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

Working document

# Adaptation to cold

**Teacher's booklet**

March 2010

# Outline of the « Adaptation to cold » LES

| NOTE: | This activity was designed within the framework of training sessions. It may require adaptation before being used with students. |
|---|---|

## PREPARATION

### 1 Catalyst

- Context

### 2 Activation of previous knowledge

- Presentation of the tool: Concepts exploration card

## REALISATION AND INTEGRATION

### 3 Learning activities

- What is heat?
- The black body effect
- Insulating power
- Resistance to heat
- Effect of humidity on temperature
- Reactions of the human body

### 4 Establishing a plan

- The power of humidity retention: protocol
- Outlining the problem for the glove design

### 5 Complex tasks

- The power of humidity retention
- Design of the glove

### 6 Synthesis activity

- The shopping game
- Comparing to nature

## Suggested teaching plan

**Total duration of the LES: 7 - 75 minute periods (some homework)**

| Lesson | Summary description in relation to the student's booklet | To be foreseen |
|---|---|---|
| Lesson 1 | • Catalyst: context – page 3<br>• Proposed challenge – page 3<br>• Network of concepts for part 1 – page 5<br>• What is heat? Complete the table with the students and answer questions - pages 6 to 8 with the group<br>• Explanations and demonstration of methods of heat propagation – page 10<br>• Homework – Complete the exercises on pages 9, 10 and 11 | - Material for the demonstration of the methods of propagation (See document: Materials preparation guide) |
| Lesson 2 | • Review of the exercises<br>• Directed laboratory: the black body effect – pages 12 to 17<br>• Review and correction of laboratory | Materials for the laboratory (See document: Materials preparation guide) |
| Lesson 3a* | • Directed laboratory: Insulating power – pages 18 to 22<br>• Review and correction of laboratory | - Materials for the laboratory (See document: Materials preparation guide) |
| Lesson 3b* | • Directed laboratory: Resistance to heat - pages 23 to 29<br>• Review and correction of laboratory<br>• Homework – preparation of the laboratory: Power of humidity retention | - Materials for the laboratory (See document: Materials preparation guide) |

| | | |
|---|---|---|
| Lesson 4 | • Validation of the protocols for the laboratory: Power of humidity - page 31 | - Materials for the laboratory depending on the manipulations suggested by the students |
| Lesson 5 | • Demonstration: Effect of humidity on temperature – page 34<br>• Network of concept for part 2 – page 35<br>• Explanation of the reactions of the human body to temperature changes – pages 36 to 39<br>• Homework: complete the shopping game – pages 40 and 41 | - Assembly for the demonstration<br>- Reference books or texts on thermoregulation<br>- Protective clothing, labels or pamphlets |
| Lesson 6 | • Design of the glove - pages 42 to 45 | Fabrication materials and baths for glove testing. (See document: Materials preparation guide) |
| Lesson 7 | • Review of the activities<br>• Comparing with nature – pages 46 and 47 | Text: Dress like a polar bear (see annex 1) |

* The students do not necessarily have to do both suggested laboratories. They are very similar. The laboratory about resistance to heat could be done as a demonstration with the teacher supplying the data to the students.

## Examples of answers expected in the student booklet – page 6

**Mechanical energy**: Any object, system or situation having movement when used (e.g. a can opener, bicycle: the pedal and chain cause the wheels to move, turning a skipping rope, etc.).

**Electrical energy**: Any object, system or situation necessitating an electrical current (e.g. an oven, car alternator, hair dryer, etc.).

**Luminous energy** : Any object, system or situation producing light (e.g. a lit candle, a light bulb, a lighted billboard, etc.).

**Chemical energy**: Any object, system or situation using a chemical reaction or links (e.g. fuel combustion, epoxy glue + hardener, a battery, etc.).

**Solar energy**: Any object, system or situation functioning on solar energy (e.g.: a solar powered calculator, solar panels for a house's energy needs, etc.).

NOTE: **It would be interesting to have a model, object or system to demonstrate each type of energy.**

## Answers expected in the student booklet – page 7 and 8

## Situations/quantity of energy

**1. A bowl of soup cools on the table**

At the start, the soup is hot because it possesses a greater quantity of energy than the ambient air. As time goes by, the more the soup loses energy while the ambient air gains energy. When the soup is completely cold, it will have same quantity of energy as the ambient air.

**2. Glass of water with ice cubes**

The water contains a greater quantity of energy than the ice cubes. When the ice cubes start to melt, the water loses energy and the ice gains energy. When there is no more ice, the contents of the glass of water possess the same quantity of energy.

**3. In the preceding images, how is the hot substance represented?** The hot substance has a large number of "sun" pictograms.

**4. In the preceding images, how is the cold substance represented?** The cold substance is represented with only a few "sun" pictograms.

### Remember:

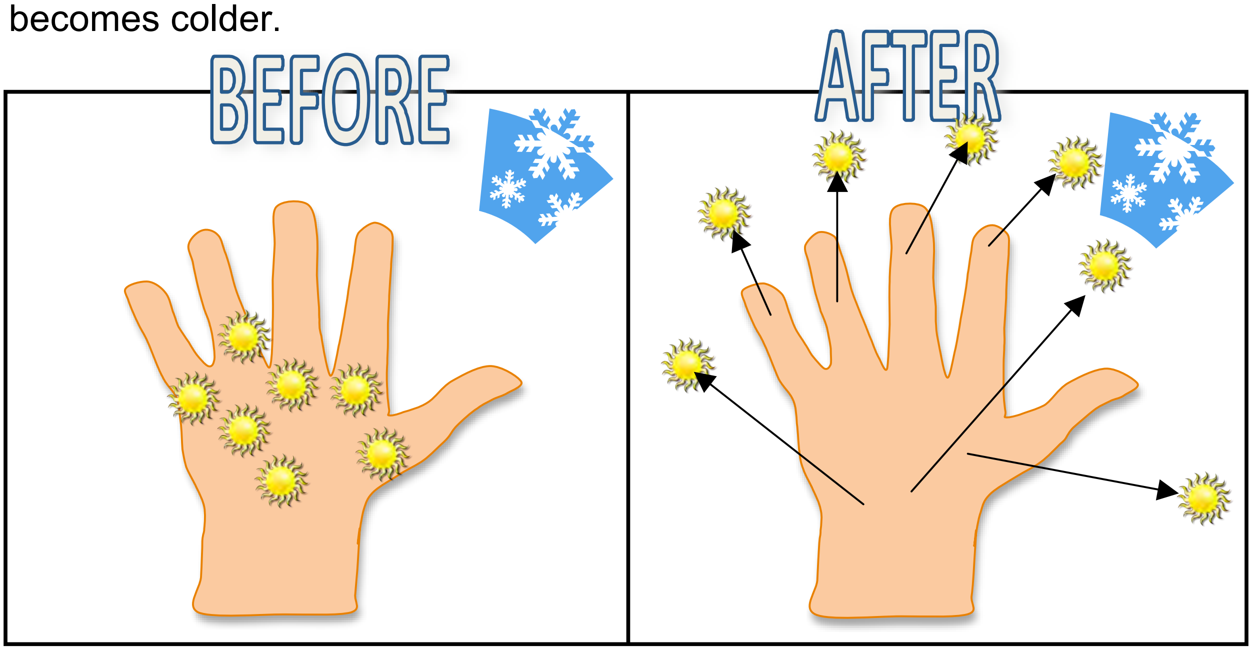
A hot substance contains a large quantity of energy while a cold substance contains a small quantity of energy. All **substances** (solids, liquids or gas) are made up of particles. Thermal energy makes the particles vibrate. The "agitation of the particles" of a substance are measured using a thermometer.

This measurement is called the temperature. The greater the amount of thermal energy a substance contains, the greater its temperature will be.

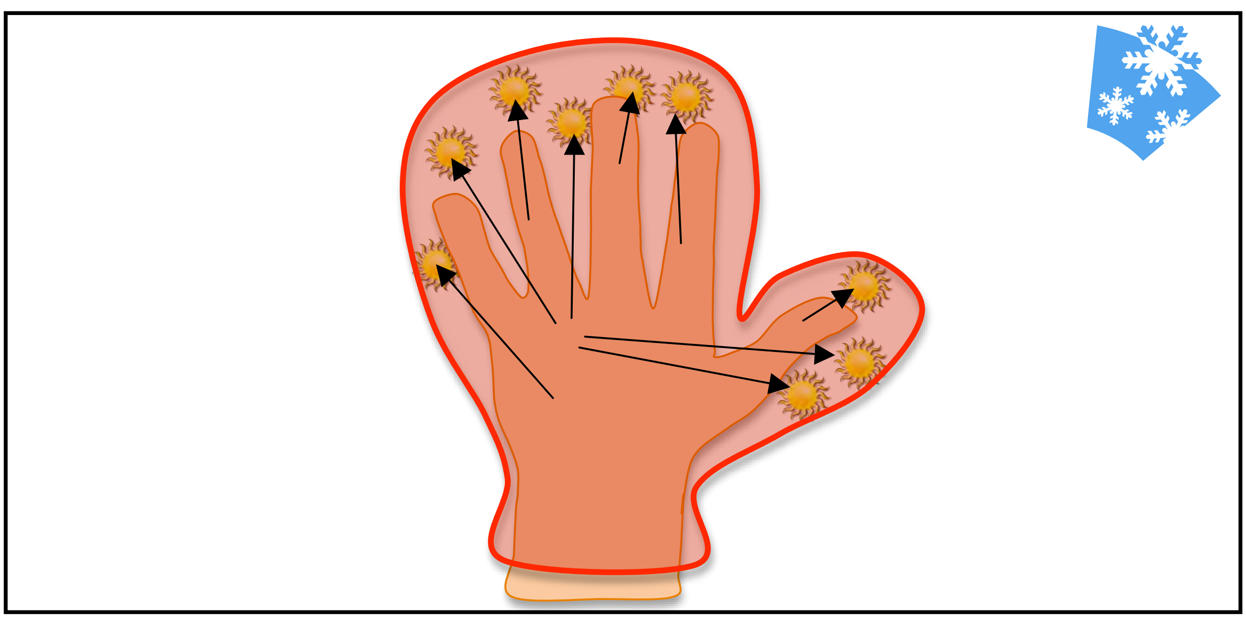
## Answers expected in the student booklet – page 9 and 10

**NOTE: It is recommended you use round yellow stickers. They are easily found in the office supplies section of many stores.**

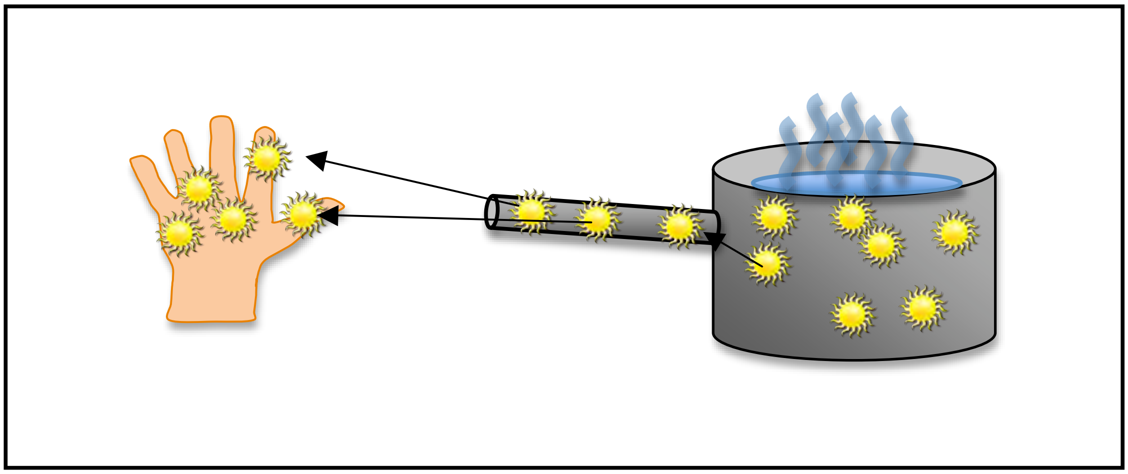
1. The hand is warmer than the ambient air. It loses energy and becomes colder.




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 of the situation**:

The heating element on which the pot is placed supplies a great deal of energy to the pot. The pot stores this energy by conduction. It thus possesses a greater quantity of energy than the hand. When it is withdrawn from the element, the pot retains this large quantity of energy. A transfer of this energy takes place, again by conduction, when the hand touches the handle. A burning sensation results.

Note: The pot also loses energy to the ambient air by radiation, but this answer is not expected from the student.

**Remember:**

**Conduction:** The action of heat transmission by direct contact from one substance to another or from one particle to another inside a substance.
**Convection:** The transportation of heat by current in the particles in a liquid or gaseous substance (fluid).

**Radiation:** Energy flow method of propagation of in the form of waves, in all directions around a source (e.g.: objects, substance, sun, flame, heating element, etc.).

## Answers expected in the student booklet – page 11

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

**Reminder: the three methods are:** **conduction, convection and radiation.**

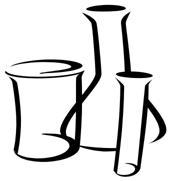
1. On a hot summer day, my asphalt driveway becomes burning hot at noon.
RADIATION: The sun transmits its energy to the asphalt. It stores the energy and becomes hot.

2. The air in the room heats up using an electric heater.
RADIATION AND CONVECTION: The heater transmits a certain amount of energy to the air around the heater by radiation. The hot air in the room tends to rise and creates a convection current. The energy is distributed in the air and the whole room ends up warmer.

3. A glass of chocolate milk heats up in the microwave oven.
RADIATION: The waves cause the particles of chocolate milk to move. The particles capture the energy transmitted, which has the effect of heating the chocolate milk.

4. Butter melts in a pot placed over a hot stove burner.
CONDUCTION: The stove's element transfers the energy to the bottom of the pot by conduction. Thus, the bottom of the pot has a greater quantity of energy than the butter. In turn, the butter gains energy by conduction from contact with the pot.

5. I burn my foot walking barefoot on my driveway at noontime.
RADIATION AND CONDUCTION: The sun has transmitted its energy by radiation to the asphalt driveway (see question 1). Since the asphalt contains more energy than the foot, it transfers its energy to the foot by contact.



# Directed laboratories

**NOTE:**

**1- For each manipulation, it is possible to use work stations. The students go from one station to the next according to a pre-established rotation. This work method could be useful if the materials are limited.**

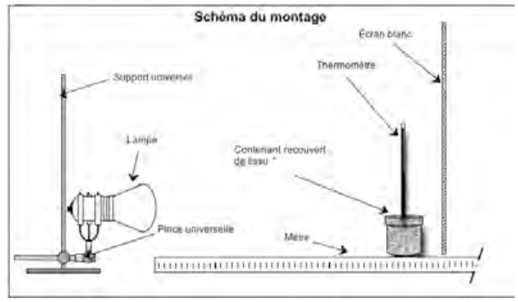
**2- In order to save time, it is suggested that all the students do laboratory 1. Labs 2 and 3 may be done only by the concerned teams (i.e. if a student wants to make a glove resistant to the cold, he will do lab 2 and if he is working on protection from the heat, lab 3 will be more appropriate). In that case, it will be important to share results obtained for each manipulation.**

**3- Fabrics: It is important to find fabrics with similar thickness and weave. If the thickness differs, thinner fabrics must be doubled or tripled in order to make the thickness uniform for all the fabrics.**

## IMPORTANT:

**RESULTS PRESENTED IN THIS GUIDE MAY DIFFER FROM YOURS. SEVERAL FACTORS MAY EXPLAIN THESE DIFFERENCES: FABRIC SAMPLES HAVING DIFFERENT CHARACTERISTICS THAN OURS (WEAVE, THICKNESS, ETC.) AND VARIABLE LABORATORY CONDITIONS (THERMOMETERS, HOT PLATES, THE GLASS OF THE TEST TUBE, ETC.).**

## 1. . Black body effect (pages 13 to 18)




In the student booklet, it is suggested that you do the first manipulation with one container, then repeat it with the other two. This way, you use only a few thermometers (economy of materials). You must, however, calculate 8 minutes per manipulation, in addition to the time allocated to cooling the thermometers between manipulations. These wait times may prevent good time management of the experiment. Should this be an issue, you will have to foresee 2 additional thermometers per work station.

**Time required for the laboratory (manipulations)**:

Installation: 10 minutes
Manipulations : 8 minutes per manipulation X 3 manipulations = 24 minutes
Cooling the thermometer: ± 2 minutes/manipulation X 3 = 6 minutes
Putting away: 10 minutes
Total : ± 50 minutes

If you opt to perform the three manipulations simultaneously, the total time will be ± 30 minutes.

**Material required for the students**:
Consult the document called: **Materials preparation guide**

## Answers expected in the student booklet – page 13

Place an « X » in the appropriate box:

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

**Hypothesis:**

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

Variables answers

If so, why? Variables answers

## Answers expected in the student booklet – page 15

**Data:**

**Variation in temperature of the containers after heating.**

LABORATOIRE #1 : L'effet de corps noir

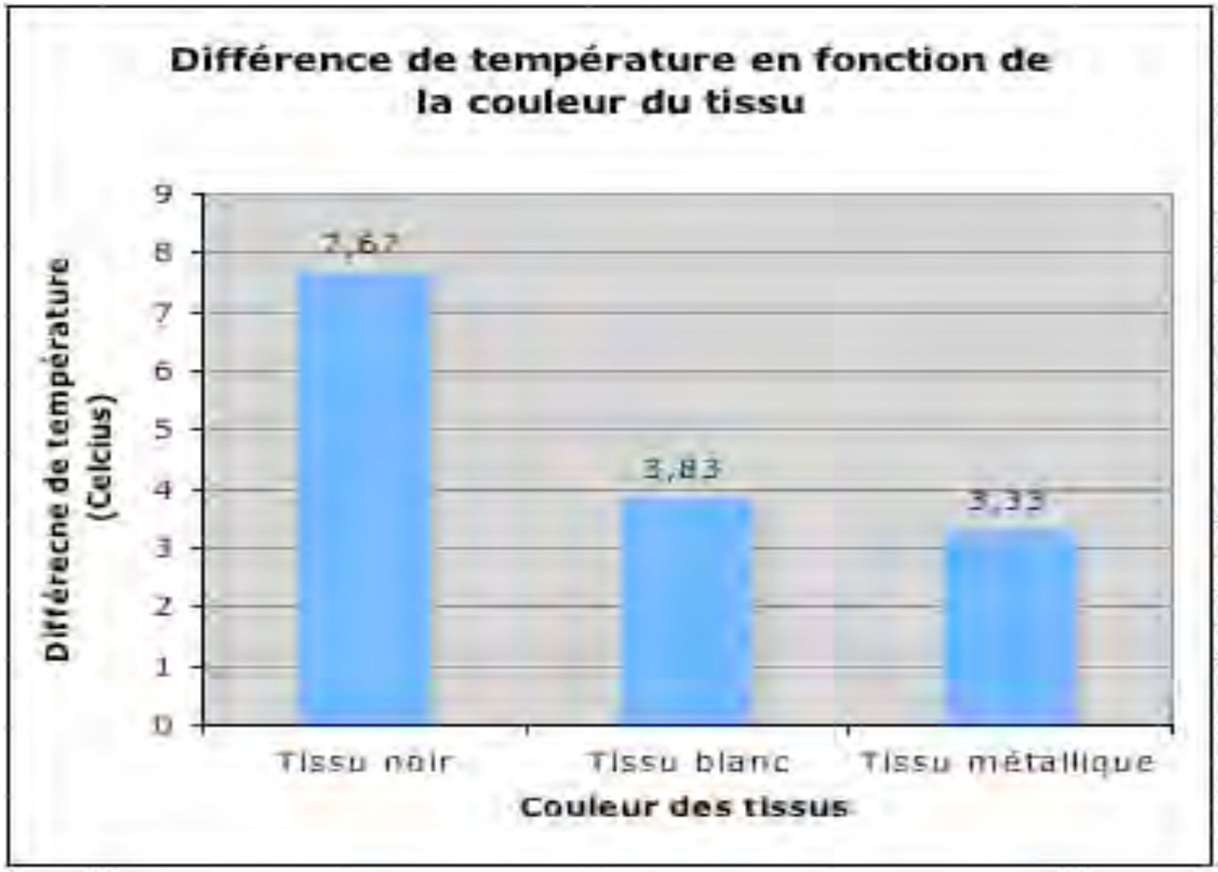
| | | $T_r$ | 1 min. | 2 min. | 3 min. | 4 min. | 5 min. | 6 min. | 7 min. | 8 min. |
|---|---|---|---|---|---|---|---|---|---|---|
| TISSU NOIR | °C | 24 | 25 | 25 | 26 | 27 | 28,5 | 30 | 31 | 32 |
| | δT° | | 1 | 1 | 2 | 3 | 4,5 | 6 | 7 | 8 |
| | °C | 24 | 25 | 25 | 26 | 27 | 28,5 | 30 | 31 | 32 |
| | δT° | | 1 | 1 | 2 | 3 | 4,5 | 6 | 7 | 8 |
| | °C | 25 | 25,5 | 26 | 27 | 28 | 29 | 30 | 31 | 32 |
| | δT° | | 0,5 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| | Moy. | | 0,83 | 1,00 | 2,00 | 3,00 | 4,33 | 5,67 | 6,67 | 7,67 |

| | | $T_r$ | 1 min. | 2 min. | 3 min. | 4 min. | 5 min. | 6 min. | 7 min. | 8 min. |
|---|---|---|---|---|---|---|---|---|---|---|
| TISSU BLANC | °C | 24 | 25 | 25 | 25 | 25,5 | 26,5 | 27 | 27,5 | 28 |
| | δT° | | 1 | 1 | 1 | 1,5 | 2,5 | 3 | 3,5 | 4 |
| | °C | 24 | 24,5 | 25 | 25,5 | 26 | 26,5 | 27 | 27 | 28 |
| | δT° | | 0,5 | 1 | 1,5 | 2 | 2,5 | 3 | 3 | 4 |
| | °C | 24 | 24,5 | 25 | 25 | 25,5 | 26 | 26,5 | 27 | 27,5 |
| | δT° | | 0,5 | 1 | 1 | 1,5 | 2 | 2,5 | 3 | 3,5 |
| | Moy. | | 0,67 | 1,00 | 1,17 | 1,67 | 2,33 | 2,83 | 3,17 | 3,83 |

| | | $T_r$ | 1 min. | 2 min. | 3 min. | 4 min. | 5 min. | 6 min. | 7 min. | 8 min. |
|---|---|---|---|---|---|---|---|---|---|---|
| TISSU MÉTALLIQUE | °C | 24 | 25 | 25,5 | 26 | 27 | 27 | 28 | 28 | 28 |
| | δT° | | 1 | 1,5 | 2 | 3 | 3 | 4 | 4 | 4 |
| | °C | 24 | 24 | 24,5 | 25 | 25 | 26 | 26 | 26,5 | 27 |
| | δT° | | 0 | 0,5 | 1 | 1 | 2 | 2 | 2,5 | 3 |
| | °C | 25 | 25 | 26 | 26 | 26,5 | 27 | 27,5 | 28 | 28 |
| | δT° | | 0 | 1 | 1 | 1,5 | 2 | 2,5 | 3 | 3 |
| | Moy. | | 0,33 | 1,00 | 1,33 | 1,83 | 2,33 | 2,83 | 3,17 | 3,33 |

**Note:** After numerous tries, we notice that the difference in temperature between the metallic and white fabrics is greater if it is heated for 8 minutes. The results may vary depending on the type of light bulb used, the type of container, the thickness and weave of the fabric used, the distance, the time, etc.

**Bar Graph (example of results):**




## Answers expected in the student booklet – page 16

**Analysis of results:**

**1.** In which container is the temperature difference the greatest?
The black covered container results in the greatest difference in temperature (the greatest variation in temperature).

**2.** In which container is the temperature difference the lowest?
The container covered with the metallic fabric results in the smallest difference in temperature (the smallest variation in temperature).

**Conclusion:**

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

a) I was right because
Variable answers

**or**

b) I was wrong because
Variable answers

---

---

2. Do you think it was important to have the same heat exposure time during the manipulation? Yes
Explain your answer. To be able to compare the containers, we must maintain constant factors, among others the heat exposure time.

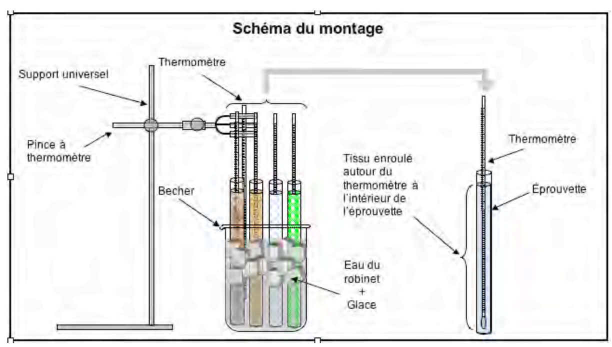
**Note: At this stage it is important to insist upon what we wanted to observe in the first place and to ensure that only one factor at a time varies, in order to be able to evaluate what influences or does not influence a problem. This is called "controlling the variables".**

## Answers expected in the student booklet – page 17

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

A dark coloured surface absorbs **more energy** 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 **radiation**. The substance **absorbs** the heat or **the thermal energy**. This phenomena is called **the black body effect**.

## 2. Insulating power (pages 18 to 22)




**Time required for the laboratory (manipulations):**

Installation: 15 minutes
Manipulations: 5 minutes
Putting away: 15 minutes
Total: ± 35 minutes

**Material required for the students:**
Consult the document called: **Materials preparation guide**

## Answers expected in the student booklet – page 18

**Hypothesis:**

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

## Answers expected in the student booklet – page 19

Place an « X » in the appropriate box:

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

## Answers expected in the student booklet – page 20

**Data:**

**Variation of temperature of the fabrics after cooling**

**LABORATOIRE #2 : Le pouvoir isolant**

| # - Tissu | $T_i$ | 1 min. | 2 min. | 3 min. | 4 min. | 5 min. | δT° | |
|---|---|---|---|---|---|---|---|---|
| 1- Acrylique | 22 | 19 | 16 | 13 | 11 | 10 | 12 | |
| 2- Coton | 23,5 | 20 | 16 | 13 | 10,5 | 9 | 14,5 | |
| 3- Laine | 23,5 | 21 | 18 | 15,5 | 13 | 12 | 11,5 | |
| 4- Nylon | 21 | 17 | 12,5 | 10 | 8 | 6 | 15 | 25X150mm |
| 5- Pellicule métallique | 21 | 18 | 14 | 11,5 | 9 | 8 | 13 | |
| 6- Polyester | 23 | 15,5 | 11,5 | 9 | 7 | 6 | 17 | |
| 7- Bulles de plastiques | 21 | 17 | 13 | 11 | 9 | 7 | 14 | |

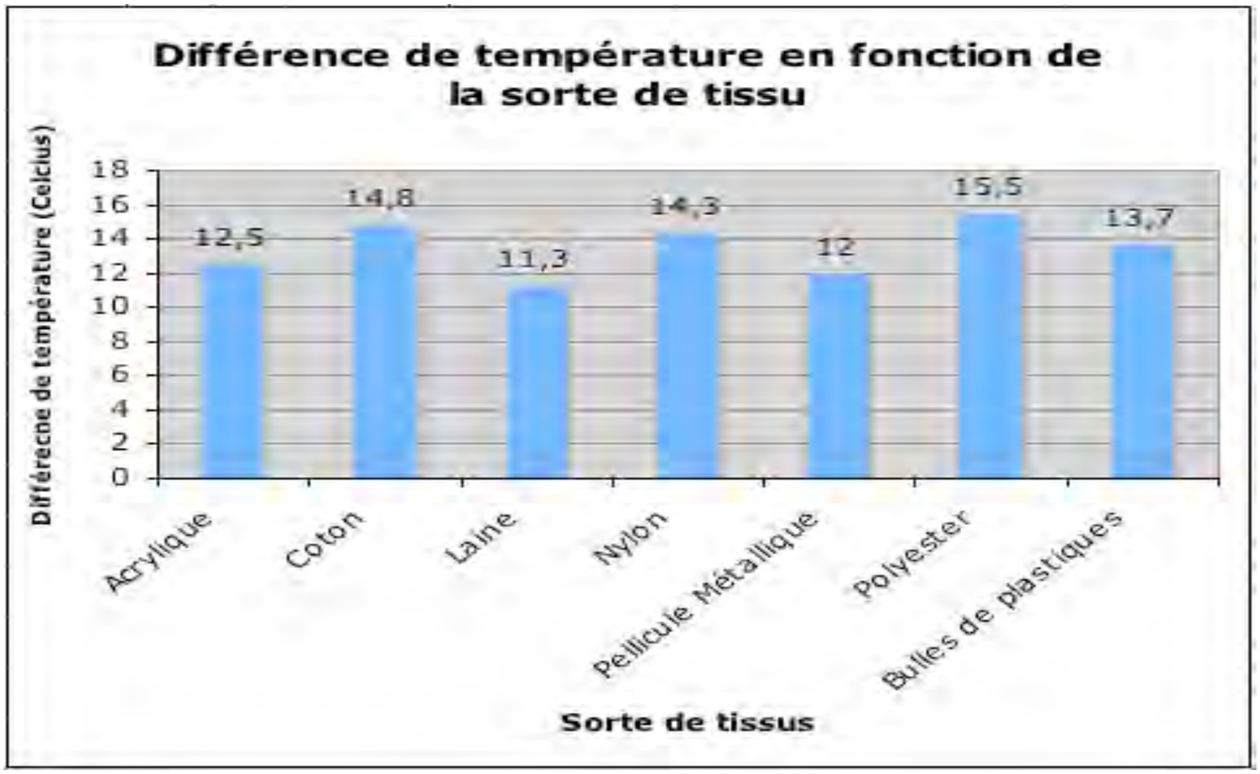
| | Moy. |
|---|---|
| 1- Acrylique | 12,5 |
| 2- Coton | 14,83 |
| 3- Laine | 11,33 |
| 4- Nylon | 14,33 |
| 5- Pellicule métallique | 12,00 |
| 6- Polyester | 15,50 |
| 7- Bulles de plastiques | 13,67 |

| # - Tissu | $T_i$ | 1 min. | 2 min. | 3 min. | 4 min. | 5 min. | δT° | |
|---|---|---|---|---|---|---|---|---|
| 1- Acrylique | 20,5 | 17 | 14 | 11,5 | 9,5 | 8 | 12,5 | |
| 2- Coton | 22 | 17,5 | 13,5 | 10,5 | 8,5 | 7 | 15 | |
| 3- Laine | 21 | 18,5 | 15,5 | 13 | 11,5 | 10 | 11 | |
| 4- Nylon | 20,5 | 17,5 | 13 | 10,5 | 8 | 7 | 13,5 | 25X150mm |
| 5- Pellicule métallique | 20 | 17 | 14 | 11 | 9 | 8 | 12 | |
| 6- Polyester | 21 | 18,5 | 16,5 | 9 | 7 | 6 | 15 | |
| 7- Bulles de plastiques | 22 | 16 | 13 | 11 | 9 | 8 | 14 | |

| # - Tissu | $T_i$ | 1 min. | 2 min. | 3 min. | 4 min. | 5 min. | δT° | |
|---|---|---|---|---|---|---|---|---|
| 1- Acrylique | 20 | 16 | 13 | 10 | 8 | 7 | 13 | |
| 2- Coton | 21 | 17 | 13 | 9 | 7 | 6 | 15 | |
| 3- Laine | 21 | 18 | 15 | 13 | 11 | 9,5 | 11,5 | |
| 4- Nylon | 20 | 14 | 11 | 8,5 | 7 | 5,5 | 14,5 | 25X150mm |
| 5- Pellicule métallique | 19 | 17 | 13 | 11 | 9 | 8 | 11 | |
| 6- Polyester | 20 | 14,5 | 11 | 8,5 | 7 | 5,5 | 14,5 | |
| 7- Bulles de plastiques | 21 | 16 | 13 | 11 | 9 | 8 | 13 | |

## Answers expected in the student booklet – page 21

**Bar Graph (example of results):**




**Note:** The students will have a four bar diagram, since they will have four samples.

**Analysis of results:**

**Careful: The fabric having the greatest variation in temperature is the one that will protect the least from the cold. This will have to be explained to the students.**

1. Which fabric had the greatest variation in temperature?
Variable answers. In our fabric samples, the polyester had the greatest variation in temperature.
2. . Which fabric(s) had the smallest variation in temperature?
Variable answers. In our fabric samples, the wool had the smallest variation.
3. What do the fabrics with the smallest temperature variations have in common?
Other than the nature of the fabric, they may contain spaces in the weave that store air, which is a very poor heat conductor.

## Answers expected in the student booklet – page 22

**Conclusion:**

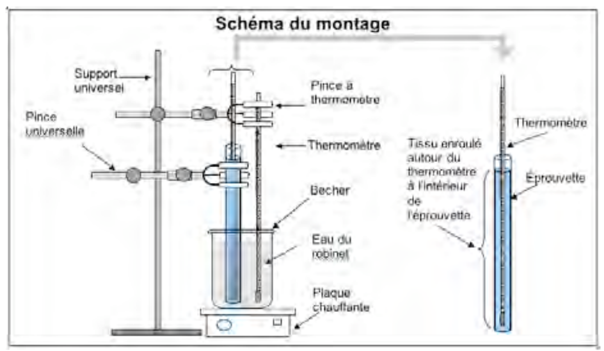
Using your results, what can you conclude in relation to your initial hypothesis?

I was right because
Variable answers

**or**

I was wrong because
Variable answers

## 3. Resistance to heat (pages 23 to 29)




In the student booklet, it is suggested you manipulate one fabric at a time. As described, the manipulation would take 50 minutes. To save time, it is possible to do two fabrics at a time. You will, however, have to foresee an additional universal clamp in the material supplied to the student. The universal clamp is necessary to affix the test tube because it is very light and will otherwise float in the beaker. By affixing the test tubes, we prevent burns from vapour or from the hot plate.

To save on installation time, the water may be heated or boiled in a kettle before the students arrive and maintained at ± 100°C.

**Time required for the laboratory (manipulations):**
Installation + heating the water: 15 minutes
Manipulations: 5 minutes (two fabrics at a time) X 2 = 10 minutes
Putting away: 15 minutes
Total: ± 45 minutes

**Material required for the students:**
Consult the document: **Materials preparation guide**

## Answers expected in the student booklet – page 23

**Hypothesis:**

I believe that variable answers will be the fabric that best insulates from cold because variable answers.

## Answers expected in the student booklet – page 24

Place an « X » in the appropriate box:

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

## Answers expected in the student booklet – page 26

**Data:**

**Variation in the temperature of the fabrics after heating**

**LABORATOIRE #3 : La résistance à la chaleur**

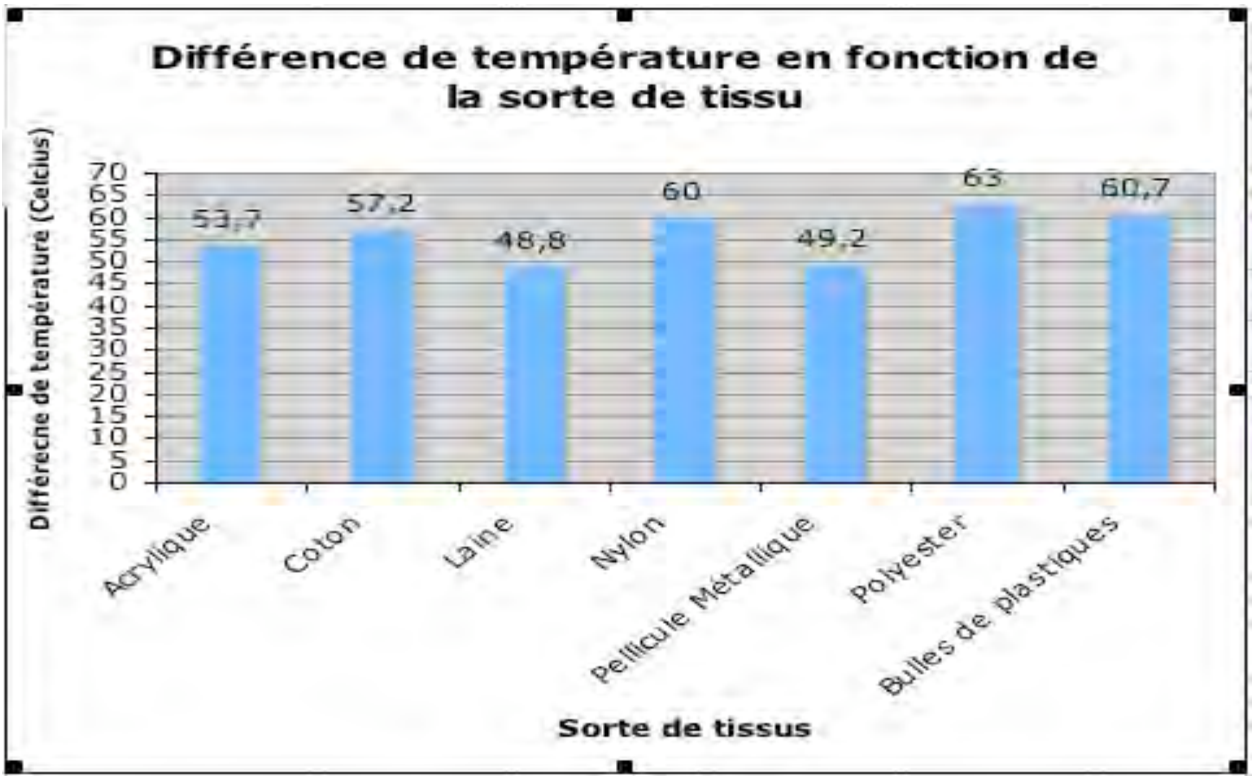
| # - Tissu | $T_i$ | 1 min. | 2 min. | 3 min. | 4 min. | 5 min. | δT° |
|---|---|---|---|---|---|---|---|
| 1- Acrylique | 20 | 34 | 48,5 | 59 | 68 | 74 | 54 |
| 2- Coton | 21 | 42 | 61 | 71 | 77,5 | 82 | 61 |
| 3- Laine | 21 | 37 | 53 | 61 | 67 | 71 | 50 |
| 4- Nylon | 20 | 42 | 58 | 68 | 75 | 80 | 60 |
| 5- Pellicule métallique | 22 | 33 | 46,5 | 57 | 64 | 70 | 48 |
| 6- Polyester | 21 | 44 | 61 | 72 | 79 | 84 | 63 |
| 7- Bulles de plastiques | 22 | 43 | 60 | 71 | 78 | 83 | 61 |

| # - Tissu | $T_i$ | 1 min. | 2 min. | 3 min. | 4 min. | 5 min. | δT° |
|---|---|---|---|---|---|---|---|
| 1- Acrylique | 21 | 35 | 50 | 61 | 69 | 75 | 54 |
| 2- Coton | 22 | 44 | 62 | 73 | 79,5 | 84 | 62 |
| 3- Laine | 23 | 38 | 52 | 61 | 67 | 71 | 48 |
| 4- Nylon | 21 | 43 | 62 | 70 | 76 | 81 | 60 |
| 5- Pellicule métallique | 20,5 | 32 | 46 | 56 | 64 | 70 | 49,5 |
| 6- Polyester | 22 | 45 | 62 | 73 | 81 | 85 | 63 |
| 7- Bulles de plastiques | 23 | 43 | 60,5 | 71 | 78,5 | 84 | 61 |

| # - Tissu | $T_i$ | 1 min. | 2 min. | 3 min. | 4 min. | 5 min. | δT° |
|---|---|---|---|---|---|---|---|
| 1- Acrylique | 22 | 36 | 51 | 62 | 69 | 75 | 53 |
| 2- Coton | 23 | 38 | 53 | 63 | 70 | 75 | 52 |
| 3- Laine | 22,5 | 38 | 53 | 61 | 66,5 | 71 | 48,5 |
| 4- Nylon | 21 | 48 | 63 | 71 | 77 | 81 | 60 |
| 5- Pellicule métallique | 20 | 32 | 45,5 | 56 | 64 | 70 | 50 |
| 6- Polyester | 22 | 46 | 63 | 74 | 80 | 85 | 63 |
| 7- Bulles de plastiques | 23 | 43 | 59 | 70 | 77 | 83 | 60 |

| # - Tissu | Essai #1 | Essai #2 | Essai #3 | Essai #4 | Essai #5 | Essai #6 | Moy. |
|---|---|---|---|---|---|---|---|
| 1- Acrylique | 54 | 54 | 53 | | | | 53,67 |
| 2- Coton | 61 | 62 | 52 | 53 | 56,5 | 59 | 57,25 |
| 3- Laine | 50 | 48 | 48,5 | | | | 48,83 |
| 4- Nylon | 60 | 60 | 60 | | | | 60,00 |
| 5- Pellicule métallique | 48 | 49,5 | 50 | | | | 49,17 |
| 6- Polyester | 63 | 63 | 63 | | | | 63,00 |
| 7- Bulles de plastiques | 61 | 61 | 60 | | | | 60,67 |

**Bar graph (example of results):**




## Answers expected in the student booklet – page 27

**Analysis of results:**

**Careful: The fabric having the greatest variation of temperature will be the one that protects the least from heat. This will have to be explained to the students.**

1. Which fabric had the greatest difference in temperature?

Variable answers. Among our samples, we noticed the polyester had a greater variation in temperature.

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

Variable answers. Among our samples, the wool had the smallest variation.

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

Other than the nature of the fabric, they may contain spaces in the weave that store air, which is a very poor heat conductor.

## Answers expected in the student booklet – page 28

**Conclusion:**

What can you conclude regarding your experiment?
Variable answers
Is your hypothesis validated?
Variable answers
Which fabric(s) are the most thermo resistant?
Depending on the samples used in the tests, the wool will be the most thermo resistant.

**Let's think as a group:**

1. What do we put as thermal insulation in the walls of a house?
Mineral wool and Styrofoam are the most commonly used insulators in the walls of our houses.

2. What is the principal characteristic of a winter sleeping bag?
Offering adequate protection from the cold.

3. . What is the principal characteristic of a winter coat?
Offering protection from the cold (wind, snow, rain).

4. What is the principal characteristic of oven mitts?
Offering protection from heat.

5. What do these objects have in common?
They all have a thick layer that stores a good deal of air (thermal insulator) to offer superior protection from heat exchanges.

## Answers expected in the student booklet – page 29

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

A loss of thermal energy or heat loss in a substance results in a decrease in temperature.

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

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

The substances that offer good resistance to heat are thermo resistant.

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

### 4. The power of humidity retention (page 30)

NOTE: For this manipulation, we tested several protocols:
- absorption test by pouring a pre-determined quantity of water (like the television diaper test);
- absorption test by capillarity;
- several other methods.

We could not reproduce the results and from one manipulation to the other: the same sample could be the most absorbent, then the least. The most efficient and most reproducible method turned out to be this one:

**Protocol:**

1. Determine the mass of the dry fabric samples.
2. Immerse the samples in a beaker of water (they must be soaked).
3. Place the first sample in a salad spinner whose mechanism ensures a uniform number of revolutions for each sample.
4. While spinning, count the number of revolutions that you will have decided ahead of time. (5 to 10).
5. Determine the mass of the sample that has been spun.
6. Repeat manipulations 3 and 4 for the other samples.

**NOTE: It is recommended that you present the salad spinner in the materials suggested to the students in order to inspire the students.**

**IMPORTANT: It is essential to obtain a salad spinner whose mechanism ensures a uniform number of revolutions for each sample. Do not place all**

the samples in at once, because they become compacted, thus falsifying the results.

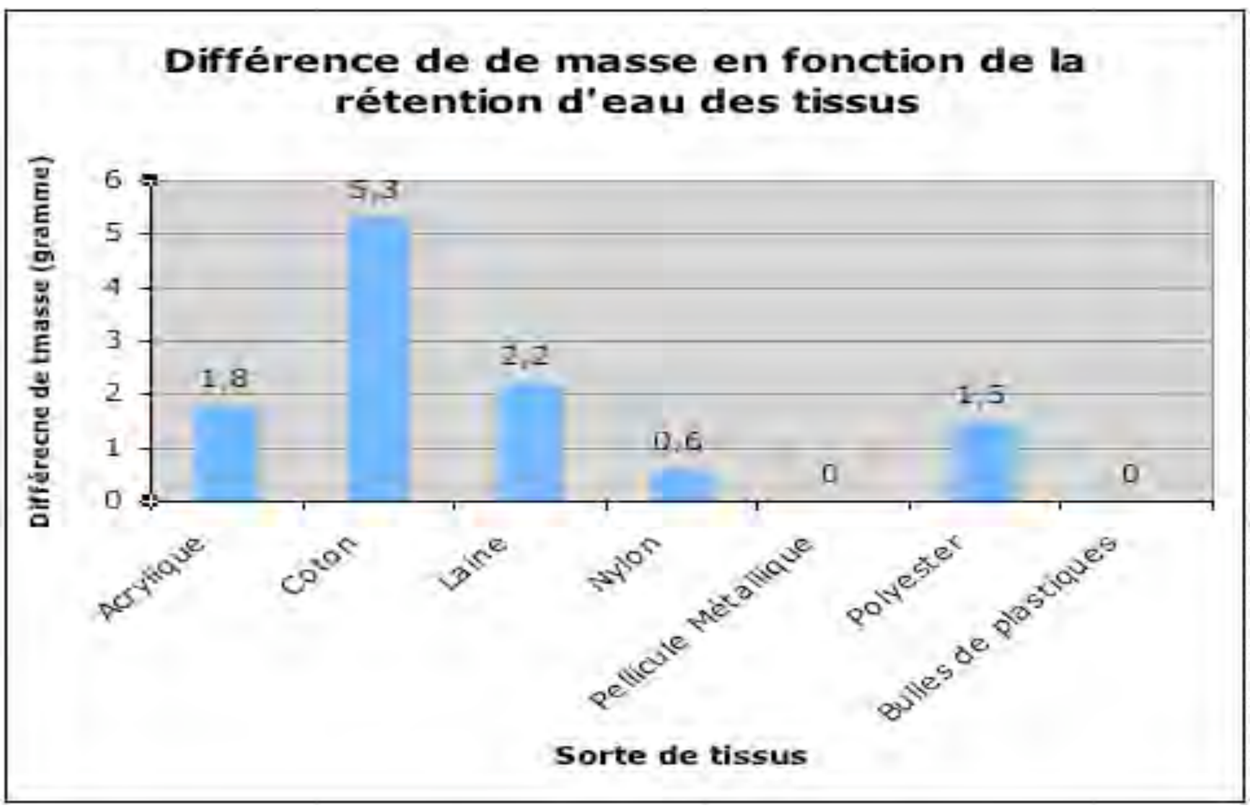
**Data:**

**Variation in the mass of the fabrics after soaking**

**LABORATOIRE #4 : Pouvoir de rétention de l'humidité**

| # - Tissu | $M_I$ | $M_F$ | $M_F$ | $M_F$ | $M_F$ | $M_F$ | $M_F$ | ∂M |
|---|---|---|---|---|---|---|---|---|
| 1- Acrylique | 1,00 | 3,25 | 2,52 | 2,93 | 2,62 | 3,03 | 2,87 | 1,87 |
| 2- Coton | 1,97 | 7,46 | 7,41 | 7,34 | 6,78 | 7,35 | 7,36 | 5,31 |
| 3- Laine | 1,48 | 3,68 | 3,67 | 3,76 | 3,76 | 3,74 | 3,56 | 2,22 |
| 4- Nylon (mauve | 0,41 | 0,55 | 0,55 | 0,54 | 0,52 | 0,54 | 0,54 | 0,13 |
| 5- Nylon (noir) | 0,57 | 1,17 | 1,11 | 1,11 | 1,11 | 1,15 | 1,21 | 0,57 |
| 6- Polyester | 1,34 | 2,69 | 2,87 | 2,77 | 2,78 | 2,95 | 2,77 | 1,47 |
| 7- Bulles de plastiques | | | | | | | | |

**Bar graph (example of results):**



## 5. Demonstration: The effect of humidity on temperature (page 34)

**Manipulations:**

1. Wrap the ends of two thermometers with facecloths having the same dimensions.

2. Immerse the point of one of the thermometers in the room temperature water until the fabric is completely damp. Note the initial temperature of the two thermometers. (They should be similar.)

3. Fan the two thermometers for two or three minutes with a paper fan.

Note the final temperature of the two thermometers.

**Results:** You will generally notice a difference in temperature of somewhere between 4 °C and 8 °C between the "dry thermometer" and the "damp thermometer". The "dry thermometer" maintains the same temperature, while that of the "damp thermometer" decreases.

**Explanation:** Water evaporates. Evaporation (passage from a liquid state to a gaseous state) is a phenomenon that requires energy. The energy is drawn from the environment, namely from around the reservoir of the thermometer. This translates to a decrease in temperature. The drier the air, the more easily the water will evaporate and the greater the temperature difference will be between the two thermometers.

**NOTE:** That is also why we are cold when we get out of the bath and our skin is wet.

## Answers expected in the student booklet – pages 36 and 37

**Homoeothermic (or endothermic):**
**Examples:** **Mammals, birds and humans**

**Poikilothermic (or ectothermic):**
**Examples:** **Insects, reptiles and fish**

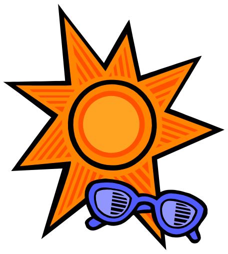
## Remember:

**The human body's normal temperature is 37.2 °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.**

## Answers expected in the student booklet – page 38

# Reactions of the human body when it is subjected to COLD

| Reactions | Operating process |
|---|---|
| **Shivering** | A reaction in homoeothermic (endothermic) animals, including humans, that consists in activating the skin muscles (at the base of the hair follicles) to heat the skin without using blood. The skin takes on the appearance of "goose bumps". Shivers may be accompanied by trembling.<br>The blood is then concentrated on the vital organs. |
| **Vasoconstriction** | Decrease in the diameter of the blood vessels in order to increase blood flow to the vital organs and maintain them at an adequate temperature. |
| **Hypothermia** | Condition in which homoeothermic animals (like humans) are no longer able to maintain an adequate corporeal temperature. Body temperature decreases to below 35 °C. Hypothermia is qualified as moderate to severe depending on body temperature. Below 30 °C, cardiac rhythm and respiration are slowed, and a state of coma is close. There is a risk of cardiac arrest and this state necessitates immediate medical assistance. |



**Answers expected in the student booklet – page 39**

## Reaction of the human body when it is subjected to heat

| Reactions | Operating process |
|---|---|
| **Sweating** | The body's defence mechanism to an increase in its temperature, which activates the skin's sweat glands to secrete sweat. Sweat will humidify the skin to allow it to lose a greater quantity of heat while it evaporates. The skin's temperature decreases thus allowing the surface blood to cool and from there to cool the vital organs. In very hot temperatures, or during intense physical effort, the body may lose up to a litre of sweat in an hour. It becomes essential to drink often and in large amounts. |
| **Vasodilation** | An increase in the diameter of the blood vessels at the surface of the skin to allow a greater quantity of blood to be cooled. The blood then cools the vital organs. |
| **Hyperthermia** | Condition in which homoeothermic animals (like humans) are no longer able to maintain a sufficiently low corporeal temperature. Body temperature increases to over 38° C. This may result from excessive exposure to the sun's heat (sun stroke) to the environment (heat stroke) or from intense effort in a very hot and humid environment (heat stroke from effort). Contrary to a fever, which is an internal body disorder, hyperthermia is the result of the environment. Body temperature above 41.5° C in a human may result in irreversible cerebral complications which may be fatal. |

## Answers expected in the student booklet – page 40

**The shopping game**

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

| | |
|---|---|
| Absorbs water or liquids | ABSORBENT |
| Protects from water or humidity | WATER RESISTANT |
| Does not conduct electricity or heat | INSULATING |
| Fabric that prevents the passage of air | WIND-BREAKER |
| Layer of sealed fabric designed to prevent the passage of water vapour | VAPOUR BARRIER |
| The action of repelling humidity from the body | ELIMINATION BY CAPILLARY ACTION |
| Absorption of all visible light received | BLACK BODY EFFECT |
| Does not allow water to penetrate | WATERPROOF |

## Answers expected in the student booklet – page 41

You will have to foresee bringing in various protective clothing (gloves, sports coats, oven mitts) with labels on them. Labels alone or pamphlets vaunting high-tech clothing or fabrics could just as easily replace the clothing.

## Comparing with nature – page 46

**Student answers may vary, but we should expect an insulating layer, some relation to the coloured fabric, an absorbent layer, water resistance, etc.**

**We recommend the text about polar bears in annex 1 of this document.**

## RECOMMENDED TECHNICAL CAPSULES

Capsule on the safe use of a hot plate available on the CPD website
http://www2.cslaval.qc.ca/cdp/UserFiles/File/telechargement/capsules_securite.pdf

Technical capsule on using a scale
http://www2.cslaval.qc.ca/cdp/UserFiles/File/telechargement/capsules_securite.pdf

## BIBLIOGRAPHY

**Books:**

PODESTO, Martine. *Tant de façons de vivre dans les conditions difficiles*, Québec Amérique, 32 p.

GONTIER, Josette. *Chaud froid*, Hachette Jeunesse, 2004, 27 p.

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

The faculty to adapt
http://www.astrosurf.org/lombry/bioastro-adaptation5.htm

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

Excerpt from the following website:
http://www.educationnature.org/programs/below_zero/activity/drspolbr.asp

## Polar Bear's protection from the cold

Polar bears live in Arctic regions. Closely related to grizzly bears, they evolved from them during the late Pleistocene Age approximately 200,000 years ago. During this evolution, polar bears developed anatomical, physiological and behavioural adaptations to life in a frozen land..

The polar bear is a sensible winter dresser, thanks to its three "coats". The first is a layer of oily, water-repellent guard hairs. Though these appear white or creamy yellow in colour, they are actually transparent and hollow. Their colour is the reflection of visible light. These hairs reflect radiant heat from the sun down to the bear's black skin. The next coat is a layer of dense underfur which snuggles against the animal's skin much like long underwear. Beneath the black skin is the final coat, a thick layer of insulating subcutaneous fat which keeps the bear's vital core warm.

The polar bear has many other sensible winter adaptations. Its well-furred ears and tail are relatively small, and so less likely to be frostbitten. Its wide, densely-furred and noiseless feet with their webbed toes, can't be beat for silently stalking prey, keeping warm, walking in snow and swimming. To avoid a chill, polar bears also shake themselves vigorously as soon as they climb out of water.

In winter, polar bears eat mostly seals, particularly ringed seals. Often they leave the meat untouched and devour the energy-rich blubber instead. (Species like Arctic foxes and ravens that follow the bears gobble up the leftovers!) (Mammals of the Canadian Wild.) Polar bears can digest fat and protein very efficiently. Depending on how active they are, the temperature, and whether they are feeding or starving, their metabolic rate fluctuates greatly. Females fast for eight months during winter while they are pregnant and giving birth! They prepare for this by gorging on seals from April until early July, and boosting their body fat to 50 per cent or more. (National Geographic, Jan. 1998, "Polar Bears".)

Arctic summers can be way too hot for these well-insulated bears! Summer dens have been found where polar bears dig deep into the permafrost to cool off. It is thought that some of these dens may have been used for hundreds of years.

Traditionally, Inuit have used the polar bear to their advantage. Skins were used to make mittens, kamiks or boots, and trousers. Sometimes, overboots were made with the fur side out to muffle their footsteps while hunting seals. Oil from the pelage or coat is used to grease sledge runners for an easier glide over the snow.