# 3.1 Experience of Water by Working at Learning Stations

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**Short description and goal**

The set-up of learning environments provides self-guided learning.

Learning stations are established as separated areas in the room and equipped for small group interactive learning. Students are allocated to small groups, maybe three to four, which rotate from station to station, as each activity is completed.

There are four experiment-based stations to explore the main properties of water and subsequently learn how water behaves in the environment. Thus the importance of water to all living beings will become obvious. The four stations are as follows:

- Cohesion / surface tension
- Adhesion / chromatography / capillarity
- Density
- Buoyancy

For each station there is a worksheet including the physical explanation of the property, the outline of the connected experiments and the materials needed.

Conclusions and solutions are separately provided on page 18/19.

**Basic conditions**

Target group ............... Children and youth aged 10-14 with or without parents

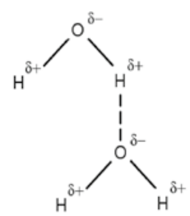
Location ...................... Room with tables and access to water

Materials..................... see worksheets

Time frame.................. approximately 3 hours

**Background knowledge**

All the above mentioned properties are ultimately caused by the structure of the water molecule. Each molecule of water is made up of two atoms of hydrogen connected to one atom of oxygen. This is summarized in the familiar formula, $H_2O$. However, due to »hydrogen bonding« – the attraction between the positively charged hydrogen atom of one water molecule and the negatively charged oxygen atom of another water molecule – water molecules are attracted to each other like small magnets. Further background knowledge concerning the individual properties is provided in the worksheets.



| **Activities** | | | |
|---|---|---|---|
| Time table | Content | Method | Material |
| Module 1 (30 min)<br>Introduction | Explanation of learning environments, introduction of the four learning stations by giving some background information on the properties of water and providing hints for the conduction of the experiments | Discussion of activities and procedures<br>Allocation of groups and rotations | Prepared working stations according to the worksheets |
| Module 2 ( 2 hours)<br>Working at the stations | Four experiment-based stations to explore the main properties of water:<br>• Cohesion / surface tension<br>• Adhesion / chromatography / capillarity<br>• Density<br>• Buoyancy | Small working groups rotating from station to station – about 30 min. per station | See description of the working stations |
| Module 3 (30 min)<br>Debriefing session with the entire group | Discussion of activities and outcomes.<br>Each station should be presented by one small group and discussed by the entire group. | Discussion and reflection | Paper, pens |

## Station Cohesion / Surface Tension

**Materials**

plastic bowls, paperclips, water cans and washing up liquid
coins (1 or 2-cent), droppers and cleaning cloth
different surfaces: waxed paper, glass, filter paper, wood, leaves etc.
glasses and corks

**Information**

The hydrogen bonds between the water molecules are rather weak and can rapidly break and form again. This is what gives water its cohesive and adhesive properties.

Cohesion is the tendency of like molecules to be attracted to one another.

Surface tension is a special case of cohesion which occurs at the surface of liquids. Water has a very high cohesion and hence a very high surface tension. This creates a type of »skin« which allows floating of light objects and enables small insects like the water strider to walk on the water surface.

**Experiments**

1. Try floating a pin or a paperclip on the top of a glass of water. Add a drop of dish soap – what happens and why?

2. Clean and dry a coin carefully. Using a dropper, place drops of water onto the coin – one by one. How many drops fit onto the coin – what is the shape of the water like?

3. Add drops of water onto the different surfaces – what happens, what are the shapes of the water drops like?

4. Fill a glass about two-thirds full with water and add a cork. How can you make the cork floatin the middle of the water surface?

## Station Adhesion / Capillarity / Chromatography

**Materials**
Different straws and tubes (clear), shallow bowls, water and food colouring
felt pens, round filter paper, glasses, water and scissors

**Information**
Adhesion is caused by weak hydrogen bonds between the water molecules. Whereas cohesion is the attraction between like molecules, adhesion means attraction between the molecules of a liquid and the molecules of a solid boundary surface in contact with the liquid.

Capillary action is the result of adhesion and cohesion.

If you place water, for example, in a narrow tube, there are molecules of the water that are attracted towards the walls of the tube by adhesive properties. Simultaneously, all water molecules in the tube are cohesively attracted towards each other. This results in the water rising within the tube. Capillary action is limited by gravity and the size of the tube.

Capillarity is one of the causes of the upward flow of water in soil and in plants.

Capillary action can be used for chromatographic purposes.The attraction of water molecules to paper (adhesion force) is larger than the attraction of the water to itself (cohesion force): hence water moves up the paper.

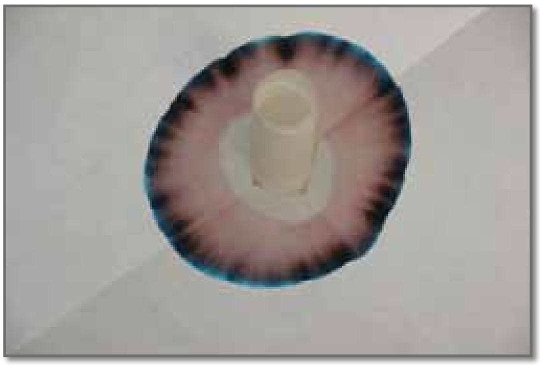
**Experiments**
1. Capillary action:
- Fill a bowl with water and add some drops of food dye.
- Place different straws and tubes upright in the bowl (straws and tubes should be as thin as possible)

What do you observe?

2. Radial chromatography:
- Fold one filter paper to make a semi circle then fold to make a quarter.
- Cut off the top of the created right angle. This paper will be your chromatogram (the paper used to separate the ink dyes).
- When you unfold the filter, it has got a little hole in the middle.
- With a felt pen (best a black one), draw a circle at a distance of about 1 cm of the centre hole or make little dots.
- Roll a second filter paper to form a cone and place it through the hole of the chromatographic paper as a wick.
- Fill a glass with water– be sure that the rim is dry!

- Place the spotted piece of filter paper over the cup so that it rests on the rim with the wick extending down into the water.

Watch the experiment for 10 to 15 minutes. Describe your observations and try to explain the phenomenon!



## Station Density

**Materials**
White bowls or caps of glasses and coloured chocolate buttons (or sugar lumps with food colouring)
glasses or cups, small cylinders or narrow glasses, droppers, teaspoons, water, hot water, ice cubes, salt, sugar and food colouring (blue, red, green)
soda cans with and without sugar (cans of same brand, size and shape).

**Information**
Density describes how much something weighs in relation to its size. It is determined by the mass of a given volume of that matter. Thus density equals mass divided by volume. On earth, mass is equal to weight. Density explains why some things float on water and some things sink – things which are less dense than water will float, things which are denser will sink. This is also true for liquids. Moreover, density of water is affected by temperature and the contents of soluents like salt or sugar.

**Experiments**
1. Experiment with chocolate buttons (or sugar lumps coloured with one or two drops of food colouring)
- Fill a plastic bowl with water – about 1cm high.
- Wait 20 seconds for the water to settle.
- Place four different coloured chocolate buttons (red, blue, yellow, green) in the bowl or cap well apart from each other.

What happens? Why?

2. Density influenced by temperature:
- Fill two glasses with about 100 ml water each - one with cold water (ice cubes) and one with hot water.
- Add several drops of blue food colouring to the cold water and some drops of red food colouring to the hot water.
- Pour some of the blue water into a cylinder or narrow glass.
- Using a pipet, slowly add red water one drop at a time and watch what happens. Hold the pipet near the water surface and be careful not to mix the colours.

What do you observe?

3. Density influenced by salt and sugar:
- Prepare three glasses with about 100ml water each.
- Add food colouring to make blue, red and green water
- Add 2 teaspoons of salt to the blue water and 2 teaspoons of sugar to the red water.
- Stir until all is dissolved.
- Pour some of the blue (salty) water into the cylinder or glass.
- Using the pipet, slowly add the red (sugar) water one or two drops at a time.

- Which is more dense – the salty or the sugar water?
- Add the green (pure) water drop-by-drop to the other two and record what happens.

4. Experiment with soda cans

- Place one soda can and one same sized diet soda can of the same brand in a container filled with water.

What happens – and why?

## Station Buoyancy

**Materials**
Clear basin filled with water, waterproof box and different stones
plastic bottles, dropper, glass and water

**Information**
Buoyancy is the force of a liquid pushing up on something. This force is equal to the weight of the liquid the object displaced. That's why some objects float and others sink. The amount of displaced liquid depends on the weight and on the shape of the object. That's why a very heavy container ship can float. It displaces a large amount of water.

**Experiments**
1. Displacement and buoyancy
- Fill the basin with water.
- Put the stones in the water – one by one – do they float?
- Take the empty box, close the lid tightly and put it in the water. It should float – otherwise take another box.
- Take the stones and the box out of the water.
- Put the smallest stone in the box, close the lid and put the box back to the basin. Does it still float?
- Add more stones – one at a time- and each time close the box and see if it still floats.

Eventually the box will sink – when does this happen?

2. Build a »Cartesian diver«:
- Fill an empty plastic bottle completely full with water.
- Put just enough water into the dropper so that it will just float upright in the water.
- Place the dropper in the bottle and screw on the cap tightly.
- Gently squeeze the bottle.
- As you squeeze, the diver will sink to the bottom of the bottle. If you stop squeezing, the diver floats back to the top.

Can you explain why?



## Observations and Solutions

**Station Cohesion / Surface Tension**

1. The dish soap will bind with the water molecules and interfere with the hydrogen bonds. The »skin« of the water will be destroyed and the paper clip will sink.

2. Surface tension not only creates the »skin« on top of the water, but it is also what causes water to stick together in drops. Because of the strong cohesion, the water molecules of each added drop are implemented into the former drop until the water will finally spill from the coin.

3. On hydrophilic surfaces – with polar compounds – the adhesion between the molecules of the water and those of the surface is stronger than the cohesion and the water is more or less soaked by the surface.

   On hydrophobic surfaces – with non-polar compounds – there is no adhesion at all and the water pulls itself into a shape with the smallest amount of surface area – a bead or sphere.

4. If you float a cork in a glass of water, eventually the cork drifts to the side because of adhesional effects. If you fill the glass with water until the water bulges over the top, the cork which is less dense then water moves to the highest point and is held in the centre of the water surface by surface tension.

**Station Adhesion / Capillarity / Chromatography**

1. Depending on the diameter, the water may »climb« up the straws and tubes or not. Capillary action is limited by gravity and the diameter of the straw. The thinner the straw or tube, the stronger the capillary action will pull the water.

2. If the paper gets soaked with water, the components of the ink at the bottom of the paper will be attracted to the paper as well as to the moving water. Thus components will move different distances according to their weights (mass), and the ink will be separated into different colours.

   Chromatography is an important method used to separate and / or to analyze complex mixtures.

**Station Density**

1. The sugar coating of the chocolate buttons dissolves quite rapidly and the food colouring in the outer layer of the sugar coating travels with the dissolved sugar. Because sugar is more dense than water, it sinks as it dissolves and spreads to areas of lower sugar concentration. There will be four quadrants of unmixed colours for quite some time, because the sugar concentration is equal on both sides of the junction. The final bleeding of the colours into each other will only happen very slowly.

2. The red (hot) water is less dense then the blue (cold) water and forms a distinct layer above the cold water.

3. Salt will increase the density of water more than sugar. Thus, there will be three layers – the salty water at the bottom, the sugar water in the middle and the pure water on top. Because the density of sea water is also controlled by temperature and the amount of dissolved salts in the water, this results in large ocean currents.

4. The regular soda will sink and the diet soda will float. That is because the sugar in the regular soda weighs much more than the sweetener in the diet soda.

**Station Buoyancy**

1. The stones sink because they are heavier than the amount of water they are displacing. The empty box floats because it displaces the same amount of water as its own weight. By filling the box with stones, it gets eventually heavier than the water it displaces and sinks.

2. The dropper floats, because there is a small air bubble in the dropper. As you squeeze the bottle, you apply pressure to the air bubble and make it smaller. The dropper becomes less buoyant and starts to sink. As you stop squeezing, you release the pressure on the bottle, the air bubble recovers its original size and the dropper floats back to the top.

Some fish keep themselves from either sinking or floating to the surface by regulating the volume of the gas within their swim bladder.

**Literature**

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- Wertenbroch, Wolfgang: Lernwerkstatt Wasser, Kohl Verlag 2007
- 365 Experimente für jeden Tag, Moses Verlag 2002
- Press, Hans Jürgen: Spiel das Wissen schafft, Ravensburger Verlag 1995

**Links**

- www.biologylessons.sdsu.edu/classes/lab1/lab1.html
- www.physikfuerkids.de/lab1/wasser/
- www.scheringstiftung.de/images/stories/pdf/Baustein_F.pdf (Unterrichtsmaterialien)
- www.chemieunterricht.de/dc2/tip/11_02.htm (Kartesischer Taucher)