

Curriculum Links

Activity 1D – Biodiesel production

The Department for Education is conducting a review of the primary and secondary National Curriculum. The links below relate to the statutory programmes of study for science in the National Curriculum, 2007 and specific sections of common science qualifications offered in UK schools.

Key stage 3

1.1 Scientific thinking

b. critically analysing and evaluating evidence from observations and experiments.

1.2 Applications and implications of science

a. exploring how the creative application of scientific ideas can bring about technological developments and consequent changes in the way people think and behave.

2.1 Practical and enquiry skills

Pupils should be able to:

- use a range of scientific methods and techniques to develop and test ideas and explanations
- assess risk and work safely in the laboratory, field and workplace
- plan and carry out practical and investigative activities, both individually and in groups.

3.1 Energy, electricity and forces

a. energy can be transferred usefully, stored, or dissipated, but cannot be created or destroyed

3.2 Chemical and material behaviour

a. the particle model provides explanations for the different physical properties and behaviour of matter

b. elements consist of atoms that combine together in chemical reactions to form compounds

c. elements and compounds show characteristic chemical properties and patterns in their behaviour.

3.4 The environment, Earth and universe

c. human activity and natural processes can lead to changes in the environment.

Key stage 4

1 How science works

1.2 Practical and enquiry skills

Pupils should be taught to:

a. plan to test a scientific idea, answer a scientific question, or solve a scientific problem

c. work accurately and safely, individually and with others, when collecting first-hand data

d. evaluate methods of collection of data and consider their validity and reliability as evidence.

1.4 Applications and implications of science

Pupils should be taught:

a. about the use of contemporary scientific and technological developments and their benefits, drawbacks and risks

b. to consider how and why decisions about science and technology are made, including those that raise ethical issues, and about the social, economic and environmental effects of such decisions

2.2 Chemical and material behaviour

In their study of science, the following should be covered:

a. chemical change takes place by the rearrangement of atoms in substances

b. there are patterns in the chemical reactions between substances

c. new materials are made from natural resources by chemical reactions

d. the properties of a material determine its uses.

2.3 Energy, electricity and radiations

In their study of science, the following should be covered:

a. energy transfers can be measured and their efficiency calculated, which is important in considering the economic costs and environmental effects of energy use

2.4 Environment, Earth and universe

In their study of science, the following should be covered:

a. the effects of human activity on the environment can be assessed using living and non-living indicators

b. the surface and the atmosphere of the Earth have changed since the Earth's origin and are changing at present

Curriculum Links

AQA Chemistry GCSE and Science GCSE

Unit C1.4 Crude oil and Fuels C1.4.3 Hydrocarbon fuels

e) Biofuels, including biodiesel and ethanol, are produced from plant material. There are economic, ethical and environmental issues surrounding their use.

C1.6 Plant oils and their uses C1.6.1 Vegetable oils

Biodiesel fuel can be produced from vegetable oils.

a) Some fruits, seeds and nuts are rich in oils that can be extracted. The plant material is crushed and the oil removed by pressing or in some cases by distillation. Water and other impurities are removed.

Additional guidance:

Knowledge of the details of the production of biodiesel is **not** required.

Suggested ideas for practical work:

- simple calorimetry investigations using small spirit burners or bottle tops to measure the energy released from various oils (weigh before and after, and measure the temperature change for a known mass of water)
- using bromine water to test fats and oils for unsaturation, eg testing sunflower oil against butter (using colorimeter to measure level of unsaturation).

AQA Science B GCSE

3.4.2.2 Fuels for cooking, heating and transport

Candidates need to understand that:

The chemical energy in hydrocarbons is released when they are burned in air, which makes them useful as fuels. Crude oil is an important source for a range of other fuels used for cooking and heating in our homes and for transport. Environmental scientists are concerned about the use of fuels obtained from crude oil for cooking, heating and transport.

Candidates need to:

1. Name suitable fuels for cooking, heating our homes and for providing transport.
2. Know that hydrocarbons contain carbon and hydrogen only.
3. Explain some of the problems of burning fossil fuels (pollution, carbon dioxide production and global warming) and that resources of fossil fuels are finite.

Within this context, candidates should be able to use scientific data and evidence to discuss, evaluate or suggest implications of the following:

- the social, economic and environmental impacts of the uses of fuels obtained from crude oil for cooking, heating and transport
- the energy content of different fuels.

Additional guidance

1. Suitable fuels include natural gas, petrol, diesel, kerosene (paraffin) and heating oil.

3.4.2.3 Generation and distribution of electricity

Candidates need to:

1. Define the terms renewable and non-renewable in the context of energy sources.
2. Know that fossil fuels (natural gas, oil and coal) release energy when they are burned, which can be used to generate electricity for our homes.
3. Explain how nuclear fuels and renewable energy sources (wind, solar, hydroelectric, wave, tidal, biomass and geothermal) may be used as alternatives to fossil fuels.
5. Explain the problems of using nuclear fuels (problems of radioactive emissions, disposal of waste) and of using renewable energy sources (unreliability and possible effects on the environment).

Within this context, candidates should be able to use scientific data and evidence to discuss, evaluate or suggest implications of the following:

- the environmental impact over time of energy production by comparing the advantages and disadvantages of using alternative energy sources
- the economic impact of using alternative energy sources

Curriculum Links

Suggestions for practical work

- Test oil fractions for viscosity, ease of ignition and sootiness of flame.
- Compare the energy content of different fuels, for example, by heating a fixed volume of water.
- Test the products of combustion of fuels to show that carbon dioxide is produced.

AQA Environmental Science GCSE

A2.4 What alternative energy technologies are available?

Scientists have developed alternative technologies to harness energy from sources other than fossil fuels. Environmental scientists use their knowledge to assess these alternatives for their efficiency and potential environmental impact.

Scientists have also developed methods of electricity generation from renewable resources that may be used instead of fossil fuels.

Candidates should know and understand that:

- renewable energy resources are usually sustainable:
- not depleted by use including wind power
- capable of rapid replacement including biofuels
- most renewable energy resources:
- use kinetic energy to turn generators, which produce electricity (exceptions include solar water heating, photovoltaics, geothermal and biofuels)
- usually need larger areas than thermal power stations to yield the same amount of energy
- may be unreliable or cannot provide a constant supply of energy
- may detract from the appearance of a land/seascape (A1)
- may affect wildlife populations or habitat (B1)

Agricultural scientists have developed plant crops, together with the use of animal and plant waste to produce renewable biofuels.

Candidates should know and understand that:

- biofuels, eg biogas, bioethanol, biodiesel, are also renewable and can:
 - be burned to produce heat but release carbon dioxide
 - be used as vehicle fuel
 - be 'carbon neutral' or 'green' as carbon dioxide taken out of the air by photosynthesis when energy crops grow is returned when the fuel is burnt so that no extra is added to the atmosphere (B2)
 - be a waste product eg from sewage plants, poultry farms (A1)
 - be environmentally damaging when land is cleared, and biodiversity (B1) and food-producing farmland are lost (A1)
 - *have a lower energy density than fossil fuel*

Environmental scientists use their knowledge of chemistry, physics and biology to consider both the advantages and disadvantages of various energy resources. They consider a number of factors before making conclusions and recommendations.

Candidates should be able to:

- describe: biofuels
- in terms of:
 - efficiency
 - predictability
 - intermittency
 - energy density*
 - potential environmental impact including:
 - emissions to air/water
 - mining/quarrying land take
 - disturbance to sediment patterns/water flow
 - hazardous waste
 - disruption of wildlife
 - noise/radio disturbance
 - loss of landscape value

Opportunities to investigate using scientific knowledge and skills:

- the amount of energy produced by different vegetable oils/alcohols
- the rise in temperature in a compost heap over time
- public attitudes towards different energy producing technologies

Curriculum Links

OCR Physics and Science A 21st Century GCSE

Module P3: Sustainable energy, P3.1 How much energy do we use?

2. recall the main primary energy sources that humans use: fossil fuels (oil, gas, coal), nuclear fuels, biofuels, wind, waves, and radiation from the Sun

OCR Biology B Gateway GCSE

Module B6: Beyond the Microscope Item B6d: Biofuels

Assessable learning outcomes both tiers: standard demand

Describe the advantages of using biofuels, to include:

- alternative sources to fossil fuels
- no increase in greenhouse gas levels

Recall that a mixture of petrol and alcohol:

- is called gasohol
- is used for cars in countries such as Brazil.

Assessable learning outcomes Higher Tier only: high demand

Explain why the burning of biofuels does not cause a net increase in greenhouse gas levels if:

- they are burnt at the same rate as the biomass is being produced
- areas of land are not cleared of other vegetation in order to grow crops for biofuels.

Explain how, in some areas, the use of large areas of land to produce biofuels is resulting in:

- habitat loss
- extinction of species.

Understand why gasohol is more economically viable in countries that have ample sugar cane and small oil reserves.

Edexcel Biology GCSE

Unit B3: Using Biology Topic 3 Biotechnology

3.19 Demonstrate an understanding of the advantages and disadvantages of replacing fossil fuels with biofuels, including the facts that biofuels are renewable and that their production uses carbon dioxide but that growing the crops to make them requires land and may affect the availability of land for growing food.

SQA Standard Grade Science

Topic 3: Energy and its Uses Renewable Sources of Energy

1 Fossil fuels and nuclear fuels are non-renewable, but waves, wind, hydroelectricity and the sun are renewable sources of energy.

2 As the stocks of fossil fuels are depleted these alternative sources of energy will become more important.

Credit Level

3 Other renewable sources of energy include sugar alcohol and geothermal heat.

In sugar-growing countries, sugar can be fermented into alcohol which can be used as a fuel.

4 There are advantages and disadvantages in the use of each alternative or renewable energy source, to include: cost, the technology involved, visual pollution, and reliability of the energy source.

Cambridge Physics iGCSE (with significant similarity to Coordinated and Combined Science iGCSE)

1. General physics 1.6 Energy, work and power 1.6 (b) Energy resources

- Distinguish between renewable and non-renewable sources of energy
- Give advantages and disadvantages of each method in terms of cost, reliability, scale and environmental impact

Curriculum Links

Key stage 5

AQA Biology A-level

Unit 1 BIOL1 Biology and disease

3.1.3 Glycerol and fatty acids combine by condensation to produce triglycerides.

OCR Biology A-level

3.2 AS Unit F212: Molecules, Biodiversity, Food and Health Module 1 Biological Molecules

Candidates should be able to:

- (p) compare, with the aid of diagrams, the structure of a triglyceride and a phospholipid;
- (q) explain how the structures of triglyceride, phospholipid and cholesterol molecules relate to their functions in living organisms;
- (r) describe how to carry out chemical tests to identify the presence of the following molecules: protein (biuret test), reducing and non-reducing sugars (Benedict's test), starch (iodine solution) and lipids (emulsion test);

OCR Chemistry A A-level

Candidates should be able to:

- (c) state that alkanes and cycloalkanes are saturated hydrocarbons;

Hydrocarbons as fuels

- (i) explain that the petroleum industry processes straight-chain hydrocarbons into branched alkanes and cyclic hydrocarbons to promote efficient combustion;
- (j) contrast the value of fossil fuels for providing energy and raw materials with:

How Science Works 6a, 7b:

Desirability of renewable fuels by 'rich' countries may lead to problems of food supply for countries supplying the 'crops for fuel'. (i) the problem of an over-reliance on non-renewable fossil fuel reserves and the importance of developing renewable plant based fuels, ie alcohols and biodiesel (see also 2.4.2)

4.1.3 Carboxylic Acids and Esters. Esters, triglycerides, unsaturated and saturated fats

How Science Works 7c:

Use of biodiesel as a fuel to increase contribution to energy requirements from renewable fuels.

- (f) describe a triglyceride as a triester of glycerol (propane-1,2,3-triol) and fatty acids;
- (g) compare the structures of saturated fats, unsaturated fats and fatty acids, including cis and trans isomers, from systematic names and shorthand formulae;
- (i) describe and explain the increased use of esters of fatty acids as biodiesel.

OCR Chemistry B Salters A-level

Unit F331: Chemistry for Life Developing Fuels. Organic functional groups

Organic functional groups

- (o) explain and use the terms: *aliphatic*, *aromatic*, *saturated* and *unsaturated*;

Applications

- (x) understand the benefits and risks associated with using fossil fuels and alternative fuels (biofuels, hydrogen, nuclear) and discuss the choices involved in making decisions about ensuring a sustainable energy supply.

Edexcel Chemistry A-level

Unit 4 General Principles of Chemistry I – Rates, Equilibria and Further 4.8 Further Organic Chemistry

4 Carboxylic acid derivatives c describe and carry out, where appropriate, the reactions of esters. iii their reaction with alcohols and acids to explain the process of trans-esterification and recall how it is applied to the manufacture of bio-diesel (as a potentially greener fuel)

Curriculum Links

SQA Chemistry Higher

Unit 2: The World of Carbon (i) Fats and oils

Natural fats and oils can be classified according to their origin as animal, vegetable or marine.

Fats and oils are esters.

The hydrolysis of fats and oils produces fatty acids and glycerol in the ratio of three moles of fatty acid to one mole of glycerol.

Glycerol (propane-1,2,3-triol) is a trihydric alcohol.

Fatty acids are saturated or unsaturated straight-chain carboxylic acids containing even numbers of carbon atoms ranging from C₄ to C₂₄, primarily C₁₆ and C₁₈.

Fats and oils consist largely of mixtures of triglycerides in which the three fatty acid molecules which are combined with each molecule of glycerol may or may not be identical.

SQA Biology: Advanced Higher Course

Unit: Cell and Molecular Biology. Structure and function of cell components

Lipids. Structure of glycerol, saturated and unsaturated fatty acids.

AQA Environmental Studies A-level

A2 Unit 3 – ENVS3 Energy Resources and Environmental Pollution 3.3.1 Energy

Renewable energy resources

Examples should be used to illustrate the factors affecting the ease of use of renewable energy resources and therefore their likely use in the future

Energy density: biofuels have medium energy densities

Ease of storage: Energy can be stored as potential energy of water in reservoirs and chemical energy in biofuels

Future energy supplies New technologies

New technologies may increase the amount of energy available for use by

- increasing the amount of energy available from existing energy resources
- allowing new resources to be exploited

Atmospheric pollution

- incomplete combustion of fossil fuels and biofuels

AQA Science in Society A-level

Unit 1 AS Exploring key scientific issues 3.1.3 Transport issues

Technical ways of reducing the impact of transport on local air quality and on greenhouse gases.

The advantages and disadvantages of different fuels, to include: fossil fuels, bio-fuels, fuel cells and hydrogen.

Fuels are valuable because they are concentrated sources of energy. There is a finite amount of fossil fuel (coal, oil, natural gas) on Earth. Other energy sources (wind, wave, biomass such as wood) are renewable.

They can be replaced in the same sort of time scale as they are used.

Unit 3 A2 Exploring key scientific issues 3.3.5 Energy futures The context

The context for this topic is the challenge of reconciling the growing demand for energy resources worldwide, especially the demand for electricity, with the policy imperative to cut down the emission of carbon dioxide and other greenhouse gases. People want the benefits of a readily available supply of electricity but must balance this against the cost of each method of generation and its environmental impact.

Renewable sources of energy are naturally and continually replenished; they include wind, solar power, geothermal, hydropower, and various forms of biomass.