# LESSON B1
# THE GREENHOUSE EFFECT: UNDERSTANDING WITH AN ANALOGY

**MAIN SUBJECTS**
Natural sciences

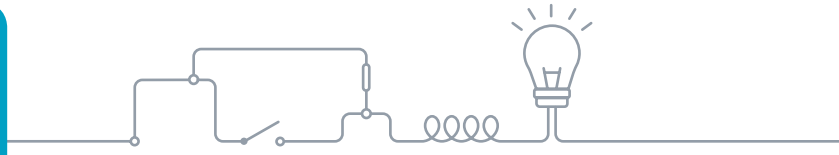
**DURATION**
~ Preparation: 10 min
~ Activity: 1 h 30

**SUMMARY**
The students learn about the greenhouse effect by building a greenhouse as an analogy with greenhouse gases in the atmosphere.

**KEY IDEAS**
~ All objects emit infrared radiation; the warmer they are, the more infrared radiation they emit.
~ When the Earth's surface is warmed by the sun, it emits infrared radiation.
~ The greenhouse gases in the Earth's atmosphere absorb infrared radiation emitted by Earth's surface. Only part of this infrared radiation escapes into space and the rest is sent back to the surface.
~ An increase in greenhouse gas concentration results in an increase in Earth's surface temperature.

**KEYWORDS**
Greenhouse effect, greenhouse gas, infrared radiation, global warming

**INQUIRY METHOD**
Experimentation



## PREPARATION 10 MIN

**MATERIALS**
For each group of 3 to 4 students:
- 1 light bulb (at least 60 W, if possible 100 W; no energy-saving lamps: use incandescent or halogen bulbs), mounted on a stand.
  Note: If the weather is sunny, the light bulbs are optional, and the experiments can be carried out in the sun;
- 2 electronic thermometers;
- 1 transparent container made of glass or transparent plastic (as thin as possible), or a container sealed with plastic wrap;
- (Optional) Modelling clay, which can be useful for sealing the container.

## INTRODUCTION 20 MIN

In the previous lessons, the students have learned that the temperature of the atmosphere is increasing, and that this global warming has several impacts on the ocean and cryosphere. This lesson starts by discussing the students' hypotheses as to the causes of the temperature increase. Guide the discussion so that the students come to the conclusion that the cause is some kind of pollution. Depending on the students' age, some may mention greenhouse gases (or at least $CO_2$, since it has already been introduced). You can ask the students to write down all the concepts they think of when they hear "greenhouse effect" (such as a greenhouse in the garden, greenhouses for flowers, growing plants, protection, warmth, humidity, danger, pollution, gas and the ozone layer).

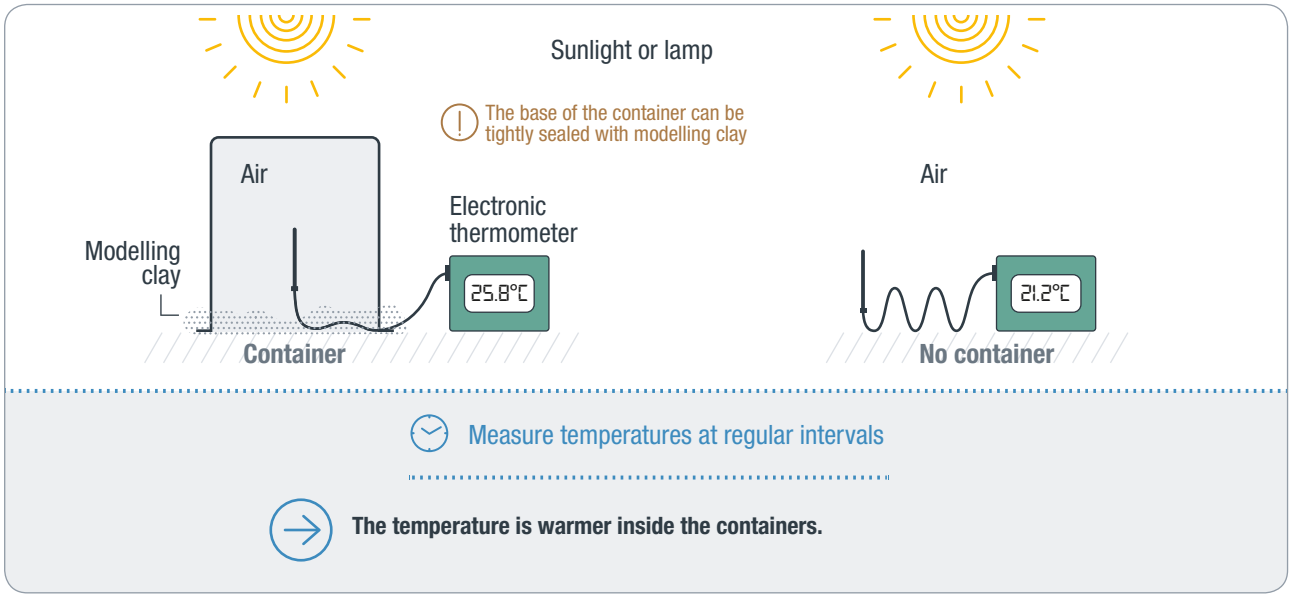
## PROCEDURE 50 MIN

**1.** Ask the students to think of an experiment they could carry out in the classroom to test the greenhouse effect. Building a greenhouse should be the most realistic proposal to emerge (see figures on the following page).

**TEACHER TIP**
For noticeable results, do the experiment under the sun and in the middle of the day. You can expect a temperature difference of up to 4 degrees. The use of electronic thermometers is not required, but make sure that your thermometer allows you to notice the change in temperature.

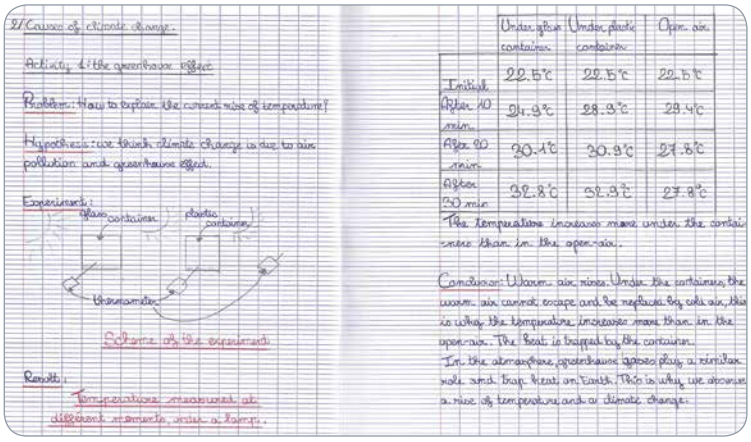
**2.** Each group builds a basic greenhouse with the provided container, with a thermometer inside. Another thermometer should be kept outside as a control.

**3.** The students should measure the temperature at regular intervals and write down the measured values in a table.




The greenhouse experiment in a plastic or glass container.

Measuring the temperature inside and outside the greenhouse.



Student notes of the experiment.



**TEACHER TIP**

In a greenhouse, two main effects contribute together to the temperature increase: the greenhouse effect and the containment. Without a cover, the hot air rises by convection and is replaced by colder air. This is prevented when you use a cover. The containment effect prevents the warm air from escaping from the greenhouse. The thermometer therefore displays a lower temperature outside than inside.

Moreover, when comparing a glass greenhouse (where, in theory, there is a greenhouse effect, resulting from the absorption of infrared radiation) with a polyethylene (plastic) greenhouse (where there is no greenhouse effect), it turns out that there is no noticeable difference in temperature increase. The dominant effect contributing to warming is the containment.

**4.** Ask the students what is making the temperature rise. Explain that the greenhouse is used as an analogy.

**5.** There are gases in the atmosphere that play the same role as the greenhouse roof. These are therefore called greenhouse gases. Such an analogy, if presented and taken as such, is entirely acceptable in the classroom.

**6.** If you choose not to do lesson B3, give the students **WORKSHEET B3.4** to analyse in groups. Discuss the source of greenhouse gases in the atmosphere.

## WRAP-UP 20 MIN

Discuss the link between the experimental results and the greenhouse gas effect that is causing global warming. The greenhouse gases act like a greenhouse, "trapping" the invisible infrared radiation emitted by the Earth's surface (and also directly by the sun) thus leading to warming "inside" the greenhouse (the Earth's surface and the lower atmosphere).

## BACKGROUND FOR TEACHERS

### GREENHOUSE EFFECT

The sunlight crosses the atmosphere and warm the Earth's surface, generating the upward emission of **infrared radiation** (heat). Some of this heat is trapped on its return to space by **greenhouse gases** in the atmosphere (mainly water vapour, carbon dioxide, methane and nitrous oxide) and sent back towards the Earth's surface. Greenhouse gases thus act like a blanket, trapping heat emitted from below. The temperature of the lower atmosphere is therefore warmer than it would otherwise be. In fact, without greenhouse gases, the average temperature of Earth's surface would be of about -18°C rather than the present average of 15°C.

The concentration of greenhouse gases changes: either because of natural causes, as in the past, or human activities, as in the present. This alters the Earth's energy equilibrium and the average surface temperature (see figure on page 10).

### INFRARED RADIATION

Our eyes are only capable of seeing part of the spectrum of the light emitted by the sun: this is visible radiation. **The atmosphere is essentially transparent to visible radiation.**

Light is composed of many forms of radiation, of different wavelengths. When using a prism, the rays are deflected to varying degrees according to their wavelength. We then see different colours (which correspond to different wavelengths), but some are invisible to our eyes. The figure below shows the spectrum of light, broken down into different wavelength ranges. Only a very small part of the spectrum, between the 400 and 700 nm wavelengths, is visible to the human eye. Infrared light, with wavelengths longer than those of visible red colour, is invisible to us.

An object that is heated (e.g. Earth heated by the sun) emits radiation of a wavelength that depends on surface temperature. At an average temperature of about 15ºC, the Earth's surface mostly emits radiation in the infrared range. **The atmosphere (due to the presence of greenhouse gases) is not transparent to infrared radiation.**

### THE GREENHOUSE EFFECT AND THE "HOLE" IN THE OZONE LAYER: TWO DISTINCT PHENOMENA

The composition of the atmosphere, as well as its temperature, varies with altitude. The lowest layer, in which we live and where most weather events occur, is called the troposphere. It represents more than 80% of the total mass of the atmosphere. It is thicker at the equator than at the poles. Above it, we find the stratosphere, and within it the "ozone layer", located at an altitude of between 15 and 30 km. Ozone is actually present throughout the atmosphere, but its concentration is particularly high in this zone. Ozone absorbs the ultraviolet radiation of sunlight (the radiation responsible for sunburn) and prevents it from reaching the Earth's surface. The massive use of certain refrigerant gases (Chlorofluorocarbons – CFCs) has resulted in a local depletion of this ozone layer, which poses a significant threat to all life on Earth. Since the Montreal Protocol was signed in 1985, the use of these gases has been prohibited, and the "hole" in the ozone layer is gradually closing. The increase in the greenhouse effect and the "ozone hole" are thus two distinct problems: not the same atmospheric gases involved (even though the ozone itself is also a greenhouse gas), not the same issues.

**Light spectrum**