

Curriculum Links

Activity 3C – Algae chromatography

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.

3.3 Organisms, behaviour and health

all living things show variation, can be classified and are interdependent, interacting with each other and their environment

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

1.1 Data, evidence, theories and explanations Pupils should be taught:

a. how scientific data can be collected and analysed

b. how interpretation of data, using creative thought, provides evidence to test ideas and develop theories

c. how explanations of many phenomena can be developed using scientific theories, models and ideas

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

b. collect data from primary or secondary sources, including using ICT sources and tools

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.

1.3 Communication skills Pupils should be taught to:

a. recall, analyse, interpret, apply and question scientific information or ideas

b. use both qualitative and quantitative approaches

c. present information, develop an argument and draw a conclusion, using scientific, technical and mathematical language, conventions and symbols and ICT tools.

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

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- 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
- c. how uncertainties in scientific knowledge and scientific ideas change over time and about the role of the scientific community in validating these changes.

2.1 Organisms and health In their study of science, the following should be covered:

- a. organisms are interdependent and adapted to their environments
- b. variation within species can lead to evolutionary changes and similarities and differences between species can be measured and classified
- c. the ways in which organisms function are related to the genes in their cells

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
- c. radiations, including ionising radiations, can transfer energy

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

AQA Biology GCSE

B2.3 Photosynthesis

f) Some glucose in plants and algae is used:

- to produce fat or oil for storage
- to produce cellulose, which strengthens the cell wall
- to produce proteins.

AQA Biology and Science GCSE

B1.5.1 Energy in biomass

a) Radiation from the Sun is the source of energy for most communities of living organisms. Green plants and algae absorb a small amount of the light that reaches them. The transfer from light energy to chemical energy occurs during photosynthesis. This energy is stored in the substances that make up the cells of the plants.

B1.6.2 The carbon cycle

a) The constant cycling of carbon is called the carbon cycle.

In the carbon cycle:

- carbon dioxide is removed from the environment by green plants and algae for photosynthesis
- the carbon from the carbon dioxide is used to make carbohydrates, fats and proteins, which make up the body of plants and algae
- when green plants and algae respire, some of this carbon becomes carbon dioxide and is released into the atmosphere

AQA Biology, Science and Additional Science GCSE

B2.3 Photosynthesis

Green plants and algae use light energy to make their own food. They obtain the raw materials they need to make this food from the air and the soil. The conditions in which plants are grown can be changed to promote growth.

Candidates should use their skills, knowledge and understanding to:

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- interpret data showing how factors affect the rate of photosynthesis
- evaluate the benefits of artificially manipulating the environment in which plants are grown.

B2.3.1 Photosynthesis

a) Photosynthesis is summarised by the equation:

light energy

carbon dioxide + water → glucose + oxygen

b) During photosynthesis:

- light energy is absorbed by a green substance called chlorophyll, which is found in chloroplasts in some plant cells and algae
 - this energy is used by converting carbon dioxide (from the air) and water (from the soil) into sugar (glucose)
 - oxygen is released as a by-product.
- c) The rate of photosynthesis may be limited by:
- shortage of light
 - low temperature
 - shortage of carbon dioxide.

f) Some glucose in plants and algae is used:

- to produce fat or oil for storage
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AQA Science B GCSE

3.3.2.3 The importance of carbon

Candidates need to understand that:

Carbon is the basis of all organic molecules and is the major element within our bodies. The carbon cycle is the process through which carbon is cycled through the air, ground, plants, animals, and fossil fuels. Large amounts of carbon exist in the atmosphere as carbon dioxide (CO₂). Carbon dioxide is cycled by green plants and algae during photosynthesis to make organic molecules. Decomposers break down dead organic matter, and release carbon dioxide into the air. Carbon is also 'locked away' in fossil fuels such as coal, petroleum and natural gas.

Candidates need to:

1. Know that carbon dioxide is removed from the environment by green plants and algae for photosynthesis.
2. Know that the carbon from the carbon dioxide is used to make carbohydrates, fats and proteins, which make up the bodies of plants and algae.
3. Know that when green plants and algae are eaten by animals some of the carbon becomes part of the fats and proteins that make up their bodies.
4. Understand that when green plants, algae and animals respire some of this carbon becomes carbon dioxide and is released into the atmosphere.
5. Understand that when plants, algae and animals die, some animals and microorganisms feed on their remains and release carbon dioxide into the atmosphere when they respire.

AQA Physics and Science A GCSE

P1.4.1 Generating electricity

a) In some power stations an energy source is used to heat water. The steam produced drives a turbine that is coupled to an electrical generator.

Energy sources include:

- the fossil fuels (coal, oil and gas) which are burned to heat water or air
- biofuels that can be burned to heat water.

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AQA Chemistry 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.

AQA Biology and Science GCSE

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AQA Biology, Science and Additional Science GCSE

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AQA Science B

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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:

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- 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

OCR Additional Science B Gateway GCSE

Module C3: Chemical Economics Item C3g: Batch or continuous?

Assessable learning outcomes both tiers: standard demand

Suggested practical and research activities to select from

Practical extraction of a natural oil from a plant.

Recall that the raw materials for speciality chemicals such as pharmaceuticals can be either made synthetically or extracted from plants.

Describe how melting point, boiling point and thin layer chromatography can be used to establish the purity of a compound.

Assessable learning outcomes both tiers: standard demand

Describe how chemicals are extracted from plant sources:

- crushing
- boiling and dissolving in suitable solvent
- chromatography.

Interpret melting point, boiling point and chromatographic data relating to the purity of a substance.

OCR Science B Gateway GCSE

Module B2: Understanding Our Environment Item B2b: Energy flow

Summary: All living things need energy to live. Ultimately this energy comes from the Sun. This item explains how energy from the Sun flows through ecosystems and how humans can harness it. The work on energy transfer provides the opportunity to examine the ethical issues raised by decisions on plant use and the environmental effects of such decisions.

OCR Physics and Science A 21st Century GCSE

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

1. understand that the demand for energy is continually increasing and that this raises issues about the availability of energy sources and the environmental effects of using these sources
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
4. understand that power stations which burn fossil fuels produce carbon dioxide which contributes to global warming and climate change

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OCR Biology and Additional Science B Gateway GCSE

Module B4: It's A Green World Item B4b: Photosynthesis

Assessable learning outcomes both tiers: standard demand

Describe the conversion of glucose and starch to other substances in plants and their use:

- glucose for energy (respiration)
- cellulose for cell walls
- proteins for growth and repair
- starch, fats and oils for storage.

Assessable learning outcomes Higher Tier only: high demand

Explain why insoluble substances such as starch are used for storage:

- does not move away in solution from storage areas
- does not affect water concentration inside cells.

OCR Additional Applied Science GCSE

Topic B3: Agriculture Biotechnology and food

B3.5 Instrumentation to monitor and control processes

Microorganisms are affected by pH and temperature. Conditions in a bioreactor are monitored and controlled using control systems.

1. draw and interpret diagrams showing how pH and temperature can be monitored in a bioreactor using appropriate sensors and data logging software
2. interpret graphical displays of data logged during the monitoring of pH and temperature in a bioreactor
3. annotate and interpret a flow diagram to describe the monitoring of a bioreactor using a systems approach (input (sensor), processor, output (graphical or numerical display, alarm))
4. annotate and interpret a flow diagram to describe the control of a bioreactor (sensor, trigger voltage, comparator, processor, output)
5. understand the use of feedback in the automatic control of a bioreactor.

Edexcel Biology GCSE

Unit B3: Using Biology Topic 3 Biotechnology

3.2 Describe a fermenter as a vessel used to cultivate microorganisms for the production of biomolecules on a large scale

3.3 Explain the need to supply suitable conditions in fermenters, and the effect they have on growth rates, including:

- a aseptic precautions
- b nutrients
- c optimum temperature
- d pH
- e oxygenation
- f agitation

3.4 Investigate the effect of factors on the growth of yeast, including pH

- Investigate the effect of glucose concentration on rate of anaerobic respiration in yeast

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

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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.

Topic 4: A Study of Environments 1: Energy from the Sun for Living Things

1 All energy for living things comes from the sun.

2 Green plants use the sun's energy to make food.

General level

3 Green plants use the light energy from the sun to make food which is stored as starch.

SQA Standard Grade Biology

Topic 2: The World of Plants Sub topic C - Making food

suggested learning activities

12 Test leaves for starch.

13 Design and carry out investigations on the requirements for photosynthesis (need for chlorophyll, for light energy and for carbon dioxide).

Learning outcomes

General level

State that green plants make their own food which may be stored as starch.

State that green plants convert light energy to chemical energy using chlorophyll.

Describe the process of photosynthesis in terms of raw materials and products

Credit level

Describe the fate of carbon dioxide as structural and storage carbohydrates in plants and as energy sources.

Explain what is meant by a limiting factor and describe the main limiting factors in the process of photosynthesis.

SQA Standard Grade Chemistry

Topic 15: Carbohydrates and Related Substances

Cambridge 21st Century science iGCSE

Module P2: Radiation and life

P2.3 How does electromagnetic radiation make life on Earth possible?

2. recall that this radiation:

- provides the energy for photosynthesis

3. recall that photosynthesis removes carbon dioxide from the atmosphere and adds oxygen, and that this reverses the effect of respiration

Cambridge Agriculture iGCSE

General Agriculture

Candidates should be able to:

(a) describe different forms of land use, including different agricultural systems and farming practices

(b) describe and explain the ways in which the uses of land in different areas may be limited by topographical, climatic and other environmental factors;

(c) understand that population growth leads to a need for efficient use of land and farm planning;

(d) describe organic production, hydroponics and genetically modified (GM) crops and be able to discuss

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arguments for and against the use of GM crops and organic production;
(e) explain the principles of supply and demand, diminishing returns, opportunities and choices facing the farmer, decision-making based on understanding of economic factors

Principles of Plant Growth

(e) describe photosynthesis in terms of carbon dioxide, water, light and chlorophyll leading to the synthesis of carbohydrates and the production of oxygen;

Cambridge Biology iGCSE (with significant similarity to Coordinated and Combined Science iGCSE) Section II: Organisation and maintenance of the organism 6. Nutrition 6.2 Plant nutrition 6.2.1 Photosynthesis

Define *photosynthesis* as the fundamental process by which plants manufacture carbohydrates from raw materials using energy from light

- State the word equation for the production of simple sugars and oxygen
- Investigate the necessity for chlorophyll, light and carbon dioxide for photosynthesis, using appropriate controls
- Describe the intake of carbon dioxide and water by plants
- Explain that chlorophyll traps light energy and converts it into chemical energy for the formation of carbohydrates and their subsequent storage

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

Key stage 5

OCR Biology A-level

Module 3: Photosynthesis

Candidates should be able to:

- (a) define the terms *autotroph* and *heterotroph*;
- (b) state that light energy is used during photosynthesis to produce complex organic molecules;
- (c) explain how respiration in plants and animals depends upon the products of photosynthesis;
- (d) state that in plants photosynthesis is a two-stage process taking place in chloroplasts;
- (e) explain, with the aid of diagrams and electron micrographs, how the structure of chloroplasts enables them to carry out their functions;
- (f) define the term *photosynthetic pigment*;
- (g) explain the importance of photosynthetic pigments in photosynthesis;
- (h) state that the light-dependent stage takes place in thylakoid membranes and that the light-independent stage takes place in the stroma;
- (i) outline how light energy is converted to chemical energy (ATP and reduced NADP) in the light-dependent stage (reference should be made to cyclic and non-cyclic photophosphorylation, but **no** biochemical detail is required);
- (j) explain the role of water in the light-dependent stage;
- (k) outline how the products of the light-dependent stage are used in the light-independent stage (Calvin cycle) to produce triose phosphate (TP) (reference should be made to ribulose biphosphate (RuBP), ribulose biphosphate carboxylase (rubisco) and glycerate 3-phosphate (GP), but **no** other biochemical detail is required);

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- (l) explain the role of carbon dioxide in the light-independent stage (Calvin cycle);
- (m) state that TP can be used to make carbohydrates, lipids and amino acids;
- (n) state that most TP is recycled to RuBP;
- (o) describe the effect on the rate of photosynthesis, and on levels of GP, RuBP and TP, of changing carbon dioxide concentration, light intensity and temperature;
- (p) discuss limiting factors in photosynthesis with reference to carbon dioxide concentration, light intensity and temperature;
- (q) describe how to investigate experimentally the factors that affect the rate of photosynthesis (HSW3).

AQA Environmental Studies A-level

A2 Unit 3 – ENV53 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 GCE Science in Society

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.