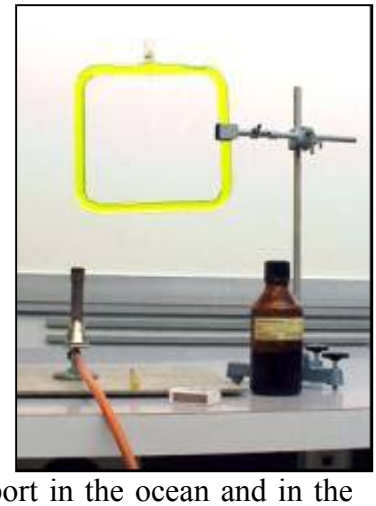
CarboSchools
School Projects and Experiments

The importance of exemplifying subject matter in classes is unchallenged. But most effective are experiments on which pupils can put their hands on, further open experiments, simple and flexible enough to stimulate pupils phantasm to expand the experiment and to create new questions (scientific thinking!).

The idea to present the following selection of project and experiments is, to motivate and stimulate teachers and scientists to find own experiments or to test and improve some of the presented ones. Most of the projects and experiments presented here are collected from the experiment archive of the physics division of the Neufeld Gymnasium in Bern. All are more or less frequent used in the regular physics classes. A few experiments are taken from physic education publications and are not yet explored by pupils.
Some of the experiments request specific didactical material, which can be found in the product line of School-publishers. Some of it, like old detectors or measuring instruments, still useful for school experiments, can perhaps be found in the archive of scientists.
Most of the experiments have a trans-disciplinary character and should be discussed in an appropriate way.

Heat transport through convection (qualitative)
[Gymnasium Neufeld Bern]



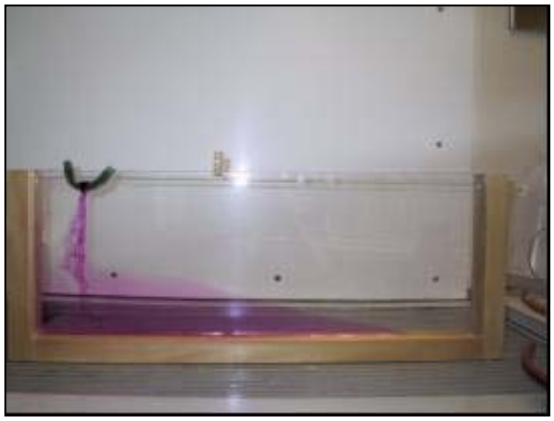
Type: Demonstration- and pupil experiment

Goal of the Experiment:
Demonstration of the convective heat transport in water.

Description:
Distilled water is filled in a circulation glass tube. The water is marked with some Fluoreszin. The heat of the Bunsen-Heater is driving the circulation through convection.

Global- /Climate Change importance:
This simple experiment illustrates the principle of the heat transport in the ocean and in the atmosphere. The experiment can be extended by creating water density differences through different grades of water salinity. Wind stress, water salinity and water temperature are the main drivers for the thermohaline circulation.

Modelling of water circulation patterns (qualitative)
[after a high school theses from Sven Niemand]



Type: Demonstration- and pupil experiment

Goal of the Experiment:
Demonstration of water circulation patterns as a function of temperature, salinity and topography.

Description:
A aquarium with the dimensions 50 x 10 x 0.5 cm is filled with water. A small piece of sponge serves as a reservoir for salt and colouring (potassium permanganate). The dynamic of the salty coloured water can now be investigated. Instead of working with salt water, a circulation can be created by heating (with a hair-drier) or cooling (ice) the water at certain places in the aquarium. With sponge material easily a submarine topography can be built and fluxes of higher complexity can by studied.

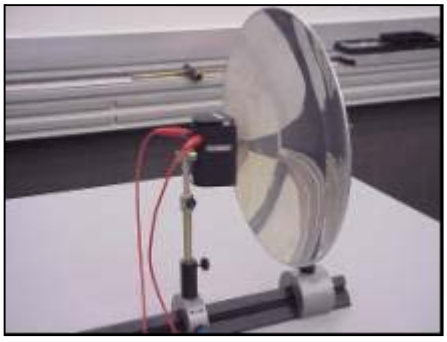
Global- /Climate Change importance:
This aquarium allows to create a two dimensional simulation of basic processes driving the global ocean circulations. Changes in salinity and/or water temperature can change the strength or the extent of the ocean circulation. Arguments for a shifts or even a turn-on-and-of of the thermohaline circulation as a consequence of global warming can be demonstrated with the experiment.

Heat transport through radiation (qualitative)
[Gymnasium Neufeld Bern]

Type: Demonstration- and pupil experiment

Goal of the Experiment:
Demonstration of the irradiative heat transport.

Description:
Two parabolic reflectors are facing each other in a distance of circa 2 m. In the focus of the first reflector a strong lamp is positioned. In the focus of the second reflector a match is fixed. Within a minute the match is lightened by the irradiative heat from the lamp.

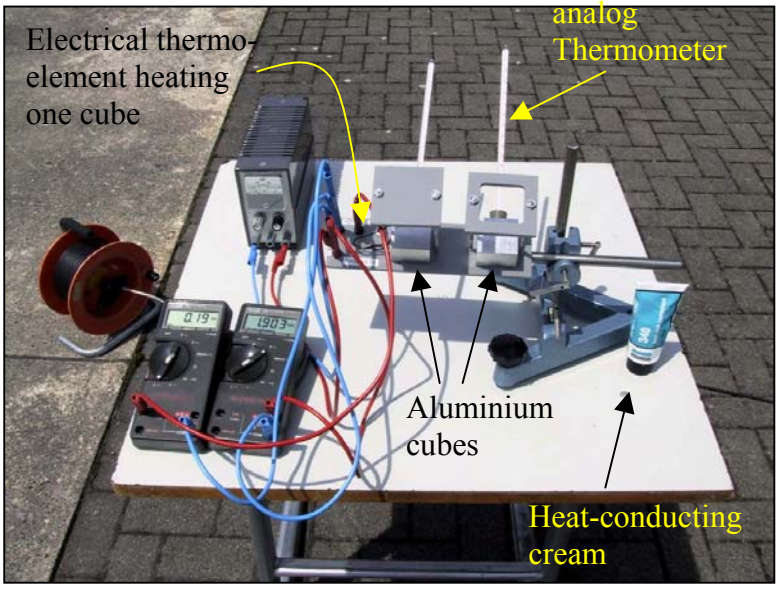


Global- /Climate Change importance:
The engine of our climate is the sun. But how reaches its energy the earth.? The energy transport through space is provided by radiation. The solar energy thus is transported to the earth by radiation.

Solar constant measurement
[Gymnasium Neufeld Bern]

Type: Pupil experiment

Goal of the Experiment:
Measuring the solar constant



Description:
Two equal Aluminium cubes are prepared with a hole to measure their temperature with a common thermometer. (To achieve a better heat flux, thermo-conductance paste is used at the contact points). A well defied area of one cube is black painted and exposed to the sun. The other cube is kept in the shadow but is heated with an electrical thermo-element. When the temperature of the first cube has come into equilibrium with the corresponding radiation power of the sun, one tries to heat the second cube to the same temperature with the electrical thermo-element by changing its currant I at a given tension U. When an equilibrium at the same temperature is reached, the used electrical power $P_{el} = U\,I$ is supposed to represent the solar power on the area which was exposed to the sunlight:

$P_{el} = U\,I = J_s\,A$ and though $J_s = U\,I\,/\,A$

(The measured solar constant is highly sensitive to the atmospheric transmission and the zenith angle of the sun as has to be corrected related to this parameters.)

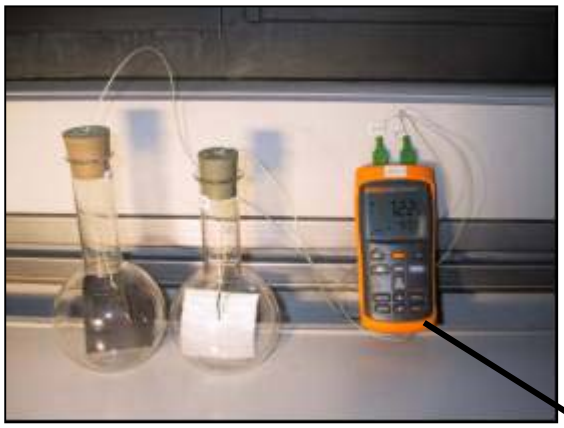
Global- /Climate Change importance:
The solar intensity and its change (careful handle with the expression solar “constant”!) is important to understand changes in the climate system. Theories are attributing most of the climate variability to changes in the solar activity and/or earth orbit parameter changes (Milankovitch cycles)

Black body radiation of a black and a white surface (qualitative determination of ε)
[Gymnasium Neufeld Bern]

Type: Demonstration- and pupil experiment

Goal of the Experiment:
The experiment shows qualitatively the emission of different irradiative wavelengths of black and white surfaces.

Description:
Two flasks are prepared, one with a black sheet, the other with a white sheet. Both flasks are closed with a plug. A thermo sensor measures the temperature inside the flasks. With a strong spotlight . The emission of the white paper is mostly in the short wave range, which passes the glass and escapes. The black paper emits mostly long wave radiation, which cannot transmit through the glass and heats the air inside the flask. Within a short time a significant temperature difference can be measured between the air in the two flasks.

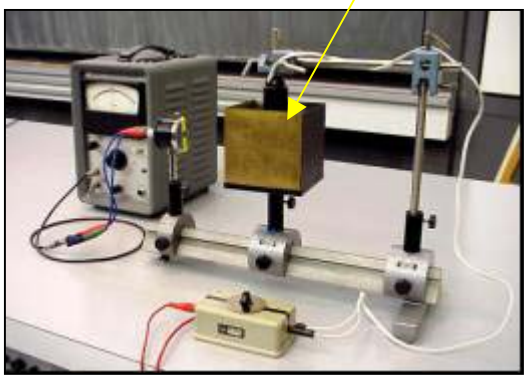


Global- /Climate Change importance:
At least two things are demonstrated by this very simple experiment: The albedo effect of bright surfaces and the low transmission of long wave radiation of glass (greenhouse-effect). It directly can be shown what happens when the earths albedo changes. The disappearing of snow- and ice covered surfaces on the earth can lead to a strong disturbance in the irradiation balance of the earth. The shift to a more long wave irradiation emission lowers the amount of transmitted irradiation through the atmosphere and leads to an increase of the global mean temperature.

Black body radiation of different surfaces with the Lesslie-cube (quantitative determination of ε)
[Gymnasium Neufeld Bern]

Type: Demonstration- and pupil experiment

Goal of the Experiment:
Measuring of the heat irradiation intensity of different surfaces.



Description:
The Lesslie-cube is a cube in which centre a carbon-filament lamp (220V, 115 W) is placed. Each side of the cube has another surface (Aluminium, Copper,

Steal, black painted Aluminium). A Millivac device is connected to a thermo-column. The thermo-column measures the heat irradiation intensity. By turning the Lesslie-cube, the surface exposed to the thermo-column can be changed and thus the infrared emission intensity can be compared. The experiment can quantitatively be evaluated by applying the Stefan-Boltzmann law.

Global- /Climate Change importance:
With the experiment the concept of the albedo can be illustrated more sophisticated for different surfaces.

Absorption of irradiation heat
[Gymnasium Neufeld Bern]

Type: Demonstration- and pupil experiment

Goal of the Experiment:
Absorption of infrared by different materials.

Description:
An infrared sensor is coupled with a Millivac device. The infrared sensor measures the infrared radiation of a 12 V lamp. Bringing different material between the lamp and the sensor, their infrared absorption can be investigated. The absorption behaviour of the following material can be tested:
Glass, water vapour, CO_2, etc…

Global- /Climate Change importance:
The experiment is preparing the understanding of the greenhouse-effect. Water vapour is the most effective green-house gas of the atmosphere.

Cloud formation by adiabatic extension and aerosol contamination
[Praxis der Naturwissenschaften - Physik, H Muckenfuss]

Type: Demonstration- and pupil experiment

Goal of the Experiment:
The experiment demonstrates, that the adiabatic condensation of water vapour is only possible with Aerosols.

Description:
A glass flask is filled to ¾ with water and is closed with a plug. Through the plug a glass tube is entering the flask. A valve splits the glass tube in two tubes. The first tube ends in a glass cylinder with a piston (syringe). The other end is open. With the syringe a the flask is evacuated. Then the valve is changed, for that the syringe can intake air and smoke from a match or a candle, held in front of the open end of the glass tube. Switching the valve again, the smoky air is let in the glass flask. When

now the syringe is pulled rapidly the water vapour condensates to fog. The experiment does not work without smoke!

Global- /Climate Change importance:
The experiment demonstrates the importance of aerosols for cloud formation. The atmospheric content of aerosols has a complex influence on the energy budget of the earth. On one hand the stimulating effect of cloud formation enhances planetary albedo, on the other hand restricts the heat emission of the earth. Further the aerosols on their own adsorb energy. There is still a huge uncertainty on the netto-effect of the aerosol content on the energy budget of the earth.

Ozone measuring station
[Gymnasium Neufeld Bern]

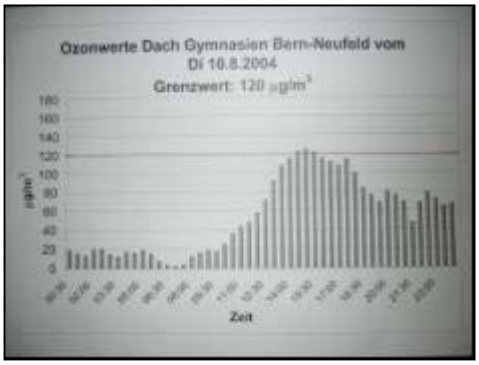
Type: Project

Goal of the Project:
Controlling of the Ozone content of the air and comparison with other ("official") measuring stations around the city.

Description:
An Ozone sensor is placed on the roof of the school. The main experiment is to install the measuring devices and to understand the layout of the system. The measurements are contiguously sampled.

The project has different aspects; the technical installation and preparation of the measuring station, the understanding of the functionality of the devices, the interpretation and comparison of the measurements with other stations, the understanding of the chemical processes to build ozone and the political dimension of the problem.

Global- /Climate Change importance:
There are two Ozone problems on earth, with are often mixed-up by pupils: The problem of the stratospheric ozone hole and the problem of the to high ozone concentration of the ground air. The least has a more direct influence on our daily life quality, especially in summer. This is the reason why this problem is more often discussed in the local politics. The ozone hole is more "popular" and more spectacular, fascinating by its global dimension and its unpredictability.



Howard's cloud classification
[Gymnasium Neufeld Bern]

Type: Project

Goal of the Project:
We ad the description of this project here, because it shows an explicit transdisciplinary approach to a scientific topic. The main topic of the project is an integral approach to the cloud classification of Luke Howard. The approach has a science historical dimension as well as a multi-disciplinary dimension. Goethe's weather-diary explicitly referring to Howard, Turners cloud paintings, the thermo-dynamical background of the cloud formation, the geographical and meteorological aspects of clouds and finally Howard's descriptive cloud classification form the content of the project. The highlight of the project is the performance, when Luke Howard itself appears in the classroom and repeats the most important section of his famous speech, originally hold in London in 1802 on the occasion of a colloquium of the British Askesian Society. This talk was historically one of the milestones in the development of atmospheric science.
This project is further a very important example for the *CarboSchool* Project to show the very important need for school work, to have authentic research in the classroom, here personified in a historical personage, but better represented in a real alive researcher!!

Description:

The core of the project can be described in three acts prefaced by a prologue. Beside this acts, the theory and the techniques (basic physical processes, painting and drawing techniques, etc…) are taught in a classical way.

Prologue:
As a prelude, during two weeks the pupils have the mission to catch at least three snapshots of the sky with a technique of their own choice (drawing, taking pictures, writing,…). After this "Prologue" the project happens within one to three days, whereas the main performance is divided in three acts, surrounded by classical inputs of background information.

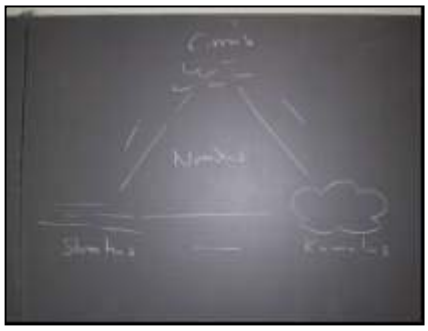
1st act:
Pupils are exposing their pictures and paintings collected during the past two weeks. The illustrations and texts are spread on several small tables. At the walls cloud paintings of famous artists are exposed. The pupils now are invited to try again to draw clouds. The class is climbing on the roof of the School. Each pupil selects a cloud an tries to draw it with wax crayon and blue paper. Back at the classroom again the new drawings are mixed among the others. The pupils now have the instruction to order the products somehow. Different order-criteria are discussed.

2nd act:

After the phase of confusing, the master of cloud classification is introduced by reading the "Ehrengedächtnis" Goethe wrote in honour of Luke Howard. The teacher then comes up with a surprise: Luke Howard is here, and he will explain us his cloud classification itself. Since he is an English man and does not know the German language, he will not speak, but present his ideas in a dumb show. Howard presents his concept of classification with his own original cloud sketches.

3rd act:

After Luke Howard has disappeared again, the pupils try to reproduce the classification concept on their own drawings. Finally the concept is fixed and completed by the modern nomenclature.



Global- /Climate Change importance:

As mentioned above the project is a good example to show the importance of the scientific authenticity of education content and context. The topic here has a more elemental relation to the theme of global change. The project emphasize the importance of the descriptive science in order to realize the processes happening every day around us. Only a good knowing of nature and the ability to name species allows a differentiated uptake of the surrounding and to recognize changes in the natural systems. In this sense the project is a contribution to sensibly pupils awareness to what happens in the atmosphere every day and in the future.