**Science (S1 – 3)**

**Updated curriculum (2017)**

**Unit 7: Living Things and Air**

 **Respiration and gas exchange**

**in animals**

**(Teachers Version)**

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**Science (S1 – 3)**

**Unit 7: Living Things and Air**

Topics: Respiration and gas exchange in animals

Estimated lesson time: 160 mins

**Respiration and gas exchange in animals**

**【Learning objectives】**

After the learning activity, I am able to:

1. recognise that food is the source of energy for all living things;
2. describe respiration as a process in which food is broken down in cells to release energy in usable form for cells;
3. compare the composition of gases between inhaled and exhaled air of animals;
4. identify the main parts of the breathing system in humans; and
5. recognise that gas exchange in humans takes place at the air sacs.
6. **Reading to learn (1)**

Same as fuels, foods store chemical energy. During the process of burning, the chemical energy stored can be converted into thermal energy and light energy. However, due to some factors such as cost effectiveness and food shortage, people did not replace fossils fuels with food as the main source of energy.

Actually, in 1900, Garman Rudolf Diesel displayed his invention to the public at the Paris World’s Fair: the engine which was powered by peanut oil.



Although burning is not commonly used to convert the chemical energy stored in food into other useful forms of energy, it can be used to measure the amount of energy stored in a food. The information is shown on the **food label** (Figure 1).

Figure 1: Food label on the food package

1. **Experiment (1)**
2. **Aim:** Understand the energy conversion during the burning of peanut
3. **Apparatus and materials**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Burning spoon | 1 |  |  | Heat-proof mat | 1 |
| Bunsen burner | 1 |  |  | Peanut |  |

1. **Procedure:** Place a peanut in the burning spoon and heat it by the Bunsen burneron the heat-proof mat (Figure 2). Observe the energy released during the process of burning.

Burning spoon



**Wear safety goggle**

Peanut

1. **Result**

Bunsen burner

The energy stored in the peanut is converted into

**thermal**

**light**

Heat-proof mat

 energy and energy by burning.

Figure 2

1. **Exercise (1)**

John conducted the following experiment to compare the amount of chemical energy stored in food A and food B (Figure 3).

Food A

 

Clip

Heat-proof mat

Heat-proof mat

Burning spoon

Same volume of water

Food A

Stand

Boiling tube

Thermometer

Food B

Burning spoon

 

Clip

Figure 3

Food B

Stand

Boiling tube

Thermometer

The results are shown in the table below:

|  |  |  |
| --- | --- | --- |
| **Food** | **Mass of food** (g) | **Increase in temperature of water****after the food is burned out**（°C） |
| A | 5 | 3 |
| B | 5 | 5 |

1. What form of energy is released from the chemical energy stored in food to raise the temperature of water when burning?

**Thermal energy**

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. Which food stores a larger amount of chemical energy?

**Food B**

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. **Reading to learn (2)**

How does human body convert the chemical energy stored in food into the energy needed for different parts of the body? Before knowing the answer, we have to understand the knowledge about “**breathing**” and “**respiration**”.

**Breathing**

****

Figure 4: Basic structure of the human respiratory system

Rib

Lung

Diaphragm

Air sac

Bronchus

Nasal cavity

Trachea

Air is taken into and out of the body by the **respiratory system**. This process is called **breathing**. The main parts of the respiratory system of a human body includes: **nasal cavity**, **trachea**, **bronchi**, **air sacs**, **lungs**, **ribs** and **diaphragm** (Figure 4).

**Respiration**

The oxygen that we get through inhalation is delivered to the cells of our bodies, and react with the food in the cells (i.e., glucose). Food is broken down, and the chemcial energy stored in food is converted into usable forms of energy for cells. Besides, carbon dioxide and water are produced. This process is called **respiration**, which is happened inside the cells (Figure 5).

Animal cell

Figure 5: Respiration of an animal cell

Food

+

Oxygen



Energy

+

Carbon dioxide

+

Water

How is oxygen delivered to the cells of the body, so that respiration can take place continuously in the cell? On the other hand, how is carbon dioxide released out of the body from the cells, and not accumulate in the body?

**Gas exchange**

When we inhale, air enters the **nasal cavity** through the **nostrils**. Air then travels along the **trachea**, the **bronchi** and the **bronchioles** to the **air sacs**. Oxygen in the air passes through the air sacs and the **capillaries** around the air sacs into the blood. Through the flow of blood, oxygen is delivered to the cells of our bodies.

Carbon dioxide

Oxygen

Direction of the flow of blood

Air Sac



On the other hand, carbon dioxide produced by the cells in respiration enters the blood. Through the flow of blood, carbon dioxide arrives at the capillaries around the air sacs. Carbon dioxide then passes into the air sacs, and is released out of our bodies when we exhale.

Capillary

Figure 6: Gas exchange in an air sac

Therefore, gas exchange occurs continuously between our bodies and the surroundings. It is carried out in the air sacs (Figure 6).

1. **Exercise (2)** (Fill in the blanks or put a tick “√” in the appropriate box)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  | **Food** | **Energy per serving** (Kcal) | **Mass per serving**(g) | **Energy per 100g**(Kcal) |
|  | **(a)** | **Instant noodles** | 473 | 100 | 473 |
|  | **(b)** | **Cake** | 152.5 | 50 | 305 |
|  | **(c)** | **Potato chips** | 294.8 | 55 | 536 |
|  | **(d)** | **Apple** | 104.2 | 200 | 52.1 |

**instant noodles**

From the table above, \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ stores the largest amount of energy per serving, and \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ stores the largest amount of energy per 100 g.

**potato chips**

**√**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 1. Food is the source of energy for all living things.
 | **True** |  **√** |  | **False** |   |
| 1. Breathing is the process of taking air into and out of the body.
 | **True** |  **√** |  | **False** |   |
| 1. Respiration takes place in cells.
 | **True** |  **√** |  | **False** |   |
| 1. Gas exchange between our bodies and the surroundings takes place in the air sacs.

**chemical energy** | **True** |   |  | **False** |   |

1. Respiration is the process by which the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ stored in food is converted into into usable forms of energy for cells. In this process, \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ is needed, and \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ and \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ are produced.

**water**

**carbon dioxide**

**oxygen**

1. **Experiment (2)**
2. **Aim:** Test for carbon dioxide released from mealworms
3. **Apparatus and materials**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Large-volume beakers (500 mL) | 2 |  | Plastic wrap |
|  | Small-volume beakers (150 mL) | 2 |  | Mealworms |
|  | Rubber bands | 2 |  | Hydrogencarbonate indicator |

1. **Procedures**

|  |  |
| --- | --- |
| 1. Put the same amount of the hydrogencarbonate indicator into two large-volume beakers respectively (Figure 7). Observe the color of the indicator.
2. Put a small amount of mealworms into a small-volume beaker. The beaker with mealworms is then put into one of the large volume beakers (Figure 8).
3. Seal the two large-volume beakers respectively with plastic wrap and rubber bands (Figure 9).
4. Observe the change in color of the hydrogencarbonate indicator after 30 minutes.
 | Large-volumebeakerIndicatorFigure 7Figure 8Small-volumebeakerMealwormsRubber bandFigure 9Plastic wrap |

1. **Results**
* At the beginning of the experiment, the color of the hydrogencarbonate indicator is \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

**red**

* After 30 minutes, the color of the hydrogencarbonate indicator

**yellow**

1. in the setup with mealworms is \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

**red**

1. in the setup without mealworm is \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.
2. **Conclusion** (circle the correct answer)

Mealworms **would / would not** release carbon dioxide.

1. **Discussion**

Explain why the setup without mealworm is needed in the above experiment.

**This is the controlled experiment to ensure the change in colour of the indicator is due to the carbon dioxide released by the mealworms.**

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. **Experiment (3)**
2. **Aim:** Compare the oxygen and carbon dioxide contents between exhaled and inhaled air of

human

1. **Apparatus and materials**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Gas jar | 1 |  | Curved plastic drinking straw | 5 |
| Cover plate | 1 |  | Burning spoon with candle | 1 |
| Water trough | 1 |  | Hydrogencarbonate indicator |  |
| Stop watch | 1 |  |  |  |

1. **Procedures**

|  |
| --- |
| Method of collecting exhaled air |
| 1. | Water troughFigure 11Figure 10Gas jar | Fill a gas jar with water in a water trough (Figure 10). Then turn the gas jar upside down in the water trough (Figure 11). |
| 2. | Figure 12Curved plastic drinking straw | Hold the gas jar to make it inclined slightly. Put one end of a curved plastic drinking straw into the gas jar. Take a deep breath, then blow into the straw slowly until the gas jar is filled with exhaled air (Figure 12).  |
| 3. | Figure 14Figure 13Cover plate | Cover the gas jar with a cover plate under water (Figure 13). Then take the gas jar out and put it upright (Figure 14). |
| Method of comparing the oxygen content between exhaled and inhaled air |
| 4. | Cover a new gas jar with a cover plate to get a jar of inhaled air.Buring spoon with candle |
| 5. | TimerFigure 15Gas jar with inhaled airGas jar with exhaled air | Light the candle on the burning spoon and put it into the jar of inhaled air and exhaled air respectively. Measure the time for a candle to extinguish by a stop watch in each gas jar (Figure 15).  |
| Method of comparing the carbon dioxide content between exhaled and inhaled air |
| 6. | Repeat Steps 1 – 4 to get a jar of exhaled air and a jar of inhaled air. |
| 7. | Figure 16Indicator | Put a small amount of hydrogencarbonate indicator into the jar of inhaled air and exhaled air respectively. Then cover each jar immediately with a cover plate. Shake each jar gently and observe the color of the indicator (Figure 16). |

1. **Results**
2. Compare the oxygen content between exhaled and inhaled air:

|  |  |  |
| --- | --- | --- |
|  | **Exhaled air** | **Inhaled air** |
| **Time for the candle to extinguish**(s) |  |  |

1. Compare the carbon dioxide content between exhaled and inhaled air:

|  |  |  |
| --- | --- | --- |
|  | **Exhaled air** | **Inhaled air** |
| **Color of the hydrogencarbonate indicator** | **yellow****red** |  |
|  |  |

1. **Conclusion** (Circle the correct answers)

Exhaled air contains **more / less** oxygen and **more / less** carbon dioxide than inhaled air.

1. **Summary**

Use the following vocabularies to write what you have learnt in this activity.

|  |  |
| --- | --- |
| Related vocabularies: | Chemical energy, burning, respiration, energy conversion, breathing, respiratory system, nasal cavity, trachea, bronchus, air bags, lungs, inhaled air, exhaled air, oxygen content, carbon dioxide content, hydrogencarbonate indicator. |

|  |
| --- |
| In this activity, I have learnt: |
|  |
|  |
|  |
|  |
|  |
|  |
|  |

1. **Self-evaluation**

|  |  |
| --- | --- |
| **Items** | **Evaluation**(Put a tick “√” in the appropriate box) |
| **Highly satisfactory** | **Satisfactory** | **Unsatisfactory** | **Highly unsatisfactory** |
| 1. | I recognise that food is the source of energy for all living things. |  |  |  |  |
| 2. | I can describe respiration as a process in which food is broken down in cells to release energy in usable form for cells. |  |  |  |  |
| 3. | I can compare the composition of gases between inhaled and exhaled air of animals. |  |  |  |  |
| 4. | I can identify the major parts of the human respiratory system. |  |  |  |  |
| 5. | I recognise that gas exchange in humans takes place at the air sacs. |  |  |  |  |

End