# Unravelling DNA

## Lesson Plan

### Learning objectives strands 2–5
- Pupils should be taught about a simple model of chromosomes, genes, and DNA in heredity.

### Learning objectives: strand 1 (HSW)
- Use appropriate materials during laboratory work.

### PLTS
- Team workers: carry out practical activities cooperatively.

### APP
- AF1 – Thinking scientifically
- AF3 – Communicating and collaborating in science

## Starter
- **Horse or beef?** Remind students about the recent news story in which horsemeat was found in beef burgers and other foods. Elicit that the horsemeat was detected by DNA tests. If you wish, show the humorous video *Say neigh to horse meat*.
- **DNA** Students tackle the true/false quiz about DNA and heredity. Go over the answers to establish key facts.

## Differentiation

### Extension
- Use textbooks to help write corrected versions of the false statements in the quiz.

### Resources
- Optional video – *Say neigh to horse meat*
  Please watch this video before the lesson to check it is suitable for your students (see URL at the end of this lesson plan).
- **Activity sheet 1**
- **Teacher and Technician Notes**

## Main
- **Modeling DNA** Student pairs make models to represent part of a DNA molecule and a chromosome.
- **Explaining DNA 1** Student pairs plan talks to explain the structures involved in heredity (cell, nucleus, chromosome, DNA, gene) and work out how to use their models to illustrate their talks.
- **Explaining DNA 2** Student pairs present their talks to each other, and peer evaluate.

## Differentiation
- **Help**
  - Show students pictures of DNA models made by others.

## Resources
- **Activity sheet 2**
- **Activity sheet 3**
- **Teacher and Technician Notes**
  - Materials for model-making
  - Pictures of DNA models made by others (see URLs at the end of this lesson plan)
## Unravelling DNA

### LESSON PLAN

<table>
<thead>
<tr>
<th>Plenary</th>
<th>Differentiation</th>
<th>Resources</th>
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</thead>
</table>
| **DNA video** Watch the video explaining the structure of DNA. Students evaluate the video by comparing it to their own talks.  
**More DNA questions** Students write down one thing they’ve learnt about DNA, and one thing they would like to know more about. | | **DNA video**  
The structure of DNA (see URL at the end of this lesson plan). |

### Homework

- Research answers to the question posed in the plenary using textbooks or the Internet.

### 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>
| **Make simple physical models to describe the structure of DNA.**  
**Use simple scientific language to describe the structure of DNA.** | **Use simple physical models to help describe the links between genes, chromosomes, and DNA.**  
**Use appropriate scientific language to communicate ideas about genes, chromosomes, and DNA.** | **Use appropriate scientific terminology to communicate ideas about the structure of DNA.** | **Identify the strengths and weaknesses of DNA models.** | **Make connections between abstract ideas and models in explaining heredity.** |

### Useful web links

**Starter – Say neigh to horsemeat video**  
http://www.youtube.com/watch?v=B5tpvV5RB8A&feature=player_detailpage

**Main – Models of DNA made by others**

**Plenary – Structure of DNA video**  
http://www.youtube.com/watch?v=gy8dk5iS1f0
In this lesson, students learn about the structure of DNA through hands-on model-making activities.

The lesson begins with a discussion about horsemeat, and the use of DNA testing to identify this meat in processed foods. The starter continues with a true/false quiz to check students’ prior knowledge of DNA.

In the main part of the lesson, students make models of DNA and other structures involved in heredity. They plan how to incorporate their models in talks to describe the structure of DNA.

The lesson ends with the viewing of a video on the structure of DNA. How does it compare as a learning tool with the students’ talks?

**Equipment required per group:**

**Starter**
- Activity sheet 1 – one each (optional)

**Main**
Per pair:
- Activity sheet 2
- Activity sheet 3
- Materials to make model DNA, including:
  - cocktail sticks
  - 2 liquorice ropes
  - small marshmallows to represent DNA bases A, T, G, and C
  - scissors
- Materials for optional models, including:
  - wool that can be unravelled to make into the shape of a chromosome
  - sticky tape to keep wool in place in chromosome model
  - box to represent cell
  - smaller box to represent nucleus

**Health and Safety notes:**
- Do not eat the model-making materials.

**Starter**

1. **Horse or beef?** Remind students about the recent news story in which horsemeat was found in burgers, lasagne, and so on. Elicit that the horsemeat was detected by DNA tests and point out that this was possible because horse DNA has certain key differences to cow DNA. Tell students that the structure of DNA, which enables these tests to be done, was discovered in 1953, 60 years ago. If you wish, show the humorous video at this point (see web link below). Please watch the video first to check that it is suitable for your class.

2. **DNA quiz** Students complete the true/false quiz on Activity sheet 1. They could use copies of the sheet or the teacher could read out the questions with students responding on mini-whiteboards. Go through the answers. The false statements are 1, 3, 5, and 9.
Main

1 Modelling DNA Student pairs follow the guidance on Activity sheet 2 to make models to represent part of a DNA molecule. Activity sheet 3 provides information and diagrams to help them. Students can be encouraged to be as creative as possible – there is certainly no one correct answer for this activity! One possible model is shown below.

Students can also use wool and sticky tape to make a model chromosome, from which the wool unravels like a strand of DNA. A further option is to make model cells from plastic boxes, with a smaller container inside to represent the nucleus.

3 Explaining DNA (planning) Student pairs follow the guidance on Activity sheet 2 part B to plan talks to describe the structures involved in heredity. They plan how to use their models, and perhaps further diagrams, to illustrate their talks.

4 Explaining DNA (presenting and evaluating) Student pairs present their talks to one other pair. Straight after each talk, the pair who were listening provide feedback on Activity sheet 2 part C. They also give oral feedback. After all talks have been completed, student pairs could compare their models.

Plenary

1 DNA Show the video about the structure of DNA. Ask students to compare the video to their talks. In what ways was the video more helpful, or less helpful, than their talks?

2 More DNA questions Students write down one thing they’ve learnt about DNA and one thing they would like to know more about. This provides a basis for their homework task.

Useful web links
Starter:
http://www.youtube.com/watch?v=B5tpvVSR8B8A&feature=player_detailpage (video)

Models made by others:
Search for DNA candy models on a search engine (images)

Plenary:
http://www.youtube.com/watch?v=qy8dk5iS1f0 (video)
DNA quiz

Decide whether each statement is true or false.

1. All living things have DNA in their cell membranes.
2. DNA is a chemical.
3. What we look like depends only on our genes.
4. A gene is a short length of DNA.
5. The DNA of every person is different.
6. With the correct equipment, it is easy to tell the difference between horse DNA and cow DNA.
7. Identical twins have the same DNA.
8. Forensic scientists use DNA evidence to help identify criminals.
9. Scientists can extract DNA from cheek cells but not from hairs.
10. Over time, scientists have worked out how to get useful information from smaller and smaller amounts of DNA.
Part A – Model making

In this activity, you will make a model to show the structure of part of a DNA molecule. Follow these steps:

- Study the diagrams carefully (see Activity sheet 3).
- Choose materials for your model.
- Draw a sketch to help plan your model.
- Make your model.

Your teacher might also ask you to make:

- a model chromosome (from sticky tape and wool)
- a model cell with a nucleus.

Part B – Explaining DNA (planning)

Heredity is the passing of characteristics from parents to offspring through genes.

Plan a talk to describe the structures involved in heredity, including:

- cells and nuclei
- chromosomes
- DNA
- genes

- Work out how to use your models to illustrate your talks.
- You will present your talk to one other pair in the class. They will use the criteria below to evaluate your talk and models.

Part C – Explaining DNA (presenting and evaluating)

- Use the success criteria in the table to evaluate the other pair’s talk and models.

<table>
<thead>
<tr>
<th>Success criteria</th>
<th>Did they meet the success criteria?</th>
<th>How could they improve?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students give clear descriptions of the structures of cells, nuclei, chromosomes, DNA, and genes.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Models help to illustrate the structures above.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Students describe shortcomings of models.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Students speak with enthusiasm.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Information – the structures of heredity

Heredity is the passing of characteristics from parents to offspring through genes.

Almost every cell has a nucleus. Inside the nucleus are chromosomes.

A chromosome is made up of a long molecule called DNA. DNA consists of atoms of carbon, hydrogen, oxygen, nitrogen, and phosphorus.

In DNA, the atoms are arranged in groups. The groups are:
- sugars
- phosphates
- bases – T, A, C, and G

You can imagine DNA as a twisted ladder. The sugars and phosphates make up the handrails. The bases are the rungs. They are always in pairs. C pairs with G, and A pairs with T.

A gene is a section of DNA. It is a set of instructions that affects how we grow or what we look like. Every gene has its own order of bases.
### The DNA Story

#### Learning objectives strands 2–5

- Pupils should be taught about a simple model of chromosomes, genes, and DNA in heredity, including the part played by Watson, Crick, Wilkins, and Franklin in the development of the DNA model.

#### Learning objectives: strand 1 (HSW)

- Use scientific ideas and models to explain phenomena and develop them creatively to generate and test theories.
- Examine the ethical and moral implications of using and applying science.
- Share developments and common understanding across disciplines and boundaries.

#### PLTS

- Independent enquirers: explore issues, events or problems from different perspectives; analyse and evaluate information, judging its relevance and value; consider the influence of circumstances, beliefs, and feelings on decisions and events.
- Self-managers: work towards goals, showing initiative, commitment, and perseverance; organise time and resources, prioritising actions.

#### APP

- AF1 – Thinking scientifically
- AF2 – Understanding the applications and implications of science

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#### Starter

- **What’s the fuss with DNA?** This is a short discussion prompted by one or two questions. The aim here is to act as an opener but mainly to introduce some wonder and awe about the importance of DNA.
- **Locating DNA in a cell** Pupils play a mystery card game to help them understand the physical location of DNA in the cell, and appreciate the relationship between DNA and other key components in the cell.
- **How scientists work together** The aim of this activity is to illustrate the way working together and sharing information aids a project. Students either sort cards into two shapes or build a structure from each other’s instructions. They will need to communicate clearly with each other to solve the simple puzzles or build similar structures.

#### Differentiation

- Help
  - Provide groups of pupils with a sheet of paper, with ‘smallest’ written at one end, ‘biggest’ at the other, and students arrange cards in order, before attempting to draw the picture.

#### Resources

- Set of cards or **Activity sheet 1**
- A set of pre-cut cards of images per group of three or two sets of images per group of two (from **Activity sheet 2**)
- **Activity sheet 2**
### The DNA Story

#### LESSON PLAN

<table>
<thead>
<tr>
<th>Main</th>
<th>Differentiation</th>
<th>Resources</th>
</tr>
</thead>
<tbody>
<tr>
<td>• <strong>The discovery of the structure of DNA</strong> Pupils use the information cards to determine the relative contribution of two research teams in the discovery of the structure of DNA.</td>
<td>Help</td>
<td>• Activity sheet 3 (table photocopied onto A3)</td>
</tr>
<tr>
<td></td>
<td>Extension</td>
<td>• Teacher and Technician Notes</td>
</tr>
<tr>
<td></td>
<td>• <strong>How the knowledge of DNA allowed other scientific developments</strong> This is a short question-and-answer session, probing pupils’ knowledge of scientific advances in DNA technology.</td>
<td>Help and extension</td>
</tr>
<tr>
<td></td>
<td>Help</td>
<td>• Activity sheet 4</td>
</tr>
<tr>
<td></td>
<td>• Work with larger copies of the template in a group.</td>
<td>• Several copies of the base pairs per student or per group with string/ribbon; teachers may choose to copy the templates onto A3</td>
</tr>
<tr>
<td></td>
<td>Extension</td>
<td>• Teacher and Technician Notes</td>
</tr>
<tr>
<td></td>
<td>• Ask pupils to research the differences between the base combinations, using textbooks or the Internet.</td>
<td>• DNA video James Watson Explains DNA Base pairing (see URL at the end of this lesson plan)</td>
</tr>
<tr>
<td></td>
<td>Help and extension</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• The questions suggested in the Teacher and Technician Notes are ramped and should be selected appropriately for the class.</td>
<td></td>
</tr>
</tbody>
</table>

#### Plenary

<table>
<thead>
<tr>
<th>Resources</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Activity sheet 3 (table photocopied onto A3)</td>
</tr>
<tr>
<td>• Teacher and Technician Notes</td>
</tr>
<tr>
<td>• Information cards on Activity sheet 3</td>
</tr>
<tr>
<td>• DNA video James Watson Explains DNA Base pairing (see URL at the end of this lesson plan)</td>
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</table>

#### Homework

<table>
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<tbody>
<tr>
<td>• Activity sheet 4</td>
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<td>• Several copies of the base pairs per student or per group with string/ribbon; teachers may choose to copy the templates onto A3</td>
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<td>• Teacher and Technician Notes</td>
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<tr>
<td>• DNA video James Watson Explains DNA Base pairing (see URL at the end of this lesson plan)</td>
</tr>
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</table>

• **Write an account of the discovery of DNA. The account should include:**
  - the key workers involved in the story
  - some idea of their contribution
  - an indication of who contributed the most.
### Learning outcomes

<table>
<thead>
<tr>
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<th>Level 6</th>
<th>Level 7</th>
</tr>
</thead>
</table>
| • Communicate conclusions using simple scientific language.  
• Describe some processes and phenomena related to organisms. | • Communicate conclusions using appropriate scientific language.  
• Describe some processes and phenomena related to organisms.  
• Recognise some applications and implications of science. | • Communicate conclusions using scientific and mathematical conventions and terminology.  
• Describe processes and phenomena, drawing on abstract ideas and using appropriate terminology.  
• Recognise that both evidence and creative thinking contribute to the development of scientific ideas.  
• Describe applications and implications of science. | • Evaluate evidence from conclusions.  
• Describe processes and phenomena, using abstract ideas and appropriate terminology.  
• Describe evidence for some accepted scientific ideas.  
• Explain the importance of some applications and implications of science. | • Communicate effectively, using a wide range of scientific and technical conventions and terminology.  
• Describe a wide range of processes and phenomena, using abstract ideas and appropriate terminology.  
• Apply and use more abstract knowledge and understanding in a range of contexts.  
• Explain how evidence supports some accepted scientific ideas.  
• Explain, using abstract ideas where appropriate, the importance of some applications and implications of science. |

### Useful web links

**Plenary – James Watson explains DNA base pairing video**

http://www.youtube.com/watch?v=PDeaLxoL75M
This lesson is based around the contributions of the different workers involved in the 1953 description of the structure of DNA. The aim is to gain some appreciation of the importance of the molecule, how it was described, and the failure of different scientists to work together.

### Equipment required per group:
- Activity sheets 1, 2, 3, and 4
- Scissors
- Tape/ribbon

**Activity sheet 2** should be copied onto card and pre-cut before the lesson.

**Activity sheet 3** information sheets might be better enlarged and laminated before the lesson.

### Health and Safety notes:
- Take care when using sharp objects, for example, scissors.

### Starter

1. **What’s the fuss with DNA?** Start the lesson with a short discussion prompted by one or two questions. The aim here is to act as an opener but mainly to introduce some wonder and awe about the importance of DNA. Prompt questions could include:
   1. What is DNA?
   2. Why is DNA important?
   3. What do you know about DNA?
   4. Why was it so important for biologists to understand the structure of DNA?

2. **Locating DNA in a cell** The aim of this starter is to help pupils understand the physical location of DNA in the cell, and appreciate the relationship between DNA and other key components in the cell.

   Pupils should follow the instructions on **Activity sheet 1**. At the end of the activity the groups should have produced a drawing of a cell with the nucleus inside, with chromosomes inside that, made of DNA. All of the key information from the cards should be annotated on the diagram.

3. **How scientists work together** In this activity pupils gain an idea of the power of communicating together and working as a team. This is an analogy to the idea of scientists working together. It is only intended that the pupils should attempt one of the two activities suggested.

   Pupils need to be supplied with photocopied cards (from **Activity sheet 2**). They follow the instructions on the worksheet. The activity should be completed by a discussion of the advantages gained from communicating together.

### Main

1. **The Discovery of the structure of DNA** Teachers will need to introduce the task. The pupils could read through the introduction on **Activity sheet 3** or the teacher could quickly discuss the importance of DNA and its structure. A basic idea of the helix structure and the words ‘backbone’ and ‘base pairs’ will help pupils complete the task.
The class is divided into groups of about four. Each group is given two information cards about the two teams of biologists involved in the discovery of DNA structure. Pupils read the cards to obtain key information. They discuss the points that they read in their groups. Pupils decide through their discussions how the two teams contributed to the discovery of the structure of DNA. How did they work together within their teams, and between the teams? Pupils sort out pieces of information that show:

a. how the teams contributed

b. how the individual teams were held back from making the discovery alone.

They then use the grid on Activity sheet 3 to help them put the information into different categories. This will provide information for a class feedback activity and the homework.

Plenary

1. D.I.Y. DNA The aim of this task is to build a model of DNA. A good introduction to this is to show the short video James Watson Explains DNA Base pairing (1 min 40 s). This can be found on YouTube (see URL at the end of this sheet).

   Pupils cut out the base pairs (from the template provided). They cut a small hole at each end of the base pairs. Pupils then place ribbon or string through the holes at the ends of the base pairs to act as the backbones. By spacing the base pairs equally and rotating the structure slightly they have built their own model of the DNA molecule.

2. How the knowledge of DNA allowed other scientific developments The aim of the task is to explore how the knowledge of the structure of DNA enabled a better understanding of biology, and a great number of technologies that hugely improve our quality of life. The format is a simple discussion, and a number of questions are listed to guide the discussion. These questions are ramped and can be used selectively with your class, depending on ability. You may want to ask pupils to do some independent research about one or more of the questions.

   a. Have scientists carried on with DNA research?
   b. Why or what do you know about DNA?
   c. Do you ever hear about DNA stories in the news?
   d. What is DNA fingerprinting?
   e. Has our knowledge of DNA helped to cure any diseases?
   f. Do you think that scientists have learnt to work together better than in the time of Watson and Crick?
   g. What do you think a genetically modified (GM) crop or organism is?
   h. Do you know of any ethical concerns raised by modern DNA research?
   i. What have you heard about the Genome 2000 project?
   j. Have scientists learnt how DNA codes work in cells?

Useful web links

Plenary:
http://www.youtube.com/watch?v=PDeaLxoL75M (video)
Locating DNA in a cell

From the beginning of the 1900s biologists thought that DNA would hold the key to a wonderful new world of biological information.

It was important for biologists to know where in the cell the DNA was actually located.

The class should be divided into groups of three. Your task is to:

1. Cut out the cards.
2. Deal out the cards equally to the members of your group.
3. Do not show other people in the group what is on your cards.
4. Discuss the information on the cards with the members of the group.
5. Work together, sharing your information, to construct a diagram showing in detail where the DNA is located in the cell. Make use of all the information you have been given.

<table>
<thead>
<tr>
<th>Genes are made of DNA.</th>
<th>The nucleus is the largest structure inside most cells.</th>
<th>The cell is the basic building block of all organisms.</th>
</tr>
</thead>
<tbody>
<tr>
<td>DNA is a chemical called deoxyribonucleic acid.</td>
<td>The nucleus contains chromosomes.</td>
<td>The nucleus controls the cell.</td>
</tr>
<tr>
<td>Many genes make up a chromosome.</td>
<td>Cells contain cytoplasm.</td>
<td>Chromosomes are made of DNA.</td>
</tr>
<tr>
<td>There are many chromosomes inside a nucleus.</td>
<td>A gene is a short section of a chromosome.</td>
<td>The nucleus is in the cytoplasm.</td>
</tr>
</tbody>
</table>
How scientists work together

When investigating a major problem, like working out the structure of DNA, there are always many teams of scientists involved. Progress is always better if the teams of scientists work together and share their ideas.

In this activity you will gain an idea of the power of communicating together and working as a team.

Your task:

1. Divide yourselves into groups of three scientists.
2. Each group will be given a set of eight cards with shapes on one side.
3. Deal the cards out to the members of the group, face down.
4. Each member of the group now has pieces of information.
5. Work together, discussing what you have and try to piece together the information to discover your mystery shapes.

Alternative task:

1. Divide yourselves into groups of two.
2. Each individual will be given a set of eight cards with shapes on one side.
3. Sit with your backs to each other.
4. One person (the leader) needs to make a shape using the cards.
5. As the leader makes the shape, they describe to the other player (the co-worker) what they are doing.
6. The co-worker attempts to make the same shape, relying on the verbal description given by the leader only.
7. When the shapes are complete, the two workers examine them.
8. How similar are they?
The discovery of the structure of DNA

In 2013 a letter written in 1953 by Francis Crick to his 12-year-old son was sold at auction for $5.3 million. Why was the letter so important? It was written by one of the biologists who was just about to reveal the structure of perhaps the most important molecule in living things, DNA.

“My dear Michael,” the letter begins, “Jim Watson and I have probably made a most important discovery. We have built a model for the structure of des-oxy-ribose-nucleic-acid (read it carefully) called D.N.A. for short. Our structure is very beautiful.” It goes on to say, “In other words we think we have found the basic copying mechanism by which life comes from life...”

Biologists knew that DNA was an important molecule, and for several years in the late 1940s and 1950s there was a great race to work out the structure of the molecule.

The molecule they described is shown here. It is a long spiral molecule called a helix. Since it has two strands in the spiral it is called a double helix. On the outside of the molecule are two strands called the backbone, which run the length of the molecule. Between the backbones are the base pairs, which look like the rungs of a ladder. The whole molecule looks like a twisted ladder.

Your task:

1. Divide yourselves into groups of four.

2. Each group will have two information cards about two different teams of scientists, both working to discover the structure of DNA.
   a. One team was Rosalind Franklin and Maurice Wilkins.
   b. The second team was James Watson and Francis Crick.

3. Read the information sheets, and discuss the work of the scientists in your groups.

4. You need to decide how the teams contributed to the discovery of DNA.

5. Decide what pieces of information show:
   a. how the teams contributed
   b. how the individual teams were held back from making the discovery alone.

6. Use the grid on the next page to help you put the information into different categories.
<table>
<thead>
<tr>
<th>Watson and Crick</th>
<th>Franklin and Wilkins</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>How the teams contributed to an understanding of the structure of DNA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>How the individual teams were held back from understanding the structure of DNA</td>
</tr>
</tbody>
</table>
Rosalind Franklin was also an expert on the technique of X-ray diffraction. She and Maurice Wilkins were to lead a team working on the structure of DNA.

In 1950 Wilkins worked out how to make threads of DNA that he could use in his X-ray technique.

In 1951 Rosalind Franklin arrived at King’s College London to work with Maurice Wilkins on the structure of DNA.

Maurice Wilkins worked at King’s College in London. He was an expert on the technique called X-ray diffraction. This was the experiment that gave most of the results used to work out the structure of DNA.

Rosalind Franklin had excellent experimental skills, and she produced high-quality photographs from which she could collect data to show the structure of DNA. She produced the key photograph in 1952.

Franklin interpreted her early data but refused to use it to build a model of the DNA molecule. This frustrated Wilkins.

In 1951 Wilkins thought the structure of DNA might be a helix, and Rosalind confirmed it.

Franklin and Wilkins did not get on well together. They did not communicate well with each other.

Wilkins thought the structure of DNA might be a helix, and Rosalind confirmed it.

Rosalind Franklin 1920–1958

Maurice Wilkins 1916–2004
Watson and Crick were fascinated with working out the structure of DNA. This was one of the key pieces of work in biology at the time.

In 1962 James Watson, Francis Crick, and Maurice Wilkins won the Nobel Prize for discovering the structure of DNA. Rosalind Franklin could not be awarded the prize as she died in 1958.

Francis Crick worked in Cambridge in the 1950s, and learnt about the theory of X-ray diffraction. In 1951 the American biologist James Watson came to Cambridge and joined Crick.

They knew that Wilkins and Franklin didn't work well together. They felt that they had the chance to have a second attempt to build a model of DNA.

Watson and Crick did not do any real experimental work on DNA. They favored building models.

Watson and Crick used data from Franklin and Wilkins and other scientists to build a successful model of DNA in February 1953. They published the model in April 1953, before Franklin and Wilkins.

Watson and Crick were shown an important X-ray photograph of Franklin's taken in 1952. This was done without her knowledge. This photograph provided vital evidence that allowed them to produce the correct model for DNA.

Franklin corrected errors in an initial model they built. She knew that the backbone was on the outside of the molecule.
D.I.Y. DNA

James Watson and Francis Crick worked out the structure of DNA by building models. They cut the shapes of the molecules out of card and put them together to build the molecule. The aim of this task is to build your own molecule of DNA.

1. Cut out the base pairs along the dotted lines.
2. Pierce small holes where indicated by the small cross. These are at the two ends of the base pairs.
3. The holes should have string or ribbon threaded through to act as the backbone.
4. Now twist the molecule using the string or ribbon on either side of the DNA strand.
**What’s inside?**

<table>
<thead>
<tr>
<th>Learning objectives strands 2–5</th>
<th>Learning objectives: strand 1 (HSW)</th>
<th>PLTS</th>
<th>APP</th>
</tr>
</thead>
</table>
| • Pupils should make links between areas of science.  
• Pupils should know that magnets attract magnetic materials. | • Plan and carry out practical and investigative activities.  
• Use a range of scientific methods and techniques to develop and test ideas. | • Creative thinkers: deduce what is hidden inside a container.  
• Independent enquirers: decide how to gather and interpret information. | • AF2 – Understanding the applications and implications of science  
• AF4 – Using investigative approaches  
• AF5 – Working critically with evidence |

**Starter**

- **What is in the tin?** Pupils are given a food tin with no label on it. They try to decide what is in the tin, for example, by shaking it, rolling it, lifting it, and by comparing it with familiar food tins.

- **Tracks** Pupils describe what they can tell from footprints on a muddy path. They explain what they can deduce in detail.

**Differentiation**

**Help**

- Provide pupils with a list of actions to try, or give a list of the possible foods for pupils to match.

**Extension**

- Some pupils may be able to explain how to tell speed, direction, how long ago the track was made, and the size or gender of a person.

**Resources**

- **Teacher and Technician Notes**
  - Supply a variety of sealed tins, for example, soup, tomatoes, and tuna. Alternatively, use opaque containers that can be sealed and put objects inside, for example, one or more beads, a lump of plasticine, crumpled paper, or water.

**Main**

- **What’s inside?** Pupils make a testing platform from card to carry out an experiment. Small magnets and/or non-magnetic blocks are concealed. Glass balls and ball bearings roll through the region. Pupils deduce what was inside the hidden region based on their results from the experiment.

**Differentiation**

**Help**

- Set the experiment up without concealing what is inside and ask pupils to record results. Then try with hiding a very simple structure, for example, a single magnet.

**Extension**

- Pupils set up all the equipment themselves. Pupils attempt extension questions on Activity sheet 2, including giving more detailed explanations to their answers.

**Resources**

- **Teacher and Technician Notes**
  - **Activity sheet 1**  
  - **Activity sheet 2**  
  - Practical equipment as described in Teacher and Technician Notes
### What’s inside?

#### LESSON PLAN

<table>
<thead>
<tr>
<th>Plenary</th>
<th>Differentiation</th>
<th>Resources</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Discuss results from each group and how reproducible the tests were. Ask for suggestions on other ways to test the structure inside the hidden region. - Show images of X-rays. Ask pupils for similarities between X-rays and their experiment.</td>
<td>- Help - Make suggestions for improvements and ask pupils to vote on each suggestion. - Extend - Identify limitations quantitatively, for example, in 90% of tests we could tell between magnets and non-magnets. - Compare other ways to investigate inside the body, for example, ultrasound, endoscope.</td>
<td>- Images of X-rays (from the Internet)</td>
</tr>
</tbody>
</table>

#### Homework

- **Famous scientists** Pupils write a short biography of one of the scientists who used X-ray crystallography. For example, Dorothy Hodgkin used X-ray crystallography to investigate proteins; Rosalind Franklin took and analysed the X-ray photographs used to determine the structure of DNA; James Watson, Francis Crick, and Maurice Wilkins won the Nobel Prize for describing the structure of DNA.

#### 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>
<tbody>
<tr>
<td>- Pupils know magnets attract magnetic materials but not glass balls. - Pupils know ball bearings and glass balls deflect from non-magnets. - Pupils make and record observations.</td>
<td>- Pupils know ball bearings are trapped by magnets but glass balls are not. - Pupils know fewer ball bearings than glass balls come through if a magnet is in the hidden region. - Pupils plan a fair test to test a prediction.</td>
<td>- Pupils tell if magnets or non-magnets are inside the hidden region. - Pupils explain why some ball bearings travel through if a magnet is inside, and some glass balls may not travel through.</td>
<td>- Pupils use results to predict arrangements of magnets and non-magnets inside the hidden region. - Pupils compare how accurate their prediction is with the actual arrangement.</td>
<td>- Pupils explain their prediction using scientific knowledge and understanding. - Pupils evaluate their experiment suggesting improvements.</td>
</tr>
</tbody>
</table>
The experiment allows pupils to carry out tests on a structure they can describe, and repeat the tests on a hidden structure. They compare their results to work out what the hidden structure is.

<table>
<thead>
<tr>
<th>Equipment required per group:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Starter</strong></td>
</tr>
<tr>
<td>• Supply a variety of sealed food tins with no labels on, for example, tinned vegetable soup, tomatoes, tuna. Otherwise use opaque containers that can be sealed with objects inside, for example, one or more beads, a lump of plasticine, crumpled paper, or water.</td>
</tr>
<tr>
<td><strong>Main</strong></td>
</tr>
<tr>
<td>• <strong>Activity sheet 1</strong> Testing platform template copied onto card</td>
</tr>
<tr>
<td>• <strong>Activity sheet 2</strong></td>
</tr>
<tr>
<td>• Strip of card, 8 cm × 11 cm (large enough to rest on side barriers and cover the hidden zone)</td>
</tr>
<tr>
<td>• Scissors</td>
</tr>
<tr>
<td>• Sellotape</td>
</tr>
<tr>
<td>• 10 glass balls the same size as the ball bearings</td>
</tr>
<tr>
<td>• 10 ball bearings about 0.5 cm across</td>
</tr>
<tr>
<td>• 2 small magnets (e.g., 2 cm long)</td>
</tr>
<tr>
<td>• 2 non-magnetic blocks a similar size to the magnets (e.g., Lego, wooden blocks, dice)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Health and Safety notes:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Take care to not slip on ball bearings or glass balls. Make sure that the testing platforms have no gaps and that pupils promptly pick up any balls that roll away.</td>
</tr>
</tbody>
</table>

**Starter**

1. **What is in the tin?** Pupils are given a food tin with no label on it. They try to decide what is in the tin, for example, by shaking it, rolling it, lifting it, and comparing it with familiar food tins. Alternatively, use opaque containers that can be sealed. Put objects inside, for example, one or more beads, a lump of plasticine, crumpled paper, or water. Question pupils carefully to follow their reasoning – even if they say they have guessed, it will be based on some information they have detected. Link this with work scientists do to determine unknown quantities by using patterns they recognise from familiar situations.

2. **Tracks** Pupils describe what they could tell from footprints on a muddy path. They should explain their reasoning in detail, for example, shoe size indicates age and gender of a person; direction and spacing of tracks determines the speed and direction of travel. Tracks in dried mud are likely to be older than tracks in wet mud. Link this with work scientists do to determine unknown quantities by using patterns they recognise from familiar situations.

**Main**

1. **What’s inside?** In the experiment, pupils deduce a hidden structure using evidence from familiar situations. They set up and analyse data from familiar situations before carrying out tests on a hidden arrangement. Pupils find glass balls and ball bearings behave in a similar way if they roll towards a non-magnetic block. If the block is magnetic, all the glass balls will pass over the magnets undeflected and reach the bottom of the testing platform. Some of the ball bearings will deflect and reach the bottom of the testing platform. Pupils can deduce if there are two hidden objects as these take up more space so the glass balls...
What’s inside?  

TEACHER AND TECHNICIAN NOTES

are more likely to deflect than pass through. If the hidden objects are magnets, most ball bearings remain in the hidden zone, stuck to the magnet. If the objects are non-magnetic then the ball bearings can pass through the hidden zone undeflected. By taking several sets of measurements with arrangements they can see, pupils should build up a database of results to compare when they test the unknown arrangements. Finally pupils test hidden arrangements. These need to be simple, limited to two objects. Pupils should apply their previous findings to these results to suggest a possible arrangement within the hidden zone.

Answers

1. If a magnet is present, all glass balls are unaffected and pass straight through the hidden zone. Only some of the ball bearings will pass through: some will be attracted to the magnet and change path on their way through the hidden zone; some will stick to the magnet. If a non-magnetic block is present, ball bearings and glass balls behave in a similar way: all of them should pass straight through the hidden zone.

2. If the magnet or block is at one side of the hidden zone, ball bearings and glass balls coming down the ramp on one side will be more affected compared to those on the other side. If the magnet or block is further from the ramp, fewer balls will change path.

3. Pupils describe the arrangements of the other group’s set-ups using their own results.

4. Pupils explain whether or not they detected the arrangement correctly.

5. Pupils describe the arrangements they set up for the other group.

6. Pupils explain whether or not the other group detected their arrangement correctly.

Extension

Answers should describe how results from known arrangements were used to determine an unknown arrangement. If scientists can describe the pattern of several crystal arrangements, for example, they can look at the pattern from the unknown material and decide which structure it is most similar to.

Plenary

1. Suitable comments are that tests are more reproducible if pupils control variables carefully, for example, the height from which the balls are released. They should also use the full width of the ramp and repeat readings several times as random variables do crop up. Taking a large number of results is better to identify trends – this includes the tests on the hidden object. Other tests depend on the pupils’ suggestions – encourage pupils to think widely, for example, shining a torch through and looking at the shadows.

2. X-rays show hidden structures inside the body and the experiment showed hidden arrangements.
Scientists often have to work out hidden structures by carrying out tests and using the results obtained. In this experiment, you will investigate how different arrangements of magnets and blocks affect the movement of ball bearings and glass balls. Then you will apply this knowledge to work out hidden arrangements of magnets and blocks.

Safety

Make sure the ball bearings and glass balls remain inside the testing platform. Pick up any that roll away.

Equipment and materials

For this experiment, you will need:

- Activity sheet 1 (the testing platform template)
- strip of card, 8 cm × 11 cm
- scissors
- sellotape
- 10 glass balls
- 10 ball bearings
- 2 magnets
- 2 blocks

Method

Making the testing platform:

1. Cut the solid lines and remove the shaded sections on the testing platform template.
2. Fold the dashed lines. All sections fold up except the one that supports the ramp.
3. Use sellotape to join the corners of the testing platform.

Investigating how magnets and blocks affect ball bearings and glass balls:

4. Place a magnet in the middle of the hidden zone.
5. Roll 10 glass balls down the ramp. Make sure they roll from the top of the ramp, and are evenly spread across the ramp. You may want to repeat readings.
6. Repeat Steps 4 and 5 with 10 ball bearings.
7. Replace the magnet with a block.
8. Repeat Steps 6 and 7.
9. Look for patterns you can use to decide if there is a hidden magnet or block.
10. Now make a hidden arrangement, using two hidden objects, for another group to guess.

Detecting arrangements

11. Using another group’s set-up, repeat Steps 4, 5, and 6, filling in the results table as you go.
12. Use your results to work out what combination of hidden objects is present.
## What's inside?

### Results

<table>
<thead>
<tr>
<th>Glass balls</th>
<th>Ball bearings</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>How many stay in the hidden zone?</strong></td>
<td><strong>How many stay in the hidden zone?</strong></td>
</tr>
<tr>
<td><strong>How many do not change path through the hidden zone?</strong></td>
<td><strong>How many do not change path through the hidden zone?</strong></td>
</tr>
<tr>
<td><strong>How many change path through the hidden zone?</strong></td>
<td><strong>How many change path through the hidden zone?</strong></td>
</tr>
</tbody>
</table>

### Conclusion

The hidden structure consists of _______ magnets and _______ blocks.

### Questions

Use your results to help with your answers.

1. Explain how you can detect if a magnet or a block is in the hidden zone.
2. Explain how you can detect where the magnet or block is placed in the hidden zone.
3. Describe the arrangement the other group set-up, and your results.
4. Did you detect the arrangement correctly? Explain your answer.
5. Describe the arrangement you set up for another group, and their results.
6. Did they detect the arrangement correctly? Explain your answer.

### Extension

Scientists often need to use measurements to work out a hidden structure. Use ideas from your experiment to explain why it is important that scientists investigate structures they can already describe before trying to work out an unknown structure.