centre de développement pédagogique
pour la formation générale en science et technologie

Working document

Adaptation to cold

Student booklet

March 2010

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Context

Several researchers are leaving for two weeks in the Canadian Rocky Mountains to carry out a study on the behaviour of animals in this region.

Since humans are a species that reacts to cold, your mandate is to suggest the best protection from wind, temperatures below -29 °C and humidity. What then, will be the most recommended combination of textiles able to ensure their comfort?

We suggest you become familiar, **experimentally**, with different **factors** involved in **heat exchanges.** You will thus be able to understand how and why we protect ourselves against these types of risks.

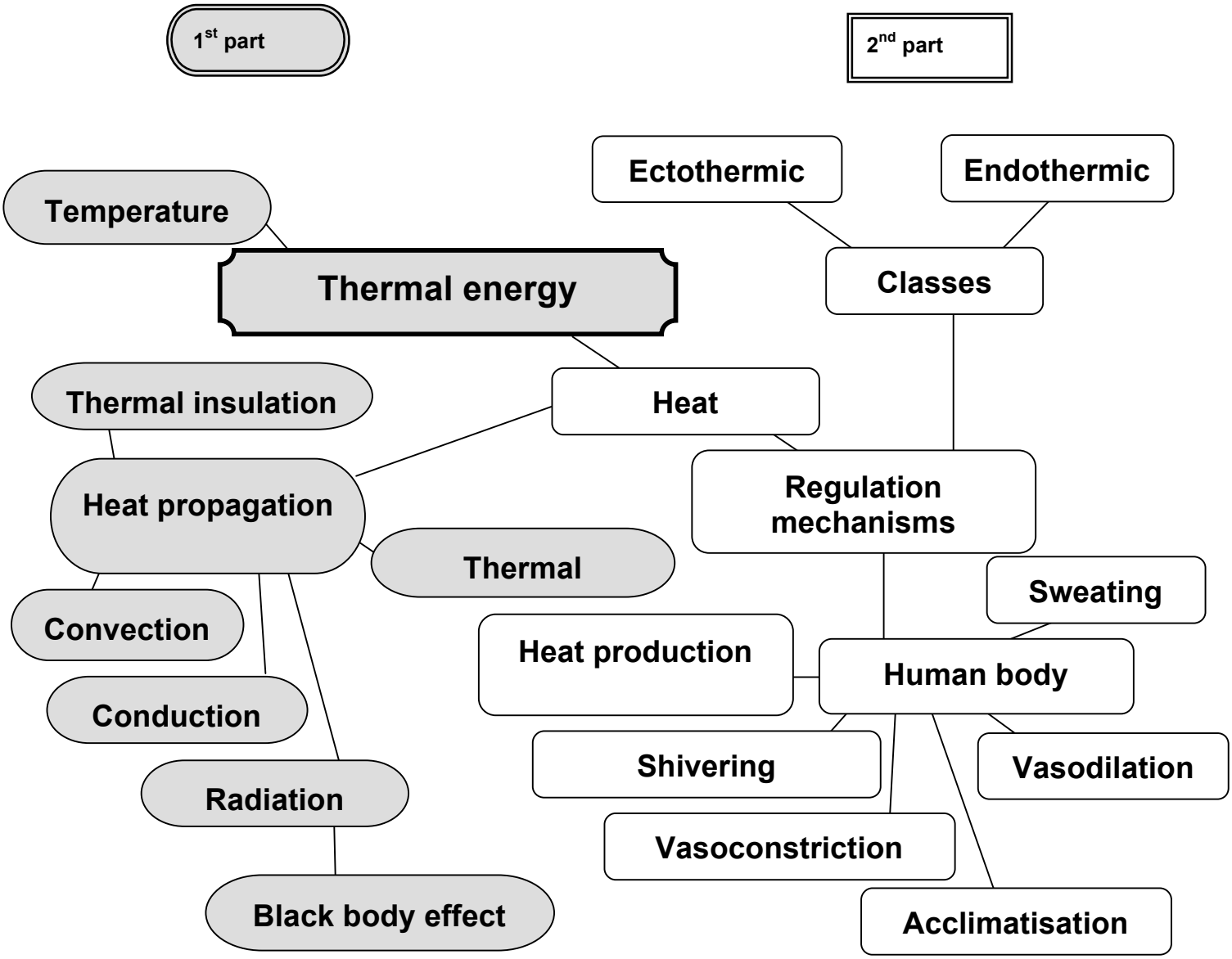
Your challenge:

You must design a protective glove.

- This glove must be resistant to cold.
- You will have to explain your operating principle based on scientific concepts.

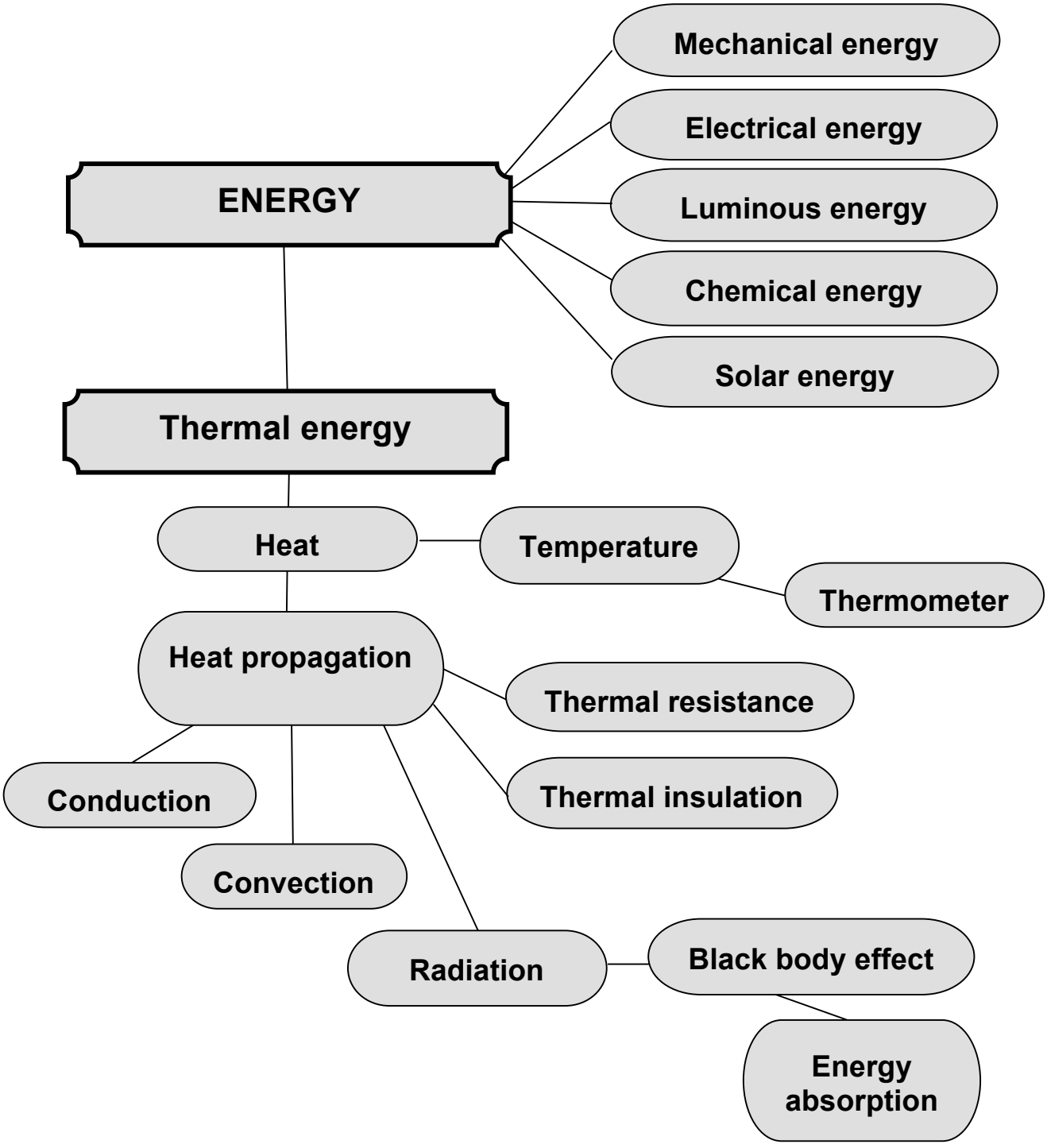
Activate your neurons…

To help you along, we suggest you use an **exploration card** for **the scientific concepts** targeted in this challenge. It will follow along with you as you learn and you may refer to it as needed. As you will have noticed, there are two colours in the card. The concepts in grey will be seen in the first part, while the others will be studied in the second part.



Explorations card for the concepts in the 1st part:

At the end of each activity, you can highlight the boxes of the concepts that you will have studied.



What is heat?

How is heat propagated?

Heat

We can replace the word **"heat"** with the term **"thermal energy".** Several **forms** (types) **of energy** exist.

What is energy?

It is a dimension that expresses **"work"** possible from a system (heating, moving, advancing, warping, resisting).

Energy is generally measured in **joules** (calories, watt, etc.).

Give an example of an object, system or situation that corresponds to each of the following forms of energy:

Form of energy	Example
Mechanical energy (Associated to a movement or displacement)	
Electrical energy (Associated to an electrical current)	
Luminous energy (Associated to a light)	
Chemical energy (Associated to a chemical reaction)	
Solar energy (Associated to solar radiation)	

In order to understand what **heat (thermal energy)** is, we will represent a quantity of thermal energy by this pictogram: 

A substance may possess a great quantity of energy, lose some (give some) or gain some.

For each of the following situations, complete the statements referring to the quantity of energy.

Choose among the following statements:

⇒ **greater quantity of energy**

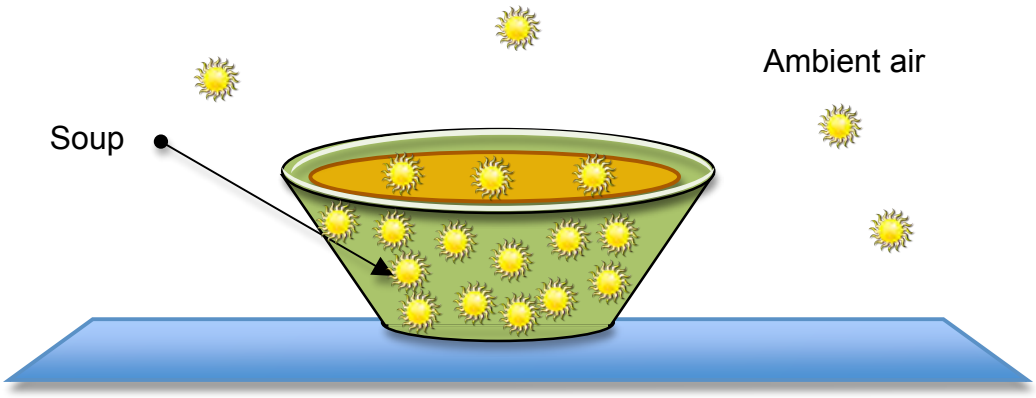
⇒ **smaller quantity of energy**

⇒ **same quantity of energy**

⇒ **loses energy**

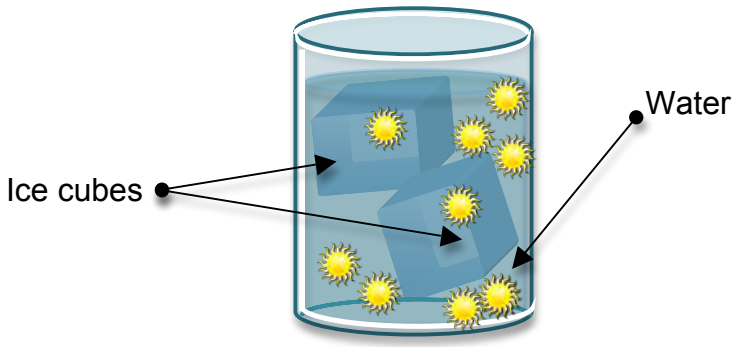
⇒ **gains energy**

1. A bowl of soup cools on the table



At the start, the soup is hot because it possesses a _____ _____ than the ambient air. As time goes by, the more the soup _____ while the ambient air _____. When the soup is completely cold, it will have _____ as the ambient air.

2. Glass of water with ice cubes



The water contains _____than the ice cubes. When the ice cubes start to melt, the water _____ and the ice _____. When there is no more ice, the contents of the glass of water possesses _____.

3. In the preceding images, how is the hot substance represented?

_____

4. In the preceding images, how is the cold substance represented?

_____

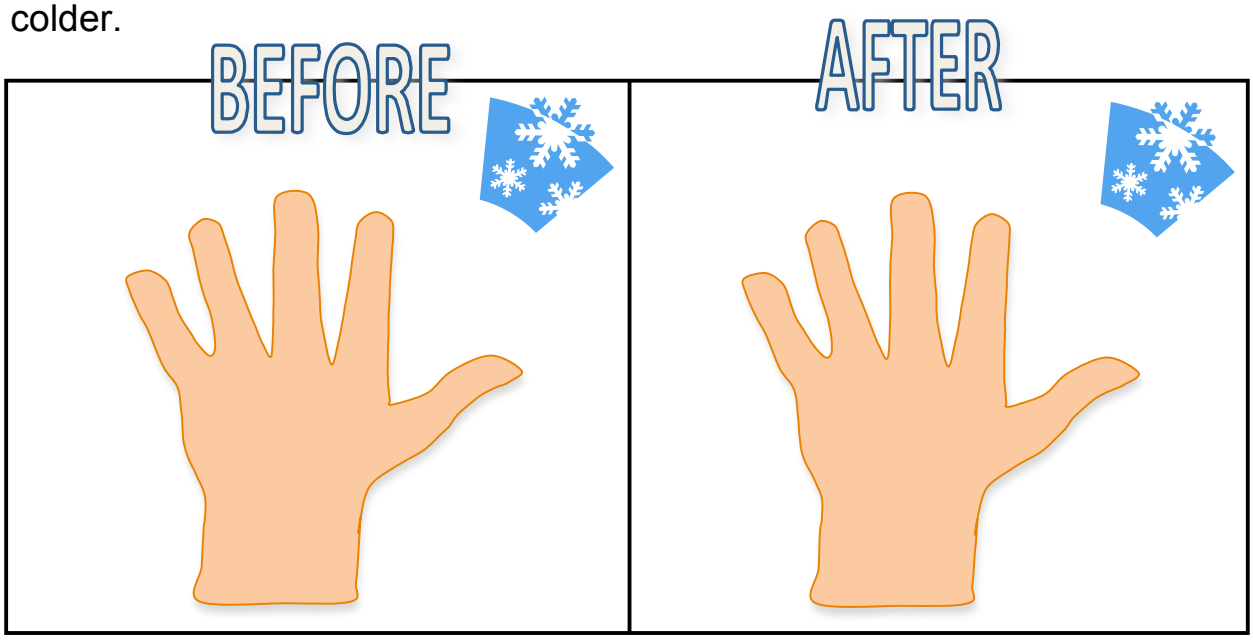
Remember:

A hot substance contains _____while a cold substance contains _____.

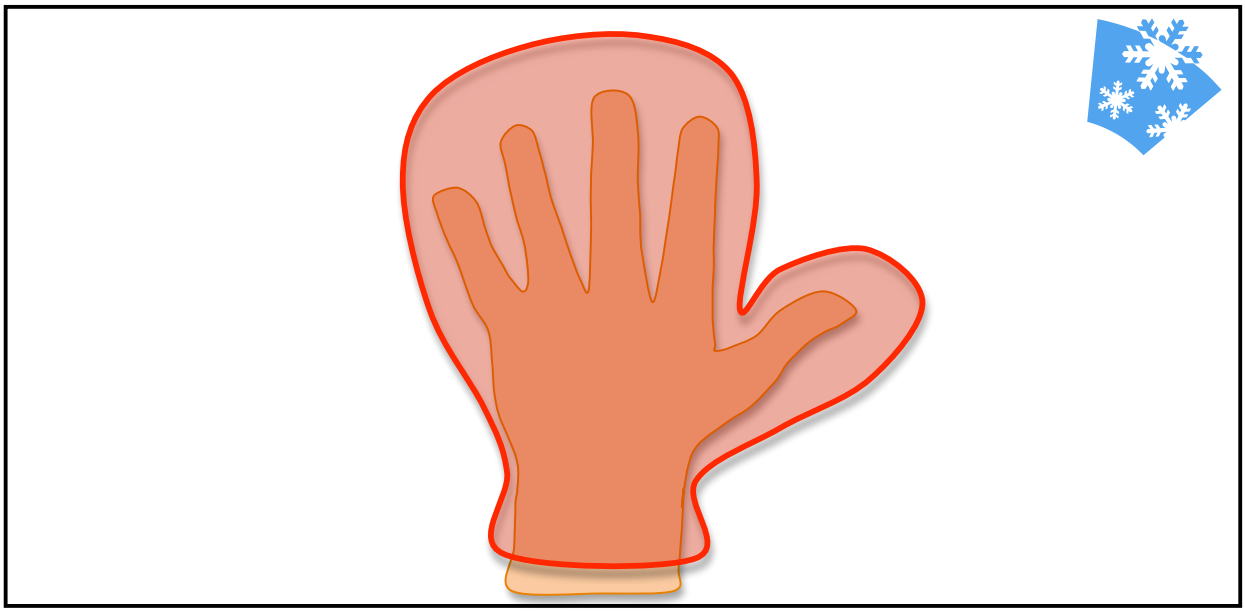
All **substances** (solids, liquids or gas) are made up of particles. Thermal energy makes the particles vibrate. The "agitation of the particles" of a substance are measured using a _____. This measurement is called the _____. The greater the amount of thermal energy a substance contains, the greater its _____.

Use the stickers supplied to represent the thermal energy (the heat) on the image below. Add arrows to represent the situation described.

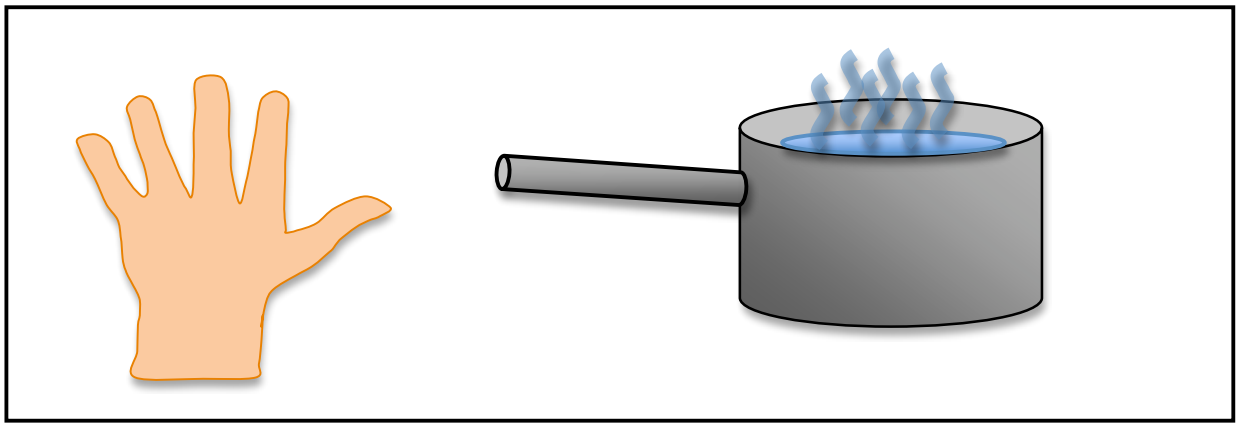
1. The hand is warmer than the ambient air. It loses energy and becomes colder.



2. The hand loses energy, but the mitten retains this energy in the layer of air inside it.



3. You have probably already touched the handle of a metal pot that had just been withdrawn from a heated element. You probably felt a burning sensation. Explain this situation using the appropriate scientific terms and illustrate the situation using the stickers.



Explanation:

_____

_____

Remember:

There are three methods of **propagation** (circulation) of heat:

Method of propagation	Definitions
Conduction	
Convection	
Radiation	

Associate the proper method of propagation of heat in each of the following statements. Explain your answer.

Reminder: the three methods are: _____,

_____ and _____.

1. On a hot summer day, my asphalt driveway becomes burning hot at noon.

_____

_____

2. The air in the room heats up using an electric heater.

_____

_____

3. A glass of chocolate milk heats up in the microwave oven.

_____

_____

4. Butter melts in a pot placed over a hot stove burner.

_____

_____

5. I burn my foot walking barefoot on my driveway at noontime.

_____

_____

Following these activities, go back to page 5 and highlight the concepts broached.

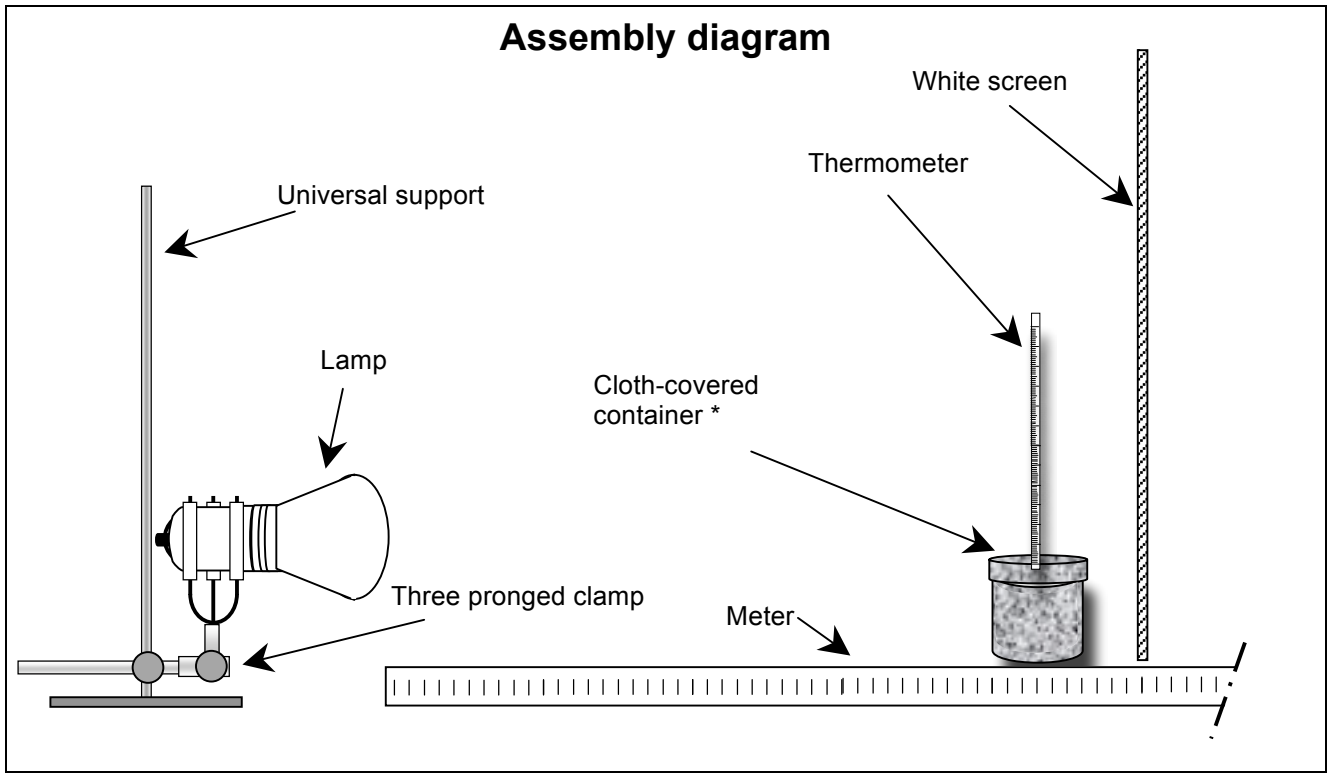
Directed Laboratories

1. The black body effect

Purpose of the manipulation:

You will have to determine if the colour of an object has an impact on its capacity to capture heat.

Here is the suggested assembly for the manipulation:



*** The container will be changed three times during the manipulation. We will successively use a container covered with black, white and metallic cloth.**

Observations of the assembly diagram:

Place an « X » in the appropriate box:

	Identical	Different
The **dimension** of the container for each trial		
The **distance** between the container and the light for each trial		
The **colour** of the **cloth covering** on the container for each trial		
The **colour** of the screen for each trial		

Hypothesis:

Do you think you will observe a difference in temperature if you heat the containers with different coloured cloth coverings?

_____

If so, why? _____

_____

Material

- 1 universal support
- 1 three pronged clamp
- 1 right angle nut (to affix the clamp)
- 1 - 250 W lamp that can be affixed using a universal clamp
- 1 thermometer
- 3 containers with perforated covers (covered with black, white and metallic fabrics)
- 1 meter
- 1 stop watch

- 1 white screen (cardboard or foam board)
- Masking tape

Protocol:

1. Affix the white screen to a wall using the masking tape.
2. Using the universal clamp, affix the lamp on the universal support.
3. Measure a distance of 50 cm between the position of the screen and the bulb.
4. Place the universal support at that spot.
5. Put the container, covered with black cloth, in front of the screen.
6. Insert the thermometer in the opening of the cover.
7. Note the **initial temperature** (starting temperature) of the air in the container. (Write this temperature in the data table.)
8. Turn on the lamp and start timing.
9. Note the **temperature every minute for 8 minutes**.
10. Turn off the lamp. **Careful! the glass of the lamp is very hot.**
11. Repeat steps #5 to #11 for the two other containers.

Important ! Wait for the temperature of the thermometer to come back to the initial temperature of the first container before repeating the manipulation.

Data:

Variation in temperature of the containers after heating.

		Covered container		
Time	**Temperature (^oC)**	**Black fabric**	**White fabric**	**Metallic fabric**
0 min.	**T_i ***			
1 min.	**Temperature (^oC)**			
2 min.				
3 min.				
4 min.				
5 min.				
6 min.				
7 min.				
8 min.	**T_f ***			
	δ (T_f -T_i)			

*** T_i = Initial temperature (starting temperature, before lighting the lamp)**
T_f = Final temperature (temperature taken after heating)
δ = Delta (The result of a subtraction)
Example of a calculation: T_i = 23 ^oC, T_f = 26 ^oC so δ (T_f -T_i) = 26 ^oC - 23 ^oC = 3 ^oC

Draw a bar graph from the data gathered.

Analysis of results:

1. In which container is the temperature difference the greatest?

_____

2. In which container is the temperature difference the lowest?

_____

Conclusion:

1. Using your results, what can you conclude in relation to your initial hypothesis?

a) I was right because

_____

_____

or

b) I was wrong because

_____

_____

2. Do you think it was important to have the same heat exposure time during the manipulation? _____

Explain your answer.

_____

_____

Competency 3 – To communicate in the languages used in science and technology	**Degrees**				
Criteria 4 – Respects the terminology, rules and conventions proper to science and technology in the production of messages	**1**	**2**	**3**	**4**	**5**

Remember:

Following the manipulation, you are able to complete the following statement using the words below:

Black body effect - absorbs - radiation - thermal energy - more energy

A dark coloured surface absorbs _____ than a pale colour. Certain substances also possess this characteristic depending on their nature. Heat emitted by a lamp (or the sun) is propagated by _____. The substance _____ the heat or _____. This phenomenon is called _____ .

Following this experiment, go back to page 5 and highlight the concepts broached by the activity.

2. Insulating power

During winter outings, you add gloves, a scarf and a toque to your clothing. These added garments protect you against the cold and prevent you from getting cold. You know of several types of fabric, but do you know which affords the best protection?

Purpose of the manipulation:

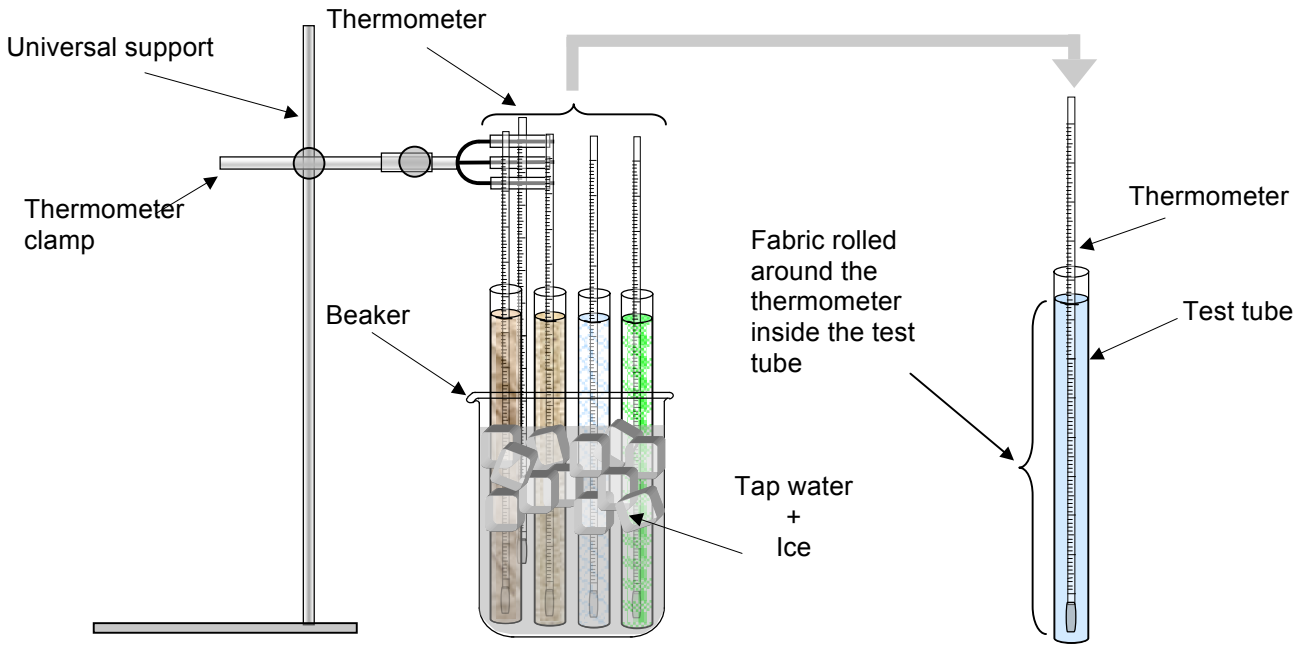
You will have to determine experimentally which fabric(s) offer the best **insulation** to cold.

Hypothesis:

I believe that _____ will be the fabric that insulates the best against the cold because _____ _____.

Here is the suggested assembly for the manipulation:

Assembly diagram



Material:

- 1 - 1000 mL beaker
- 1 universal support
- 1 thermometer clamp
- 5 thermometers
- 4 - 25 X150 test tubes
- 1 test tube stand
- Stopwatch or watch
- Tap water
- Ice
- 4 pieces of different fabrics of the same size

Observations of the assembly diagram:

Place an « X » in the appropriate box:

	Identical	**Different**
The **dimension of the piece of fabric** in each test tube		
The **dimension of the test tube**		
The **initial temperature of the water** in the beaker		
The type **(its nature)** of fabric in each test tube		

Protocol:

1. Place ten to twelve ice cubes in a 1000 mL beaker.
2. Pour enough cold tap water in the beaker to cover the ice cubes.
3. Affix the thermometer clamp onto the universal support.
4. Insert the thermometer in the clamp and adjust it so that the reservoir of the thermometer is immersed in the middle of the beaker.

5. Roll a piece of fabric around a thermometer and place them both in a test tube.
6. Place the test tube in the test tube holder.
7. Repeat operations #3 and #4 for the other pieces of fabric.
8. Number the test tubes, respecting the numbers in the data compilation table.
9. Note the **initial temperature** (starting temperature) of each test tube and of the ice water in the beaker.
10. Gently place the test tubes into the ice water.
11. Note the temperature **every minute, for five minutes.** (Lift the thermometer slightly in order to see the graduations.)
12. Withdraw the test tubes from the beaker and put them back in the stand.

Data:

Temperature of the fabrics

		0 min.	1 min.	2 min.	3 min.	4 min.	5 min.	
Test tube #	**Fabric**	**T_i * (^oC)**	**Temperature (^oC)**				**T_f * (^oC)**	**δ ($T_f - T_i$) (^oC)**
1								
2								
3								
4								

Draw a bar graph from the data gathered.

Analysis of the results:

1. Which fabric had the greatest variation in temperature?

2. Which fabric(s) had the smallest variation in temperature?

3. What do the fabrics with the smallest temperature variations have in common?

Conclusion:

Using your results, what can you conclude in relation to your initial hypothesis?

I was right because

_____

_____

or

I was wrong because

_____

_____

Following this experiment, go back to page 5 and highlight the concepts broached by the activity.

Competency 3 – To communicate in the languages used in science and technology	Degrees				
Criteria 4 – Respects the terminology, rules and conventions proper to science and technology in the production of messages	**1**	**2**	**3**	**4**	**5**

3. Resistance to heat

You must withdraw a cookie sheet from the oven. What must you wear in order to not burn your hands? You know of several insulating fabrics, but do you know which will be the most **thermo resistant*?**

*thermo resistant: adjective, that insulates from and withstands heat

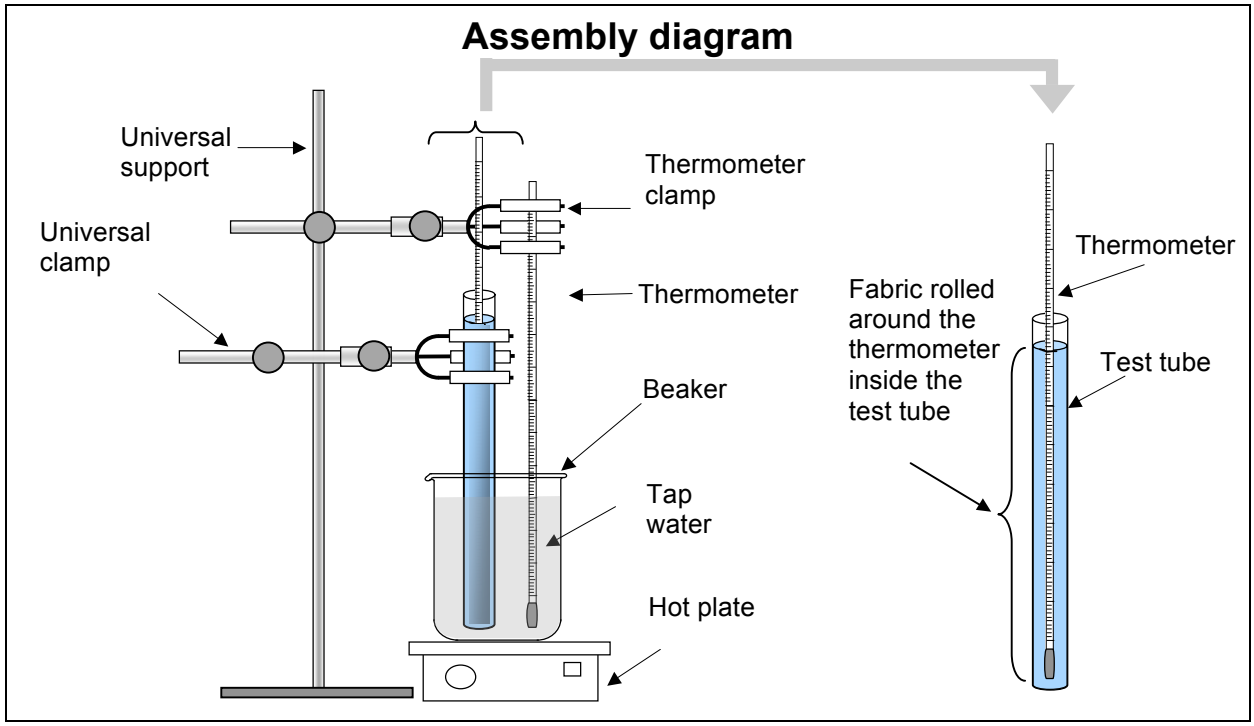
Purpose of the manipulation:

Determine experimentally which fabric is the most thermo resistant.

Hypothesis:

I believe that _____ will be the most thermo resistant fabric because _____

Here is the suggested assembly for the manipulation:



Material:

- 1 hot plate
- 1 universal support
- 1 thermometer clamp
- 1 universal clamp
- 5 thermometers
- 1 - 1000 mL beaker
- 1 beaker clamp
- 4 - 25 X 150 test tubes
- 1 test tube stand
- 1 stopwatch or watch
- Tap water
- 4 pieces of different fabrics of the same size

Observations of the assembly diagram:

Place an « X » in the appropriate box:

	Identical	**Different**
The **dimension** of the pieces of fabric		
The **dimension** of the test tubes		
The initial **temperature** of the environment		
The **nature** of the fabrics		

Protocol:

1. Pour 1000 mL of tap water into a 1000 mL beaker.
2. Place the beaker on a hot plate.
3. Insert the thermometer in a thermometer clamp and affix it to the universal support.

IMPORTANT: The thermometer must not touch the bottom of the beaker.

4. Turn on the hot plate to maximum in order to make the water boil.
5. Roll the first fabric around a thermometer and place them both in a test tube.
6. Place the test tube in the test tube stand.
7. Repeat operations #5 and #6 for the other pieces of fabric.
8. Number the test tubes, respecting the numbers from the data compilation table.
9. Note the **initial temperature** (starting temperature) in each test tube.
10. Once the water is boiling, place the first test tube in the beaker.
11. Note the temperature of the test tube **every minute for five minutes.**
12. Repeat steps #9 to #12 for the other fabric samples.

Data:

Temperature of the fabrics

		0 min.	1 min.	2 min.	3 min.	4 min.	5 min.	
Test tube #	Fabric	T_i * (^oC)	Temperature (^oC)				T_f * (^oC)	δ ($T_f - T_i$) (^oC)
1								
2								
3								
4								

Draw a bar graph using the gathered data.

Analysis of the results:

1. Which fabric had the greatest difference in temperature?

2. Which fabric(s) had the smallest difference in temperature?

3. What do the fabrics with the smallest temperature variations have in common?

Conclusion:

What can you conclude regarding your experiment?

Is your hypothesis validated?

Which fabric(s) are the most thermo resistant?

Let's think as a group:

1. What do we put as thermal insulation in the walls of a house?
2. What is the principal characteristic of a winter sleeping bag?
3. What is the principal characteristic of a winter coat?
4. What is the principal characteristic of oven mitts?
5. What do these objects have in common?

Competency 3 – To communicate in the languages used in science and technology	Degrees				
Criteria 4 – Respects the terminology, rules and conventions proper to science and technology in the production of messages	**1**	**2**	**3**	**4**	**5**

Remember:

Following the last two manipulations, you should be able to complete the following statement using the words below:

Heat loss - conduction - air - thermal insulation - temperature - thermo resistant

A loss of thermal energy or_____ in a substance results in a decrease in _____.

Heat travels from one substance to another substance it is touching by _____.

The substances that offer the best resistance to heat losses possess good _____.

The substances that offer good resistance to heat are _____.

In both cases, these fabrics contain a lot of _____.

Following this experiment, go back to page 5 and highlight the concepts broached by the activity.

4. The power of humidity retention

Certain fabrics retain more humidity (water) than others. The fabric of a bathing suit differs from that of a dish cloth.

You know of many fabrics, but could you say which has the best humidity retention?

Your challenge: using the supplied materials, imagine a way to verify the power of humidity absorption of a fabric.

Purpose of the manipulation:

Determine experimentally which fabric absorbs the most humidity.

1. Formulate an hypothesis in relation to the purpose of your manipulation.

❑ It may help to look for inspiration in the preceding laboratories.

2. Observe the materials available to you and imagine a way to verify your hypothesis.

Compile your list of required materials:

3. Carry out the assembly diagram that you intend to use.

3. Write all the stages of the experimental protocol.

REMINDER

- ❑ What must remain identical throughout your manipulations?
- ❑ What must vary?
- ❑ Will your operations allow you to verify your initial hypothesis?
- ❑ What will you have to measure?
- ❑ Are there measurements you need to take before the manipulation?
- ❑ Have you foreseen a table to compile your data?
- ❑ Compare your protocol to those of the previous laboratories. Is the presentation similar?

5. Create a data table.

6. Analysis of results

REMINDER

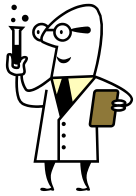
- ❑ Present your results (which will allow you to answer your initial question) using a bar or pie graph.
- ❑ Explain what you notice about these results (which will allow you to verify your hypothesis).

Diagram or graph:

Explanations:

7. Conclusion

Competency 1 – Seeks answers or solutions to scientific or technological problems	Degrees				
Criteria 1 – Comprehension of the situation	1	2	3	4	5
Criteria 2 – Elaboration of a process appropriate to the situation	1	2	3	4	5
Criteria 3 – Carrying out the process	1	2	3	4	5
Criteria 4 – Formulation of conclusions, explanations or solutions	1	2	3	4	5



5. Demonstration:

The effect of humidity on temperature

You must have noticed that we shiver when we get out of the bath or that damp clothes on a clothes line appear cold to us. Does the temperature truly diminish when a surface is wet?

We will attempt to answer this question experimentally.

Purpose of the manipulation:

Determine experimentally if humidity has an influence on the temperature of a fabric or of skin.

Prediction:

- ❑ I think that the temperature will diminish.

  or

- ❑ I think there will be no difference.

Explanation of the phenomenon:

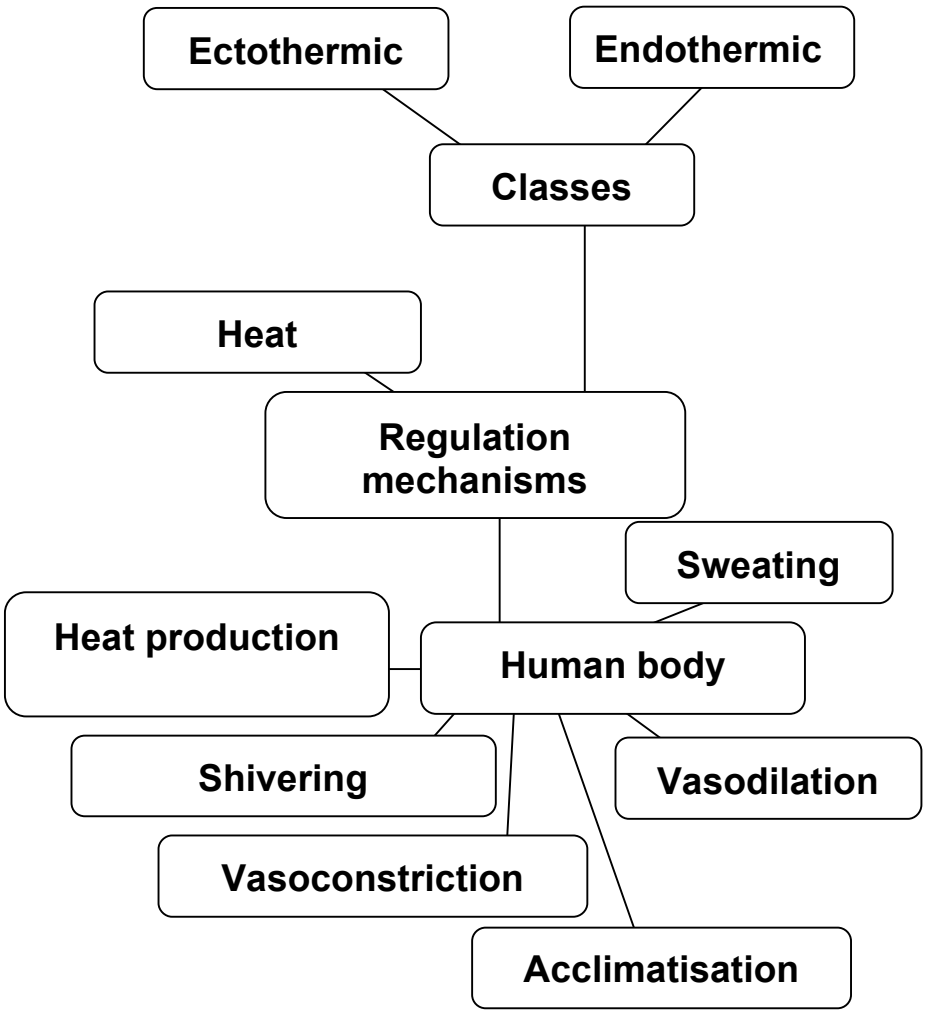
Conclusion :

Following this experiment, go back to page 5 and highlight the concepts broached by the activity.

Activate your neurons…

Explorations card for the concepts in the 2nd part

To help you along, we suggest you use a second **exploration card** for **the scientific concepts** targeted in this part. It will follow along with you as you learn and you may refer to it as needed.



Reaction of the human body to temperature changes

Since the dawn of man, the human body has been exposed to conditions of extreme hot or cold. To resist these conditions, man has developed and adapted clothing, tools and many other technological objects in order to ensure his comfort.

But before all else, the human body possesses defence mechanisms to face temperature changes. It reacts so as to regulate its internal temperature. This action mechanism is called **thermoregulation.**

Classes

Animals are classed in two large categories depending on their method of **thermoregulation:**

<u>Homoeothermic (or endothermic)</u>:

An animal whose **corporeal temperature** remains relatively constant and elevated. Its organism produces heat and **regulates** the temperature even if that of the environment changes. They are often called "hot-blooded animals".

Examples:

<u>Poikilothermic (or ectothermic)</u>:

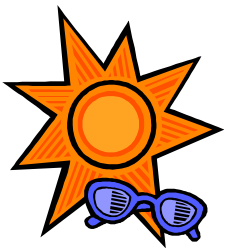
An animal that draws its heat from its environment. To regulate its corporeal temperature the animal adapts its behaviour according to the context. Its temperature may vary slightly. They are often called "cold blooded" animals.

Examples:

Remember:

The human body's normal temperature is _____ °C.

Obviously, if the body is not at the ideal temperature, it doesn't function well. It can, however, count on some defence mechanisms against temperature changes.



All these regulation mechanisms are possible thanks to blood circulation. Blood ensures heat distribution throughout the body.

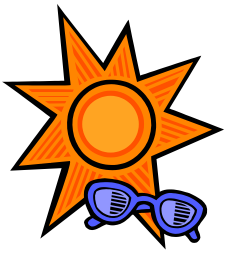
Following this activity, go back to page 35 and highlight the concepts broached.

Reactions of the human body when it is subjected to COLD

Using the texts supplied by your teacher, complete the following table:

Reactions	Operating process
Shivering	
Vasoconstriction	
Hypothermia	

Reactions of the human body when it is subjected to heat



Using the texts supplied by your teacher, complete the following table:

Reactions	Operating process
Sweating	
Vasodilation	
Hyperthermia	

Following this activity, go back to page 35 and highlight the concepts broached.

The shopping game

In order to help you better carry our your design, here are several words related to textiles. Associate the words with the appropriate definition. They were found on labels or in pamphlets that vaunt the merits of different sportswear.

Wind-breaker - black body effect - elimination by capillary action - water-resistant - waterproof - insulating - vapour barrier- thermo resistant - absorbent

Absorbs water or liquids.	
Protects from water or humidity	
Does not conduct electricity or heat	
Fabric that prevents the passage of air	
Layer of sealed fabric designed to prevent the passage of water vapour	
The action of repelling humidity from the body	
Absorption of all visible light received	
Does not allow water to penetrate	

Let's use our knowledge…

Choose an article of clothing among those suggested to you. Associate it to an activity. Justify your choice using your knowledge.

Article of clothing	→	Activity

Justification:

Now you're ready to take up the challenge!

Design of the glove

SPECIFICATIONS BOOKLET
For the design of a protective glove

Global function:
The glove must offer protection and good thermal insulation.

In terms of the human aspect , the glove must:
- allow the user not to get cold;

In terms of the *physical aspect*, the glove must:
- allow for the best protection from cold;

In terms of the *technical aspect*, the glove must:
- be comprised of three layers of fabric among the supplied samples;
- be assembled respecting the pattern supplied in annex 1;
- be able to be slipped onto the test tube available for the test;

In terms of the *industrial aspect*, the glove must:
- be able to be completely carried out in your classroom;
- be entirely carried out with the materials available and the raw materials supplied to you;

In terms of the *economic aspect*, the glove must:
- no contraints;

In terms of the *environmental aspect*, the glove must:
- no contraints.

Design booklet

1. Outline the problem

Explain what you have to do in relation to the proposed specifications booklet.

2. Simmer your ideas (text and sketches)

3. Evaluate the ideas and choose (justify your choice)

Explain and draw the retained solution on the next page.

Your choice and justification

4. Carry out a prototype of the retained solution

Note all decisions made.

Design or construction problems	Adjustments or modifications

5 Carry out a test of the glove

Evaluate the efficacy and suggest improvements to your solution.

 **Tests carried out and results obtained**	**Improvements**

Competency 1 – Seeks answers or solutions to scientific or technological problems	Degrees				
Criteria 1 – Comprehension of the situation	**1**	**2**	**3**	**4**	**5**
Criteria 2 – Elaboration of a process appropriate to the situation	**1**	**2**	**3**	**4**	**5**
Criteria 3 – Carrying out the process	**1**	**2**	**3**	**4**	**5**
Criteria 4 – Formulation of conclusions, explanations or solutions	**1**	**2**	**3**	**4**	**5**

Comparing with nature…

Illustrate and explain the superposition of your fabrics using a diagram, and compare your solution to the diagram of the polar bear's skin.

Polar Bear

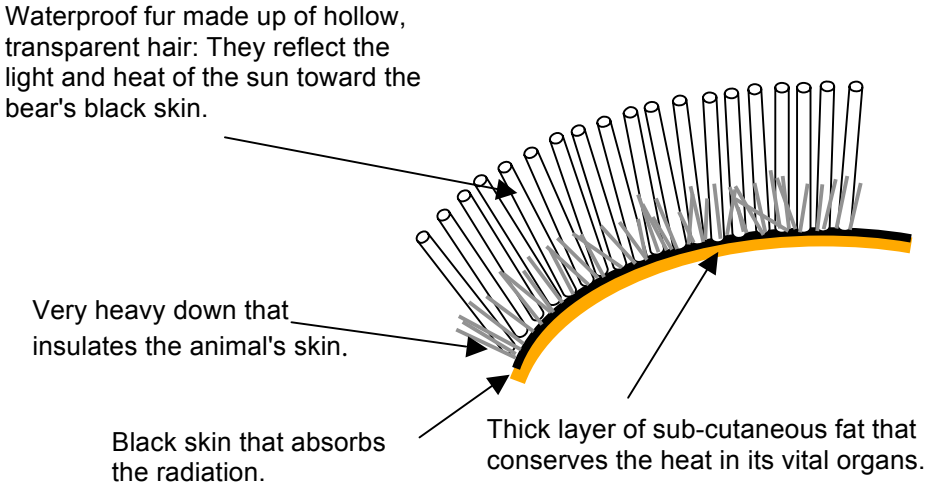


Diagram of the superposition of fabrics in your glove

Compare your solution to the polar bear's pelt.

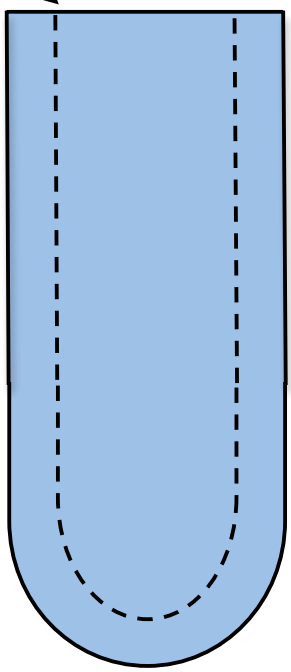
- What are the commonalities?
- What are the differences?
- Do you recognise certain scientific concepts studied in the course of this learning situation? If so, which ones?

Competency 2 – Makes the most of his/her knowledge of science and technology	Degrees				
Criteria 3 – Production of pertinent explanations or solutions	**1**	**2**	**3**	**4**	**5**

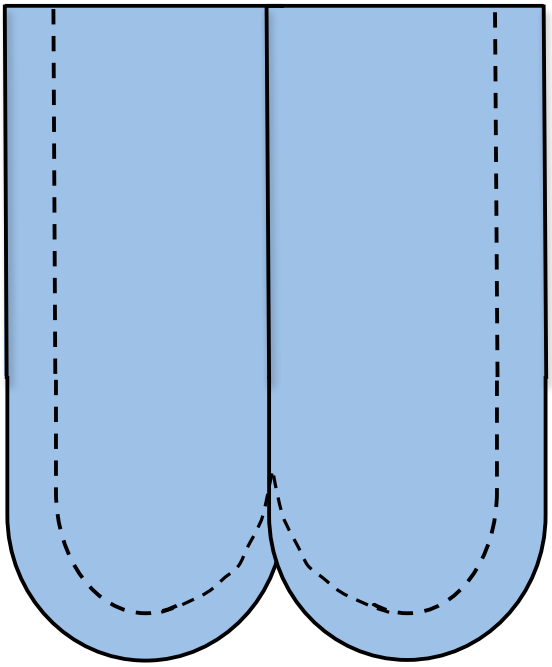
ANNEX 1

Pattern of the finger of the glove (model A):

Stitching or stapling line



Pattern of the finger of the glove (model B):



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PARKER, Steve. *Les matériaux, Les textiles*, Gamma, École Active, Canada, 2002, 31 p.

Web sites:

La nature en hiver !
http://www.univers-nature.com/dossiers/nature_hiver.html

La faculté d'adaptation
http://www.astrosurf.org/lombry/bioastro-adaptation5.htm

Dress like a polar bear
http://www.educationnature.org/programs/below_zero/activity/drspolbr.asp

The « Gore-tex$_{TM}$ » web site, which presents animations about the characteristics of different specialised clothing, including gloves.
http://www.gore-tex.com/remote/Satellite/home