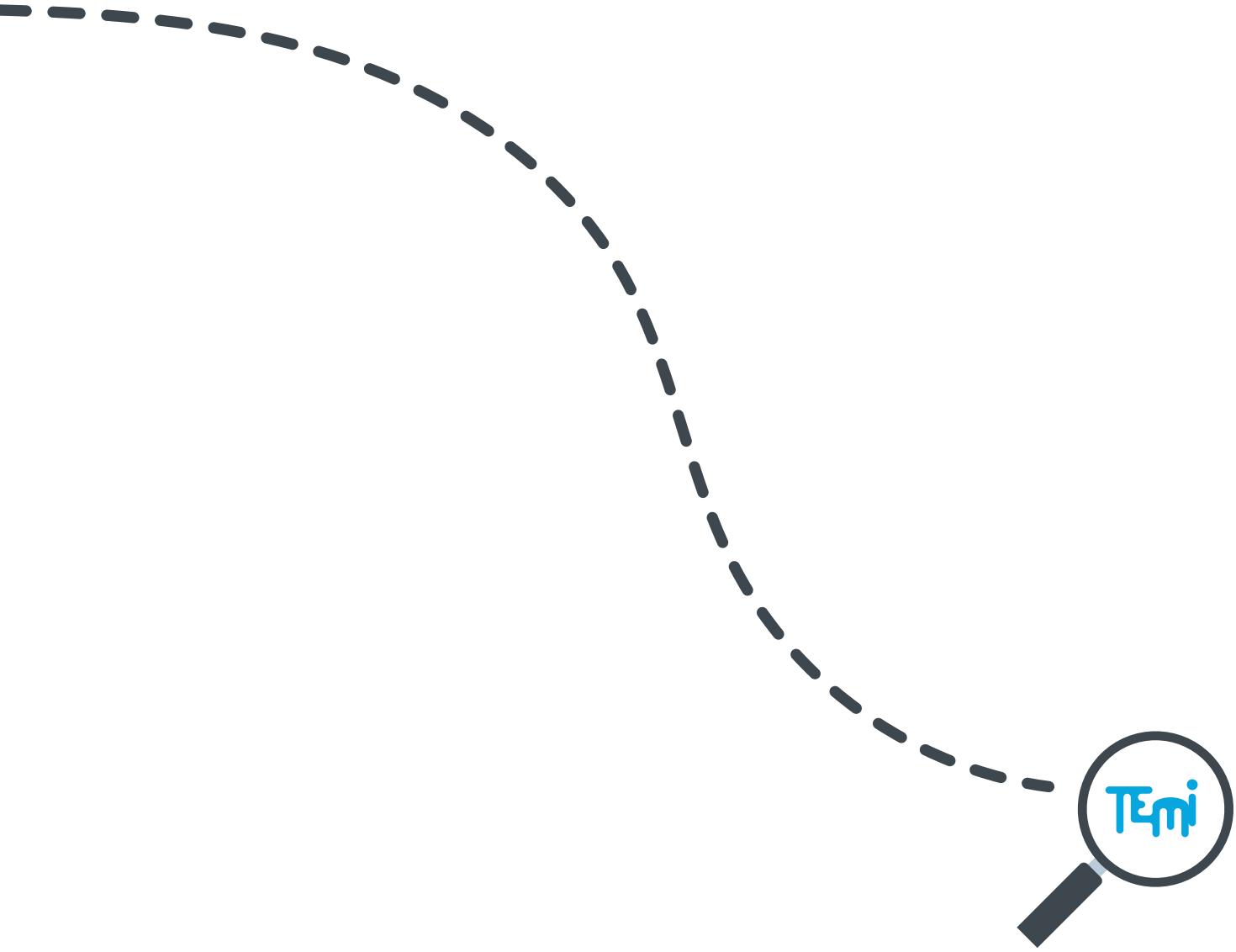
The (un)reliable indicator

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**

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What's the mystery?

Students are testing different substances for the pH-value. Some students are testing crystal deodorants using a red cabbage indicator and a universal indicator. The universal indicator suggests that the deodorant reacts as an acid, whereas the red cabbage suggests that the deodorant reacts as a base. What is happening here?

DOMAIN(S)

Chemistry.

SUBDOMAIN KEYWORDS

Acids, bases, indicators, complex formation, pigments, dyeing.

AGE GROUP

On a submicroscopic level: **16** to **18** years old.
On a phenomenological level: **12** years and older.

EXPECTED TIME FOR THE MYSTERY

Approximate time for teacher preparation:
30 min.
Approximate time in classroom:
Two to **three** individual **50 min.** lessons.

SAFETY/SUPERVISION

There are no particular safety restrictions for the suggested materials.

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

- Several substances to test whether they are basic or acidic, e.g. lemon juice, vinegar, soap, baking powder, water, and crystal (alum) deodorants. These cause the mystery.
- Substances to explore the mystery: iron salts, aluminium salts, several deodorants (some with and some without aluminium salts, either liquid or solid), alum, red roses, raspberries, etc. Put the crystal deodorants in a beaker with water some minutes before using the solution.
- Red cabbage indicator, universal indicator, indicator paper, pH-metre, etc.
- Charts showing the colours of the red cabbage indicator and the universal indicator at different pH values.

LEARNING OBJECTIVES

Students can describe how a red cabbage indicator normally works. They learn details about anthocyanidins and realise that they form coordination complexes with aluminium and iron ions. Students learn to be sceptical and reflective about outcomes. Students learn to use different measuring devices to be sure about the outcome.

Guidance notes for teachers

Engage

CAPTURE STUDENTS' ATTENTION

The students can determine the pH value of several substances (including crystal (alum) deodorants) using a red cabbage indicator and a universal indicator. The universal indicator suggests that the crystal deodorant reacts as an acid, whereas the red cabbage indicates a different result. It suggests that the deodorant reacts as a base. The students get tripped up while checking the pH-values of different substances as a result of this discrepancy. The teacher has to be attentive to the moment when the students come across the mystery.

Explore

COLLECT DATA FROM EXPERIMENTS

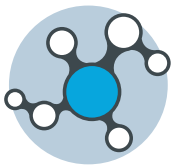
After discovering the discrepancy between the two indicators when testing the crystal deodorant, the students construct a hypothesis about which indicator is right. Which indicator do they trust more and why? The students have to collect as much evidence as possible to support the hypothesis. By experimenting with the two indicators, the students get their first ideas of the reason behind the phenomenon.

Explain

WHAT'S THE SCIENCE BEHIND THE MYSTERY?

Red cabbage contains cyanidin, which belongs to the group of anthocyanidins and is responsible for the colour of the red cabbage indicator.

Anthocyanidins form coordination complexes with aluminium, boron, or iron ions (deodorants often contain aluminium ions), which causes the bluish violet colouring. This colouring is not caused by a specific pH-value, but rather by an extended mesomeric effect.



Extend

WHAT OTHER RELATED AREAS CAN BE EXPLORED?

Students could test if red berries or other red or blue parts of plants also react like red cabbage (e.g. grapes, bilberries, blackberries, blueberries, cherries, cranberries, elderberries, hawthorns, loganberries, acai berries, and raspberries). Cyanidin can also be found in other fruits, such as apples and plums, and in red radishes and red onions.

Students could also investigate the reaction of the red cabbage indicator with other metal ions. Other natural indicators could also be investigated by the students (e.g. curcuma, red roses, hydrangeas flowers, etc).

Students could also investigate bathochromic effects within organic substances used for dyeing fabric.

Evaluate

CHECK THE LEVEL OF STUDENT SCIENTIFIC UNDERSTANDING

The students should explain the chemical background of the way in which pink hydrangea flowers turn blue by adding alum to the water which is used to water the plant. The reason is that hydrangeas flowers contain the same pigments as red cabbage. So the same complexes are formed as with aluminium and iron ions: this changes the colour of the flower to blue.

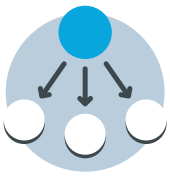
Showmanship

TIPS ON HOW TO TEACH AND PRESENT THIS MYSTERY

The mystery presents itself in the engage phase when the students discover the discrepancies between the two indicators when testing the crystal deodorants.

The task of the teacher is to show interest and enthusiasm for the mysterious result. This will alert the students and guide them to the explore phase.

If you need to save the time, present the mystery. First, use the two indicators with a soap solution, then with lemon juice, and afterwards with crystal deodorant solution. The students have to check the pH-value after every step.



GRR

TEACHING SKILLS USING GRADUAL RELEASE OF RESPONSIBILITY

The starting experiment is a structured enquiry (level 1). The students systematically test the substance on their pH-value. When the mystery arises, the students have to discuss the trustworthiness of indicators.

The following experimental sequence is a guided enquiry (level 2). The enquiry skills the students can develop are planning experiments, conducting experiments, recording observations systematically, comparing results, giving priority to evidence, formulating explanations from evidence, and transferring knowledge to extended tasks.

Resources

You find more background information about the subject matter here (in German):
https://roempp.thieme.de/roempp4.0/do/data/RD-01-02670

More background information about different indicators (in German):
http://www.chemieunterricht.de/dc2/phph/fotom-tk-1.htm

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STUDENT WORKSHEET

You are able to change colours! Just follow the instructions and you will see how.

Log your ideas, observations, procedures, and results in your exercise book.

Engage

WHAT'S INTERESTING?

Task: Get together in groups of four. Two members of the group should add a red cabbage indicator to the substances available. The other two should add a universal indicator to the substances. Compare the resulting colours to the scales provided that show the colours of the two indicators to determine the pH-value.

Compare your results.
Do you agree on all points?

Explore

WHAT'S HAPPENING?

Task: If the members of your group do not agree: which result represents the 'real' pH-value? Which indicator do you trust more? Why?

Phrase a hypothesis and find as much evidence as possible to support it. You may use all the materials provided on the table.

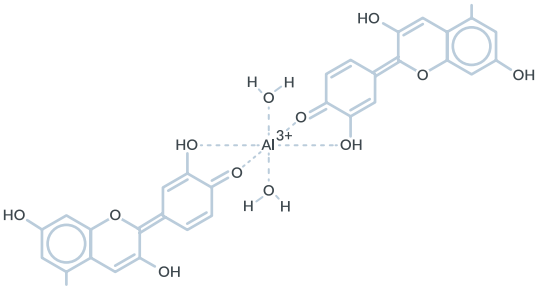
Explain

WHAT'S CAUSING IT?

Task 1: Use the Internet to find out which pigment red cabbage contains. In which class of pigment does it belong? Summarise your results in your exercise book.

Task 2: Find out why the colour of the red cabbage indicator changes when you add acidic or basic substances.

Task 3: For secondary school students: have a look at the following molecular structure. Discuss it with your group members and use it to try to explain the mystery.



Extend

WHAT'S SIMILAR?

Task 1: How does red cabbage indicator react with other metal ions (e.g. boron ions, iron ions, etc.)? Investigate whether they produce the same or a similar effect.

Task 2: Search the Internet for more objects which contain the same pigment as red cabbage.
Write at least five of them in your exercise book.

Task 3: Search the Internet for other natural indicators. Test which colours they produce when you add basic, neutral, and acidic substances to them.

Evaluate

WHAT'S MY UNDERSTANDING?

Task: It is possible to change the colour of pink hydrangea flowers to blue. This can be done by adding alum to the water, which is used to water the plant.

Explain what happens and how this procedure works using the knowledge of chemistry you've just gained.