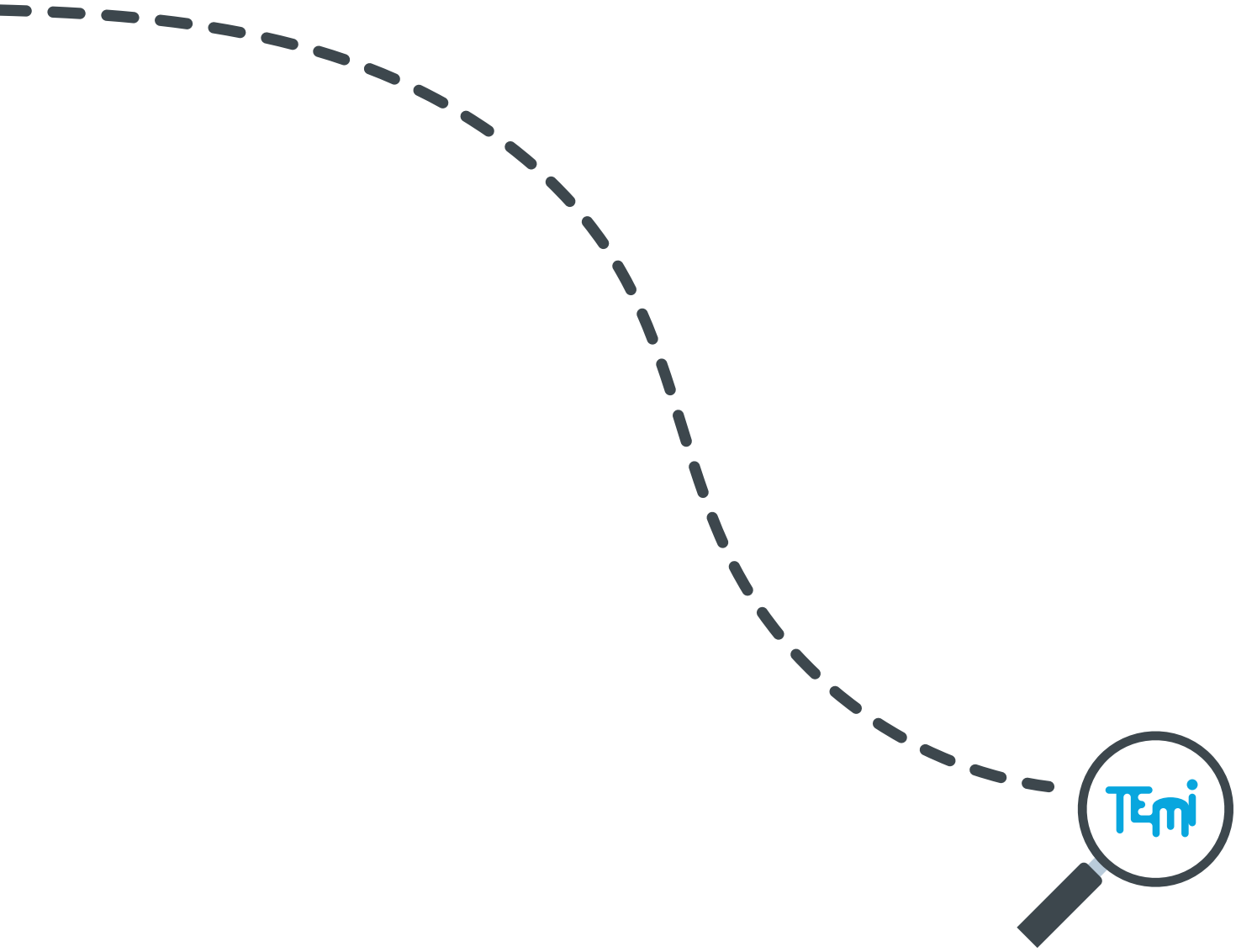
Chemical garden

CLASSROOM SCIENCE ACTIVITY TO
SUPPORT STUDENT ENQUIRY-BASED LEARNING



This classroom-tested teaching plan uses the four innovations of the TEMI project, as detailed in the Teaching the TEMI Way (TEMI, 2015).

You should read this companion book to get the most from your teaching. The **TEMI** techniques used in this teaching plan are: **1)** productive science mysteries, **2)** the **5E model** for engaged learning, **3)** the use of presentation skills to engage your students, and **4)** the apprenticeship model for learning through gradual release of responsibility. You might also wish to use the hypothesiser lifeline sheet (available on the **TEMI** website) to help your students document their ideas and discoveries as they work.

To know more about **TEMI** and find more resources **www.teachingmysteries.eu**

This research project has received funding from the European Community's Seventh Framework Programme (FP7/2007-2013) under grant agreement no. 321403.

teachingmysteries.eu

FP7-Science-in-Society-2012-1, Grant Agreement N. 321403

Co-funded by the Seventh Framework Program of the European Union

Chemical garden

What's the mystery?

The chemical garden is a well-established experiment from the chemistry of salts, solubility, diffusion, and solutions. The nice thing is that if metal salts are put in sodium water glass solution, it can lead to an effect reminiscent of plants growing. This growing process can be observed and analysed. In the end, the experiment looks like a wild garden.

DOMAIN(S)

Chemistry.

SUBDOMAIN KEYWORDS

Salts, crystals, solubility, diffusion, membranes, sodium silicates, osmosis.

AGE GROUP

12 to **16** years old.

EXPECTED TIME FOR THE MYSTERY

Approximate time for teacher preparation:
15 min.

Approximate time in classroom:
90 min. lessons.

SAFETY/SUPERVISION

Lab coat and safety goggles.

Disclaimer: the authors of this teaching material will not be held responsible for any injury or damage to persons or properties that might occur in its use.

PREPARATION AND LIST OF MATERIALS

- Sodium water glass solution
- Iron(III)chloride
- Copper(II)sulphate
- Copper(I)chloride
- Calcium chloride dihydrate
- Potassium permanganate
- Water
- Sand
- Plastic beakers (20 ml and 200 ml)
- Glass beakers (200 ml)
- Glass rod
- Test tubes
- Test tube rack
- Test tube holder
- Heating plate
- Graduated cylinders (10 ml and 25 ml)
- Spatula
- Thermometer
- Magnifying glass
- Microscope
- Petri dishes

LEARNING OBJECTIVES

Students will learn about salts, solubility, semi-permeable membranes, diffusion, and osmosis.

Guidance notes for teachers

Engage

CAPTURE STUDENTS' ATTENTION

The teacher presents a ready-'grown' chemical garden. The students can start to 'grow' their own gardens in very small plastic beakers. They can make observations about the growing crystals, and raise questions about the crystal growth and the nature of the mysterious solution. Questions might concern the phenomenon in general, differences in the behaviours of various salts, factors influencing the growth, or the composition and behaviour of the generally unknown water glass solution.

Explore

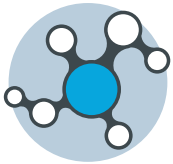
COLLECT DATA FROM EXPERIMENTS

The students enquire into the mysterious behaviour of the metal salt crystals when put into the water glass solution. They explore the process and the resulting structures. Factors that might be investigated concern the behaviours of different sorts of metal salt, different temperatures, or varying concentrations of the water glass solution. A central experiment is using a colourless salt and a water glass solution coloured by ink; the resulting structures and membranes are then observed with a magnifying glass or a microscope.

Explain

WHAT'S THE SCIENCE BEHIND THE MYSTERY?

Water glass is a barely soluble membrane made of certain metal cations on the surfaces of the crystals. The membrane is semi-permeable. Water passes through the membrane while the metal ions do not. Water enters the membrane mantle because of osmotic pressure. Water dissolves further ions from the crystal. As water passes through the membrane, the pressure inside the mantle constantly increases. At a certain point, the mantle cracks and a new membrane is formed. This mainly happens on the top of the mantle because of a gradient in density. Constant repetition of this effect leads to a growth in the structure.



Extend

WHAT OTHER RELATED AREAS CAN BE EXPLORED?

The task can be extended by reflecting on the potential technical applications of sodium water glass (e.g. in house building). After drying, sodium water glass forms a hydrophobic coating that can be used to seal porous surfaces. Students can also learn about the different structures and the uses of silicates.

Evaluate

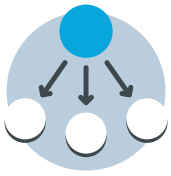
CHECK THE LEVEL OF STUDENT SCIENTIFIC UNDERSTANDING

An experiment about another semi-permeable membrane (cellophane) can be used to assess whether students are able to apply their new knowledge to another example. The cellophane film in this case acts as a membrane. As with the chemical garden, this is permeable to water. Solved substances like sugar cannot pass the membrane, just as the metal salt ions cannot do so in the chemical garden experiment.

Showmanship

TIPS ON HOW TO TEACH AND PRESENT THIS MYSTERY

This mystery can be carried out without further aids as a demonstration experiment. It should be ensured that the students can observe the experiment closely. Since the crystals are very small, the students must be close to the experiment in order to observe it. The teacher leads the demonstration in silence without further impulse or comment. The experiment is so fascinating to the students that they begin to question the phenomenon automatically.



GRR

TEACHING SKILLS USING GRADUAL RELEASE OF RESPONSIBILITY

The mystery is presented as a guided enquiry (level 2). Students should investigate the structures formed by the metal salt crystals in the water glass solution. They may investigate the behaviour of solutions with different concentrations, at various temperatures, or with different sizes of crystal. The students can make their own plans about how to do the experiments. Observations must be collected and organised in order to explain the phenomenon.

Solving the mystery: the most helpful evidence for finding the explanation is working order no. 4. Once the students have dyed the crystal, they can identify that the silicate mantle acts as semi-permeable membrane. One sees that there must be a membrane, as this has been coloured from outside to the core. However, the original crystal retains its initial colour.

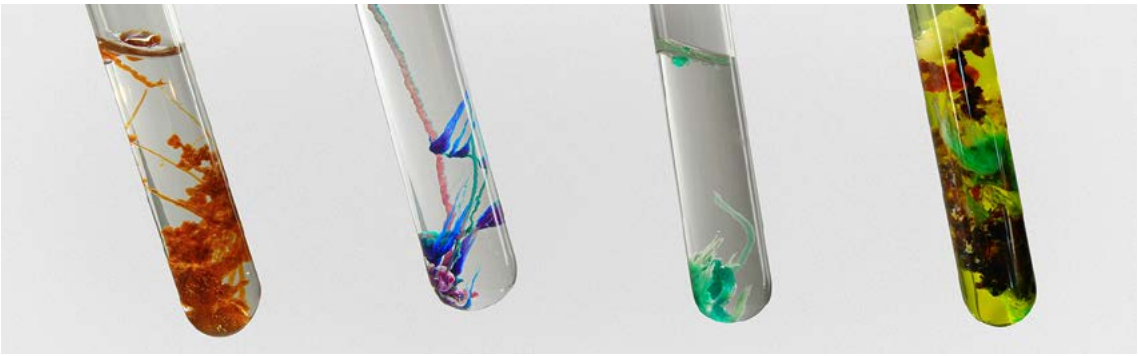
Resources

Brandl, H. (1998). Trickkiste Chemie. Bayerischer Schulbuch Verlag, München.

Chemical garden

STUDENT WORKSHEET

Nature offers a lot of fascinating phenomena, like beautiful flowers and picturesque gardens. However, living organisms die off as time passes. Flowers shrivel, leaves lose their colour, and, finally, only the memory remains. Chemistry offers an alternative. Chemists know how to create artificial and everlasting gardens. How do they do so? How do chemists 'grow' a chemical garden like the ones in the picture below?



Engage

WHAT'S INTERESTING?

Task: Take one of the small plastic beakers (0.02 ml). Add some water glass solution. Add small crystals of iron(III) chloride, copper(I)chloride, or sodium permanganate.

Describe your observations and suggest questions.

Explore

WHAT'S HAPPENING?

Task 1: Explore the behaviour of the iron(III) chloride crystals in the sodium water glass solution. Investigate the resulting structures with a magnifying glass or a microscope. Describe your observations and suggest an explanation of the observed effects.

Task 2: Explore the behaviour of different metal salts in sodium water glass solutions with different concentrations. You might take iron(III)chloride, copper(II)sulphate, and calcium chloride dihydrate. Describe your observations and suggest an explanation of the observed effects.

Task 3: Explore the behaviour of iron(III)chloride in the sodium water glass solution at various temperatures and with crystals of differing degrees of fragmentation. Describe your observations and suggest an explanation of the observed effects.

Task 4: Explore the behaviour of colourless metal salts in a sodium water glass solution coloured with blue ink. Describe your observations and suggest an explanation of the observed effects.

Explain
WHAT'S CAUSING IT?

Task 1: Draw pictures of the different observations.

Task 2: Develop a table to categorise all your observations from the different experiments.

Task 3: Explain how and why the crystals in the chemical garden grow. You can search the Internet for further explanations. You may search for topics like crystals, solubility, and the function of semi-permeable membranes.

Extend
WHAT'S SIMILAR?

Task: Conduct the following experiment and explain how sodium water glass can be used in construction.

Materials:
Sodium water glass solution, vinegar essence, water, clinker, limestone, paintbrush, hair dryer.

Procedure:
1. Paint half of the surface of the clinker and the limestone with the water glass solution.
2. Dry with the hair dryer.
3. Sprinkle the whole clinker with water.
4. Sprinkle the whole limestone with vinegar essence.
5. Describe your observation and explain.

Source: Kober, F. (1984). Struktur der Silicate. Der Chemieunterricht, 3/5, 21.

Evaluate
WHAT'S MY UNDERSTANDING?

Task: Conduct the following experiment and explain how this experiment is connected to understanding the chemical garden.

1. Take a small plastic container with a waterproof cap. Drill holes into the bottom and into the cap.
2. Take off the cap. Put a piece of cellophane foil over the container and fix it on the cap.
3. Turn the container around. Put syrup in through the hole in the bottom.
4. Fix a straw through the hole at the bottom either with a pierced stopper or plasticine.
5. Place the container bottom-up in a beaker containing some water.
6. Describe and explain your observation.