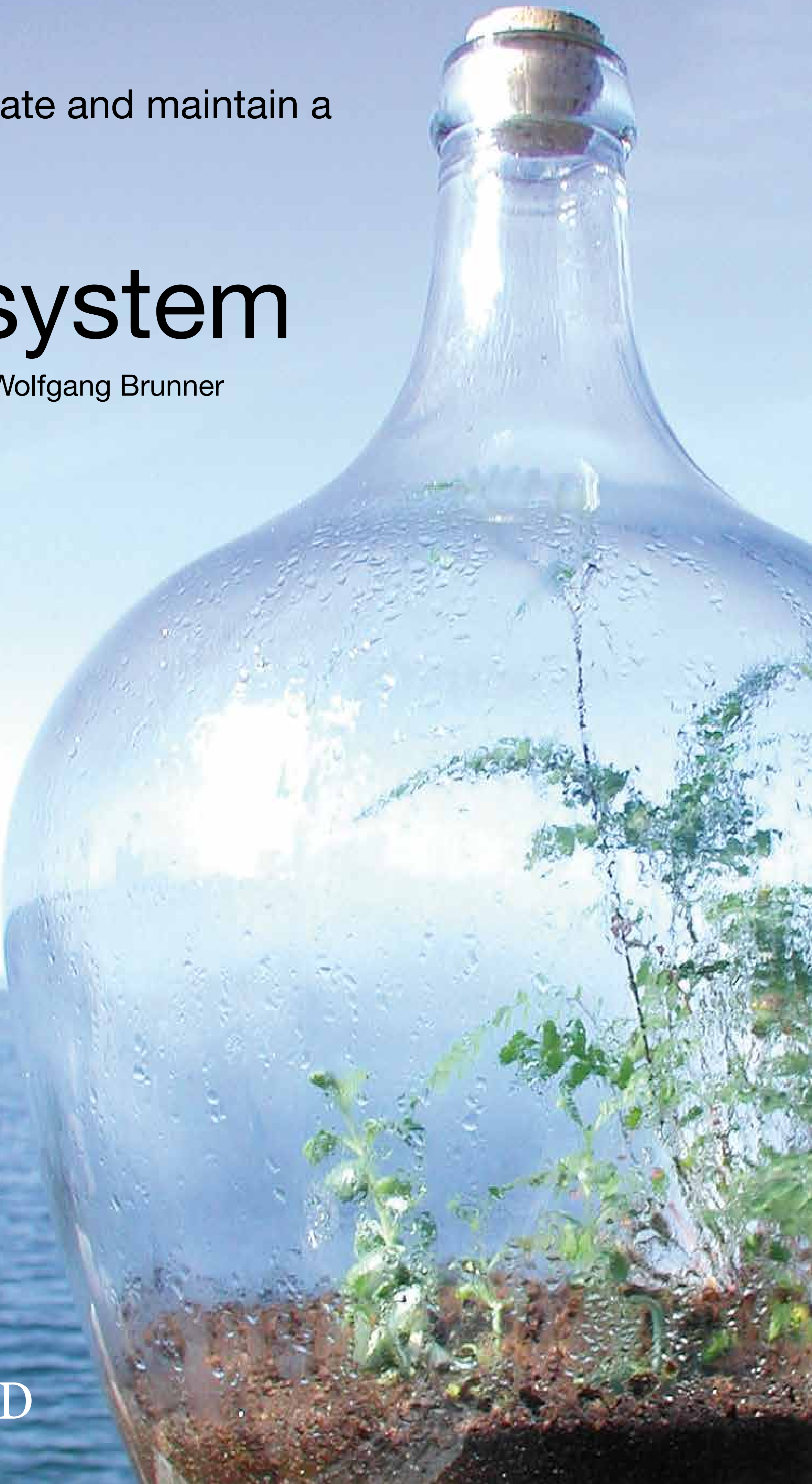
How to create and maintain a

Mini Ecosystem

developed by Wolfgang Brunner



SWEDISH INTERNATIONAL CENTRE OF EDUCATION FOR SUSTAINABLE DEVELOPMENT

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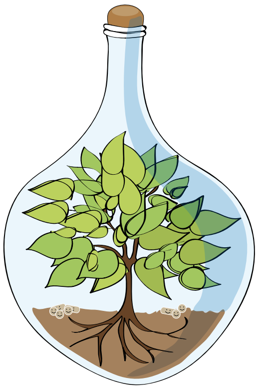


Why a Mini Ecosystem?

If you put soil and plants into a closed room, you create circumstances for the students to get a deeper understanding of basic life processes and interplay in nature. Facts you earlier learned about respiration and photosynthesis within single or separated plants suddenly become much more challenging when you put them into a sealed room! – Will they manage to survive, and if, how can that be possible?

The life processes that evolve within the bottle have a dept and range that can feed discussions from kindergarten to a college or university level. In the earlier ages the pupils may just wonder about the beauty and magic of "the enclosed garden". Higher up they may have discussions about what different types of circulation that keeps the system alive, or of self organisation and system dynamics. The bottle provides us with a simplified view of how an ecosystem or the entire biosphere works. It also is a useful model when we discuss carbon dioxide sinks, greenhouse effect and climate change.

What you need

A glass bottle that can be closed (1–25 litre)

Soil

Plants with small leaves, for instance Ficus pumila, Hedera helix, Sedum ssp.

Funnel with a wide opening or a rolled newspaper

Rods or sticks long enough to reach to the bottom of the bottle

How to get started

1. Make sure that the bottle is clean.
2. Put a sufficient amount of soil into the bottle by using the funnel and the stick. Be careful so that you don't get a lot of soil on the sides of the bottle. It is often good to use fresh planting soil, with a high organic content, directly from a flower store. (But of course if you put a cactus inside you choose a soil those suites that type of plant.)
3. Take the stick and make a small hole in the soil where you wish to plant the plant.
4. If the plant is too big to enter the bottle, carefully divide it and compress the soil around its roots.
5. Hold the plant in the upper leaves and put the compressed roots inside the bottle. Aim at the prepared hole and drop the plant. Use the sticks to make sure that the roots have sufficient contact with the surrounding soil. Repeat if you want more plants inside.
6. When satisfied close the bottle and put it in a place with good light conditions, *but not in direct sunshine!*
7. Usually you don't have to add any water, but if you after closing at no time see condense water inside the bottle, it might be necessary to ad a *small* amount.

Maintaining the system

Light and water

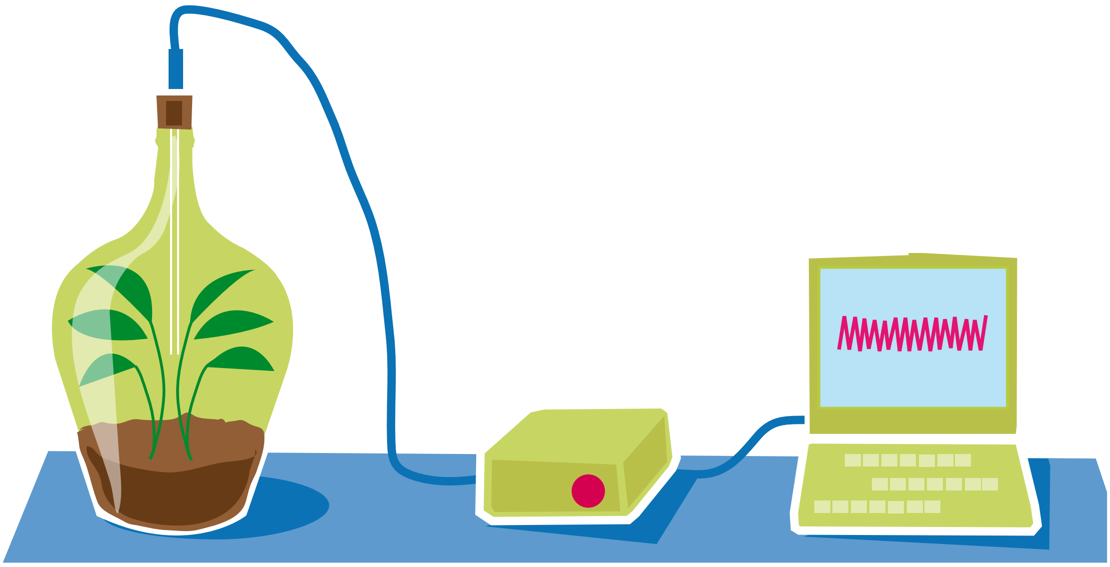
Since the bottle is closed it is very easy to take care of. The most important factor is of course that the system receives enough light, but without the risk of becoming overheated. That means that you may bee have to protect it from too much radiation during the summer and ad additional light during the dark part of the year. (If my systems collapse it is mostly during the dark season)

Another factor that that sometimes creates difficulties is that you add too much water. We are so used to take care of our pot plants by watering them once or twice a week that we tend to give the plants in our bottle to much water already from start. Usually the moisture in the soil is enough, also because that metabolic water is emitted as the bacteria begin to decompose the organic material in the soil.

Self organisation
Besides light and water the system takes care of itself. Of course no single species can manage to live by itself in a sealed room. After a while it becomes obvious to the students that there are and must be *a number of species* inside the bottle: plants, different bacteria, fungi, algae, small insects, and so on – and also that they work together in order to maintain the circulation of the life essential substances within the bottle. The system takes care of itself and develops through self organisation!

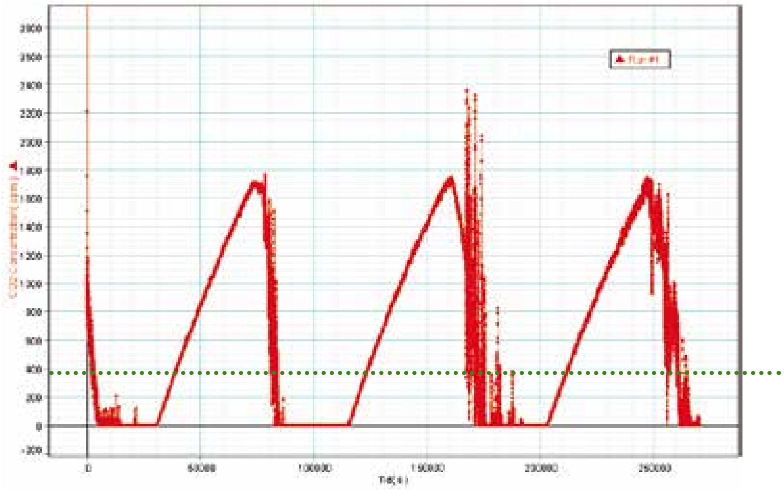
Small ecosystems with just a few interacting species are of course very fragile. In spite of this, many of my bottles have survived and flourished for a very long time, some of them even for more than ten years. There are many secrets behind that fact and in this we have a rich field of biological and chemical phenomena that we can discuss together with our students. Here are some examples:

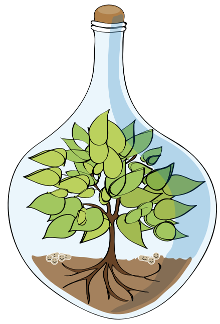
– For how long can it grow?
– What happens when the "life space" inside is filled up?
– What keeps the system in balance?
– How does the circulation of water and minerals function?
– Will the bottle gain weight as the plants grow?
– Who or what regulates the amount of oxygen and carbon dioxide within the bottle?



The breath of the bottle
They get a deeper understanding of photosynthesis, but also how essential the work of the decomposers is, in providing fresh carbon dioxide to the growing plants. They realise that the amount of carbon dioxide fluctuates during day and night, as if the entire system had a common breathing.
If we are ambitious we can measure this breathing with a CO_2 tester. Have we reached this far with our students, we also can begin to use our bottle as a model to understand bigger ecosystems or even the entire biosphere. Do we have the same type of breathing in these systems? In such a case, what would the breathing of Gaia - the entire Earth, look like? With help of the bottle it is also easy to get into discussions about carbon dioxide sinks, greenhouse effect and climate change.

The breath of the bottle





The CO_2 content in the atmosphere

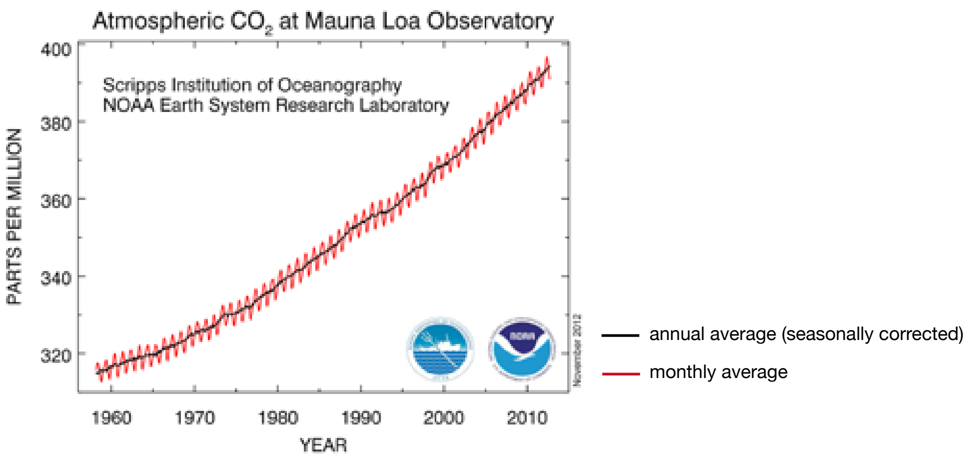
System dynamics

The graph above shows the concentration of carbon dioxide in a densely grown bottle during three days and nights. As a comparison you can see the average amount of carbon dioxide in the atmosphere of the Earth, which now a days is about 395 ppm* (ppm = part per million, green dotted line). The concentration of carbon dioxide reaches its highest level at the end of the night. After that it will fall very abruptly as daylight returns and photosynthesis gets started. In the late afternoon and evening photosynthesis will decrease and respiration from all living organism in the bottle, even the plant, will dominate. Due to that the concentration will rise again.

The reason why there is such a strong fluctuation during day and night derives from the fact that the measurements are from a bottle densely grown with plants. That means that you have a big biomass of plants compared with the amount of air, and due to that also a small carbon dioxide buffer for the plants to take from. The photosynthesis is so efficient that the organisms in the soil not are able to provide the needed amount of carbon dioxide, and for that reason the growth of the plants will stop completely. It is fascinating to see how efficient the plants are and also that they can function under circumstances that are far beyond what they experience in daily life in our atmosphere.

The breath of Gaia

CO_2 concentration in the atmosphere: Mauna Loa curve



The mini ecosystem provides our students with a living demonstration object which enables them to reach very far in understanding interplay in nature. Gradually they get a better and deeper understanding of it and the fascination grows. They make more and more comparison between their bottle and our common Earth, and they comment on the mutual dependence within the systems and admire how beautiful they are!

* This figure is changing. In 2012 it is 395 ppm.

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