WEATHER

Changes in weather anywhere in the world affect our day-to-day life.

You will inquire weather elements and evaluate their impact on our everyday life.

Õppematerjal on valminud Tallinna Ülikooli Haridusinnovatsiooni keskuse projekti raames, 2021

Questions we are going to discuss:
What are weather elements?
What is the difference between weather and climate?
How does weather affect our everyday life?

You are going to do an investigation and a report about weather. You are going to conduct research about weather, measure the actual weather and compare it to the predicted weather or actual weather from previous years.

UNIT OUTLINE

Lesson 1: weather, reading weather maps, new vocabulary.

Lesson 2: air temperature, speed and direction of wind.

Lesson 3: precipitation, clouds.

Lesson 4: lesson outside, measuring the weather elements.

Lesson 5: planning the weather observation, giving feedback in groups, writing the introduction and method of the report.

HW: doing the observation independently.

Lesson 6: writing the results and conclusion of the report.

KNOWLEDGE AND SKILLS

Tick the box once you have acquired the knowledge or skill. Make sure you have ticked all the boxes by the end of the unit. If you need help, ask your teacher.

By the end of this unit you can:

- □ name weather elements;
- □ outline what temperature is and how it is measured;
- □ outline what causes wind and how it is measured;
- □ outline how clouds are formed;
- □ outline what humidity is and how it is measured;

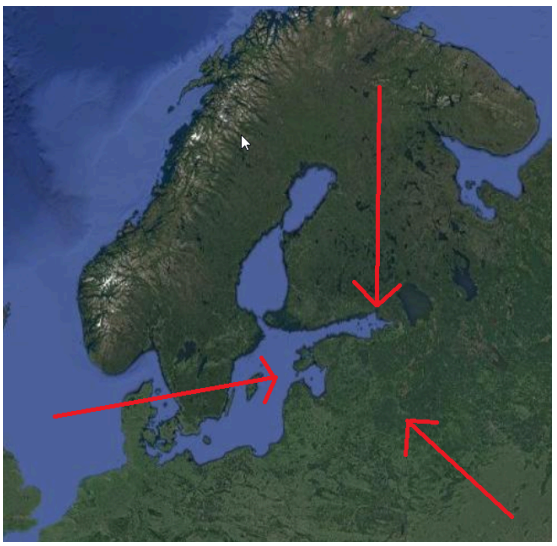
- □ describe how different types of precipitation is formed;
- □ outline a research question that connects with our topic;
- □ outline a testable hypothesis and explain it using scientific reasoning;
- □ outline how you manipulate variables and collect data;
- □ design a method for weather investigations;
- □ present collected and transformed data in tables and graphs;
- □ interpret collected data about weather to answer research question;
- □ discuss whether your hypothesis was correct;
- □ discuss whether your method was suitable to do this investigation;
- □ suggest improvements to the method.

WEATHER

What is weather? Weather is the current state of the atmosphere at a certain place and time. Weather conditions in the atmosphere can be observed. Weather is described by factors such as air pressure, temperature, humidity, cloud coverage, precipitation, wind and visibility.

Think! Use the terms from a weather report and describe the current weather. Do it again tomorrow and compare the conditions to each other.

Weather depends on the differences of temperature, moisture and air pressure between places**.** The differences cause air masses to move around and when one air mass is replaced by another, we get different weather. Sometimes this can happen in a couple of hours. Air masses that move from tropical regions to polar regions cool down over time and cold air masses formed in polar regions warm up and become more humid when they move towards the equator.



On the right you can see the different air masses that regulate the weather here in Estonia. From the west humid air masses that arrive from above the Atlantic Ocean have the biggest impact on our weather. In summer these air masses bring rain and colder temperatures and in winter they bring warmer weather and sleet. From the north wind usually brings cold air masses and in winter this may cause temperatures as low as -30°C. Air masses that come from Eurasian mainland bring dry air masses. In summer this means warm and sunny days and in winter these air masses bring crispy cold.

Think! Why do we need weather forecasts? Which professions depend on the forecasts the most?

Weather observations are made in **weather stations.** To describe weather with much precision, you need to know the numerical values of weather elements. These values can be measured with **weather tools**. There are about 30 weather stations in Estonia. All weather stations follow the same rules and measure at certain times to make sure all values are comparable. If we want to make forecasts, we also have to share data internationally. Meteorologists get a lot of data from the satellites and use complex computer programs to analyse data and make models and forecasts.

Research! Which weather station is closest to your home? What do people do there? Write the answers into your notebook.

Weather forecasts usually have a weather map included. Weather maps show the weather in different locations. These maps usually include temperature, wind direction and speed and cloud cover. Sometimes they also show air pressure, depth of snow, road conditions or water temperature. This information is important for people to plan their everyday life.

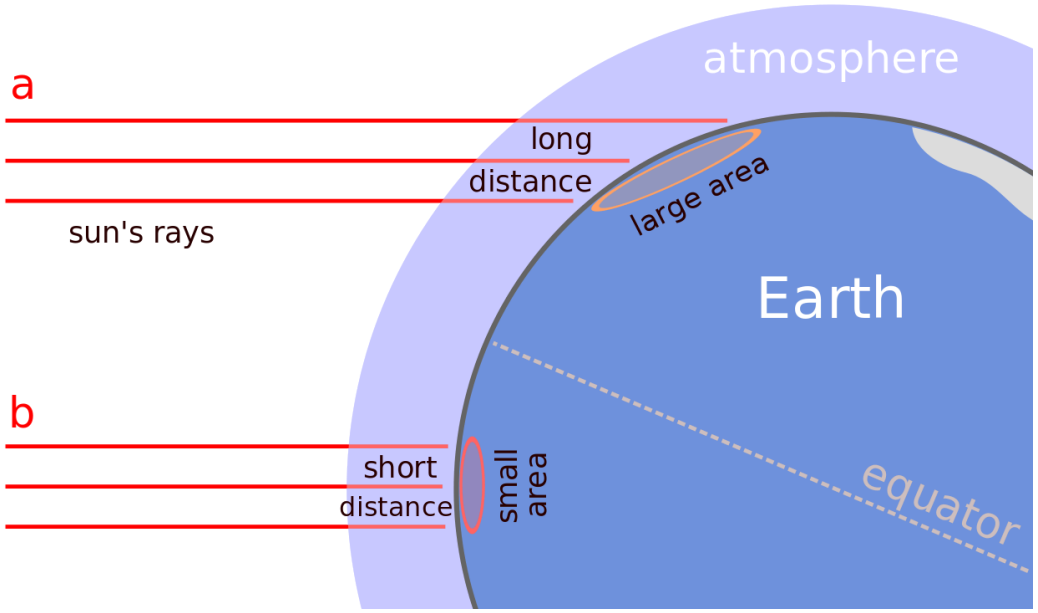
Practice vocabulary! Match the following terms with their definitions

TERM	DEFINITION
1. weather	**A** how hot or cold something is
2. climate	**B** rain or snow that falls to the ground
3. climate change	**C** a large area of air that has nearly the same temperature and humidity at any height
4. wind	**D** the way the Earth's average weather is changing
5. cloud	**E** the expected weather conditions
6. humidity	**F** a white or grey mass that floats in the sky, made of small water drops
7. precipitation	**G** the temperature or conditions outside
8. air mass	**H** a natural, fast movement of air
9. temperature	**I** a measurement of how much water there is in the air
10. forecast	**J** the weather conditions that an area usually has

AIR TEMPERATURE

Temperature is a measure of how hot or cold something is. An instrument that measures and displays temperature is called a **thermometer**. Some thermometers work based on **thermal expansion** but some thermometers are digital.

Air temperature is one of the most important **weather elements** that people observe. But why does temperature change so much? In the morning the sun is low above the



horizon and the sun's rays are at a low angle. The higher the angle of the sun's rays, the more heat is absorbed by earth. After a few hours it is a little higher already, at noon it is at its highest and then it begins to descend again. The height of the sun in the sky and the air temperature are closely linked. The same effect can be seen when seasons change. In summer the angle of the sun's rays is higher and therefore we get more heat. In winter, the angle is lower and we get less heat.

Source: Peter Halaszhttps://commons.wikimedia.org/wiki/File:Oblique_rays_03_Pengo.svg

Practice!

1. When is the angle of the sunbeams falling to the ground the highest?
    a. At sunrise
    b. At midday

c. At sunset

2. How does this affect temperature?

Sun's rays do not heat up air directly. Radiation from the sun heats up Earth's landmasses and oceans and heat is transferred to air from earth and water. The amount of radiation reaching the ground depends on whether the weather is clear or cloudy. Some of the solar radiation that passes through the atmosphere is absorbed by dust and airborne dust and does not reach the ground. Some of the solar radiation is **reflected** back from the clouds, dust and ground.

There are also differences in how land and water warm up. Land heats up and cools down much more easily than water. During daytime, land temperatures might change by tens of degrees, while water temperature changes by less than half a degree, i.e. it takes less energy to change the temperature of land compared to water. Water is usually of lighter color and reflects more light. Land is darker and absorbs heat. The water warms more slowly, because the waves mix water and take warm water deeper, and in addition, there is evaporation from the sunny water surface, which also needs heat. The land surface layer heats up fast and the air above it is usually warmer than above the water surface.

You have certainly experienced that on a hot summer day it is almost impossible to go barefoot on asphalt. That is because the dark color absorbs a lot of sunlight. The air above the asphalt is also very hot because the hot asphalt surface heats up air. The warmer the item is, the more heat it gives to the surrounding air. This is also the reason why people usually wear light clothing in hot climates. Lighter clothing absorbs less heat and makes it easier to tolerate the high air temperature.

Rising above ground, air becomes increasingly cool: the air temperature drops by an average of 6 °C per kilometer. Therefore, high mountain peaks are covered with snow even where the mountains are hot at the base year round.

Practice!

1. Fill in the gaps or underline the correct answer.

Radiation from the Sun passes through the _____, reaches the _____ of land and water and is _____ in it. Earth

and water warm up differently. Water warms up more slowly because

1) _____

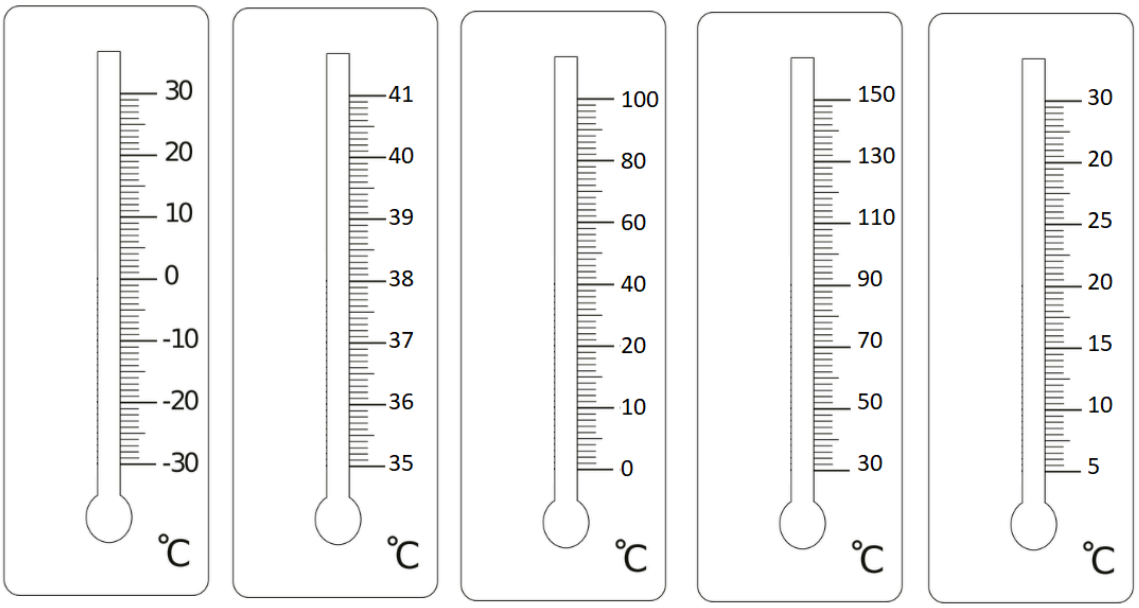
and 2) _____.

Earth warms up faster, so it can be claimed that some surfaces _____ more heat than others. This affects air temperature in different regions in the following way: _____ .

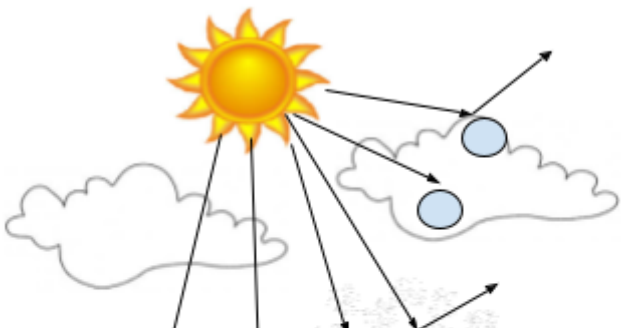
Darker color absorbs **more/less** sunlight. The warmer the surface is, the **more/less** heat it gives to the surrounding air.

The weather element directly dependent on the amount of light absorbed by the Earth is _____ . The height of the sun above the horizon affects temperature in the following way: _____ .

2. Connect the thermometer and the environment that can be measured with this thermometer. Draw the column of mercury and explain why you chose this certain level/height for the mercury column.



Indoor temperature Outdoor temperature Temperature in sauna
Body temperature Water temperature



Write the number of the process inside the circle.

1. Light is reflected from the dust particles in the air.

2. Light is absorbed by the dust particles in the air.
3. Light is reflected from the clouds.
4. Light is absorbed by the clouds.
5. Light is reflected from the ground.
6. Light is absorbed by the ground.

SPEED AND DIRECTION OF WIND

When looking at weather forecasts or planning events, we usually focus on what kind of air temperature is to be expected and whether rainfall will occur. But how hot or cold the weather feels, is also dependent on wind speed. Body loses heat to its surroundings during cold and windy days. That is why it is useful to look at the wind speed when deciding what to wear.

Wind direction also plays an important role in what weather will come. When it is said that a **northerly** wind is blowing, it means that the air is moving towards us from north. Storms are most frequently brought to the Baltic Sea by westerly winds. That is because the wind coming from the sea carries a lot of moisture. The northeasterly wind mostly brings cloudless sky with dry and cold air. Southerly wind brings warm air temperatures.

Wind speed and direction are especially important for sailors and pilots among other people. If there is a storm, smaller ships will remain in the harbor and aircrafts will not be allowed to take off from the airport. A storm can break trees, power lines, can lift roofs from houses and sink the ships at sea. Wind speed and direction affect our everyday boat connection between mainland and islands as well as with Helsinki and Stockholm. Heavy snowfall with strong winds can clog the roads and leave the cars in the snow.

To describe the observable effects of wind, a scale was developed in 1805 by Sir Francis Beaufort. Beaufort scale links visual effects with wind speed.

Force	Wind (Knots)	WMO Classification	Appearance of Wind Effects	
			On the Water	On Land
0	Less than 1	Calm	Sea surface smooth and mirror-like	Calm, smoke rises vertically
1	1-3	Light Air	Scaly ripples, no foam crests	Smoke drift indicates wind direction, still wind vanes
2	4-6	Light Breeze	Small wavelets, crests glassy, no breaking	Wind felt on face, leaves rustle, vanes begin to move
3	7-10	Gentle Breeze	Large wavelets, crests begin to break, scattered whitecaps	Leaves and small twigs constantly moving, light flags extended
4	11-16	Moderate Breeze	Small waves 1-4 ft. becoming longer, numerous whitecaps	Dust, leaves, and loose paper lifted, small tree branches move
5	17-21	Fresh Breeze	Moderate waves 4-8 ft taking longer form, many whitecaps, some spray	Small trees in leaf begin to sway
6	22-27	Strong Breeze	Larger waves 8-13 ft, whitecaps common, more spray	Larger tree branches moving, whistling in wires
7	28-33	Near Gale	Sea heaps up, waves 13-19 ft, white foam streaks off breakers	Whole trees moving, resistance felt walking against wind
8	34-40	Gale	Moderately high (18-25 ft) waves of greater length, edges of crests begin to break into spindrift, foam blown in streaks	Twigs breaking off trees, generally impedes progress
9	41-47	Strong Gale	High waves (23-32 ft), sea begins to roll, dense streaks of foam, spray may reduce visibility	Slight structural damage occurs, slate blows off roofs
10	48-55	Storm	Very high waves (29-41 ft) with overhanging crests, sea white with densely blown foam, heavy rolling, lowered visibility	Seldom experienced on land, trees broken or uprooted, "considerable structural damage"
11	56-63	Violent Storm	Exceptionally high (37-52 ft) waves, foam patches cover sea, visibility more reduced	
12	64+	Hurricane	Air filled with foam, waves over 45 ft, sea completely white with driving spray, visibility greatly reduced	

Source: Beaufort Wind Scale, NOAA

https://www.spc.noaa.gov/faq/tornado/beaufort.html

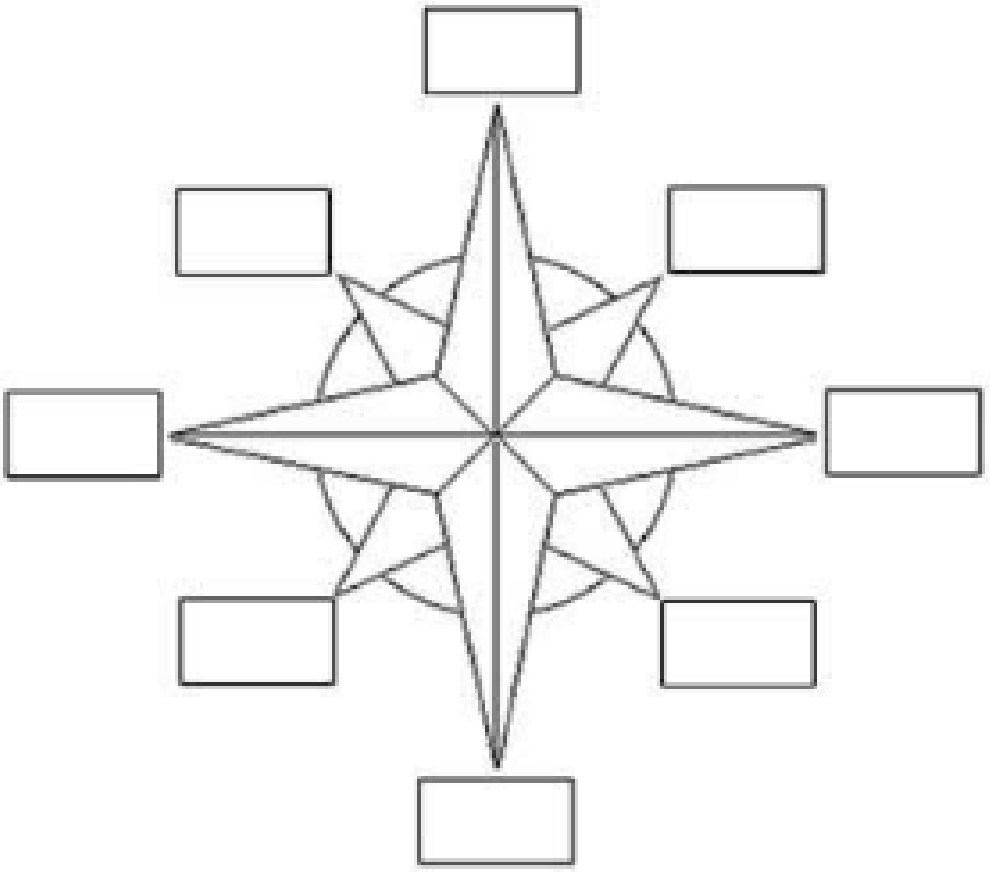
Usually the weather report tells us how many meters per second (m/s) wind blows. For example, a wind speed of 5 m/s means that the air moves 5 meters in 1 second. The wind speed can also be estimated by the effects of wind on different objects.

Practice! Answer the questions into your notebook.

1. Which properties of wind are usually described in weather reports?
2. What are the units that we use to measure wind speed?
3. What does it mean if we say that the wind is northerly?
4. Why is it important to know the speed of wind?
5. Why is it important to know the direction of wind?
6. What do the symbols of the cardinal points mean?

N _____ **S** _____ **E** _____ **W** _____

7. Write the symbols of the cardinal directions into the boxes on the diagram.



8. Write the opposite of the cardinal direction.

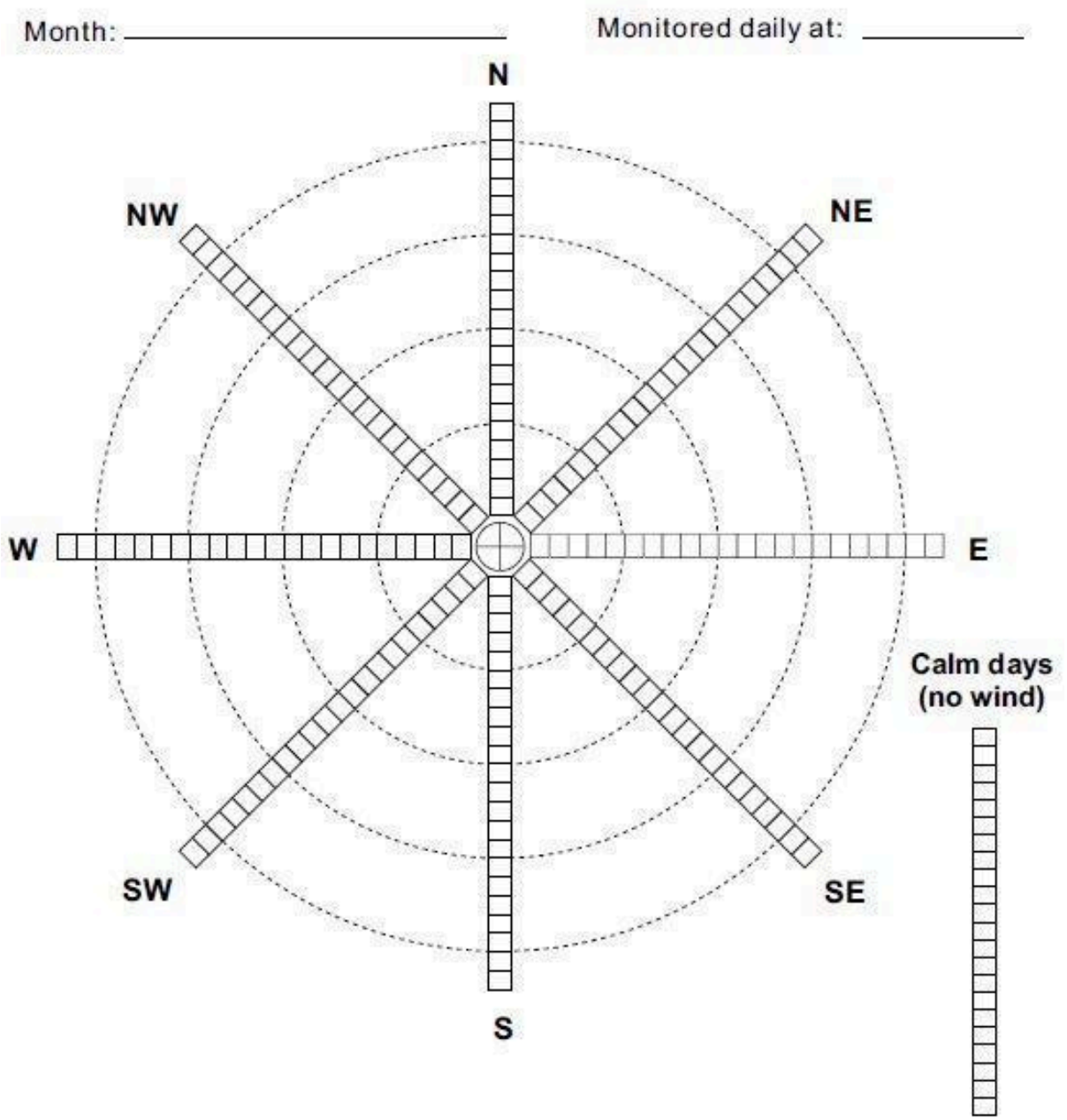
South: Northeast:

North: Southeast:

Northwest: East:

West: Southwest:

9. Use weather reports from the past month to fill in the wind observation sheet for the last two weeks.



Source: Skywatchers Charts and Log Sheets. Government of Canada
https://www.ec.gc.ca/meteoaloeil-skywatchers/default.asp?lang=En&n=2F827B29-1&offset=8&toc=hide

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CLOUDS AND HUMIDITY

On most days you can see at least some clouds in the sky. They can be anything from barely noticeable to thick enough to block out sunlight. Clouds are given different names based on their shape and their height in the sky. Some clouds are near the ground, while others are almost as high as jet planes fly. Some are puffy like cotton. Others are grey and uniform. The diagram below shows where different types of clouds are located in the sky.

Cumulus clouds (*rünkpilved)* are the puffy clouds that look like puffs of cotton. They are formed when warm air rises up and cools down, causing part of the water vapor to condensate into clouds. Cumulus clouds that do not get very tall are indicators of fair weather. If they do grow tall, they can turn into thunderstorms. The bottom of cumulus clouds are fairly close to the ground.

Stratus clouds (*kihtpilved*) look like flat sheets of clouds. They are formed 2 km above the ground if cold air has replaced warm air near the ground and warm air is pressed higher. Stuck above a colder air mass, warm air cools down and clouds are formed. These clouds can mean an overcast day or steady rain. They may stay in one place for several days.

Cirrus clouds (*kiudpilved*) are high feathery clouds. They are made from tiny ice crystals and they are very thin so the sun can shine through them. They are indicators of fair weather when they are scattered in a clear blue sky.

Nimbus is another word associated with clouds. Adding “nimbus” means precipitation is falling from the cloud. Cumulonimbus clouds are the “thunderheads” that can be seen on a warm summer day and can bring strong winds, hail, and rain. Nimbostratus clouds will bring a long steady rain.

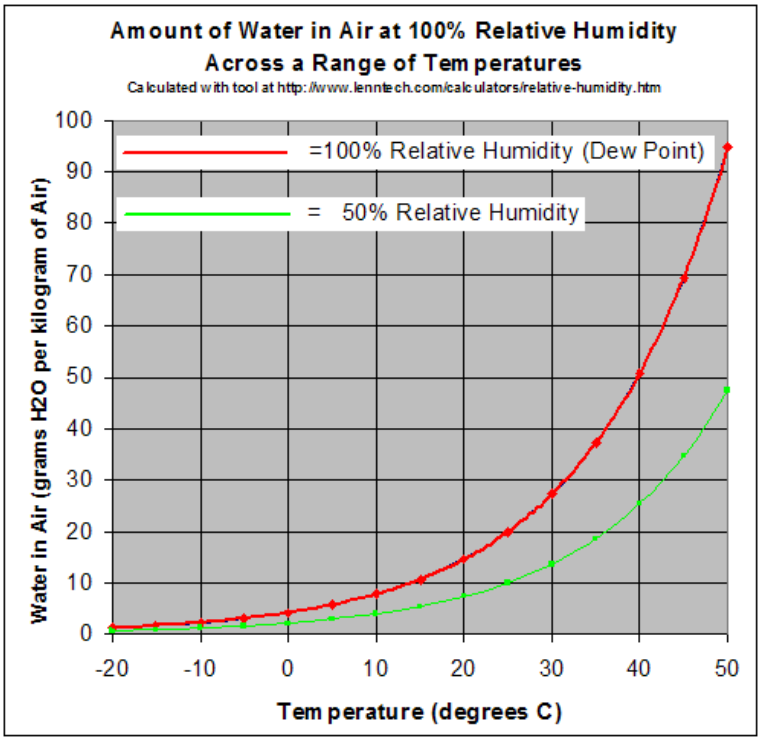
Practice!

1. Why are clouds formed when warm air rises up from the ground?
2. Which cloud type is described with each statement? Write cumulus, stratus or cirrus after each statement.

Gray and cover the sky like a blanket.
Remind cotton wool.
Are made of tiny ice crystals.
Appear in the sky on a warm sunny summer day.
Appear a few days before the rain.
Light, feathery and very high.
Can turn into thunder clouds.
Most rainy clouds

Humidity is the amount of water vapor in the air. As more water evaporates, humidity of the air increases. Warm air can hold in more water vapor than cold air. If we want to decrease the humidity, we can cool down air. **Dew point** is the temperature at which more condensation than evaporation occurs. When air temperature drops below the dew point, water vapor condenses to form dew, fog, and clouds.

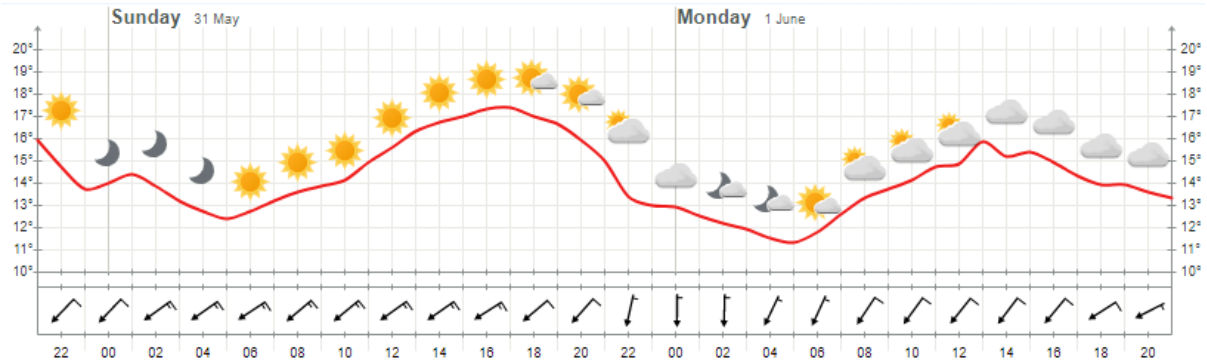
You have probably heard a weather report mention that “relative humidity is 100%”. This means that it is going to rain or it is already raining because at current temperature, the amount of water vapor in the air is the maximum there can be. On the chart on the right, you can see the maximum



amount of water that air can hold at different temperatures.

Chart source: English Wikipedia user GregBenson
https://commons.wikimedia.org/wiki/File:Relative_Humidity.png

Practice!



Source: Weather report for Tallinn, 31st of May and 1st of June from Yr.no
https://www.yr.no/place/Estonia/Harjumaa/Tallinn/hour_by_hour.html

3. Look at the diagram above. When is temperature the highest? How much water can be stored in the air before it forms clouds and starts to rain?
4. When is temperature the lowest? How low? How much water can air hold at that temperature?
5. What is the relative humidity at 22:00 on Sunday if the amount of water vapor in the air is 10 grams per 1 kg of air? Hint: use the chart on the previous page to find the maximum amount of water vapor that air can hold at that temperature and compare it to 10 grams per 1 kg.

Cloud Watchers

Weather Forecasting Chart

Cumulus 		Stratus 		Cirrus 	
If the cloud is:	***The weather could be:***	***If the cloud is:***	***The weather could be:***	***If the cloud is:***	***The weather could be:***
Low	Sunny	Low	A little rain	High	Sunny, dry
Medium	Thunderstorms	Medium	Rain		
High	Getting colder	High	Rain or snow		

Our Cloud Observations for _____

(date)

Observation #1 Time:

Drawing	Shape	Level	Color	Temp.	Rain?
	Cumulus Stratus Cirrus	Low Medium High	White Light Gray Dark Gray		Yes No

Observation #2 Time:

Drawing	Shape	Level	Color	Temp.	Rain?
	Cumulus Stratus Cirrus	Low Medium High	White Light Gray Dark Gray		Yes No

Observation #3 Time:

Drawing	Shape	Level	Color	Temp.	Rain?
	Cumulus Stratus Cirrus	Low Medium High	White Light Gray Dark Gray		Yes No

Source: National Science Teaching Association

http://static.nsta.org/connections/elementaryschool/201004TeachingThroughTradeBooksCloudWatchers.pdf

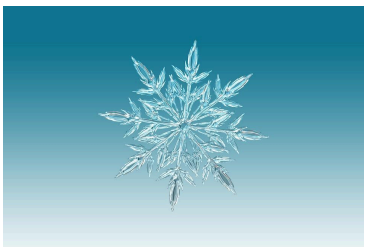
PRECIPITATION

You have probably experienced how unpleasant an unexpected rain can be. Rain is a type of **precipitation** *(sademed)***. Precipitation** is any form of water that falls to Earth's surface from the clouds. Precipitation is measured as the thickness of water that reaches ground and it is measured in millimeters. Precipitation is measured by a rain gauge (picture on the right). A rain gauge is a small tube of glass or plastic with the upper end open. A measuring scale is usually attached to the tube, so that the amount of precipitation can be measured in inches or centimeters.

Source: English Wikipedia user Bidgee
https://commons.wikimedia.org/wiki/File:Rain_recorded_in_a_rain_gauge.jpg

Snow is transferred to a warm place where it melts before the amount can be measured. Snow can also be measured as the thickness of the snow layer covering land. That can be done using a ruler or a measuring tape. Daily measurements are used to calculate the daily, monthly or yearly precipitation. For this purpose, the measured precipitation amounts are summed up. Modern measuring instruments record the amount of precipitation automatically and the data goes directly to the computer.

Rain *(vihm)*, snow *(lumi)*, slush *(lörts)* or hail *(rahe)* falling on the ground is called precipitation. Inside the cloud, the small droplets are constantly moving around.



Water droplets and ice crystals are so small and light that they are hanging in the air. That's why every cloud does not produce rain. Rain will begin when the droplets collide with each other and become so heavy that they will no longer stay in the air.

At temperatures below 0°C the water vapor freezes and becomes ice crystals. Snowflakes are formed from the combined ice crystals. The longer the ice crystals

move in the cloud, the larger and more special snowflakes will fall to the ground. If air near the ground is warmer than 0°C the snow will melt and we get rain or sleet.

Sometimes water condenses into water droplets near the ground. Fog *(udu)* is just a cloud at the ground. Fog is formed if air is cooled to the dew point. When the air temperature is the same as the dew point temperature, condensation occurs and the tiny water droplets become visible. Fog is more frequent in late evenings, because the water vapor that gets into the air on a hot day does not fit into the cold air at night. Part of it is released as droplets. Fog often dissipates with daylight. This is sometimes referred to as the fog “burning off” but that analogy is not correct. When the sun rises, the air and ground warm up. This leads to the air temperature being warmer than the dew point temperature, which causes the fog droplets to evaporate. When wet air comes into contact with cool ground, water vapor condenses and creates dew *(kaste)*.

Have you ever stepped outside and all the trees and surfaces are covered with frost? If air temperature drops below zero, ice crystals may form from the water vapor. If these ice crystals are gathered on surfaces, they offer a very beautiful sight. On a clear autumn morning, the land is often covered with frost *(hall)* (left picture below). Rime ice *(härmatis)* (right picture below) can be seen on windows as an ice flower on a cold winter day, sometimes as a sugar-like powder on cars or trees and other plants. When you breathe on the window in frosty weather, rime ice occurs quickly.

The amount of precipitation depends on the location. Some regions in the world have wet and dry seasons. In Estonia we get an even amount of precipitation throughout the year. Estonia is located by the sea, so the air is moist. We get about 700 millimeters of precipitation a year.

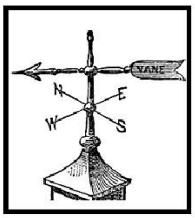
Research! What is the average amount of precipitation in your hometown?

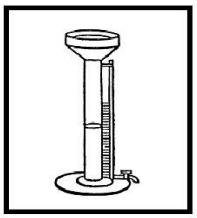
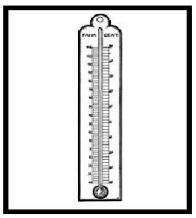
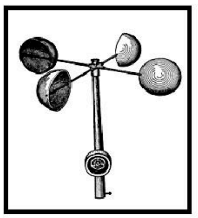
Research! What is the driest place on Earth? Which place has the highest amount of precipitation? Draw a table into your notebook to compare the precipitation in Estonia and in these places. Write a short summary of the data.

Weather Tools

1. Unscramble the words.
2. Draw lines connecting the words to the matching pictures.
3. Draw lines connecting the pictures to the matching functions.

maemeonert _ _ _ _ _ _ _ _ _ _	taewehr naev _ _ _ _ _ _ _ _ _ _ _ _	rebamorte _ _ _ _ _ _ _ _ _ _	temtemhreor _ _ _ _ _ _ _ _ _ _ _ _	irna uggae _ _ _ _ _ _ _ _ _ _ _

Measures wind speed	Measures amount of precipitation	Measures air temperature	Measures air pressure	Determines wind direction

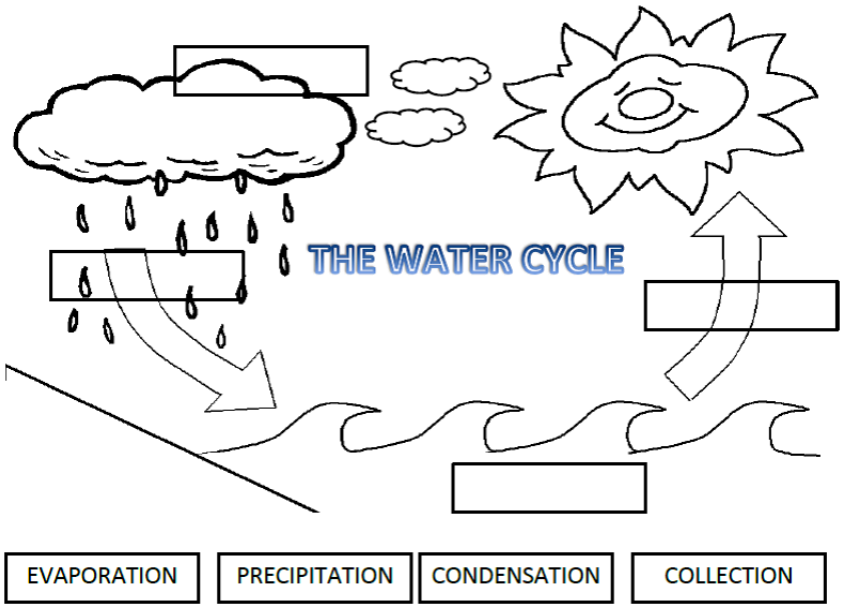
Source: Website of the Government of Canada, Teacher's Corner
http://ec.gc.ca/meteoaloeil-skywatchers/664F561F-3A85-4475-809C-04F3EB893BE8/student%20activity%20booklet_e.pdf

Revising weather - how is weather formed?

Source: Website of the Government of Canada, Teacher's Corner
http://ec.gc.ca/meteoaloeil-skywatchers/664F561F-3A85-4475-809C-04F3EB893BE8/student%20activity%20booklet_e.pdf

Task 1. Color all 4 word boxes with different colors. Color appropriate box on the picture the same color as the correct word.

Explain how clouds are formed.



How and why does precipitation happen?

EVAPORATION | PRECIPITATION | CONDENSATION | COLLECTION

Task 2. Indicate whether true (T) or false (F).

1. _____ A front is the transition zone between two different air masses.
2. _____ If the grass is wet with dew in the morning, then skies were probably clear overnight.
3. _____ Fog only forms when the relative humidity is high.
4. _____ Seasons are caused by the earth rotating on its axis.
5. _____ Clouds can be made of water droplets, ice crystals, or both at the same time.
6. _____ Temperatures are normally warmer five kilometres above the Earth than they are at the Earth's surface.
7. _____ Air moves from areas of higher pressure toward areas of lower pressure, creating wind.
8. _____ Lightning is only dangerous to people holding metal objects.
9. _____ Earth's atmosphere receives its heat directly from the sun.
10. _____ Air masses can pick up moisture as they move over large bodies of water, which can be deposited in the form of precipitation when they move onshore again.

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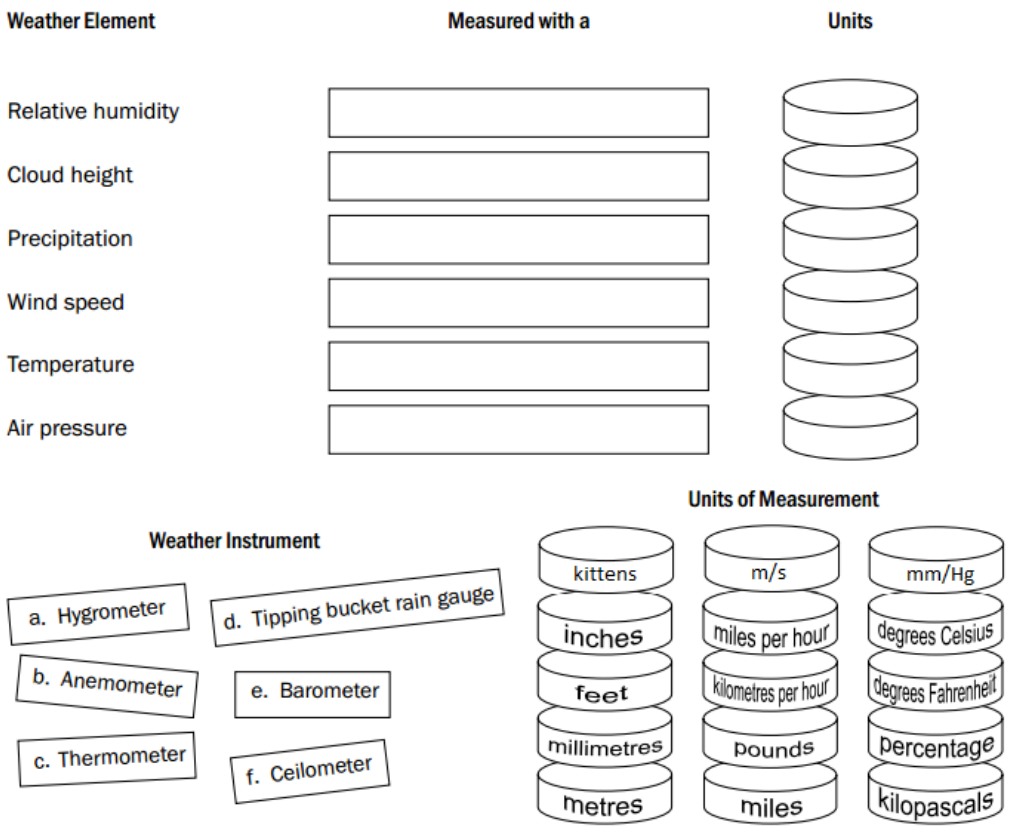
Task 3.

Match each weather element with the name of the instrument used to measure it or detect its presence.

Then, from the selection at the bottom, choose the correct unit of measurement for each in Estonia



Task 4. From the choices below, pick any 2 old folk sayings and explain in your own words why they might work.

1. When the dew is on the grass, rain shall never come to pass.

2. Red sky at night, sailor's delight. Red sky at morning, sailors take warning.

3. When windows won't open and salt clogs the shaker, the weather will favour the umbrella maker.

4. When clouds appear like rocks and towers, Earth's refreshed by frequent showers.

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Task 5. Use your previous knowledge to try and connect terms with their definitions. If you do not know some of the terms, try to guess the meaning or use elimination and connect all other terms, then connect what is left.

BLM-1

Weather Vocabulary—Definitions

Match the following weather terms with the appropriate descriptions by writing the correct letter in the space provided. Each answer may be used only once.

1. sublimation	a. A term used to describe how hot, humid weather feels to the average person
2. tornado	b. The changing of a liquid into a vapour
3. haze	c. A line on a weather map joining points with equal atmospheric pressure
4. isobar	d. The changing of a solid into a vapour
5. dew point	e. Tiny visible water droplets that are suspended in the air
6. front	f. A violently rotating column of air extending from the base of a thunderstorm
7. evaporation	g. The temperature at which the air will become saturated
8. typhoon	h. A suspension of dry particles such as dust or smoke in the air
9. fog	i. Another name for a hurricane in other parts of the world
10. cyclone	j. Another name for any low pressure system
11. humidex	k. The process by which warm air rises
12. convection	l. A line on a weather map representing the boundary between two air masses

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WEATHER OBSERVATION

Walk around and make observations about weather and people. Observe weather both in an open space (1), near a building (2) and on top of Harju mountain (3) to see if there are any differences.

	What can you observe?	What is the measured value?
Temperature	1. 2. 3.	1. 2. 3.
Speed of wind	1. 2. 3.	1. 2. 3.
Direction of wind	1. 2. 3.	1. 2. 3.
Air pressure	1. 2. 3.	1. 2. 3.
Humidity	1. 2. 3.	1. 2. 3.

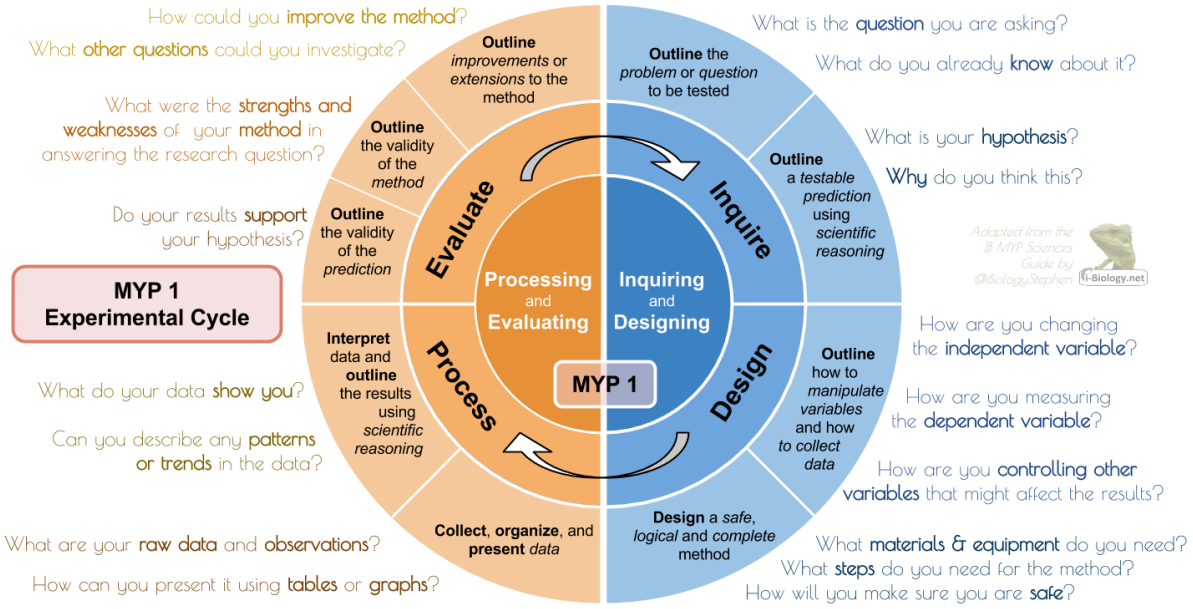
Sky conditions (precipitation and clouds)	1. 2. 3.	1. 2. 3.

PRACTICE FOR THE SUMMATIVE ASSESSMENT

For this unit your summative assessment is a report about an investigation about weather. You can find the **report outline** in Tera. The criteria assessed are B - inquiring and designing and C - processing and evaluating.

In criterion B you have to:
i. **outline** ***(****kirjelda lühidalt)* a research question that you are going to test in your investigation;
ii. **outline** a hypothesis (a prediction of the results) and give your reasons for predicting such outcome;
iii. **outline** how you are going to gather data and change your independent variable, measure your dependent variable and keep controlled variables constant;
iv. design a **safe, logical and complete** method to investigate your research question.

In criterion C you have to:
i. **collect, organize, transform and present** *(kogu, korrasta, teisenda ja esitle)* the data from your weather observation using properly labelled tables and graphs;
ii. **correctly interpret** *(tõlgenda)* data and answer your research question using **scientific reasoning** - referring to sources or your previous knowledge of the topic;
iii. **discuss** *(arutle)* whether your hypothesis was correct giving arguments both for and against it and referring to your data;
iv. **discuss** the suitability of your method to do this kind of research by listing the strengths and weaknesses of the method;
v. **describe** improvements that would make the method or investigation better.



Use these sentence starters to plan your lab. Make sure your lab report has all four major sections.

Research Question: Outline the problem or question to be tested

- ❑ I want to investigate....
  - ❑ This is because I have observed that...

OR

- ❑ I will test the effect of ... on ....
  - ❑ This is because I have observed that...

I have given brief details on how my **problem** is connected to the topic we are studying. I have stated the problem as a research question.

Variables: Outline how to *manipulate variables* and how to *collect data*

- ❑ The **independent variable** is the variable **I am changing**.
  - ❑ My independent variable is...
  - ❑ I will change the independent variable by increasing / decreasing from ... to ...
  - ❑ I will change the independent variable in increments of ...
- ❑ The **dependent variable** is the variable **I will measure**.
  - ❑ My dependent variable is...
  - ❑ I will measure the dependent variable by...
  - ❑ I will repeat my measurements ... times to be more reliable.
- ❑ The **controlled variables** are variables that I will **keep the same** to make my test more reliable. Identify at least 3.
  - ❑ I will control ... by ... because ...

I have given brief details on how to manipulate the independent **variable**, how to measure the dependent **variable** to collect relevant data, and how to manipulate the controlled **variables**.

Hypothesis: Outline a *testable prediction* using *scientific reasoning*

- ❑ I predict that if I increase / decrease ... then ... will ...
  - ❑ This is because...
  - ❑ Other information that supports my hypothesis is....
- ❑ My prediction is / is not testable. I know this because ....

My **hypothesis** is testable, and includes my **variables**, with my reasons as a 'because' statement.

Method & Materials: Design a safe, *logical* and *complete* method

- ❑ There are some / no risks in this investigation because...
- ❑ I will **stay safe** by ...
- ❑ I will **keep others safe** by ...
- ❑ I need to use these **materials** and **equipment** in my investigation...
- ❑ I need to **carry out these steps** in my investigation...
- ❑ This is a photo / diagram of my investigation

My **procedures** are safe, complete, and logical. Someone else would have no problem with my lab because I describe how to work with the variables and collect data.

I have selected every **material** I will need, including quantities, and I won't need to ask for anything on the day of the lab.

Commonly-confused words. Make sure ***you*** use them correctly.

Facts
are *simple truths* that we use when we describe the universe. Often we can measure them.

Hypothesis
is a *testable prediction* that we make, with a logical *reason*.

A **scientific problem** is a **question** that we are trying to solve by making a **hypothesis** and **testing** it with an **experiment**.

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Criterion B: Inquiring & Designing

i. outline an appropriate problem or research question to be tested by a scientific investigation
ii. outline a testable prediction using scientific reasoning
iii.outline how to manipulate the variables, and outline how data will be collected
iv.design scientific investigations

Level	*The student is able to:*
1-2	i. **select** a problem or question to be tested by a scientific investigation ii. **select** a testable prediction iii. **state** a variable iv. design a **method with limited success.**
3-4	i. **state** a problem or question to be tested by a scientific investigation ii. **state** a testable prediction iii. **state** how to manipulate the variables, and **state** how **data** will be collected iv. design a **safe method** in which he or she **selects materials and equipment.**
5-6	i. **state** a problem or question to be tested by a scientific investigation ii. **outline** a testable prediction iii. **outline** how to manipulate the variables, and **state** how **relevant data** will be collected iv. design a **complete and safe method** in which he or she **selects appropriate materials and equipment.**
7-8	i. **outline** a problem or question to be tested by a scientific investigation ii. **outline** a testable prediction **using scientific reasoning** iii. **outline** how to manipulate the variables, and **outline** how sufficient, relevant data will be collected iv. design a **logical, complete and safe method** in which he or she **selects appropriate materials and equipment.**

Self Reflection Rubric

B	*i. outline an appropriate problem or question to be tested by a scientific investigation*	*ii. outline a testable prediction using scientific reasoning*	*iii. outline how to manipulate the variables, and outline how data will be collected*	*iv. design scientific investigations*
1-2	I have selected a **problem** from those provided.	I have selected a **hypothesis** from those provided.	I have stated a **variable.**	I have a **procedure** written down for my lab.
3-4	I have stated a **problem** as a research question.	My **hypothesis** is testable.	I have stated how to manipulate the independent **variable,** and stated how to measure the dependent **variable.**	My **procedures** are safe. I have selected the **materials** I will need.
5-6	I have stated a **problem** as a research question that connects with our topic.	My **hypothesis** is testable, and includes my **variables.**	I have given brief details on how to manipulate the independent **variable,** and stated how to measure the dependent **variable** to collect relevant data.	My **procedures** are safe and complete. Someone else could probably do my lab because I describe how to collect data. I have selected the **materials** I will need, including quantities.
7-8	I have given brief details on how my **problem** is connected to the topic we are studying. I have stated the problem as a research question.	My **hypothesis** is testable, and includes my **variables,** with my reasons as a 'because' statement.	I have given brief details on how to manipulate the independent **variable,** how to measure the dependent **variable** to collect relevant data, and how to manipulate the controlled **variables.**	My **procedures** are safe, complete, and logical. Someone else would have no problem with my lab because I describe how to work with the variables and collect data. I have selected every **material** I will need, including quantities, and I won't need to ask for anything on the day of the lab.

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Use these sentence starters to guide the conclusion section of your lab report.

Data: Collect, organize and present data

- ❑ This table shows my measurements.
- ❑ This graph shows my final results.
- ❑ I made these **observations** while carrying out my experiment...
- ❑ I think my data were / were not reliable because...

I have correctly organized the data I collected in my experiment using tables that include units in the proper place. I have processed my data using proper methods and showed examples. My graph is correct, including titles, axis labels, and I have used lines of best fit.

Patterns: Interpret data and outline the results using *scientific reasoning*

- ❑ My data show that ....
- ❑ My data suggest that ...
- ❑ This might be because ...
- ❑ Another source that supports this reason is... which says...
- ❑ I conclude that this experiment has / has not helped me solve my original problem. This is because...

I have correctly used knowledge and understanding of science to recognize **patterns** and draw conclusions from the data. I have correctly given some details of how and the variables are related.

Validity of Hypothesis: Discuss the *validity* of the *prediction*

- ❑ I predicted that ...
- ❑ My data support / do not support /partially support my prediction.
- ❑ I think this because...

I have evaluated my hypothesis by considering many possibilities. I have used the data to clearly state if I my hypothesis has been supported or not. I use scientific reasons and sources to help explain my reasons.

Validity of Method: Discuss the *validity* of the *method*

- ❑ The method I followed did allow / did not allow / partially allowed me to answer the research question.
  - ❑ I think this because...
- ❑ Some *strengths* in the method were...
- ❑ Some *weaknesses* in the method I was given were...
- ❑ Something I found *difficult* in carrying out the method was...
- ❑ If I wanted to test the same problem again, I would / would not use the same method. This is because...

I have **evaluated my method** by considering the strengths and limitations of my procedures and lab work. I have discussed the validity and reliability of my methods, and addressed its significance.

Improvements: Describe improvements or extensions to the method

- ❑ I could improve the method by ....
- ❑ I would make these improvements because...
- ❑ This investigation has made me think of a new question, which is...
- ❑ I could test this by...
- ❑ I would like to find out more about ... because...

I have provided details of how I **suggest improvement** to limitations in my procedures. These suggestions are realistic and based on scientific reasoning and research.

Commonly-confused words. Make sure ***you*** use them correctly.

Facts
are *simple truths* that we use when we describe the universe. Often we can measure them.

Hypothesis
is a *testable prediction* that we make, with a logical *reason*.

Good scientists
are not trying to '*prove*' themselves '*right*'.

Good scientists want to **test their ideas** in case they are not supported. This gives them more interesting questions to ask next

'Banned words'

- "Proves"
- "Correct"
- "Right"
- "Wrong"

These are not scientific.

Instead we talk about how the evidence we collect (our data) do or do not support our hypothesis.

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Criterion C: Processing & Evaluating

i. present collected and transformed data
ii. interpret data and outline results using scientific reasoning
iii. discuss the validity of a prediction based on the outcome of the scientific investigation
iv. discuss the validity of the method
v. describe improvements or extensions to the method

Level	*The student is able to:*
1-2	i. **collect and present** data in numerical and/or visual forms ii. **interpret** data iii. **state** the validity of a prediction based on the outcome of a scientific investigation, **with limited success** iv. **state** the validity of the method based on the outcome of a scientific investigation, **with limited success** v. **state** improvements or extensions to the method that would benefit the scientific investigation, **with limited success**.
3-4	i. **correctly collect and present** data in numerical and/or visual forms ii. **accurately interpret** data and **outline** results iii. **state** the validity of a prediction based on the outcome of a scientific investigation iv. **state** the validity of the method based on the outcome of a scientific investigation v. **state** improvements or extensions to the method that would benefit the scientific investigation.
5-6	i. **correctly collect, organize and present** data in numerical and/or visual forms ii. **accurately interpret** data and **outline** results **using scientific reasoning** iii. **outline** the validity of a prediction based on the outcome of a scientific investigation iv. **outline** the validity of the method based on the outcome of a scientific investigation v. **outline** improvements or extensions to the method that would benefit the scientific investigation.
7-8	i. **correctly collect, organize, transform and present** data in numerical and/or visual forms ii. **accurately interpret** data and **outline** results **using correct scientific reasoning** iii. **discuss** the validity of a prediction based on the outcome of a scientific investigation iv. **discuss** the validity of the method based on the outcome of a scientific investigation v. **describe** improvements or extensions to the method that would benefit the scientific investigation.

Self Reflection Rubric

C	*i. present collected and transformed data*	*ii. interpret data and outline results using scientific reasoning*	*iii. discuss the prediction of a based on the outcome of the scientific investigation*	*iv. discuss the validity of the method*	*v. describe improvements or extensions to the method*
1-2	I have presented the data I collected in my experiment using tables or graphs.	I have attempted to recognize patterns and draw conclusions from the data.	I have evaluated my hypothesis.	I have evaluated my method.	I have stated how I suggest improvement to my procedures.
3-4	I have presented the data I collected in my experiment by using the correct type of graph, including titles, axis labels.	I have used knowledge and understanding of science to recognize patterns and draw conclusions from the data.	I have evaluated my hypothesis by stating if it has been supported or not, based on my data.	I have evaluated my method by listing errors in my procedures and lab work.	I have stated how I suggest improvement to limitations in my procedures.
5-6	I have organized the data I collected in my experiment using tables that include units in the proper place. My graph is the correct type, including titles, axis labels, and I have used lines of best fit.	I have correctly used knowledge and understanding of science to recognize patterns and draw conclusions from the data. I have given some details of how and the variables are related.	I have evaluated my hypothesis by briefly mentioning the data to state if I my hypothesis has been supported or not, based on my data.	I have evaluated my method by briefly considering my procedures and lab work.	I have given brief details of how I suggest improvement to limitations in my procedures.
7-8	I have correctly organized the data I collected in my experiment using tables that include units in the proper place. I have processed my data using proper methods and showed examples. My graph is correct, including titles, axis labels, and I have used lines of best fit.	I have correctly used knowledge and understanding of science to recognize patterns and draw conclusions from the data. I have correctly given some details of how and the variables are related.	I have evaluated my hypothesis by considering many possibilities. I have used the data to clearly state if I my hypothesis has been supported or not. I use scientific reasons and sources to help explain my reasons.	I have evaluated my method by considering the strengths and limitations of my procedures and lab work. I have discussed the validity and reliability of my methods, and addressed its significance.	I have provided details of how I suggest improvement to limitations in my procedures. These suggestions are realistic and based on scientific reasoning and research.

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Õppematerjal on valminud Tallinna Ülikooli Haridusinnovatsiooni keskuse projekti raames, 2021

Tallinn English College

Name: _____

5th Grade

Headline: _____

Practical Report

Teacher:

Tallinn 202X

INTRODUCTION

What is the topic of your research?

_____

Why did you choose that topic? Why is your topic important?

_____

_____

What is the research question of your experiment?

_____

How is your research question related to the topic?

_____

_____

Propose a hypothesis about your research question – what do you think, how will your independent variable (variable that you are changing) affect your dependent variable (variable that you are measuring)?

_____

_____

Explain your hypothesis using the information you have learned about the topic.

_____

_____

1. METHOD

Describe your method in detail.

What is the **variable** you are going to **change** in your experiment? (Independent variable)

_____

_____

How are you going to change your independent variable?

_____

_____

What is the **variable** you are going to **measure** in your experiment? (Dependent variable)

_____

_____

How are you going to measure your dependent variable?

_____

_____

What are the **variables** you are going to **keep constant** in your experiment? (Controlled variables)

_____

_____

How are you going to make sure your controlled variables do not change?

_____

_____

What equipment did you use for your experiment? Write down all the equipment and substances used, including the amounts and sizes.

_____

_____

Were there any concerns about this experiment? Were there any safety requirements you had to follow?

_____

_____

Describe your method step-by-step in detail. Include information about how many trials you did and how you collected the data. If possible, include a picture or a drawing of the set-up of your experiment.

1.

2.

...

2. RESULTS

During the experiment, I could see that...

Table 1. ...

Here is a graph with my results:

Graph 1. ...

From the graph, it can be seen that...

Give a short summary of the results:

CONCLUSION

State your research question again:

_____

_____

Based on the results of your experiment, answer your research question – how did the independent variable affect the dependent variable?

_____

_____

_____

Did your data support your **hypothesis**? Explain your answer!

_____

_____

_____

_____

What did you learn during this experiment?

_____

_____

Were there any **weaknesses** or **limitations** in your method? Could there have been anything wrong with the method or did you make any mistakes in carrying out your method?

_____

_____

What are the **strengths** of your method?

_____

_____

How could you improve your weaknesses and limitations?

_____

_____

_____

What would you do differently in your method next time? Why?

_____

_____

_____

_____

BIBLIOGRAPHY

NB! Organise sources alphabetically!

Example:

Leigar, M. (2016) "Weather forecast". Source: www.weather.com

Smith, K. (2006) "Precipitation". Source: www.precipitation.ee

If the source has no year of publishing given, write (n.d.). Example:

Smith, K. (n.d) "Precipitation". Source: www.precipitation.ee

Impressum

Kogumik on koostatud Tallinna Inglise Kolledži 5. klassi inglise keele ja loodusõpetuse lõimitud õppeprogrammi järgi. Lõimitud õppeprogrammi loomist ja rakendamist Tallinna Inglise Kolledžis on toetanud Kaasaegse Kooli Sihtasutus. Käesolev kogumik on valminud Tallinna Ülikooli Haridusinnovatsiooni keskuse projekti raames.

Kogumiku autorid: Luise Tiks ja Kaia Norberg.