DNA

Learning Objectives:

- Understand that x-rays can be used to image molecules;
- Understand that cells contain DNA;
- Understand that molecules are made of atoms;
- Build on the idea that we see things when light travels from an object, or reflects off it, into our eyes.

Science Skills:

- Making detailed observations and comparisons, taking note of patterns;
- Exploring and talking about ideas;
- Encountering more abstract scientific ideas and begin to recognise how these ideas help to understand and predict how the world operates;
- Recognising how scientists learn and make small steps towards new scientific ideas over time;
- Using equipment and following practical instructions with accuracy and precision;
- Planning adaptions and/or improvements to a practical method;
- Gaining new scientific vocabulary.

Resources:

- Rosalind Franklin DNA Powerpoint
- Pens and paper
- Scissors (or guillotine)
- Cardboard or sheet metal (that can be cut with scissors) x 2 colours
- Ruler
- Double sided sticky tape or glue
- 2 x paperclips or rubber bands
- A stick
- You may also like: a hook
- Caesar wheel template worksheets
- A split pin

What you should know before you start - *See Slide 1 of the DNA Powerpoint*

X-rays

We see things when light travels from an object, or reflects off it, into our eyes. **Molecules** are made up of lots of atoms bonded together. **Molecules** are too small to see with our eyes, or even a microscope. But we can see them with **x-rays** so long as the molecules are set into a hard crystal.

DNA

If you look under a microscope, you'll see that every bit of our bodies is made up of cells, like tiny bricks, that stack together to make our skin, our teeth, our hair – and everything inside us. Inside those cells is a **molecule** called **DNA**. **DNA** stores information about how to make us: the colour and shape and placement of our skin, teeth, hair, and everything inside us. The shape of the **DNA molecule** is a **double helix** – a twisted ladder, like a wind spinner.

QUICKSTARTER – X-ray imaging

Ask:

- What do you know about x-rays?
- Which of these are x-ray pictures?

Introduce them to the three pictures on *Slide 2*. All of these are x-ray images, but one is a medical picture of bones, and the others are scatter patterns from molecules. The first image is Photo 51, Rosalind Franklin's photograph of DNA. Scientists use a bit of maths and a bit of guesswork to turn scatter patterns into pictures of molecules. Can you see the patterns?

Photo 51: https://en.wikipedia.org/wiki/File:Photo_51_x-ray_diffraction_image.jpg
First medical x-ray: https://commons.wikimedia.org/wiki/File:First_medical_X-ray_by_Wilhelm_R%C3%B6ntgen_of_his_wife_Anna_Bertha_Ludwig%27s_hand_-_18951222.jpg
Protein scattering pattern: https://en.wikipedia.org/wiki/X-ray_scattering_techniques#/media/File:X-ray_diffraction_pattern_3clpro.jpg

Rosalind Franklin's story *[See Photos on Slide 2]*
Listen to the story about Rosalind Franklin, make a timeline of her life, draw her in her laboratory, create a costume, or build a piece of her equipment.

In July 1920, a girl called Rosalind Franklin was born, who enjoyed doing arithmetic for fun. She liked to keep her feelings to herself, and some people thought she was scary because she could hold their eye for a long time. Although Jewish, she was agnostic, declaring "science and everyday life cannot and should not be separated!"

She studied physics and chemistry at St Paul's Girls' School in London (which few girls were allowed to do), and enjoyed trekking in France where she thought the lifestyle "vastly superior"! She didn't enjoy music, and was so bad at it that her teacher actually called in her mother to delicately inquire whether Rosalind had impaired hearing.

Later, she studied natural sciences at Cambridge University. At the time, they didn't give degrees to women, but they would just six years later, and Rosalind claimed a "retrospective" qualification whilst fearlessly volunteering as a WWII Air Raid Warden and researching the holes in coal for her doctorate (or PhD).

Using her French connections, Rosalind was able to wangle herself a research job in Paris, where she was taught how to set molecules into crystals, how to take x-ray pictures, and how to interpret them. Back in London, she was appointed to solve the structure of DNA (the molecule that codes how we look and behave) with x-rays and supervise a student.

What Rosalind didn't know was that no one had told Maurice Wilkins, the student's old supervisor. She built on Wilkins' work, making a better x-ray tube and camera. Her experimental skills let her make incredible never-before crystals of the difficult DNA molecule. You can imagine the rumpus when Wilkins found out!

Jealous, Wilkins went behind Rosalind's back and gave photo 51 ("amongst the most beautiful X-ray photographs of any substance ever taken") to Watson and Crick – two other scientists trying to solve the structure of DNA. Using it, they built a model of the double helix. Rosalind was not impressed. In her opinion, it was too early to come to conclusions, because she and her student had found two types of DNA: wet and dry. Which was the true one?

Rosalind decided it was better to walk away with dignity – and go to Birkbeck College to work on polio.

Whilst there, Rosalind discovered a mysterious bulge in her abdomen. Her friend remarked, "You're not pregnant?", to which she responded, "I wish I were." She was diagnosed with ovarian cancer, operated on, and two tumours removed – but to no avail. Ever unemotional, Rosalind returned to work, publishing 13 papers, before dying in 1958, aged, 37.

Watson and Crick finished their model of DNA, gaining the 1962 Nobel Prize. Rosalind never gained credit. Her work on polio went on to win another Nobel Prize.

MAIN TASK – DNA wind spinner

Ask:

- What is a double helix?

Look carefully at the pictures on *Slide 3*

Double helix:
https://www.needpix.com/photo/1123115/gene-outline-dna-icon-dna-icon-double-helix-genetic-genetics
DNA:
https://en.wikipedia.org/wiki/Nucleic_acid_double_helix#/media/File:Double_stranded_DNA_with_coloured_bases.png

Ask:

- How does a wind spinner work?

Look at the picture of a wind spinner on *Slide 4*, and discuss how it is affected by the wind and why it creates an illusion as it turns.

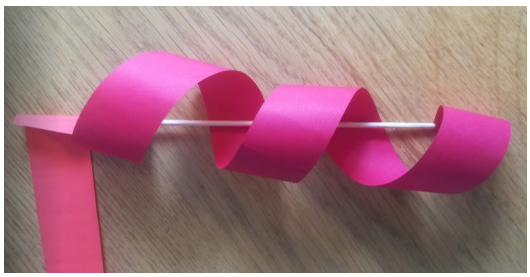
Wind spinner: https://www.windandweather.com/p/56443?aff=7593 (not a free image)

Instructions *See Slide 5*

1. Cut two long strips of cardboard in two different colours, using a ruler to make sure your line is straight. To make extra long strips, stick strips together using double-sided sticky tape or glue (alternatively, thin sheet metal, folded foil, or foil-backed paper provides a robust material that can be rolled by hand and is durable outdoors).

2. To introduce curl, wrap round a finger (or somebody else's!), and secure with a paperclip/rubber band.

3. Release the paperclip and extend your helices. Use double sided sticky tape or glue to attach them to a stick, wrap round and attach at the other end.



Wrap up
Ask:

- Think about the method you have used to make a DNA wind spinner, and imagine you are a scientist in a lab. How could you modify the method to make something similar but different? Perhaps you could make the same shape another way, or another shape with a similar method.

EXTENSION ACTIVITY – making a Caesar Wheel
Crystallographers crack atomic "codes" using a bit of a maths and a bit of guesswork to transform their x-ray map into a 3D picture of the atoms.

To make your own code, cut out the two wheels from the *Caesar Wheel Worksheet* [*Slide 6*] and fill in the alphabet on the big wheel in alphabetical order. On the small wheel, write the alphabet (or anything else!) in the boxes round the edge, in a random order. Use a split pin to join the two wheels through the centres.

REVIEW

ALL: Can recall that x-rays are used to picture things too small to see with light and that DNA is a double helix shape. Can tell part of Rosalind Franklin's story of discovery.
MOST: Can identify DNA as a molecule found in cells. Can identify that x-ray images need decoding.
SOME: Can link the pattern produced by x-ray imaging to a visual code.