Teaching science for understanding

Electric circuits

A teaching scheme developed from research evidence on students' learning about electric circuits

Centre for Studies in Science and Mathematics Education
The University of Leeds

Teaching Science for Understanding: Electric Circuits

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Contents

Acknowledgements

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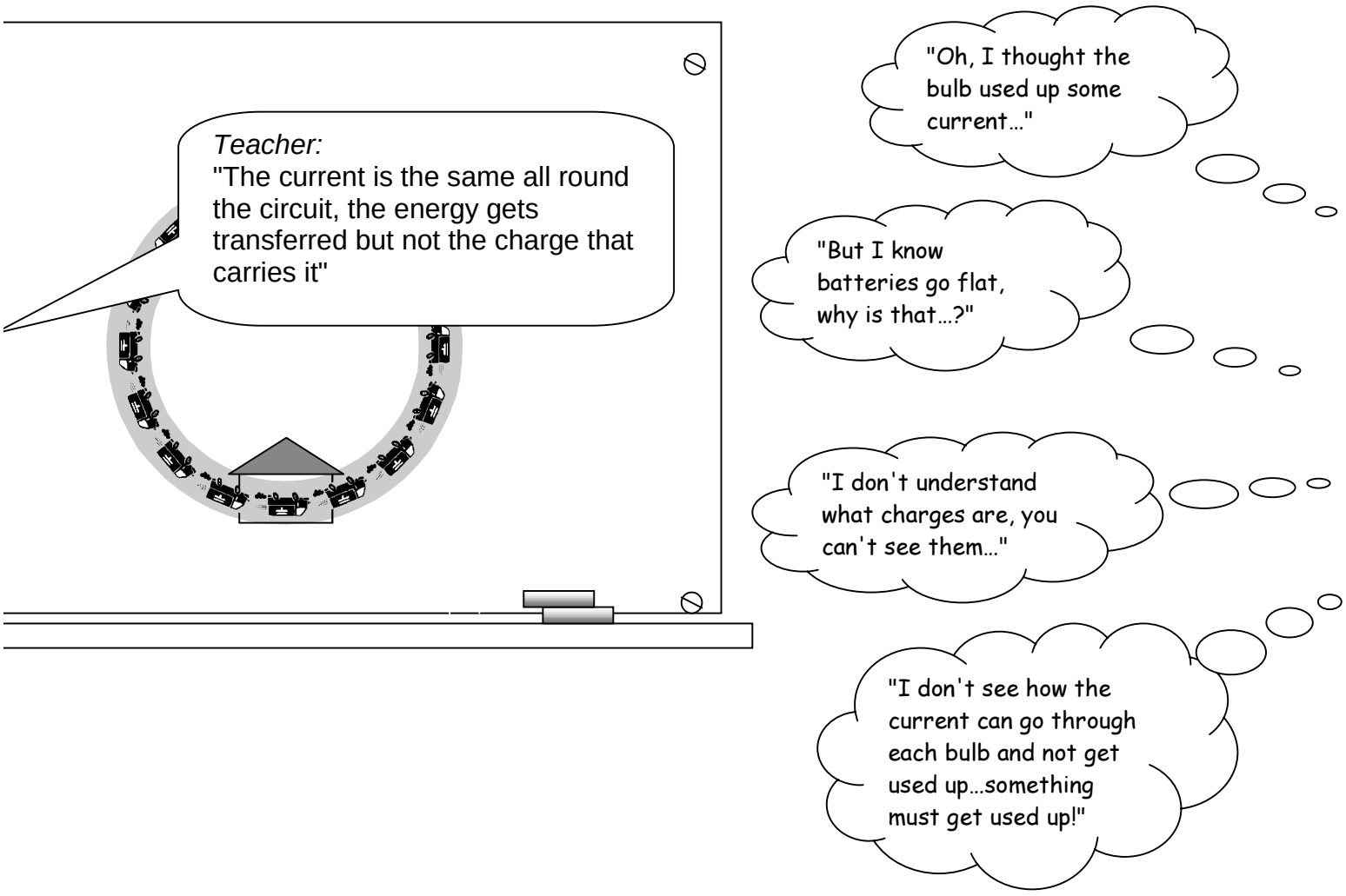
Beth Pettifer, Horsforth School, Leeds

The idea behind 'Teaching for Understanding'

Both your experiences as a teacher, and research into children's understanding of science, will tell you that pupils have everyday ideas about some scientific concepts that can conflict with the ideas you are trying to teach them.

So when you explain how electric current transfers energy some of the pupils in your class may be trying to make sense of how this fits in with, for example, common sense ideas about bulbs 'using up' electricity.



The activities in this pack are designed to present the science in a way that recognises some of the existing ideas and developing problems pupils have. The teaching sequence involves the development of a **scientific model** of energy transfer via an electric current in a way that is understandable to pupils because it is based on the systematic use of a simple **analogy**.

The aim is for pupils not just to 'know' how electric circuits work in terms of how current varies with voltage and resistance, but to **understand** the underlying ideas of how energy is transferred around a circuit by charges.

How to use this teaching pack

This teaching scheme consists of a sequence of teacher and pupil activities that form 4 lessons. Throughout the scheme there is guidance about the **teaching goal** for each activity and how you might **stage** the activities in the classroom to make the most of them.

The activities

A key feature of these activities is that they provide opportunities for talk between the students and yourself about the scientific ideas.

The teacher's talk

The teacher's role shifts during the sequence of lessons between presenting an analogy, leading class discussion about the analogy, relating it to the scientific circuit model and talking with individual pupils or groups of pupils about their developing understandings.

Throughout the sequence the focus is on the **ideas** involved.

The pupils' talk and written work

During the sequence, pupils are encouraged to talk through the new ideas, the analogy and circuit model, for themselves. In a similar way the writing during the lessons involves both recording the scientific view and working with that view, in familiar and new contexts.

It is what *you* do with the activities in the classroom, the bit that cannot be designed, that makes the crucial difference. Throughout the scheme a series of symbols *(see page 3)* are used to indicate the suggested *'teacher talk'* and *'type of writing'*. Further guidance about particular activities is given in the teachers' notes that support each activity.

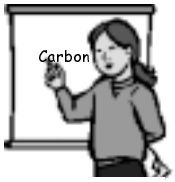
The teachers' notes are split into three sections. The first section provides an overview of the teaching sequence split into 4 lessons. Ideally these would be lessons of roughly 60 minutes duration but the activities can be split up otherwise, according to your judgement. The second section gives more detailed guidance about each activity. The third section provides a resource list for each lesson.

The final part of this pack contains all the student worksheets, workcards and overhead transparencies for the activities.

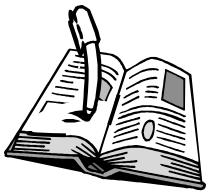
A key to the symbols.

The purpose of the symbols in the margins below is to give you a quick way to check what type of talking or writing is intended for each activity.

These three symbols indicate the type of talking for the teacher:

		The purpose of the *talk*	How and when it happens
Presenting		You are introducing or reviewing **new ideas** relating to the analogy and to the scientific model.	This may be through a presentation by you or by whole-class discussion led by you.
Discussing / probing		You are finding out about the pupils' ideas and understandings relating to the analogy and to the scientific model.	This may be through asking open questions, 'what do you think?' in whole-class or small group situations.
Supporting		You are supporting the pupils as they talk about their developing ideas, using key questions and offering appropriate responses to their questions.	This is likely to be achieved as the pupils are working on paired or small group activities.

These two symbols indicate the type of writing that is needed in the activity:

		The purpose of the writing	How it happens
Recording		Making a record of the accepted view relating to both the analogy and to the scientific circuit model.	Through: notes from the teacher; pre-prepared handouts; pupil notes.
Reviewing / applying		To encourage pupils to think about the new ideas as they apply and review them in written tasks.	Through class and homework written exercises.

An Overview of the lessons

FROM SUPERMARKETS TO ELECTRIC CIRCUITS - *Lesson 1*

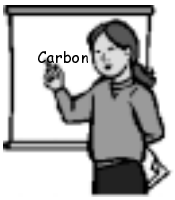
The first lesson starts with getting pupils to think individually about electric circuits (drawing on their ideas from KS2).

A teacher demonstration of an electric circuit provides a further context in which the pupils' ideas can be discussed before an analogy for an electric circuit is introduced.

Activity 1.1 20 minutes
Thinking again about electric circuits!
Two questions are used to probe the initial understandings of the pupils about electric circuits.

Activity 1.2 10 minutes
The BIG Circuit
A demo circuit comprising battery/switch/bulb is set up. The circuit runs right round the room.

Activity 1.3 30 minutes
The supermarket picture
The supermarket picture is first introduced here and it will be used throughout the lessons. It provides a way of helping pupils to develop an understanding of things they can't see (charge, energy, current) by relating them directly to familiar everyday objects (vans delivering bread).



PREDICTING AND MEASURING ELECTRIC CURRENTS - *Lesson 2*

The aim of the second lesson is to help pupils to develop their understandings of the Electric Circuit Model through reference to the Supermarket Picture, and to understand why current is conserved (and energy transferred).

Activity 2.1 10 minutes
Electric circuits and supermarkets revisited
The second lesson starts with a review of the Supermarket Picture and Electric Circuit Model.

Activity 2.2 40 minutes
Predicting and Measuring currents
The pupils use the Supermarket Picture and Electric Circuit Model to make

predictions of currents in simple circuits and to explain their measurements of current in simple circuits

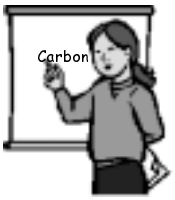
Activity 2.3 10 minutes
The BIG circuit
Pupils apply current conservation ideas to the BIG circuit.

ADDING BULBS IN SERIES…ADDING RESISTANCE- *Lesson 3*

Having used the Electric Circuit Model to explain why current is conserved, attention now turns to using the Supermarket Picture to develop an explanation as to why the current all around the circuit goes down when a second bulb is added in series. This involves introducing the concept of RESISTANCE.

Activity 3.1 15 minutes
Which Supermarket picture fits best?
Pupils talk about the Supermarket Picture and relate it to the Electric Circuit Model.

Activity 3.2 10minutes
The concept of resistance
Introducing the concept of resistance making links to both the Supermarket Picture and Electric Circuit Model.



Activity 3.3 10 minutes
Why are bulbs in series dimmer?
Pupils use the Supermarket Picture and Electric Circuit Model to explain the brightness of bulbs in a circuit with two bulbs.

Activity 3.4 25 minutes
Adding RESISTANCE!
Pupils are asked to draw on the Electric Circuit Model ideas to predict what will happen as the resistance in a circuit is increased and to make measurements to confirm this.

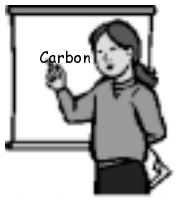
ADDING EXTRA CELLS TO THE CIRCUIT- ***Lesson 4***

The aim of this lesson is firstly to review, via the Supermarket Picture and Electric Circuit Model, the effect of adding extra resistance in series to a circuit.

Attention is then turned to the effect of adding extra cells to the circuit.

Finally pupils consider different numbers of bulbs and cells before the teacher leads a review of the whole sequence of lessons.

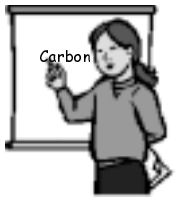
Activity 4.1 10 minutes
Back to the idea of RESISTANCE
A discussion of why the current gets less when an extra bulb is added in series and when a thin piece of wire is added to the circuit.



Activity 4.2 20 minutes
Adding cells to the circuit
Pupils are asked to predict the effect of adding cells to a circuit, then measure the effect and finally offer an explanation for the results

Activity 4.3 10 minutes
Putting the ideas together
Pupils look at different combinations of numbers of batteries and bulbs.

Activity 4.4 20 minutes
Final review of lesson sequence
Some time is spent in talking through the key ideas raised in the lesson sequence.



The lessons in detail

Lesson 1

TEACHING 'STORY'
The first lesson starts with the pupils working individually on two written questions.

ACTIVITY 1.1: THINKING AGAIN… ABOUT ELECTRIC CIRCUITS!

PURPOSE
The questions are used for two main reasons:
a. to encourage individual pupils to think through their ideas about electric circuits.
b. to provide the teacher with formative assessment information about the pupils' initial thinking

PREPARATION AND RESOURCES
Worksheets 1.1 and 1.2
A4 envelopes

PUPIL INSTRUCTIONS
Pupils work individually on the two questions, and are encouraged to think (!) and to write down their answers with as much detail as possible
On completion of the answers each pupil places their sheets in a 'special' envelope which they will return to at the end of the electricity lessons. The teacher needs to look through the responses, so… "don't stick the envelopes down just yet, I'll read through your ideas , then seal the envelopes myself!"

ACTIVITY 1.2: THE 'BIG' CIRCUIT

TEACHING 'STORY'

Having had the chance to think their ideas through for themselves, the pupils are now shown a 'real' circuit and are encouraged to bring their ideas out into the open through class discussion.

The 'BIG' circuit consists of a battery and bulb. The battery, or power pack, is at the front of the room, the bulb at the back and the connecting wires run right round the perimeter, possibly taped to the classroom walls.

PURPOSE:

- *to 'open-up' the problem of coming to understand how an electric circuit works;*
- *to probe pupils' existing understandings of electric circuits;*
- *to set the target of developing a* ***scientific model*** *to explain how an electric circuit works.*

PREPARATION AND RESOURCES

The 'Big' circuit (see technicians notes)

INSTRUCTIONS

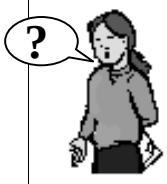
Demonstrate the BIG circuit:

- what will happen when the switch is closed?....bulb lights
- when the bulb lights what forms of energy are given out?.....heat and light
- where does this energy come from in the first place?...the battery

This happens instantly (observe), even though there is quite a distance between battery and bulb

- how does the energy get from battery to bulb?
- how come it happens so quickly?

We can see light being given out by the bulb and we can feel the heating that occurs...we can see the effect.
We cannot see how this happens: what happens in the battery/wires/bulb ?



TEACHING 'STORY'

It can be anticipated that in response to what happens with the BIG circuit, pupils will talk about, electricity/electric current/flow/energy. These ideas can be built upon to develop a model for the simple electrical circuits.

"The aim of the next few lessons is for you to become experts in understanding and explaining how electric circuits work!"

"All though we cannot see what is happening inside the wires and other parts of the circuit, scientists have a **model** to explain what is going on."

"We want to understand this Scientific Model!"

ACTIVITY 1.3: THE SUPERMARKET PICTURE

TEACHING 'STORY'

The Supermarket Picture is presented as an analogy which provides a way of helping pupils to develop an understanding of abstract concepts (such as energy, charge, current) by relating them directly to familiar everyday objects (such as supermarket delivery vans).

The word 'analogy' may or may not be used in class. We have found it useful to refer to the 'Supermarket Picture', which is used to help understand the 'Scientific Model' of simple circuits.

Part 1

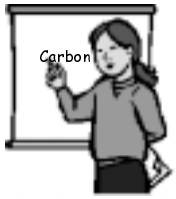
PURPOSE

The first job is to introduce the analogy to the pupils: inviting them to think about 'something quite different' which will help them understand how electric circuits work. The Supermarket Picture will be used throughout the lessons, so it is important that the pupils understand it.

PREPARATION AND RESOURCES

OHT 1.3 assembled
Stick-in-sheet 1.4

INSTRUCTIONS



Teacher presentation: Key features of the supermarket analogy

The pupils might be asked to imagine that a new supermarket has just opened and that it is so busy, a special system of delivering bread from the nearby bakery has been set up with a chain of delivery vans:

These features should be talked through as the Supermarket Picture is introduced and developed:

a. individual delivery van carry bread/sticky buns from bakery to supermarket
b. the bread/sticky buns are loaded onto the vans in the bakery
c. the vans deliver the bread/sticky buns to the supermarket where they are sold (and dispersed with the shoppers).
d. after leaving the supermarket, each empty van returns to the bakery to collect more bread/sticky buns.

e. the chain of vans is set in motion by the bakery manager
f. as soon as the vans are set in motion, bread/sticky buns are delivered to the supermarket.

g. all vans move at the same speed (nose to tail).
h. if the vans are speeded up, more bread/sticky buns are delivered to the supermarket in a given time.
i. **if more bread/sticky buns are loaded onto each van, more bread/sticky buns are delivered to the supermarket in a given time.**

These key features should be further explored through discussion. It is crucially important that the pupils understand the details of the analogy.

All pupils are provided with stick-in-sheet 1.3 of the Supermarket Picture.

ACTIVITY 1.3 CONTINUED

Part 2

PURPOSE

To make the link from Supermarket Picture to the electrical circuit.

PREPARATION AND RESOURCES

Stick-in-sheet 1.3
Worksheet 1.5

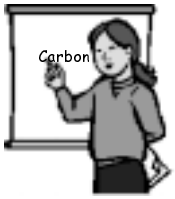
INSTRUCTIONS

The pupils are now invited to think back to the BIG circuit and to suggest how the Supermarket Picture might be similar.

First of all ask the pupils to talk with the person next to them to decide which parts of the Supermarket Picture link to which parts of the Big Circuit.

Take feedback and run through the key points:

- **the battery provides energy [just like the bakery provides bread/sticky buns];**
- **the energy is carried around the circuit by electrical charges [just like the bread/sticky buns are carried around by the vans];**
- **the charges are atom-sized particles which are already there in the wires [just like the waiting delivery vans];**
- **the flow of charges is called an electric current [just like the line of moving vans];**
- **the energy carried by the charges is given out in the bulb as heat and light and the charges then return to the battery to collect more energy [just like the bread/sticky buns carried by the vans are sold in the supermarket and the vans then return to the bakery to collect more bread/stick buns].**



All pupils are provided with a stick-in-sheet 1.3 of the electric circuit model.

The pupils work on these new ideas by completing (possibly for homework) Worksheet 1.5: 'Supermarkets and Electric Circuits'

THE BOTTOM LINE

By the end of the lesson, pupils should have:

- thought about their own ideas about electric circuits;
- been introduced to the supermarket picture;
- identified the inks between the supermarket picture and electric circuits.

Lesson 2

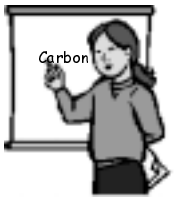
ACTIVITY 2.1: ELECTRIC CIRCUITS AND SUPERMARKETS REVISITED

TEACHING 'STORY'
The second lesson starts with a review of the Supermarket Picture, the Electric Circuit Model, and the relationship between the two.

PURPOSE
For the teacher to help pupils to develop and consolidate their understandings of the Electric Circuit Model, with its component parts; charge, current, energy, and how these relate to the Supermarket picture.

PREPARATION AND RESOURCES
OHT 1.3

INSTRUCTIONS
To review the two models the teacher should move discussion back and forth between the supermarket picture and the scientific circuit model. The following points relating to the scientific model should be emphasised:



- **Battery: provides energy and sets charges in motion [the bakery]**
- **Energy: provided by the battery, is given out as heat and light in the bulb [the bread]**
- **Charge: atom sized particles already in the wires that are set in motion by the battery. Charges transport energy around the circuit [the bread vans]**
- **Current: a measure of the amount of charge passing each point in the circuit each second [the number of vans passing each second]**

TEACHING 'STORY'
The following teaching questions relate to key aspects of the Electric Circuit Model. They should be discussed at this point with the class and the Supermarket Picture referred to, to help the pupils visualise what is happening in the electric circuit.

- *Why do batteries go flat? [All the energy is used up...no more bread left in the bakery].*
- *What actually gets used up in an electric circuit? Some people say it's the charge or electric current. What do you think? [The energy gets used up in the bulb, the charge simply carries the energy and returns to the battery for more...the bread/sticky buns are given out in the supermarket and the vans return to the bakery for more].*
- *How come the BIG CIRCUIT lights up straight away? [Charges carrying energy are ready to pass through the bulb as soon as the switch is closed].*

ACTIVITY 2.2: PREDICTING AND MEASURING ELECTRIC CURRENTS

TEACHING 'STORY'

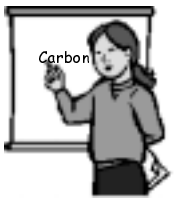
Having raised the crucial point that current/charge are not used up in the circuit, attention is now turned to practical measurements of electric currents.
The approach taken in this sequence is to present the scientific model and to use it to make predictions of current in simple circuits. Here the pupils are moving from model to data.

PURPOSE

For the teacher to support pupils in developing an understanding of the electric circuit model by relating the model, and predictions from the model, to practical measurements of electric current.

PREPARATION AND RESOURCES

Cells, Bulbs, Ammeters, Connecting wires.
Worksheet 2.1: Predicting and measuring current.



INSTRUCTIONS

Pupils measure the current on one side of the bulb, predict the current on the other side of bulb and then measure the current on the other side of bulb.

1. Introduce the ammeter as the instrument used to measure electric currents and the unit of measurement, the Ampere (Amp). The Amp is a measure of how much charge passes a given point in a circuit each second [the number of vans passing each second].
2. Demonstrate connection of an ammeter to a simple circuit containing a battery and bulb.
3. It may also be necessary to introduce standard circuit diagram symbols at this point.

TEACHING 'STORY'

Review pupil findings from the practical work. The current stays the same all the way around the circuits. How does this relate to the Supermarket Picture? Use Supermarket OHT:

- *bread gets delivered to the supermarket, vans keep going;*
- *energy gets delivered to the bulb, charges keep going.*

ACTIVITY 2.3: THE BIG CIRCUIT

TEACHING 'STORY'
Attention is now turned back to the BIG circuit, to apply the new idea of the electric current being the same all around a simple circuit. The pupils can either complete worksheet 2.2: the BIG circuit, during the lesson or for homework.

PURPOSE
To allow the pupils to apply the idea of current being conserved and to allow the teacher to probe developing pupil understandings

PREPARATION AND RESOURCES
Worksheet 2.2: The BIG circuit

INSTRUCTIONS
Pupils complete worksheet 2.2

TEACHING 'STORY'
Review pupil responses to the 'Big Circuit' worksheet.
The current stays the same all of the way around the circuit.

How does this relate to the Supermarket Picture? Use Supermarket OHT.
- bread gets delivered to the supermarket, vans keep going
- energy gets delivered to the bulb, charges keep going

THE BOTTOM LINE
By the end of this lesson the pupils should know that:
- Current is conserved around a circuit, it is the energy that is used up in a bulb

The pupils have:
- Used the supermarket picture to make predictions about current
- Used the supermarket picture to explain conservation of current

Lesson 3

ACTIVITY 3.1: WHICH SUPERMARKET PICTURE FITS BEST?

TEACHING 'STORY'

The third lesson starts with an activity designed to get the pupils to talk about the Supermarket Picture and to relate it to the Electric Circuit Model.

PURPOSE

The central purpose of this activity is to get the pupils to talk about the Supermarket Picture for themselves and to relate it to the Electric Circuit Model.

PREPARATION AND RESOURCES

Worksheet 3.1: Which Supermarket Picture fits best?

INSTRUCTIONS

See pupil worksheet 3.1: Which Supermarket Picture fits best?

The pupils discuss the worksheet in pairs before completing their answers. Then review the response with the whole class.

- Circuit A is the best fit. One bakery / two supermarkets. Bread vans 'conserved' and all moving in the same direction.
- Circuit B is no good. Two bakeries / one supermarket/
- Circuit C is no good. Bread vans travelling in opposite directions (like a 'clashing current' model).
- Circuit D is no good. Bread vans get 'used up' in the supermarkets (current not conserved).

ACTIVITY 3.2: THE CONCEPT OF RESISTANCE

TEACHING 'STORY'

Having used the electric circuit model to predict that current is conserved, attention now turns to using the Supermarket Picture to develop an explanation as to why the current all around the circuit goes down when a second bulb is added in series. This development involves introducing the concept of RESISTANCE.

This point then needs reinforcing with the points of each activity so far to show that the scientific model of plant nutrition is perhaps plausible after all.

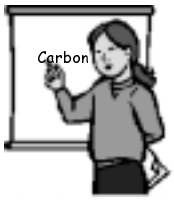
PURPOSE

To introduce the idea of resistance and link it to the bulbs in the electric circuit model and the supermarkets in the Supermarket Picture.

PREPARATION AND RESOURCES

A large clear bulb with a clearly visible filament

INSTRUCTIONS



In lesson 2, the pupils have already seen that adding a second bulb to a circuit reduces the current all around that circuit. The current value is the **same** all the way round, but it is **smaller**.

Start this teacher presentation by reviewing the earlier finding and repeat with a demonstration circuit, showing the reduced current as an extra bulb is added. Pose the question of **why** the current is reduced. Encourage the pupils to think in terms of the Supermarket Picture:

"With two supermarkets the whole chain of vans is slowed down as each van visits, first one supermarket, then the other. Also, the load of bread on each van must be shared between the supermarkets."

Explain that in the electric bulb there is a piece of very thin wire (the filament) which has the effect of slowing down the flow of charges. Just as the vans are slowed down by adding a supermarket, so the charges are slowed down by adding a bulb. Because the bulb has this effect it is said to have a 'RESISTANCE' to the flow of current.

ACTIVITY 3.3: WHY ARE THE BULBS IN SERIES DIMMER?

PURPOSE

To understand the effect of adding bulbs in series to a circuit.

PREPARATION AND RESOURCES

Worksheet 3.1: Two bulbs: how bright is that?

INSTRUCTIONS

See pupil worksheet 3.2: Two bulbs: how bright is that?

Continuing on from the previous discussion of RESISTANCE the pupils work in pairs on worksheet 3.2. After time for discussion and feedback to the whole class, the point is made that the bulbs in series are DIMMER for two reasons:

1. The flow of charge has been slowed down, so energy arrives more slowly at each bulb.
2. The energy carried by each unit of charge is **shared** between the two bulbs.

ACTIVITY 3.4: ADDING RESISTANCE!

TEACHING 'STORY'
Having introduced the idea of resistance, the pupils are given the opportunity to use this idea in predicting and explaining the behaviour of another circuit.

PURPOSE
A practical activity in which the pupils are asked to draw on the Electric Circuit Model ideas to predict and explain what happens as the resistance in a circuit is increased.

PREPARATION AND RESOURCES
Cells, Bulbs, Ammeters, Wires, Crocodile clips
2cm and 10cm lengths of fine gauge nichrome wire
Worksheet 3.3: Adding resistance!

INSTRUCTIONS
See pupil worksheet 3.3: Adding resistance!

Pupils measure the current in a circuit with a short and a long section of resistance wire.
They are asked to make a prediction and explain their observation.

Learning Note:
Some pupils develop the notion that the charges slow down in the resistance wire and then speed up again in the connecting wires...NO! The charges sit nose-to-tail (just like the vans)...if one slows down they all slow down...in all parts of the circuit.

THE BOTTOM LINE
By the end of this lesson all of the pupils should know that:
- adding an extra bulb makes both bulbs dimmer;
- adding an extra bulb reduces the current;
- adding an extra bulb increases the resistance (hence reducing the current).

Some pupils will also understand that the bulbs are dimmer because:
- energy is shared between the bulbs;
- the current is reduced (charge arrives at each of the bulbs more slowly).

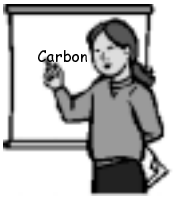
Lesson 4

ACTIVITY 4.1: BACK TO THE IDEA OF RESISTANCE

TEACHING 'STORY'
The fourth lesson starts with a review of the effect of adding resistance to a circuit.

PURPOSE
To review, using the Supermarket Picture and Electric Circuit Model, the effect of adding extra resistance in series to a circuit.

INSTRUCTIONS
Recap on the ideas introduced last lesson about resistance:
- why the current get less when an extra bulb is added in series;
- why the current get less when a thin piece of wire is added to the circuit.



Think about the Supermarket Picture: as an extra supermarket is added the movement of vans is slowed down all around the circuit (the vans run bumper to bumper).

Think about the Electric Circuit Model: as the second bulb is added, the flow of charge all around the circuit is slowed down, the current gets smaller.
- Why do the bulbs get dimmer?

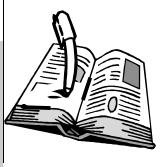
ACTIVITY 4.2: ADDING CELLS TO THE CIRCUIT

TEACHING 'STORY'
Attention now turns to the effect of adding extra cells to the circuit

PURPOSE
To understand the effect of adding extra cells to the circuit in terms of the electric circuit model

PREPARATION AND RESOURCES
Cells, Bulbs, Ammeters, Connecting wires
Worksheet 4.1: Adding cells to the circuit

INSTRUCTIONS
Part A Making predictions and explaining why...



First of all the pupils are asked to make a prediction of what happens to bulb brightness and the current as a second cell is added to the circuit (pupils might refer back to circuits from lesson 2 here).

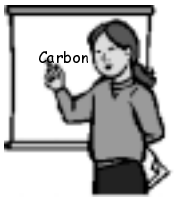
This might be done through discussion in pairs or through whole class discussion and individual responses

ACTIVITY 4.2 CONTINUED

Pupils should be encouraged to draw upon the Supermarket Picture in talking through their predictions and explanations with each other.

Part B Making measurements...
Then, the pupils set up the circuits on the worksheet and measure the current in each.

Part C Developing an explanation with the whole class...
An explanation for the increased brightness of bulb and the increased size of current is talked through with the class.



Referring to the Supermarket Picture:
- more bread is loaded into each van
- the vans are sent out quicker, with a bigger 'push' from the bakery

Referring to the electric circuit:
There are two reasons why the bulb is brighter:
- more energy is loaded onto each charge in the two batteries (two lots of energy)
- the charges are pushed around more quickly by the cells (the current increases)

...so more energy arrives...and is given out...in a certain time.

Once again the Supermarket Picture can help in explaining electric current and help pupils to develop a twofold explanation for increased bulb brightness when cells are added.

ACTIVITY 4.3: PUTTING THE IDEAS TOGETHER

TEACHING 'STORY'
The ideas from lessons 3 and 4 are brought together as the effects of changing both the number of cells and bulbs are considered.

PURPOSE
To consider the effects of changing the number of bulbs and the number of cells.

PREPARATION AND RESOURCES
Worksheet 4.2: Blockbuster!

INSTRUCTIONS
Here the pupils look at different combinations of numbers of batteries and bulbs:

- why is one battery/one bulb the same as two batteries/two bulbs?
- what happens with three batteries and two bulbs?

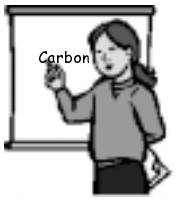
Depending on time this could include measuring the current in circuits with different combinations of cells and bulbs.

Alternatively the 'Blockbuster' worksheet is available for homework, discussion or extension purposes.

ACTIVITY 4.4: FINAL REVIEW

PURPOSE
A final review of the sequence of lessons

TEACHER PRESENTATION



Some time needs to be spent in talking through the key ideas raised in the lesson sequence which now constitute a simple Electric Circuit Model. These are outlined below:

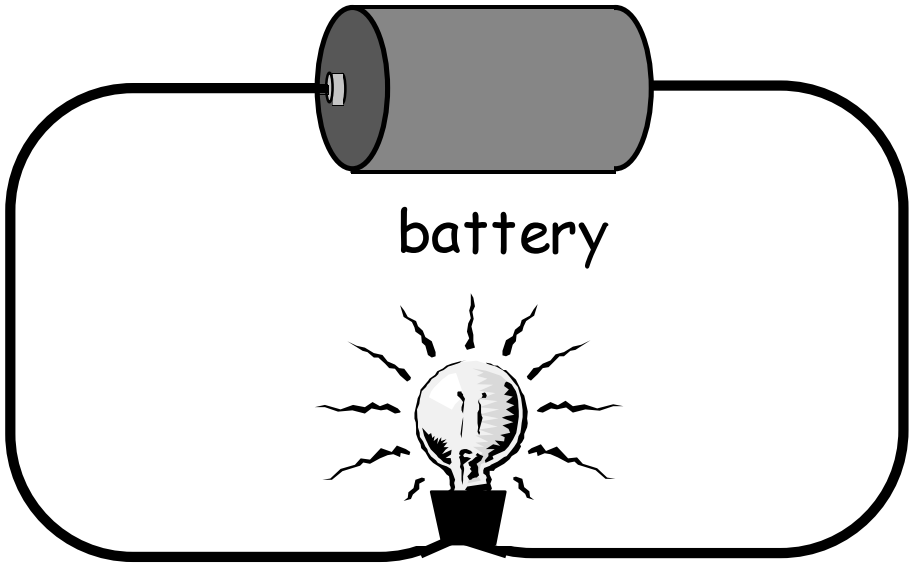
THE WHOLE TEACHING 'STORY'
To do with current/charge:
1. electric current is a flow of charges;
2. electric current is measured in Amps;
3. the size of the electric current is a measure of how many charges pass each point in the circuit in a fixed time.

To do with energy and energy transfer:
1. the cell/battery provides energy;
2. the cell/battery sets charges moving;
3. charges carry energy;
4. energy is transferred from battery to bulb by the electric current;
5. energy is given out in the bulb as heat and light;
6. the electric current does not get used up.

Making changes to the circuit:
1. increasing the number of cells increases current;
2. increasing the number of cells increases energy carried by charges;
3. increasing the number of bulbs increases resistance;
4. increasing the number of bulbs reduces current around the whole circuit.

THE BOTTOM LINE
Pupils should now be able to use a simple Electric Circuit Model, supported by the Supermarket Picture, to explain why:
- bulbs become dimmer as more are added in series;
  - energy shared
  - current reduced
- bulbs become brighter as extra cells are added;
  - increased energy
  - current increased

Bulb Light



This is a very simple electric circuit.

1. Explain in as much detail as you can (thinking about both battery and bulb) why you think the bulb lights up.

_____

_____

_____

2. a) How could you change the circuit to make the bulb brighter?

_____

b) Explain why this would work.

_____

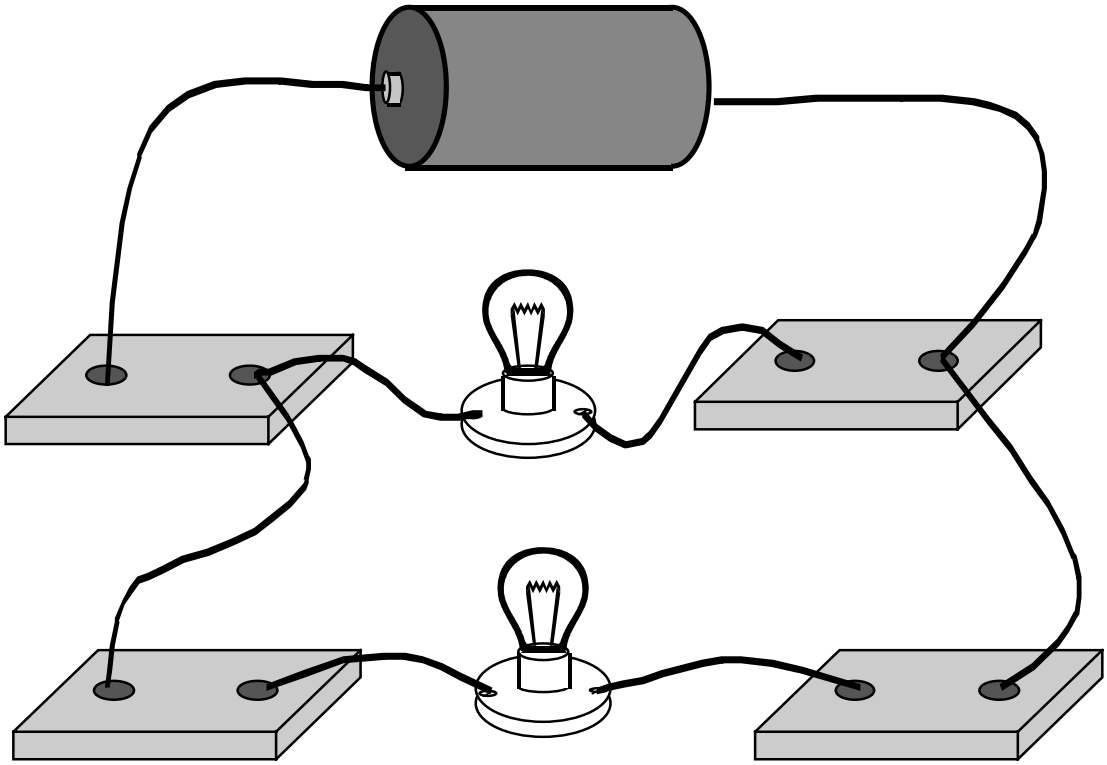
_____

3. If the circuit is left, why will the battery go FLAT eventually?

_____

_____

Open and Close



Emma wants to make bulb 1 light (and bulb 2 stay off). Which switches does she need to close?

_____

James wants to make bulb 2 light (and bulb 1 stay off). Which switches does he need to close?

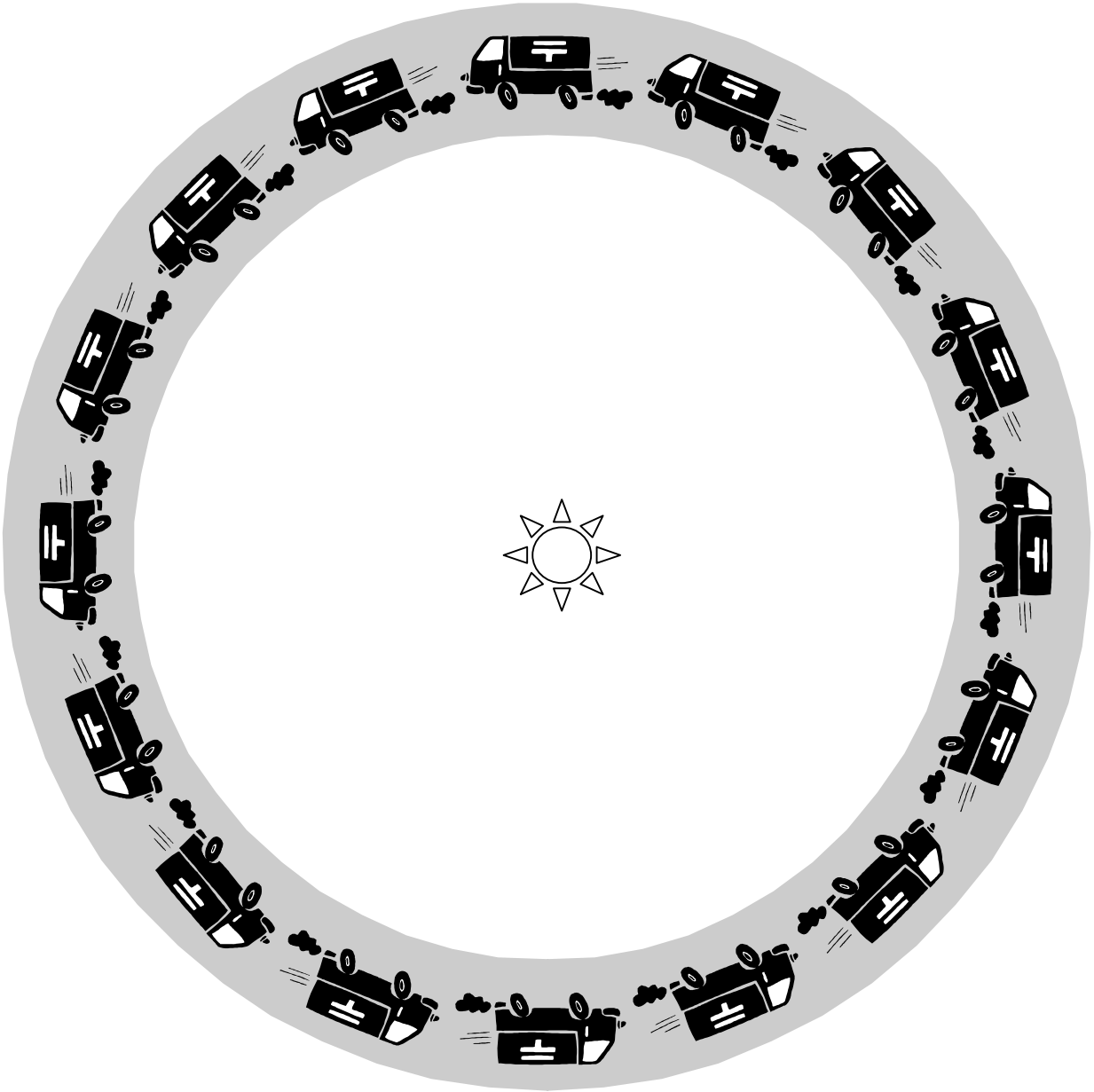
_____

Explain why you have chosen these switches.

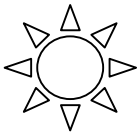
_____

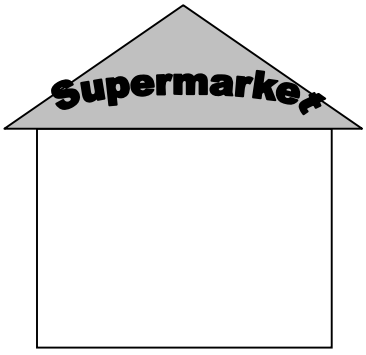
_____

_____

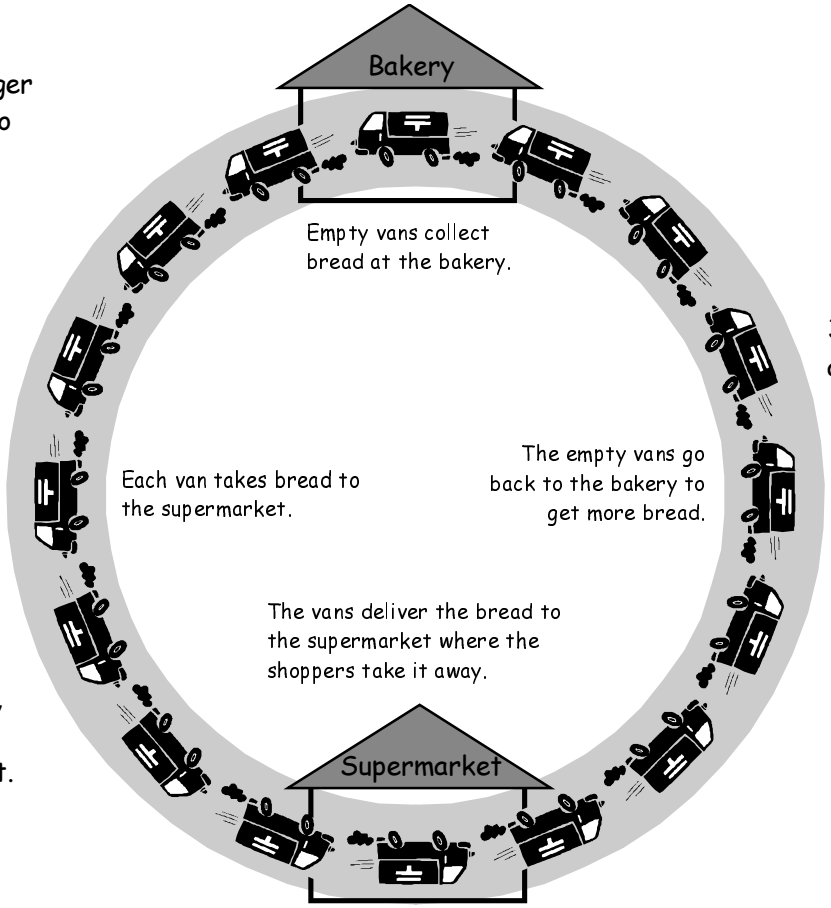



Bakery




Supermarket

1. The bakery manager loads the bread onto the vans and sends them off.



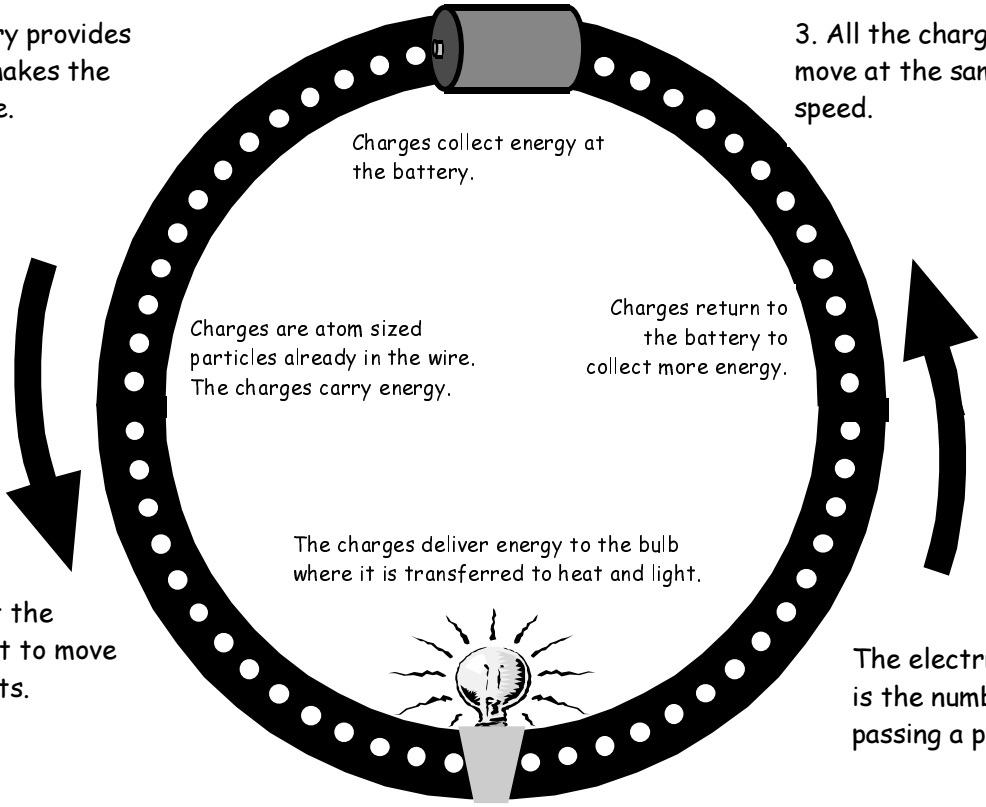
3. All the vans move at the same speed.

2. As soon as the vans start to move, bread is delivered to the supermarket.

4. If the manager speeds the vans up, more bread is delivered to the supermarket in a certain time.

5. If the manager loads more bread on to each van, more bread is delivered to the supermarket in a certain time.

1. The battery provides energy and makes the charges move.



3. All the charges move at the same speed.

2. As soon at the charges start to move the bulb lights.

The electric current (Amps) is the number of charges passing a point each second.

4. If the charges speed up more energy is delivered to the bulb in a certain time.

5. If more energy is carried by each charge, more energy is delivered to the bulb in a certain time.

Supermarkets & Electric Circuits

1. The bakery is like the _____ in the circuit.

2. The vans are like the _____ in the wire.

3. The bread the vans are carrying is like the _____ carried by the _____ in the wire.

4. The supermarket is like the _____ . Here, the bread is passed onto the customers just like the _____ carried by the charge is transferred to _____ energy and _____ energy in the bulb.

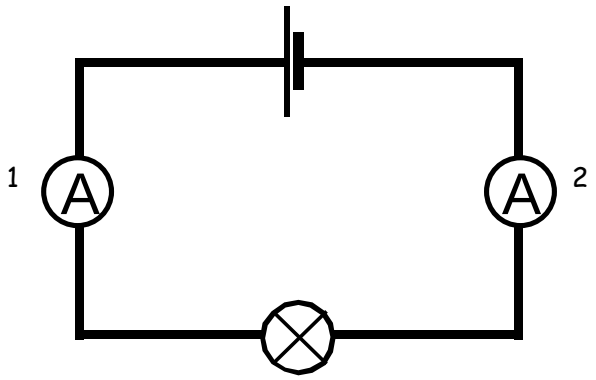
5. The empty vans return to the bakery for more bread. This is the same as the _____ going back to the _____ for more _____.

6. If the bakery manager speeds up the vans leaving the bakery, bread
arrives quicker at the supermarket. This is like _____ arriving more quickly at the _____ in the circuit.

7. If the bakery manager loads more bread onto each van, then more bread is delivered to the supermarket in a certain time. This is like more _____ being delivered to the _____ in a certain time in the circuit.

The chain of moving vans is like a flow of _____ . In a circuit, we call this an _____ _____.

Predicting and Measuring Currents

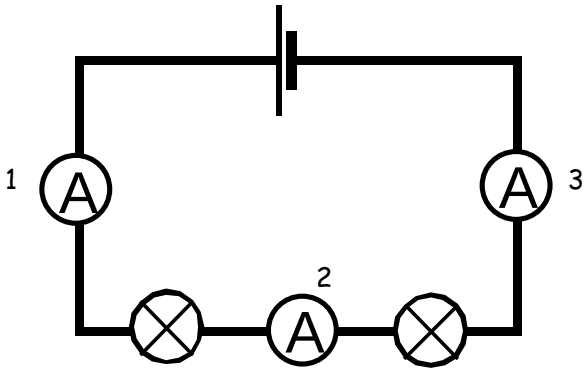


Circuit A

Measure Current 1 = _____ Amps

Predict Current 2 = _____Amps

Measure Current 2 = _____Amps



Circuit B

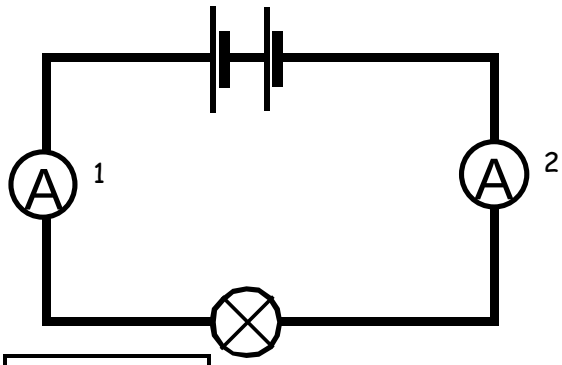
Measure Current 1 = _____ Amps

Predict Current 2 = _____Amps

Predict Current 3 = _____Amps

Measure Current 2 = _____Amps

Measure Current 3 = _____Amps



Circuit C

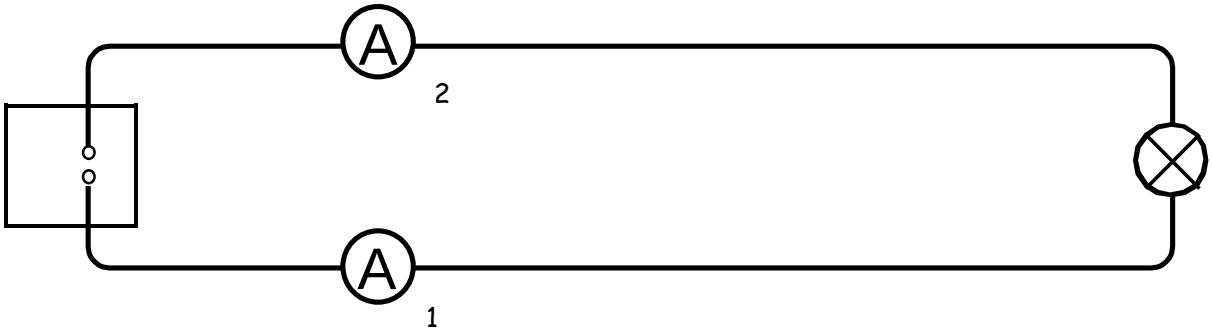
Measure Current 1 = _____ Amps

Predict Current 2 = _____Amps

Measure Current 2 = _____Amps

The BIG circuit

Mr. Harris set up the BIG circuit in his laboratory.



He measured the currents in two places and found:

Current 1 = 1.8 Amps

Current 2 = 1.8 Amps

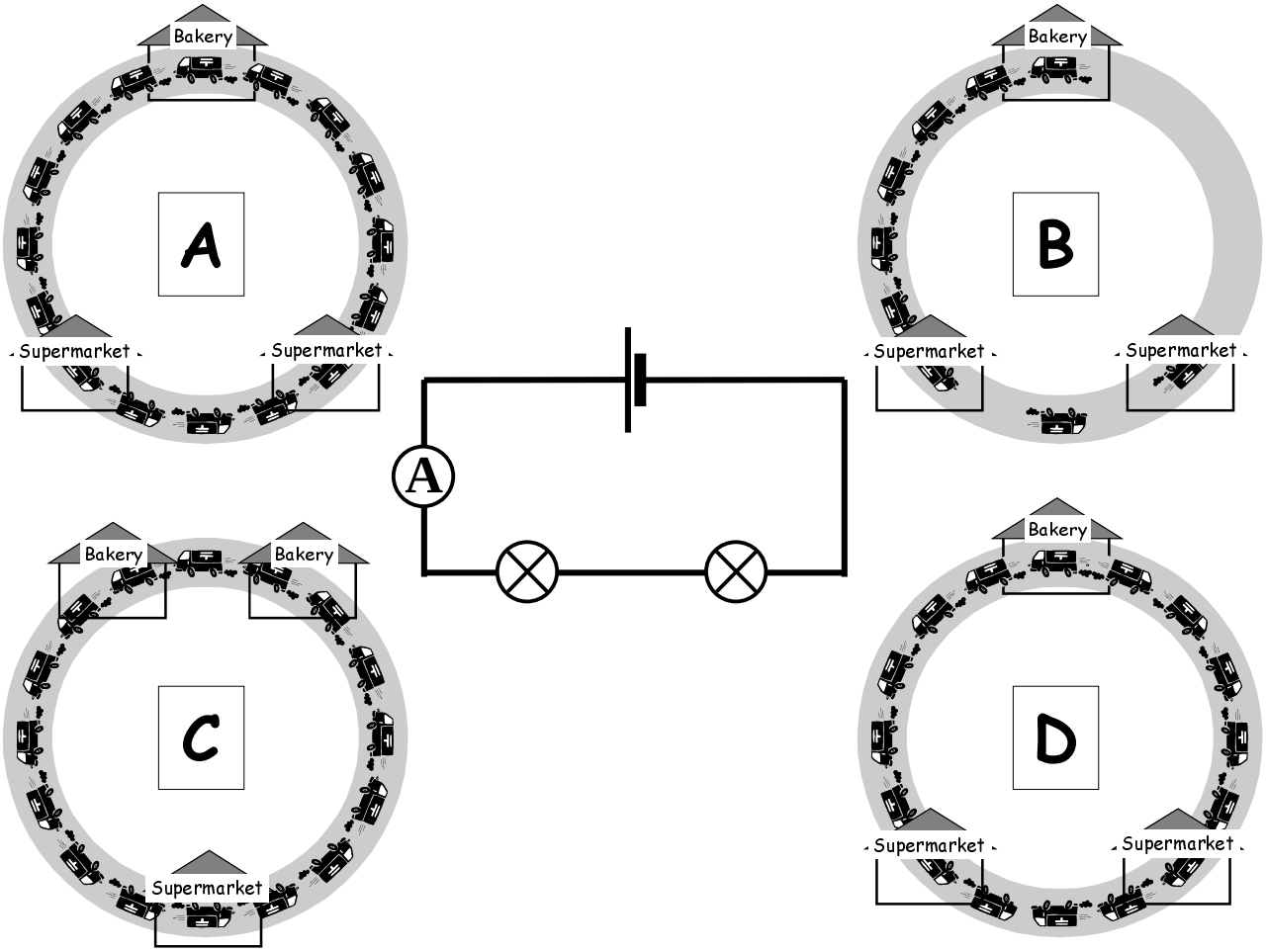
Robbie said: ' that's not right, the current gets used up in the bulb to give heat and light'.

1. Is Robbie correct? _____ (Yes/No)

2. Explain why you think this. (You might want to refer to the supermarket picture ideas.)

_____
_____
_____
_____
_____
_____
_____
_____
_____

Which Supermarket Picture fits best?



Which Supermarket / Bakery Picture fits the electric circuit best?

❒ is **best** because . . . . . .

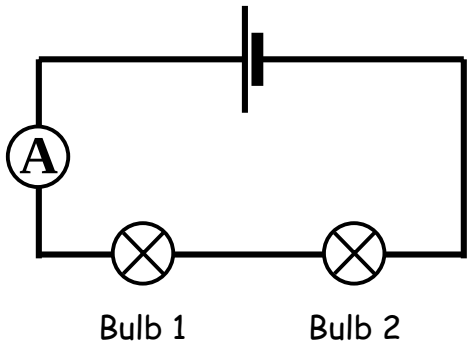
❒ is no good because . . . . . .

❒ is no good because . . . . . .

❒ is no good because . . . . . .

Two Bulbs… how bright is that?

Use the Supermarket Picture to predict the brightness of the two bulbs in the electric circuit and to explain their brightness



We predict that in the circuit Bulb 1 will be normal / dim and Bulb 2 will be normal / dim .

Our explanation for this (thinking about the Supermarket Picture) is that…

. . . . . .

. . . . . .

. . . . . .

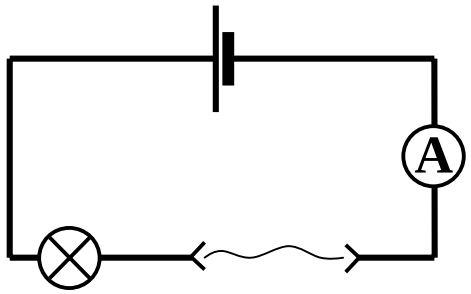
. . . . . .

. . . . . .

. . . . . .

Adding Resistance!

Set up the circuit below and measure the current in the circuit.



Write down a what you think will happen to the current with a longer length of wire in the circuit.

I think the current will be:

A. greater
B. the same
C. less

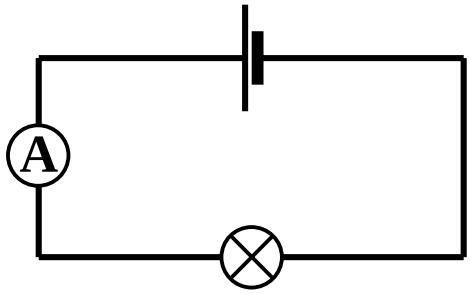
Change the length of wire for a longer one and measure the current in the circuit again.

What can you say about what happens to the current when you add a longer wire to the circuit?

Explain your observations.

Adding cells to the circuit

Circuit A



If another battery is added to circuit A

The bulb will be . . . . . .

I think this because . . . . . .

. . . . . .

. . . . . .

The current will be . . . . . .

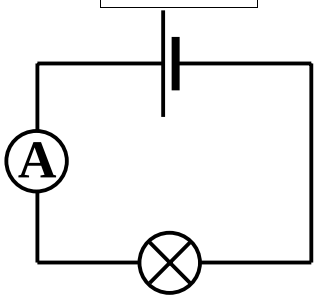
I think this because . . . . . .

. . . . . .

. . . . . .

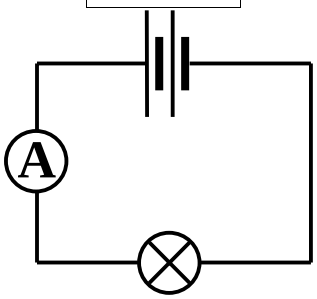
Now set up circuit A,B and C and measure the current in each circuit.

Circuit A



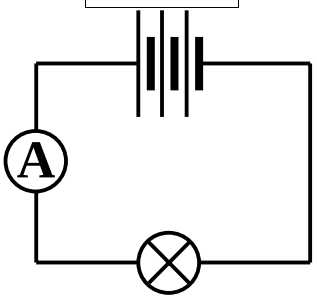
……A

Circuit B



……A

Circuit C

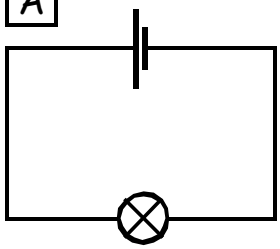


……A

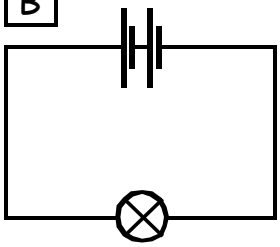
Blockbuster!

Look at these circuits:

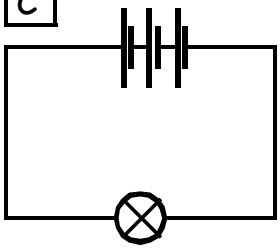
A



B



C



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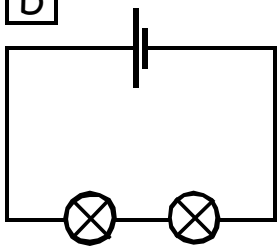
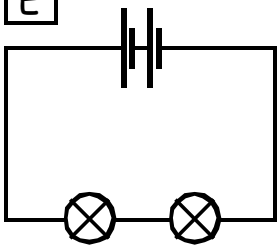
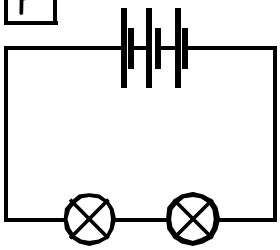


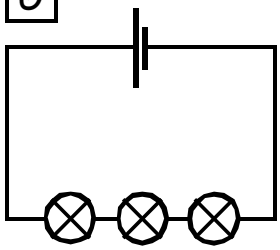
E



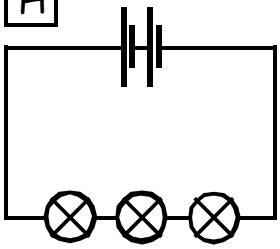
F



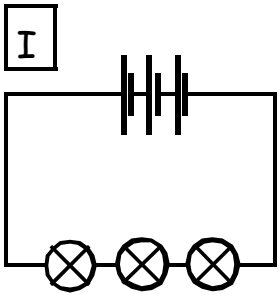
G



H



I



In which circuit is each bulb BRIGHTEST?

In which circuit is each bulb DIMMEST?

In which circuit is the current BIGGEST?

In which circuit is the current LEAST?

In which three circuits are the bulbs the same BRIGHTNESS and the currents the SAME?

Equipment that needs assembling in advance of the teaching

OHT 1.3 'The Supermarket Picture' needs assembling.

1. Photocopy both parts of the OHT.
2. Cut out the circle of 'bread vans' on sheet 1.3**a** and pin this with a paper fastener to the centre of the circle on sheet 1.3**b** so that the 'bread vans' can revolve freely.

The 'BIG' circuit consists of a battery and bulb. The battery, or power pack, is at the front of the room, the bulb at the back of the room and the connecting wires run right round the perimeter of the room, possibly taped to the classroom walls.

Resources lesson by lesson

Lesson 1

Class sets of

- Worksheet 1.1
- Worksheet 1.2
- Stick-in-sheet 1.4
- Worksheet 1.5
- A4 envelopes

Single set of

- The 'Big' circuit

A circuit consisting of a power pack and a large bulb set up with the connecting wires running around the perimeter of the classroom

- OHT 1.3 (see above)

Lesson 2

Class sets of

- Worksheet 2.1
- Worksheet 2.2

- 1 Cell per group
- 2 Bulbs per group
- 1 Ammeter per group
- 4 Connecting wires per group

Single set of

- OHT 1.3

Lesson 3

Class sets of

- Worksheet 3.1
- Worksheet 3.2

- 1 Cell per group
- 1 Bulb per group
- 1 Ammeter per group
- 4 Connecting wires per group
- 2 crocodile clips per group
- a 2cm long pieces of fine gauge nichrome wire per group
- a 10cm long pieces of fine gauge nichrome wire per group

- Large sheets of paper and thick pens

Lesson 4

Class sets of

- Worksheet 4.1
- Worksheet 4.2

- 2 Cells per group
- 2 Bulbs per group
- 1 Ammeter per group
- 4 Connecting wires per group