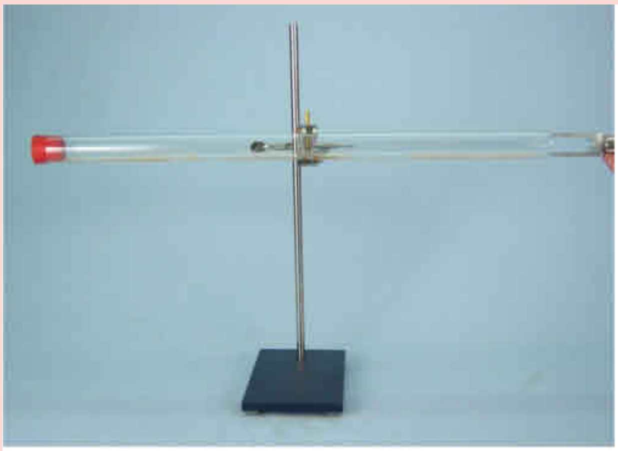
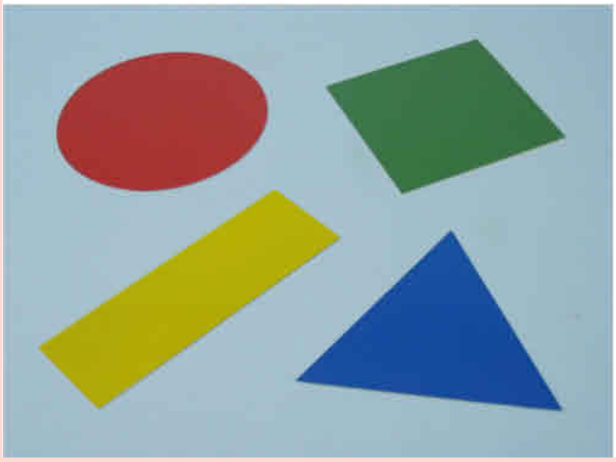
Student and Demonstration Experiments

TESS
beginner

Senses






13242-02

TESS beginner Student and Demonstration experiments

Senses

Order No. 13242-02

PHYWE series of publications
TESS beginner Student and Demonstration experiments: Senses
Order No. 13242-02

Authors of experimental literature: Sabine Iwanek, Wiebke Kutzborski

1st edition

Contents

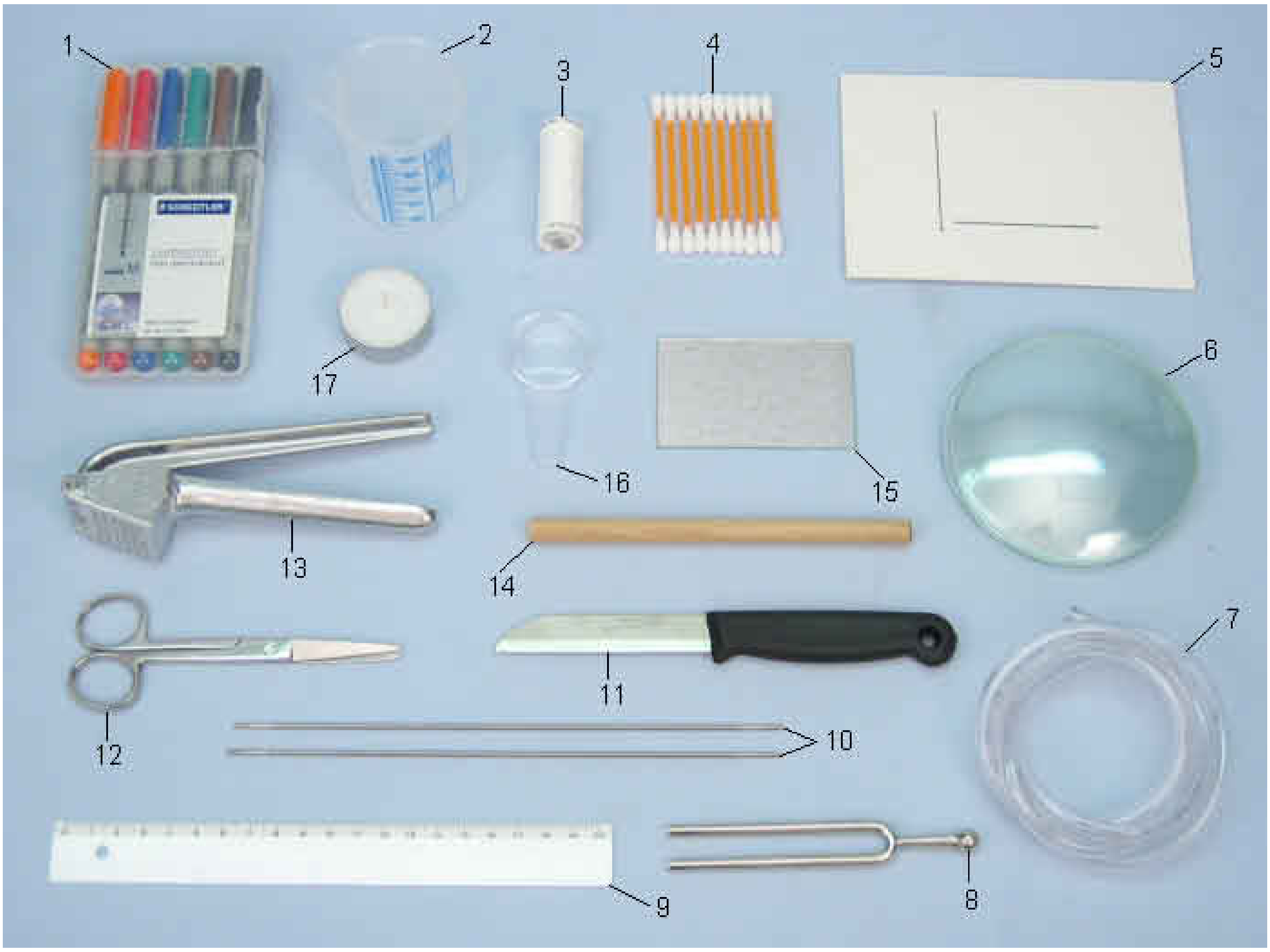
Student experiments:

Demonstration experiments:

Equipment and Storage

Student Set, Senses 13241-88

	Description	No.	Quantity
(1)	Marking pencils,set,water soluble	38710-20	1
(2)	Beaker, 100 ml, low form, plastic	36011-01	1
(3)	Silk thread,200m	02412-00	1
(4)	Cotton bud, 100 pcs.	13241-10	1
(5)	Set of cards "sight", e.g. blind spot	13241-20	1
(6)	Watch glass, dia.100 mm	34574-00	5
(7)	PVC tubing, ID 6 mm	47527-00	1
(8)	Tuning fork 440 Hz	03424-00	1
(9)	Ruler, plastic, 200 mm	09937-01	1
(10)	Knitting needle	13241-40	2
(11)	Knife, stainless	33476-00	1
(12)	Scissors, straight, l=125mm	46970-00	1
(13)	Press, manual	64154-00	1
(14)	Touching bristle	64928-00	1
(15)	Mirror, 80x50 mm	08209-01	1
(16)	Magnifier, plastic, 5x, d=30mm	88002-01	1
(17)	Tea light, dia = 3.6 cm	13241-31	1



Demo-Set, Senses 13242-88

	Description	No.	Quantity
(1)	Retort stand	37694-00	1
(2)	Butane burner for cartridge	32180-00	1
(3)	Beaker, low, 400 ml	46055-00	1
(4)	Light box	09801-01	1
(5)	Power supply 12V / 2A	12151-99	1
(6)	Figures / types and colours	64923-00	1
(7)	Wire gauze, ceramic cen.	33287-01	1
(8)	Kundt's apparatus	03475-88	1
(9)	Ring with boss head	37701-01	1
(10)	Tuning fork,1700 Hz	03423-00	1
(11)	Lab thermometer,-10..+100C	38056-00	1
(12)	Beaker, low, 50 ml	46052-00	5
(13)	Glass rod	40485-03	5

	Description	No.	Quantity
(14)	Cork dust, 3 g	03477-00	1
(15)	Dropping pipette with bulb	47131-01	1
(16)	Block, planoconcave lens	09810-05	1
(17)	Block,planoconvex lens	09810-04	1
(18)	Block, semicircular	09810-01	1
(19)	Ruler, plastic, 200 mm	09937-01	1
(20)	Striking hammer	03429-01	1
(21)	Dividers, nickel-plated	64857-00	1
(22)	Universal clamp	37718-00	1
(23)	Right angle clamp	37697-00	1
(24)	Spoon + spatula	46949-00	1
(25)	Rubber stopper	39260-00	1

Storage tray

Which structures can you find on your tongue?

Task

Examine how your tongue looks.

Material

1 Mirror
1 Magnifying glass

Pencil

Fig. 1

Set-up and procedure

- Look at your tongue in a mirror. Use the magnifying glass to see more details.
- Describe and make a sketch of what you see.

Observations

1. Describe your tongue. Which different structures can you recognise?

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2. Make sketch of the outlines of your tongue and enter in it all of the details which you saw as exactly as possible.

Evaluation

1. Which functions does the tongue carry out?

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2. Which part of the tongue could be responsible for which task?

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Room for notes

(Which structures can you find on your tongue?)

Observation

1. My tongue is pink and moist. It is thicker at the back than at the front. There are small elevations on the upper side of it. It is sometimes coated with a beige coloured coating. Blue strips and a thin skin, which tensions when the tongue is bent back, are to be seen at the underside. The tongue can be easily moved in many ways.
2. The tongue has a good supply of blood and is so reddish in colour. There are wart-shaped elevations on the skin of the tongue, which is a continuation of the mucous membrane of the mouth. They are the gustatory papillae and this is where the actual gustatory organs, the taste buds and the gustatory nerves are situated. The beige coloured coating consists of the tongue epithelium, which is sometimes thickened, saliva and food residues. The thick part at the back is the root of the tongue. Bluish blood vessels are to be seen at the underside of the tongue and the frenulum of the tongue can also be seen here.

Evaluation

1. The tongue is responsible for the perception of taste. In addition, it forms saliva which causes a better lubrication of bits of food. The tongue transports food around in the mouth so that it can be thoroughly chewed. It is also indispensable for speech, as it generates many sounds.
2. The taste organs are in the wart-shaped elevations on the top of the tongue. Saliva is formed in numerous salivary glands which are in particular situated in the back part of the tongue in the region of the root of the tongue. Muscle fibres in the tongue are responsible for the extraordinarily mobility of the tongue and its ability to change shape.

Room for notes

What does the nose have to do with taste?

Task

Try to recognise various fruits by tasting them only with your tongue.

Material

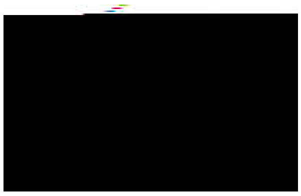
5 Watch glass
1 Knife
1 Hand press

Tea spoon
Fruits: e.g. apple, pear, banana, carrot, kohlrabi, potato
Scarf or cloth for blindfolding

Fig. 1

Set-up and procedure

- Peel the fruit, cut them into small pieces, successively press them in the hand press and put each fruit puree in a separate dish.
- Select a tester and blindfold him or her.
- While the tester is holding his nose, put a spoonful of fruit puree in his or her mouth.
- The tester is now to say which fruit that was without being able to use eyes or nose, in other words, only using the sense of taste of his or her tongue.
- Now you be the tester. What could you taste?
- Let go of your nose, what can you taste now that you can again breathe through it?



Observations

1. What did you taste with your eyes closed and holding your nose?

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2. What did you taste with your eyes closed but no longer holding your nose?

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Evaluation

1. Why does the sensation of taste change when you hold your nose?

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2. Why are most foodstuffs quite tasteless when you have a cold?

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(What does the nose have to do with taste?)

Material

Teaspoon

Fruit: e.g. apple, pear, banana, carrot, kohlrabi, potato

Preparation

The dishes and fruit presses should be washed prior to use. The presses are best soaked for a while after use to ensure that no fruit residues remain in the holes.

Observation

1. The samples could not be clearly identified. Only “sweet” and “sour” could be recognised.
2. Using the nose as well allows one to taste the characteristic odours of the various fruits.

Evaluation

1. Holding your nose switches the sense of smell off. It is the smell, however, which gives a fruit its characteristic aroma. Nose and tongue work together to perceive a special impression of taste.
2. For the perception of a smell, the aroma must penetrate to the sense of smell nerves in the nose. When one has a cold, however, the mucous membranes in the nose are swollen, so that the flow of air which transports the smell substances is hindered. In addition, the sensory cells in the olfactory mucosa are covered by a tenacious layer of phlegm and it is therefore difficult for them to pick substances up.

Room for notes

Where can the tongue best sense taste?

Task
Examine at which part of the tongue “sweet”, “salty”, “sour” and “bitter” are perceived.

Material
5 Watch glass
Cotton buds

Absorbent paper (e.g. paper towels)

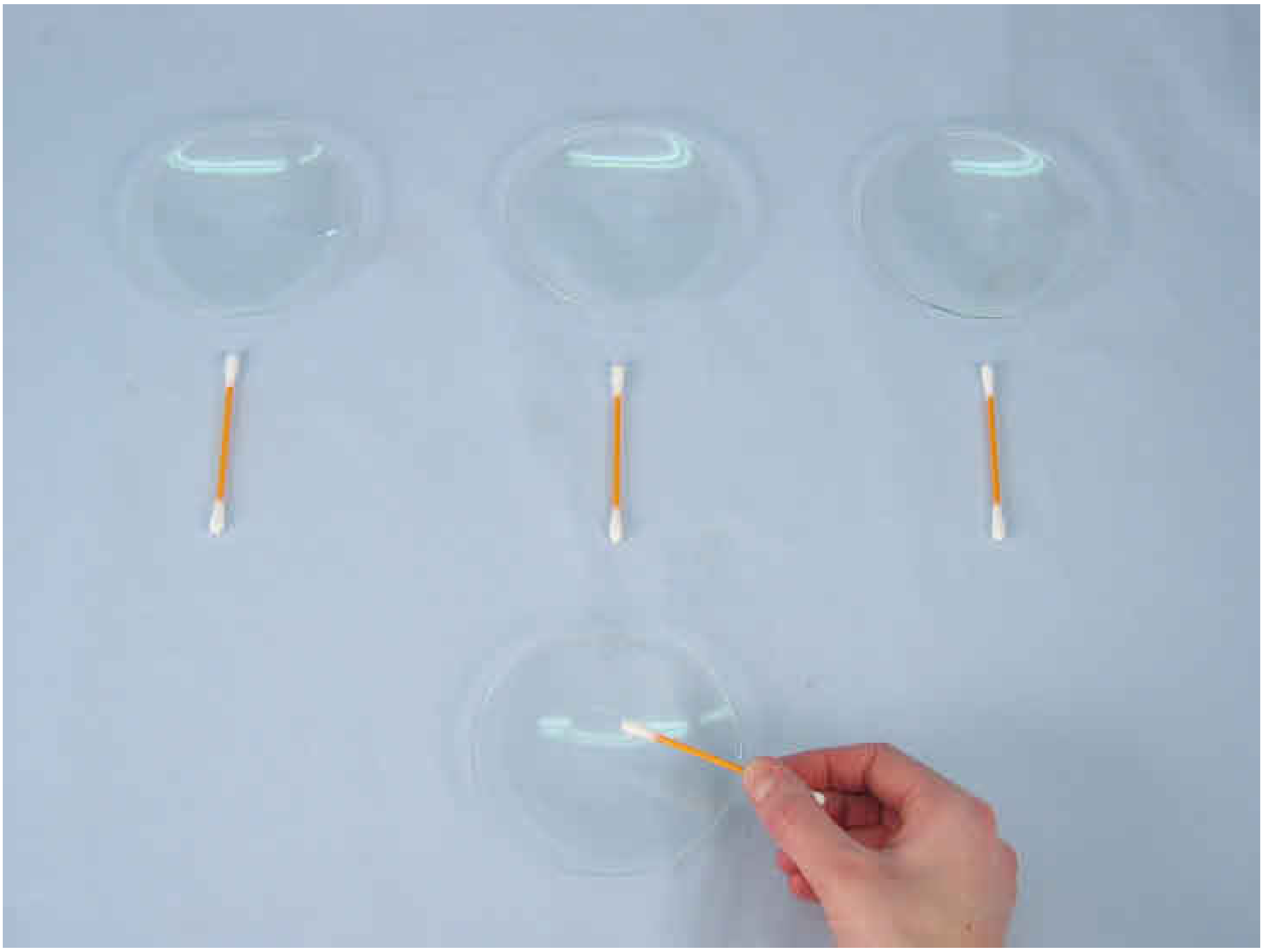

Fig. 1

Set-up and procedure

- Let your teacher put four different solutions, each with a different flavour, in the watch glasses.
- Each tester dabs his or her tongue as dry as possible with a paper towel.
- They are each given a cotton bud which was previously dipped in one of the solutions.
- They are each to touch the tongue with it at various positions to try to find out which flavour is on it.
- Carry out this test with all four solutions.
- Change the testers among yourselves and enter the region where you most strongly sensed each separate taste in the “tongue” drawings.
- Compare your results.

Observations

1. Which flavours did you recognise? Mark the regions where your sensation of taste was strongest.

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Evaluation

1. Enter the four sensations of taste at the side of the Table and write in examples of foods with each particular taste alongside them.

2. For what is the sense of taste useful?

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A matter of taste

(Where can the tongue best sense taste?)

Material

5 Beakers, 50 ml
5 Stirrer rods
5 Dropping pipette
1 Spoon spatula

Salt, sugar, vinegar or citric acid, grapefruit, glutamate

Preparation

Prepare the solutions for the four tastes, sweet, salty, sour und bitter. For the sweet solution, dissolve three spoonfuls of sugar in 40 ml of water, for the salty solution just one spoonful of salt is sufficient. Only dilute the vinegar or citric acid for the sour solution just a little. For the bitter taste, either cocoa powder or quinine can be used (neither of these are water soluble, however).

To prepare the glutamate solution, add two spoonfuls to 40 ml of water.

Observation

1.

sweet	sour	salty	bitter

[redacted]

Taste buds are not specialized with regard to the quality of taste but have sensory cells for all qualities. Despite this, regions can be found in which one quality of taste is preferentially perceived. These regions can differ slightly from person to person.

In the western world, a differentiation is usually made with the four taste qualities: sweet, salty, sour and bitter. In China, though, one reckons also with hot as well as with “xiang” (biting and aromatic like onions and garlic) and “xian” (tasty, savoury, fleshy). In the meantime “xian” has also been recognised as a fifth taste quality. It has been named “umami” (japanese for “pleasant taste”) and one can taste it in particular in stock cubes, Parmesan cheese, tomato juice or tuna fish. Three chemical substances are responsible for the umami sensation, of which monosodium glutamate (E 621) is the most well known. Glutamate is a salt of glutamic acid, which is one of the most frequently found amino acids. It is used as flavour modifier (or enhancer) in many convenience foods and, with oversensitive people, is suspected to cause the so-called “China restaurant syndrome”. This is accompanied by headaches, mouth dryness, itching and hot, reddened cheeks.

We recommend that the glutamate sample be tested last, because the “umami” flavour is found to be very intensive by many people, so much so that it disturbs their perception of other flavours in the food.

Evaluation

2. The sense of taste serves to select foods. A sweet taste points to a high-calorie food containing sugar, a salty taste to essential minerals, a sour taste stimulates the appetite but also points to food that has gone bad, a bitter taste is a warning of poisonous substances, in particular of plant ingredients.
   Glutamate serves to enhance protein-rich foods such as meat and is an appetite stimulant.
   Everyone knows how it is to have an “appetite” for a special food, and the human body often shows its need for certain ingredients.

Which outer features does the skin have?

Task

Examine your skin with a magnifying glass and blotting paper.

Material

1 Magnifying glass
1 Knife

Pencil
Paper
Blotting paper

Fig. 1

Set-up and procedure

- Look at your skin at various positions under the magnifying glass and make a sketch of a part of it. Which structures can you recognise?
- Press a piece of blotting paper against the skin of your forehead.
- Use the knife to scrape a small heap of graphite dust from the tip of the pencil onto the paper, press the tip of your forefinger in it and roll your forefinger over the paper. You have now made your fingerprint. Compare fingerprints.

Observations

1. What can you recognise under the magnifying glass?

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2. Which change is there in the blotting paper?

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Evaluation

1. Which purpose could the structures which you have discovered fulfil?

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2. Which substance did you find on the blotting paper and what is the purpose of it on skin?

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(Which outer features does the skin have?)

Observation

1. Hair, flakes of skin, grooves and lines, pigmentation marks, pores, hard skin.
2. The blotting paper has become darker.

Evaluation

1. Hair serves for feeling and also limits heat loss via the skin.
   Flakes of skin are continually given off by the outer skin layer while the skin below is renewed.
   The grooves and lines in the skin serve for better extensibility. They give each person a unique and distinctive profile.
   Pigments are coloured particles which are contained in pigment cells. They prevent the penetration of harmful UV radiation in sunlight into the lower skin layers.
   Sweat passes through the pores to the surface of the skin and evaporates there to cool the body.
   Hard skin results at positions which are particularly strongly burdened, e.g. at the soles of feet or on the hands, and protects them from damage.
2. The dark stain on the blotting paper is a grease mark.
   The greasy film protects the skin from drying out and prevents the penetration of pathogens. The grease is formed by sebaceous glands in the skin.

Room for notes

Does skin have the same sensitivity all over?

Task

Use the feeling bristle to examine how sensitive the skin is at various parts of the body.

Material

1 Magnifying glass
1 Knife

Pencil
Paper
Blotting paper

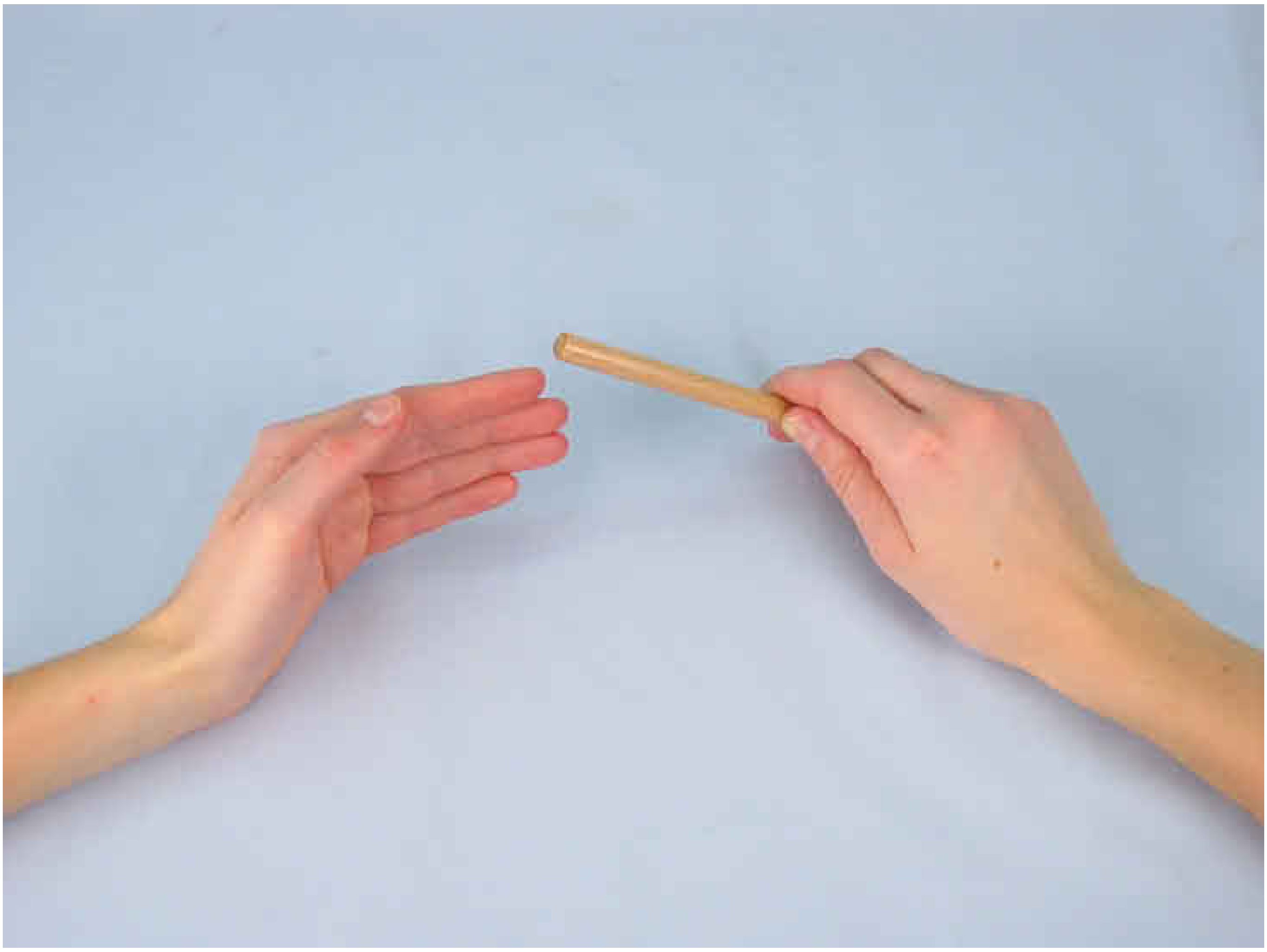

Fig. 1

Set-up and procedure

- Select a test person and blindfold him or her.
- Very lightly touch the fingertip of the test subject ten times at different positions, whereby the test subject is to say when he or she feels a touch.
- Record the total number of touches and the touches which were perceived.
- Repeat this procedure at other parts of the body: Face, forearm, neck, leg. Record the results.

Observations

1.

Part of the body	Total number of touches	Perceived touches
Fingertip		
Face		
Forearm		
Neck		
Leg		

Evaluation

1. Which parts of the body are particularly sensitive?

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2. Why is it practical that skin is more sensitive at some parts than at others?

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(Does skin have the same sensitivity all over?)

Observation

1.

Part of the body	Total number of touches	Perceived touches
Fingertip	10	10
Face	10	10
Forearm	10	9
Neck	10	7
Leg	10	6

Evaluation

1. The skin is most sensitive at the fingertips. Every touch is felt there. The face also has a high sensitivity to touch. The skin is less sensitive at the other parts of the body which were tested.
2. The skin is particularly sensitive wherever touches are of great importance. Fingertips are used to test how something feels. Facial skin is very sensitive to touch so that eyes, nose and mouth can be well protected, e.g. one can immediately feel the landing of an insect and can then quickly get rid of it.

Skin contains sensory cells which can perceive cold, warmth and pain. The so-called Meissner's corpuscles for touch stimuli lie in the dermis directly under the epidermis. They are particularly densely arranged alongside each other at the fingertips and the lips. The more such corpuscles there are, the greater is the sensitivity of the skin.

Room for notes

Where does one sense heat and cold?

Task

Find out at which spots on the skin heat and cold are perceived.

Material

1 Knitting needle
1 Beaker
1 Ruler
3 Non-permanent markers (red, blue, black)

Hot water
Ice cubes
Paper towels

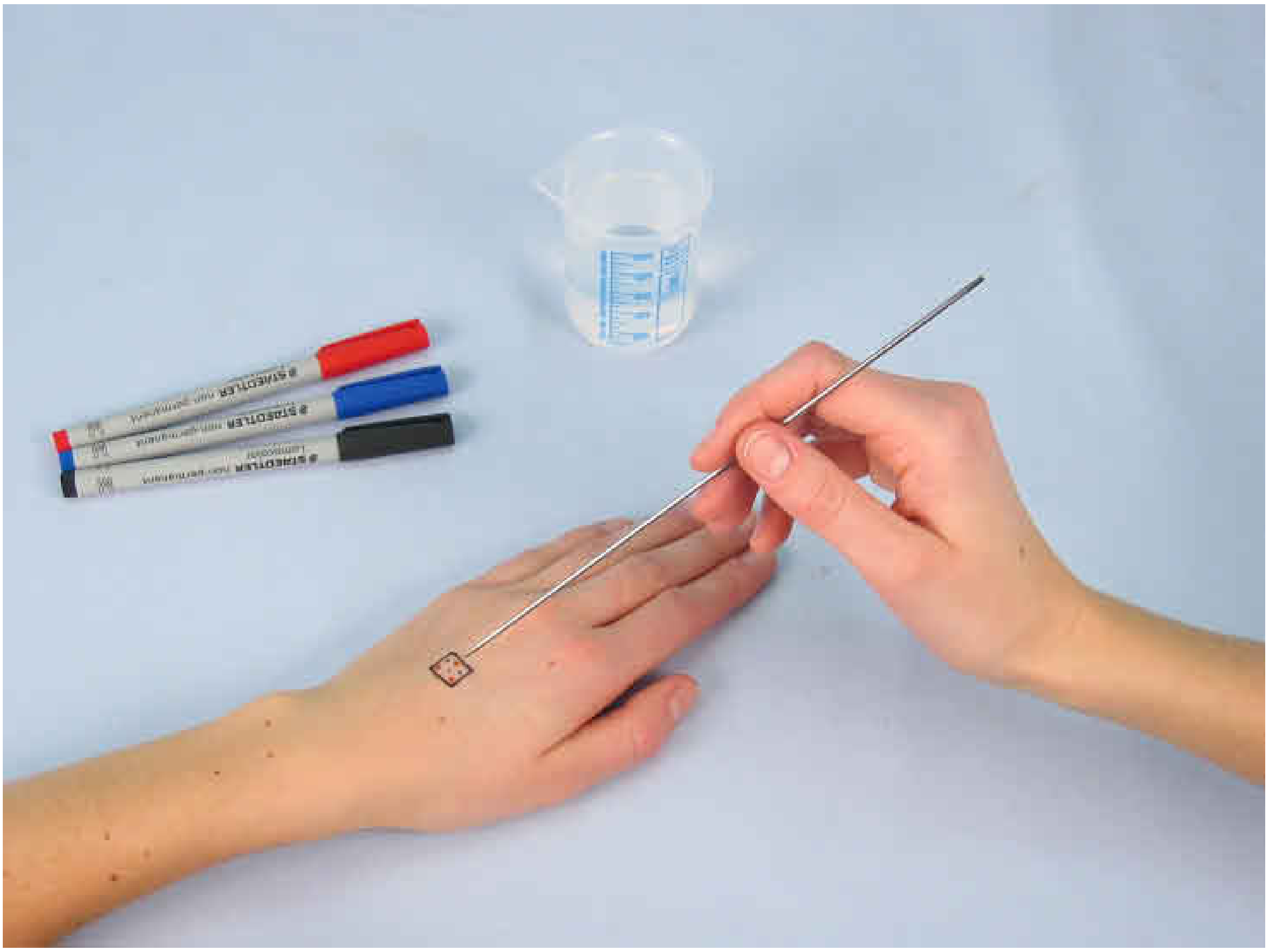

Fig. 1

Set-up and procedure

- Fill the beaker with hot tap water and stand a knitting needle in it.
- Now use the black, non-permanent pen to draw a square with a side length of about 1 cm on the back of the hand of a test subject.
- Take the knitting needle from the beaker and dry it with a paper towel.
- Very lightly successively touch the skin of the test subject with the knitting needle at all spots within the square. The test subject is not to look at what you are doing.
- When doing this, hold the knitting needle in the hot water again for a moment after a few touches have been made so that it does not cool down too much.
- Use the red non-permanent pen to mark all spots at which the test subject felt the warmth.
- Pour the hot water out of the beaker and fill it with ice cubes and a little water.
- Stand the knitting needle in the icy water for a few minutes and repeat the procedure.
- Use the blue non-permanent pen to mark all spots at which the test person felt the cold.
- Record the results.

Observations

1. Number of hot spots: ……………………

   Number of cold spots: ……………………

Evaluation

1. Against which temperature stimulus can the body particularly quickly react?

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Hot or cold

(Where does one sense heat and cold?)

Material

Hot tap water, cold tap water, ice cubes, paper towels

Observation

1. Number of hot spots: 2

   Number of cold spots: 12 - 13

Evaluation

1. The body can react much quicker to cold a stimulus than to a hot one, as it has far more measuring spots for cold.

Thermal stimuli are perceived by free nerve endings, cold stimuli by Ruffini's corpuscles, whereby the receptors react to changes in temperature. Hot spots measure skin temperature within a range from 30 to 48°C. They report pain at above 44°C. There are two hot spots per cm² of skin, which is much less than the number of measuring spots for cold. In addition, the hot spots are situated deeper and are connected to slower conducting nerve fibres. Cold spots have a measuring range of 5 to 43°C and report pain at a skin temperature below 17°C. There are 12 - 13 cold spots per square cm which are just below the surface of the skin and are connected to rapidly conducting nerve fibres.

Room for notes

How does sound get into your ear?

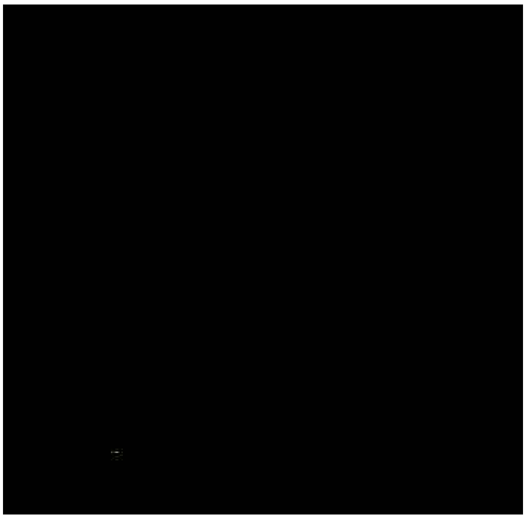
Task

Examine the behaviour of a tuning fork.

Material

1 Tuning fork
1 Beaker, 100 ml

Water



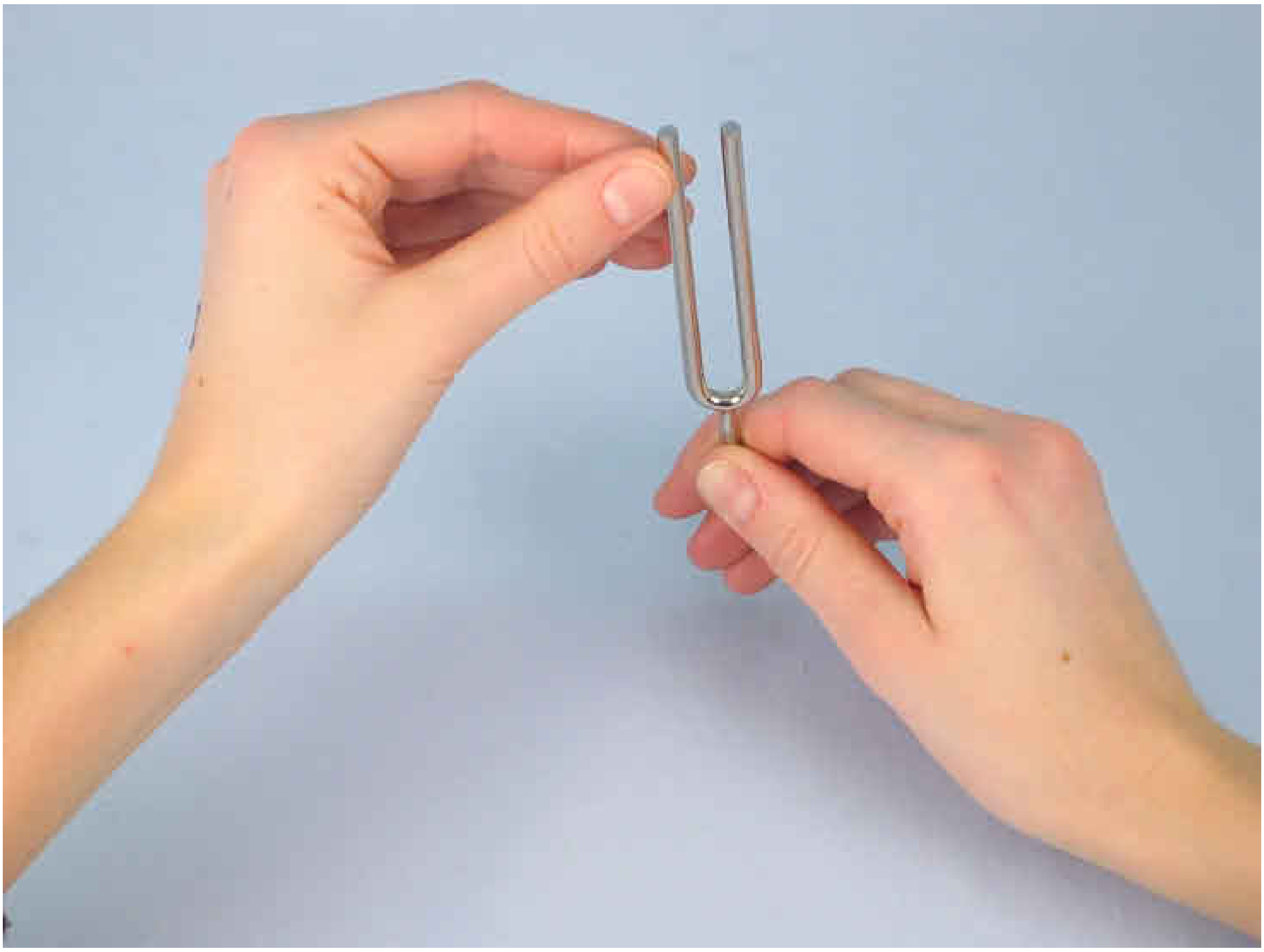


Fig. 1

Set-up and procedure

- Strike the tuning fork against the edge of the table and hold it near to your ear. Turn it slowly in different directions.
- Strike the tuning fork again and touch it with your hand.
- Fill the beaker with water, strike the tuning fork and dip it in the water.

Fig. 2

Observations

1. What did you hear when you struck the tuning fork and turned it in various directions?

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2. What did you feel as you touched the tuning fork?

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3. What could you see in the water?

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Evaluation

1. What is a tuning fork used for?

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2. Can you explain why the water in the beaker behaved as it did?

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3. Why can a tone be heard when you strike a tuning fork?

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4. How does the sound get into your ear?

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(How does sound get into your ear?)

Observation

1. There was a steady tone which only slowly became quieter. Turning the tuning fork caused the tone to become louder or quieter according to the position of it.
2. The tuning fork vibrated. Touching it caused the vibration of it to be quickly reduced and the tone was no longer to be heard.
3. When the vibrating tuning fork was in the water small waves were to be seen on the surface in the shape of a pattern.

Evaluation

1. A tuning fork is used to tune an instrument. It enables a particular tone to be generated, in this case a concert pitch “a”. While this is being propagated, one can, for example, so tension a guitar string until a match is made.
2. Striking the tuning fork caused it to vibrate. These vibrations were transmitted to the water and could be seen as waves on the surface of the water.
3. The oscillations of the tuning fork cause the surrounding air to vibrate and waves are formed just as were seen in the water. The waves in the air are not visible, but can be heard as a tone. This tone has 440 Hz (Hertz, the unit for frequency), which means that it vibrates back and forth 440 times in one second. Because of the shape of the tuning fork, the waves do not spread out equally in all directions, which is why the tone one hears sometimes louder and sometimes quieter when the tuning fork is turned.
4. The sound waves are carried further by the air until they reach the ear where special sensory cells can perceive the sound.

Room for notes

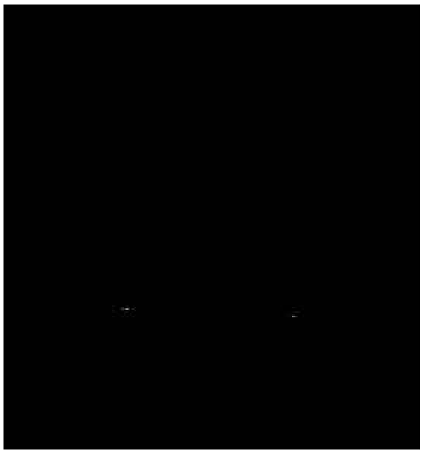
Can you make music with a ruler and a knitting needle?

Task

Play tunes with the help of a ruler and a knitting needle.

Material

1 Knitting needle
1 Ruler



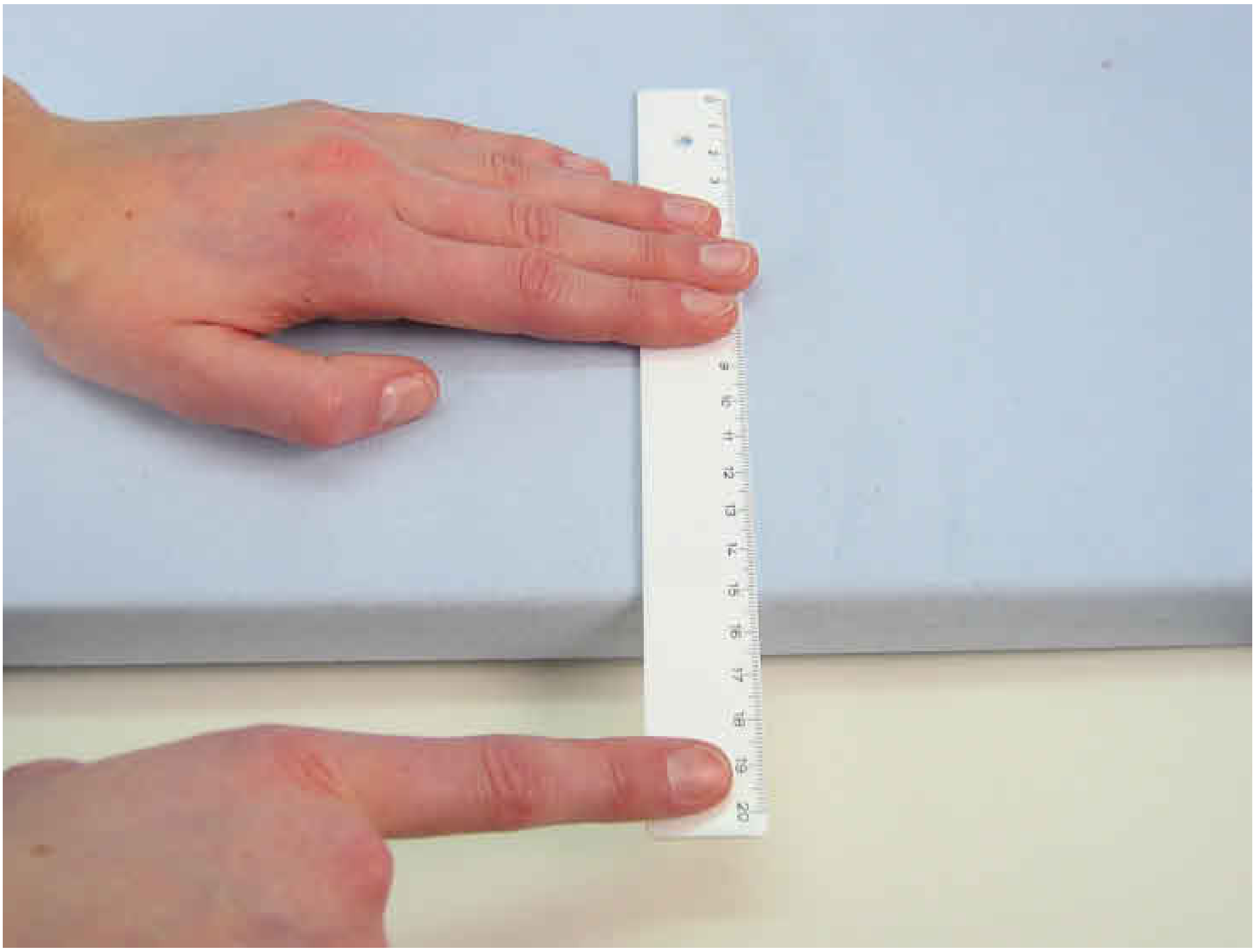


Fig. 1

Set-up and procedure

- Hold the ruler so at the edge of the table that about 15 cm of it protrudes out from the edge.
- Use your thumb to bring the overhanging part to slightly vibrate.
- Draw the ruler a back to the table while it is vibrating. What happens?
- Try to play a tune with the ruler.
- Now use the knitting needle in place of the ruler.

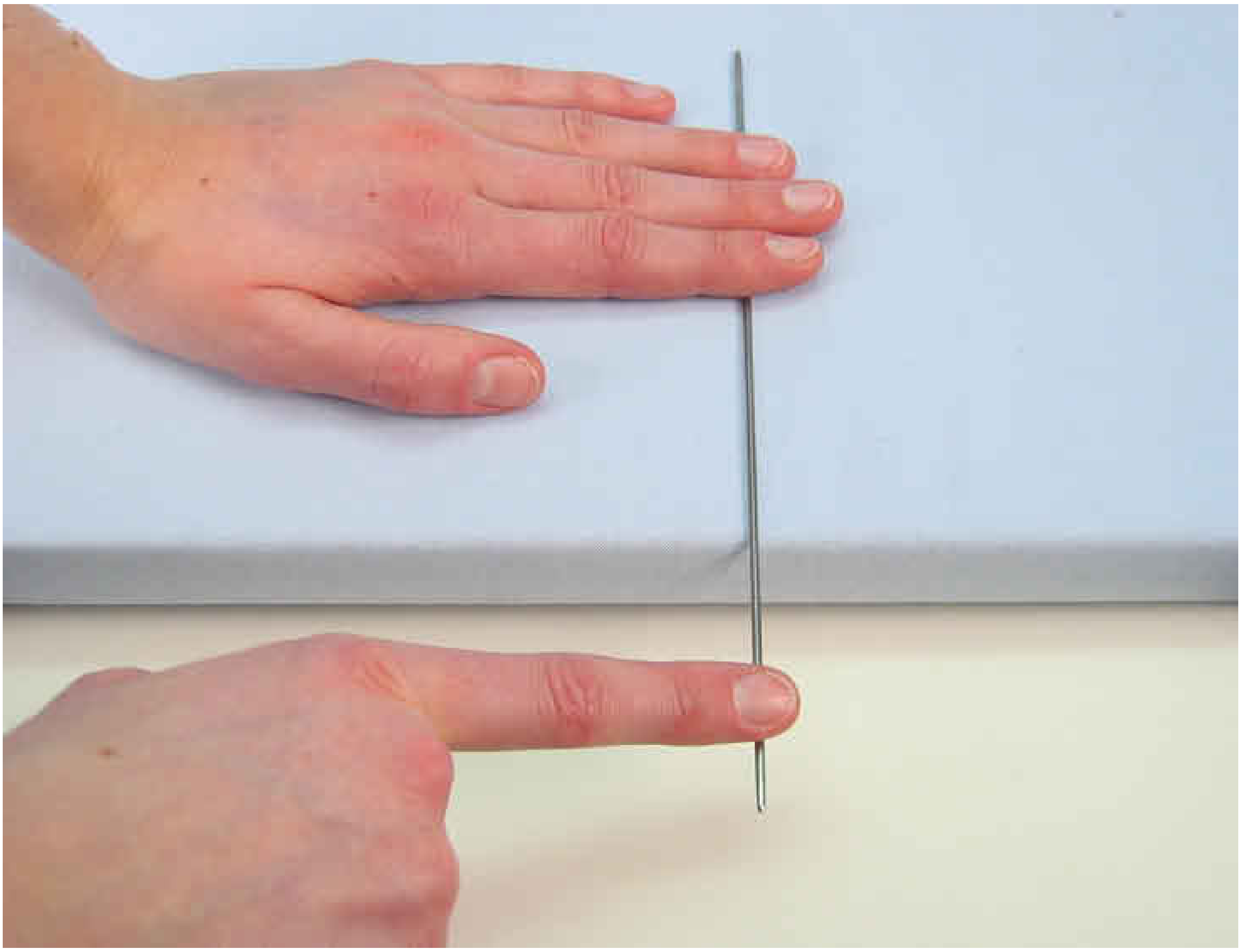
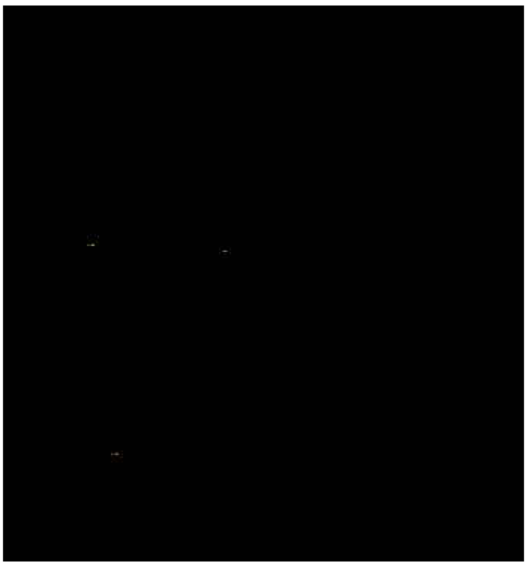


Fig. 2

Observations

1. What can you hear when the ruler is brought to oscillate? What happens when you draw it back towards the table?

2. How do the oscillations visibly change?



Evaluation

1. Explain how the different tones are caused.

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2. In which part of the ruler can you best make music and why?

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3. Which other objects could you use to make music?

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4. How does sound get into your ear?

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(Can you make music with a ruler and a knitting needle?)

Material

Bottles, glasses, plates, balloons, water

Observation

1. When the ruler vibrated, a tone could be heard until the oscillation came to an end. Moving the ruler back over the edge of the table caused the tone to change.
2. The further the ruler protruded over the edge of the table, the greater the deflection of the oscillations. When only a little of it was protruding, it had smaller oscillations.

Evaluation

1. When the ruler or knitting needle is brought to oscillate, the oscillations are transmitted to the air where they continue as sound waves. Lengthening or reducing the length of the oscillating part by drawing it across the edge of the table causes the tone to change.
2. The ruler sounds best when it is protrudes between 8 and 18 cm over the edge of the table because it swings best here. With a shorter protruding length, the oscillations do not keep going for long enough and the tone is dull. With a longer protruding length, one can no longer get a good hold on the ruler.
3. Glasses, plates, bottles (they give different tones when filled to different heights with water), balloons, felt pen and cartridge pen caps (blow in them), straws and many more.
   It could be a good idea to try out various "instrument" possibilities here and to discuss how each tone is caused.
4. The sound waves are carried further by the air until they reach the ear where there are special sensory cells which perceive sound.

Room for notes

How can you determine from where a sound comes?

Task

Test exactly how you can recognize from which direction a sound comes.

Material

1 Plastic tube
1 Knitting needle
1 Ruler

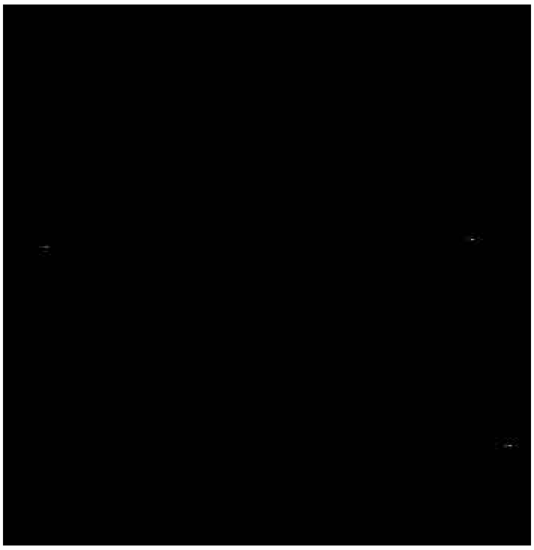

Fig. 1

Set-up and procedure

- Hold one end of the plastic tube at your ear and bring the middle part of the tube to be along your back.
- A classmate must now use the knitting needle to hit lightly against various positions on the tube. Try to recognize if the individual hits were more to the side of your right ear or of your left ear.
- The position on the tube which you think is in the middle is to be marked. Check the lengths to each tube end to determine how exactly the actual middle corresponds to where you thought it was.

Observations

1. What did you feel when hits were made on various parts of the tube?

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Deviation from the middle (in cm): ....

Evaluation

1. Explain what you could recognize when the hose was hit.

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2. Why does one need both ears to perceive from which direction a sound comes?

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(How can you determine from where a sound comes?)

Observation

1. The sound of the hit was sometimes heard as being to the right and sometimes as being to the left, although the sounder was not louder at the right ear than at the left ear.

Evaluation

1. When a hit was made nearer to the right ear, the sound had to travel a shorter distance to the right ear than to the left ear and so reaches it more quickly.
   The corresponding time difference is what makes it possible to determine from where the sound comes.
   When a hit was made on the middle of the hose, the sound needed the same time to reach each of the two ears. There is no time difference and the sound is perceived as being the same distance away.
2. The direction from which the sound comes can be recognized because the sound reaches the ear which is turned towards the source of the sound quicker than the other ear. If one can only hear with one ear, such a difference cannot be determined.

Room for notes

How does the eye change in the dark?

Task

Look at an eye in a mirror and examine how it behaves in the dark.

Material

1 Mirror

Pencil
White paper
Scarf or cloth for blindfolding

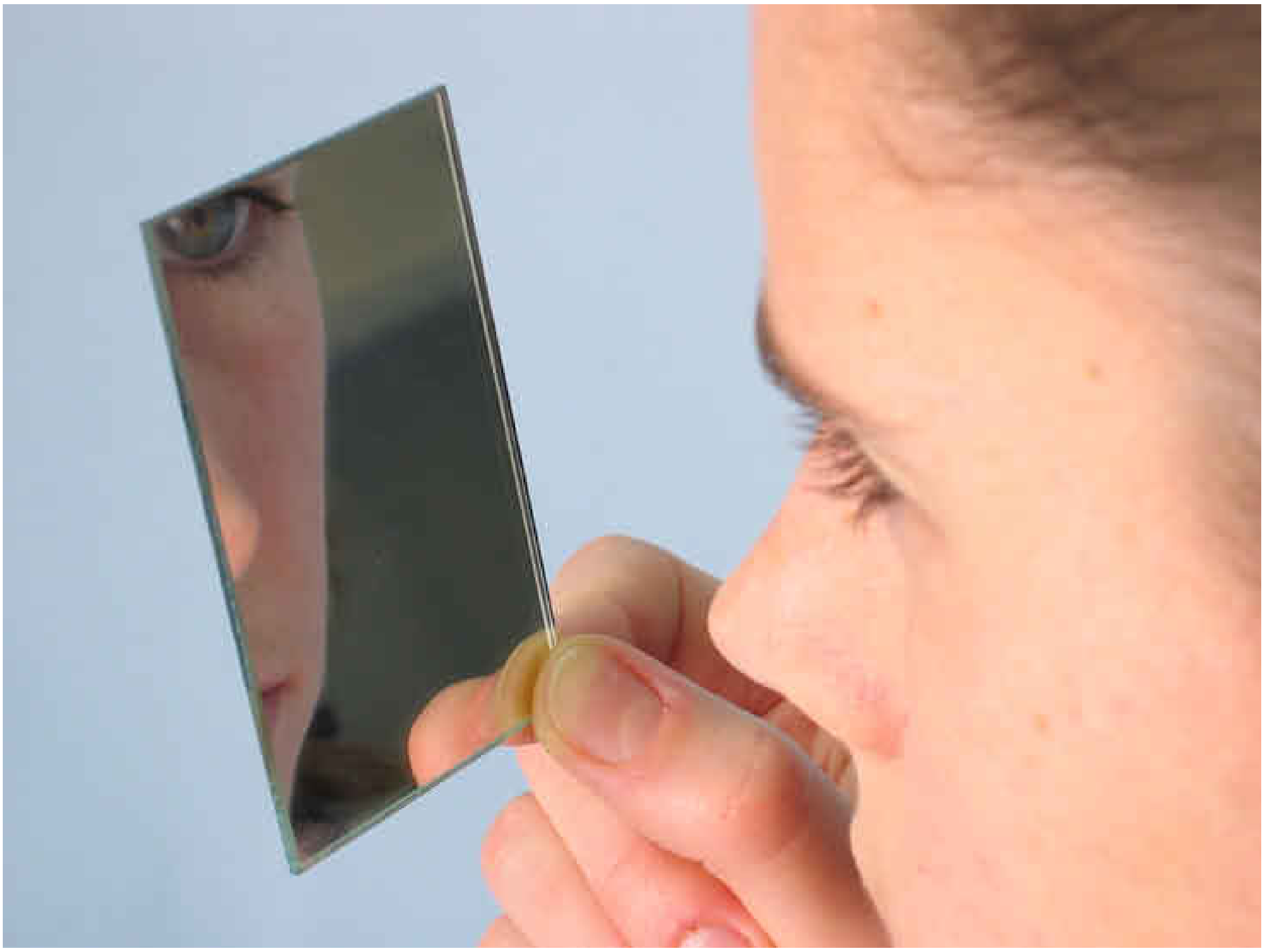

Fig. 1

Set-up and procedure

- Look at one of your eyes in the mirror and make a drawing of it as accurately as you can.
- Carefully draw one of your lower eyelids downwards. What can you see on the edge of the eyelid towards your nose? Lift up one of your upper eyelids. What do you see?
- Let someone blindfold you then wait several minutes. Take the blindfold off and look immediately in the mirror. What do you observe?

Observations

1. What did you discover on the edge of the eyelids in the vicinity of the inner corner of the eye?

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2. Which observation did you make as you suddenly exposed your eye to light after dark?

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Evaluation

1. Label the various parts of the eye in the drawing with the following terms: Eyebrow, eyelashes, lower eyelid, upper eyelid, iris, pupil and dermis.
2. Write in the purposes which the various parts of the eye fulfil.

Eyebrows: ....

....

....

Eyelashes: ....

....

....

Eyelids: ....

....

....

Iris: ....

....

....

Pupil: ....

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Dermis: ....

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Lacrimal openings...

....

....

3. Explain why the eye changes in the way it does when it is exposed to light directly after dark.

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(How does the eye change in the dark?)

Observation

1. There are point-shaped openings at the edges of the upper and lower eyelids (lacrimal openings).
2. That the still widened pupil was quickly contracting to a small, black circle.

Evaluation

1.

2. **Eyebrows:** Lead off sweat and rain
   Eyelashes: Also prevent drops of sweat or rain from reaching the eye
   Eyelids: Protect against dazzling light and from foreign particles. They blink to distribute lachrymal fluid which keeps the eyes moist and rinses away dust and pathogens.
   Iris: Coloured skin which can contract or expand according to the incidence of light
   Pupil: Circular hole in the iris which can change its size.
   Dermis: Stabile white skin which envelopes the eye and is responsible for the shape of it. It is transparent in the area of the pupil
   Lacrimal openings: These collect lacrimal fluid which is formed in the glands above the eye and lead it into the lacrimal sac in the inner corner of the eye, from where it is led through the lacrimal canal.
3. The pupil is opened wide in the dark so that as much light as possible comes into the eye to generate a picture on the retina. The brighter the light, the greater the contraction of the pupil, as too much light could cause damage to the retina. Contraction and expansion is brought about by muscle fibres which run radially in the iris.

Room for notes

What does the eye see sharply?

Task

Examine in which region you can sharply see.

Material

2 Marker pens (black and red)
1 Ruler

Fig. 1

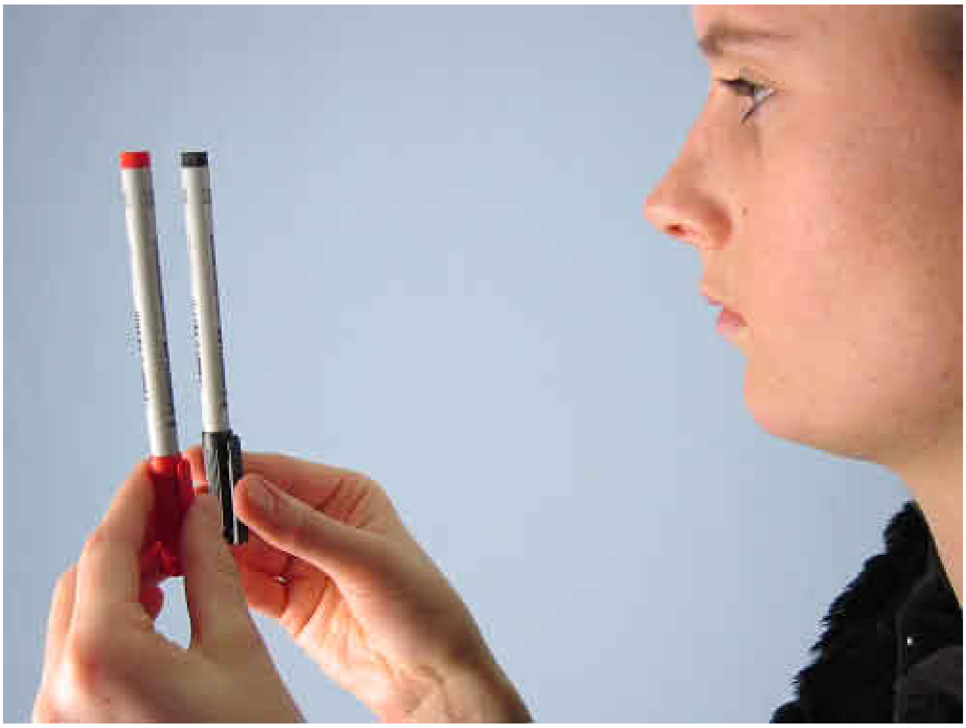

Fig. 2

Set-up and procedure

- Hold the black pen 20 cm away from your eyes and the red one with your other arm stretched out in the same direction of vision (Fig. 1).
- Look alternately at the back and the red pen. What do you notice?
- Now hold the red pen alongside the black one but just a little distance away from it. Look alternately at the red and black pen without turning your head. Describe how you see the pens (Fig. 2).
- Close one eye and bring the red pen so near that you can just still sharply see the print on it. This is the near point. Measure the distance (Fig. 3).
- Look at the black pen while holding it in front of your eyes and do not change where you are looking. A classmate selects one of the coloured pens and leads it slowly from the side in your field of view. Say immediately when you see that it is approaching and when you can recognize the colour of the pen.

Fig. 3

Observations

1. What did you notice when you alternately look at the pen which is near and the one which is farther away?

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   ....

   ....

2. How did you see the pens which were held alongside each other when you looked at them alternately?

   ....

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   ....

3. Distance away of the near point:

   ....

4. What did you notice when a coloured object came nearer from the side while you looked straight ahead?

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Evaluation

1. What do the eyes see sharp and what out of focus?

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2. In which region can the eyes recognize colours?

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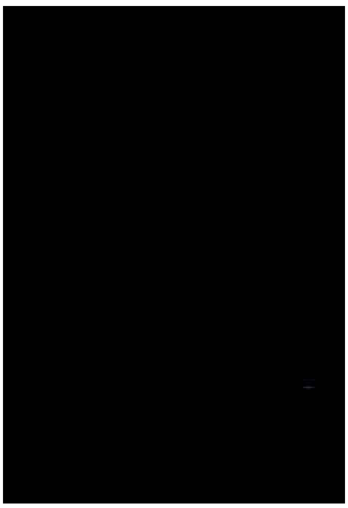

(What does the eye see sharply?)

Material

Bottles, glasses, plates, balloons, water

Observation

1. It was always so that only the pen which I was consciously looking at was sharp. The pens alternately changed from sharp to blurred or blurred to sharp when I looked back and forth.
2. Even when the pens were alongside each other I could only see one of then sharply.
3. The near point is age dependent. It is about 7 cm with ten year olds and about 25 cm with 45 year olds, for example.
4. I could first only recognize that something was coming nearer, the colour only became clear later.

Evaluation

1. Our eyes can only see an object clearly in a small region. They must adjust themselves to the correct distance, which is why one cannot sharply see near and far objects simultaneously. One also only sees objects sharply which lie in a middle region. To see something sharply which is at a side, the eyes must be turned to the corresponding direction.

Adjustment of the eyes to distance is named accommodation. Differently far distant objects are pictured on the retina by means of the crystalline lens of the eye. For this, the ciliary muscles change the shape of the lens and therefore also the refractive power of it. With relaxed ciliary muscles the lens is flatter and the eye is adjusted to far away. Contraction of the ciliary muscles leads to a greater curvature and so to a higher refractive power, whereby objects which are near are sharply imaged. Experiment D 4 is very suitable to demonstrate the effect of lenses with different curvatures.

The elasticity of the lens decreases with age. It can therefore no longer be so strongly curved and the near point becomes more distant.

The retina on which the image is formed contains visual cells which transmit the perceptions to the brain via the nerve tracts. Visual cells are particularly numerous in the central fovea. This is why one sees objects in the middle most sharply.

2. Colours are better recognisable the more they are in the middle region. One can only see black and white at the edge of the field of vision.

Different types of visual cells are required for black-and-white television and for colour television. The colour-sensitive cones are situated in the central fovea and the number of them is reduced outside of this. The rods are situated in the side regions of the retina.

Room for notes

How can you reproduce a candle on a white background?

Task

Use a magnifying glass to generate the picture of a candle on a screen.

Material

1 Magnifying glass
1 White card
1 Tea warmer candle
1 Ruler
Storage box

Matches or lighter
Handkerchief

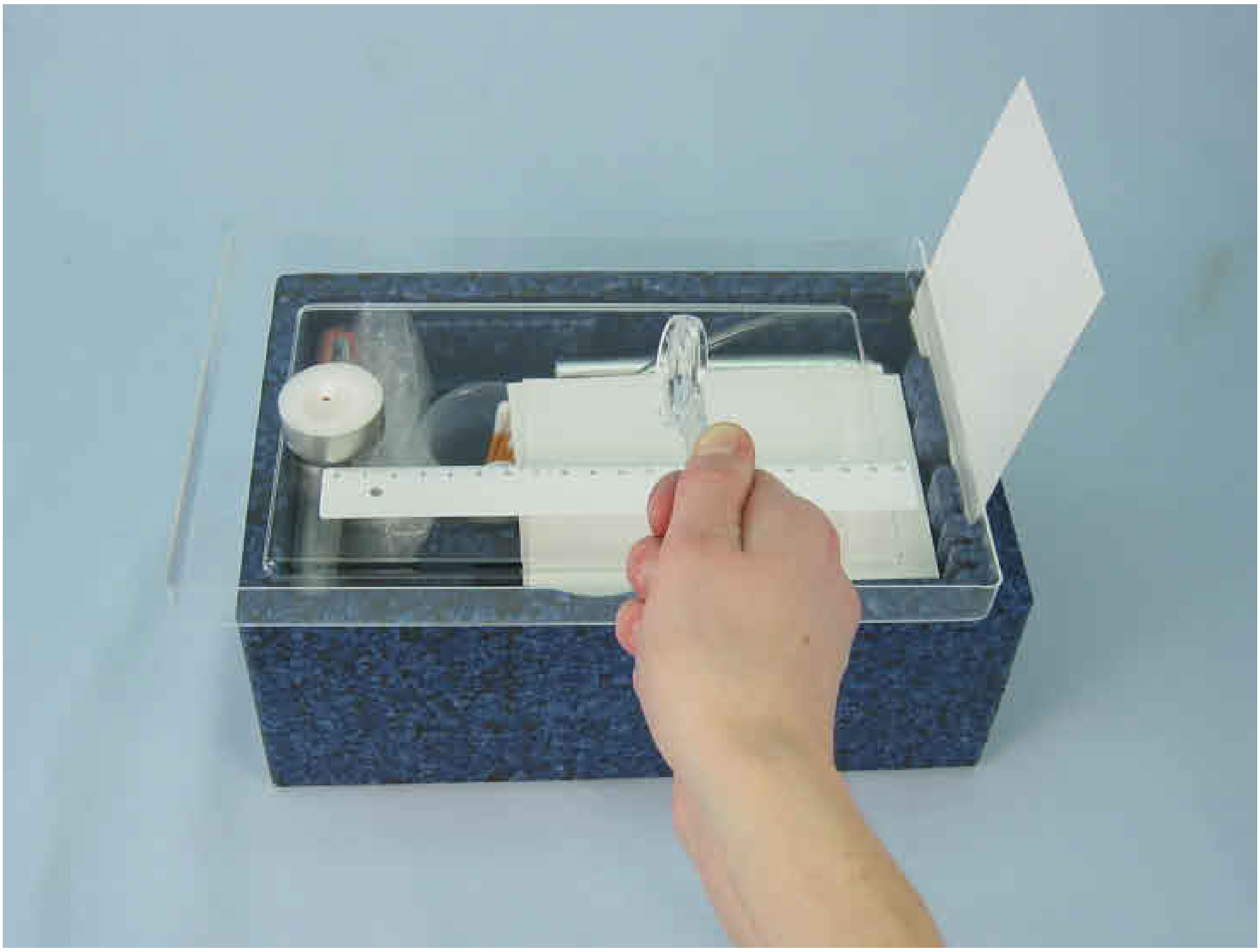

Fig. 1

Set-up and procedure

- Set up the experiment as shown in Fig. 1.
- Push the candle to the edge of the depression in the cover.
- Position the ruler between the candle and the screen so that the zero marking lines up with the wick.
- Light the candle.
- Hold the magnifying glass in front of the candle and move it slowly towards the screen.
- Describe what you observe at different distances from the candle.
- Wrap the magnifying glass in a handkerchief and feel the shape of its lens through the cloth.

Observations

1. What did you observe as you held the magnifying glass between the candle and the screen and then moved it towards the screen?

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2. What is the shape of the lens of the magnifying glass?

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Evaluation

1. Compare the experimental set-up with the structure of the eye. Which parts in the set up correspond to which parts of the eye? Make use of the drawing of a cross section of the eye for this.

Fig. 2

Room for notes

(How can you reproduce a candle on a white background?)

Material

Matches or lighter

Preparation

The effect can be better recognized when the room is darkened.

Observation

1. As soon as the magnifying glass was held in front of the candle there was a bright spot on the screen. Moving it towards the screen caused the spot to get smaller. At 8 cm distance from the candle an outline of an upside down flame could be seen. The picture of the flame was most sharp at approx. 12 cm distance and from then on became less sharp. A second picture was to be seen above the first one. At about 17 cm distance only light spots were to be seen which became larger and less sharp and finally merged into each other.
2. The lens is not flat but has a bulge in the middle to the outside.

This shape of a lens is named a convex lens. A convex lens is also called a converging lens.

The effect of various lens shapes can be demonstrated by practical demonstration D 4.

Evaluation

1. The lens corresponds to the lens of the eye, the screen the retina, the upside down image on the screen the image on the retina.

Eyes also perceive objects with different degrees of sharpness according to their distance away. The eye can adjust to the different distances, however.

The image on the retina is upside down, just as it is on the screen. It is processed in the brain so that we see the world the right way up.

Room for notes

Blind spot

Why does everyone have a blind spot?

Task

Find your blind spot.

Material

1 Blind spot card

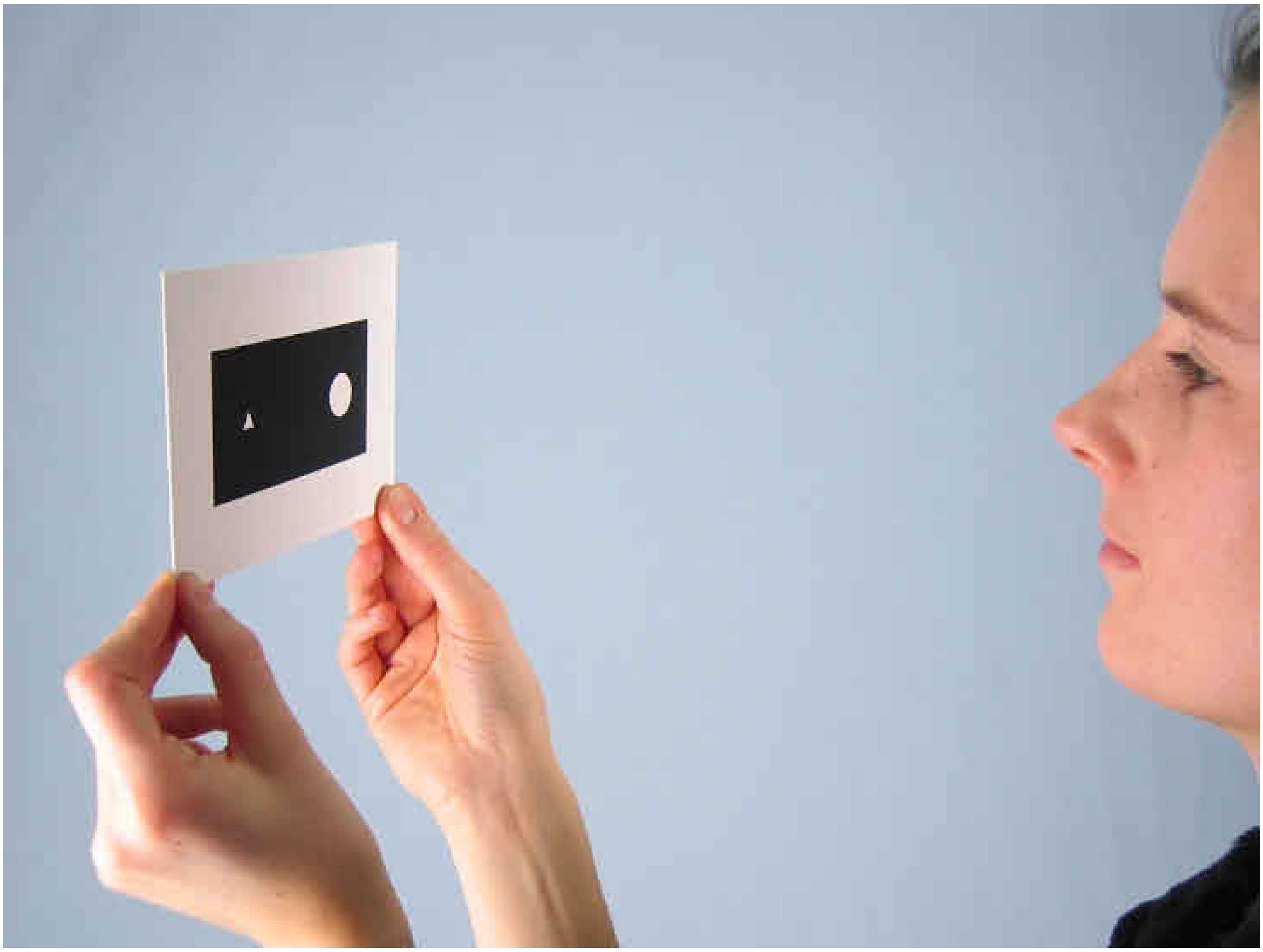

Fig. 1

Set-up and procedure

- Everybody has a spot on his or her retina at which no image can be formed. Proceed as follows to find your blind spot.
- Hold the card with the circle and triangle at a distance of 30 – 40 cm from your eyes. The circle should be to the right of the triangle.
- Close your right eye, or cover it with a hand, and look at the circle with your left eye. You can still see the triangle at the side but it is somewhat blurred.
- Now slowly bring the card towards the left eye while you keep looking at the circle. What happens?

Observations

1. What do you notice when you brought the card towards your eye?

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Evaluation

1. Look at the structure of the eye. At which position do you think the blind spot could be?

2. Explain what happened while you were bringing the card towards your eye.

Fig. 2

Room for notes

(Why does everyone have a blind spot?)

Observation

1. The triangle disappeared at a certain distance from my eye. It came back again when I moved the card further.

Evaluation

1. There is a position on the retina at which the optic nerve exits. There are no visual receptors there, so that no image can be generated at this spot.
2. The image on the retina changed as the card came nearer to my eye. The circle which I was looking at stayed at the position of sharpest sight at the middle of the retina. The image of the triangle wandered about on the retina, however, and was at sometime at the exit point of the optic nerve and so could not be seen. As the card came nearer, the triangle wandered on, away from the blind spot, and could again be seen.

Room for notes

Why does one need two eyes for good sight?

Task

Find why there is difference in your sight when you look with both eyes open or only one eye open.

Material

2 Knitting needles
1 Spatial sight card
1 White card

Fig. 1

Set-up and procedure

- Hold the two knitting needles out horizontally at eye level and about 30 cm from your eyes, so that their tips are at a distance of 20 - 30 cm from each other and point towards each other.
- Close one eye and move the tips rapidly together to bring the tips to touch each other. Did you manage this?
- Repeat this procedure with both eyes open. What do you notice?
- Put the spatial sight card on the table and position the white card between the two drawings.
- Hold the white card so up that you can only see one of the drawings with each eye, then look at the drawings first with one eye open, then with the other eye open.
- Now look in the direction of the drawings with both eyes but try to adjust your eyes not to look at them but through them. To do this, direct your sight as though you are looking at an object which is far away directly behind them. What do you perceive?
- Successively close one eye then the other several times. How does the drawing change?

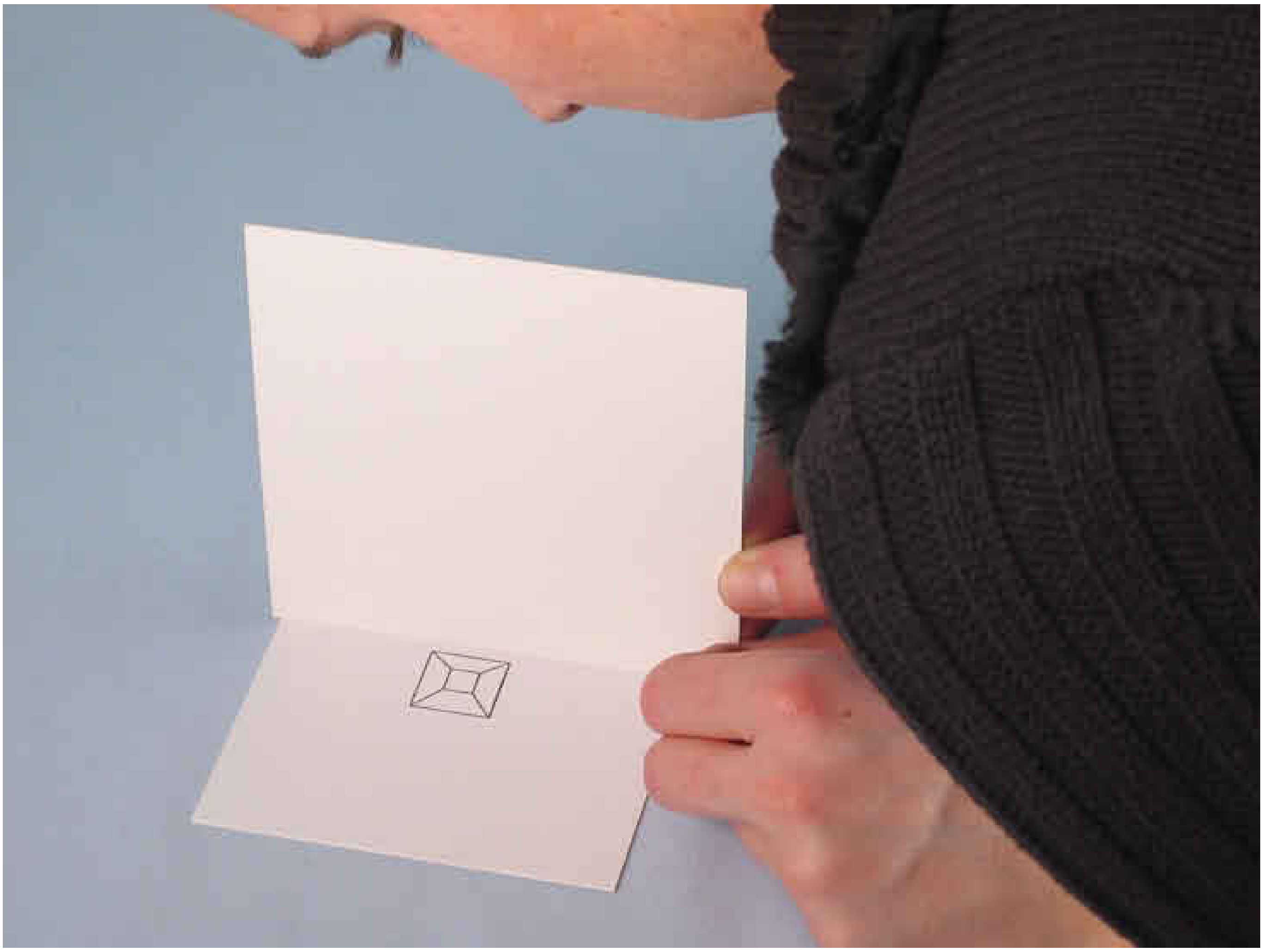

Fig. 2

Observations

1. What was noticeable as you tried to bring the knitting needle tips together?

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2. What did you perceive when you looked at the drawings on the card first with one eye and then with both eyes?

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Evaluation

1. Why is it so difficult to bring the knitting needle tips together when you are only looking at them with one eye?

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2. How does the spatial impression of the drawings on the card come about?

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Room for notes

[redacted]

(Why does one need two eyes for good sight?)

Observation

1. Looking with only one eye, the tips of the two knitting needles almost always miss each other when one tries to bring them together, but they can mostly be brought to touch each other when looking with both eyes.
2. When looking at the drawings from above with both eyes open, the perception was of a four-sided stump of a pyramid. This spatial impression was not given when looking at it with one eye and only one of the drawings can then be seen.

Evaluation

1. One needs both eyes open to be able to judge positions of objects, i.e. to decide with certainty which object is nearer and which further away.
2. Each of the two eyes sees a drawing. When one looks at them with both eyes they merge into each other and a spatial image is seen.

When two objects are looked at with both eyes, each forms an image on the retina. These images are not separately perceived, however, as they are on corresponding parts of the retina, so they merge to a single impression. As each eye sees the object from a slightly different perspective, the images are slightly different and a spatial impression is given.

Room for notes

How can you trick your eyes?

Task

Determine if you always perceive a realistic picture.

Material

2 Optical illusion cards
1 Ruler
1 Scissors
1 Piece of string
1 Knitting needle

White cardboard

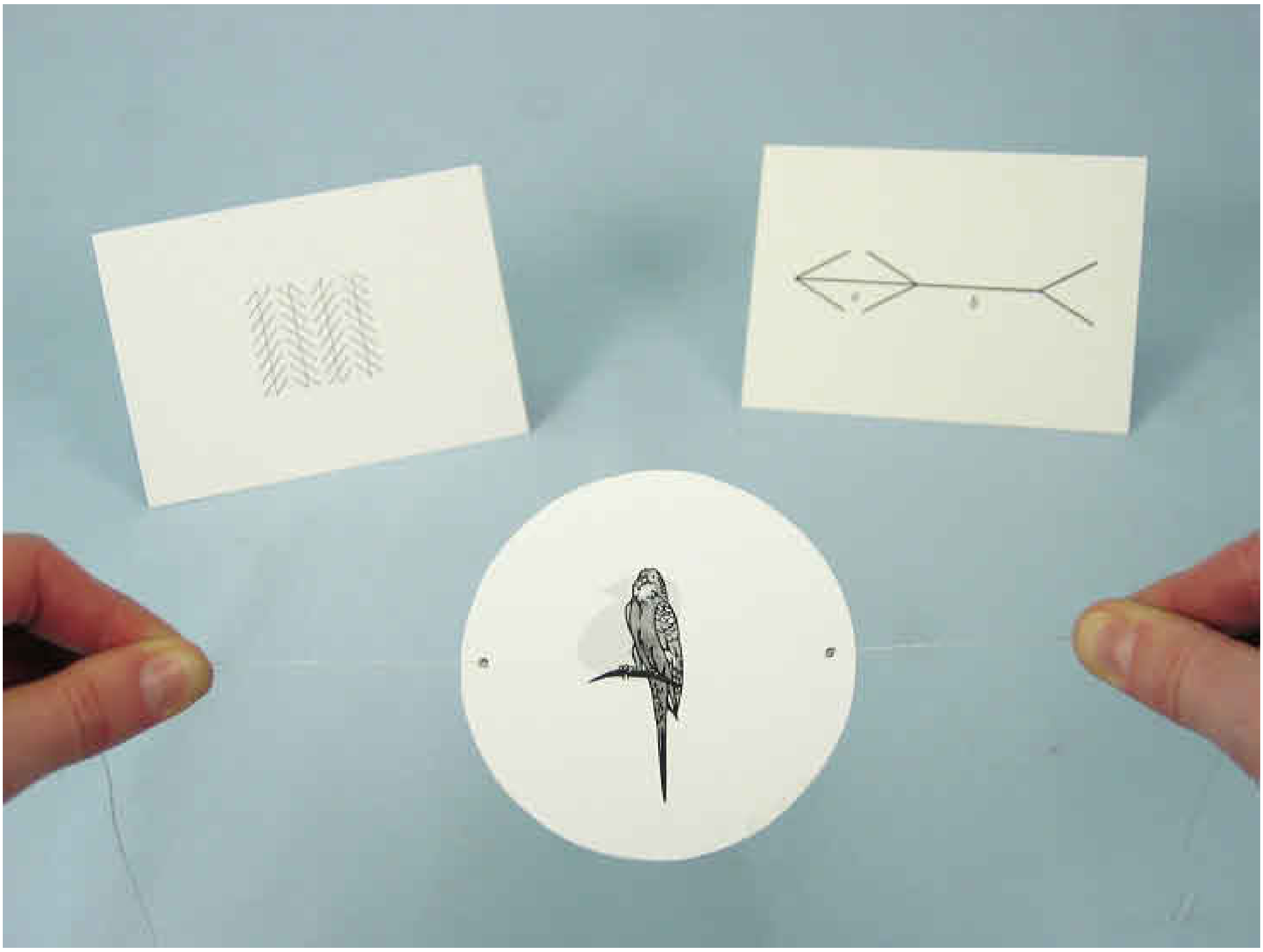

Fig. 1

Set-up and procedure

- Take a look at the card with the lines which are labelled "*a*" and "*b*".
- Estimate whether line *a* or line *b* is longer.
- Use the ruler to measure the two lines.
- Now look at the card with the four lines alongside each other which have sloped hatching.
- Which of the four lines are inclined to the right and which to the left?
- Use the ruler again to check your impressions by first measuring the distances between the top ends of the lines, then the distances between the bottom ends of them.
- Cut a round disc out from the white cardboard.
- Use the knitting needle to poke holes in the left and the right of the disc. Thread a piece of string through these holes.
- Draw a bird cage on the front of the disc and a bird on the back of it (or a man with an umbrella on the front and rain on the back, or similar), whereby the drawing on the back must be upside down with regard to the one on the front.
- Hold the two ends of the string and whirl the string around so that it winds up.
- Now draw on the ends of the string so that the disc rapidly revolves.

Observations

1. Which line appears to be longer: Line a or line b? What did you determine with the ruler?

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2. Which of the lines is inclined to the left and which to the right and what did you determine with the ruler?

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3. What was to be observed as the disc rapidly revolved?

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Evaluation

1. How can you explain your estimation of the lengths of lines a and b?

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2. What causes the impression of inclined lines?

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3. Explain your impression as the disc rapidly revolved.

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4. Which technology exploits this optical illusion?

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Room for notes

(How can you trick your eyes?)

Observation

1. Line a appeared to be shorter than line b, but measurement showed that they were both of the same length.
2. The four lines appear to be alternately inclined to the left and right, bur measurement showed that the lower and upper ends were all at the same distance from each other.
3. The bird appeared to be perched in the cage and the man with the umbrella to be standing in the rain.

Evaluation

1. Line a appeared to be shorter because of the angles directed into it. They led one to look at the inside of the line. Line b is the opposite because the angles lead outwards and one's look is automatically led to the outside which makes the line appear to be longer.
2. The eye is distracted here by changing inclined hatching. More room seems to be required for the hatched lines in the direction in which they are pointing and the parallel lines seem to be pressed away from each other. The room between the four parallel lines appears to be narrowed in the other direction.
3. When the eye is exposed to pictures in quick succession it can no longer perceive the individual pictures as being separate. This is why the back and the front of the disc appeared to show a single picture.
4. This illusion is used in the film industry.

One has the impression that there is a sequence of movements, whereby in reality one sees numerous individual pictures which differ in that a moved object successively moves a little bit further. As the pictures are seen in a rapid succession, one really believes that the object moves. In cinemas, pictures are shown at a rate of 32 – 36 per second, whereas in television 50 pictures are transmitted per second.

Room for notes

We not only breathe through our noses but also take in smells with them which are then analysed by our brains. The olfactory mucosa above the upper nasal concha is the actual olfactory organ. This region is distinguished by its yellow to brown colour. The size of it is only about 2 x 5 cm², whereas that of a dog is 2 x 25 cm². It contains sensory cells which specialise in the perception of small molecules, each of which only responds to a single smell particle. We humans have 347 different cells, dogs and rats have more than 1200 of them.

Material

1	Beaker, low, 400 ml	46055-00
1	Glass rod	40485-03
1	Butane burner for cartridge	32180-00
1	Retort stand	37694-00
1	Ring with boss head	37701-01
1	Universal clamp	37718-00
1	Right angle clamp	37697-00
1	Wire gauze, ceramic cen.	33287-01
1	Lab thermometer	38056-00

Aromatic oil
Water

Fig. 1

Set up and procedure

- After setting up the apparatus as shown, heat the water up to about 80°C.
- Drop a few drops of aromatic oil in the hot water in the beaker.
- Now request the students to signal when they can smell the smell which is given off.
- Note in which succession the smell is perceived at the various parts of the room.
- Discuss how the smell spreads out in the room.

Observations

The smell spreads out slowly in the room. The further away a student is from the beaker, the later he or she perceives it.

Evaluation

The smell spreads out in air as an invisible, gaseous substance which, as soon as it reaches a nose, is taken up by the sensory cells in the olfactory mucosa and recognized as a stimulus.

Our sense of touch enables us to feel weight differences of down to a few thousandths of a gram. The Meissner's and Vater's corpuscles which are to be found in the dermis and the free nerve endings in the epidermis act as contact stimuli receptors. The denser the receptors are, the more sensitive skin is at this position. A pair of dividers is to be used here to examine how far apart stimuli must be to still be felt as being separate.

Material

1	Dividers, nickel-plated	64857-00
1	Ruler, plastic, 200 mm	09937-01
	Scarf or cloth for blindfolding	

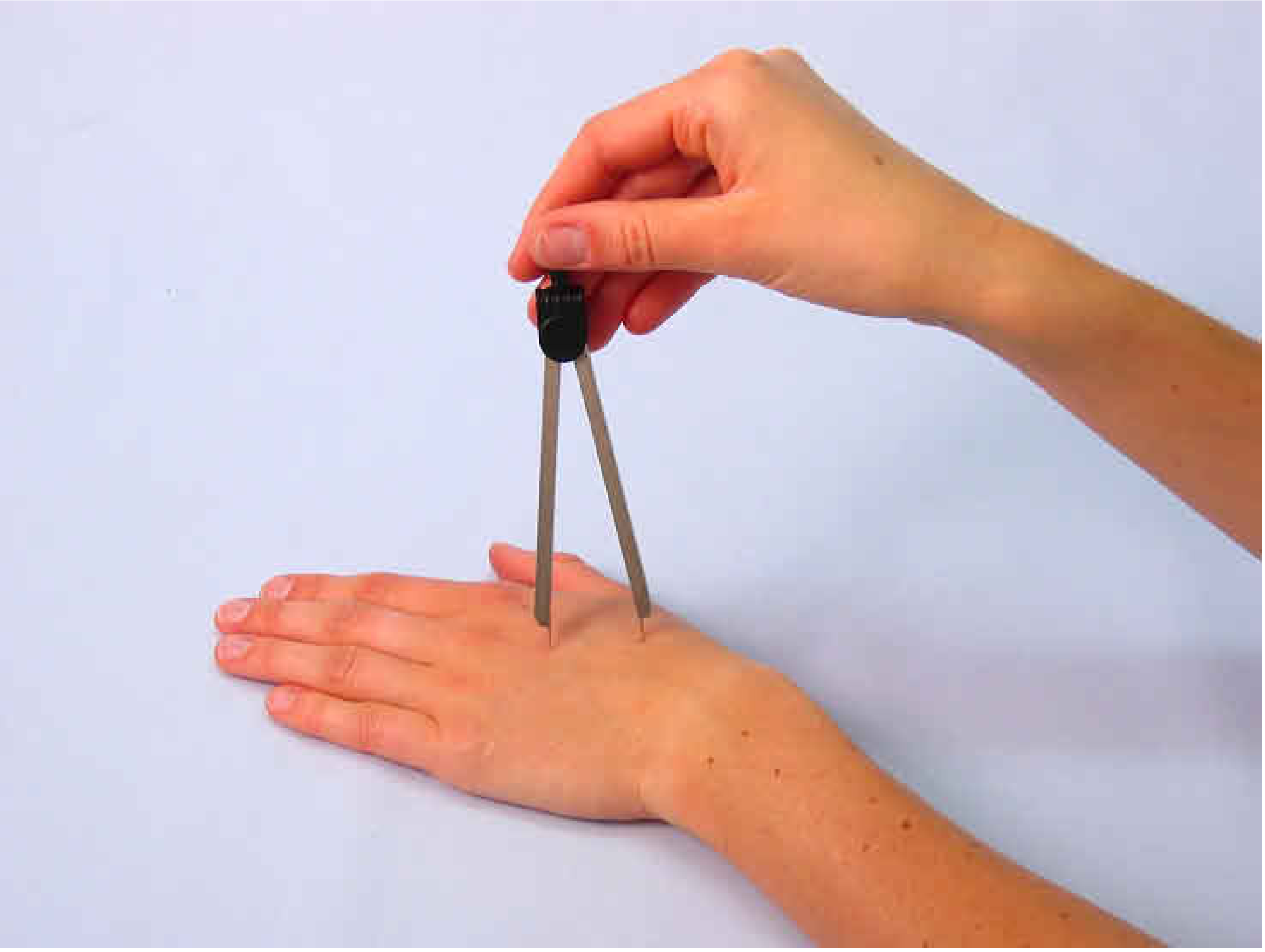

Fig. 1

Set up and procedure

- A test person is to be selected and blindfolded.
- Open the dividers to be about 5 cm apart.
- Touch the back of the hand of the test person with either one or both of the tips several times. The test person is to say each time how many tips he or she felt.
- Close the dividers in steps of 0.5 cm and repeat the test with each width.
- Carry out the same procedure on the forearm and at a fingertip but begin now with a 1.5 cm divider width.
- Record the results of the experiment.

Observations

At the back of the hand, contact stimuli are no longer felt to be separated from less than 3 cm on, at the forearm this distance is 4 cm and at the finger tip less than 2 mm.

Evaluation

The experiment demonstrates that touch receptors are distributed at different densities in the skin at different parts of the body. Fingertips have the most receptors.

Meissner's corpuscles are receptors for sensations of being touched. They are in the dermis and consist of cross layered sensory cells with spiral nerve fibres.

Vater's corpuscles react to pressure, stretching, vibrations and shaking. They switch themselves off under continuous pressure and consist of layered lamellar corpuscles with spaces between which are filled with liquid.

The intraepithelial nerve endings are sensory nerve fibres which trigger feelings of warmth, cold, contact and pain.

The movement of cork dust particles after a sound wave was radiated in can be observed in Kundt’s tube. Because of reflection at the closed end of the tube, there are positions at which there are powerful air movements and others at which there is no movement. The result is the formation of a pattern in the cork dust.

Material

1	Kundt's apparatus	03475-88
1	Rubber stopper	39260-00
1	Tuning fork,1700 Hz	03423-00
1	Striking hammer	03429-01
1	Retort stand	37694-00
1	Right angle clamp	37697-00
1	Universal clamp	37718-00

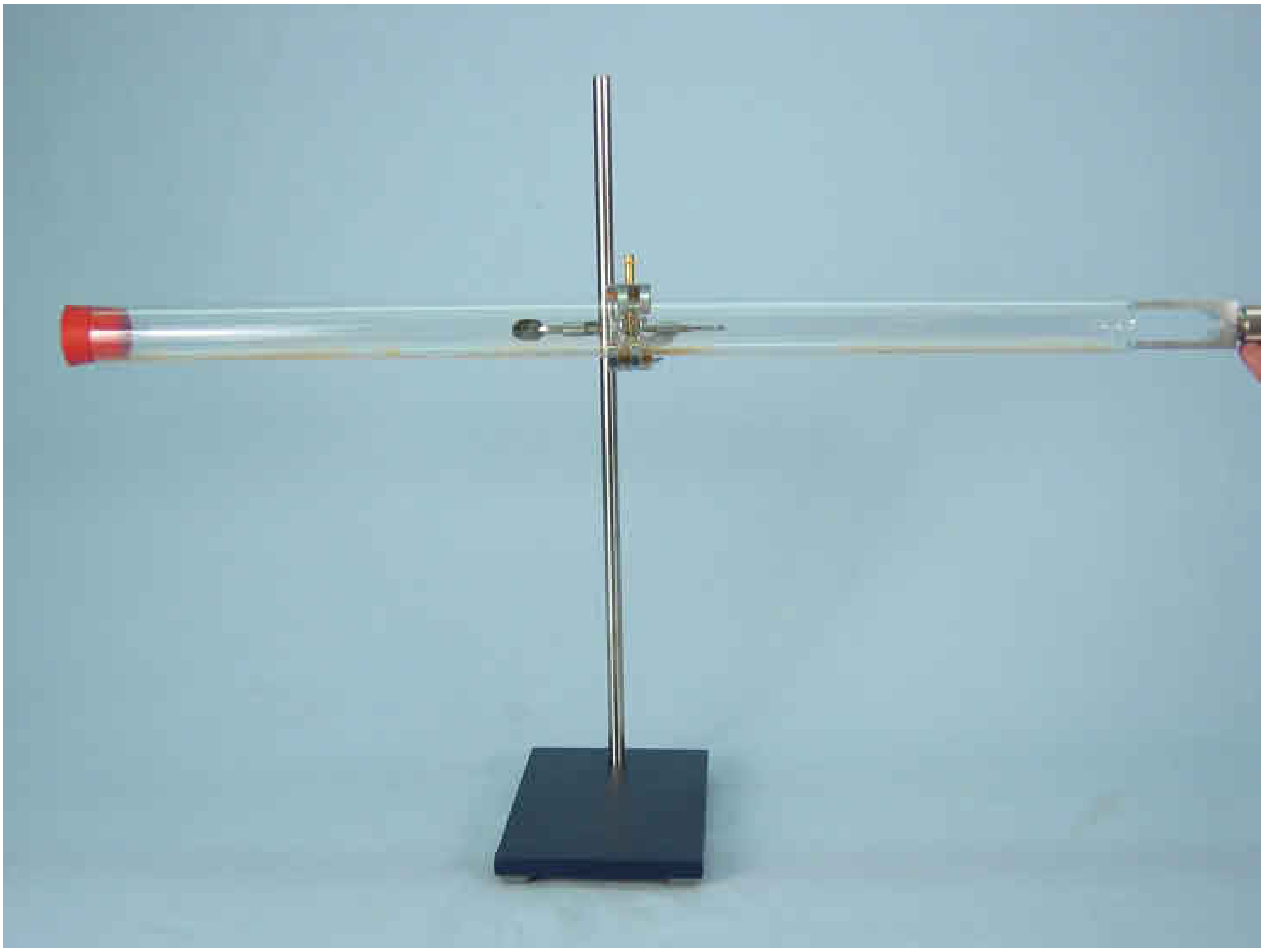

Fig. 1

Set up and procedure

- Fix Kundt's tube in position in the stand.
- Sprinkle cork dust evenly over the whole length of the filling strip and insert the filling strip in the glass tube.
- A rapid tip over of the filling strip now gives a thin cork dust layer in the tube.
- Close the tube at one side with a rubber stopper.
- Hold the tuning fork horizontally and very close to the open tube end. Powerfully hit the tuning fork with the striking hammer and observe the cork dust.
- To carry this procedure out a second time, turn the tube a little so that the cork dust again forms a closed strip.
- Kundt's tube can easily be cleaned freed of cork dust by once drawing the tuning bar the whole way through.

Observations

The cork dust is arranged in narrow lines lying alongside each other at a regular distance apart.

Evaluation

The cork dust particles have been brought to move by the vibrations of the tuning fork. As the tuning fork had no direct contact with the cork dust, the movement of it must have been passed on by the intermediate air. The movement of the cork dust has so made the movement of the air visible. This explains how you can perceive tones and sounds: The movement of a body causes the air to oscillate and the oscillations move further to your ear, where they are registered by your sensory cells.

When rays of light pass from one substance to another, they are refracted at the border between the two substances. This effect occurs, for example, when light in air meets a plastic or glass lens, or the light permeable tissue of the lens of the eye. Exactly how the light is refracted depends on the incident angle, the material and the shape of the lens.

The characteristics of light and the refraction of it at different interfaces are relatively complex phenomena. Here, the characteristics of convex and concave plastic lenses are examined in order to obtain indications of how the lens of the eye could function.

Material

1	Light box	09801-01
1	Power supply 12V / 2A	12151-99
1	Block,planoconvex lens	09810-04
1	Block, planoconcave lens	09810-05
1	Block, semicircular	09810-01

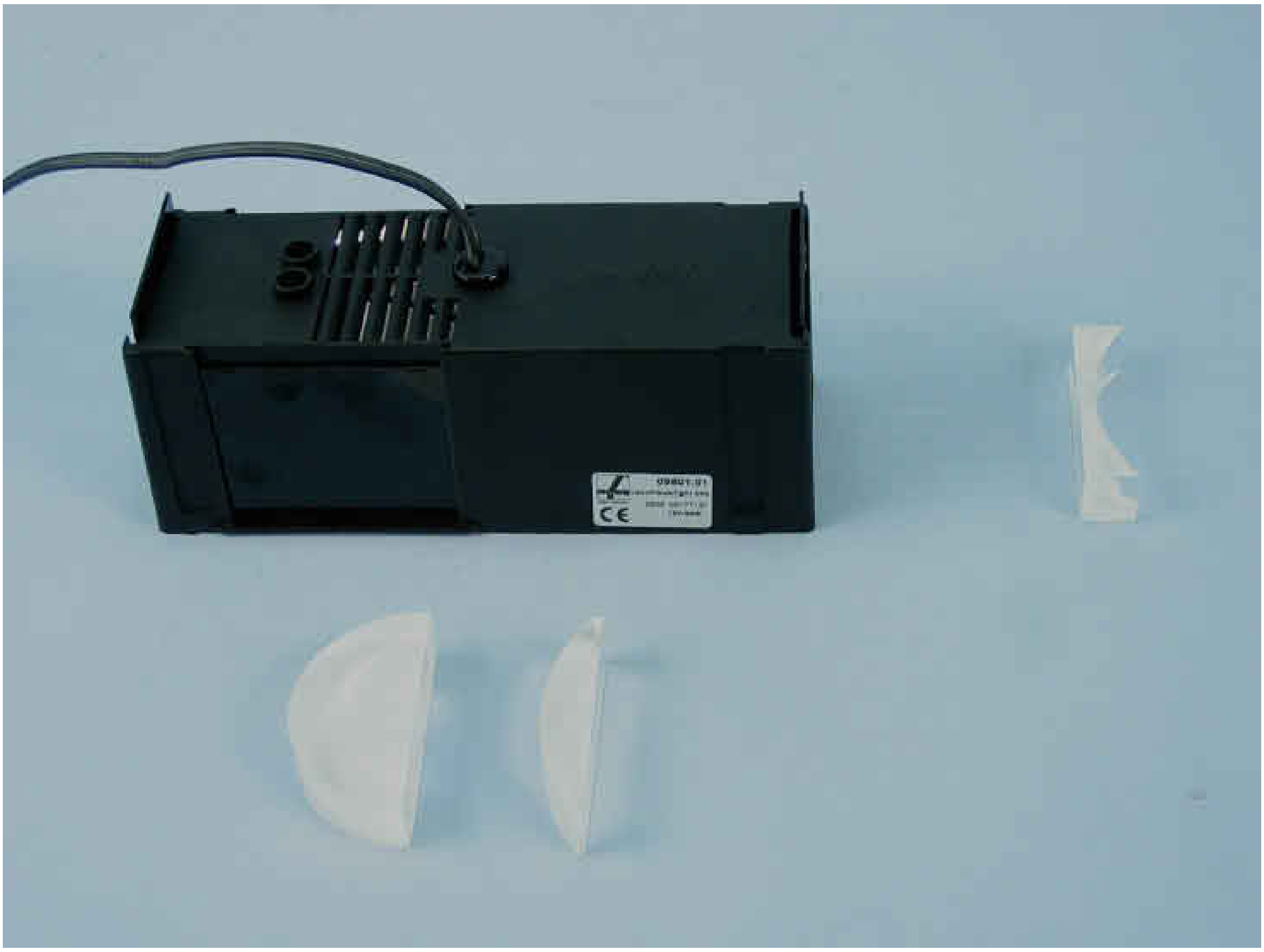

Fig. 1

Set up and procedure

- Position the five-slit screen in the light box at the lens side.
- Connect the power supply to the light box. Five parallel rays can be seen.
- Now position first the plano-concave model lens, then the plano-convex model lens in the path of the rays.
- Observe how the rays are displaced.
- Hold the greatly curved semicircular object body in the path of the rays. This can serve as model for the curvature of the lens of the eye during accommodation.
- Finally discuss the different types of diffraction of the light.

Observations

After passage through the concave lens, the rays of light are displaced outwards - scattered.

The convex lens causes the rays to converge at a point.

The greatly curved convex lens causes the rays to converge at a short distance behind that point.

Evaluation

Convex lenses cause light rays to converge at a so-called focal point. They are therefore named converging lenses. An image point is given at the focal point when the light rays come from an object. Numerous image points form a picture of the object. The lens used in experiment S 12 and the eye lens are converging lenses. The greater the curvature of a converging lens, the greater the light rays are diffracted and the shorter is the distance to the focal point. The curvature of the lens of the eye can be changed by small muscles and so be matched to different distances.

Concave lenses are called dispersing lenses. They have no focal point and cannot form an image of an object behind the lens.

The retina is the light sensitive layer in the eye on which there are different types of visual cells: The rods only measure the brightness of incident light, while the cones specialize on measuring the colour shares.

This experiment is to demonstrate the different photosensitivity of rods and cones.

Material

1 Figures / types and colours 64923-00

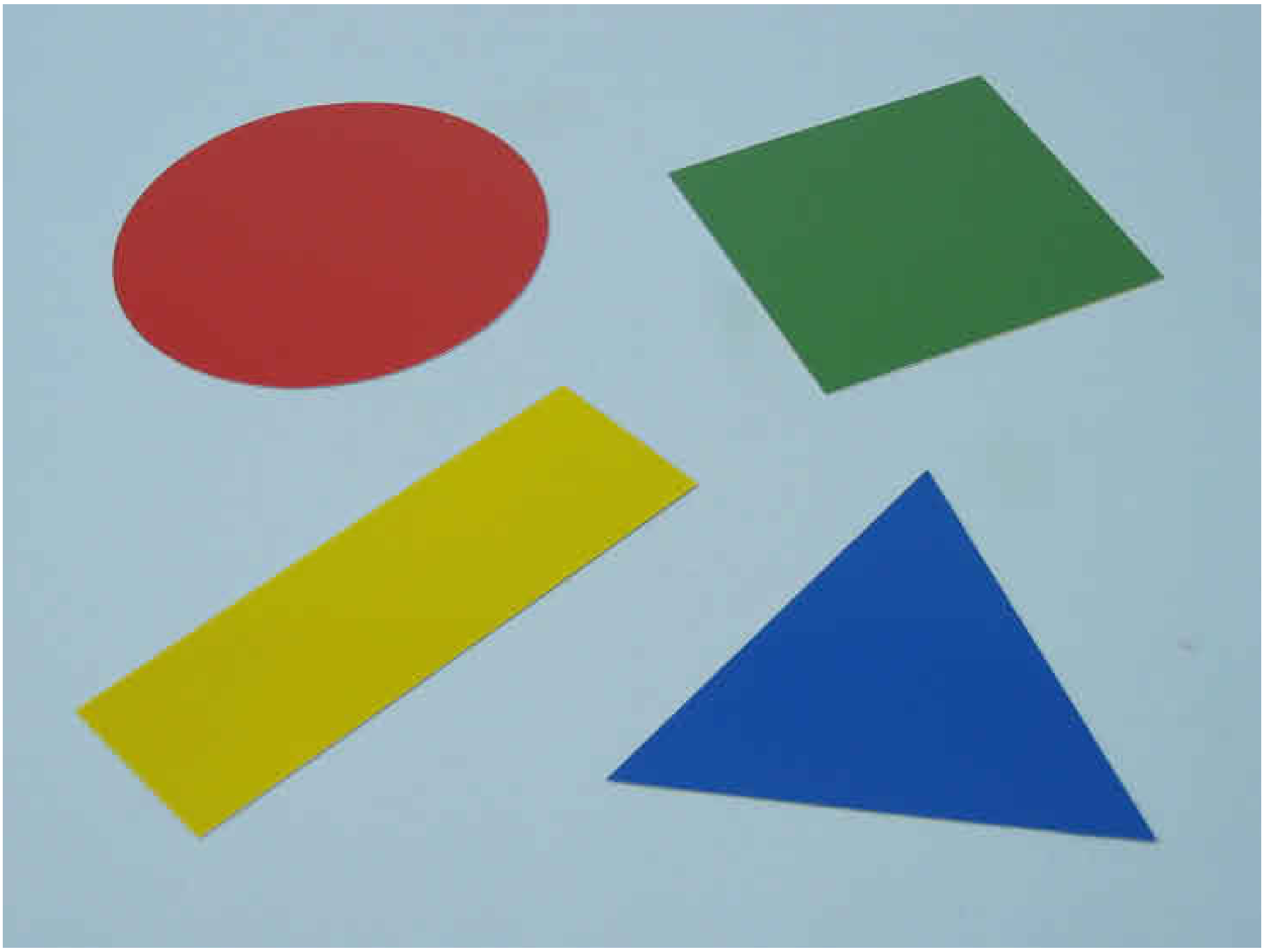

Fig. 1

Set up and procedure

- For this experiment the room must be darkened so that the outlines of fittings and furnishings can only just be recognised.
- Show the four shapes (quadratic, square, triangular, circular) and colours (red, yellow, green, blue). What is to be seen?
- Now stepwise lighten the room and observe in which succession which characteristics can be recognised.

Observations

Whereas the shapes can be recognised even at the greatest darkness, no impressions of colour can be seen. The various colours appear as various grades of gray tones. The colours are only recognised after slow brightening of the room.

Evaluation

Because of their high photosensitivity, rods also function at night and deliver simple black and white images to the brain even in the weakest light. This is why one can still recognise shapes in the dark.

The cones differentiate between colours. There are three cone types: Red-sensitive L-cones (L stands for Long wavelengths), green-sensitive M-cones (M stands for Medium wavelengths) and red-sensitive S-cones (S stands for Short wavelengths). Cones have such a low sensitivity that they can only function under good light conditions. At twilight and in the dark, their functionality is greatly reduced, so that the more sensitive rods must help out. As the rods are only sensitive to brightness, however, the ability to see colours is reduced with the coming of darkness. This is why you cannot recognise colours at night and all cats appear to be gray.

Rode and cones are not evenly distributed over the retina. The cones are concentrated in the area of the fovea, where the human eye sees most sharply. The cone density rapidly decreases away from this point. There are almost only rods at the edge of the field of vision. As cones function during the day and rods at night, one sees most sharply at the fovea region in the daytime but at the outer rod areas at night. Because of this, many people see less sharply at night as during the day and can only recognise some stars when they do not look directly at them.

