Hair

At a glance

	Content summary	National Curriculum links	Activities
Lesson 1	Investigating shampoos as mixtures and testing their chemical properties	Using appropriate techniques in an investigation; scientific attitudes; understanding mixtures	**Activity A:** What is in a shampoo? **Activity B:** Testing the properties of shampoo
Lesson 2	Finding out about hair and the chemistry of how shampoos work	Understanding uses and implications of science; use specialist vocabulary	**Activity B:** What is hair?

Background and National Curriculum links

These activities are designed for one or two Year 7-9 lessons on the theme of hair, focusing on understanding the chemical structure of hair and the chemistry involved in keeping hair clean.

Lesson 1

The properties and chemistry of shampoo are investigated. Students also develop an understanding of the structure of hair and the work of formulation chemists.

National Curriculum

- Use appropriate techniques, apparatus and materials to investigate a range of shampoos.
- Evaluate data, showing awareness of potential sources of random and systematic error.
- Identify and answer further questions arising from the results.
- Develop understanding of mixtures.
- Apply the pH scale using an indicator to measure acidity/alkalinity.

Lesson 2

Students find out about the structure of hair and how shampoos work. They discuss the advantages and disadvantages of using modern liquid shampoos.

National Curriculum

- Understand the uses and implications of science relating to shampoos in our society.
- Understand and use technical and specialist vocabulary relating to hair and shampoos.

Teacher subject knowledge

Teachers should know about emulsions and suspensions, acid-base chemistry and the action of soaps. Understanding of the work of formulation chemists would be helpful. One activity involves accessing a cosmetics chemicals database. Hence, some knowledge of colloquial and systematic names of chemicals used in shampoo formulations is useful. Understanding that hair comprises fibres of a protein called keratin is valuable background knowledge.

Cross-curricular links

The history of shampoo and hairstyles connects with aspects of social history. Hairstyles in various societies pay homage to nature and natural surroundings; scare enemies; demonstrate maturity and marital status; and symbolise power and wisdom. Hair dyes based on henna, indigo and turmeric have been known and used for several thousand years. Shampoo became commercially available only from about the 1930s onwards. Previous methods for cleaning hair used various natural substances, including milk, fruit juices, coconut and palm oils, fats, liquorice, herbs such as rosemary and thyme and other plants, including elm bark and nettles. In Renaissance Italy (14th – 17th centuries), women washed hair with a strongly alkaline soap called 'lye', and conditioned hair with bacon fat and liquorice. Using lye in hair cleaning persisted to the 19th century (Victorian era), when women added to this routine by breaking an egg over the head. Egg was massaged into hair then rinsed out. Gentler soaps such as 'castile' and 'ivory' became popular from the 1850s, together with a conditioner called 'Macassar oil', which was a blend of palm, coconut and 'ylang-ylang' oils.

Current and traditional hairstyles in the UK can be described as 'short back and sides', 'number 1', 'perm', cornrow, 'cut-and-blow dry', plaits, French knot, (penny) bun, crop, bob, Mohawk, buzz cut, 'DA' ('duck's anatomy' or ducktail). What do these terms mean? Do we judge people by their hair?

Today, hair products are mixtures of sophisticated, mainly synthetic, chemicals. Students can research cultural hairstyles, the history of hair dyes and the chemicals used to create styles and colours. Discuss what current 'fashionable' hairstyles represent, if anything.

Student background knowledge

Students should know about the chemical action of soap in cleansing and the pH scale.

Resources and timing

One or two lessons of 50-60 minutes are needed.

Technical requirements

Lesson 1

This is a genuine investigation. The results will depend on the shampoos. Ask students to bring their own shampoo in its original bottle, with its price. Try to obtain a range of about 15 – 20 depending on class size.

For Activity A, photocopy shampoo labels, each with the name of the shampoo. Make sets of up to 5, so 3 x 5 sets if 15 different shampoos are available. Distribute copies of the labels to groups of students. Students do not need to study all shampoos: each group could be given one set only, and different sets shared across the class.

Copies can be retained for future use. The complexity of the task can be altered by restricting the number of labels given to students and reducing the contents of the database. For example, they could test only their own shampoo, and one other for comparison.

For Activity B, samples of each shampoo are needed. Prepare these in small beakers, clearly labelled with the shampoo name. Students can be supplied with samples that match the labels provided in Activity A. The complexity can be varied by reducing the number of shampoos that students test, see above.

A table is provided to record results from both activities.

For Activity C, students need copies of the 'Hair' information sheet.

Activity A: What is in a shampoo?

Each pair or group will require:

- copies of 5 – 6 different shampoo bottle labels
- access to the Cosmetics Ingredients Database – this is attached

Ask students to look at some shampoo labels.

- Students need access to up to 5 – 6 labels from different shampoos (see above). The number can be varied depending on students' ability and/or the time available.
- Ask students to identify in each shampoo ingredients such as:

  SURFACTANT PRESERVATIVE EMULSIFIER SALT PERFUME
- The price of each shampoo is helpful to know.

Discuss:

1. Why do shampoos have so many ingredients?

Shampoo is a 'formulation' of chemicals designed to clean and care for hair. The word 'shampoo' derives from a Hindi word 'chāmpo'. This is derived from Sanskrit 'chapayati' (रोटकि), meaning to press, knead or soothe. Shampoos usually contain:

- A surfactant such as sodium laureth, sodium lauryl sulfate, ammonium laureth or ammonium lauryl sulfate;
- A preservative to stop bacterial growth, such as butylparaben, benzyl alcohol, disodium EDTA or citric acid;
- An emulsifier, for example, cocoamidopropyl betaine or cocoamide DEA;
- Salt, usually sodium chloride or magnesium chloride;
- A thickener, such as behenyl alcohol or carbomer;
- Perfume, often a fruit oil, such as citrus sinesis, or 'Parfum', which is a mixture of perfumes.

2. What types of chemicals are in all shampoos?

   All shampoos contain 'aqua' (water), surfactant, preservative, emulsifier, salt and perfume.

3. Which ingredient actually cleans the hair?

   The surfactant is the cleaning agent.

4. Why do shampoos contain a 'preservative'?

   Shampoos are often stored in warm, damp places. This environment is good for bacterial growth. The preservative stops bacteria growing in the shampoo.

5. What do students notice?

   There is a limited range of surfactants in shampoos.
   Ingredients vary by price – more expensive products use 'fancier' ingredients, especially perfumes and may have more ingredients than cheaper shampoos.
   Specialist shampoos may have additional ingredients, e.g. to treat dandruff, protect colours in dyed hair, or may include a conditioner.

6. Why does shampoo have perfume?

   The perfume makes the shampoo and our hair smell pleasant. Without this the shampoo would not have a smell. It is there for cosmetic reasons only.

7. What type of mixture is shampoo?

   Shampoo is an emulsion. This is a fine mixture of droplets of one liquid in another liquid in which it is insoluble or immiscible. Think of a fine mixture of oil and water.

Conclusion

What is shampoo? How does shampoo work? Why do we use it?

Shampoo is a type of soap that cleans dirt and grease from hair. A chemical reaction occurs between a chemical in the shampoo and grease. The products of the reaction are carried away by water. Dirt is removed by water. We use it to make our hair look and smell pleasant. We probably wash our hair more often than is really necessary.

Extension

This activity could be extended to include conditioners, hair gels and other styling products. Students can find out about the differences in formulation between these products.

Activity B: Testing the properties of shampoos

To test shampoos each pair or group will require:

- Universal Indicator solution; pH chart
- About 200 cm^3 distilled water
- 6 test tubes and a rack
- Dropping pipette
- Eye protection for each student
- Selection of about 6 shampoo samples – ask students to bring shampoos from home; these can be distributed in small sample bottles so individual students are not identified
- About 200 cm^3 cooking oil (the type of oil is unimportant)
- 6 Petri dishes or similar transparent vessel
- Piece of dark paper about 10 cm x 10 cm to go under a Petri dish / equivalent

Comparing results

- Most shampoos have pH values between 6 and 7.5. Discuss if the type of shampoo makes a difference (i.e. for 'volume', 'normal hair', 'greasy hair') to pH.
- The oil test results depend on the thickener(s) added. Thicker shampoos tend to spread out less. These may clean better than thinner shampoos as they stay in the hair longer. However, the thickener may be there as a cheap 'filler' ingredient to add texture, while not making the shampoo clean better.

Extension

This activity could be extended to include conditioners, hair gels and other styling products. Students can find out about the differences in formulation between these products.

Lesson 2

Activity C: What is hair?

Each student will require a copy of the 'Hair' information sheets.

This comprehension activity could be a homework task or used in class. Students read the text and complete the tasks related to text that follow.

Parts 1 – 3 are about the structure of hair, how hair grows and why we should wash our hair. This is suitable for students of all abilities.

Parts 4 and 5 are about how shampoo works and making hair manageable and shiny. This section requires a higher level of reading ability.

Parts 1, 2 and 3

Hair fibre layer	Made of keratin?	Structure / colour
Inner	Yes	Honeycomb
Middle	Yes	Coloured
Outer	Yes	Scaly

Things that make our hair dirty: dead skin, grease, smoke, chemicals.
We wash hair to keep the cuticles and our scalp in good condition and to stop hair becoming smelly.

Parts 4 and 5

Statement	True	False	Not sure
Oil in hair washes it naturally so we don't need shampoo		X	
Dirt in hair can be cells, dust, chemicals and smoke	X		
A 10p piece-sized amount of shampoo cleans 2 – 4 m^2 of hair	X		
Dry hair is caused by using too much shampoo		X	X
Surfactants are acidic salts		X	
Grease and dirt dissolve in shampoo		X	
Conditioners contain silicon	X		
Greasy hair doesn't shine	X		
Vinegar or lemon juice can be a natural conditioner	X		

The advantages and disadvantages of the shampoos we use today may include:

Advantages

- Liquid shampoos are convenient to buy and easy to use.
- Surfactants are excellent cleaners.
- Shampoos are formulated to be gentle on the scalp and hair.
- Knowing our hair looks good and is clean helps self-esteem.

Disadvantages

- Shampoos contain complex synthetic chemicals that take time to decompose and may be toxic to ecosystems once washed into the drainage system.
- The chemicals are expensive and many are derivatives from crude oil.

Extensions

Students can investigate

- how hair products create specific hairstyles.
- how hair fashions change over time - why do fashions change?
- Why is hair significant in many cultures?

Visit a hair salon or a training academy. See how hair products are used to create and style hair. Find out what is in the products and how hairdressers use them to create specific styles and effects.

Resources

The hair salon chain Toni and Guy has a strong education ethos, running twenty training academies in the UK: https://toniandguy.com/education. The website also includes a Digital Academy featuring educational hair technique videos and global live webinars. A subscription may be required for some events.

This article discusses traditional hairstyles in a variety of societies:
Hairstyles from Around the World (marieclaire.com)

Activities

Lesson 1

Activity A: What is in a shampoo?

Look at the labels of one or more shampoos.

Use the database to find out about the chemicals in shampoo. Record the chemicals you find in the table. You are going to do a pH and oil test next so leave blank for now.

Shampoo	Price/100ml	Surfactant	Preservative	Emulsifier	Salt	Perfume	pH	Oil test

Questions

1. Compare results for the shampoos tested. What do you notice?
2. Why do shampoos have so many ingredients?
3. What types of chemicals are in all shampoos?
4. Which ingredient actually cleans the hair?
5. Why do shampoos contain a 'preservative'?
6. What do you notice about the chemicals in shampoos?
7. Why does shampoo have perfume?
8. What type of mixture is shampoo?

Conclusion

What is shampoo? How does shampoo work? Why do we use it?

Activity B: How does shampoo work? Investigating pH and oil-dispersing properties

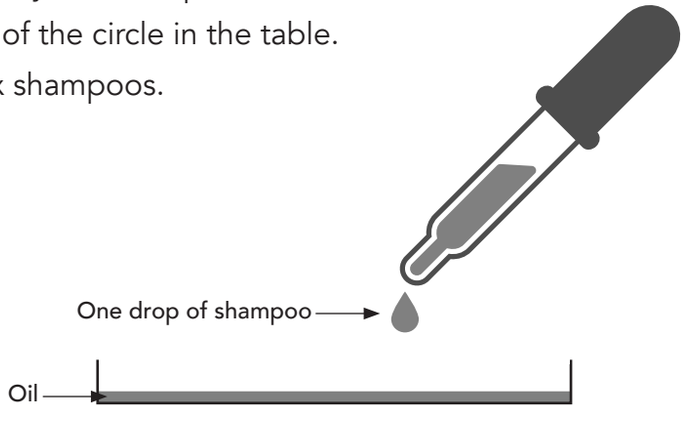
In this activity you will find out more about the shampoos.

pH test

1. Place one drop of the shampoo in a test-tube.
2. Fill the tube three-quarters full with distilled water.
3. Add two drops of Universal Indicator solution.
4. Find the pH value of the shampoo solution by reading this from a pH chart.
5. Record the pH value in the table.
6. Repeat the test for up to six shampoos.

Oil test

1. Pour the oil into a Petri dish to make a thin film over the base.
2. Place the dish on a dark background.
3. Use a pipette to drip one drop of shampoo onto the centre of the oil.
4. Wait until the drop has stopped spreading out, then measure the diameter of the circle formed by the shampoo.
5. Write the diameter of the circle in the table.
6. Repeat for up to six shampoos.



Discussion

1. Look at the oil test carefully to find the best shampoo for dissolving grease.
2. What are the pH values of the shampoos? Are most acidic or alkaline?
3. Explain how the chemicals in the shampoo link to its properties.

Overall, the best shampoo I tested was:

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This shampoo was best because:

Hair: Lesson 1: Cosmetics Ingredients Database		
Name[1]	Chemical type	Description and additional information
Acid		Compound that dissolves in water to make a solution with a pH less than 7.
Alkali		Compound that dissolves in water to make a solution with a pH above 7.
Aloe barbadensis	Skin softener	Softens skin, soothes burns and injuries.
Aloe vera	Skin softener	See *Aloe barbadensis*.
Ammonium laureth sulfate	Surfactant	See Surfactants. Compound made from coconut oils. Good at breaking up oils and soil, so effective in shampoos. Good cleansing agent and foam maker.
Ammonium lauryl sulfate	Surfactant	See Surfactants. Compound made from coconut oils. Mild cleansing properties when used at pH 5-6. Non-toxic and not irritating when used in 'rinse-off' products.
Ammonium xylenesulfonate	Solvent	Flammable liquid that does not mix with water. No known toxic or irritant effects.
Antiseptic		Compound preventing infection of the skin by bacteria. Small cuts can be treated with an antiseptic.
Aqua	Neutral	This is the name used in European cosmetic products for water. Water is the main ingredient of many cosmetic products so is found first in the ingredients list. Sterile water must be used – this means the water must be boiled to ensure no bacteria or other microorganisms are present.
Behenyl alcohol	Emulsifier Thickener	Non-toxic.
Benzophenone	Preservative	This compound prevents the shampoo from reacting with UV light. May cause skin irritation.
Benzyl alcohol	Solvent Preservative Antiseptic	Irritating and corrosive to skin when in concentrated solution.
Betaines		Compounds used in shampoos to lower the irritation potential of surfactants. No known toxicity.
2-bromo-2-nitropane-1,3-diol	Preservative	Safe when used up to 0.1% concentration.
Binder		A substance that absorbs water, swells and helps to hold other ingredients together.
BHT (Butylated hydroxytoluene)	Preservative Anti-oxidant	Can cause allergic reactions.
Butylparaben	Preservative	See Parabens.

[1] Latin names are written as used on shampoo and cosmetics labels. These are often scientific names for the plant, not the oil itself.

Hair: Lesson 1: Cosmetics Ingredients Database cont.

Name[1]	Chemical type	Description and additional information
Camellia sinensis	Oil Perfume	Oil from the camellia plant. The same plant produces green tea, which has positive effects including reducing blood pressure.
Carbomer	Emulsifier Thickener	White powder. See Emulsifiers. No known toxicity or skin-irritating properties.
Carboxylic acids	Acid	Molecules based on carbon atoms. The acidity is due to the -COOH (carboxylate) group. The substance dissolves in water making an acidic solution. Used to lower pH of cosmetics.
Castor oil	Oil	Oil from the seed of the castor oil plant. Soothing to skin.
Cellulose gums	Emulsifier Film former	See Emulsifiers and Film formers. Compounds from plant cell walls that are resistant to decomposition by bacteria. Non-toxic.
Cetearyl alcohol	Emulsifier	Very widely used in hair products. A waxy substance. Non-toxic and not irritating to the skin/scalp.
Cetyl alcohol	Skin softener	Widely used ingredient made from palmitic acid. Added as a solid, waxy substance. Non-toxic and not irritating.
Chamomilla recutita	Oil	Oil from the camomile plant. Soothing to skin.
Chlorhexidine digluconate	Antiseptic Alkali	Cleans bacteria from skin. Can cause dermatitis, which is severe irritation of the skin, in concentrated solution. Safe up to 0.2% concentration.
Citric acid	Acid Sequestering agent Preservative	Compound obtained from citrus fruit: lemons, oranges, grapefruit. Non-toxic – can be drunk in solution of water to help provide vitamin C.
Citrus limonium	Oil	Lemon oil obtained from the skin of lemons.
Citrus paradisi	Oil	Grapefruit oil obtained from the skin of grapefruit.
Citrus	Oil	Sweet orange oil obtained from the skin of oranges.
Cocoglucoside		See Glucosides.
Cocoamide DEA/MEA	Solvent Emulsifier Surfactant Humectant	See DEA.
Cocoamidopropyl betaine	Emulsifier Surfactant Thickener	Compound based on coconut oil and beets, e.g. sugar beet. May cause skin irritation.
Coconut acid	Surfactant Skin cleanser	Compound found in coconut oil. Used widely in soaps and shampoos. Very good skin cleanser. May cause skin irritation.
CI number	Colouring pigment	Many colouring pigments can be used. Each is registered and given a number.
Colophonium		This is a resin obtained from pine trees. Used to give colour – usually yellow-orange.
Cucumis melo (Latin)		Melon extract – usually juice. Used in products for dry hair to improve skin condition.

Hair: Lesson 1: Cosmetics Ingredients Database cont.

Name[1]	Chemical type	Description and additional information
Dandruff		Human skin flakes produced most often on the scalp. Skin and allergy specialists disagree about its cause – could be an allergic reaction. Shampoos to treat this use zinc pyrithione and a surfactant.
DEA (Diethanolamine)	Emulsifier Humectant Surfactant Solvent	This compound is found in coconut and soybean oils and is used to make other substances. Has useful properties but may cause skin irritation. Can be contaminated with cancer-causing compounds called nitrosamines during manufacture.
DMDM hydantoin	Preservative	'DMDM' stands for 'dimethylol dimethyl'. Can irritate the skin. See Preservatives.
Dimethicone	Oil	Protects skin, forming a barrier to other liquids.
Dipropylene glycol		See Glycols.
Disodium dityrylbiphenyl disulfonate	Colouring agent	This gives colour to the product. Its use is banned in the USA.
Disodium EDTA	Preservative	'EDTA' stands for 'ethylenediaminetetraacetic acid'.
Disodium laureth sulfosuccinate	Surfactant	See Surfactants.
Disodium PEG-4-Cocoamido MIPA sulfosuccinate	Surfactant	See Surfactants. 'PEG' stands for 'polyethylene glycol' and 'MIPA' stands for 'monoisopropanolamine'.
Disodium phosphate	Salt	See Sodium phosphate.
Distearyl ether	Skin softener	This is made from stearic acid. See Stearic acid and Skin softeners.
Elaesis guineensis	Oil	Palm kernel oil obtained from the African palm tree.
Emulsifier		Substance added to help make an emulsion. An emulsion is the mixture of two liquids that do not usually mix together, such as oil and water. The emulsifier helps to keep the two liquids mixed, stopping layers forming.
Ethyoxydiglycol	Solvent	Non-toxic and not irritating.
Film former		Compounds giving cosmetic products a film-like appearance – shiny, glossy and with a silky feel.
Formaldehyde	Preservative disinfectant	Highly toxic substance causing skin irritation. Use in cosmetics is banned in Japan and Sweden. Concentration must be less than 0.2%. See Preservatives.
Glucosides	Thickening agent	Compounds made in reactions between sugars and alcohol.
Glycerin	Solvent humectant Skin softener	Also called 'glycerol'. A compound made during soap manufacture. Very widely used. Non-toxic and not irritating to skin.
Glyceryl cocoate		See Coconut oil and Glycerin.
Glycols	Humectants	Name is from 'Glycerin' and 'Alcohol'. See Humectants. May cause skin irritation.

Hair: Lesson 1: Cosmetics Ingredients Database cont.		
Name[1]	**Chemical type**	**Description and additional information**
Glycol distearate/stearate		See Stearic acid.
Guar hydroxypropyltrimonium chloride	Preservative surfactant Antiseptic	Can be toxic. May irritate the skin when used in concentrated solutions. Concentrations as low as 0.1% can Irritate the eye.
Hammamelis virginiana	Skin anaesthetic Skin freshener	Common name is 'witch hazel'. Obtained from a plant. Makes the skin feel 'tight' and fresh as it dries up grease and moisture.
Hexylene glycol		See Glycols.
Helianthus annus	Oil	Sunflower seed oil. Contains Vitamin E, which is thought to help keep skin looking young. Used in anti-aging products. No known toxicity.
Humectant		A substance used to preserve moisture content.
Humulus lupulus	Perfume	From the hop plant. Hops are used in brewing beer. Can cause skin irritation.
Hydroxypropylmethylcellulose		See Cellulose gums.
Isopropyl myristate		A compound made in a reaction between an acid and an alcohol. Used to form lather. Causes blackheads and is being removed from cosmetics.
Lactic acid	Skin freshener	See Carboxylic acids. Corrosive in concentrated solutions. May sting sensitive skin.
Lanolin		Greasy substance from wool that absorbs water and holds it on to the skin. Can cause skin irritation.
Laureth number 1-23	Surfactant	See Surfactants.
Laureth 11 carboxylic acid	Acid	See Carboxylic acids.
Lauric acid	Foam maker Acid	Compound that reacts with water to make a foam. The molecules are made from 10 carbon atoms joined in a line, with hydrogen atoms and oxygen atoms. See also Carboxylic acids.
Lauryl glucoside	Surfactant	See Surfactants.
Magnesium nitrate	Salt	See Nitrates.
Magnolia biondii	Perfume	Non-toxic perfume from the magnolia tree.
Maleated soybean oil	Preservative oil	Soybean oil from the soya bean plant that has been partially changed to maleic acid. Maleic acid is a carboxylic acid (see Carboxylic acids). The change is made to reduce the effects of soybean oil on the skin – these include skin irritation, hair damage and acne-like pimples.
Menthol	Skin anaesthetic Skin freshener	Gives a 'cool' feeling to the skin. Acts as an anaesthetic when in 100% concentration. Non-toxic below 3%.
Methyl lactate	Skin freshener	See Menthol and Lactic acid. This is a compound made from these two substances.

Hair: Lesson 1: Cosmetics Ingredients Database cont.		
Name[1]	**Chemical type**	**Description and additional information**
Methylchloroisothiazolinone (MCT) and Methylisothiazolinone (MIT)	Preservatives	Usually used with methylisothiazolinone. Both are toxic and can cause skin irritation. Safe in very low concentrations in shampoos that rinse off the skin.
Methyldibromo glutaronitrile	Preservative	Toxic substance absorbed through the skin. Safe to use in rinse-off products.
Methylparaben	Preservative	See Parabens.
Mica	Solid powder Lubricant	Used to give a glow or colour. Not irritating to skin.
Niacinamide	Vitamin B	Used to treat skin diseases. No known toxicity or irritating properties.
Nitrates	Salt	Used to help keep colour compounds (see CI number) the correct shade.
Olea europaea	Oil	Olive oil, obtained from olives. The same oil can be used in cooking. May cause skin irritation.
Palm kernel acid	Acid Oil Surfactant Emulsifier	This is the oil from the palm nut produced by the palm tree. See Surfactants, Emulsifiers
Palmitic acid	Acid Oil	Compound occurring naturally in many animal fats and plant oils including cow's milk, palm nuts and butter. Each molecule has 16 carbon atoms arranged in a long chain, with hydrogen and oxygen atoms. See Carboxylic acid.
Panthenol	Skin softener Vitamin B complex	Widely used in hair products. Also known as Vitamin B complex factor. Is good for the body and non-toxic.
Panthenyl ethylether		This is made from panthenol (see above).
Parabens	Preservatives	Most commonly used ingredient other than water. Used in low concentrations so will be found at the ends of ingredients lists. These compounds stop bacteria growing in the product and are not irritating or toxic. Some claims are made that parabens may be cancer causing.
Paraffinium liquidium	Skin softener	Liquid paraffin obtained from wood, coal and petroleum. Non-toxic and not irritating to skin.
Parfum		This is the general name given to 'fragrance'. This could mean one or more compounds added to give the product an attractive smell.
PEG (polyethyleneglycol)	Binder Skin softener Solvent Humectant	See Binders, Surfactants, Skin softeners, Solvents, Humectants.
PEG 6 caprylic/capric glycerides	Skin softener	See Skin softeners.
PEG 7 glycerylcocoate	Skin cleanser	Non-toxic and not irritating to skin.
PEG 40 hydrogenated castor oil		See PEG and castor oil.
PEG 150 distearate	Skin cleanser	Compound made from stearic acid and PEG.

Hair: Lesson 1: Cosmetics Ingredients Database cont.		
Name[1]	**Chemical type**	**Description and additional information**
PEG 200 hydroxyglycerylpalmitate	Skin cleanser	Non-toxic and not irritating to skin.
Petrolatum	Skin softener	This is the main ingredient in Vaseline and other petroleum jelly products. Used as skin softener, and protects skin from irritation.
Phenoxyethanol	Antiseptic	Not irritating to skin, but can irritate eyes above 2.2% concentration.
Polyquaternium 1-14	Antiseptic Surfactant Preservative	These compounds can be toxic and irritating to skin even at low concentrations.
Polysorbates 1-85	Emulsifier	See Emulsifiers. Non-toxic and not irritating to skin.
PPG 9 laurate	Preservative	PPG stands for 'Polypropylglycol'. A compound made from a glycol and lauric acid.
Preservative		Compound used to stop bacteria and other microorganisms, e.g. yeasts, from growing in the product. This is essential to keep the product safe for use. Preservatives keep the product colour, appearance and texture. All cosmetics include preservatives. Most used today are non-toxic.
Propylene glycol	Humectant solvent Wetting agent	Also called 1,2-propanediol. This is a widely used cosmetic ingredient with similar properties to glycerin. It is toxic and its use is being phased out.
PVP/dimethylaminoethyl-methylacrylate copolymer	Film former Thickener	See Film former and Thickener. A polymer is a compound made from many smaller molecules joined together. Many copies of small molecules called polyvinylpyrrolidone (PVP) and dimethylaminoethylmethacrylate are joined in an alternating line to make one long molecule.
Saccharum officinarium (Latin)		Sugar cane extract. Also called 'Black strap molasses'. No use in cosmetics identified.
Salt		The general name for a compound produced in a reaction between an acid and an alkali. The other product is water. 'Salt' here means 'sodium chloride', but this is not the chemical meaning.
Sequestering agent		Preservative that prevents changes in colour, texture or appearance.
Skin cleanser		Compound removing grease from the skin.
Skin freshener		Compound creating a 'tight' feeling to the skin. Usually evaporates quickly from the skin, giving a cooling effect.
Skin softener		Compound absorbed into the skin and replaces moisture. Helps to remove dry patches. Also called 'emollients'.
Sodium benzoate	Preservative	Non-toxic.
Sodium C12-13 pareth sulfate	Salt, Skin softener, Humectant	Compound based on PEG.
Sodium citrate	Sequestering agent	Non-toxic.

Hair: Lesson 1: Cosmetics Ingredients Database cont.

Name[1]	Chemical type	Description and additional information
Sodium chloride Salt	Salt Antiseptic	May cause drying of the skin. May cause skin irritation.
Sodium cocoyl isethionate	Skin cleanser	Safe in concentration up to 50% in rinse-off products.
Sodium isethionate	Alkali emulsifier	This is the name cosmetic producers use for sodium hydroxide. This is toxic and corrosive.
Sodium lauroamphoacetate	Surfactant	See Surfactants.
Sodium laureth sulfate	Water softener Surfactant Skin cleanser	Can cause skin and eye irritation in high concentrations. See Surfactants, Water softeners, Skin cleansers.
Sodium lauryl sulfate	Emulsifier surfactant	See Surfactants and Emulsifiers. May cause drying of skin by removing grease. May be irritating to skin.
Sodium methyl paraben	Preservative	See Parabens.
Sodium palm kernelate	Salt Soap	Compound produced by reacting palm kernel acid with sodium hydroxide. Acts as a soap.
Sodium palmitate	Salt Soap	Compound produced by reacting sodium hydroxide with palmitic acid. Acts as a soap.
Sodium peanutate		Peanut oil.
Sodium phosphate	Salt	Compound used to keep pH constant. Non-toxic and not irritating.
Sodium stearate	Salt Soap	Compound produced by reacting sodium hydroxide with stearic acid. Acts as a soap.
Sodium styrene/acrylates copolymer	Binder Film former	May cause skin irritation.
Sodium tallowate	Salt	Compound formed from tallow, a mixture of animal fats.
Solvent		Liquid used to make solutions. Solid substances are added to the solvent. These dissolve, making the solution.
Sorbic acid	Preservative Humectant	Produces velvet-like feel on the skin. Non-toxic, but may cause irritation to sensitive skins.
Stearic acid	Acid	Naturally occurring compound found in butter, animal fats and oils. Molecule has 18 carbon atoms arranged in a long chain, bonded to hydrogen and oxygen atoms. Widely used cosmetic ingredient.
Sulfonated oils	Emulsifier Wetting agent	Removes colour from natural and dyed hair. May cause drying of the skin.
Surfactants		Compounds that lower the surface tension of water. The name 'surfactant' comes from 'surface active'. There are four types: anionic, cationic, amphoteric and nonionic. The type depends on whether the surfactant molecule breaks up into charged particles called 'ions' in water. Found in all substances used for washing hair.
TEA dodecylbenzenesulfonate	Emulsifier	See Sulfonated oils.
Tetrasodium EDTA	Preservative	Prevents colour, texture and appearance changes. See EDTA.

Hair: Lesson 1: Cosmetics Ingredients Database cont.		
Name[1]	**Chemical type**	**Description and additional information**
Tetrasodium etidronate	Thickener	Compound added to make the product less 'runny'.
Titanium dioxide	Pigment	White compound used to make an opaque product. Not irritating to skin.
Tocophenylacetate	Antioxidant	Prevents oxygen in the air reacting with compounds in the product.
Trideceth-7		See PEG and Glycols.
Triclocarban	Antiseptic	Used to kill bacteria in 'medicated' products.
Triclosan	Antiseptic	Used to kill bacteria in 'medicated' products.
Trimethylopropane tricaprylate/ tricaprate	Perfume	Used to help make product smell attractive. Occurs naturally in sweat, cow and goat milks, coconut oil and palm oil. Non-toxic.
Water softener		Compound added to remove calcium and magnesium ions that cause 'hard' water and prevent a lather forming with soap.
Wetting agent		A compound that dissolves in water and helps to make water spread across a surface by lowering surface tension. This means the same as surfactant, but in cosmetics seems to be used to describe different compounds.
Zinc pyrithione/pyridinethione	Anti-dandruff substance	Added to shampoos to treat dandruff (see Dandruff). Some evidence that this can damage nerves.
Zinc sulfate	Salt Skin freshener	Compound made in the reaction between sulfuric acid and zinc metal. May cause skin irritation.

Activity C: Hair

1. What is hair?

Our bodies are covered with hair. Most hairs are fine, short and cannot be seen. Hair is not alive. Hair is made by living cells buried in the skin. When we think of 'hair' we usually mean thick hair that keeps our heads warm. On average, a human head is covered with 100 000 hair fibres. Hair is made from a protein called 'keratin'. The same protein makes human nails and is found in claws, hooves, feathers and fur on the bodies of other animals.

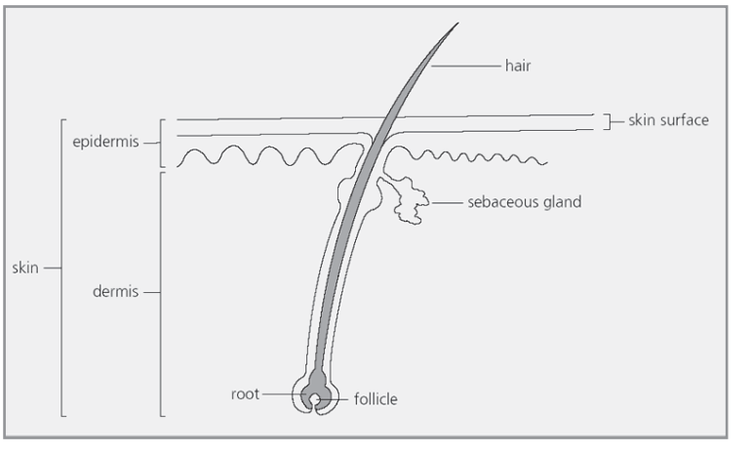


Figure 1: A hair on a human head.
Source: *Contemporary Chemistry for Schools and Colleges*, Royal Society of Chemistry, 2003.

Each head hair has three layers made of keratin:

- **Inner:** This has a honeycomb like structure.
- **Middle:** This is the bulkiest part of hair fibre. It is coloured.
- **Outer:** This is a thin layer called the **cuticle**. The cuticle protects the hair fibre. Under the microscope, the cuticle looks scaly and has overlapping layers.

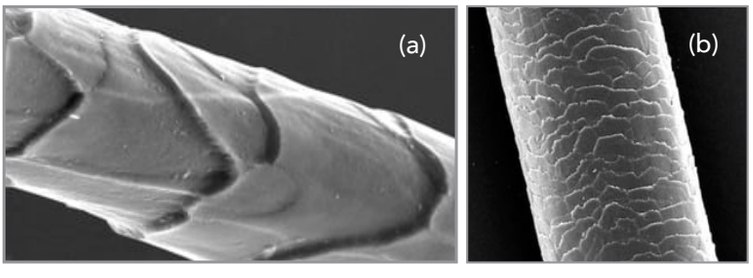


Figure 2: Hair cuticle (a) high resolution (b) low resolution
Source: hair cuticle structure image creative commons - Bing images

2. How does hair grow?

Hair fibres grow from a living root in a sac under the skin called a 'follicle'. Follicle cells multiply, are pushed upwards by those underneath and fill up with keratin. Some cells harden and die. These make the cuticle that coats the keratin fibres. Glands, called sebaceous glands, near the base of the hair follicle produce 'sebum', an oily substance. This makes the hair shiny, keeps the cuticle scales flat and stops hair fibre drying out.

What to do: Read the information then highlight or underline:

- How many hairs are on a human head.
- The name of the protein hair is made from.
- Whether hair is alive or dead.
- What is sebum?

Complete this table from the information above:

Hair fibre layer	Made of keratin?	Structure / colour
Inner		
Middle		
Outer		

3. Why do we wash our hair?

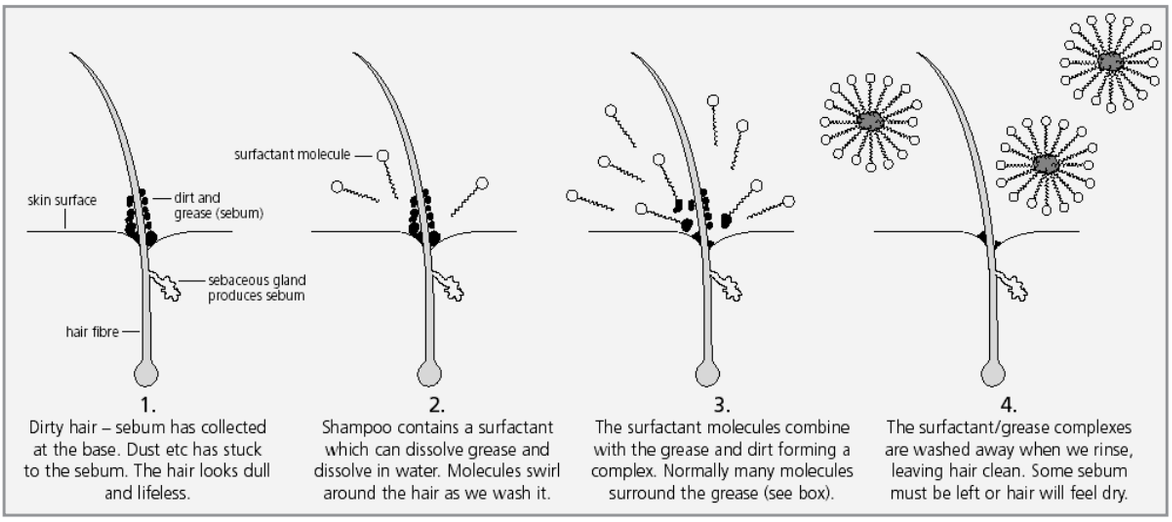
We wash hair when it gets dirty. Dirty hair feels sticky and unpleasant. Unwashed hair smells unpleasant. Some people think that hair will wash itself if left unwashed – this is not true! Dirt from our bodies is made from grease and dead skin cells. Grease comes from the sebaceous glands. Dead cells come from the scalp and cuticle. Dirt from the outside world can be dust, smoke, chemicals (e.g. from a swimming pool) and anything else from the environment that contacts our hair. Dirt is around 5% of hair mass.

- Highlight or underline three things that make hair dirty.
- Explain why we need to wash our hair.

4. Washing hair – how does shampoo work?

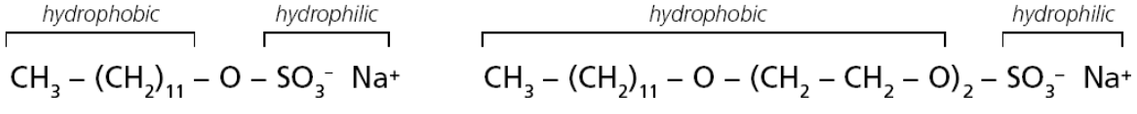
Shampoos are excellent cleaners. Typically, the surface area of head hair to clean is 2 – 4 m^2. This area only needs a small amount of shampoo, about the size of a 10p piece. The chemical in shampoo that cleans hair is a surfactant. Surfactant means 'surface active' chemical. The diagrams show how a surfactant works.

Figure 3: How a surfactant works on hair.



The surfactant strips away grease and dirt. If the surfactant is too efficient, hair will have no natural oil (sebum). This will cause hair to be dry. Makers choose surfactants carefully to balance cleaning ability with caring for the hair and scalp.

Popular surfactants in shampoo are sodium lauryl sulfate and sodium laureth sulfate. The molecular structures of these two compounds are:



Sodium lauryl sulfate *Sodium laureth sulfate*

The surfactants are salts. The hydrophilic end dissolves in water. The long hydrophobic end surrounds the dirt and grease, forming a globule. Rinsing hair removes the surfactant/dirt globule, leaving clean hair. Sodium laureth sulfate is gentler on the skin than sodium lauryl sulfate. This may be because as a slightly larger molecule it does not get into skin pores easily.

5. Making hair manageable and shiny

Chemists make mixtures called 'conditioners'. Chemicals in conditioners contain silicon atoms. An example is 'dimethiconol'. Conditioners stick to hair fibres,

making a water-resistant coating. When hair is dried, conditioners make hair feel smooth and slippery. Hairdressers say this makes hair more 'manageable'. Hair shines when light reflects off hair fibres. Smooth surfaces reflect light more evenly. To make hair smooth, cuticle scales must lie flat. If the cuticle is rough, light is not reflected evenly and hair will not shine. Another way of making hair shiny is to use a shampoo with a slightly acidic pH. Traditionally, rinsing hair in vinegar or lemon juice made it shine.

What to do

- Using all the information provided, decide if the statements in the table are true, false, or if you are not sure. Put one tick in the table for each statement.

Statement	True	False	Not sure
Oil in hair washes it naturally so we don't need shampoo			
Dirt in hair can be cells, dust, chemicals and smoke			
A 10p piece-sized amount of shampoo cleans 2 – 4 m^2 of hair			
Dry hair is caused by using too much shampoo			
Surfactants are acidic salts			
Grease and dirt dissolve in shampoo			
Conditioners contain silicon			
Greasy hair doesn't shine			
Vinegar or lemon juice can be a natural conditioner			

- Discuss advantages and disadvantages of modern liquid shampoos. Think about:
  1. Are they good for the environment?
  2. Where do the chemicals that make up shampoos come from?
  3. How does having hair in good condition make us feel?