

Microbiology in the Curriculum

(England, Wales & Northern Ireland)

The Qualifications and Curriculum Authority QCA (www.qca.org.uk) came into being in on the 1st October 1977. One of its many functions is to act as the regulatory body for public examinations and public qualifications. QCA has taken the lead in the design and development of the new National Qualifications Framework, within which the new and revised post 16 qualifications are located. It also defines the standards of quality assurance expected of awarding bodies.

The three new awarding bodies OCR (www.ocr.org.uk) , AQA (www.aqa.org.uk) and Edexcel (www.edexcel.org.uk) have replaced the old examining boards. They have produced new specifications which replace the previous syllabuses. These are QCA approved and fit the new National Qualifications Framework.

The information below gives a summary of microbiology in the curriculum at GCSE and Advanced Subsidiary GCE & Advanced GCE for the 3 awarding bodies OCR, AQA and Edexcel.

KEY STAGE 4/GCSE DOUBLE SCIENCE (14-16)

OCR Science double award specification A

PoS 2.2p

The defence mechanisms of the body, including the role of the skin, blood and mucous membranes of the respiratory tract.

Block 2.4 Breathing

5) Describe how the mucus-secreting cells and cilia help to keep the lungs clean and prevent infection.

Block 2.6 Transport - blood

10) Describe how blood along with the skin, acts as defence against infection, limited to:

- the skin and the formation of blood clots acting as barriers against infection.
- white cells protecting against infection either by engulfing microbes or by producing antibodies.

PoS 2.5f

The role of microbes and other organisms in the decomposition of organic materials and in the cycling of carbon and nitrogen.

Block 2.7 Ecology

Food chains and energy flow.

11) Describe the role of decomposers, such as bacteria and fungi, in the breakdown of organic matter released from food chains.

12) Explain how carbon is recycled in nature to include:

- soil bacteria and fungi, acting as decomposers, to release carbon dioxide into the air.

13) Explain how nitrogen is recycled in nature, to include:

- soil bacteria and fungi acting as decomposers, to convert proteins and urea into ammonia.
- the conversion of this ammonia to nitrites by nitrifying bacteria.
- the conversion of nitrates to nitrogen gas by denitrifying bacteria.
- the fixing of nitrogen gas by nitrogen-fixing bacteria living in root nodules or the soil.

KEY STAGE 4/GCSE (14-16) continued

PoS 3.2p

How the Earth's atmosphere and oceans have changed over time.

Block 3.7 Earth cycles

6) Recall that ammonia in the early atmosphere was removed by:

- nitrifying bacteria, which changed the ammonia into nitrates.
- conversion into nitrogen by denitrifying bacteria.

OCR Science double award specification B

PoS 2.2p

The defence mechanisms of the body, including the role of the skin, blood and mucous membranes of the respiratory tract.

Module title Health in the balance (higher tier)

Explain how the ciliated cells and mucus in the breathing system combine to trap air-borne particles and prevent infection.

Explain that each disease organism has its own antigens and that specific antibodies are needed.

Explain the process of immunization:

- harmless form of the disease organism given.
- harmless form still carries antigens.
- antigens trigger immune response - antibody production.
- immunity remains.

PoS 2.5f

The role of microbes and other organisms in the decomposition of organic materials and in the cycling of carbon and nitrogen.

Module title Ecology (higher tier)

Explain the effects of changing temperature, and the amounts of oxygen and moisture on the rate of decay:

- effect on microbial respiration.
- effect on growth of micro-organisms.

Describe the cycling of carbon and nitrogen made possible by the activity of microbes and other living things:

- carbon cycle (to include the role of soil organisms).
- nitrogen cycle (to include decay, the roles of nitrifying, denitrifying and nitrogen fixing bacteria).

OCR Science double award specification C

PoS 2.2p

The defence mechanisms of the body, including the role of the skin, blood and mucous membranes of the respiratory tract.

Health

1) Know the defences of the body against entry of microbes, including the role of the skin and white blood cells.

2) Know the role of white blood cells in fighting infection.

3) Know how the mucous membranes of the respiratory tract protect against infection.

4) Understand that the immune system 'recognises' foreign bodies and creates antibodies which destroy them.

KEY STAGE 4/GCSE (14-16) continued

- 5) Understand why patients who have had infectious disease often have improved immunity to re-infection.
- 6) The role of immunization in establishing suitable antibodies in advance of infection.

PoS 2.5f

The role of microbes and other organisms in the decomposition of organic materials and in the cycling of carbon and nitrogen.

Energy and nutrient transfer

- 6) Understand that organic materials are often broken down by bacteria, which obtain nutrients from them.
- 7) Understand the main stages and processes of the nitrogen cycle.
- 8/9) Understand the main processes by which carbon dioxide is released into and removed from the atmosphere.

OCR Biology award specification

As per specification A with the following extension blocks

Extension option A

Block A3 Microbes and food

The place microbes have in our food supply today is the emphasis of this block. It explores food spoilage and how it can be avoided. The use made of micro-organisms in food manufacture is studied in some detail. The principles of genetically engineered enzymes are included along with the social and ethical issues surrounding genetic engineering in relation to food production.

Block A4 Microbes and disease

Both plant and animal diseases are considered in this block. Common diseases that affect populations are investigated. The development of antibiotics is followed by work on immunization.

Extension option B

Block B2 Microbes in action

This block studies microbes from different environments. Their uses to humans are explored through enzymes and antibiotics. The problems they cause are studied with regard to disease and how microbial growth may be prevented, slowed down or eradicated.

Block B4 Gene technology

A detailed study of DNA and the different forms of RNA and their role in protein synthesis. The procedures, uses and ethical implications of genetic profiling and engineering finish this block.

AQA Double Award specification B

Humans as organisms

Circulation

White blood cells have a nucleus. They form part of the body's defence system against microbes.

Diseases can be caused when micro-organisms such as certain bacteria and viruses enter the body:

- o bacterial cells consist of cytoplasm and a membrane surrounded by a cell wall; the genes are not in a distinct nucleus.

KEY STAGE 4/GCSE (14-16) continued

- viruses are smaller than bacteria; they consist of only a protein coat surrounding a few genes; they can only reproduce inside living cells.

Diseases are more likely to occur if large numbers of micro-organisms enter the body as a result of unhygienic conditions or contact with infected people.

The body has several methods of defending itself against the entry of micro-organisms:

- the skin acts as a barrier.
- the breathing organs produce a sticky liquid mucus which covers the lining of these organs and traps micro-organisms.
- the blood produces clots that seal cuts.

White blood cells help to defend against infective micro-organisms:

- by ingesting micro-organisms.
- by producing antibodies which destroy particular bacteria or viruses.
- by producing antitoxins which counteract the toxins released by the micro-organisms.

When people are vaccinated they are immunized against the disease by introducing a mild, or dead, form of the infecting organism into their bodies.

The white cells respond by producing antibodies. If the infective organism enters the body, antibodies are rapidly produced to destroy it.

Once they have produced antibodies against a particular bacterium or virus, white blood cells can quickly produce them again so that the person is immune to that disease.

Candidates should be able, when provided with appropriate information, to evaluate evidence relating living conditions and lifestyle to the spread of disease.

Controlling inheritance

Genes from the chromosomes of humans and other organisms can be 'cut out' using enzymes and transferred to bacterial cells. The transferred gene continues to make the same protein in the bacterial cell. By culturing the genetically engineered bacteria on a large scale, commercial quantities of the protein can be produced. This process is used in the manufacture of drugs and hormones, including human insulin.

Evolution

Evolution occurs via natural selection:

- individuals with characteristics most suited to the environment are more likely to survive and breed successfully.
- the genes which have enabled these individuals to survive are then passed on to the next generation.

Candidates should be able to explain how over-use of antibiotics can lead to evolution of resistant bacteria.

Human impact on the environment

Untreated sewage provides food for micro-organisms. This has the same effect (eutrophication) in water as dead vegetation.

Nutrient cycles

Living things remove materials from the environment for growth and other processes. These materials are returned to the environment either in waste materials or when living things die and decay.

Materials decay because they are broken down by micro-organisms.

KEY STAGE 4/GCSE (14-16) continued

Micro-organisms break down materials faster in warm, moist conditions.

Many micro-organisms are also more active when there is plenty of oxygen.

Micro-organisms are used:

- at sewage works to break down waste from humans.
- in compost heaps to break down waste plant products.

The decay process releases substances which other organisms need to grow.

In a stable community the processes which remove materials are balanced by processes which return materials. These materials are constantly cycled.

Carbon cycle:

- when plants and animals die, some animals and micro-organisms feed on their bodies; carbon is released into the atmosphere as carbon dioxide when these organisms respire.

Nitrogen cycle:

- when putrefying bacteria and fungi break down the waste products of animals and the protein from dead animals and plants, ammonium compounds are produced;
- nitrifying bacteria convert ammonium compounds to nitrates.

AQA Biology specification

As per AQA Double Award specification B plus the following

Controlling diseases

10.28 Treating infectious disease.

This section builds on the causative agents of disease.

Candidates should be able to describe Pasteur's evidence that decay and disease can be caused by living organisms.

Candidates should be able, when provided with additional information, to explain how the treatment of disease has changed as a result of increased understanding of the action of antibiotics and immunity.

Candidates should be able, when provided with appropriate information, to evaluate the advantages and disadvantages of being vaccinated against a particular disease.

Applied microbiology

10.30 Using micro-organisms to make food and drinks.

10.31 Growing micro-organisms in fermenters.

Edexcel Double Award specification A

Humans as organisms

Circulation

Understand the roles of the components of blood combating infection, including the ingestion of micro-organisms and the production of antibodies which destroy micro-organisms; blood clotting (to prevent blood loss and entry of micro-organisms).

KEY STAGE 4/GCSE (14-16) continued

Living organisms in their environment

Ecosystems

- describe the stages in the carbon cycle, including the roles of micro-organisms.
- describe the stages in the nitrogen cycle, including the role of nitrogen-fixing bacteria, decomposers, nitrifying bacteria and denitrifying bacteria (specific names of bacteria are not required).

Edexcel Biology specification A

As per Edexcel Double Award specification A plus the following:

B5 Micro-organisms and diseases in humans

Structure and reproduction of micro-organisms

The spread and control of disease

B6 Biotechnology

Fermentation

Gene technology:

- understand that sections of DNA coding for specific proteins can be transferred into micro-organisms, which are then cultivated in fermenters to produce useful substances such as human insulin.

Edexcel Double Award specification B

Module 1 The human body - action and control

The blood

Describe the function of blood in defence against infection:

- the white blood cells ingest bacteria and produce antibodies.

The skin

Describe the function of the skin in defence against infection:

- to include the outer layer of dead cells, the physical barrier to the environment and the role of the oil glands.

Module 7 Food production and the environment

Action of micro-organisms in ecosystems:

- describe how the process of decay is affected by the presence of micro-organisms.
- describe the carbon cycle including the role of micro-organisms.
- describe the nitrogen cycle and explain the roles of nitrogen-fixing bacteria, decomposers, nitrifying bacteria and denitrifying bacteria.

Edexcel Biology specification B

As per Edexcel Double Award specification B plus the following

Module 13 Micro-organisms and diseases in humans

Structure and reproduction of micro-organisms

The spread and control of disease.

Module 13 Biotechnology

Fermentation

Gene technology

- understand that sections of DNA coding for specific proteins can be transferred into micro-organisms, which are then cultivated in fermenters to produce useful substances such as human insulin.

ADVANCED SUBSIDIARY GCE & ADVANCED GCE (POST-16 QUALIFICATIONS)

The Advanced Subsidiary (AS) course was introduced in September 2000 for the award of the first qualification in August 2001. It may be used in one of two ways:

- as a final qualification, allowing candidates to broaden their studies and to defer their decisions about specialization.
- as the first half (50%) of an Advanced Level qualification, which must be completed before an Advanced Level award can be made.

The Advanced Level examination is in two parts:

- Advanced Subsidiary (AS) – 50% of the total award;
- A second examination, called A2 – 50% of the total award.

OCR Biology

Advanced Subsidiary GCE

5.2 Module 2803

Human health and disease

5.2.1 Introduction to health and disease

Content

- Definitions of the terms health and disease.
- Global patterns of disease distribution.

5.2.5 Infectious Diseases

Content

- Cholera, malaria, tuberculosis and AIDS
- Antibiotics

5.2.6 Immunity

Content

- The immune system.
- The role of vaccination in controlling disease.

Advanced GCE (A2)

5.6 Module 2805

Option 02 Applications of Genetics

5.6.4 Genetic engineering

Content

Recombinant DNA.

- The modification of organisms by genetic engineering.
- Ethical implications of genetic engineering.

5.8 Module 2805

Option 04 Microbiology and Biotechnology

5.8.1 Microbiology

Content

- Features of Viruses, Prokaryotae, Protoctista and Fungi.
- Structure and life cycle of a bacteriophage and a retrovirus.
- Structure and asexual reproduction of *Escherichia coli*.
- Gram staining as a method of the primary identification of bacteria.

POST 16 QUALIFICATIONS continued

5.8.2 Techniques used in microbiology and cell culture

Content

- Scientific and economic reasons for culturing micro-organisms and plant cells.
- *In vitro* growth requirements of bacteria, fungi and plant cells.
- Techniques used in the preparation and growth of micro-organisms and plant cells.
- Aseptic techniques.
- Specialist laboratory requirements.

5.8.3 Large-scale production

Content

- Batch and continuous culture of micro-organisms.
- Large scale production methods.
- Problems associated with large-scale production.

5.8.4 Biotechnology in food production

Content

- The production of novel genomes.
- The use of micro-organisms and enzymes in food production.
- Micro-organisms as a food source.
- Social, economic, ethical and environmental implications.

5.8.5 Biotechnology in medicine

- Monoclonal antibodies and their importance.

5.8.6 Biotechnology in industry and public health

- Biogas and gasohol.
- The treatment of domestic and industrial waste.

AQA Biology/Biology (human) specification A

Advanced Subsidiary GCE

Module 1 (*Biology and Human Biology*) Molecules, cells and systems

10.1 The cell is the basic unit of structure in prokaryotic and eukaryotic organisms

Content

- Eukaryotic cells.

10.2 The electron microscope and the technique of cell fractionation may be used to study ultrastructure

Content

- Electron microscopes.
- Cell ultrastructure.

Module 2 (*Biology only*) Making use of biology

11.1 Enzymes may be isolated from micro-organisms and have important applications in biotechnological processes

Content

- Isolation of enzymes.

11.4 Gene technology has many applications in a modern world

Content

- Recombinant DNA.

POST 16 QUALIFICATIONS continued

Module 3 (*Human Biology only*) Pathogens and disease

12.1 Bacteria and viruses are examples of pathogenic micro-organisms

Content

- Bacteria.
- Viruses.
- The association of micro-organisms with disease.

12.3 Mammalian blood possesses a number of defensive functions

Content

- Principles of immunology.
- Passive and active immunity.

12.6 Gene technology may be used in combating disease

Content

- Recombinant DNA.

12.9 Drugs are used in the control and treatment of disease

Content

- Antibiotics.
- Monoclonal antibodies.

Advanced GCE (A2)

Module 5 (*Biology and Human Biology*) Inheritance, evolution and ecosystems

14.4 Evolution has resulted in different species of organisms. They are classified into five kingdoms.

Content

- The five-kingdom classification.

14.9 Decomposition and recycling maintain the balance of nutrients in an ecosystem

Content

- Carbon and nitrogen cycles.

AQA Biology Specification B

Advanced Subsidiary GCE

Module 2 Genes and genetic engineering

11.4 Applications of gene technology

Content

- Genetically engineered micro-organisms.
- Genetic markers.
- Large scale culturing.
- Evaluation of genetic engineering.

Advanced GCE (A2)

Module 4 Energy, control and continuity

13.14 Classification

Content

- Principles of taxonomy.
- The five kingdoms.

POST-16 QUALIFICATIONS continued

Module 5 Environment

14.1 Materials are recycled in ecosystems

Content

- Nutrient cycles.

Module 7 Option Microbes and disease

15.7 Bacteria

Content

- Structure and function.
- Nutrition and binary fission.

15.8 Culturing bacteria

Content

- Aseptic techniques.
- Monitoring the growth of bacteria.
- Population growth patterns.

15.9 Commercial biotechnology

Content

- Screening procedures.
- Continuous and batch cultures.
- Useful products from micro-organisms.
- Isolated enzymes.
- Immobilised enzymes.

15.10 Bacterial disease

Content

- Pathogenicity.
- Transmission.

15.11 Viral disease

Content

- Characteristics of viruses.
- Transmission.
- How viruses cause disease.

15.12 Protection against disease

Content

- Natural defence mechanisms.
- The immune response.
- Cell-mediated immunity.
- Antibody-mediated immunity.
- Immunological memory.
- Vaccination.
- Passive immunity.
- Antibiotics.
- Antibiotic resistance.

Module 8 Option behaviour and populations

15.7 Human populations and health

Content

- Social conditions.
- Infectious disease.

POST 16 QUALIFICATIONS continued

Edexcel Biology and Biology (Human) specification

Advanced Subsidiary GCE in Biology 8040 and Biology (Human) 8042

Unit 1 6101 Molecules and cells

1.3 Cellular organization

Content

- Prokaryotic cells.

Unit 2B (Biology) Exchange, transport and reproduction

Content

- Gas exchange in protozoa.

Unit 3 6103 Energy and the environment

3.1 Modes of nutrition

Content

- Autotrophic and heterotrophic nutrition.
- Saprobiontic and parasitic nutrition.
- Mutualistic nutrition.

3.4 Recycling of nutrients

Advanced GCE (A2) in Biology 9040 and Biology (Human) 9042

Unit 4 6104 Options

Option A Microbiology and biotechnology

A.1 Diversity of micro-organisms

Content

- Bacteria.
- Fungi (yeasts and moulds).
- Viruses.

A.2 Culture techniques

Content

- Requirements for growth.
- Methods for culturing.
- Growth of cultures.

A.3 Use of micro-organisms in biotechnology

Content

- Food and drink.
- Medical applications.

Option B Food science

B.2 Food additives

B.3 Food storage

Content

- Short- and long-term storage
- Packaging.

B.4 Biotechnology and food production

Content

- Fermentations.

POST-16 QUALIFICATIONS continued

Option C Human health and fitness

C.3 Human disorders

Unit 5B (Biology) 6105 Genetics, evolution and biodiversity

Content

- Gene technology.

Unit 5H (Human Biology) 6115 Genetics, human evolution and biodiversity

Content

- Gene technology.