Instrument Supplement: Test Instrument to Measure Student Scientific Inquiry Competence in Biology (TOSSIC-B).

Pitcher Plants

Melanie bought pitcher plants some time ago. They belong to the group of carnivorous plants. The pitchers growing at the end of their leaves are traps for insects such as flies. Trapped insects are digested in the pitchers using a liquid and serve as a source of additional nutrients for the plant.

Pitcher plants are indigenous in the tropical highlands and therefore prefer the following conditions:

- Year-round high daytime temperatures of approx. 25-35°C,
- High air humidity (approx. 70%) and
- Moist soil without waterlogging.

Melanie has put her plants onto the window sill.

But her plants do not seem to grow very well. She can see this because the pitchers are getting brown and die.

Why do Melanie's pitcher plants not thrive?

Task

Formulate at least one hypothesis (assumption) that addresses this question. Use the text and justify your answer.

Dummy Tests with Guppies

Dummy Tests

Dummy tests are experiments with replicas of animals (dummy). Such replicas are, for example, made from modeling clay. Dummy tests are often used in behavioral biology and serve to find out which characteristics of the simulated animal trigger a specific behavior in living animals. Usually, a dummy having only certain features of the real animal is used and then selectively changed.

Dummy tests are particularly useful for studying the courtship of animals, e.g. fish. One can, for example, examine certain characteristics of the female by the reaction of the dummies of females to males (Figure 2).

The Courtship Behavior of Guppies

Figure 2. Dummy of guppy female.

Guppies are small aquarium fish (Figure 3). Males are usually about 4cm and females about 7cm in length. Guppies have a particularly conspicuous courtship. A pairing ready guppy male courts the female by bending his body into an S-shape and unfolding the tail and dorsal fin. This behavior is called S-bending (Figure 4). The S-bending is an innate behavior that can regularly be triggered by certain stimuli (characteristics of the female). Depending on the excitation of the male, S-bending occurs several times in succession.

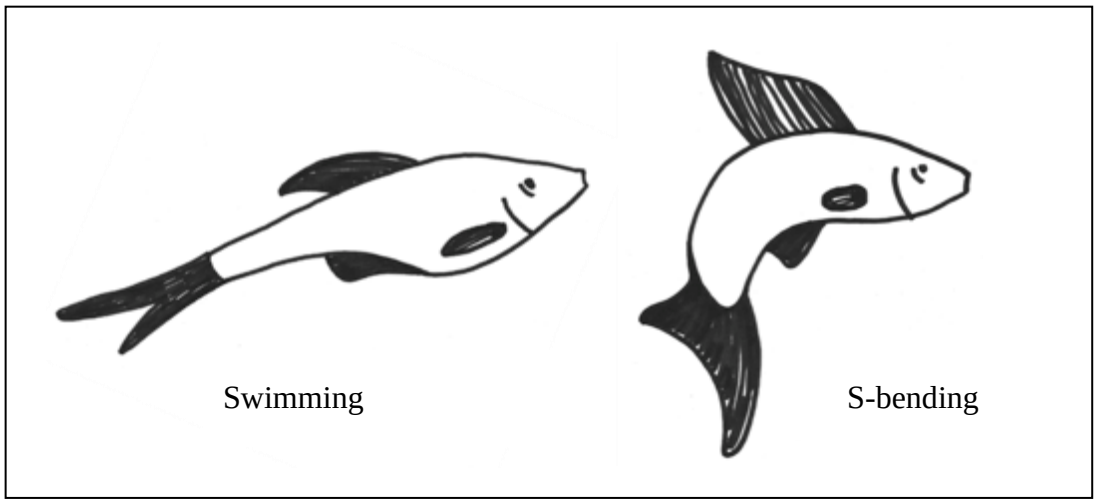

Figure 4. Guppy male swimming (left) and courting with S-bending (right). Drawing by Kathrin Ziepprecht.

Imagine that you examine the courtship behavior of guppies. You want to find out which characteristics of the female trigger the male's S-bending and thus are important factors for the courtship.

You suspect that the size of the female is a possible trigger because it is probably a sign of sexual maturity of the female.

Your hypothesis is:

The size of the female is a trigger for the S-bending of the male. The larger the female is, the stronger the courtship behavior of the male.

Task

Describe as precisely as possible an experiment to test this hypothesis (dummy test). What should the experiment look like and what should be taken into consideration.

(If you want to draw your experimental design, make sure to describe it as accurately as possible!)

The Effect of Nicotine

Nicotine

Tobacco plants contained a high concentration of nicotine. Nicotine is absorbed by humans while smoking tobacco.

Nicotine is a harmful neurotoxin that affects the nerves of the heart. Consumed in high doses it can even be fatal.

Water fleas

The water flea is a water-living crustacean, about 2-6 mm in size. It is often used as an experimental animal to investigate the effect of pollutants. The heart of the water flea is located in its back and because the water flea is slightly transparent it is easy to see (see Figure 5). The nerves of the water flea's heart are similar to those of humans.

Sina and Steffen want to investigate whether nicotine has an effect on heartrate and they want to use the water flea as an experimental animal.

Their hypothesis is:

Nicotine affects the heart rate (beats per minute). The higher the nicotine concentration is, the lower the heart rate.

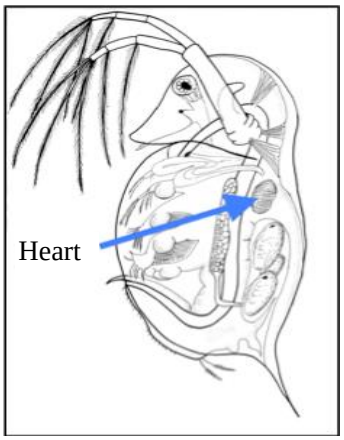

Figure 5. Water flea and heart position. Drawing by Wulff & Meier 2010.

To check their hypothesis, they perform an experiment:

1. They prepare two tobacco solutions with different concentrations of nicotine (tobacco solution 1: 0.009%; tobacco solution 2: 0.018%).
2. Then they place a water flea in a small water dish under a microscope.
3. Then they add tobacco solution 1 to the water.
4. They observe the water flea for 30 minutes. They count the beats per minute.
5. After these 30 minutes, they let the water flea rest in water without tobacco until it returns to its original heart rate.
6. Then they add tobacco solution 2 and watch the water flea for 30 minutes again to determine the heart rate.

They record their data and present the results graphically (Figure 6):

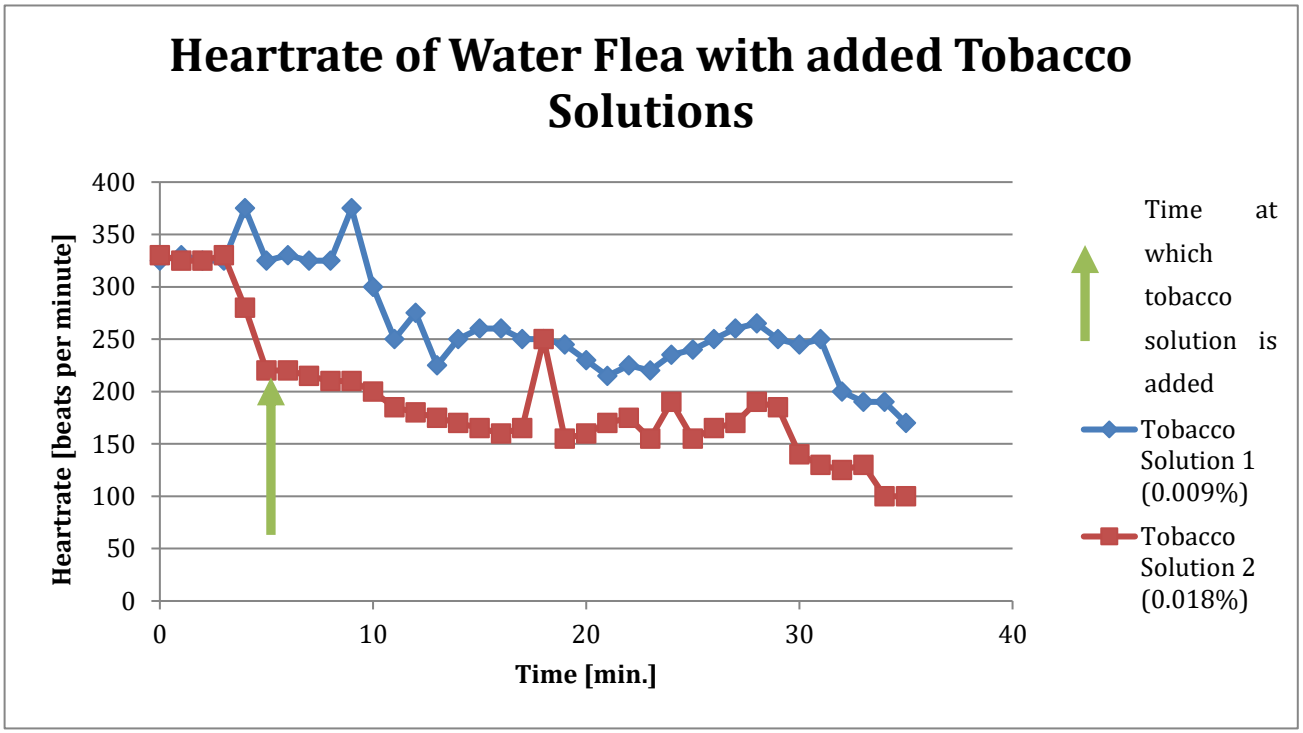

Figure 6. Results from the Water Flea experiment.

Task

Describe and interpret the data with respect to the hypothesis. Which conclusions can Sina and Steffen draw from that data?

Apple Juice

Apple juice is mostly produced on an industrial scale and can be purchased in both naturally cloudy and clear form (see Figure 7). Normally apple juice is cloudy. This is due to so-called "suspended solids", the smallest cellular components of apples still present in the juice which cannot be removed by filtration.

Clear apple juice is usually cleared through the use of enzymes. The enzymes, usually a mixture of pectinase, cellulose and amylase, decompose the remaining cell components and thus clarify the juice of suspended solids. The enzymes needed are commercially available.

Figure 7. Apple Juice naturally cloudy (left) and clear (right).

Melanie and Martin want to produce apple juice for the first time on their own. Both students want their apple juice to be clear and therefore they decided to add enzymes.

They juiced apples and processed the juice as follows:

- they added 0.1g of the enzyme mixture to the apple juice,
- added lemon juice because the acid of the lemon juice contributes to the durability and makes the apple juice more sour and
- they heated the apple juice to 100 °C to make it durable.

Finally, they put the warm juice into bottles and closed the bottles.

After completing these steps they recognize that their apple juice is still cloudy and the enzymes apparently did not act adequately.

What could be the reason that the enzymes in the apple juice did not fully clear the solution?

Task

Formulate at least one hypothesis (assumption) that addresses this question. Use the text and justify your answer.

Food preservation

Food spoils

The process of decay in food is called spoilage and includes the deterioration of quality. Reasons for spoilage are, for example, reactions caused by enzymes. These enzymes are originally contained in food. Any bacteria or fungi can be a source of enzymes.

Food Preservation

Food preservation is the curing of food that counteracts spoilage. Besides drying, cooling or bottling, pickling is a way of preservation. Gherkins, peppers and corn are preserved that way. By pickling the pH value of the pickling-solution is decreased (see Information).

Enzymes and Detection

Enzymes are proteins that catalyze (accelerate) specific reactions. Enzymatic reactions can be made visible by detections. For example, the enzyme amylase catalyzes the degradation of starch. Starch can be made visible by coloration. If starch is present, the specific coloration turns violet. If you add amylase into a colored starch-solution, the solution will slowly lose color, because the starch is degraded by amylase.

Information pH value

The pH value is a measure for the acidic or basic character of solutions. It is mostly indicated on a scale of 0 to 14, where 0 is strongly acidic (like hydrochloric acid), 14 strongly alkaline (sodium hydroxide) and 7 neutral (water).

A solution's pH value can be measured via test-strips and it can be varied by adding acids or alkali.

Imagine the following scenario: you want to investigate the conditions of enzyme activity such as the amylase. You want to find out which factors can influence enzymatic reactions. You specifically want to know whether the pH value can influence the enzyme reaction.

You guess that the pH value plays an important role in enzyme functioning.

Your hypothesis is:

The pH value influences the enzymatic reaction. The lower the pH value of the solution, the faster the enzymatic reaction.

Task

Describe as precisely as possible what an experiment to test this hypothesis (dummy test) should look like and what must be taken into consideration.

(If you want to draw your experimental design, make sure to describe it as accurately as possible!)

Fever

Human body temperature is relatively constant at approximately 38°C. If it gets too cold, the body reacts with goose bumps and shivering to warm up. But even when the body reacts to a disease with fever, the body temperature rarely rises above 41°C.

Enzymes

Enzymes play an important role in the metabolism of living beings. Without enzymes vital reactions could not take place. Therefore it is important for organisms that optimal conditions for enzymes prevail and that their inner environment (such as body-temperature) is adapted to the enzymes.

Sarah and Pascal wish to investigate which factors influence the functioning of enzymes. They suspect that temperature is an important condition for enzymes to function.

Their hypothesis is:

Temperature affects the functioning of enzymes. The warmer the surrounding environment is, the faster the enzymatic reaction.

Yeasts and fermentation tube

Sarah and Pascal have decided to use yeast as a model for their experiment since one can investigate the enzyme action on yeast well. Yeasts are unicellular fungi that process glucose (sugar) to generate energy. This produces CO_2, which can be seen with the aid of a fermentation tube. Fermentation tubes are bent glass tubes filled with water (see Figure 8). Fermentation tubes can be attached to a test tube using a stopper. If gas is produced as CO_2 inside the test tube, it rises and leaves the tube in bubbles through the water.

To verify their hypotheses Sarah and Pascal conducted an experiment and noted the following in their report (see Figure 9):

Protocol

First we created a yeast slurry by mixing 10g baker's yeast with water and a little glucose powder.
We filled the fermentation tube with water until both balls were half full.

For the first measurement we filled a container with 40°C water and placed the test tube in it which was closed with the fermentation tube and contained the yeast suspension .
For 5 minutes we counted the bubbles that rose through the fermentation tube per minute.
Then we cooled off the water with ice to 20 °C and again counted the bubbles per minute for another 5 minutes.
Our measured values can be illustrated using the following graph:

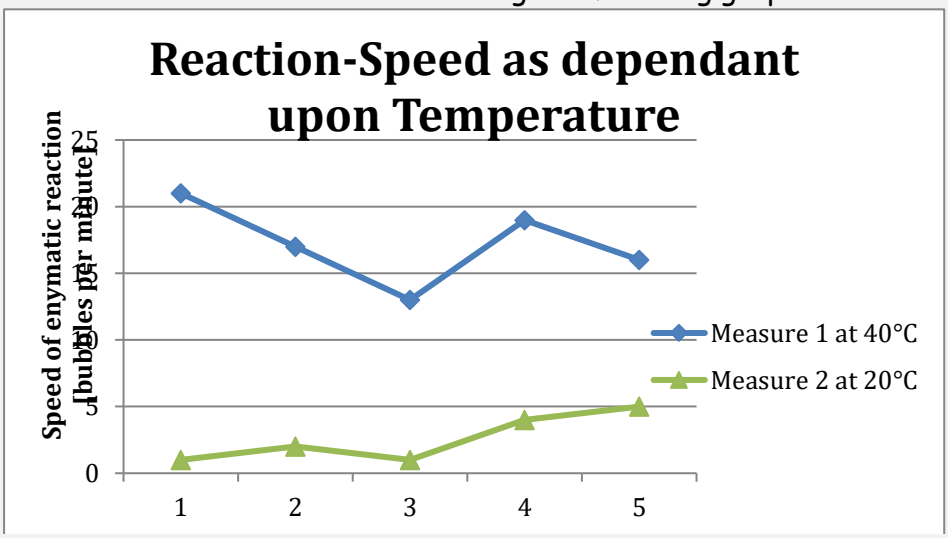

Figure 9. Protocol. Source: www.klassenzeitung.de/Referate/Klasse_11/bio/Protokoll4.doc; adapted.

Task

Describe and interpret the data with respect to the hypothesis. What conclusions can Sarah and Pascal draw from that data?