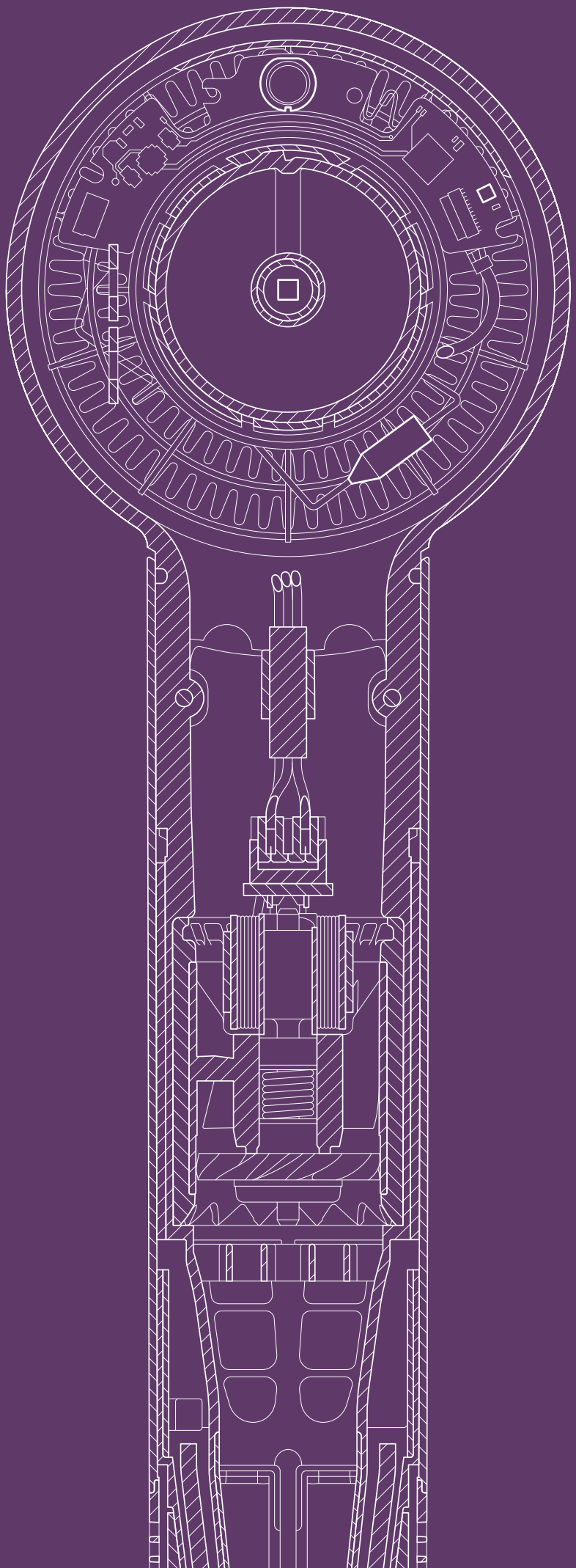
THE JAMES DYSON FOUNDATION

TEACHER'S PACK

Key stage 3 and 4
Engineering solutions:
Hair science



CONTENTS

You can find all the videos on our website:
jamesdysonfoundation.co.uk

INTRODUCTION

Engineering is vital to our everyday lives – from essentials like running water and transport to mobile phones, the internet and household appliances. There are many different types of engineers, who all hold diverse skills and who all love to solve problems. Dyson has been applying engineering and science principles to the beauty industry for years – designing, testing and iterating technology to ensure hair can be protected when styling.

For Dyson engineers to design the best products, they need to understand all things 'hair'. This includes different hair types, knowing what makes hair healthy, what causes it to become damaged, as well as understanding that hair can reflect our identity, personality and beliefs.

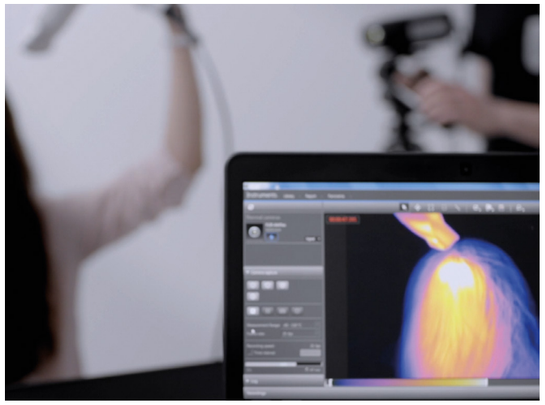
If you follow the lesson plans provided, students will:
Understand what hair science is and the role engineers play within it.
Learn about the structure, composition and fibre structure of hair.
Gain a broader understanding of different hair types.
Use investigative and analytical skills to better understand causes of hair damage and the wider impact of this.
Understand how engineers use hair science to create new technologies to provide solutions to users.
Use an understanding of the iterative design process to design a new hair styling solution.

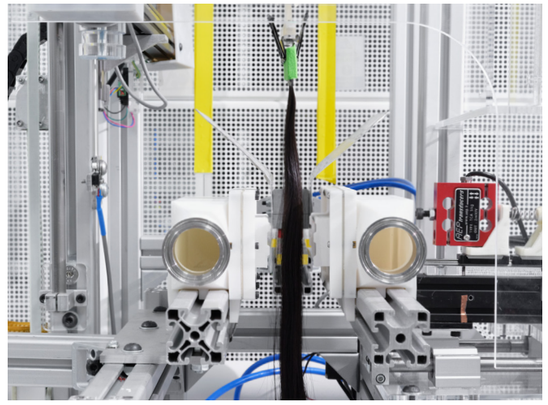
Please note each lesson ranges from 80–90 minutes. These lessons can be adapted to suit different timetables. For example, the starter or wrap-up activities can be omitted to reduce each session to 60 minutes. It is also possible to teach each section in isolation if time is limited.

This resource contains lesson plans, supporting presentation decks and videos. This teacher's pack contains summary information for you, explaining how the lessons relate to Dyson's technology and their hair science research. Please familiarise yourself with this information before you start teaching.

This pack was designed to complement the Science, Design and Technology and Mathematics curriculum for Key Stage 3 and 4.

You can find the videos, posters and presentation decks on our website: **www.jamesdysonfoundation.co.uk**

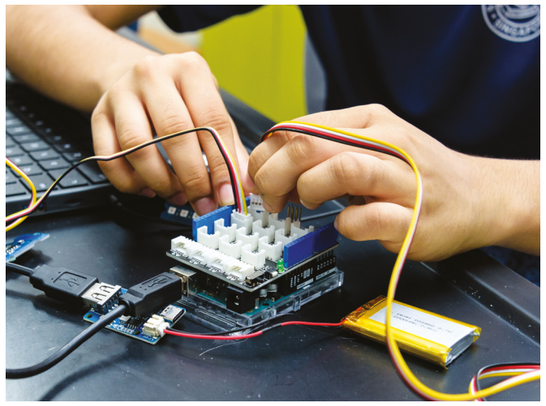


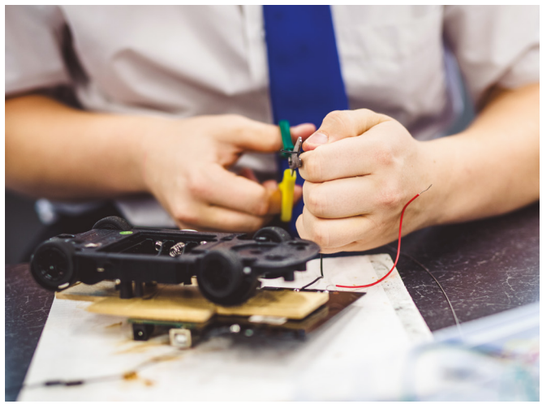


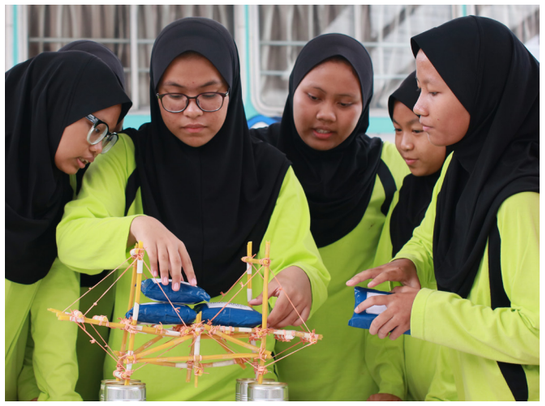
The James Dyson Foundation is Dyson's registered charity. Set up in 2002, it exists to inspire the next generation of engineers through educational resources, workshops, and an international design competition.

"Young engineers have the passion, awareness, and intelligence to solve some of the world's biggest problems. I set up the James Dyson Foundation to inspire the next generation of engineers with hands-on learning and experimentation, helping them to connect the theory they learn in the classroom with exciting and important engineering problems and solutions in the outside world."

James Dyson







SECTION 01
ENGINEERING AND HAIR SCIENCE

Students will learn about how engineering and science principles are applied to the beauty industry and understand the breadth of engineers involved in the development of Dyson's hair care technology.

BEAUTY TECHNOLOGY AT DYSON

2016
Dyson Supersonic™ hair dryer

The hair dryer reinvented. The Dyson digital motor V9 mounted in the handle creates powerful airflow to dry hair quickly. Intelligent heat control measures and regulates air temperature up to 20 times a second, to protect hair from extreme heat damage.

2018
Dyson Airwrap™ multi-styler

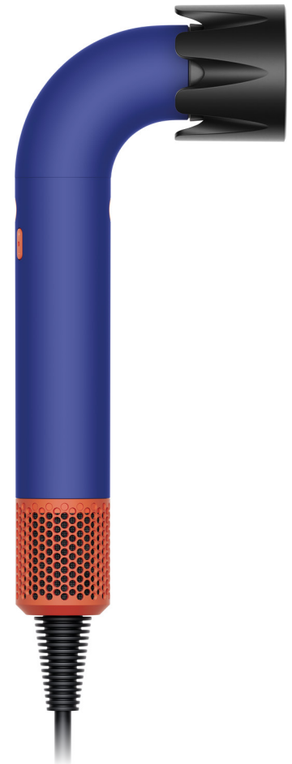
Combining the powerful Dyson digital motor with aerodynamics, the Dyson Airwrap™ styler uses the Coanda effect to style hair without extreme heat. A spinning vortex of air around the barrel gently attracts, wraps and curls hair.

2020
Dyson Corrale™ straightener

The Dyson Corrale™ straightener has flexing manganese copper alloy plates. They shape to gather hair neatly together, producing enhanced styling with less heat. Its 4-cell lithium-ion battery enables cordfree versatility with corded thermal performance.

2023
Dyson Airstrait™ straightener

A new way to straighten hair, from wet to dry with air, without hot plates with no heat damage. Equipped with precise directional high-pressure airflow projected downwards at a 45° angle, it creates the tension needed to align hair for a smooth end style with a natural straight finish.



2024
Dyson Supersonic r™ professional hair dryer

Dyson's lightest, smallest, and most precise styling tool. The Dyson Supersonic r™ has a technology streamlined heater, the Dyson Hyperdymium™ motor and intelligent Radio Frequency Identification sensors in each attachment which communicate with the hair dryer, automatically adjusting the motor and heater to deliver optimal airflow and temperature.

2024
Dyson Supersonic nural™ hair dryer

The Supersonic Nural™ is our most intelligent hair dryer for healthier scalp and hair. It has smart and automatic Nural™ sensor technology to protect scalp health and enhance hair's natural shine. New and improved attachments are equipped with attachment recognition, for fast healthy drying with no extreme heat.

MEET THE ENGINEERS

Engineering isn't all about maths and physics. These subjects weren't my strong suit and it wasn't until I got to university that I realised there was a course that complemented my need to understand how things worked but also my passion for art and design. Product Design is a combination of engineering, art and design, and making things that people want.

Jacob Parmenter
Senior Concept Engineer

My father works in kitchen design and my mother is an artist, so growing up I had an inherent love for art and design. However, I've always had a fascination for how things work.

A concept engineer is similar to a design engineer but we're very focused on the user of a product. We'll take market and user insights to identify a problem and then try to solve that problem with a physical solution, bringing different concepts to life.

I'm really lucky to work with a variety of teams, such as the Competitive Insights and Market Insights teams, as well as the Technical teams which are working on highly advanced solutions which I have to understand and turn into realistic concepts. We will spend the day sketching, mindmapping, and prototyping to create a huge number of concepts before determining which one solves the problem best.

When I was younger, I never imagined I'd be working with hair dryers and hair straighteners but it has been one of the most exciting things I've ever done. I'm really lucky that I get to work with such amazing people!

If you're thinking about a career in engineering, go for it. It's one of those areas that's so broad and evolving very quickly. The most exciting thing about engineering is that it's people-centric, so if you like making a change and impacting people's lives, it's a very easy way to do that.

Nathalie Moore
Category Development Engineer

A Category Development Engineer will take a consumer segment, such as a professional hairdresser, and understand as much about this consumer segment as we can. We will then advocate for them in the product development process to ensure their needs are met.

No day is the same because the problems you tackle every day are really different so your approach is always different. Some days, I might be presenting insights that I've been putting together but other days I may be in the lab, putting prototypes together or assembling things that tell a product's story.

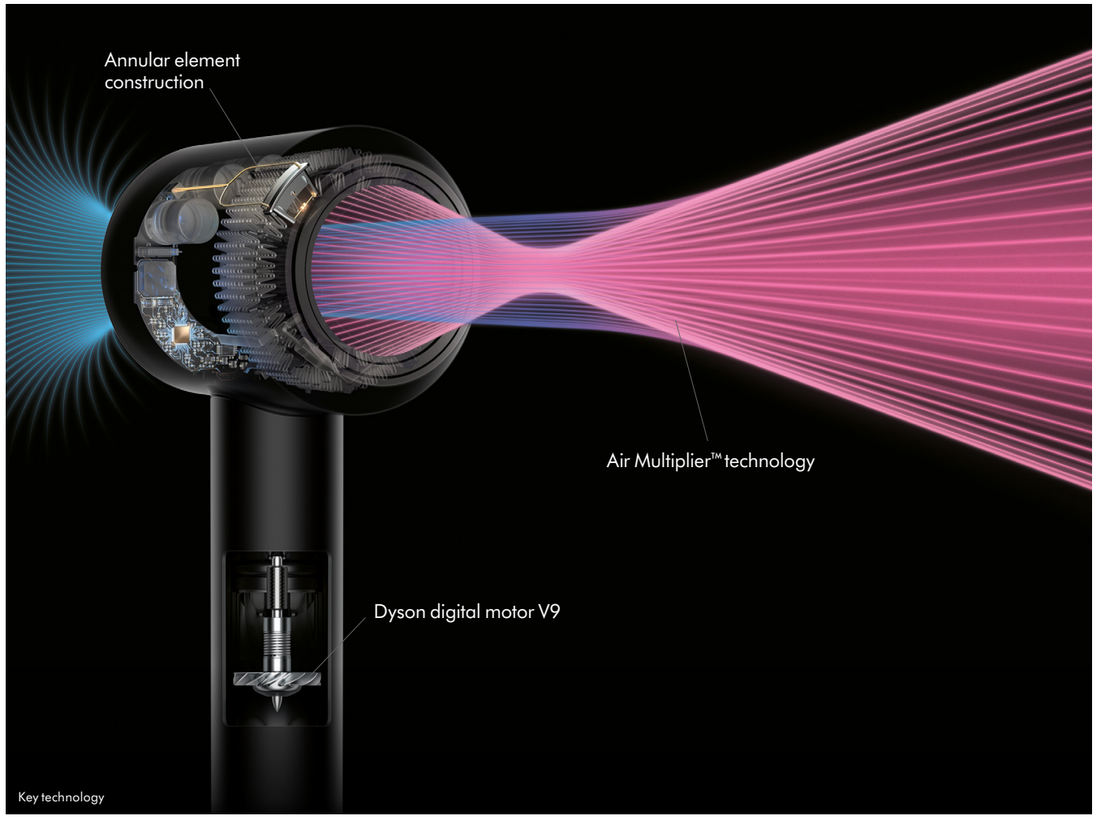
I work with a lot of different engineers. For example, I work closely with the quality and satisfaction engineers after products have been launched. This team will evaluate the consumer segment feedback and implement those changes into future products.

I just love the idea of engineering pushing those boundaries – being told that something can't happen is such a big motivator to do more – and it can also be really creative!

DYSON SUPERSONIC™ HAIR DRYER

The Dyson Supersonic™ hair dryer challenges conventional hair dryer design which tends to be bulky and cause heat damage. Dyson engineers achieved this using the Dyson Digital Motor V9 and Air Multiplier™ technology. It is an example of the pioneering approach of Dyson engineers who use the iterative design process to develop better technology and challenge the norm.

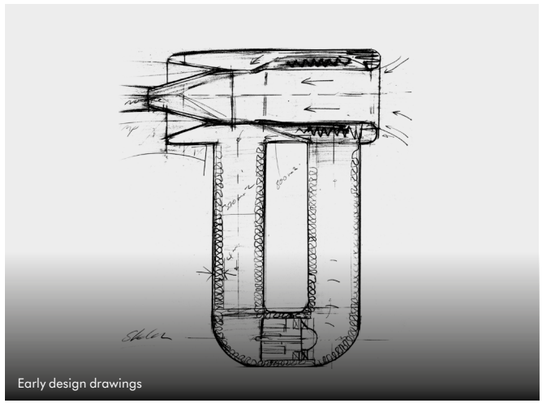
Using these technologies air is drawn into the Supersonic™ by the motor, creating a jet of air that passes over a ramp to channel its direction. Surrounding air is drawn into the airflow (this is called inducement and entrainment). The result is that the volume of air coming out of the hair dryer is three times that going into the motor. This system is called Air Multiplier™ technology.

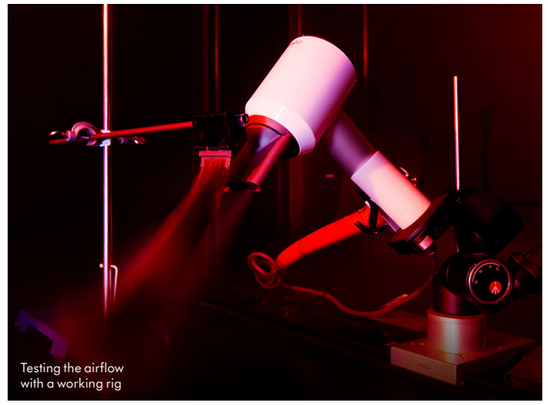


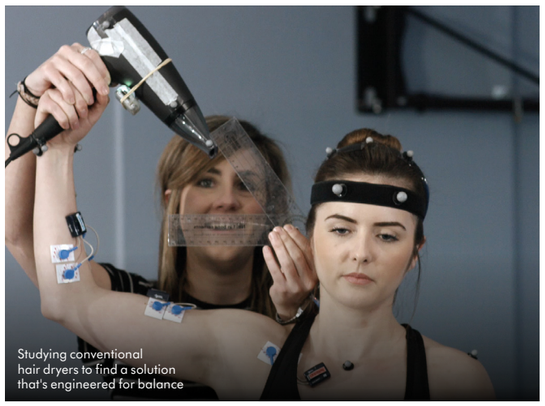
Key technology

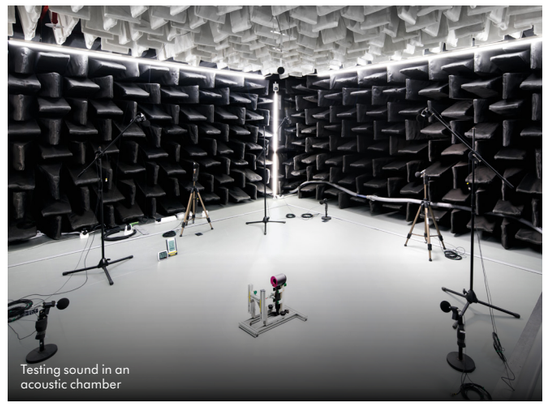
The noise, vibration and air flow within the Dyson Supersonic™ hair dryer were also analysed by several different teams of engineers. This included acoustic engineers, aerodynamic engineers and analysis engineers. Based on their evaluations, the motor was moved to the handle of the machine, surrounded by acoustic silencers to muffle the sound. This allowed the Dyson Supersonic™ hair dryer to remain quiet without compromising on performance.

Moving the motor to the handle, as opposed to it being in the head of most conventional hairdyers, also made the Supersonic lighter and more comfortable use when styling.


Early design drawings


Testing the airflow with a working rig


Studying conventional hair dryers to find a solution that's engineered for balance


Testing sound in an acoustic chamber

It took over five years to develop the Dyson Supersonic™ hair dryer. Dyson engineers built 600 prototypes – and 599 of them were failures. But each one taught them something – how could it be made better.

Initial concept rig

First working rig

A-rig
Initial integrated rig with V9 motor and custom heating element

B-rig
First fully integrated rig with V9 motor, heater and electronics

C-rig
Further iterative developments

Thermal rig
Concept air aimplifier to detail the thermal characteristics

D-rig
Multiple rigs for user trials and testing

E-rig
Fully detailed rigs proving specification

01-rig
Last prototype build prior to tooling and manufacture

First engineering build from plastic components

DYSON AIRWRAP™ MULTI-STYLER

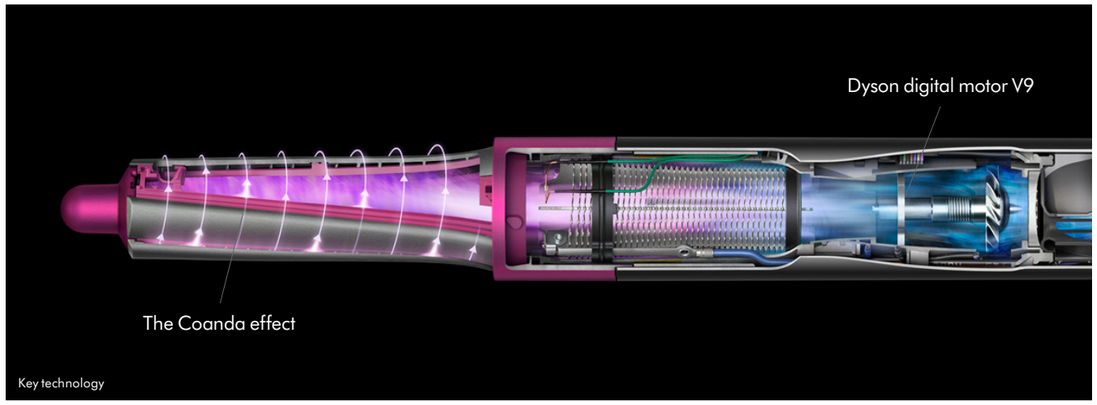
Since the development of the Dyson Supersonic hair dryer, Dyson engineers have used the iterative design process to develop new technologies.

The Dyson Airwrap™ multi-styler was first launched in 2018. The development of this machine took over six years, with Dyson engineers designing and testing nearly 650 prototypes before achieving the final product. The brief specified that it needed to provide a solution to issues that were occurring with other conventional styling products, such as weak airflow and hair tangling. Another important part of the brief was that the machine needed to maintain and enhance the user's hair health.

The Dyson Airwrap™ multi-styler is powered by Dyson's digital motor V9. Inside the motor there is a 13-blade impeller which spins up to 110,000 revolutions per minute, while the Dyson digital motor creates a wind pressure of 3.2kpa, creating the Coanda effect. The Coanda effect occurs when a high-speed jet of air flows across a surface and, due to differences in pressure, the air flow attaches itself to the surface.

Ensuring the Airwrap™ could maintain a strong airflow around a very tight barrel was one of the main challenges. After multiple iterations, the solution was to incorporate six slots along the barrel. Each slot multiplied the air flow which provided a spinning vortex. It took almost 500 prototypes before the barrels were finalised.

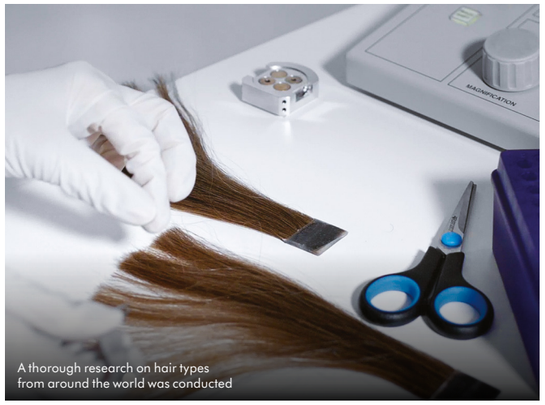
Barrel prototypes of the Dyson Airwrap™



Key technology

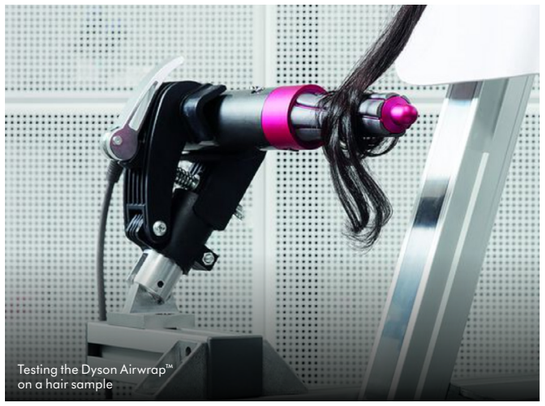
During the development of the Dyson Airwrap™ multi-styler, engineers conducted thorough research to understand different hair types from around the world. Following this research, Dyson engineers were able to utilise a range of technologies for testing prototypes. This included a Scanning Electron Microscope (SEM) which allowed hair strands to be seen at microscopic scale, determining the health of the hair after the use of a prototype. They also measured the strength and elasticity of each hair strand in relation to changes in temperature, providing information on the impact of thermal damage to hair.

To maintain and enhance user's hair health, Dyson engineers added a glass bead thermistor to the Airwrap™. This measures air temperature up to 40 times per second to ensure the air is regulated below 150°C. Anything above this temperature can cause extreme damage to the hair.

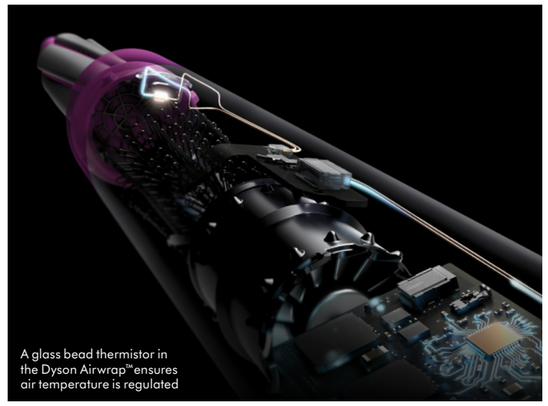


A thorough research on hair types from around the world was conducted

Dyson engineers studied hair strands using SEM technology



Testing the Dyson Airwrap™ on a hair sample



A glass bead thermistor in the Dyson Airwrap™ ensures air temperature is regulated

Dyson Airwrap™ multi-styler

LESSON 01
INTRODUCTION TO ENGINEERING AND HAIR SCIENCE

Duration: 1 hour 30 minutes
Resources: A3 paper, pencils, Lesson 01: Healthy hair presentation deck, Videos: Engineer Profiles, access to a laptop or computer.

Learning objective:

Students will be introduced to the concept of hair science and understand how Dyson engineers have used hair science to inform Dyson technologies. Students will analyse different engineering solutions to hair styling.

Starter: 10 minutes

Activity

Split the class into small groups and provide them with a piece of A3 paper. Display the question 'What is an engineer?' on the board and ask students to note down ideas. After 5-minutes, bring the class back together to share these ideas.

Display the **Lesson 01: Healthy hair presentation deck** and ask the students to decide as a class if the image is displaying a healthy or unhealthy hair. Note these answers down and share the correct answers at the end. Share the **Introduction to Hair Science** video. Discuss anything the students found interesting.

Main activity: 60 minutes

Activity

Explain to the students that Dyson engineers are problem-solvers and have used knowledge of hair science to inform engineering solutions. Explain that lots of different types of engineers are involved in this process and share the following videos.

– **Engineer Profile: Jacob Parmenter, Senior Concept Engineer**
– **Engineer Profile: Nathalie Moore, Category Development Engineer**

Split the class into small groups and ask them to discuss what they found interesting about the videos and what they didn't know before about the role of engineers in hair science. Ask the groups to feed back to the class. You may allocate one video per group for them to focus their discussion on.

Explain that Dyson engineers identified problems with existing hairdryers. Ask the students what they think this could be. This should include:

– Heavy and not user-friendly to handle;
– Weak airflow or slow;
– Not happy with end result;
– Overheating and hair damage.

After identifying these problems Dyson engineers developed the Dyson Supersonic™. Since then Dyson engineers have used their understanding of hair science to develop more technologies to assist with healthy hair styling.

Split the classroom into six groups and allocate them a Dyson product to investigate. This can be one of the following:

– Dyson Supersonic™ hair dryer
– Dyson Airwrap™ multi-styler
– Dyson Corrale™ hair straightener
– Dyson Airstrait™ straightener
– Dyson Supersonic r™ Professional hair dryer
– Dyson Supersonic nural™ hair dryer

Ask them to research how the product supports good hair health and what technologies enable this, challenging them to suggest improvements they could make to the design of the product. Students can research using the internet or using the information provided in this teacher's pack. Come together as a class to discuss the findings. Explain that these series of products is an example of Dyson engineers using the iterative design process to constantly improve upon existing technology and provide better solutions to users.

Wrap up: 20 minutes

Activity

Revisit the student's answers to the 'What is an engineer?' starter activity – ask the students if their understanding of what engineers do has changed over the course of the lesson.

SECTION 02
THE SCIENCE OF HAIR DAMAGE

Students will learn more about hair science, including composition, structure, colour and the growth cycle. Students will conduct tests to understand how bonds work.

WHAT IS 'HAIR TYPE'?

Hair type is the natural shape of a person's hair strand. A person's hair type is based on various factors, including shape, diameter and volume.

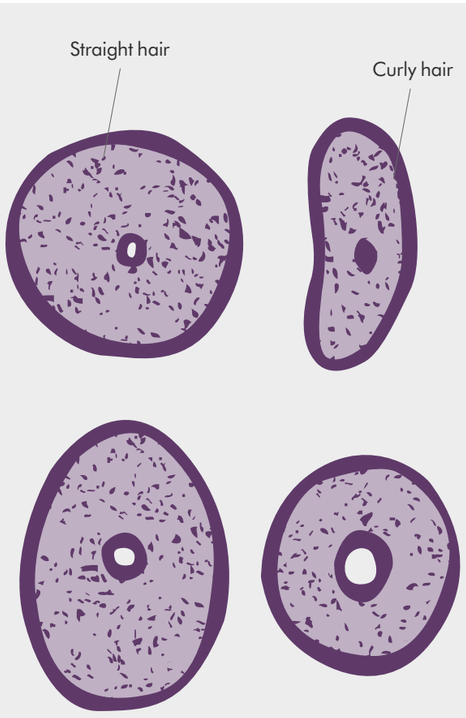
Shape
Hair can vary from straight to tight curls. Straighter hair typically has a rounder cross-sectional area. Curly hair has a flatter, more elliptical or oval shape. Curlier hair can often tangle more easily and is often resistant to being straightened.

Diameter
The diameter of fine hair can be as small as 40 micrometres, with coarse hair being around 120 micrometres. Thicker hair is often harder to style but the style will last longer than finer hair.

Volume
Volume is determined by the thickness of hair and the number of hairs a person has. A high number of finer hairs and a low number of thicker hairs will have the same overall volume.

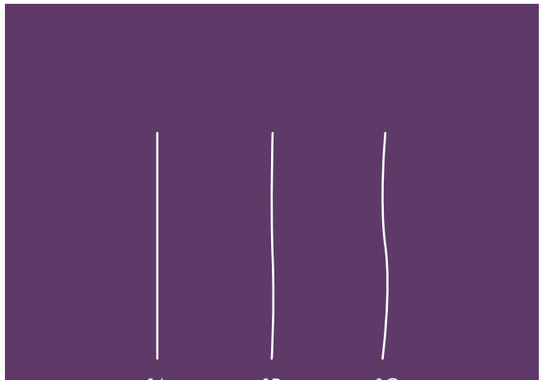
To design and build successful hair care products, Dyson engineers wanted to understand hair types around the world to ensure their designs meet the needs of its users.

This is particularly important for individuals with curly and coily hair as they are faced with unique challenges when styling because existing products often ignore these hair types. Dyson engineers are committed to supporting these users through their research and development. One example of this is the Dyson Diffuser attachment. This tool was re-engineered to disperse air more evenly around curly hair to simulate natural drying, helping to reduce frizz and redefine natural curls and waves.



Cross sections of different hair shapes


The Dyson Diffuser attachment in use

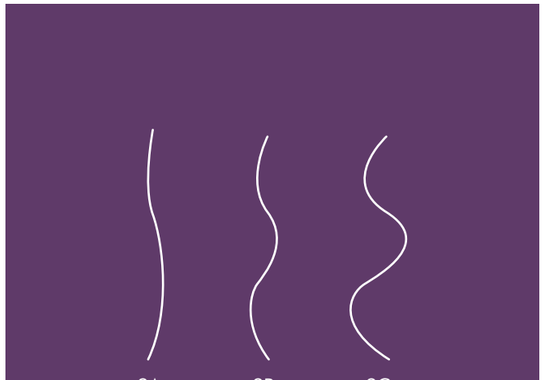


Type 1: Straight

1A. Straight

1B. Straight with a slight wave

1C. Straight with a slight wave and some S-waves

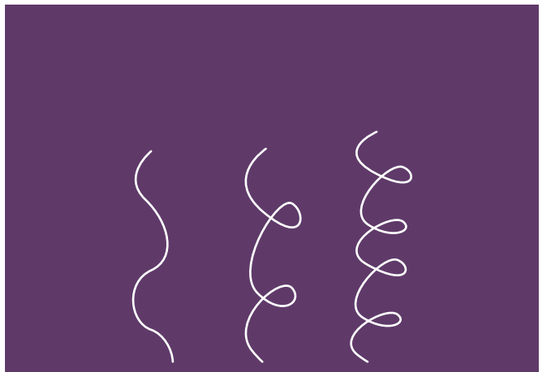


Type 2: Wavy

2A. Loose with stretched S-waves

2B. Shorter more distinct S-waves

2C. Distinct S-waves with some spiral curling

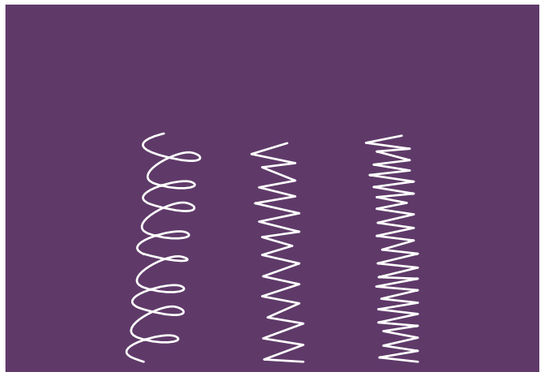


Type 3: Curly

3A. Big loose spiral curls

3B. Bouncy ringlets

3C. Tight corkscrews



Type 4: Very curly to kinky

4A. Tightly coiled curls

4B. Z-pattern, tightly coiled, sharp angled

4C. Mostly Z-pattern, very tightly kinked

HAIR IN CULTURE AND IDENTITY

Our hairstyles and our hair symbolise who we are, indicating social or marital status, religion and other areas of identity. For some, hair can be seen as a sacred gift from nature and is therefore not cut. Others might choose to cover their hair due to their religious beliefs or to protect it and keep it healthy.

Some examples of how hair can represent cultural identity and personal significance are shown on the right.

Braiding

In many African cultures, hair braiding is a traditional art passed down through generations. The patterns and styles signify social status, age, and community ties. In some tribes, the braiding is often reserved only for spiritual individuals.

Red hair

Red hair, occurring in just one to two percent of the population, is the least common of all hair colours. The Netherlands hosts one of the largest redhead-themed celebrations in the world: the annual Roodharigendag ('Redhead Days') festival, attracting thousands of attendees.

Uncut hair for faith

In Sikhism, uncut hair, known as Kesh, is one of the five articles of faith. This symbolises respect for the perfection of God's creation.

Uncut hair for tradition

The world's longest hair belongs to women who are members of China's Red Yao Tribe. Traditionally, they only cut their hair once in their lifetime at age 18 – some can grow hair up to six feet long!

Long hair

In Native American cultures, long hair is often seen as a source of strength, wisdom, pride and a reflection of identity.

Wig

The ancient Egyptians created the wig to shield shaved, hairless heads from the sun.

Locs

In Rastafarianism, locs are worn to represent a spiritual journey and a connection to African heritage and roots.

Religious head covering

In Catholicism, nuns wear a head covering known as a veil to symbolise their commitment to God and to show their separation from the secular world.

Head covering

In Islam, some women choose to wear a head covering to demonstrate modesty. Typically, Muslim women who do choose to cover their hair do so in public and reserve the privilege of showing their hair to close family members, other Muslim women, and sometimes non-Muslim women depending on their belief.

HAIR COMPOSITION AND STRUCTURE

The three key components of hair

Protein
a-keratin is a long, fibrous protein made up of amino acids that gives hair its shape and structural properties. Keratin is also found in the nails and skin. Hair will, on average, be made up of 79% a-keratin. a-keratin fibres are less than 2 nanometres (nm) wide and 45nm long. Billions of these proteins combine to form a single strand of hair. The fibres then combine to form larger cortex cell structures, each around 1–6 microns (µm) thick and 50–100µm long.

The fibres and structures are held together by a matrix that acts like a glue, culminating in a strand of hair that is protected by the cuticle layer. The shape of keratin is similar to a spring, which allows hair to stretch slightly with minimal damage. When stretched too far, it changes permanently to β-keratin, which is weaker and less elastic, making the hair easier to break.

Water
Hair naturally contains 'bound' water but the amount depends on the humidity of the environment. The more humid an environment, the more water there will be. When there is an excess of 'free' water, hair is considered wet. On average, hair is made-up of 17% water.

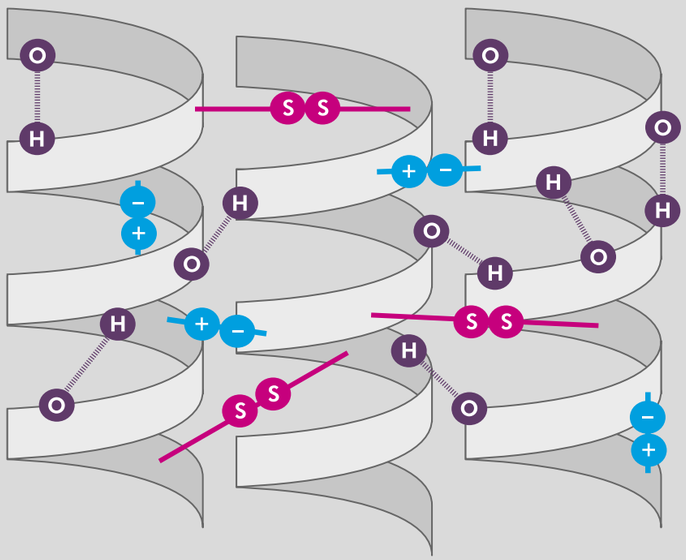
Fats and oils
These are present in hair to act as a glue to help hold the structure and make it water repellent. The amount produced can be affected by numerous factors, including climate changes and how frequently hair is washed. On average, hair will be made-up of 4% fats and oils.

What gives keratin its shape?

Disulphide bonds
These are strong, permanent bonds that give hair most of its strength. They are only disrupted by very high temperatures and chemical treatments. These bonds form between the cysteine amino acids found within keratin and connect the fibres together to form protofibrils, the structure of the hair.

Salt bridges
These are weak, temporary bonds that can be broken and reset during styling. They can be broken by high pH, water and heat during styling, as well as chemical treatments.

Hydrogen bonds
These are also temporary bonds but are naturally weaker than both the disulphide bonds and salt bridges. They can be easily broken by water and heat and reset during styling, making it easier to style hair temporarily.



HAIR FIBRE STRUCTURE

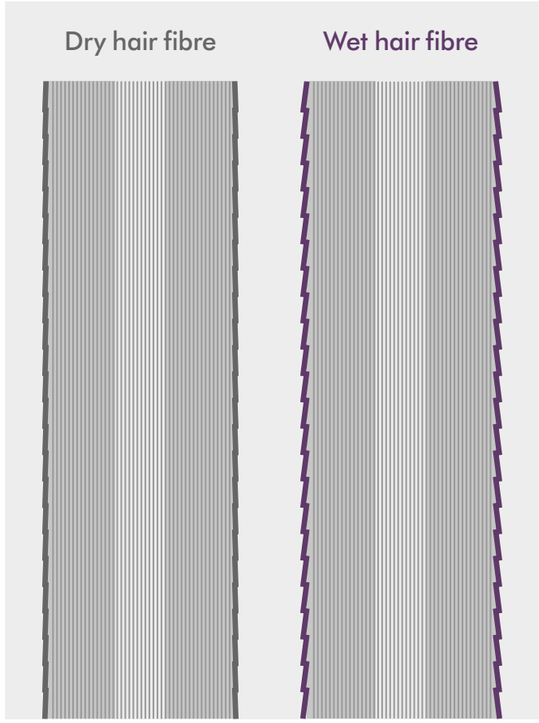
The outer layer of hair, known as the cuticle, is made up of overlapping transparent cells that protect hair from damage and reflect light to make the hair shiny. You can visualise this like roof tiles protecting a house. When first grown, cuticles lay flat and are tightly bound together.

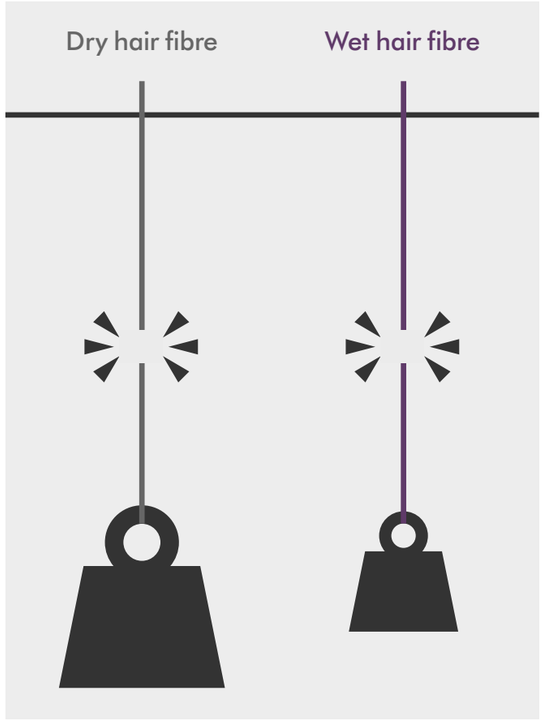
The cuticle doesn't absorb water evenly which often distorts the hair, making it rough in texture and increasing strand friction. Water on the surface of the hair also causes strands to stick together weakly, increasing tangling and damage to the hair when brushed, combed or styled.

The centre of the hair strand, known as the cortex, is made up of long, thin cortical cells containing a-keratin. These structures give hair its strength, elasticity and contain melanin pigments which give hair its colour.

Within the cortex, water can cause hair to swell in diameter by an average of over 10%. This can cause breakages in the hydrogen bonds which hold the structure of hair together, weakening it by over 40%, subject to the hair type. This can make it easier to permanently damage hair, either by making it thinner or snapping the strands while brushing, combing or styling.

Within the cortex is also the medulla, the innermost layer of the hair shaft. The medulla is often only present in thicker hair types and consists of a soft, thin core of transparent cells. The medulla can increase the thermal insulation of hair as well as add more volume.





HAIR COLOUR

Hair naturally has a slightly off-white colour. The presence or absence of melanin granules dictate the final colour of hair. An abundance of one type of melanin, called eumelanin, gives people black or brown coloured hair. An abundance of another pigment, called pheomelanin, gives people red coloured hair.

The amount and type of melanin you have is determined by your genetics. This gene in humans is referred to as MC1R. This will provide instructions for making a protein called the melanocortin 1 receptor, which is involved in the pathway that produces melanin. Therefore, your hair colour will be formed through the dominant gene you've inherited from your parents. Often, the brown hair gene dominates over blonde, red and other hair colours.

THE HAIR GROWTH CYCLE

The rate that hair grows is dictated by genetics. However, other factors can be seen to disrupt growth when severe enough. These include diet, stress, hormonal imbalances and certain medical treatments.

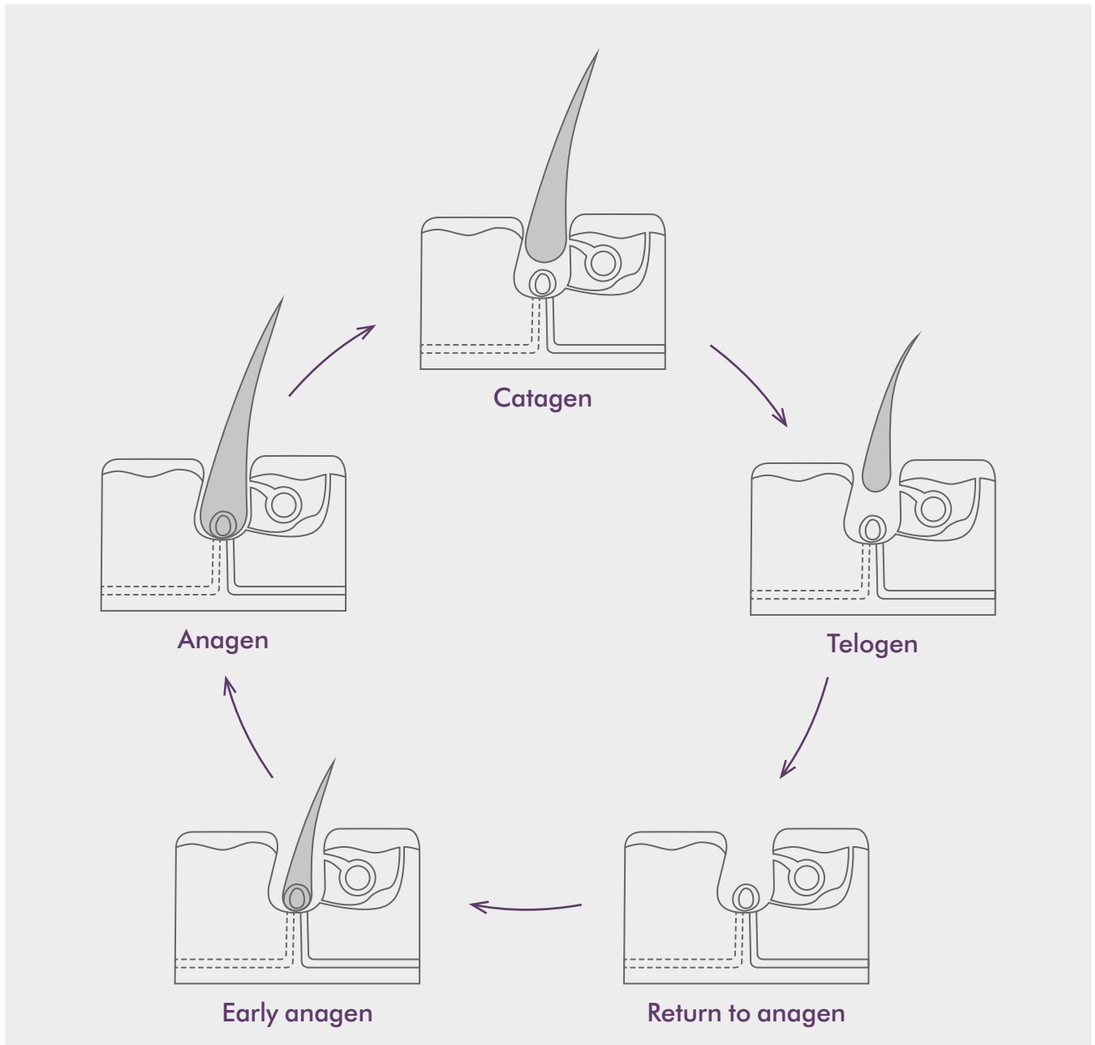
The hair growth cycle has three stages:

Anagen
Nine out of ten hairs are in anagen, also known as the growth phase, which typically lasts between two and six years. Hair grows approximately 0.9–1.3cm per month. Typically, hair can grow to one metre in length before it falls out.

Catagen
This is a short, transitional phase of the hair growth cycle, typically lasting one to two weeks. This phase signals the end of active growth. During this phase the follicle prepares to shed the hair.

Telogen
This is the final phase of the hair growth cycle and when the hair is released from the follicle and falls out. You naturally lose 50–100 hairs a day but more can be lost or broken through different damage mechanisms.

The follicle will then rest for up to three months before the cycle restarts.



Did you know?

Hair strands grow for two to six years, collecting damage and weakening along the way.

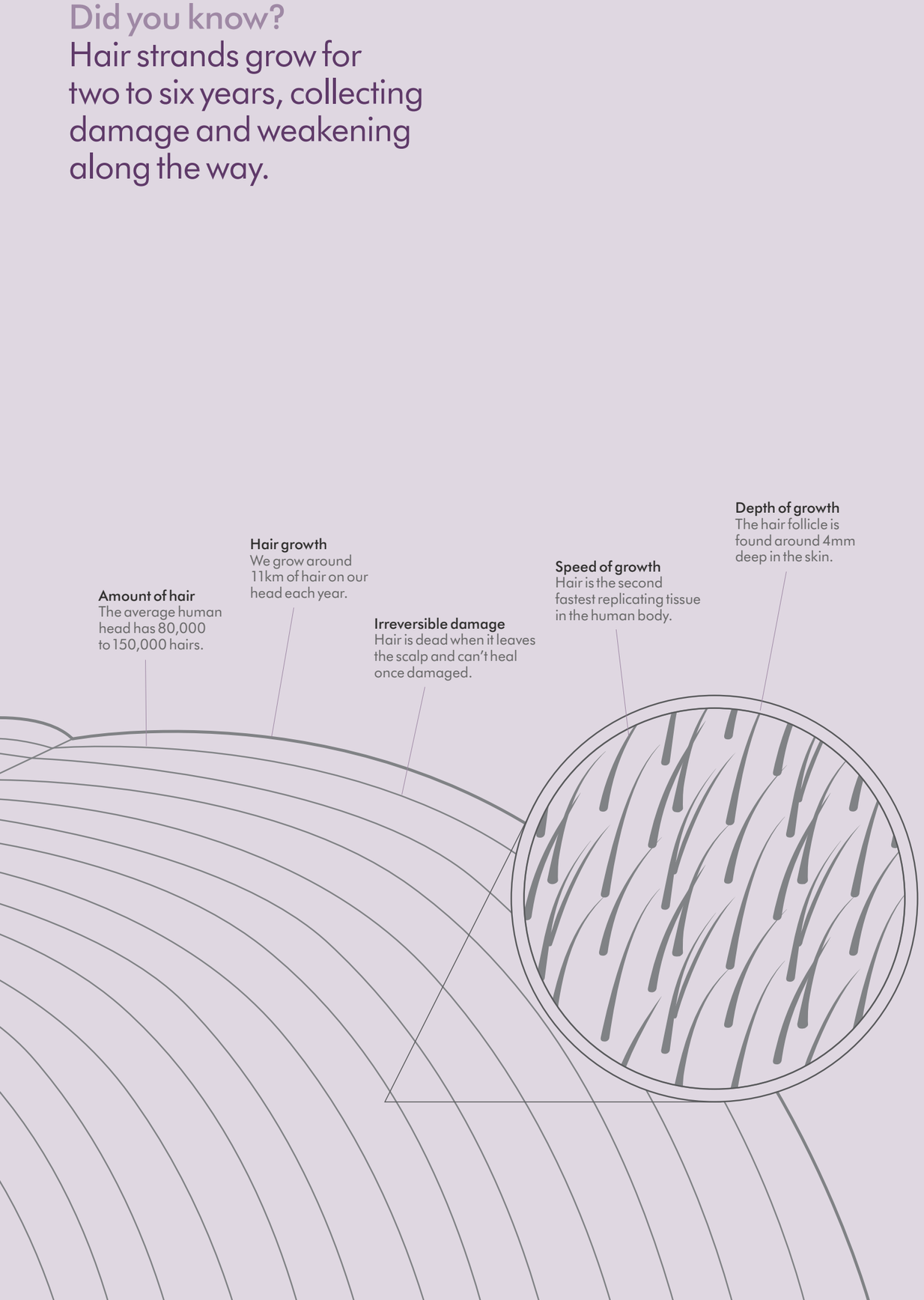
Amount of hair
The average human head has 80,000 to 150,000 hairs.

Hair growth
We grow around 11km of hair on our head each year.

Irreversible damage
Hair is dead when it leaves the scalp and can't heal once damaged.

Speed of growth
Hair is the second fastest replicating tissue in the human body.

Depth of growth
The hair follicle is found around 4mm deep in the skin.



TYPES OF HAIR LOSS

Androgenic alopecia

This is the general thinning of hair growth, also known as male or female pattern baldness. This is when normal hair is converted to vellus hair (thin, short and unpigmented hair). This can be caused by a range of factors, such as genetics, age and hormonal changes.

Traction alopecia

This is when hair loss occurs along the front and sides of the scalp, often caused by a persistent, prolonged or repetitive pulling force being applied to the hair. For example, over-use of hair weaves, tight pony-tails or braiding techniques.

Alopecia areata

This is sudden and unpredictable patchy hair loss. This can progress into total head hair loss (alopecia totalis) and total body hair loss (alopecia universalis). This can often be caused by autoimmune diseases which causes the body's immune system to attack the hair follicles.

Telogen effluvium

This is when large numbers of hair follicles are induced into their resting phase (telogen), resulting in increased hair shedding. This can be a short or long-term condition that develops two or three months after the triggering cause. This can stem from a range of causes, such as systemic diseases, weight loss, drugs, illness, stress, iron deficiency and scalp inflammation.

Postpartum alopecia

Another time when hair loss can occur is during pregnancy. During the second and third trimesters of pregnancy, a number of hairs in the growth phase anagen increase. After the birth, hormonal changes can lead to a large number of follicles ending up in either the catagen or telogen states. As a result, women can often shed more hair, sometimes known as postpartum alopecia.

SCALP HEALTH

The scalp is essential in determining the health and condition of someone's hair. The scalp is made up of a very thick layer of skin, ranging from 3–7mm per person, as well as a series of connective tissue which is dense with nerves and capillaries. The Stratum Corneum, the uppermost skin layer, contains numerous hair follicles and large sebaceous glands. When this part of the scalp is functioning properly it can provide protection from dehydration, toxins, bacteria and damage caused by styling.

All scalps have a unique microbiome that influences the health of scalp and hair and consists of a complex combination of bacteria, fungi and viruses. There are various internal and external factors that can affect the scalp, and therefore the microbiome.

The Stratum Corneum is the uppermost layer of skin on the scalp

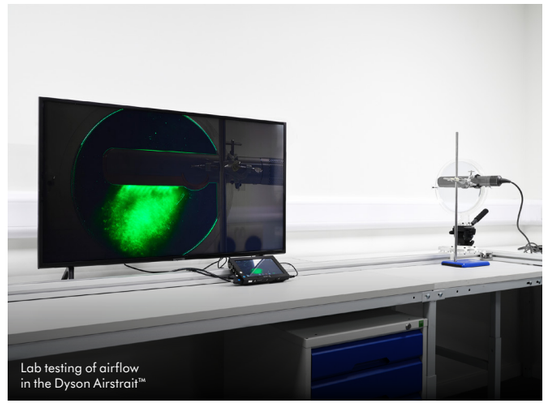
DYSON AIRSTRAIT™ STRAIGHTENER

The Dyson Airstrait™ straightener was under development for over six years. The brief for this product was to design something that could style hair from wet to dry without causing heat damage. Water can naturally weaken your hair's bonds, meaning when hair is wet it is more susceptible to damage. If you were to apply high temperatures to wet hair, this could cause further damage, including more frizz, flyaways and less shine.

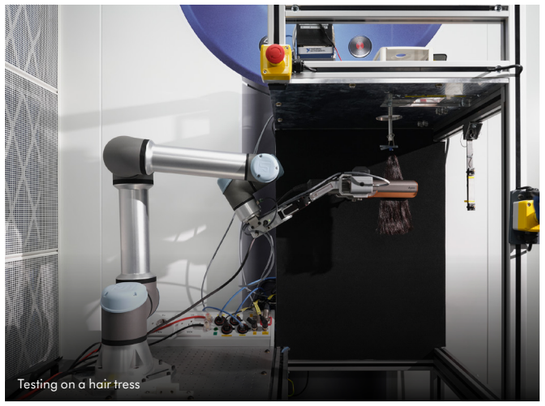
The Dyson Airstrait™ straightener is powered by the Hyperdymium™ motor. This motor was designed to be small and light but powerful enough to generate the airflow needed to dry and straighten hair simultaneously. The motor is powered by a 13-blade impeller which spins up to 106,000rpm, propelling over 11.9 litres of air through the machine per second, generating up to 3.5kPa of air pressure.

Along the arms of the Dyson Airstrait™ straightener, there are two 1.5mm apertures. The airflow is accelerated through these apertures, creating two high-velocity downward blades of air. Projected at a 45° angle, they converge to form one focused jet of air, creating the downward force to straighten hair as it dries. This directional airflow helps align the hair strands. To protect hair from heat damage, the Dyson Airstrait™ straightener has a glass bead thermistor which measures the temperature of the airflow up to 16 times per second. This data is sent to the microprocessor which regulates the heating element, ensuring airflow doesn't exceed the temperature required.

Dyson Airstrait™ prototypes

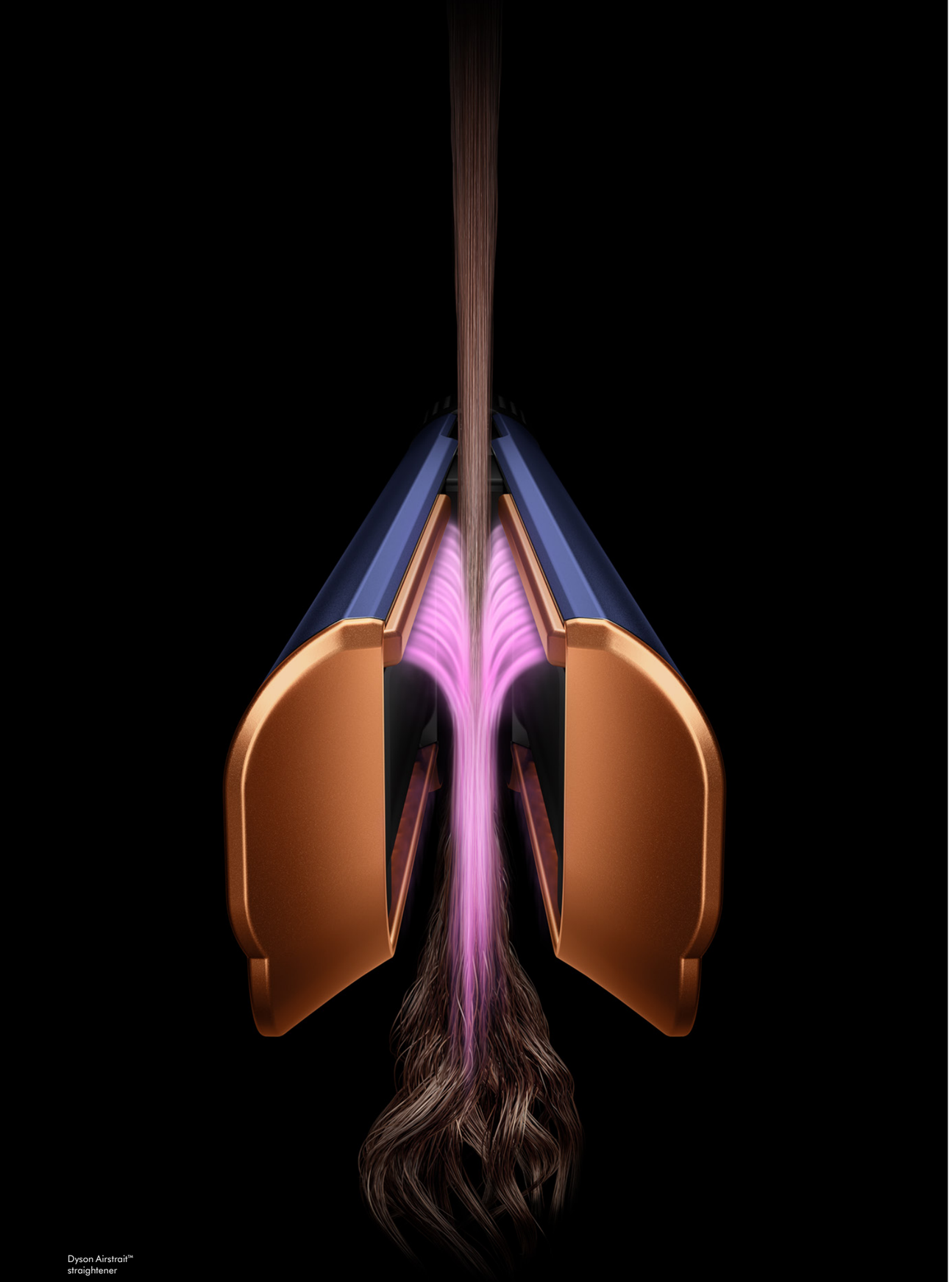


Lab testing of airflow in the Dyson Airstrait™



Testing on a hair tress

Real life testing



Dyson Airstrait™ straightener

LESSON 02
WHAT IS HAIR MADE FROM?

Duration: 1 hour 20 minutes
Resources: Lesson 02: Structure, composition and bonds presentation deck, paper, pencils, hair samples (which could be found on clothing or hair brushes) or a substitution for hair (cotton, string, elastic), weights or substitutes found in the classroom.

Learning objective:

Students will learn about the structure and composition of hair, and how hair differs for each individual. Students will conduct tests to understand the bonds that exist in hair and what could damage them.

Starter: 5 minutes

Activity

Before you begin, please note: In many cultures, hair can be seen as very personal and touching someone's hair without permission can be seen as intrusive and disrespectful. Please remind students that it is important to always ask for consent before touching someone else's hair to show consideration for others' feelings and the cultural significance attached to their hair.

Ask the students to discuss in pairs how they choose to style their hair. Encourage them to talk about how and when they wash it, if they style it, if they use any tools such as a hair dryer or curler, and any products they use.

Main activity: 60 minutes

Activity

Use the **Lesson 02: Structure, composition and bonds presentation deck** to share context on what hair is made from and how this can differ between hair types.

Explain to the students that there are three types of bonds in hair: disulphide, salt bridges and hydrogen bonds. Using molymods or pencil and paper, ask the students to build or draw these bonds. Ask them to consider the following questions:

– Which are the strongest and why?
– What do they think could disrupt these bonds within the hair?

Come together as a class to discuss which bonds they think are the strongest and what they think could damage those bonds.

Based on their learning of the structure, composition and bonds of hair, explain to the students they'll be conducting their own experiment to understand the difference in hair types. Using a hair sample or a replacement for hair, attach a variation of weights using adhesive to see how strong the hair strand is. Students should note heat, chemicals and physical forces. The latter will be the focus for the remainder of the lesson to introduce students to different hair types. Provide students with a sample of wet hair and ask them to repeat the experiment. Ask the students to note their findings:

– How much weight can the hair hold before it breaks?
– Does it stretch at all before it breaks?
– Has this been influenced by the cross-section of the hair strand?
– What happens when the hair sample is wet?

Students should note that wet hair breaks more easily because water causes the hair strand to swell in diameter, breaking hydrogen bonds that hold the hair together.

Ask the students to discuss if using different hair types could affect the outcome of the experiment. For example, coarse hair has a larger cross-sectional area which means it may be more resistant to weight than thinner hair.

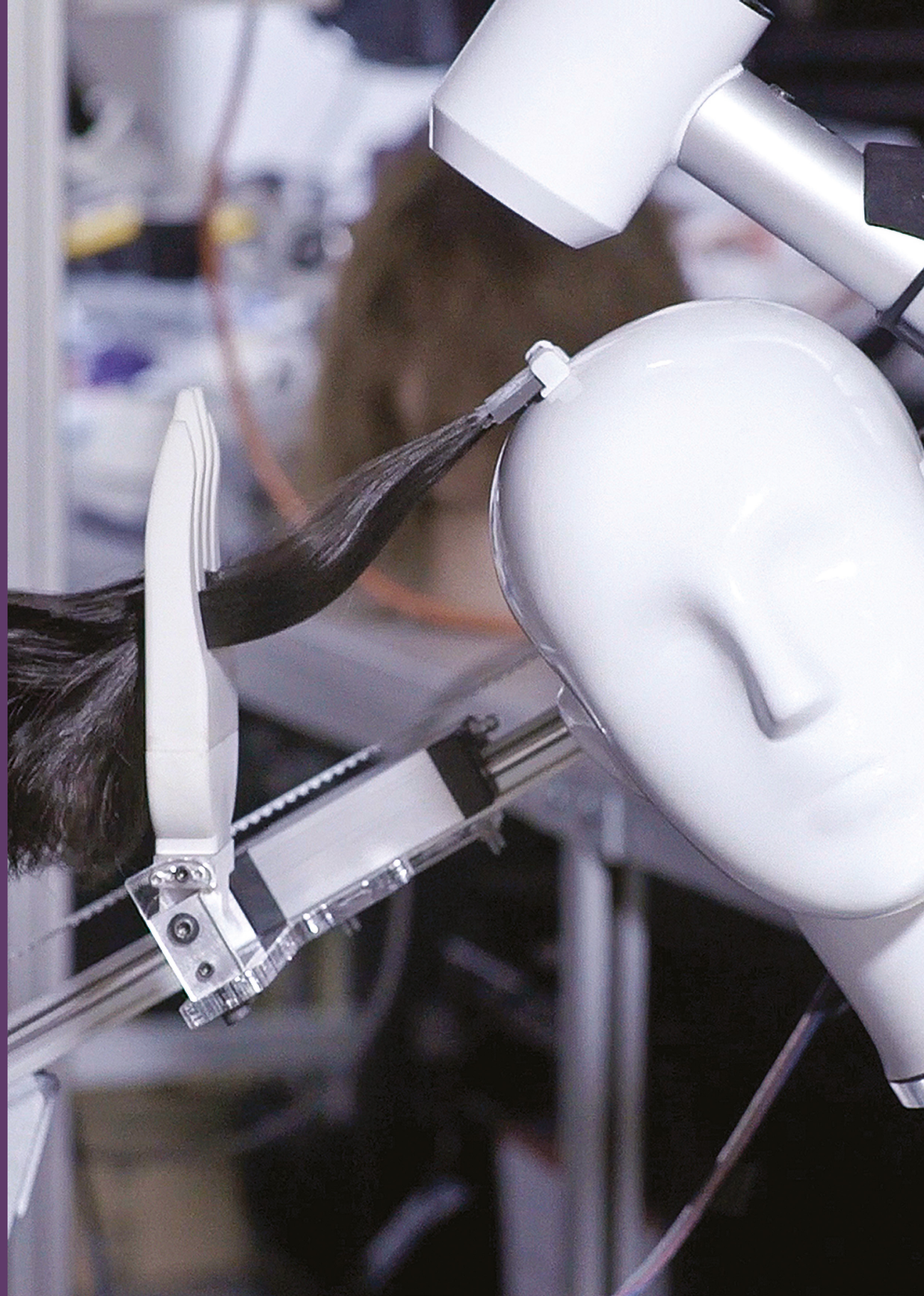
Wrap up: 15 minutes

Activity

Come together as a class to discuss findings and identify if there are any themes amongst the class. Do the similar hair types produce similar results? Why? Have there been any findings that surprised them? Encourage them to relate this experiment back to what people may do in real life with their hair which can cause damage.

SECTION 03
ENGINEERING SOLUTIONS TO HAIR STYLING

Students will learn more about different types of hair damage and how Dyson engineers have used the iterative design process to improve technologies that protect hair health when styling. Students will use their knowledge to design a new hair styling solution.



TYPES OF HAIR DAMAGE

Thermal

When using heat that is over 150°C the α-keratin will slowly convert to a β-keratin making hair weaker with less elastic. When using heat which is over 230°C, hair will begin to melt and the disulphide bonds will break down quickly, meaning hair will be easily broken.

Chemicals

Chemicals that are used to colour or perm hair, as well as the chlorine which is in swimming pools, can be harmful to hair. They force the cuticle cells apart by disrupting or removing the lipids that hold them together, making the hair strand rougher, less hydrophobic – meaning it cannot repel water – and weaker.

Mechanical

Hair brushing, interacting and playing with your hair and the tangling of hair can cause damage. It will roughen, or even remove, the cuticle of the hair strand, increasing strand to strand friction. Stretching hair can cause the keratin in the cortex to collapse and form β-keratin, making it weaker.

UV

UV light can cause the proteins and lipids in hair to degrade, weakening the fibre structure and making it less hydrophobic. If your hair is unpigmented, or lighter in shade, it can naturally be less resistant to UV. Therefore, being exposed to temperatures of 81°C and above can cause hair to turn yellow. The melanin in hair absorbs UV, protecting the cortex from damage. UV damage primarily affects the cuticle layer of hair as there is no melanin to protect it.

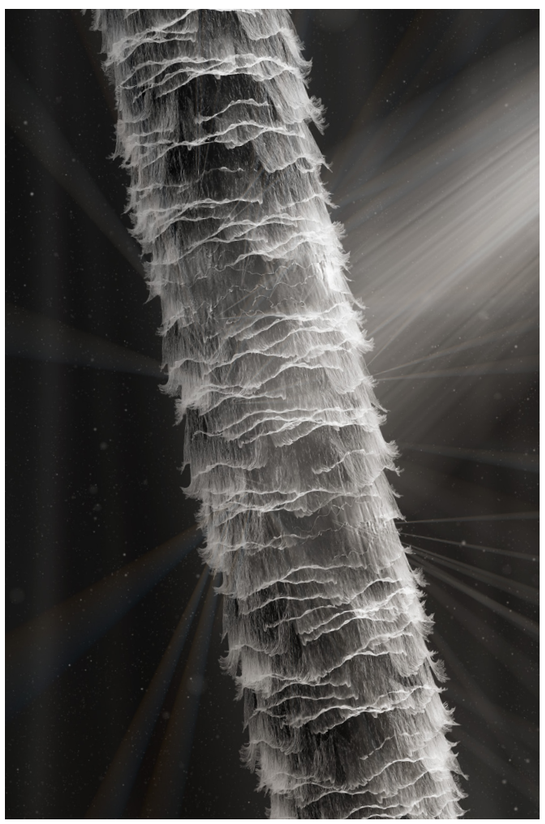
EFFECTS OF HAIR DAMAGE

Cuticle damage
Hair can become less hydrophobic. This will enable water to penetrate the hair shaft more quickly, leading to poorer style retention.

The hair strand will become rougher, removing shine from the hair. The protective layer on hair will be reduced, leading to increased damage of the cortex.

Split ends
Split ends and split strands occur when the cortex layer is severely damaged. Once it becomes brittle, cracks will form if the strand is bent or pressure is applied to it.

Once the hair enters this state, continued brushing can cause the cracks to propagate through the length of the hair until it splits.



EFFECTS OF HAIR DAMAGE

Friction, density and surface area
When a hair strand becomes damaged, the cuticle will become rough, increasing strand to strand friction. Higher friction will increase the force required to brush hair, resulting in the generation of static and an increase in flyaways. Flyaway hairs are single fibres that are repelled due to static interactions. If your hair has an uneven density, a low fibre to fibre alignment and an uneven surface area, you will likely see an increased chance of frizz. Frizz can be caused by a change in weather conditions, such as higher humidity, or by physical interactions with your hair.

Uneven density
This is defined as having visible and uneven gaps in the body of your hair.

Low fibre to fibre alignment
This is defined as fibres not being evenly aligned down the body of hair. This is amplified in curly hair, as the fibres won't align with each other to form controlled curls.

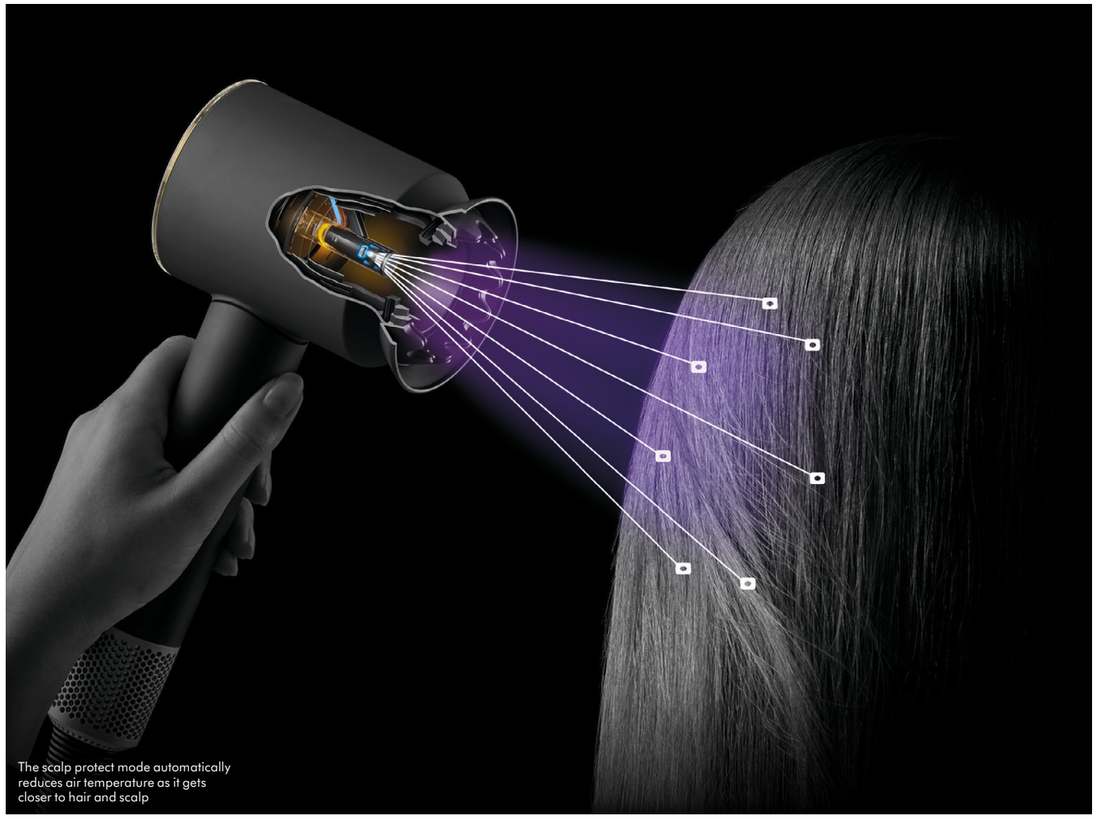
Uneven surface area distribution
This is defined as hair having a high volume surface area difference between the bottom and top sections of the hair. This can be caused by split ends or tip damage, increasing the volume of the hair tips.

Brushing and combing can cause hair bonds to be broken and reformed as they apply tension to the hair.

DYSON SUPERSONIC NURAL™ HAIR DRYER

The Dyson Supersonic Nural™ hair dryer was designed to dry hair faster, while limiting heat damage and protecting scalp health.

The Dyson Supersonic Nural™ hair dryer is powered by a Dyson Hyperdymium™ motor. This is the smallest and lightest motor that has been developed by Dyson engineers, measuring up to 27mm in diameter and weighing only 49g. The Supersonic Nural™ contains the same glass bead thermistor as other Dyson beauty products, meaning it can monitor air temperature over 40 times per second to ensure the heat is regulated, helping to protect hair and scalp health.



The scalp protect mode automatically reduces air temperature as it gets closer to hair and scalp

The focus of the Dyson Supersonic Nural™ hair dryer is to ensure hair health is protected all the way down to the scalp. This has been achieved by Dyson engineers through the development of a Time-of-Flight sensor. This sensor collects nine million data points every second, enabling the distance from the hair dryer to the user's scalp to be measured. This sensor automatically adjusts the heat settings to ensure the temperature remains at a consistent 55°C; the optimum temperature needed to maintain scalp moisture levels and prevent over drying.

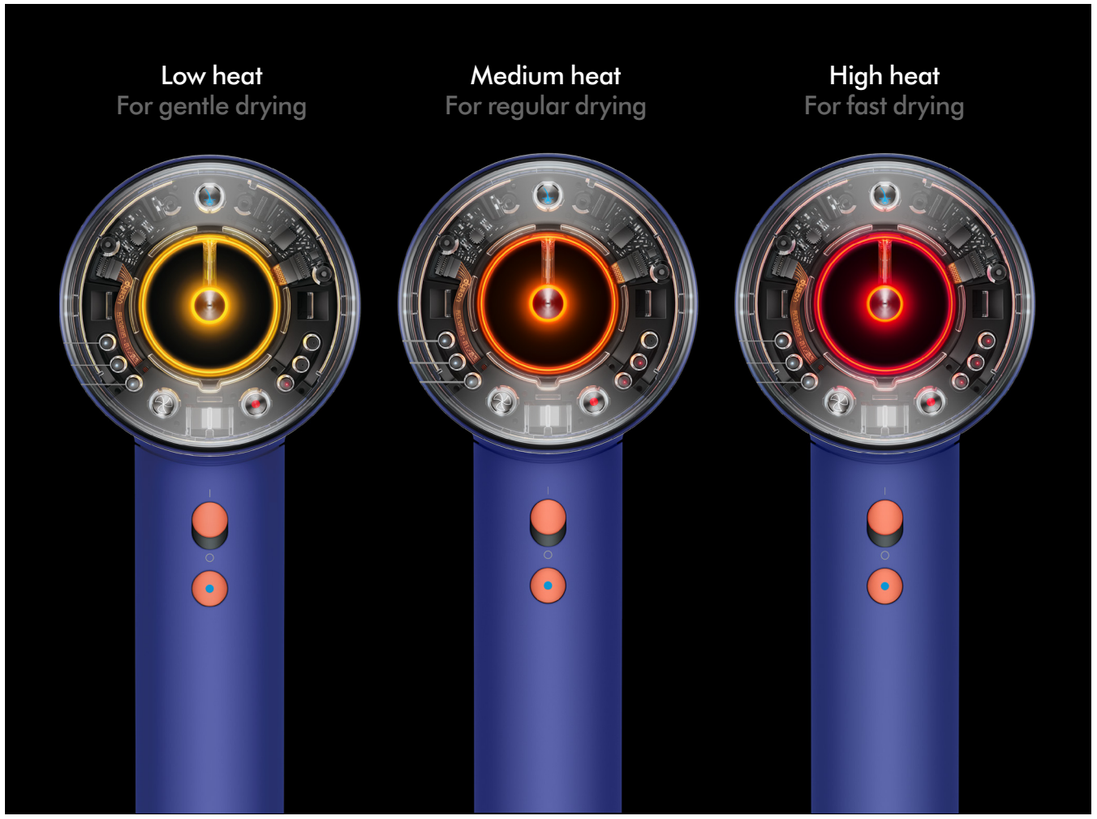
Colour illumination
When using the Supersonic Nural™, it will show users what distance they are holding the device from their scalp through the following:

Yellow
0–10cm low heat;

Orange
10–22cm, medium heat;

Red
22–42cm, high heat.

The Supersonic Nural™ also includes intelligent attachments which contain a Hall Sensor. This means they can be customised by the user to the correct airflow and heat settings for their hair type. Finally, it also has a motion-sensor accelerometer. This enables the machine to pause when the user puts it down, deactivating the heater, decreasing airflow and noise.



LESSON 03
ENGINEERING SOLUTIONS TO HAIR STYLING

Duration: 1 hour 20 minutes
Resources: A substitute material for human hair (e.g. string or cooked spaghetti), a range of items to cause damage to the hair substitute (e.g. scissors, coloured pens, heat), paper, pencils, cardboard, tape and glue (if available).

Learning objective:

Students will undertake a scientific experiment to further understand hair damage. Students will use their knowledge of hair science and engineering to sketch and prototype their own hair styling engineering solution.

Starter: 10 minutes

Activity

Explain to the students that they will be investigating the effects of hair damage through a scientific experiment. They will need to identify a household item which can be used in replacement of human hair, e.g. string or spaghetti. This can be organised ahead of the lesson.

Break the students into small groups of three or four and ask them to consider why scientists may need to use substitutes rather than real hair when understanding the effects of hair damage. This could be due to substitutes being more readily available and costing less than using real human hair.

Main activity: 60 minutes

Activity

Using resources available within the classroom, ask each group of students to cause damage to the item they're using as a substitute to hair. This could be through the use of scissors, heat, food colouring or coloured pens. Ask the students to consider how real hair may become damaged in similar ways in the real world. Some examples of this are heat from styling tools or sunlight, hair dye, chemicals, and abrasion.

Bring the class back together to discuss these ideas and ask them to start thinking about how you may be able to protect against these types of damage. If appropriate, ask the students to reflect on things they do to ensure they protect their hair health.

As a class discuss how the different Dyson technologies the students have learnt about help minimise hair damage when styling. They can consider the following:

– Monitoring the temperature using 'Time of Flight' sensors in Dyson Supersonic Nural™
– Using flexible copper plates in the Dyson Corrale™ to bend around hair to prevent pulling hair and causing mechanical damage.

Split the class into groups. Ask each group to use their knowledge of hair science, damage and Dyson technology to sketch a new design of either:

– A new hair styling product
– An attachment for the Dyson Supersonic™, Dyson Supersonic Nural™ or Dyson Airwrap™.
– Encourage them to think about functionality, useability and the technology they'd include.

If time allows the groups may also rapid prototype their designs using cardboard, tape and glue.

Wrap up: 10 minutes

Activity

Ask each group to present their new product or attachment to the rest of the class. Encourage other students to provide feedback on what they like and what they think could be improved about their designs. Discuss any similarities amongst the groups.

Ask the students to note down answers to the following questions individually.

– What have you learnt about hair science that you didn't know before?
– Why is it important to understand hair science when developing new technologies to help with hair styling?
– What have you learnt about engineering that you haven't learnt before?

Discuss the students' answers as a class.

You can find more James Dyson Foundation educational resources online at www.jamesdysonfoundation.co.uk

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INSPIRING THE NEXT GENERATION OF ENGINEERS

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