# Fuelling Scott

## LESSON PLAN

### Learning objectives strands 2–5

- Energy can be transferred usefully
- The particle model provides explanations of the different physical properties and behaviour of matter

### Learning objectives: strand 1 (HSW)

- Analyse and evaluate evidence from experiments

### PLTS

- Independent enquirers: analyse and evaluate information

### APP

- AF1 – Thinking scientifically
- AF5 – Working critically with evidence

## Starter

- **Scott’s last expedition** Show video clip, or pictures, to introduce Scott’s 1910–1912 expedition to the South Pole. Briefly ask students to suggest why Scott and his team did not survive.

- **How did Scott get water?** Students suggest ideas. They will probably suggest melting snow.

- **Why didn’t Scott eat snow?** In groups of four, each student uses one card cut from Activity sheet 1 to explore one of four key questions and outline the answer to the other three group members.

## Main

- **Practical – What mass of fuel melts ice?** Students investigate the mass of fuel needed to provide enough energy to melt 100 g of ice and heat it to body temperature.

- **How much fuel did Scott need?** Students follow the steps to estimate the mass of fuel needed to provide drinking water for five expedition members for one day.

## Resources

- Expedition video clip, for example, *Scott of the Antarctic profile with Sir Ranulph Fiennes* http://www.youtube.com/watch?v=kjA3_6x6l0g

- **Activity sheet 1**

## Differentiation

**Help**

- For third task, student pairs within groups of four explore questions A and C only.

**Extension**

- Give students the four questions on Activity sheet 1, and ask them to use the Internet to research answers.

**Help**

- To make the calculation simpler, work out the mass of fuel needed for one person for one day.

**Extension**

- Before handing out Activity sheet 2, ask students to identify the data needed for the calculation.

- Calculate the number of sledge biscuits needed to provide enough energy to warm and melt snow inside the body. One biscuit provides around 2000 kJ.

- **Teacher and Technician Notes**

- **Activity sheet 2**
# Fuelling Scott

## LESSON PLAN

### Plenary
- **Why did some fuel disappear?** Tell students that, when the explorers opened the stored fuel tanks, some of the fuel had disappeared. Ask students to speculate what had happened to it. The answer is that the leather washers used to seal the tanks had degraded in the cold. Some fuel evaporated. Discuss the impact of this loss on the ability to produce enough drinking water.

- **Advise a future expedition to the South Pole on their water and fuel requirements** How much water will they need? How much fuel is needed to melt snow to provide this water? How much spare fuel should they take?

### Differentiation

**Extension**
- Calculate the mass of fuel remaining if 50% of the mass calculated in **Activity sheet 3** was lost by evaporation. What mass of snow could this mass of fuel melt and warm? Would this be enough to avoid dehydration?

### Resources
- **Teacher and Technician Notes**

---

### Homework
- Use the Internet to find out what other fuels the expedition took with them to Antarctica, and what they used these fuels for.
- Write a series of Frequently Asked Questions (and answers) on the water and fuel requirements of Scott’s expedition for a centenary website on the expedition.

### Learning outcomes

<table>
<thead>
<tr>
<th>Level 3</th>
<th>Level 4</th>
<th>Level 5</th>
<th>Level 6</th>
<th>Level 7</th>
</tr>
</thead>
</table>
| - Recognise that water melts on heating  
- Describe simply what the experiment shows  | - Recognise that scientific evidence supports the idea that energy is needed to melt ice and heat water  
- Identify evidence used in drawing a conclusion from the experiment | - Explain that when water is heated, its particles move faster  
- Draw conclusions using several pieces of supporting evidence | - Use the particle model to explain melting  
- Draw conclusions that are consistent with the evidence collected and use scientific knowledge and understanding to explain them | - Make connections between ideas about energy and particles to explain melting ice and warming ice and water  
- Assess the strength of evidence and decide whether it is sufficient to support conclusions |
Fuelling Scott

In this lesson, students consider why Scott and his team did not survive on their expedition to the South Pole. Where did their drinking water come from? Why not eat snow? How much fuel was needed to melt enough snow to avoid dehydration, and what might happen if some fuel was lost?

Students address these questions by doing a practical to find the mass of fuel needed to melt 100 g of ice. They calculate the mass of fuel needed to supply enough energy to melt enough ice for five explorers for one week. Finally, they consider the impacts of dwindling fuel supplies.

Equipment required per group:

Starter

- Activity sheet 1 (one per group of four, cut into four cards)

Main

- Activity sheet 2
  - Practical:
    - 100 g of ice
    - stand, boss, and clamp
    - container in which to heat 100 g of ice (metal calorimeter or food can)
    - thermometer
    - spirit burner with fuel (any alcohol fuel is suitable, for example, ethanol or meths, propan-1-ol, butan-1-ol)
    - access to balance

- Activity sheet 3

Health and Safety notes:

- The fuel is flammable. Wear eye protection. Keep lids on spirit burners at all time, except when burning the fuel.

Starter

1 Scott’s last expedition Show video clip, or pictures, to introduce Scott’s last expedition to the South Pole, from 1910 to 1912. Ask students to suggest why Scott did not survive.

2 How did Scott get water? Ask students to suggest ideas. They will probably suggest melting snow.

3 Let them eat snow? In groups of four, each student uses one card cut from Activity sheet 1 to explore one of four key questions and outline the answer to the other three group members.

Question A asks why not eat snow? The key point here is that snow can provide liquid water, but melting and warming it in the body requires energy from large amounts of food.

Question B gets students to consider the particle model of melting and warming water. You could encourage students to draw particle diagrams to illustrate their explanations.
Question C introduces the idea of paraffin fuel, describing it as a mixture of compounds made up of carbon and hydrogen.

Question D shows the type of stove used by Scott and his team. The stove heats food and melts snow simultaneously.

Main

4 Practical – What mass of fuel melts ice?
Detailed instructions for this task are on Activity sheet 2. Depending on the fuel chosen, students will find that about 1 g of fuel is needed to melt 100 g of ice and heat the liquid water to body temperature.

Paraffin is not used since its flame is smoky.

5 How much fuel did Scott need?
Following the steps on the sheet, the mass of fuel required to provide body-temperature drinking water for five explorers for one week is about 1.75 kg.

The explorers would have taken much of their water in hot drinks such as tea, or in foods such as stew.

The second extension task asks students to calculate the number of sledging biscuits needed to provide enough energy to warm and melt snow inside the body. One sledging biscuit of the type used by Scott provides about 2000 kJ. The energy needed to melt and warm 5000 g of water is approximately 2447 kJ.

Plenary

6 Why did some fuel disappear?
Tell students why the fuel disappeared (the leather washers used to seal the tanks had degraded in the cold) and explain that the fuel had actually evaporated.
Norwegian explorer Roald Amundsen, who on a rival expedition reached the South Pole before Scott and successfully returned his men from the South Pole, had sealed his fuel cans more securely, with solder, which was not damaged in the cold.

7 Advise a future expedition
Students could tackle this task in pairs, perhaps producing a website page or planning a talk to give to a group as they prepare for an expedition.

Answers
Activity sheet 1 – Approximately 1 g of fuel is required.
Activity sheet 2 – Approximately 2.75 kg is required for five people for one week.
Let them eat snow?
Explorers need plenty to drink. Captain Scott and his team were surrounded by snow, but they did not just eat the snow. They melted it first. To melt snow they needed heat. The heat came from burning fuel, which Scott and his team dragged huge distances on sledges. Why did they bother?

1. Cut cards from the boxes below. Give one to each member of your group.
2. Study the information on your card. Think about how to explain it to your group.
3. Take it in turns to read out the question on your card, and explain the answer to the others in your group.

**A Why not eat snow?**

The average temperature in the Antarctic is –57 °C. Antarctic snow is very cold. Snow is water in the solid state.

If you eat snow, your body heats it to its melting point (0 °C). The snow melts, forming water in the liquid state. The water heats up, to body temperature (37 °C).

Heating and melting snow need energy. Where does the energy come from? It comes from the food you eat.

You need to eat a large amount of food to provide energy to heat and melt enough snow to provide the water you need.

**B Where did the heat come from?**

Scott and his team burned fuel to melt snow.

They chose paraffin fuel. Paraffin is a mixture of compounds.

Most of the compounds are made up of atoms of carbon and hydrogen only. The formula of one of the compounds in paraffin is C_{12}H_{26}.

 Burning 1 kg of paraffin releases about 45 million joules of energy as heat.

**C What happens to the particles when snow melts?**

Snow is water in the solid state. Its particles are arranged in a regular pattern.

Antarctic snow is very cold. As it heats up, its particles vibrate faster.

Snow melts at 0 °C. As it melts, its particles gain enough energy to move around, in and out of each other. The water is now in its liquid state.

The liquid water warms up. Its particles still move around, in and out of each other, but they have more energy, so they move faster.

**D How did Scott’s stove work?**

Scott and his team used a Nansen stove to melt snow and cook food at the same time.
**What mass of fuel melts ice?** Scott and his team burned fuel to melt snow. What mass of fuel did they need? To answer this question, you will find the mass of fuel to melt a known mass of ice, and then to heat the liquid water to body temperature.

1. Set up the apparatus below.

2. Copy the results table below.

<table>
<thead>
<tr>
<th>Mass of ice (g)</th>
<th>Mass of spirit burner, lid, and fuel before burning (g)</th>
<th>Mass of spirit burner, lid, and fuel after burning (g)</th>
<th>Mass of fuel burned (g)</th>
<th>Mass of fuel that would need to be burned to melt exactly 100 g of ice and heat it to 37 °C (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3. Weigh the spirit burner, lid, and fuel. Write down the mass.

4. Weigh out about 100 g of ice. Write its mass in the first line of the table.

5. Place the spirit burner under the ice container. Light the wick.

6. Heat the ice with the spirit burner until the ice melts and the water temperature reaches body temperature (37 °C).

7. Place the lid on the spirit burner. The flame will go out.

8. Weigh the spirit burner, lid, and fuel. Write the mass in the table.

9. Calculate the mass of fuel burned. Write the mass in the table.

10. If you have time, repeat the experiment twice more. Each time, use about 100 g of ice. Write the exact mass you use in your table.

11. Use the three values in the final column of the table to calculate the average mass of fuel that, on burning, melts exactly 100 g of ice and then heats the liquid water to 37 °C.
**How much fuel did Scott need?**

In your experiment you worked out the mass of fuel needed to melt 100 g of ice and then heat the liquid water to body temperature. Now you will calculate the mass of fuel needed to melt snow to provide enough water for all the expedition members.

**How much water did Scott and his team need?**

Scott and his team got plenty of exercise as they dragged their heavy sledge for long distances. So they needed to drink plenty of water – one estimate suggests they needed 5 litres, or 5000 g, each day as drinking water, tea, or in stews.

Without enough water, the explorers would suffer from dehydration. This swells blood vessels in the brain and lungs, increasing the risk of blood clots and strokes.

1. For part of the expedition, Scott rationed his team to just 2 litres of water each day. What effects might this have had on them?

**Calculating the amount of fuel needed by Scott and his team**

2. In Activity 2, you found the mass of fuel needed to melt 100 g of ice and heat it to body temperature. Use this value to calculate the mass of fuel needed to melt 5000 g of ice and heat it to body temperature.

\[
\text{Mass of fuel needed for 5000 g of water} = \frac{\text{mass of fuel for 100 g water} \times 5000 \text{ g}}{100 \text{ g}}
\]

This is the mass of fuel needed to provide water for one explorer for one day.

3. Scott took four others with him to the South Pole. What mass of fuel did they need in total?

\[
\text{Mass of fuel needed for 5 explorers for one day} = \text{mass of fuel for one explorer for one day} \times 5
\]

4. The explorers carried several days’ fuel with them at any one time. Calculate the mass of fuel needed to supply drinking water for 5 explorers for one week (7 days).

\[
\text{Mass of fuel needed for 5 explorers for 7 days} = \text{mass of fuel needed for 5 explorers for one day} \times 7
\]

**How heavy does this mass of fuel feel?**

5. Find the mass of a big book, or your school bag.

\[\text{Mass} = \text{__________ g}\]

6. Compare the mass of the book, or your school bag, to the mass of fuel needed for five explorers for one week. Imagine dragging this mass behind you for many miles in subzero temperatures.