Energy and change

A project funded by the Nuffield Foundation

Theme B

Hot and cold

Theme B - Hot and cold

What is this theme about?

The activities in this theme are concerned with looking at temperature differences, at what temperature differences can do and how they can arise. In later themes this will lead into thinking about energy, and how energy tends to flow from hot to cold. However, in the present theme, we are not concerned with the concept of energy. The aim is to encourage children to pay attention to things that are hot and things that are cold in order for them to get a feeling about the relative sizes of temperatures. An important idea here is that temperature differences tend to level out or become equal. They do not spontaneously appear by themselves, though they can be created as a result of other changes, such as objects rubbing together. Temperature differences are useful to us because they can be used to *do* things, such as making an engine run.

The activities

B1 A ladder of temperatures

B2 Measuring temperatures

B3 What happens next?

B4 What is best for making things hotter?

B5 Ways of making things hotter

B6 Inventions

B7 Making an engine

Activity B1 - A ladder of temperatures

The aim of this activity is to give pupils a feeling for a range of different temperatures.

Pupils match objects and situations to the ladder of temperatures. This could be done by cutting them out or simply writing the numbers next to the temperatures. Some of the matches should be known to the pupils, others they may need to work out by a process of elimination, and some are quite difficult. After they have made the matches and checked their answers, they could make a poster showing this ladder.

Answers:

A	6 000°C	surface of Sun (4)
B	2 500°C	light bulb filament (11)
C	1 500°C	iron melts (13)
D	1 200°C	candle flame (15)
E	200°C	oil in a frying pan (7)
F	100°C	water boils (2)
G	70°C	hot cup of tea (12)
H	45°C	hot bath (8)
I	37°C	human body (1)
J	20°C	room temperature (3)
K	10°C	average temperature in Britain (10)
L	0°C	ice freezes (5)
M	-60°C	Antarctica (coldest average for year) (6)
N	-170°C	surface of Saturn (14)
O	-273°C	coldest possible temperature (9)

Answers to questions:

1 Room temperature (about 20°C) is warmer than the average temperature in Britain (10°C). (This is the reason we need to spend money on fuels to maintain this temperature difference!)

2 Saturn is colder than the Earth because it is further from the Sun. (Each planet reaches a steady state temperature in which the energy arriving from the Sun is balanced by the energy escaping into space.)

3 A candle flame is not hot enough to melt iron. (It is necessary for a flame to have a richer supply of oxygen to reach the temperature required.)

Activity B2 - Measuring temperature

This is a practical activity in which pupils gain experiences in looking at situations in which temperatures are becoming equal.

The first of these tasks is a pupil activity. The remaining tasks (2-6) are intended to be set up as a circus. Note that different thermometers may give readings one or two degrees apart when they are at the same temperature. So, for each task it is important to select thermometers that agree with each other if pupils are to be convinced that the temperatures really are the same!

Apparatus:
1 Each pupil will need: beaker, test-tube, thermometer, access to hot water (one thermometer is better than two to ensure that when the temperatures are equal pupils get the same reading!).
2 Two beakers containing different amounts of water at room temperature, two thermometers and clamps.
3 Wood block with hole, metal block with hole, three thermometers and clamps (one thermometer to measure temperature of room).
4 Beaker with hot water, metal block with hole, two thermometers and clamps.
5 Vacuum flask and hot water, beaker and hot water, two thermometers and clamps.
6 Two beakers with water at room temperature, insulation, two thermometers and clamps.

Answers:
1 B 2 A 3 A 4 B 5 B 6 B

The lack of a temperature difference in the insulated and uninsulated beakers (6) may the most surprising result. This is taken up later in the activities in Theme E (Energy from hot to cold).

Activity B3 - What happens next?

This aim of this activity is to encourage pupils to pay attention to differences in changes, and to make the point that eventually these temperatures will become equal.

For each change, pupils should be encouraged first to think about what the two thermometers represent in the first picture; then they need to think about what happens to them.

Answers:
1 2 3 4
5 6 E 7 B C F 8 A D

Question 3: 1, 2 and 4 could never happen spontaneously. 3 might happen but it is not at equilibrium - the temperatures would eventually become equal. 5 is the same as the starting point - if there was perfect insulation, then it might continue as this.

Activity B4 - What is best for making things hot?

This activity is intended to reinforce the idea that temperatures tend to become equal.

The important point is that bigger temperature differences can do more - they are better at making things hot. (Bigger temperature differences are also better for making things move - this idea will be taken up in activity B7.)

Answers:
1 The bucket of warm water cannot warm up the block since it is at the same temperature.
2 Only the flame is hotter than the metal block and can make it hotter.
3 The block is hotter than all of the other things, so none can make it hotter.

Activity B5 - Ways of making things hotter

In many processes of change, something becomes hotter. This activity is intended to encourage pupils to pay attention to what is happening in such processes.

The first sheet is an OHP which introduces various ways in which things can become hotter. Note that often things become hotter even when we would rather they did not. (This idea will be taken up later when thinking about energy and efficiency. Whenever a temperature difference appears, energy will flow - sometimes this is what we want, but sometimes it leads to energy 'escaping'.

The second sheet is a pupil activity, in which they identify various ways in which things become hotter described in a piece of text.

Activity B6 - Inventions

This activity introduces a time scale for inventions, in order to put some important inventions in context.

Before doing this activity, pupils could be asked to think about 'What are the 5 most important things ever invented' and to write their answers down. This could form the basis of a class discussion.

The important point of this activity in the context of the theme 'Hot and cold' is that while fuels have been used for many thousands of years to make things hot, only more recently have they been used to make things move (the steam engine) and even more recently to generate electricity (dynamo).

A	500000 BC	fire (19)
B	3500 BC	writing (18)
C	1000 BC	making iron (2)
D	330 BC	wheel (14)
E	150	paper (13)
F	1300	cannon (gun) (9)
G	1455	printing press (3)
H	1608	telescope (5)
I	1657	clock (pendulum) (8)
J	1698	steam engine (20)
K	1855	car (17)
L	1860	dynamo (generates electricity) (10)
M	1873	electric motor (4)
N	1888	photography (11)
O	1903	aeroplane (1)
P	1942	computer (6)
Q	1952	hydrogen bomb (7)
R	1960	laser (16)
S	1971	microchip (15)
T	1983	walking robot (12)

Answers to questions:

1 Fuels were used for making things hot before being used to make things move.

2 Fuels were used for making things move before being used to make electricity.

Activity B7 - Making an engine

This activity introduces the idea that a temperature difference can be used to make something move.

The first part is a simple experiment to use a temperature difference to drive a 'model' engine. This would also be an appropriate point to demonstrate a steam engine and to discuss how the fuel is used to create a temperature difference which makes the engine move. This can be related back to the previous activity - for hundreds of thousands of years fuels were used to make things hot, but only more recently (for example, with the invention of the steam engine) to make things move.

The second part of the activity makes the point that bigger temperature differences can do more - they are better for making things move. (See also activity B4, which made the point that bigger temperature differences are better at making things hot.)

A ladder of temperatures

Match the things below to the correct temperatures.

A	6 000°C	1 human body
B	2 500°C	2 water boils
C	1 500°C	3 room temperature
D	1 200°C	4 surface of Sun
E	200°C	5 ice freezes
F	100°C	6 Antarctica (coldest average for year)
G	70°C	7 oil in a frying pan
H	45°C	8 hot bath
I	37°C	9 coldest possible temperature
J	20°C	10 average temperature in Britain
K	10°C	11 light bulb filament
L	0°C	12 hot cup of tea
M	-60°C	13 iron melts
N	-170°C	14 surface of Saturn
O	-273°C	15 candle flame

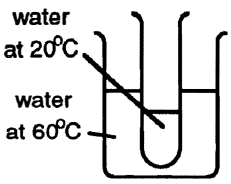
1 Which is warmer - room temperature or the average temperature in Britain?

2 Why is Saturn colder than the Earth?

3 Could you melt iron with a candle flame?

Measuring temperature

1 Three pupils are talking about what will happen here:



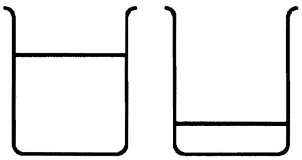
A "If you leave it, the water in the test tube will get a bit warmer. But it won't get as warm as the water in the beaker."

B "I think that they will both end up at the same temperature."

C "No, surely the water in the test tube will be hotter than the water in the beaker."

Which one do you think is right? Do an experiment to check.
Write about what you did in your book. Were you right? Explain why this happens.

2 Two beakers of water are left for an hour:

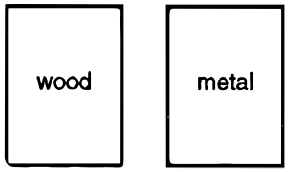


A "The water will be the same temperature in each beaker."

B "No, I think the first beaker will have a higher temperature - because there's more water."

Which one do you think is right? Check on the display '2'.
Write about this in your book. Were you right? Explain why this happens.

3 A metal block and a wooden block are left for an hour:

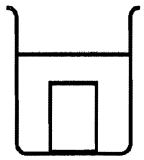


A "Both blocks will be the same temperature as the air in the room"

B "No, I think the metal will have a lower temperature."

Which one do you think is right? Check on the display '3'.
Write about this in your book. Were you right? Explain why this happens.

4 A lump of metal is put in some hot water:

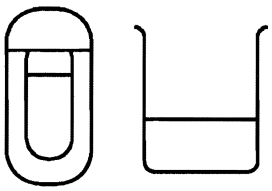


A "The metal will end up hotter than the water."

B "No, I think they will both have the same temperature."

Which one do you think is right? Check on the display '4'.
Write about this in your book. Were you right? Explain why this happens.

5 Some hot water is put in a vacuum flask and some in a beaker:

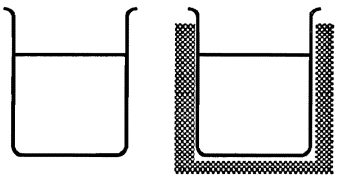


A "I think that they will both cool down the same."

B "I think that the water in the beaker will cool quicker."

Which one do you think is right? Check on the display '5'.
Write about this in your book. Were you right? Explain why this happens.

6 Here are two beakers with water. One beaker is surrounded with loft insulation.



A "I think that the one with loft insulation will get warmer."

B "I think that they will both be at the same temperature - the temperature of the room"

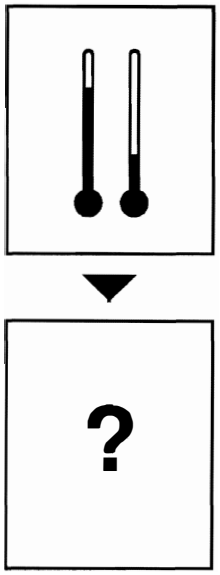
Which one do you think is right? Check on the display '6'.
Write about this in your book. Were you right? Explain why this happens.

What happens next?

1 The changes below are all about things which are at different temperatures.

2 The picture below shows these two temperatures. What eventually happens to the temperatures in the changes? Match each change to the picture you think is best.

3 Do any of these pictures show something which could never happen?



A a hot metal block left in a room

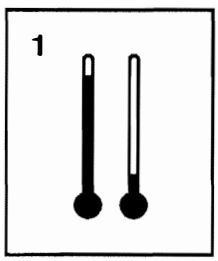
B a hot metal block put into cold water

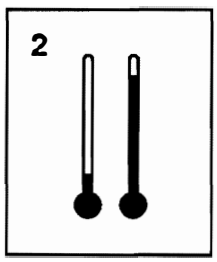
C a cold metal block put into hot water

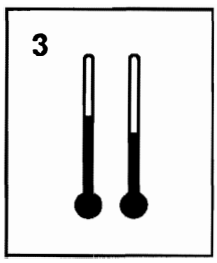
D a hot oven after it is turned off

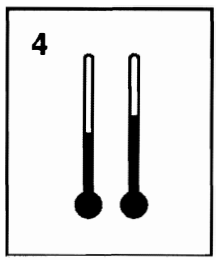
E a bottle of cold milk left in a warm room

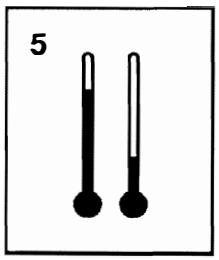
F cold milk added to a hot cup of tea

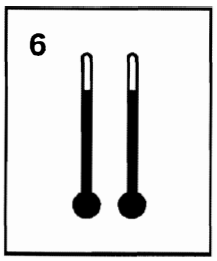


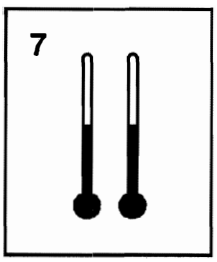


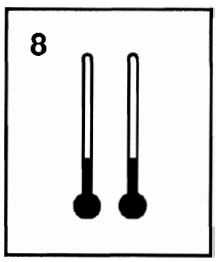










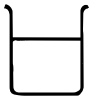


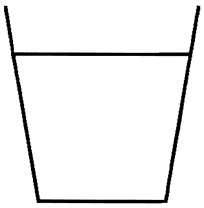
What is best for making things hot?

1 Here is a metal block. 30 °C

How many of these could be used to make it hotter?

flame 1 000 °C 

beaker of water 80 °C 

bucket of water 30 °C 

Put a circle around the ones which would make the metal hotter.

Explain your answer. _____

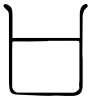
_____

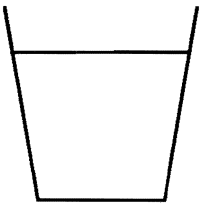
_____

2 Here is a metal block. 200 °C

How many of these could be used to make it hotter?

flame 1 000 °C 

beaker of water 80 °C 

bucket of water 30 °C 

Put a circle around the ones which would make the metal hotter.

Explain your answer. _____

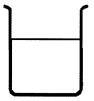
_____

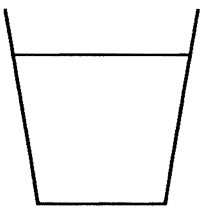
_____

3 Here is a metal block. 1 500 °C

How many of these could be used to make it hotter?

flame 1 000 °C 

beaker of water 80 °C 

bucket of water 30 °C 

Put a circle around the ones which would make the metal hotter.

Explain your answer. _____

_____

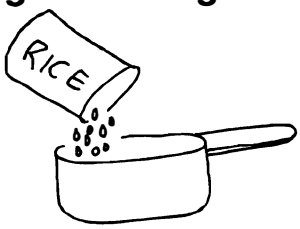
_____

Ways of making things hotter

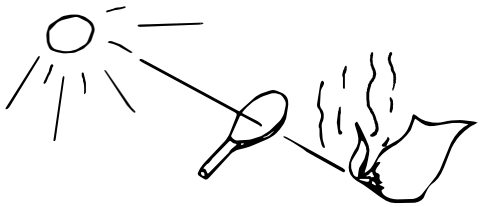
If you have got something hot, like a cup of tea, it will cool down. It will become the same temperature as the room. The temperatures will become equal.

How can we make things hotter? How can we make the temperatures unequal?

A using something even hotter



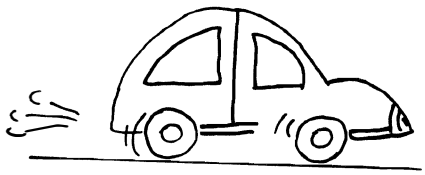
putting rice into boiling water



the Sun making some paper hot

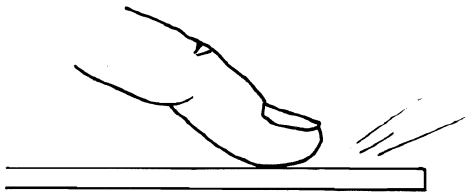
B using a burning fuel

a candle



petrol in a car engine

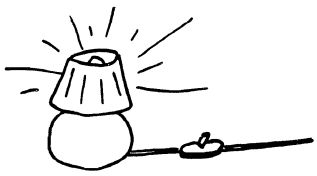
C using something moving (rubbing, bending, hitting)



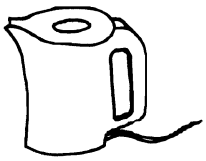
rubbing your finger on a table

bending a paper clip

D using electricity



an electric lamp



an electric kettle

Ways of making things hotter

Here are some ways of making something hotter:

A using something even hotter
B using a burning fuel
C using something moving (rubbing, bending, hitting)
D using electricity

Below are some everyday examples.

1 Read the text, looking for examples of 'using something even hotter'. Underline each example and put 'A' next to it.

2 Now do the same thing for 'B', 'C' and 'D'.

Some everyday examples

In the kitchen, we often need to make things hotter. For example, you cook vegetables by putting them in hot water. Cakes are cooked by putting them in a hot oven. Some cookers use gas as a fuel. Other cookers use electricity. There are many electrical appliances which may be used in a kitchen. For example, kettles and washing machines both have electrical elements to make water hot.

Other electrical appliances get hot even though that is not what we use them for. For example, we do not switch on a TV to warm the room up, but the TV gets hot anyway. An electric drill has a motor in it which gets hot. If you are using it to drill a hole in some wood, the wood gets warm. This is because the drill is rubbing on it.

A car engine works by burning petrol in it, and it can get quite hot. It needs to be cooled down by water. After a long journey, the tyres can feel quite warm. This is because they rub on the road. Brakes work by having a brake pad rub on part of the wheel - this gets hot when you put the brakes on. The headlamps on a car are quite powerful, and they get very hot. You can feel this if you put your hand in front of them.

We need to keep our bodies warm - this is one reason that we eat food. If we are outside on a cold day, our bodies get colder. Having a hot bath is one way of warming ourselves up. Usually it is our hands and feet that feel coldest. One way of warming your hands up is to rub them together. Another way is to blow on them.

Inventions

Here are some important inventions. Can you work out when they were invented? Match 5 inventions to each group. (If you can, try matching the exact date - this is more difficult.)

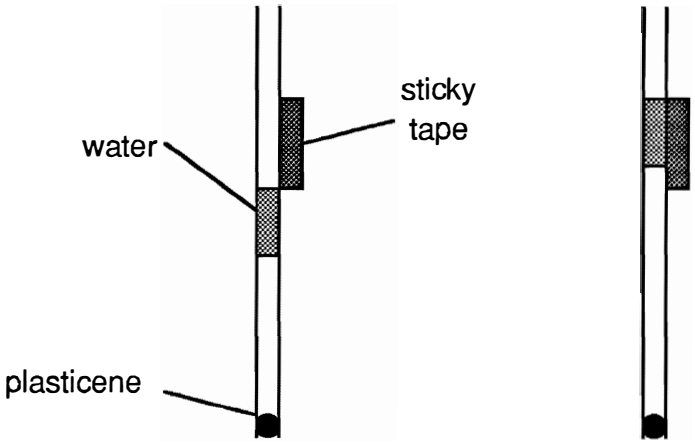
Group 1 Before 1000
500 000 BC
3500 BC
1000 BC
330 BC
150
Group 2 1000 - 1700
1300
1455
1608
1657
1698
Group 3 1700 - 1940
1855
1860
1873
1888
1903
Group 4 After 1940
1942
1952
1960
1971
1983

1 aeroplane
2 making iron
3 printing press
4 electric motor
5 telescope
6 computer
7 hydrogen bomb
8 clock (pendulum)
9 cannon (gun)
10 dynamo (generates electricity)
11 photography
12 walking robot
13 paper
14 wheel
15 microchip
16 laser
17 car
18 writing
19 fire
20 steam engine

1 What were fuels first used for - making things move or making things hot?
2 What were fuels first used for - making things move or making electricity?

Making an engine

1 Set up your model 'engine' like this diagram.



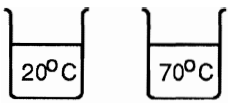
2 Warm the tube up so that the top of the water gets to the top of the sticky tape. Then cool it down so that the water goes back to where it was.

3 How long does it take to do this 5 times? What is the fastest you can make it do this?

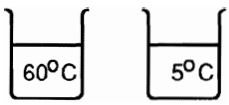
Questions

Will these pairs of beakers will make the water move up and down quickly? For each pair, say whether they will work well and explain your answer.

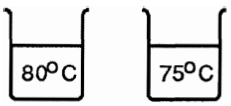
1



2



3



4