always work with fireproof materials in the classroom

agriculture



Other greenhouse gases

E_8 Dryness

You need:

- Dry and green needles from a coniferous tree
- Magnifying glass (May-September) or match
- Fireproof base
- Sun
- Glass of water

Caution: Carry out the experiment on the playground (asphalt) in a place protected from the wind or in a laboratory environment.

1. What do the needles of a conifer tree contain? Examine the needles with your senses.
2. Place **3** dry needles on the fireproof base and light them with a magnifying glass or a match.
3. The same experiment with **3** fresh, green needles.
4. Describe the difference between the two experiments.
5. Which natural disasters does this experiment explain? Why?

Throw away used needles after the experiment.

E_8 Dryness

- The needles of conifers are hard and dry to the touch. They are covered in a layer of wax. Their needles contain essential oils that burn very well. If you rub the needles between your fingers, you can smell the essential oil.
- Dried needles can be lit with a magnifying glass and the sun, but fresh green needles are not so easy to light as they still have moisture inside.
- When it is hot and dry, trees shed some of their needles and are unable to supply them all.
- Dry, resinous tree needles are particularly good fuel, and in periods of drought the dried out needles and branches can cause large-scale forest fires.

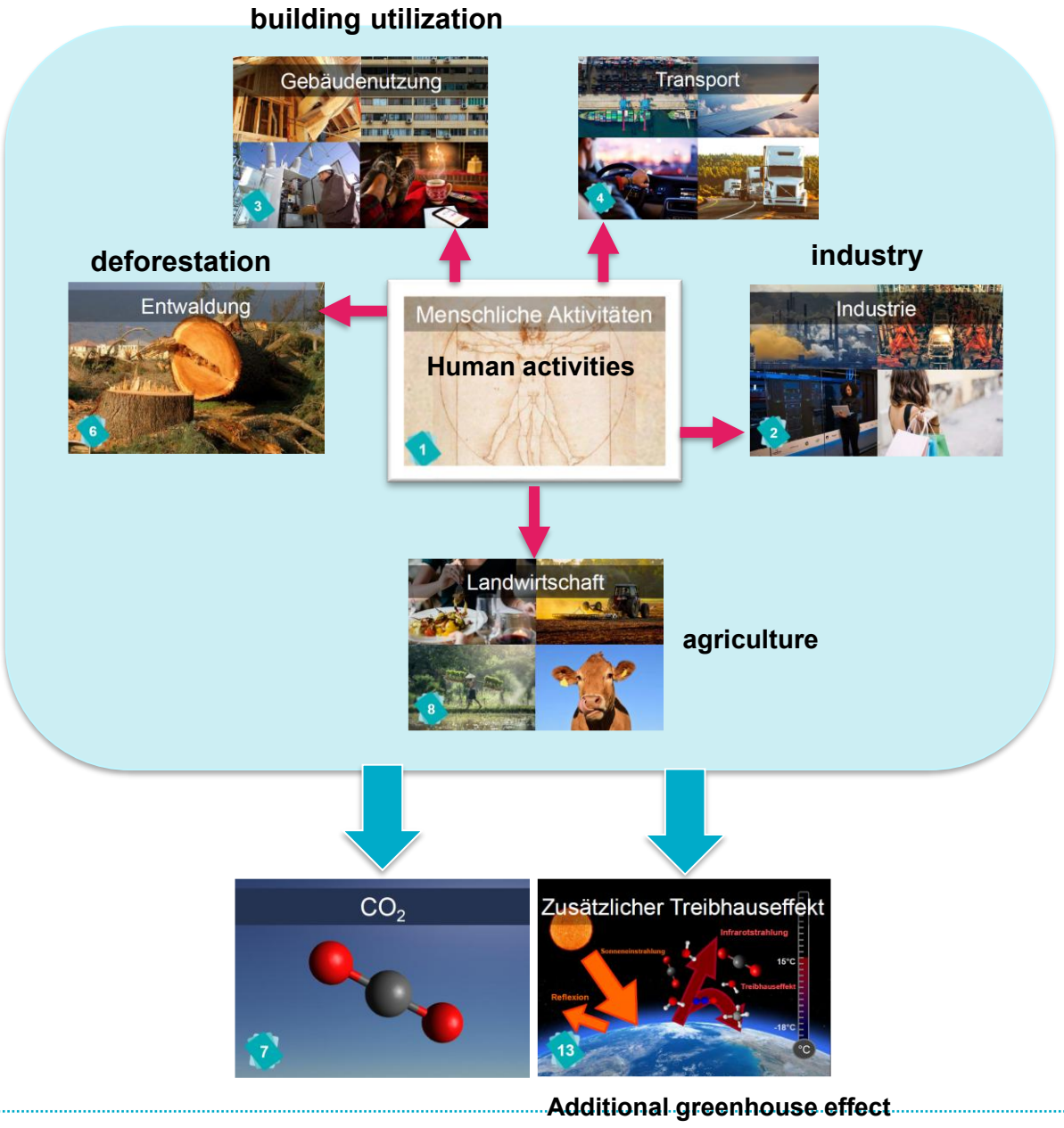
After a very dry summer (Canada), dry conifers are deliberately set alight in winter because the snow cover prevents the fire from spreading.

And now?

- Causes of climate worming
- Recognize consequences
- Climate Fresk Puzzle
- Who needs to do something?
- Where to start?
- Projects and discussions
- Fake and Facts

Causes of climate change

For example: use maps from the "Climate Fresk" and search for causes → Group



Effects

Search for climate changes in the maps

Associated cards:

Increase temperatur

Increase in water tempera

glacier melt

freshwater resources

Melting of sea ice

Disruption of the water cycle

Floods
High water
Droughts
Forest fires

Famine
Human health
Climate refugees
Armed conflicts

Consequences

rmation

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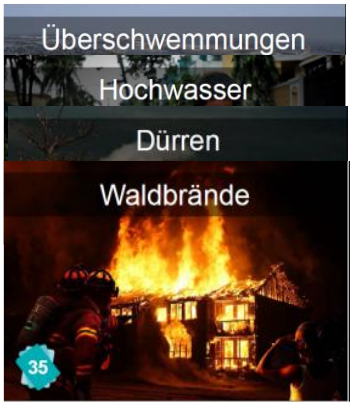

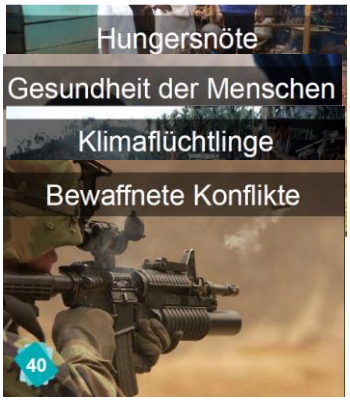

Plants and animals

Environment

People

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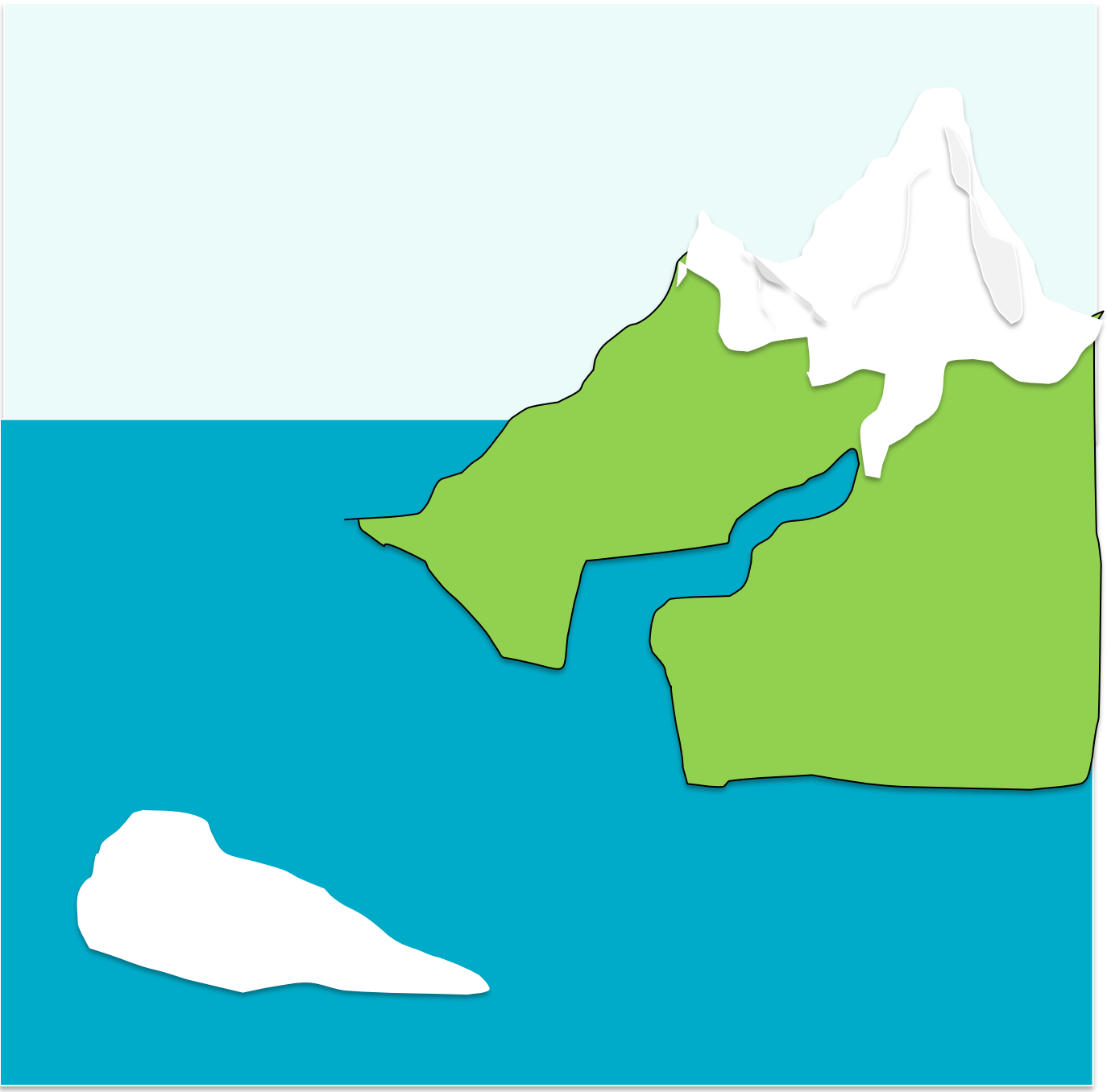
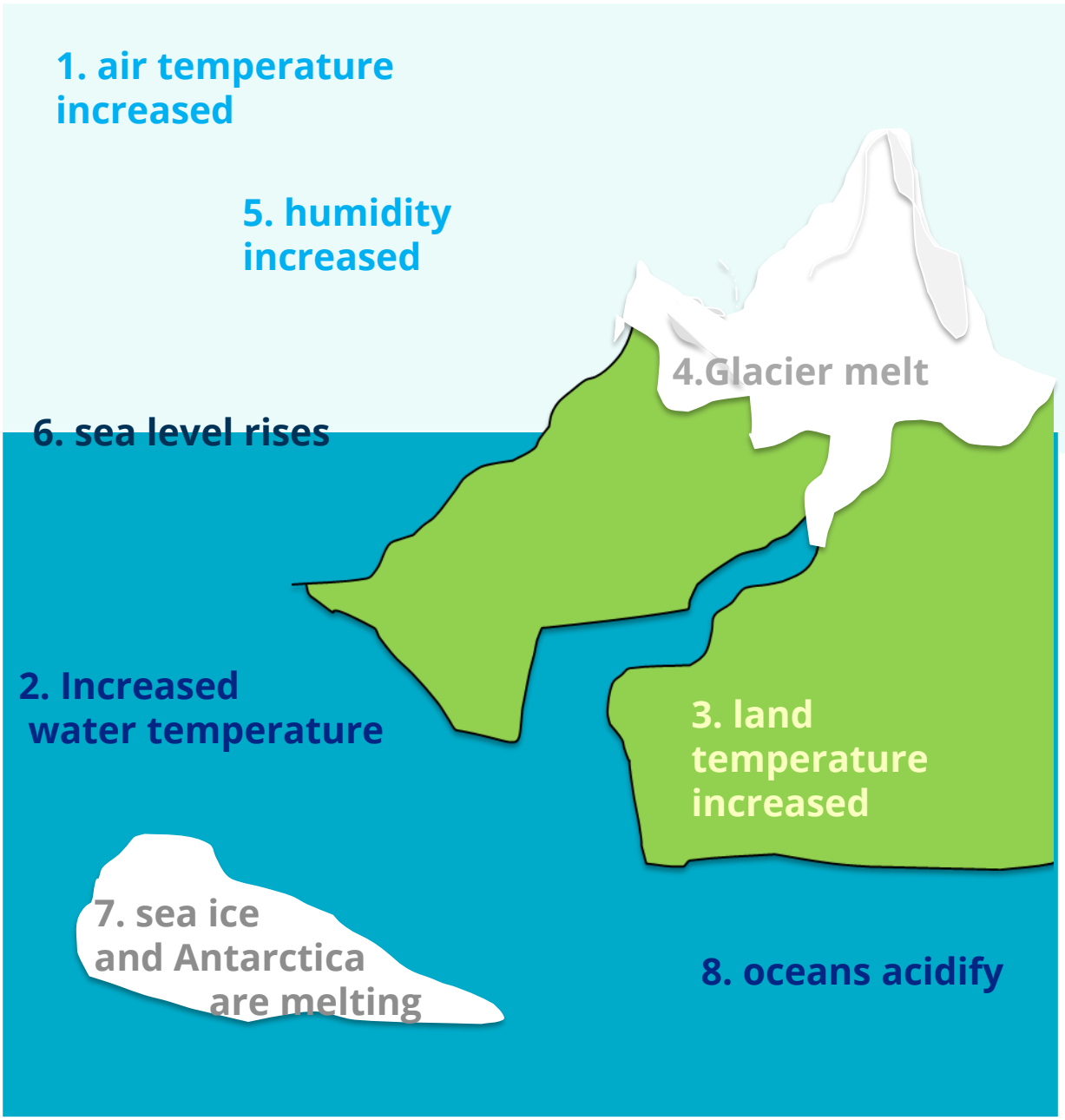
AB2 : Signs of global warming global warming

Label the sketch with climate changes that we know about.



AB2 Solution: Signs of global warming global warming



Ready for the Climate Fresk?

Preparation

- Sort the cards into sets (set number is on the back). Cover 2-3m table with wrapping paper
- Provide 5 felt-tip pens for each group
- Divide into groups of 4 - 7 pupils per group
- Place the 5 sets of cards at the end of the table.

Puzzles: 1st phase

- Start of game 1. 1st set lies on the table in an unorganised order. The group should arrange the cards in a sequence of causes and effects. All players always discuss the order. When all the cards have been placed, discuss the order with the game leader.
- 2nd set: distribute set 2 (distribute all cards). The cards laid can be moved at any time. There are also parallel effects,
  i.e. 1 cause produces 4 consequences.
- 3rd set as before, but now connections can also be drawn in with the felt-tip pen.
- 4th/5th set with connections The large connections are drawn in at the end.
- At the end you have a collage that shows the connections of climate change.

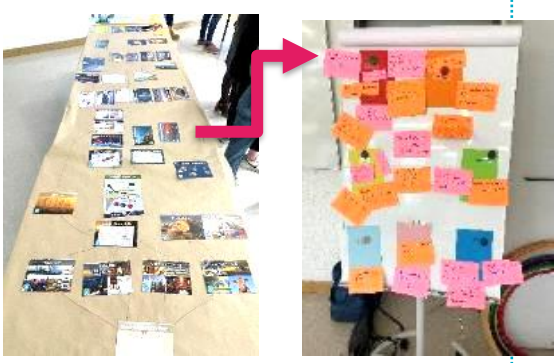
Creative editing: 2nd phase

- The pupils give their Fresk a title. They can also decorate the Fresk with small drawings (group personalises their Fresk). Encourage the pupils with drawing skills and creativity to get involved. This phase enables a link to be made with other parts of the brain.
- Discussion: What activated you personally? Which 3 cards are important to you (frame, etc.)?

Emotions: 3rd phase: How do you feel? Emotion tree. Select 1 figure, 1 word + 1 sentence

What can we do: 4th phase

- 2 min Brainstorming What can we / I do?
  What as a school?
  Note on post-it or on the board→ Take photos.
- 30-day challenge for everyone
- After 30 days ask pupils about changes.
  Are we ready for more action?
- Show sheet: "Why we don't act"
  Recognise obstacles.



Brief explanations of ClimateFresk

Phase 1

Set 1

- Difference between the natural and man-made greenhouse effect
- Why melting sea ice does not cause sea levels to rise

Set 2

- Link between agriculture and deforestation
- CO2 emissions due to deforestation (slash-and-burn)
- Carbon sink (belongs to the map "CO2 emissions")
- Other greenhouse gases

Set 3

- Disruption of the water cycle
- **cards 16 - 21** in **a vertical line** temperature rise".
- **End of Set 3:** Start drawing arrows between cards

Set 4/5

- Types of flooding (sea level rise, tsunamis, cyclones...). Difference from floods.
- Difference between heat waves and drought

Phase 2

- Cover picture, title, front page Highlight 2-3 cards, arrows
- 2-3 pupils tell the story of the puzzle on the table

Phase 3

- Visit and discuss groups
- Address feelings → Emotion tree

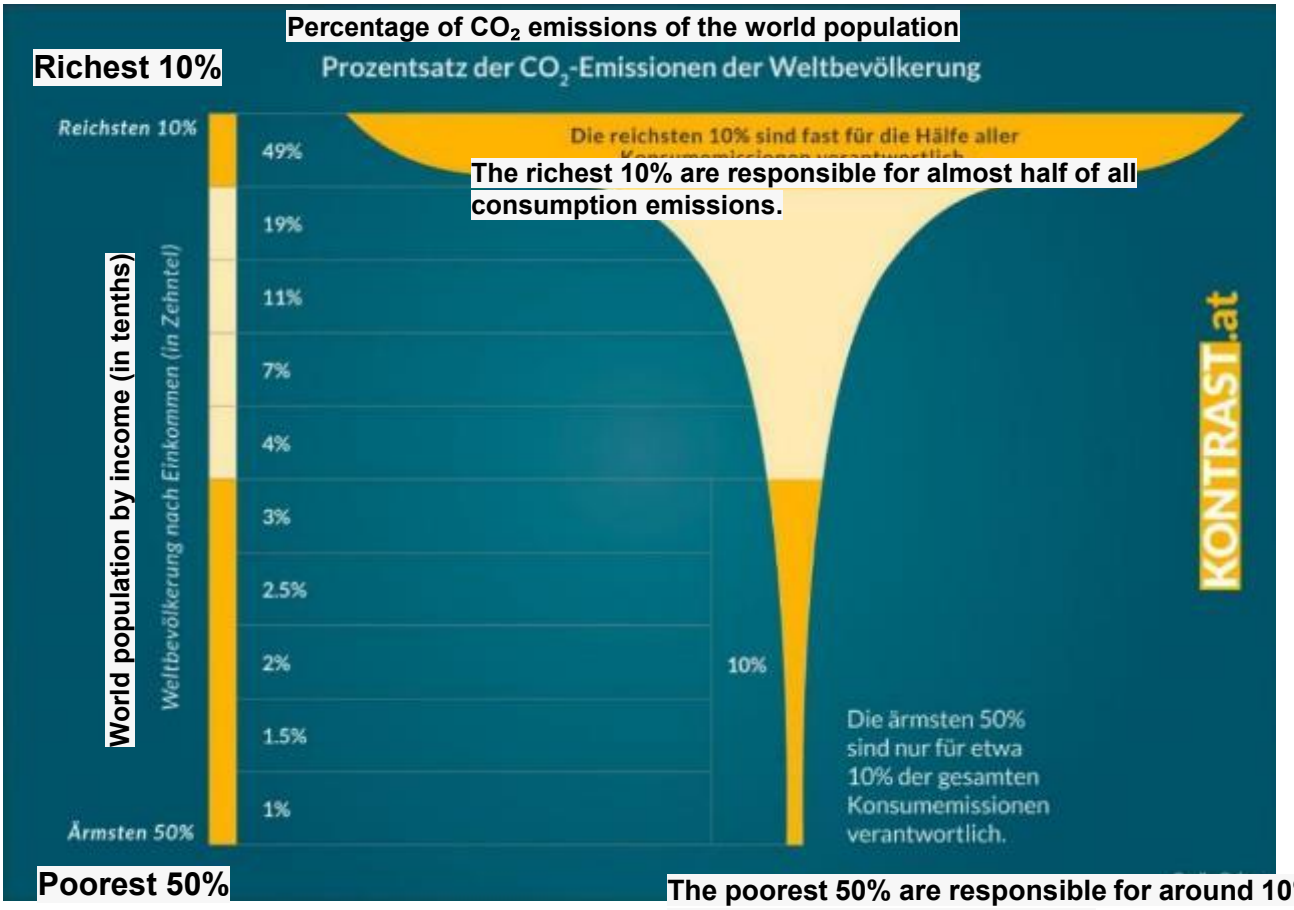
Phase 4

- Where are we today, what can we do?
- Suggest 6 topics for collaboration, brainstorm solutions, take up ideas they had and stick them on post-its on the board, organise them, vote.
- Where can we personally help?
- What are you/we changing? 30-day challenge

Scool fresco

Climate killer no.1

Who has to do something?



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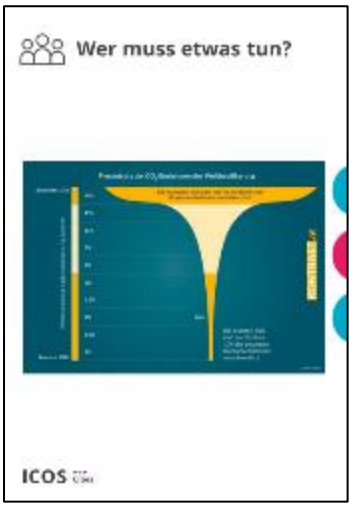
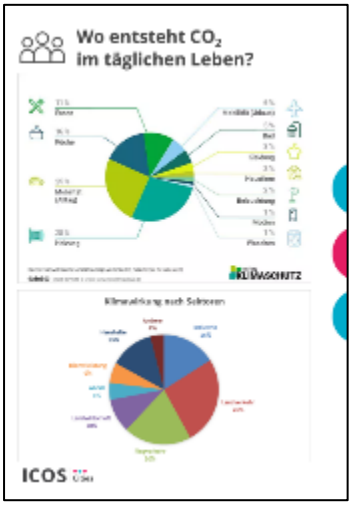
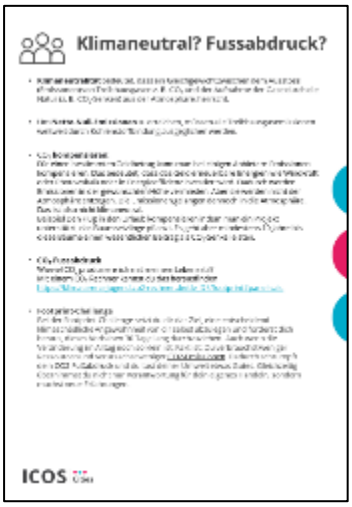
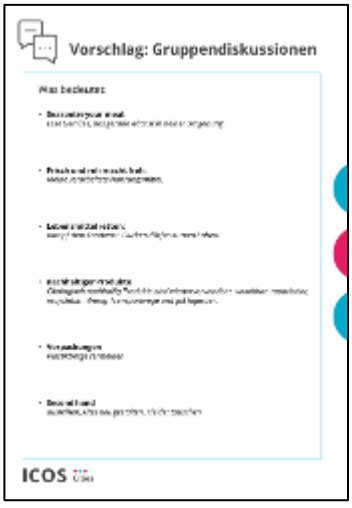
Where to start?

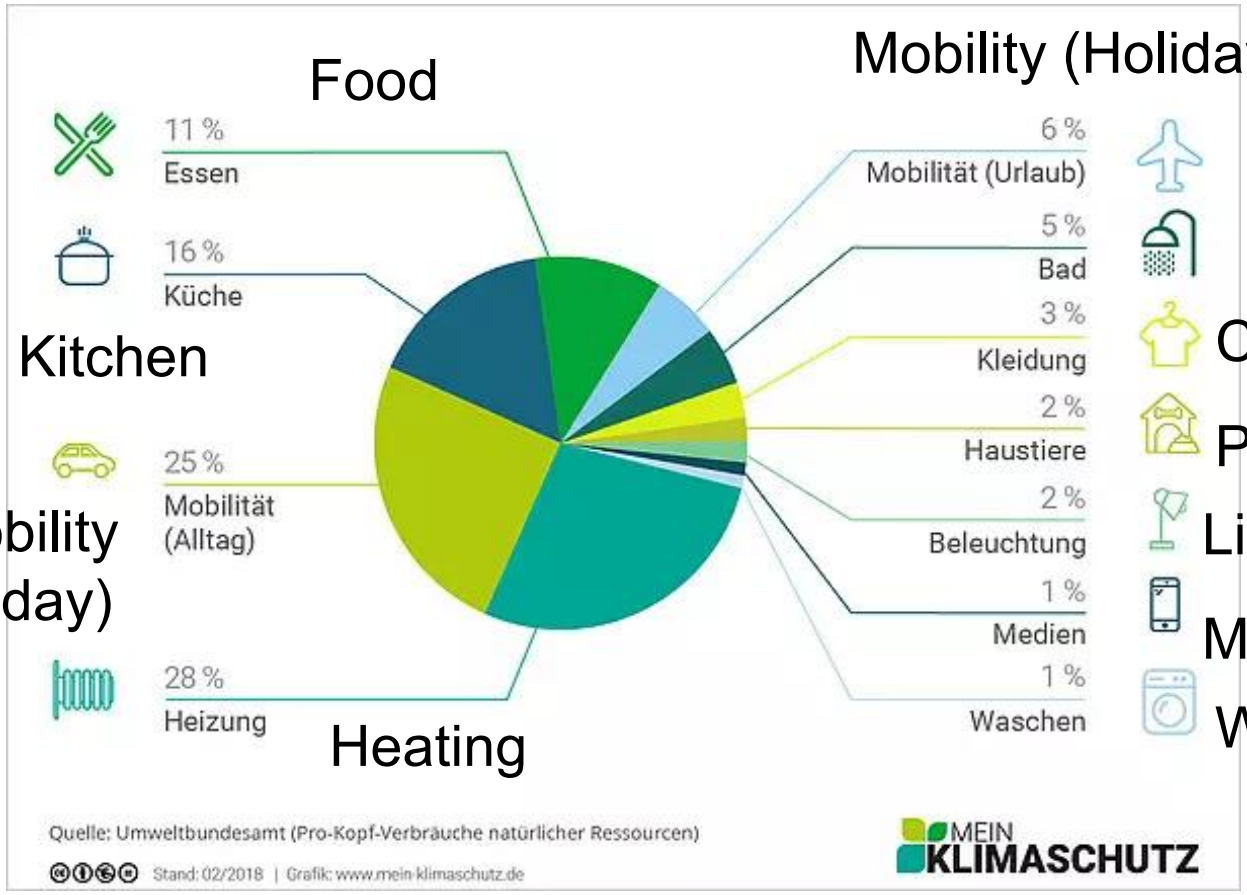


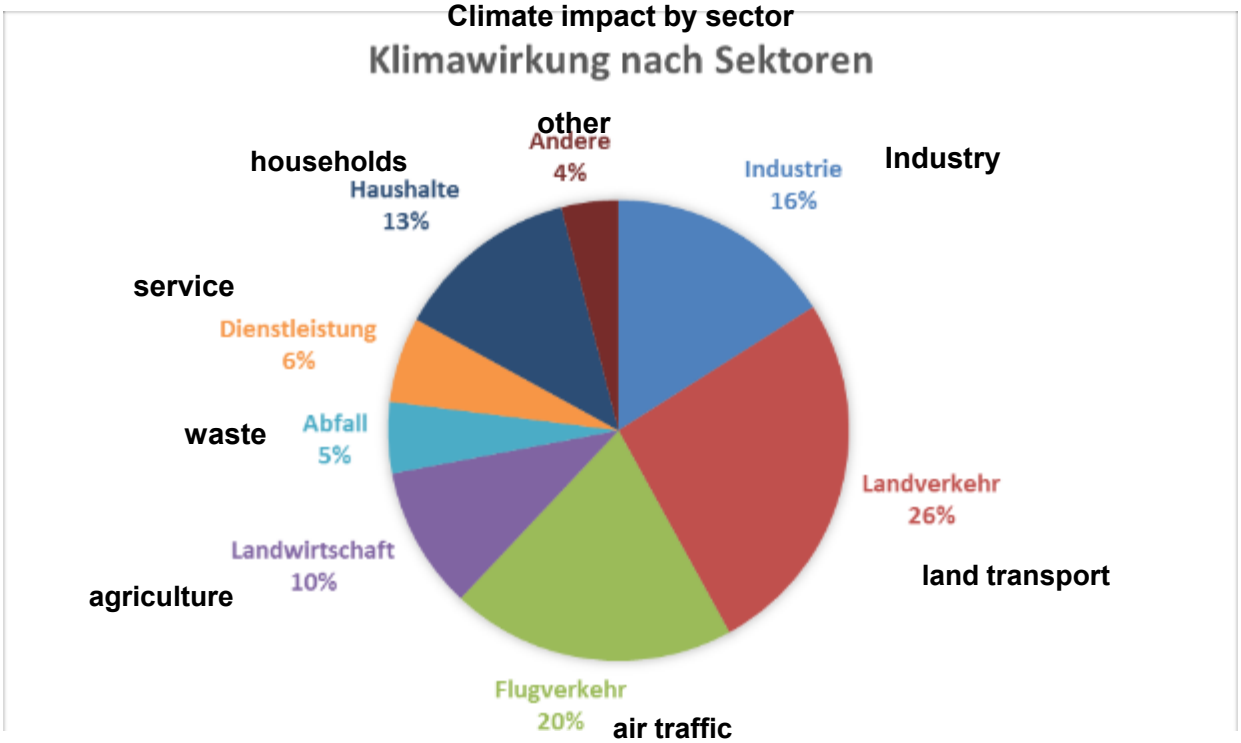




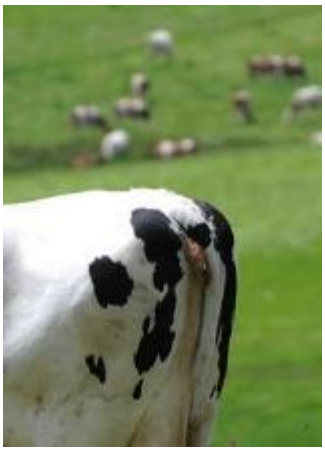


Where can CO2 be reduced?





Meat



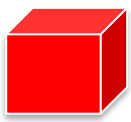
Our farm animals are eating up the rainforest.

- The massive meat consumption in Europe is destroying the rainforest through feed production.
- In order for the animals to grow as quickly as possible, they need protein-rich feed, e.g. soya meal (e.g. from Brazil).
- In Brazil, the Amazon rainforests are cleared or burnt down for soya production.
- The soya monocultures are sprayed with plant toxins that damage the soil and water. No country sprays more toxins against weeds, insects or fungi than Brazil.
- If the rainforest is cleared or burnt down, the CO_2 escapes and valuable CO_2 reservoirs are lost along with the forest.
- Animal production produces the greenhouse gas methane, which cattle emit.
- The greenhouse gas N2O (= nitrous oxide) is produced when fields are sprayed with artificial fertiliser. The nitrogen fertiliser is not completely absorbed by the plants. In combination with oxygen, this produces nitrous oxide, a gas that is much more harmful to the climate than CO2 .
- Factory farming produces too much manure, which destroys biodiversity and increases the greenhouse gas methane.
- Every year, 10.5 million animals die because their meat ends up spoilt or even unspoilt in household waste.
- The use of antibiotics in factory farming creates resistant bacteria.

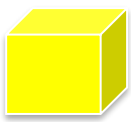
We can do that:

- Eat meat only 1-2 times a week.
- Spreads made from vegetables instead of salami or ham.
- Meat from regional, species-appropriate production.
- Eat regionally and seasonally.
- Favour fresh and unprocessed food.
- Take storage and transport routes into account.
- Only buy the amount of food that you can consume within a reasonable time Food waste.
- Take a container with you and minimise food packaging.

What can we do?

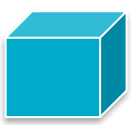


Food

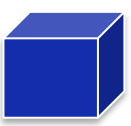


Consumption

Energy



Mobility

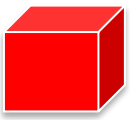


Free Time

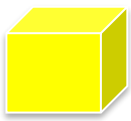
Waste

ICOS Cities

What can we do?

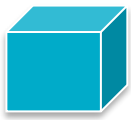


Food
- Eat less meat, seasonal, regional, no fast food, no food waste, cook fresh and take away.
- No factory farming
- Around 55 kg of food is thrown away per capita in Germany every year, half of which is fresh fruit/vegetables and home-cooked and prepared food.
- Protect drinking water

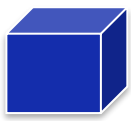


Consumption
- Wearing clothes for longer: The average European buys 65 to 70 new items of clothing a year
- Recycle
- Avoid disposable packaging
- Question: Do I really need this?
- Repair

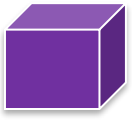
Energy
- Replace fossil fuels (gas, oil, coal)
- Switch off electronic devices, avoid stand-by
- Reduce the heat in rooms to 20° - 21 °C in winter.
- Take short showers (10-15 min), avoid baths
- Look at the energy consumption of appliances (categories A...E)



Mobility
- Use car less
- Avoid flying
- Walk or cycle to your holiday destination
- Holiday destinations in Europe by train



Free time
- Reduce mobility
- Doing sport on site
- Do something together
- Create a garden close to nature



Waste
- Avoid waste
- Avoid disposable packaging
- Recycle plastic
- Dispose of waste correctly

Fact or *Fake* I

There is no scientific consensus on whether humans have an influence on climate change.

- The fact is that 97 per cent of all climate scientists agree that humans are largely responsible for climate change.
- The other three per cent follow economic and political interests, for example being paid by the fossil fuel industry, i.e. producers of oil and natural gas products, and their main aim is to cause confusion.

There is no global warming.

- The fact is that human influence on the climate and global warming is not a matter of personal opinion, but a scientific fact. 18 of the 19 warmest years since measurements began in 1880 occurred after the year 2000.

Sometimes it's hotter, sometimes it's colder, that's always been the case: it was warmer in the Middle Ages than it is today

- The fact is that the rise in temperature cannot be explained by natural influences, as most natural factors that influence the climate have an effect over much longer periods of time. Furthermore, the whole world is affected by this climate crisis and not individual regions, as was the case in the Middle Ages. The rise in temperature can only be explained by the influence of humans.

The earth has stopped warming since 1998 and climate change will soon come to a halt due to declining solar activity.

- The fact is: the temperature curve is pointing upwards, so there has been and will be no "pause" in global warming. Even if surface temperatures fluctuate, the warming of the oceans, for example, remains the same. The lower solar activity could only have a very small effect (around -0.3 degrees) on the impending global warming. The argument that fluctuations in sunspots, with their increased radiation values, are responsible for the measurable rise in temperature over the last four decades can be clearly contradicted. Solar activity is falling, while the temperature and carbon dioxide content of the atmosphere are rising. Solar activity and global warming are decoupled, they are even developing in opposite directions.

Nature releases much more CO2 than humans, and the man-made contribution is far too small to have an impact on the global climate.

- The fact is that there have been natural fluctuations in the amount of CO2 in the atmosphere for thousands of years, but it was only with the burning of fossil fuels such as oil and coal that the natural balance was disturbed. Even though the man-made contribution only accounts for four per cent of the carbon cycle, the impact is huge. Compared to pre-industrial times, there is 40 per cent more CO2 in the atmosphere today. Even small changes in CO2 concentration have an effect on the climate system.

Fact or *Fake* II

How are we going to predict the climate? The weather services aren't even sure what the weather will be like in the next two weeks! What's more, a cold winter makes me doubt whether global warming is true at all!

- The fact is: weather and climate are not the same thing. Local weather is determined by the short-term state of the atmosphere. The global climate, however, refers to long periods of at least 30 years. A cold winter does not change the long-term trend of global warming, but we can still expect isolated cold records. In recent decades, there have been twice as many heat records as cold records. In addition, long-term temperature changes are difficult for us to perceive, but we can feel short-term cold and heat periods on our own bodies. Analogy: If you switch on the hob, it is rather difficult to predict exactly where the individual bubbles will come up when the water boils (analogous to the weather). However, you can say with certainty that bubbles will form (climate).

Climate change is not so bad after all - it can also have positive effects

- The fact is that the negative effects of climate change on our environment, agriculture, health and economy are much greater than the possible positive consequences. Moreover, better conditions for agriculture or lower heating costs would only occur regionally and often only last for a short time. At the same time, the increasing rise in temperature is leading to chaotic weather patterns such as heavy rain and storms, which can have unforeseeable consequences for agriculture, for example.

Climate protection is just the latest trend.

- The fact is: the insinuation that climate protection is a trend and that celebrities or companies want to use it to polish up their image is not an argument against climate protection. It just shows that many people have recognised the importance of the issue. However, "greenwashing", i.e. the attempt by companies and individuals to present themselves as particularly environmentally conscious in order to make a profit from this, should of course be critically questioned.

"Who is supposed to understand all this?"

- The fact is: climate change is a complicated topic - but the main components and individual measures are easy to understand. Try to adapt to the other person's level of knowledge and explain things simply. If someone throws around technical terms that you don't know - ask them.

"And you don't care that this costs jobs?"

- The fact is: this is not about talking about unemployment, but about distracting from the topic of climate change. Bringing up another problem or frequently jumping to other topics is a sign that the other person has no desire to talk about the content of a topic

As long as the others don't do anything, there's no point!"

- The fact is: when it comes to global problems, we often feel powerless. But climate protection starts on a small scale. Everyone can do their bit - and often save money in the process. What's more, climate protection is also an opportunity to recognise developments early on and take on a pioneering role. New jobs are created at regional level, for example.

Group discussions

What means:

- **Seasonalise your meal:**
  Eat vegetables that are currently growing in your area.

- **Fresh and raw makes you happy:**
  Avoid processed foods.

- **Saving food:**
  the fight against food waste. Cucumbers can have curves!

- **Sustainable products:**
  Ecologically sustainable products are reusable, washable, repairable, recyclable, can be transported over short distances and are easy to store.

- **Packaging:**
  Avoid mountains of plastic

- **Second-hand:**
  I*tems, redesign old things, swap clothes tauschen*

Project topics

- Mobile phones, petrol, meat: what do they have in common?
- Coal-fired power or beef?
- Tackle the biggest problems first - which ones?
- Money and climate. what the bank does with your money. loans, investments, fair money
- Greenhouse gas emissions
- Saving energy in mobility: kilometres per year, weight of the car?
- Consumption: direct and indirect energy consumption
- Choose

Kitchen and household

Shopping tips:

- Use reusable bags for shopping.
- Take food out of the freezer in good time and defrost it slowly in the fridge - instead of quickly in the microwave.
- Use recycled paper instead of paper made from fresh pulp.

Bathroom tips:

- Use an energy-saving shower head in the shower, which mixes the water with air and thus reduces consumption.
- Showering is more energy-friendly than bathing
- Short shower times save energy

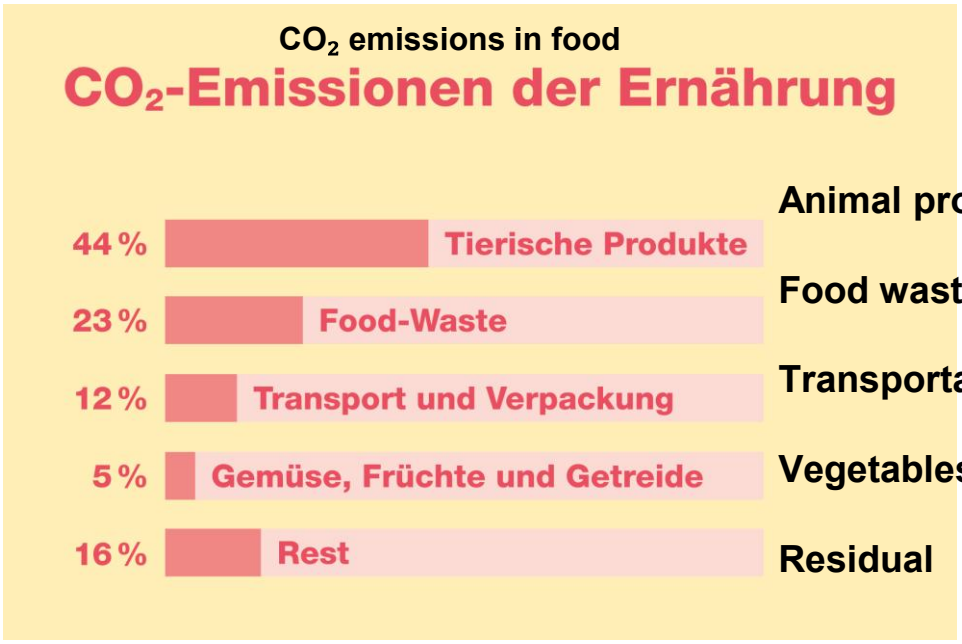
Tips for saving electricity:

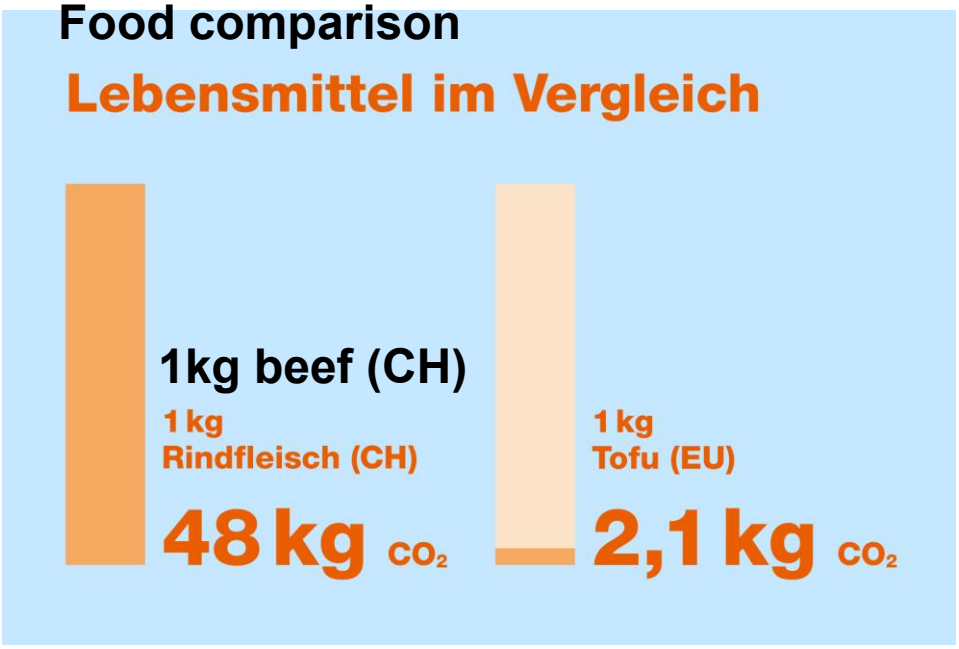
- Avoid using electrical appliances in stand-by mode and use a multi-plug strip with a power switch to switch off several devices such as computers, monitors and printers at the same time.
- Don't charge your batteries too early or for too long, as this shortens their lifespan. If possible, use devices with a mains plug, as the production of batteries has a negative impact on the environment.
- Switch off devices completely overnight

Nutrition tips:

- Improving the CO2 balance: climate protection by giving up meat
- 35% of all greenhouse gases caused by humans. Animal products account for the largest share at 57%. Beef is the worst performer: Example: 1kg of beef -> requires 15kg of feed and 40m2 of cultivation area. 120kg of carrots + 80kg of apples ≈ 400kg of apples -> 40m2
- The main greenhouse gas released during animal husbandry is methane. It is produced during digestion. Cattle burp and fart it into the atmosphere. Methane is 25 times worse for the climate than CO2. Methane is also released when liquid manure is spread on the fields.

Facts City of Zurich





Around 330kg of edible food per person per year ends up in the bin, but that doesn't have to be the case.

https://www.stadt-zuerich.ch/site/zuerich-co2/de/index/wissen.html

Visible changes

https://www.youtube.com/watch?v=X1IH3GYJcXk