Food science and technology guide

School-based syllabus

First assessment 2019

Diploma Programme
Food science and technology—guide

This school-based syllabus guide was developed in 2017
by Sha Tin College, Hong Kong and Island School, Hong Kong
in conjunction with the IB.

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Purpose of this document

This publication is intended to guide the planning, teaching and assessment of the subject in schools. Subject teachers are the primary audience, although it is expected that teachers will use the guide to inform students and parents about the subject.

This guide can be found on the SBS page of the programme resources centre (PRC).

Additional resources

Additional publications such as specimen papers and markschemes, subject reports (where available) and grade descriptors can also be found on the SBS page of the programme resources centre (PRC).

This is particularly important in SBS subjects, as schools are expected to support each other in the advancement of their subject. The “host” school for an SBS is usually able to provide information and contact details of other schools offering the subject. Schools are given contact details of the host school for their SBS in their letter of authorization.

Acknowledgment

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The Diploma Programme

The Diploma Programme is a rigorous pre-university course of study designed for students in the 16 to 19 age range. It is a broad-based two-year course that aims to encourage students to be knowledgeable and inquiring, but also caring and compassionate. There is a strong emphasis on encouraging students to develop intercultural understanding, open-mindedness, and the attitudes necessary for them to respect and evaluate a range of points of view.

The Diploma Programme model

The course is presented as six academic areas enclosing a central core (see figure 1). It encourages the concurrent study of a broad range of academic areas. Students study two modern languages (or a modern language and a classical language), a humanities or social science subject, an experimental science, mathematics and one of the creative arts. It is this comprehensive range of subjects that makes the Diploma Programme a demanding course of study designed to prepare students effectively for university entrance. In each of the academic areas students have flexibility in making their choices, which means they can choose subjects that particularly interest them and that they may wish to study further at university.

Figure 1

Diploma Programme model

Choosing the right combination

Students are required to choose one subject from each of the six academic areas, although they can, instead of an arts subject, choose two subjects from another area. Normally, three subjects (and not more than four) are taken at higher level (HL), and the others are taken at standard level (SL). The IB recommends 240 teaching hours for HL subjects and 150 hours for SL. Subjects at HL are studied in greater depth and breadth than at SL.

At both levels, many skills are developed, especially those of critical thinking and analysis. At the end of the course, students' abilities are measured by means of external assessment. Many subjects contain some element of coursework assessed by teachers.

The core of the Diploma Programme model

All Diploma Programme students participate in the three course elements that make up the core of the model.

Theory of knowledge (TOK) is a course that is fundamentally about critical thinking and inquiry into the process of knowing rather than about learning a specific body of knowledge. The TOK course examines the nature of knowledge and how we know what we claim to know. It does this by encouraging students to analyse knowledge claims and explore questions about the construction of knowledge. The task of TOK is to emphasize connections between areas of shared knowledge and link them to personal knowledge in such a way that an individual becomes more aware of his or her own perspectives and how they might differ from others.

Creativity, activity, service (CAS) is at the heart of the Diploma Programme. The emphasis in CAS is on helping students to develop their own identities, in accordance with the ethical principles embodied in the IB mission statement and the IB learner profile. It involves students in a range of activities alongside their academic studies throughout the Diploma Programme. The three strands of CAS are creativity (arts, and other experiences that involve creative thinking), activity (physical exertion contributing to a healthy lifestyle) and service (an unpaid and voluntary exchange that has a learning benefit for the student). Possibly, more than any other component in the Diploma Programme, CAS contributes to the IB's mission to create a better and more peaceful world through intercultural understanding and respect.

The extended essay, including the world studies extended essay, offers the opportunity for IB students to investigate a topic of special interest, in the form of a 4,000-word piece of independent research. The area of research undertaken is chosen from one of the students' six Diploma Programme subjects, or in the case of the inter-disciplinary World Studies essay, two subjects, and acquaints them with the independent research and writing skills expected at university. This leads to a major piece of formally presented, structured writing, in which ideas and findings are communicated in a reasoned and coherent manner, appropriate to the subject or subjects chosen. It is intended to promote high-level research and writing skills, intellectual discovery and creativity. An authentic learning experience it provides students with an opportunity to engage in personal research on a topic of choice, under the guidance of a supervisor.

School-based syllabuses - regulations

The following conditions apply to the teaching of school-based syllabuses;

- School-based syllabuses (SBS) are only available at standard level
- School-based syllabuses may only be offered by schools who have been authorized by the IB to do so prior to the commencement of the course
- A student may not combine an SBS with a pilot programme or another SBS within the same Diploma

Approaches to teaching and approaches to learning

Approaches to teaching and learning across the Diploma Programme refers to deliberate strategies, skills and attitudes which permeate the teaching and learning environment. These approaches and tools, intrinsically linked with the learner profile attributes, enhance student learning and assist student preparation for the Diploma Programme assessment and beyond. The aims of approaches to teaching and learning in the Diploma Programme are to:

- empower teachers as teachers of learners as well as teachers of content
- empower teachers to create clearer strategies for facilitating learning experiences in which students are more meaningfully engaged in structured inquiry and greater critical and creative thinking
- promote both the aims of individual subjects (making them more than course aspirations) and linking previously isolated knowledge (concurrency of learning)
- encourage students to develop an explicit variety of skills that will equip them to continue to be actively engaged in learning after they leave school, and to help them not only obtain university admission through better grades but also prepare for success during tertiary education and beyond
- enhance further the coherence and relevance of the students' Diploma Programme experience
- allow schools to identify the distinctive nature of an IB Diploma Programme education, with its blend of idealism and practicality.

The five approaches to learning (developing thinking skills, social skills, communication skills, self-management skills and research skills) along with the six approaches to teaching (teaching that is inquiry-based, conceptually focussed, contextualised, collaborative, differentiated and informed by assessment) encompass the key values and principles that underpin IB pedagogy.

Details of the approaches to teaching and approaches to learning can be found at
https://xmltwo.ibo.org/publications/DP/Group0/d_0_dpatl_gui_1502_1/static/dpatl/

The IB mission statement and the IB learner profile

The Diploma Programme aims to develop in students the knowledge, skills and attitudes they will need to fulfil the aims of the IB, as expressed in the organization's mission statement and the learner profile. Teaching and learning in the Diploma Programme represent the reality in daily practice of the organization's educational philosophy.

Academic honesty

Academic honesty in the Diploma Programme is a set of values and behaviours informed by the attributes of the learner profile. In teaching, learning and assessment, academic honesty serves to promote personal integrity, engender respect for the integrity of others and their work, and ensure that all students have an equal opportunity to demonstrate the knowledge and skills they acquire during their studies.

All coursework—including work submitted for assessment—is to be authentic, based on the student's individual and original ideas with the ideas and work of others fully acknowledged. Assessment tasks that require teachers to provide guidance to students or that require students to work collaboratively must be completed in full compliance with the detailed guidelines provided by the IB for the relevant subjects.

For further information on academic honesty in the IB and the Diploma Programme, please consult the IB publications *Academic honesty, The Diploma Programme: From principles into practice* and *General regulations: Diploma Programme*. Specific information regarding academic honesty as it pertains to external and internal assessment components of this Diploma Programme subject can be found in this guide.

Acknowledging the ideas or work of another person

Coordinators and teachers are reminded that candidates must acknowledge all sources used in work submitted for assessment. The following is intended as a clarification of this requirement.

Diploma Programme candidates submit work for assessment in a variety of media that may include audio-visual material, text, graphs, images and/or data published in print or electronic sources. If a candidate uses the work or ideas of another person, the candidate must acknowledge the source using a standard style of referencing in a consistent manner. A candidate's failure to acknowledge a source will be investigated by the IB as a potential breach of regulations that may result in a penalty imposed by the IB final award committee.

The IB does not prescribe which style(s) of referencing or in-text citation should be used by candidates; this is left to the discretion of appropriate faculty/staff in the candidate's school. The wide range of subjects, three response languages and the diversity of referencing styles make it impractical and restrictive to insist on particular styles. In practice, certain styles may prove most commonly used, but schools are free to choose a style that is appropriate for the subject concerned and the language in which candidates' work is written. Regardless of the reference style adopted by the school for a given subject, it is expected that the minimum information given includes: name of author, date of publication, title of source, and page numbers as applicable.

Candidates are expected to use a standard style and use it consistently so that credit is given to all sources used, including sources that have been paraphrased or summarized. When writing text candidates must clearly distinguish between their words and those of others by the use of quotation marks (or other method, such as indentation) followed by an appropriate citation that denotes an entry in the bibliography. If an electronic source is cited, the date of access must be indicated. Candidates are not expected to show faultless expertise in referencing, but are expected to demonstrate that all sources have been acknowledged. Candidates must be advised that audio-visual material, text, graphs, images and/or data published in print or in electronic sources that is not their own must also attribute the source. Again, an appropriate style of referencing/citation must be used.

Learning diversity and learning support requirements

Schools must ensure that equal access arrangements and reasonable adjustments are provided to candidates with learning support requirements that are in line with the IB documents *Candidates with assessment access requirements* and *Learning diversity within the International Baccalaureate programmes/Special educational needs within the International Baccalaureate programmes*.

Nature of science

The Nature of science (NOS) is an overarching theme in the Food science and technology course. This supports and guides teachers in their understanding of what is meant by the nature of science.

Although this section is about the nature of science, the interpretation of the word technology is important, and the role of technology emerging from and contributing to science needs to be clarified. In today's world, the words science and technology are often used interchangeably; however, historically this is not the case. Technology emerged before science, and materials were used to produce useful and decorative artefacts long before there was an understanding of why materials had different properties that could be used for different purposes. In the modern world the reverse is the case: an understanding of the underlying science is the basis for technological developments. These new technologies in their turn drive developments in science.

Despite their mutual dependence they are based on different values: science on evidence, rationality and the quest for deeper understanding; technology on the practical, the appropriate and the useful with an increasingly important emphasis on sustainability.

1. What is science and what is the scientific endeavour?

1.1 The underlying assumption of science is that the universe has an independent, external reality accessible to human senses and amenable to human reason.

1.2 Pure science aims to come to a common understanding of this external universe; applied science and engineering develop technologies that result in new processes and products. However, the boundaries between these fields are fuzzy.

1.3 Scientists use a wide variety of methodologies which, taken together, make up the process of science. There is no single "scientific method". Scientists have used, and do use, different methods at different times to build up their knowledge and ideas but they have a common understanding about what makes them all scientifically valid.

1.4 This is an exciting and challenging adventure involving much creativity and imagination as well as exacting and detailed thinking and application. Scientists also have to be ready for unplanned, surprising, accidental discoveries. The history of science shows this is a very common occurrence.

1.5 Many scientific discoveries have involved flashes of intuition and many have come from speculation or simple curiosity about particular phenomena.

1.6 Scientists have a common terminology and a common reasoning process, which involves using deductive and inductive logic through analogies and generalizations. They share mathematics, the language of science, as a powerful tool. Indeed, some scientific explanations only exist in mathematical form.

1.7 Scientists must adopt a sceptical attitude to claims. This does not mean that they disbelieve everything, but rather that they suspend judgment until they have a good reason to believe a claim to be true or false. Such reasons are based on evidence and argument.

1.8 The importance of evidence is a fundamental common understanding. Evidence can be obtained by observation or experiment. It can be gathered by human senses, primarily sight, but much modern science is carried out using instrumentation and sensors that can gather information remotely and automatically in areas that are too small, or too far away, or otherwise beyond human sense perception. Improved instrumentation and new technology have often been the drivers for new discoveries. Observations followed by analysis and deduction led to the Big Bang theory of the origin of the universe and to the theory of evolution by natural selection. In these cases, no controlled experiments were possible. Disciplines such as geology and astronomy rely strongly on collecting data in the field, but all disciplines use observation to collect evidence to some extent. Experimentation in a controlled environment, generally in laboratories, is the other way of obtaining evidence in the form of data, and there are many conventions and understandings as to how this is to be achieved.

1.9 This evidence is used to develop theories, generalize from data to form laws and propose hypotheses. These theories and hypotheses are used to make predictions that can be tested. In this way theories can be supported or opposed and can be modified or replaced by new theories.

1.10 Models, some simple, some very complex, based on theoretical understanding, are developed to explain processes that may not be observable. Computer-based mathematical models are used to make testable predictions, which can be especially useful when experimentation is not possible. Models tested against experiments or data from observations may prove inadequate, in which case they may be modified or replaced by new models.

1.11 The outcomes of experiments, the insights provided by modelling and observations of the natural world may be used as further evidence for a claim.

1.12 The growth in computing power has made modelling much more powerful. Models, usually mathematical, are now used to derive new understandings when no experiments are possible (and sometimes when they are). This dynamic modelling of complex situations involving large amounts of data, a large number of variables and complex and lengthy calculations is only possible as a result of increased computing power. Modelling of the Earth's climate, for example, is used to predict or make a range of projections of future climatic conditions. A range of different models has been developed in this field and results from different models have been compared to see which models are most accurate. Models can sometimes be tested by using data from the past and used to see if they can predict the present situation. If a model passes this test, we gain confidence in its accuracy.

1.13 Both the ideas and the processes of science can only occur in a human context. Science is carried out by a community of people from a wide variety of backgrounds and traditions, and this has clearly influenced the way science has proceeded at different times. It is important to understand, however, that to do science is to be involved in a community of inquiry with certain common principles, methodologies, understandings and processes.

2. The understanding of science

2.1 Theories, laws and hypotheses are concepts used by scientists. Though these concepts are connected, there is no progression from one to the other. These words have a special meaning in science and it is important to distinguish these from their everyday use.

2.2 Theories are themselves integrated, comprehensive models of how the universe, or parts of it, work. A theory can incorporate facts and laws and tested hypotheses. Predictions can be made from the theories and these can be tested in experiments or by careful observations. Examples are the germ theory of disease or atomic theory.

2.3 Theories generally accommodate the assumptions and premises of other theories, creating a consistent understanding across a range of phenomena and disciplines. Occasionally, however, a new theory will radically change how essential concepts are understood or framed, impacting other theories and causing what is sometimes called a "paradigm shift" in science. One of the most famous paradigm shifts in science occurred when our idea of time changed from an absolute frame of reference to an observer-dependent frame of reference within Einstein's theory of relativity. Darwin's theory of evolution by natural selection also changed our understanding of life on Earth.

2.4 Laws are descriptive, norma1.tive statements derived from observations of regular patterns of behaviour. They are generally mathematical in form and can be used to calculate outcomes and to make predictions. Like theories and hypotheses, laws cannot be proven. Scientific laws may have exceptions and may be modified or rejected based on new evidence. Laws do not necessarily explain a phenomenon. For example, Newton's law of universal gravitation tells us that the force between two masses is inversely proportional to the square of the distance between them, and allows us to calculate the force between masses at any distance apart, but it does not explain why masses attract each other. Also, note that the term law has been used in different ways in science, and whether a particular idea is called a law may be partly a result of the discipline and time period at which it was developed.

2.5 Scientists sometimes form hypotheses—explanatory statements about the world that could be true or false, and which often suggest a causal relationship or a correlation between factors. Hypotheses can be tested by both experiments and observations of the natural world and can be supported or opposed.

2.6 To be scientific, an idea (for example, a theory or hypothesis) must focus on the natural world and natural explanations and must be testable. Scientists strive to develop hypotheses and theories that are compatible with accepted principles and that simplify and unify existing ideas.

2.7 The principle of Occam's razor is used as a guide to developing a theory. The theory should be as simple as possible while maximizing explanatory power.

2.8 The ideas of correlation and cause are very important in science. A correlation is a statistical link or association between one variable and another. A correlation can be positive or negative and a correlation coefficient can be calculated that will have a value between +1, 0 and −1. A strong correlation (positive or negative) between one factor and another suggests some sort of causal relationship between the two factors but more evidence is usually required before scientists accept the idea of a causal relationship. To establish a causal relationship, ie one factor causing another, scientists need to have a plausible scientific mechanism linking the factors. This strengthens the case that one causes the other, for example smoking and lung cancer. This mechanism can be tested in experiments.

2.9 The ideal situation is to investigate the relationship between one factor and another while controlling all other factors in an experimental setting; however, this is often impossible and scientists, especially in biology and medicine, use sampling, cohort studies and case control studies to strengthen their understanding of causation when experiments (such as double-blind tests and clinical trials) are not possible. Epidemiology in the field of medicine involves the statistical analysis of data to discover possible correlations when little established scientific knowledge is available or the circumstances are too difficult to control entirely. Here, as in other fields, mathematical analysis of probability also plays a role.

3. The objectivity of science

3.1 Data is the lifeblood of scientists and may be qualitative or quantitative. It can be obtained purely from observations or from specifically designed experiments, remotely using electronic sensors or by direct measurement. The best data for making accurate and precise descriptions and predictions is often quantitative and amenable to mathematical analysis. Scientists analyse data and look for patterns, trends and discrepancies, attempting to discover relationships and establish causal links. This is not always possible, so identifying and classifying observations and artefacts (eg types of galaxies or fossils) is still an important aspect of scientific work.

3.2 Taking repeated measurements and large numbers of readings can improve reliability in data collection. Data can be presented in a variety of formats such as linear and logarithmic graphs that can be analysed for, say, direct or inverse proportion or for power relationships.

3.3 Scientists need to be aware of random errors and systematic errors, and use techniques such as error bars and lines of best fit on graphs to portray the data as realistically and honestly as possible. There is a need to consider whether outlying data points should be discarded or not.

3.4 Scientists need to understand the difference between errors and uncertainties, accuracy and precision, and need to understand and use the mathematical ideas of average, mean, mode, median, etc. Statistical methods such as standard deviation and chi-squared tests are often used. It is important to be able to assess how accurate a result is. A key part of the training and skill of scientists is in being able to decide which technique is appropriate in different circumstances.

3.5 It is also very important for scientists to be aware of the cognitive biases that may impact experimental design and interpretation. The confirmation bias, for example, is a well-documented cognitive bias that urges us to find reasons to reject data that is unexpected or does not conform to our expectations or desires, and to perhaps too readily accept data that agrees with these expectations or desires. The processes and methodologies of science are largely designed to account for these biases. However, care must always be taken to avoid succumbing to them.

3.6 Although scientists cannot ever be certain that a result or finding is correct, we know that some scientific results are very close to certainty. Scientists often speak of "levels of confidence" when discussing outcomes. The discovery of the existence of a Higgs boson is such an example of a "level of confidence". This particle may never be directly observable, but to establish its "existence" particle physicists had to pass the self-imposed definition of what can be regarded as a discovery—

the 5-sigma “level of certainty”—or about a 0.00003% chance that the effect is not real based on experimental evidence.

3.7 In recent decades, the growth in computing power, sensor technology and networks has allowed scientists to collect large amounts of data. Streams of data are downloaded continuously from many sources such as remote sensing satellites and space probes and large amounts of data are generated in gene sequencing machines. Experiments in CERN’s Large Hadron Collider regularly produce 23 petabytes of data per second, which is equivalent to 13.3 years of high definition TV content per second.

3.8 Research involves analysing large amounts of this data, stored in databases, looking for patterns and unique events. This has to be done using software that is generally written by the scientists involved. The data and the software may not be published with the scientific results but would be made generally available to other researchers.

4. The human face of science

4.1 Science is highly collaborative and the scientific community is composed of people working in science, engineering and technology. It is common to work in teams from many disciplines so that different areas of expertise and specializations can contribute to a common goal that is beyond one scientific field. It is also the case that how a problem is framed in the paradigm of one discipline might limit possible solutions, so framing problems using a variety of perspectives, in which new solutions are possible, can be extremely useful.

4.2 Teamwork of this sort takes place with the common understanding that science should be open-minded and independent of religion, culture, politics, nationality, age and gender. Science involves the free global interchange of information and ideas. Of course, individual scientists are human and may have biases and prejudices, but the institutions, practices and methodologies of science help keep the scientific endeavour as a whole unbiased.

4.3 As well as collaborating on the exchange of results, scientists work on a daily basis in collaborative groups on a small and large scale within and between disciplines, laboratories, organizations and countries, facilitated even more by virtual communication. Examples of large-scale collaboration include:

- The Manhattan project, the aim of which was to build and test an atomic bomb. It eventually employed more than 130,000 people and resulted in the creation of multiple production and research sites that operated in secret, culminating in the dropping of two atomic bombs on Hiroshima and Nagasaki.

- The Human Genome Project (HGP), which was an international scientific research project set up to map the human genome. The $3-billion project beginning in 1990 produced a draft of the genome in 2000. The sequence of the DNA is stored in databases available to anyone on the internet.

- The IPCC (Intergovernmental Panel on Climate Change), organized under the auspices of the United Nations, is officially composed of about 2,500 scientists. They produce reports summarizing the work of many more scientists from all around the world.

- CERN, the European Organization for Nuclear Research, an international organization set up in 1954, is the world’s largest particle physics laboratory. The laboratory, situated in Geneva, employs about 2,400 people and shares results with 10,000 scientists and engineers covering over 100 nationalities from 600 or more universities and research facilities.

All the above examples are controversial to some degree and have aroused emotions among scientists and the public.

4.4 Scientists spend a considerable amount of time reading the published results of other scientists. They publish their own results in scientific journals after a process called peer review. This is when the work of a scientist or, more usually, a team of scientists is anonymously and independently reviewed by several scientists working in the same field who decide if the research methodologies are sound and if the work represents a new contribution to knowledge in that field. They also attend conferences to make presentations and display posters of their work. Publication of peer-reviewed journals on the internet has increased the efficiency with which the scientific literature can be searched and accessed. There are a large number of national and international organizations for scientists working in specialized areas within subjects.

4.5 Scientists often work in areas, or produce findings, that have significant ethical and political implications. These areas include cloning, genetic engineering of food and organisms, stem cell and reproductive technologies, nuclear power, weapons development (nuclear, chemical and biological), transplantation of tissue and organs and in areas that involve testing on animals (see *IB animal experimentation policy*). There are also questions involving intellectual property rights and the free exchange of information that may impact significantly on a society. Science is undertaken in universities, commercial companies, government organizations, defence agencies and international organizations. Questions of patents and intellectual property rights arise when work is done in a protected environment.

4.6 The integrity and honest representation of data is paramount in science—results should not be fixed or manipulated or doctored. To help ensure academic honesty and guard against plagiarism, all sources are quoted and appropriate acknowledgment made of help or support. Peer review and the scrutiny and scepticism of the scientific community also help achieve these goals.

4.7 All science has to be funded and the source of the funding is crucial in decisions regarding the type of research to be conducted. Funding from governments and charitable foundations is sometimes for pure research with no obvious direct benefit to anyone, whereas funding from private companies is often for applied research to produce a particular product or technology. Political and economic factors often determine the nature and extent of the funding. Scientists often have to spend time applying for research grants and have to make a case for what they want to research.

4.8 Science has been used to solve many problems and improve humankinds' lot, but it has also been used in morally questionable ways and in ways that inadvertently caused problems. Advances in sanitation, clean water supplies and hygiene led to significant decreases in death rates but without compensating decreases in birth rates, this led to huge population increases with all the problems of resources, energy and food supplies that entails. Ethical discussions, risk–benefit analyses, risk assessment and the precautionary principle are all parts of the scientific way of addressing the common good.

5. Scientific literacy and the public understanding of science

5.1 An understanding of the nature of science is vital when society needs to make decisions involving scientific findings and issues. How does the public judge? It may not be possible to make judgments based on the public’s direct understanding of a science, but important questions can be asked about whether scientific processes were followed and scientists have a role in answering such questions.

5.2 As experts in their particular fields, scientists are well placed to explain to the public their issues and findings. Outside their specializations, they may be no more qualified than ordinary citizens to advise others on scientific issues, although their understanding of the processes of science can help them to make personal decisions and to educate the public as to whether claims are scientifically credible.

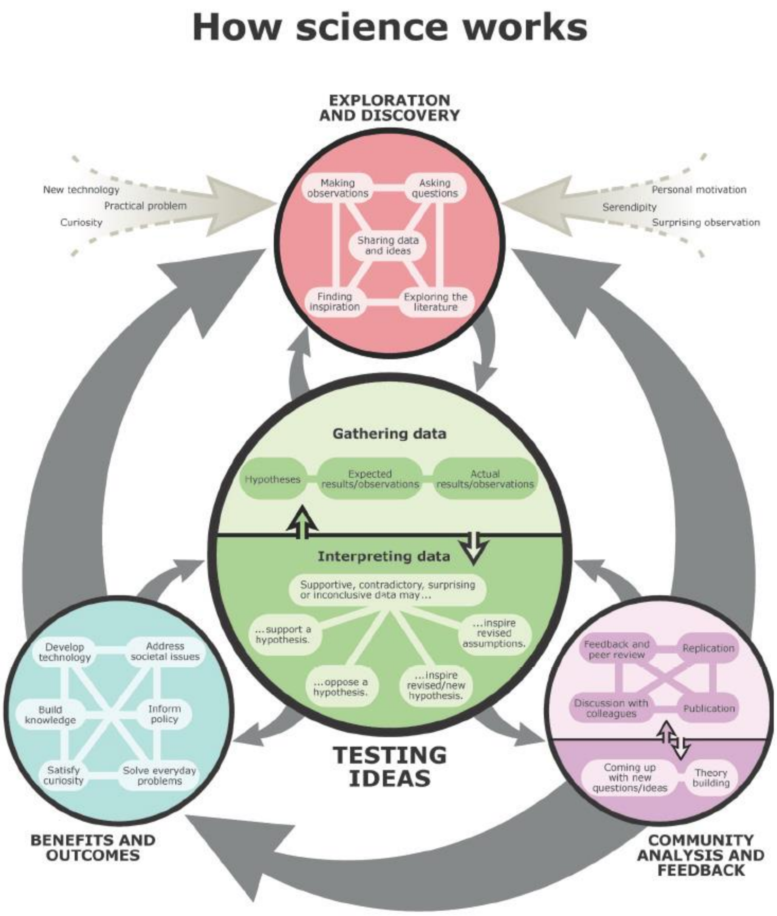
5.3 As well as comprising knowledge of how scientists work and think, scientific literacy involves being aware of faulty reasoning. There are many cognitive biases/fallacies of reasoning to which people are susceptible (including scientists) and these need to be corrected whenever possible. Examples of these are the confirmation bias, hasty generalizations, *post hoc ergo propter hoc* (false cause), the straw man fallacy, redefinition (moving the goal posts), the appeal to tradition, false authority and the accumulation of anecdotes being regarded as evidence.

5.4 When such biases and fallacies are not properly managed or corrected, or when the processes and checks and balances of science are ignored or misapplied, the result is pseudoscience. *Pseudoscience* is the term applied to those beliefs and practices that claim to be scientific but do not meet or follow the standards of proper scientific methodologies, ie they lack supporting evidence or a theoretical framework, are not always testable and hence falsifiable, are expressed in a non-rigorous or unclear manner and often fail to be supported by scientific testing.

5.5 Another key issue is the use of appropriate terminology. Words that scientists agree on as being scientific terms will often have a different meaning in everyday life and scientific discourse with the public needs to take this into account. For example, a theory in everyday use means a hunch or speculation, but in science an accepted theory is a scientific idea that has produced predictions that have been thoroughly tested in many different ways. An aerosol is just a spray can to the general public, but in science it is a suspension of solid or liquid particles in a gas.

5.6 Whatever the field of science—whether it is in pure research, applied research or in engineering new technology—there is boundless scope for creative and imaginative thinking. Science has achieved a great deal but there are many, many unanswered questions to challenge future scientists.

The following flow chart is part of an interactive flow chart showing the scientific process of inquiry in practice. The interactive version can be found at “How science works: The flowchart.” Understanding Science. University of California Museum of Paleontology. 1 February 2013 <http://undsci.berkeley.edu/article/scienceflowchart>.



Nature of the subject

Food science and technology

An understanding of food is increasingly crucial to individual and societal well-being. The world faces challenges in terms of food production, nutritional well-being, food safety and quality. As a major global industry, the food industry has to respond to consumers who increasingly demand greater choice, convenience and safety, whilst aiming to develop and manufacture food products to meet the needs and wants of rapidly changing societies. Students will learn about key aspects of food science and technology including nutritional science, food processing, safety and quality, and food related issues with impact on society.

What is food science?

A study of food science involves gaining knowledge about nutrition, and about the changes that occur in food through its cooking and processing. This requires scientific methodology, gaining evidence from observation and or experimentation. We can use our human senses to evaluate the colour, flavour and texture of food, but require scientific instruments and expertise, e.g. to test food samples for harmful pathogens, or to calculate nutritional values.

What is food technology?

Technology can be defined as the application of scientific knowledge for practical purposes that can lead to improved efficiency as well as new affordances [i.e. possibilities for action] (Spector, 2012; Stevenson, 2013). Historically food technology has helped with providing food for growing populations that have moved from rural to urbanized areas, becoming reliant on food that is produced for them by others.

An emphasis on appropriate and sustainable food production and processing is increasingly important and is dependent on both scientific evidence and technological practical application. It is necessary to have an understanding of the nature of nutritional raw materials, production processes and technological innovations within the food industry in order to determine how the wide-ranging food needs of individuals and societies can be met. The development, production and supply of food are based on scientific understandings of the physical, chemical, nutritional and microbiological properties of foods. Food technologists need an understanding of food science and its technological application, as well as imagination and creativity, to be able to develop new solutions to global needs.

Food science and technology:

- provides structured processes for food production based on well-established scientific principles.
- explores possibilities and constraints to find solutions to problems or opportunities, and carries out in-depth investigations of these to establish clear parameters for development.
- requires imagination and creativity together with substantial factual, procedural and conceptual knowledge, to develop new food products and processes.
- is human-centred and focuses on meeting individual and society's needs and or wants.
- identifies nutritional properties of food materials with regard to health and dietary issues.
- involves collaborative endeavours requiring diverse teams of experts, such as microbiologists, engineers, packaging specialists and buyers.
- involves an understanding of safety and hygiene principles and practices.

Food scientists and technologists need to:

- consider nutritional value, sustainability, environmental impact, ethical and moral issues when exploring food production and processing.
- assess how consumers will purchase and use food products to ensure that products retain their aesthetic properties and are safe to consume.
- maintain an unbiased view of a situation and evaluate a context objectively, highlighting the strengths, weaknesses, opportunities and threats.
- have a responsibility to the community and the environment.

Food and the role of science and technology:

- Both science and technology have a fundamental relationship within the knowledge and understanding of food.
- Traditional food technology is based on practices that comprised of techniques and processes that have little understanding of food science. In contrast, modern food technology involves the application of scientific discoveries alongside technological advances.
- Scientific and technological discovery can be applied to the food production and processing to enable new food product attributes.
- The food industry uses new and existing technologies and scientific principles.
- The rapid pace of scientific discovery has impacted the rate that new technologies are developed. New technologies allow new food products to be developed, which solve long-standing problems, improve on existing solutions and fill gaps in markets.
- Often, by solving one food related problem or creating a new process or product, there are unforeseen consequences for society, which bring new technological or scientific problems.
- The food industry remains involved in developing technology to improve products, processing and production methods.
- The digital revolution has enabled increased sharing and building knowledge of food science and technology.
- The concept of sustainability and food security is becoming a greater priority for the society at large. The development of sustainable food production and processing using science and technology is a response to environmental and social pressures relating to climate change, population growth, and energy and resource depletion.

Characteristics of a food technologist:

The following characteristics frame a profile of both professional and aspiring food technologists. They reflect the desirable abilities, skill sets and mind-set for these professionals. Food technologists can/are able to:

- seek, establish and verify broad concepts and general principles that underlie scientific and technological methodology.
- conduct thorough research, synthesize evidence and apply the findings to the development of innovative food product.
- carefully observe and monitor short- and long-term trends and ask pertinent questions to explore new food related opportunities.
- assess the risks associated with food design production, and processing as well as any associated moral, social, ethical or environmental issues.
- empathize with individuals, groups and cultures to ascertain and identify consumer needs or market opportunities.
- collaborate, inspire and enthuse through effective communication using a variety of appropriate modes and media.
- appreciate the influence of others within the continuous development of meeting the food needs and wants of society.

Food science and technology and the core

As with all Diploma Programme courses, Food science and technology should both support, and be supported by, the three elements of the Diploma Programme core.

Food science and technology and theory of knowledge

The theory of knowledge (TOK) course engages students in reflection on the nature of knowledge and on how we know what we claim to know. The course identifies eight ways of knowing: reason, emotion, language, sense perception, intuition, imagination, faith and memory. Students explore these means of producing knowledge within the context of various areas of knowledge: the natural sciences, the social sciences, the arts, ethics, history, mathematics, religious knowledge systems and indigenous knowledge systems. The course also requires students to make comparisons between the different areas of knowledge; reflecting on how knowledge is arrived at in the various disciplines, what the disciplines have in common, and the differences between them.

TOK lessons can support students in their study of Food science and technology, just as the study of Food science and technology can support students in their TOK course. TOK provides a space for students to engage in stimulating wider discussions about questions such as the extent to which technology is both an enabler and limiter of knowledge. It also provides an opportunity for students to reflect on the methodologies of Food science and technology, and how these compare to the methodologies of other areas of knowledge.

In this way there are rich opportunities for students to make links between their Food science and technology and TOK courses. One way in which Food science and technology teachers can help students to make these links to TOK is by drawing students' attention to knowledge questions which arise from their subject content. Knowledge questions are open-ended questions about knowledge, and include questions such as:

- How does classification and categorization help and/or hinder the pursuit of knowledge?
- There are commonly accepted ways of assuring quality in food production. How do other areas of knowledge ensure the quality of their output?
- To what extent do different cultural contexts impact knowledge obtained through practices associated with food?
- On what basis might we decide between the judgments of experts if they disagree?

Suggestions for TOK discussions and examples of relevant knowledge questions are provided throughout this guide, within the sub-topics in the syllabus content. Teachers can also find suggestions of interesting knowledge questions for discussion in the "Areas of knowledge" and "Knowledge frameworks" sections of the Theory of knowledge guide. Students should be encouraged to raise and discuss such knowledge questions in both their food science and technology and TOK classes.

Food science and technology and the extended essay

From May 2019, extended essays are not allowed in any school-based syllabus. However, ideas for research topics could be developed within the contexts of extended essays in mainstream DP subjects.

Food science and technology and international-mindedness

Science itself is an international endeavour—the exchange of information and ideas across national boundaries has been essential to the progress of science. This exchange is not a new phenomenon but it has accelerated in recent times with the development of information and communication technologies. Indeed, the idea that science is a Western invention is a myth—many of the foundations of modern-day science were laid many centuries before by Arabic, Indian and Chinese civilizations, among others. The scientific method in its widest sense, with its emphasis on peer review, open-mindedness and freedom of thought, transcends politics, religion, gender and nationality. Where appropriate within certain topics, the syllabus details sections in the group 4 guides contain links illustrating the international aspects of science.

Food science and technology is a global endeavour, with the international exchange of information leading to the development of new food knowledge, processes and products. The emergence of new pathogens, environmental changes and the developments of modern biotechnology offer both threats and opportunities to world food production. Globalization of food has impacted on lifestyle in most parts of the world both positively and negatively. The study of food science and technology aims to develop internationally minded people whose enhanced understanding of food science and technology can facilitate the development of creative and appropriate solutions.

Students' attention should be drawn to sections of the syllabus with links to international-mindedness. Examples of issues relating to international-mindedness are given within sub-topics in the syllabus content.

The IB learner profile

The food science and technology course is closely linked to the IB learner profile. By following the course, students will have engaged with the attributes of the IB learner profile, for example, the requirements of the internal assessment provide opportunities for students to develop every aspect of the profile. For each attribute of the learner profile, a number of references are given below.

Learner profile attribute	Food science and technology

Inquirers	Aims 1, 2 and 8 Practical work and internal assessment
Knowledgeable	Aims 1, 2, 4, 6 and 10 Practical work and internal assessment
Thinkers	Aims 2, 3, 4, 7 and 10 Practical work and internal assessment
Communicators	Aims 2, 4 and 7; external assessment Practical work and internal assessment; group 4 project
Principled	Aims 9 and 10 Practical work and internal assessment: ethical behaviour/practice (*Ethical practice poster*, *Animal experimentation policy*); academic honesty
Open-minded	Aims 2, 3, 6, 7, 8, 9 and 10 Practical work and internal assessment; group 4 project
Caring	Aims 6, 8, 9 and 10 Practical work and internal assessment; group 4 project; ethical behaviour/practice (*Ethical practice poster*, *Animal experimentation policy*)
Risk-takers	Aims 1, 3 and 7 Practical work and internal assessment; group 4 project
Balanced	Aims 5, 6, 8, 9 and 10 Practical work and internal assessment
Reflective	Aims 1, 5, 6, 8, 9 and 10 Practical work and internal assessment; group 4 project

Approaches to the teaching of food science and technology

There are a variety of approaches to the teaching of food science and technology. By its very nature, food science and technology lends itself to a practical approach, and it is expected that this will be reflected throughout the course.

The order in which the syllabus is arranged is not the order in which it should be taught, and it is up to individual teachers to decide on an arrangement that suits their circumstances.

Engaging with sensitive topics

As part of the food science and technology course, students will be required to think about, and evaluate, their own lifestyle choices, and to engage with those of others. There are frequent opportunities for debate of ethical issues relating to food, including healthy eating choices of individuals. Students and teachers may therefore encounter conflict between their own values and beliefs in relation to health, and those of others. There may well be situations where social and cultural pressures impact on an individual’s understanding of health issues, and discussing such pressures could even influence their lifestyle choices in a positive or negative way. Teachers are advised to respond to these issues in a sensitive way.

Prior learning

Past experience shows that students will be able to study a group 4 science subject at SL successfully with no background in, or previous knowledge of, science. Their approach to learning, characterized by the IB learner profile attributes, will be significant here.

Links to the Middle Years Programme

Students who have undertaken the MYP science, design and mathematics courses will be well prepared for group 4 subjects. The alignment between MYP science and the Diploma Programme group 4 courses allows for a smooth transition for students between programmes. The concurrent planning of the new group 4 courses and MYP: Next Chapter (both launched in 2014) has helped develop a closer alignment.

Scientific inquiry is central to teaching and learning science in the MYP. It enables students to develop a way of thinking and a set of skills and processes that, while allowing them to acquire and use knowledge, equip them with the capabilities to tackle, with confidence, the internal assessment component of group 4 subjects. The vision of MYP sciences is to contribute to the development of students as 21st century learners. A holistic sciences programme allows students to develop and utilize a mixture of cognitive abilities, social skills, personal motivation, conceptual knowledge and problem-solving competencies within an inquiry-based learning environment (Rhoton 2010). Inquiry aims to support students’ understanding by providing them with opportunities to independently and collaboratively investigate relevant issues through both research and experimentation. This forms a firm base of scientific understanding with deep conceptual roots for students entering group 4 courses.

In the MYP, teachers make decisions about student achievement using their professional judgment, guided by criteria that are public, precise and known in advance, ensuring that assessment is transparent. The IB describes this approach as “criterion-related”—a philosophy of assessment that is neither “norm-referenced” (where students must be compared to each other and to an expected distribution of achievement) nor “criterion-referenced” (where students must master all strands of specific criteria at lower achievement levels before they can be considered to have achieved the next level). It is important to emphasize that the single most important aim of MYP assessment (consistent with the PYP and DP) is to support curricular goals and encourage appropriate student learning. Assessments are based upon evaluating course aims and objectives and, therefore, effective teaching to the course requirements also ensures effective teaching for formal assessment requirements.

Students need to understand what the assessment expectations, standards and practices are and these should all be introduced early and naturally in teaching, as well as in class and homework activities. Experience with criterion-related assessment greatly assists students entering group 4 courses with understanding internal assessment requirements.

MYP science is a concept-driven curriculum, aimed at helping the learner construct meaning through improved critical thinking and the transfer of knowledge. At the top level are key concepts which are broad, organizing, powerful ideas that have relevance within the science course but also transcend it, having relevance in other subject groups. These key concepts facilitate both disciplinary and interdisciplinary learning as well as making connections with other subjects. While the key concepts provide breadth, the related concepts in MYP science add depth to the programme. The related concept can be considered to be the big idea of the unit which brings focus and depth and leads students towards the conceptual understanding.

Across the MYP there are 16 key concepts with the three highlighted below the focus for MYP science.

The key concepts across the MYP curriculum			
Aesthetics	**Change**	Communication	Communities
Connections	Creativity	Culture	Development
Form	Global interactions	Identity	Logic
Perspective	**Relationships**	**Systems**	Time, place and space

Links to the IB Career-related Programme

In the IB Career-related Programme (CP), students study at least two Diploma Programme subjects which support their career-related study. Food science and technology can serve this purpose for CP students.

Aims

Sciences aims

Through studying sciences, students should become aware of how scientists work and communicate with each other. While the scientific method may take on a wide variety of forms, it is the emphasis on a practical approach through experimental work that characterizes these subjects.

1. appreciate scientific study and creativity within a global context through stimulating and challenging opportunities

2. acquire a body of knowledge, methods and techniques that characterize science and technology

3. apply and use a body of knowledge, methods and techniques that characterize science and technology

4. develop an ability to analyse, evaluate and synthesize scientific information5. develop a critical awareness of the need for, and the value of, effective collaboration and communication during scientific activities

5. develop experimental and investigative scientific skills including the use of current technologies

6. develop experimental and investigative scientific skills including the use of current technologies

7. develop an appreciation of the possibilities and limitations of science and technology

8. develop an understanding of the relationships between scientific disciplines and their influence on other areas of knowledge.

Assessment objectives

The assessment objectives for food science and technology reflect those parts of the aims that will be formally assessed either internally or externally. It is the intention that students are able to fulfil the following assessment objectives:

1. Demonstrate knowledge and understanding of:

    a) facts, concepts and terminology
    b) methodologies and techniques
    c) communicating scientific information.

2. Apply:

    a) facts, concepts and terminology
    b) methodologies and techniques
    c) methods of communicating scientific information.

3. Formulate, analyse and evaluate:

    a) hypotheses, research questions and predictions
    b) methodologies and techniques
    c) primary and secondary data
    d) scientific explanations.

4. Demonstrate the appropriate research, experimental, and personal skills necessary to carry out insightful and ethical investigations

Syllabus outline

Syllabus component	Recommended teaching hours
Core	100
1. Nutrition 1.1 The contribution to the diet of macronutrients 1.2 Sources and nutritional properties of micronutrients 1.3 The digestion, absorption and metabolism of food 1.4 Nutritional and dietary requirements. 1.5 Influences on nutritional status. 1.6 Nutritional awareness and responsibilities	25
2. Materials, components and their application 2.1 Functional properties of protein in foods 2.2 Functional properties of carbohydrate in foods 2.3 Functional properties of fat in foods 2.4 Functional properties of additives 2.5 Functional properties of additional ingredients 2.6 Food fortification	25
3. Food quality and safety 3.1 Food Spoilage 3.2 Food Poisoning 3.3 Principles of temperature control 3.4 Safe food handling and preparation 3.5 Organoleptic properties 3.6 Packaging and food quality	25
4. Food process engineering 4.1 Food processing methods 4.2 Food processing: preservation by temperature control 4.3 Food processing: preservation by dehydration and irradiation 4.4 The effect of processing on colour 4.5 The effect of food processing on flavour 4.6 The effect of food processing on texture	25
Practical scheme of work:	**50**
• Food Investigation (internal assessment – IA) • Group 4 project • Practical activities	10 10 30
Total teaching hours	**150**

Structure of the syllabus

Topics

Topics are numbered for ease of reference (for example, **Topic 2** - M**aterials, components and their applications**).

The syllabus as provided in the subject guide is not intended to be a teaching order. Instead it provides detail of what must be covered by the end of the course. A school should develop a scheme of work that best works for their students. For example, the scheme of work could be developed to match available resources, to take into account student prior learning and experience, or in conjunction with other local requirements.

However the course is planned, adequate time must be provided for examination revision. Time must also be given for students to reflect on their learning experience and their growth as learners.

Sub-topics

Sub-topics are numbered as follows, "2.1 Functional properties of protein in foods" Further information and guidance about possible teaching times are contained in the teacher support material.

Each sub-topic begins with an essential idea. The essential idea is an enduring interpretation that is considered part of the general understanding of design. Below the essential idea the sub-topic is presented in three columns.

The first column is the "Nature of food science and technology". This gives specific examples in context illustrating some aspects of the nature of food science and technology. These are linked directly to specific references in the "Nature of food science and technology" section of the guide to support teachers in their understanding of the general theme to be addressed. The second column lists understandings, which are the main general ideas to be taught, and "Guidance" gives information about the limits and constraints and the depth of treatment required. The third column gives suggestions to teachers about relevant references to international-mindedness. It also gives examples of TOK knowledge questions (see Theory of knowledge guide published 2013) that can be used to focus students' thoughts on the preparation of the TOK prescribed essay. The "Utilization" section may link the sub-topic to other parts of the subject syllabus and other Diploma Programme subject guides. Finally, the "Aims" section refers to how Food science and technology aims are being addressed in the sub-topic.

Topic 1: <Title>
Essential idea: This lists the essential idea for each sub-topic.

1.1 Sub-topic		
Nature of food science and technology: This section relates the sub-topic to the overarching theme of nature of food science and technology.	**Understandings:** This section will provide specifics of the content requirements for each sub-topic. **Application and guidance:** This section will provide constraints to the requirements for the Understandings.	**International-mindedness:** Ideas that teachers can easily integrate into the delivery of their lessons. **Theory of knowledge:** Examples of TOK knowledge questions. **Utilization:** (including syllabus and cross-curricular links) Links to other diploma to other Diploma Programme courses. **Aims:** Links to the Food science and technology aims.

Food science and technology practical skills

I hear and I forget. I see and I remember. I do and I understand.
- Confucius

Integral to the experience of students in any of the group 4 courses is their experience in the classroom, workshop, laboratory, and kitchen or in the field. Practical activities allow students to interact directly with natural materials, and primary and secondary data sources. These experiences provide the students with the opportunity to design investigations, collect data, develop manipulative skills, analyse results, collaborate with peers and evaluate and communicate their findings. Practical activities can be used to introduce a topic, investigate a phenomenon or allow students to consider and examine questions and curiosities.

By providing students with the opportunity for hands-on experimentation, they are carrying out some of the same processes that designers undertake.

It is important that students are involved in an inquiry-based practical programme that allows for the development of design thinking. It is not enough for students just to be able follow directions and to simply replicate a given procedure, they must be provided with the opportunities for genuine inquiry. Developing inquiry skills will give students the ability to construct an explanation based on reliable evidence and logical reasoning. Once developed, these higher-order thinking skills will enable students to be lifelong learners and design literate.

A school's practical scheme of work should allow students to experience the full breadth and depth of the course. This practical scheme of work must also prepare students to undertake the food Investigation that is required for the internal assessment. The development of students' manipulative skills should involve them being able to follow instructions accurately and demonstrate the safe, competent and methodical use of a range of techniques and equipment, which can then be applied to a range of design contexts.

Mathematical requirements

All DP food science and technology students should be able to:

- perform the basic arithmetic functions: addition, subtraction, multiplication and division
- carry out calculations involving means, decimals, fractions, percentages, ratios, approximations and reciprocals
- use standard notation (for example, 3.6×10^6)
- use direct and inverse proportion
- solve simple algebraic equations
- plot and interpret graphs (with suitable scales and axes) including two variables that show linear and non-linear relationships
- interpret graphs, including the significance of gradients, changes in gradients, intercepts and areas
- interpret data presented in various forms (for example, bar charts, histograms and pie charts)

Use of information technology

In accordance with aim 7, the use of information and communication technology (ICT) is strongly encouraged throughout the course in both practical and theory work.

ICT can be used whenever appropriate:

- as a means of expanding students' knowledge of the world in which they live
- as a channel for developing concepts and skills
- as a powerful communication tool.

Syllabus content

Topic 1: Nutrition — 25 hours

Essential idea: Macronutrients are vital to good health and achieving a satisfactory balance is essential to well-being.

1.1 The contribution to the diet of macronutrients		
Nature of food science and technology: An excess or deficient intake of protein, carbohydrate or fat is detrimental to health. To maintain health, it is therefore necessary to understand and implement the nutritional properties, sources and recommended daily amounts of these macronutrients. (1.7)	**Understandings:** • Sources and nutritional properties of macronutrients • High and low biological values of protein (HBV and LBV) • Indispensable and dispensable amino acids • Classifications of carbohydrates • Sources and nutritional properties of fibre (non-starch polysaccharide) • Classifications of fats • Essential fatty acids • Recommended daily amounts of macronutrients. • Malnutrition may be caused by a deficiency, imbalance or excess of nutrients in the diet **Application and guidance** Students should understand and where appropriate, be able to discuss and evaluate: • the nutritional properties and sources of plant, animal and novel proteins, and their biological values (HBV, LBV). Indispensable and dispensable amino acids, and protein complementation e.g. rice and beans in Central America. • the nutritional properties and sources of sugars (intrinsic, extrinsic and non-milk extrinsic sugars) and starches. Starches are staple foods (e.g. cassava, rice, wheat, maize) significance to energy intakes.	**International mindedness:** There are short and long term socio-economic implications of macronutrient malnutrition in less economically developed countries (LEDC) and more economically developed countries (MEDC) countries. **Theory of Knowledge:** What role does intuition play in knowing what nutrients your body needs? **Utilization:** Biology - Topic 2.3 Biology - Topic 2.4 Biology - Option D.1 Sports, exercise and health science - Topic 3.1 **Aims:** 1. a sense of curiosity as they acquire the skills necessary for independent and lifelong learning and action through inquiry into the world of food science and technology. 8. understand how food science and technology promote intellectual, physical and emotional balance and contribute to personal and social well-being.

1.1 The contribution to the diet of macronutrients		
	• the function of soluble and insoluble Fibre (Non Starch Polysaccharide) in the diet. E.g. reducing blood cholesterol levels and risks of coronary heart disease (CHD). • the nutritional properties and sources of animal and plant fat. How monounsaturated, polyunsaturated and saturated fats impact on health, role of essential fatty acids. • the impact of macronutrient excess e.g. obesity, coronary heart disease, dental decay and diabetes. • Consider the impact of macronutrient deficiency diseases (malnutrition) on MEDC and LEDC countries e.g. obesity, kwashiorkor, marasmus, pellagra, beri beri, scurvy and rickets.	

Essential idea: Micronutrients are vital to good health and obtaining the recommended balance is essential to well-being.

1.2 The use and contribution to the diet of micronutrients		
Nature of food science and technology: A deficient intake of vitamins and minerals is detrimental to health. To maintain health, it is therefore necessary to understand the nutritional properties, sources and recommended daily amounts of these micronutrients. (1.7)	**Understandings:** • The nutritional properties of micronutrients • Sources of micronutrients • Bioavailability and absorption of micronutrients • Classification of vitamins • Classification of minerals • Different recommended daily amounts of micronutrients • Excess and deficiency of micronutrients • The interrelationship between nutrients **Application and guidance:** Students should understand and where appropriate, be able to discuss and evaluate:	**International mindedness:** The Vitamin and Mineral Nutrition Information System (VMNIS), formerly known as the Micronutrient Deficiency Information System (MDIS), was established in 1991 following a request by the World Health Assembly to strengthen surveillance of micronutrient deficiencies at the global level. **Theory of Knowledge:** How does classification and categorization help or hinder our interpretation of nutritional knowledge? **Utilization:** Biology - Option D1

1.2 The use and contribution to the diet of micronutrients		
	• the properties of the water soluble vitamins B (B1 Thiamin, B2 Riboflavin, B3 Niacin, B5 Pantothenic acid, B6 Pyridoxine, B7 Biotin, B9 Folic Acid and B12 Cobalamins) and C (Ascorbic Acid). • the properties of the fat-soluble vitamins A (Retinol), D (Cholecalciferol), E (Tocopherols) and K Phylloquinone). • the factors affecting the bioavailability and absorption of micronutrients. • the impact of vitamin deficiency or excess intake e.g. cases of excess vitamin A intake in children in Western Europe, effect of lack of Vitamin A on eyesight in parts of Central Africa. • minerals (calcium, magnesium, potassium, sodium, phosphorus, and zinc) and trace elements (iodine, fluorine, iron, manganese, and selenium). • the impact of deficiency mineral intake. e.g. globally - anaemia, and in Central Asia - osteoporosis, iodine deficiency. • the interrelationships between nutrients e.g. Iron and vitamin C, Vitamin D and calcium, B vitamins and energy release from carbohydrates.	Chemistry - Option B.5 Sports, exercise and health science - Topic 3.1 **Aims:** 1. a sense of curiosity as they acquire the skills necessary for independent and lifelong learning and action through inquiry into the world of food science and technology. 8. understand how food science and technology promote intellectual, physical and emotional balance and contribute to personal and social well-being.

Essential idea: When food is consumed, it must be broken down, physically and chemically so that nutrients can be absorbed

1.3 The digestion, absorption and metabolism of food		
Nature of food science and technology science: Nutrients required by the body are digested, which breaks down large insoluble food molecules into smaller water soluble food molecules, which are then absorbed into the bloodstream. (1.1)	**Understandings:** • Mechanical and chemical digestive processes • Absorption into the blood and lymphatic systems • Distinguish between absorption and assimilation of nutrients • Understand how the macronutrients are broken down and utilised • The rate of transit of materials through the large intestine is positively correlated with their fibre (non starch polysaccharide) content **Application and guidance:**	**International mindedness:** Lactose intolerance more prevalent in people of Asian, Native American and African descent. **Theory of Knowledge:** Collective wisdom has differing opinions on digestion e.g. a digestif in France, drinking tea in China. To what extent is this thinking based on science?

1.3 The digestion, absorption and metabolism of food		
	Students should understand and where appropriate, be able to discuss and evaluate: • the mechanical and chemical processes at each stage of the digestive system: mouth, oesophagus stomach, peristalsis through the small intestine and large intestine. • The role of bile in emulsifying fats, as well as the need for enzymes as catalysts in digestion, including: amylase, pepsin, invertase (sucrase), lactase and maltase. • the chemical process of metabolism through catabolism and anabolism. • the process of absorption through the intestine, including the structure of ileum and the structure of the villi. • that starch, glycogen, lipids and nucleic acids are digested into monomers and that cellulose remains undigested. • the different methods of membrane transport are required to absorb different nutrients. • how the amount of dietary fibre (non starch polysaccharide) aids bowel movement and colonic transit time.	To what extent has food preparation throughout the ages had digestion as a priority? **Utilization:** Biology - Topic 6.1 Biology - Option D.2 **Aims:** 3. apply and use a body of knowledge, methods and techniques, methods and techniques that characterize food science and food technology.

Essential idea: Nutrients are needed by the body and vital to good health but amounts can vary according to specific dietary needs.

1.4 Nutrition and dietary requirements		
Nature of food science and technology: Recommended nutrient intakes are estimates of the energy and nutritional requirements of different groups by age, gender and within a specific stage of a person's life cycle. They are not rigid recommendations for individuals	**Understandings:** • Explain dietary requirements • Explain the energy balance and recommended nutrient intakes (including fibre (NSP) and water) • Explain the function of Water, fluids and hydration • Explain the factors affecting food and nutritional requirements: age, gender, stage in the life cycle e.g. pregnancy and health status • Explain and Interpret nutritional requirements	**International mindedness:** The World Health Organisation (WHO) compiles statistics about how countries are achieving optimal nutritional targets as set out in the Millennium Development Goals. **Theory of Knowledge:**

1.4 Nutrition and dietary requirements		
but assist consumers with interpreting nutritional data. (1.6, 3.7)	**Application and guidance:** Students should understand and where appropriate, be able to discuss and evaluate: • why the recommended nutrient intakes vary between countries e.g. Dietary Reference Values (DRV) in the UK, Dietary Reference Intake (RDI) in the USA, References Values in HK. • the functions of water and other fluids in the diet and factors that impact on hydration • the factors effecting energy balance in terms of calorie input and output • the different dietary requirements of different age groups, occupations, and life stages including of pregnant and lactating women, young children and teenagers. • how statutory food labelling aims to give consumers dietary and nutritional requirements in easy to understand form. Consumer information in the form of labels and advertising requires interpretation.	To what extent might a lack of knowledge be relevant to making poor nutritional food choices? **Utilization:** Biology - Option D1 **Aims:** 7. develop and apply 21st Century communication and collaboration skills in the of and participation in food science and technology activities.

Essential idea: Making optimal nutritional decisions involves a complex interrelationship between physiological, psychological, social, economic, and moral factors.

1.5 Influences on nutritional status		
Nature of food science and technology: Decisions about food choice are complex because of an interplay of physiological, psychological, social, economic and moral factors, which is further complicated by potentially contradictory or confusing nutritional advice in the media. (1.11, 2.6, 3.3).	**Understandings:** • Optimal nutrition and nutritional status • Physiological, psychological, social, economic and moral factors • Allergies and intolerances • Reliability and validity of nutritional information **Application and guidance:** Students should understand: and where appropriate, be able to discuss and evaluate:	**International mindedness:** Food producers need to be cognizant of cultural and religious differences that will impact on food choice and acceptability. **Theory of Knowledge:** There are positive effects of exposure to sun such as the production of Vitamin D as well as health risks associated with exposure to

1.5 Influences on nutritional status		
	• how optimal nutrition and nutritional status varies due to physiological, psychological, social, economic and moral factors. • the physiological factors specifically relating to needs of people with food allergies and intolerances, including coeliac; and people with medical conditions linked to diet, such as diabetes. • how optimal nutrition and nutritional status varies due to social, economic and moral factors such as religion, ethical issues and disposable income. • the reliability and validity of sources of nutritional information that could be misleading due to potential conflicting interests of the food industry, government and media. • the effects of contemporary diets on a person's health and well being. • the psychological issues of comfort eating, body image and peer pressure.	UV rays. How can conflicting knowledge claims be balanced? To what extent are religious belief systems responsible for the preparation and cooking of food in different cultures? **Utilization:** Biology - Option D1 **Aims:** 6. develop an ability to analyse, evaluate and synthesize scientific information and research data to inform food science and technology decisions. 9. understand and appreciate the impact of culture in terms of food science and food technology development

Essential idea: Societies may have both individual and collective organisations providing health support and advice. Local, national and international policies are aimed at achieving optimal public health.

1.6 Nutritional awareness and responsibilities		
Nature of food science and technology: Governments have a responsibility towards public health; individuals have a role to play in this endeavour. Food and diet are key issues in relation to public health. Local, national and international agencies act in the consumer's' interest during food production and supply, to promote public health initiatives and to regulate food advertising. Levels of consumer protection vary between countries for	**Understandings:** • Overweight and obesity • Public health and health services • Raising public awareness of food-related health issues • The role of governments in promoting public health • Modifiable and non-modifiable factors • Levels of consumer protection **Application and guidance:** Students should understand and where appropriate, be able to discuss and evaluate: • the terms overweight and obesity, and the way these can be measured to track public health.	**International mindedness:** Health campaigns and messages from governments vary from country to country e.g. Healthy Eating Pyramid in Hong Kong, Eat-Well Plate in UK. **Theory of Knowledge:** What role does emotion and reason play in public health initiatives? **Utilization:** Geography - Option F **Aims:**

1.6 Nutritional awareness and responsibilities		
economic and political reasons. (1.2, 2.8, 3.5, 3.6)	• the impact of chronic food-related issues, for example obesity, on health services. • the impact of acute food-related issues, for example, a food poisoning outbreak, on health services. • different government campaigns that promote public health, raise awareness about the health risks e.g. diet related cancers, cardiovascular disease, and be able to evaluate their efficacy • the difference between modifiable (dietary decisions) and non-modifiable factors that impact on health (genetics, gender, age, socio-economic status). • why political and economic factors affect the level of consumer protection around the world e.g. European Union food regulations are used by all member states.	2: appreciate the scientific study of food and food technology in personal, local and global contexts through stimulating and challenging opportunities.

Topic 2: Materials, Components and their application	25 hours

Essential Idea: The ability of protein to denature and coagulate is widely exploited in the preparation of a diverse range of products.

2.1 Functional properties of proteins in foods		
Nature of food science and technology: There are many different protein foods from animal and vegetable sources. By understanding the effect of agitation, or the addition of acids or heat, the structure of protein is altered and impacts on the sensory qualities of finished products (1.1, 3.1)	**Understandings:** • The chemical composition and structure of proteins • Denaturation and coagulation • Maillard reaction • Gelation of protein • Gluten formation **Application and guidance:** Students should understand and where appropriate, be able to discuss and evaluate: • how amino acids are joined by peptide bonds to form polypeptide chains. • the difference in structure of globular and fibrous proteins. • denaturation and coagulation of proteins through: heat, acid, agitation, enzymes and salt. • the effects of preparation and cooking methods of meat, fish and eggs. • how browning occurs through the Maillard reaction (non-enzymic browning) between protein chains and reducing sugars. • the gelation of proteins in products such as custard and cheese. • the role of gluten when making bread and pasta.	**International mindedness:** The impact of geography, climate, culture and religion on protein availability and choice. **Theory of Knowledge:** To what extent does food science share a common glossary of terms with other areas of knowledge? **Utilization:** Biology - Topic 2.4 Chemistry - Option B.2 Food science and technology - Topic 1.1 **Aims:** 6. develop an ability to analyse, evaluate and synthesize scientific information and research data to inform food science and technology decisions.

Essential Idea: Understanding the effect of heat on carbohydrates is particularly important to food preparation.

2.2 Functional properties of carbohydrate in foods		
Nature of food science and technology: Starch is often used to form the structure of baked food products and to thicken sauces. Sugar is widely used as a sweetener and when heated it adds colour to products, such as cakes and breads. (1.1, 3.1)	**Understandings:** • The chemical composition and structure of carbohydrates • Dextrinization • Caramelisation and crystallisation • Gelatinisation • Pectin gels **Application and guidance:** Students should understand and where appropriate, be able to discuss and evaluate: • the structure of monosaccharides, disaccharides and polysaccharides. • the impact of dry heat, acids and enzymes on dextrinization of starch. • the impact of temperature, agitation and acidity and presence of other ingredients on the Caramelisation and crystallisation of sugar. • the impact of temperature, agitation and pH on gelatinisation of starch. • how the levels of amylose and amylopectin in different starches (e.g. potato starch, rice flour, corn flour) affects the organoleptic properties of starch. • the impact of acids on pectin gelation.	**International mindedness:** Carbohydrates are often staple foods (e.g. rice, maize, wheat, cassava) because they are often a cheap and plentiful source of energy. Different types of grains used make flour in different parts of the world. **Theory of Knowledge:** How does categorization or classification help or hinder the pursuit of knowledge? **Utilization:** Biology - Topic 2.3 Chemistry - Option B.4 Food science and technology - Topic 1.1 **Aims:** 6. develop an ability to analyse, evaluate and synthesize scientific information and research data to inform food science and technology decisions.

Essential Idea: The composition of fats affects how food is prepared, and so impacts on the sensory and nutritional characteristics of a finished product.

<table>
<tr><th colspan="3">2.3 Functional properties of fats in food</th></tr>
<tr>
<td>Nature of food science and technology:

Fats are obtained from plant and animal sources. The chemical composition of plant and animal fats affects the way it can be used to prepare food products e.g. smoke point, lamination of pastries. It is important to use the appropriate type of fat for the desired outcome. For example, butter is used to make pastry, and using oil would not give the desired shortening effect. (1.1, 3.1)</td>
<td>Understandings:
• The chemical composition and structure of fats
• Emulsification and homogenisation
• Aeration and foams
• Plasticity and shortening
• Hydrogenation
• Melting and smoke points
Application and guidance:
Students should understand and where appropriate, be able to discuss and evaluate:

• the structure of triglycerides, saturated fatty acids, unsaturated fatty acids (monounsaturated and polyunsaturated).
• the impact of oil and water in the emulsification and homogenisation process.
• how creaming, rubbing- in, whisking and layering are to aerate and create foams.
• the role of the plasticity of different fats on shortening of food products.
• the advantages and disadvantages of hydrogenating fats and oils.
• how the chemical composition of fats impacts on the melting and smoke points of fats.</td>
<td>International mindedness:
Cultural and generational attitudes to the types of fat used in food preparation.

Theory of Knowledge:
Do different interpretations of vocabulary pose problems for sharing knowledge?

Utilization:
Biology - Topic 2.3
Chemistry - Option B.3
Food science and technology - Topic 1.1

Aims:
1. a sense of curiosity as they acquire the skills necessary for independent and lifelong learning and action through inquiry into the world of food science and technology.</td>
</tr>
</table>

Essential Idea: Additives are used in small amounts and can be beneficial to extending shelf life and improving sensory qualities.

2.4 Functional properties of additives		
Nature of food science and technology: Additives are substances added to foods to perform specific functions. Their use can be controversial and consumers may be wary of their use. For example, the flavour enhancer monosodium glutamate (MSG), which has been reported to have negative side effects if consumed in large quantities. (1.1, 1.4, 3.1)	**Understandings:** • Classification of additives: natural, nature identical and synthetic additives • Functions of additives • Benefits and risks of additives in foods • Functions of sweeteners **Application and guidance:** Students should understand and where appropriate, be able to discuss and evaluate: • classifications and uses of additives in a range of food products (e.g. ready-made sauces, low fat yoghurts, confectionery, baked products). • the function of additives: flavours, flavour enhancers, colours, preservatives, antioxidants, stabilisers, emulsifiers sweeteners, thickening and gelling agents • the advantages and disadvantages of different types of additives to both the producers and consumers, e.g. consider MSG, saccharin and aspartame.	**International mindedness:** Variations in additives permitted in some countries but banned in others due to legislative controls and enforcement **Theory of Knowledge:** How does the methodology of natural sciences aim to ensure all additives are safe for consumption? Can we ever be certain that additive safety is 'proven'? **Utilization:** Food science and technology - Topic 4 **Aims:** 3. acquire a body of knowledge, methods and techniques that characterize food science and food technology.

Essential idea: Additional ingredients have important functions for the sensory characteristics and shelf life of food products.

2.5 Functional properties of additional ingredients		
Nature of food science and technology: Additional ingredients have been used for many years to improve sensory qualities and shelf life of foods both domestically and commercially. (1.5, 1.12, 2.3)	**Understandings:** • Categories of additional ingredients: raising agents, acids and alkalis, and salt • Types of raising agents and their application • Types of acids and alkalis and their application **Application and guidance:** Students should understand and where appropriate, be able to discuss and evaluate: • the different properties of additional ingredients used both domestically and commercially e.g. salting, pickling, fermentation and leavening. • the factors and processes that affect the function of different raising agents (yeast, baking powder, bicarbonate of soda) in the bread and cakes. • the use of adding acid to food products. e.g. ascorbic acid to prevent browning, vinegar to extend shelf life and lactic acid in cheese making, addition of acid to bicarbonate of soda.	**International mindedness:** Foods using the functional properties of salt, raising agent and acids are found throughout the world e.g. kimchi, sauerkraut, naan. **Theory of Knowledge:** How can we decide whether one ingredient is a better choice than another? **Utilization** Food science and technology - Topic 4 **Aims** 3. Acquire a body of knowledge, methods, and techniques that characterize food science and food technology.

Essential Idea: Food fortification increases the content of essential micronutrients, irrespective of whether the nutrients were originally in the food before processing.

2.6 Food fortification		
Nature of food science and technology: Vitamins are added to improve the nutritional quality of the food supply and to provide a public health benefit with minimal risk to health. For	**Understandings:** • Types of food fortification • Reasons for food fortification • Criticisms and limitations of food fortification • Food supplements	**International mindedness:** International organisations, such as The World Health Organisation, (WHO), have recognized that there are over 2 billion people worldwide who suffer from a variety of micronutrient deficiencies **Theory of Knowledge:**

2.6 Food fortification		
example, Vitamin B12 in breakfast cereals. (2.7)	**Application and guidance:** Students should understand and where appropriate, be able to discuss and evaluate: • four types of fortification: bio-fortification, synthetic biology, commercial fortification and home fortification. • how food can be fortified by replacing nutrients which were lost during manufacture (e.g. B group vitamins, minerals such as iron and calcium). • how food can be fortified to act as a public health intervention (e.g. fluoride in drinking water). • how food can be fortified to ensure the nutritional equivalence of substitute foods (e.g. to make butter and margarine similar in content, soy milk and cow milk). • how food can be fortified ensure the appropriate vitamin and mineral nutrient composition of foods for special dietary purposes (e.g. gluten-free products, low sodium). • the criticisms and limitations related to food fortification. • how food supplements can be used for health and body development.	What are the ethical considerations associated with the fortification of food? **Utilization:** Food science and technology - Topic 1.2 **Aims:** 7. develop and apply 21st century communication and collaboration skills in the study of and participation in food science and technology activities. 10. become critically aware, as global citizens, of the ethical implications of global food science and technology developments.

Topic 3: Food Quality and Safety — 25 hours

Essential idea: Food deteriorates over time but actions can be taken to slow down the rate of spoilage, reduce food waste and prevent illness.

3.1 Food Spoilage		
Nature of food science and technology: Food deterioration occurs due to microbial and chemical activity. An understanding of how and why food spoils is essential to minimising risks to health and unnecessary waste. (1.1, 1.9)	**Understandings:** • Classifications of micro-organisms • Causes of food spoilage and contamination. • Rancidity • Water Activity • Monitoring food spoilage and bacterial growth • Expiry dates **Application and guidance:** Students should understand and where appropriate, be able to discuss and evaluate: • how micro-organisms are classified as: moulds, yeasts and bacteria. • how food spoilage and contamination can occur by means of biological, physical and chemical. Examples include enzymic, microbial activity, purification, fermentation, infestation and low temperature injury absorption. • hydrolytic and oxidative rancidity. • the importance of water activity in microbial spoilage. • how scientific principles are used to monitor food spoilage and bacteria growth. • the advantages and disadvantages of expiry dates (e.g. best before and use by dates).	**International mindedness:** Technological and economic advances enable the reduction of food spoilage in many parts of the world. **Theory of Knowledge:** How do emotion and reason establish whether or not food is safe to eat? **Utilization:** Food science and technology - Topic 4.1, 4.5 **Aims:** 8. understand how food science and technology promote intellectual, physical and emotional balance and contribute to personal and social well-being.

Essential idea: Food poisoning is an illness caused by eating harmful or contaminated foods. There are three types of food poisoning: chemical, biological and bacterial.

<table>
<tr><th colspan="3">3.2 Food poisoning</th></tr>
<tr>
<td>Nature of food science and technology:

Chemical food poisoning occurs when food is contaminated with chemicals. Biological poisoning is caused by eating foods containing naturally occurring poisons. Bacterial food poisoning is caused by eating food that is contaminated with pathogenic bacteria. (1.13)</td>
<td>Understandings:
• Types and causes of chemical, biological and bacterial food poisoning
• High-risk foods
• Symptoms of food poisoning
• Lifestyle factors that cause food poisoning

Application and guidance:
Students should understand and where appropriate, be able to discuss and evaluate:

• types and causes of chemicals of food poisoning e.g. pesticides and cleaning products.

• types and causes of biological of food poisoning e.g. toxins naturally occurring in plants such as poisonous mushrooms, green potatoes and rhubarb leaves.

• types and causes of bacterial food poisoning e.g. salmonella, staphylococcus aureus, bacillus cereus, Escherichia coli, listeria monocytogenes, clostridium botulinum and novo virus.

• foods that are high in protein and water are more susceptible to cause bacterial food poisoning e.g. meat, fish, eggs and dairy foods.

• the symptoms that occur from different types of food poisoning and consider the impact on the health service.

• how lifestyle factors contribute to the increased incidence of food poisoning.</td>
<td>International mindedness:
Bacterial food poisoning is the most significant food-transmitted disease in developed countries and is a far greater hazard than food-borne infections. However, in developing country contexts foodborne
infections are a significant cause of illness.

Theory of Knowledge:
How might technology support or contradict knowledge claims made through sensory perception with regards to food?

Utilization:
Biology - Option B.3

Aims:
8. understand how food science and technology promote intellectual, physical and emotional balance and contribute to personal and social well-being.</td>
</tr>
</table>

Essential idea: The growth of food poisoning bacteria can be controlled by complying to strict temperatures when storing and cooking high risk foods.

<table>
<tr><th colspan="3">3.3 Principles of temperature control</th></tr>
<tr>
<td>Nature of food science and technology:

To prevent food poisoning it is vital that food is cooked and stored at temperatures where microorganisms are inhibited or destroyed (2.4)</td>
<td>Understandings:
• Classification of microorganisms according to temperature growth
• The danger zone
• Monitoring temperature
• Cooking techniques and the effect on destroyed harmful bacteria and toxins

Application and guidance:
Students should understand and where appropriate, be able to discuss and evaluate:

• different types of microorganisms can be classified due to their optimum temperature growth range (psychrophiles, mesophiles, thermophiles).
• why advice for the temperature range of the danger zone varies marginally for the processes of food storage, cooking and serving.
• how temperature control is used to prevent bacterial growth at different stages of production, including critical food preparation temperatures e.g. freezing, chilling, cooking, hot-holding.
• advantages and disadvantages of different cooking techniques (such as frying, roasting, barbecuing and sous vide) to destroy harmful bacteria and toxins.</td>
<td>International mindedness:
There are international standards for food quality assurance but the implementation may vary.

Theory of Knowledge:
Some foods such as oysters and sushi are eaten raw but may potentially contain harmful bacteria. How can it be decided what constitutes an acceptable level of risk?

Utilization:
Biology - Option B.3

Aims:
8. understand how food science and technology promote intellectual, physical and emotional balance and contribute to personal and social well-being.</td>
</tr>
</table>

Essential idea: Food safety is concerned with the safe production, storage and preparation of food. Following safe and hygienic food handling practices are essential to prevent potential food contamination and poisoning.

3.4 Safe food handling and preparation		
Nature of food science and technology: Safe and hygienic food handling practices in the production, storage and preparation of food involves the application of rigorous controls at all stages of the production and supply chain. (1.9)	**Understandings:** • Basic food hygiene • Cross contamination • Food premises design for safe food preparation • Controls and scale of production • Quality assurance and risk assessment • Food laws and regulations **Application and guidance:** Students should understand and where appropriate, be able to discuss and evaluate: • the benefits of good personal hygiene and safety the consequences or poor hygiene and safety. • how cross contamination can be avoided throughout production and the supply chain. • how the design of food preparation areas can help to prevent the contamination of food by prevention of physical, chemical and biological contamination. • how hygiene and safety controls change as scale of production increases: a comparison between domestic and large scale commercial production. • the role of environmental health officers and food premise inspections. • how throughout the supply chain and production, quality assurance is used to identify hazards and control risks. • how HACCP, COSHH and other relevant food safety legislation is used to regulating and evaluating by use of inspections to check compliance.	**International mindedness:** There are international standards for food quality assurance but the implementation may vary. **Theory of Knowledge:** International standards may be seen to impose certain requirements. Can one group of people know what is best for others? **Utilization:** Biology - Option B.3 **Aims**: 4. apply and use a body of knowledge, methods and techniques creatively to address and critically consider issues related to food science and technology.

Essential idea: Organoleptic properties have a major impact of the acceptability of food. It is therefore imperative that appropriate sensory testing is carried out to ensure foods satisfy the needs and wants the specified target groups.

3.5 Organoleptic Properties		
Nature of food science and technology: Organoleptic properties include appearance, texture, taste and odour. Sensory testing methods are used to conduct reliable results under controlled environments. The concept of fair testing is crucial to obtain sensory data.(1.3, 1.13, 3.2)	**Understandings:** • Sensory properties of food • The purpose and importance of sensory tests • Advantages and disadvantages of different types of sensory testing **Application and guidance:** Students should understand and where appropriate, be able to discuss and evaluate: • the sensory properties of food, derived from: appearance, taste, texture, touch and smell. • how the sensory properties of food affect consumer food choices. • how sensory testing is a subjective evaluation of how people perceive a product. • the importance of sensory testing to food manufacturers. • the advantages and disadvantages of different types of sensory tests: difference tests, paired comparison test, triangle test, two out of five test, ranking test, rating tests (hedonic scales, unipolar and bipolar scales), significant results and profiling.	**International mindedness:** Increased travel has led to greater exposure to a variety of food textures and flavours which means consumers are more willing to try new foods. **Theory of Knowledge:** How might the collection and interpretation of sensory data be affected by the limitations of our senses? **Utilization:** Design technology (HL) 9.4: Market research **Aims:** 4. apply and use a body of knowledge, methods and techniques creatively to address and critically consider issues related to food science and technology. 5. develop experimental and investigative skills that generate useful qualitative and quantitative data.

Essential idea: Innovations and refinements in food packaging can extend shelf life, enable the safe transportation and increase usability.

<table>
<tr><th colspan="3">3.6 Packaging and food quality</th></tr>
<tr>
<td>Nature of food science and technology:

Packaging traditionally provided protection for food products. In many countries packaging and labelling now also provides marketing opportunities for manufacturers, as well as convenience and information for consumers which relate to their lifestyles. The implications of packaging on the environment is an area of growing concern.
(1.11, 1.13,2.5)</td>
<td>Understandings

• Reasons for packaging foods
• Advantages and disadvantages of packaging materials
• Primary and secondary packaging
• Packaging design
• Environmental impact of packaging

Application and guidance:
Students should understand and where appropriate, be able to discuss and evaluate:

• why food is packaged e.g. transportation, containment, protection, safety and hygiene.
• the advantages and disadvantages of packaging. e.g. plastic, paper, metal and glass.
• why food has both primary and secondary packaging. e.g. the Ferrero Roche.
• the design of packaging such as minimal use of materials, recycling, use of biodegradable materials, use of reusable containers.
• the environmental impact of food packaging and transporting packaged foods; availability and choice and prevention of waste food versus environmental impact of packaging.</td>
<td>International mindedness:
Legislation about packaging materials, use of bags and requiring packaging to be recycled or reused varies between countries.

Theory of Knowledge:
Experts sometimes disagree about packaging and environmental impact; on what basis might we decide between the judgments of experts if they disagree?

Utilization
Design Technology - Topic 4

Aims
10. Become critically aware, as global citizens, of the ethical implications of global food science and technology developments.</td>
</tr>
</table>

Topic 4: Food process engineering — 25 hours

Essential idea: Food processing combines raw food ingredients to produce marketable food products that can be easily prepared and served by the consumer.

4.1 Food processing methods		
Nature of food science and technology: Food processing is the transformation of raw ingredients, by physical or chemical means into food, or of food into other forms. Food processing can be primary or secondary to extend the shelf life and/or add value to a product. (1.10, 1.12, 2.2)	**Understandings:** • Primary, secondary and tertiary processing • Physical processing methods • Chemical processing methods • Traditional preservation processes • Fermentation • Adding value to food commodities • Ethical food production **Application and guidance:** Students should understand and where appropriate, be able to discuss and evaluate: • primary, secondary and tertiary processing e.g. cleaning and grading of the wheat, wheat milled into flour, flour made into bread. • physical processing methods e.g. milling. • chemical processing methods e.g. nitrates and nitrites in food preservation. • the use of salt, sugar, vinegar and smoking in the preservation of foods. • the positive and negative effects of micro-organisms and enzymes in the production of alcohol, cheeses, yoghurts, bread making and mycoproteins. • how food processing enhances the value of food commodities. • how foods are processed ethically e.g. fair-trade, organic and free range. • sustainability and food security	**International mindedness:** The opportunities for primary and secondary processing of food can be dependent on the economic development of a country. **Theory of Knowledge:** To what extent does a sense of the aesthetics of food products override engineering practicalities? **Utilization:** Biology - Option B.1 Food science and technology - Topic 3.3 Design Technology - Topic 4.5 **Aims:** 10. become critically aware, as global citizens, of the ethical implications of global food science and technology developments.

Essential idea: Food preservation is carried out to increase food choice and convenience for consumer and to add value for food producers.

4.2 Food processing: preservation by temperature control		
Nature of food science and technology: The deterioration of food products can be slowed by processing foods at different temperatures to reduce the rate of microbial growth, thereby extending shelf life. (1.1, 1.9)	**Understandings** • The principles of temperature control • Methods of heat processing • Methods of cold processing **Application and guidance:** Students should understand and where appropriate, be able to discuss and evaluate: • methods of heat processing: pasteurisation, sterilization, canning and aseptic canning. • methods of chilling and freezing (horizontal plate freezing, blast freezing, fluidised bed freezing. Cryogenic freezing). • the advantages and disadvantages to the manufacturer and consumer of different heat and cold processing methods. • how organoleptic properties are changed during heat and cold processing.	**International mindedness:** Globalisation has impacted on local food choice because **c**onsumers have greater access to food which they can now store by refrigeration and freezing. **Theory of Knowledge:** How can we judge whether one method of food processing is better than another? **Utilization** Food science and technology Topic 3 Biology Option F **Aims** 3. Acquire a body of knowledge, methods and techniques that characterize food science and food technology.

Essential idea: Food preservation is carried out to increase food choice and convenience for consumer and to add value for food producers.

4.3 Food processing: preservation by dehydration and irradiation		
Nature of food science and technology: The deterioration of food products can be slowed by processing foods by the removal or reduction in the water content and through irradiation to change the chemical structure, thereby extending shelf life. (1.1, 1.9)	**Understandings** • The principles of dehydration • Methods of dehydration • The principles of irradiation • Advantages and disadvantages of food irradiation • Irradiation processes	**International mindedness:** Dehydration has been used to preserve food for thousands of years in many parts of the world and it continues to make an important contribution to food availability both domestically and commercially.

4.3 Food processing: preservation by dehydration and irradiation		
	Application and guidance: Students should understand and where appropriate, be able to discuss and evaluate: • how water activity impacts on dehydration of different foods. • methods of dehydration (tunnel drying, roller drying, sun drying, warm air drying, spray drying, freeze drying). • the process of food irradiation, as an application of ionizing radiation to food. • the use of irradiated foods to reduce microbial spoilage, insect damage and inhibition of sprouting and ripening of fruits and vegetables. • consumer reaction to the wholesomeness of irradiated foods. • how organoleptic properties are changed through dehydration and irradiation processing.	**Theory of Knowledge:** Do new technologies affect the beliefs of a society? **Utilization** Food science and technology Topic 3 Biology Topic 3 and Option F **Aims** 3. Acquire a body of knowledge, methods and techniques that characterize food science and food technology.

Essential idea: Colour plays a significant role in the aesthetic appeal of food, as well as an indicator of flavour, freshness and overall quality.

4.4 The effect of food processing on colour		
Nature of food science and technology: When food is processed manufacturers may attempt: to minimise colour damage, restore colour or introduce new colour. This involves an understanding of both synthetic dyes and naturally occurring colours pigments (1.13, 2.1)	**Understandings:** • Naturally occurring pigments • Synthetic food dyes • Colour restoration • Colour and the impact of heat • Colour and the impact of pH • Colour and the impact of preservation processes • Consumer attitudes to food colours • Legislation controlling the use of food colours **Application and guidance:** Students should understand and where appropriate, be able to discuss and evaluate:	**International mindedness:** Synthetic food dyes are used throughout the world but the USA and Europe are the main centres for toxicological testing (Proudlove, 2001, p. 68). **Theory of Knowledge:** Are we conditioned to associate the colours of food with other particular sensory qualities? **Utilization:** Food science and technology - Topic 3.5 **Aims:** 10. become critically aware, as global citizens, of the ethical implications of global food science and technology developments.

<table>
<tr><th colspan="3">4.4 The effect of food processing on colour</th></tr>
<tr><td></td><td>

how naturally occurring pigments give colour to food e.g. anthocyanins, carotenoids and chlorophyll.
how synthetic food dyes give colour to food e.g. tartrazine, quinoline and erythrosine.
reasons for the use of natural food colours and synthetic food dyes to restore or introduce new colour to food products.
the effect of heat, acids, alkalis and other preservation techniques on anthocyanins, carotenoids, chlorophyll.
consumer attitudes to the use of natural and synthetic food colours.
why many countries have strict legislation to control the use of colours in food.

</td><td></td></tr>
</table>

Essential idea: Flavour is significant to the appeal of food and is linked to taste and odour.

<table>
<tr><th colspan="3">4.5 The effect of food processing on flavour</th></tr>
<tr><td>Nature of food science and technology:
Food processing can impact on flavour. An understanding of natural, nature identical and synthetic flavours is needed to maintain flavour uniformity and restore flavour lost through processing. (1.5, 2.1)</td><td>Understandings:

The five tastes
Natural flavours
Nature identical flavours
Synthetic flavours
Flavour and the impact of preservation processes
Advantages and disadvantages of flavours
Flavour enhancers/modifiers

Application and guidance:
Students should understand and where appropriate, be able to discuss and evaluate:

the five main tastes: umami, salt, sweet, sour and bitter; other flavours are odours.
the sources and use of natural flavours e.g. spices, herbs, essential oils.

</td><td>International mindedness:
Some international brands (Coca-Cola, Nestle) modify their products to suit consumer flavour preferences in different parts of the world.

Theory of Knowledge:
To what extent can flavour trigger memory?

Utilization:
Food Science and Technology - Unit 2.4
Food science and technology - Topic 3.5

Aims:
9. understand and appreciate the impact of culture in terms of food science and food technology development.</td></tr>
</table>

4.5 The effect of food processing on flavour		
	• the sources and use of nature identical e.g. nature identical vanillin. • the sources and use of synthetic flavours e.g. strawberry flavour may contain 10 to 12 synthetic organic chemicals. • how preservation techniques impact on flavour. • the advantages and disadvantages of natural, nature identical and synthetic flavours. • the use of flavour enhancers such as MSG and ribonucleotides. • how the use of gas chromatography and spectrometry has contributed to the study of flavour and aroma.	

Essential idea: Food processing can modify the texture of food to increase its organoleptic appeal.

4.6 The effect of food processing on texture		
Nature of food science and technology: During food processing texture can be modified by the use of thickeners, stabilisers and emulsifiers, and also by mechanical action and heating. (2.3, 2.5)	**Understandings:** • Colloidal systems: suspensions, emulsions, gels and foams • Thickening and gelling • Emulsifiers and stabilisers • Preservation techniques • Mechanical action to alter texture **Application and guidance:** Students should understand and where appropriate, be able to discuss and evaluate: • colloidal systems in food and how to distinguish between suspensions, emulsions and foams. • the use of maize and wheat as a traditional thickener, and pectin as a gelling agent in jam. • the types of starch modification (e.g. cross linking, acid modified, stabilisation, pre-gelatinised) and their impact on food processing.	**International mindedness:** Cultural, as well as physiological and psychological factors help shape attitudes to food texture e.g. crispness of stir fried vegetables (Szczesniak, 2002). **Theory of Knowledge:** How do we associate the texture of food with other quality attributes? **Utilization:** Food science and technology - Topic 3.5 **Aims:** 3. acquire a body of knowledge, methods and techniques that characterize food science and food technology.

4.6 The effect of food processing on texture		
	• the reasons for modifying starch, including thickening, stabilising, and improving mouthfeel. • the reasons for using gums include thickening and stabilising. Types of gums (e.g. Xanthan gum, alginates) and their impact on food processing. • the role of emulsifiers to form stable emulsions including lecithin and glyceryl monostearate (GMS); the role stabilisers absorbing large amounts of water. • how traditional preservation techniques have an impact on the texture of food. • how mechanical action is used to create foams and heat is used to create solid foams.	

Assessment in the Diploma Programme

General

Assessment is an integral part of teaching and learning. The most important aims of assessment in the Diploma Programme are that it should support curricular goals and encourage appropriate student learning. Both external and internal assessments are used in the Diploma Programme. IB examiners mark work produced for external assessment, while work produced for internal assessment is marked by teachers and externally moderated by the IB.

There are two types of assessment identified by the IB.

- Formative assessment informs both teaching and learning. It is concerned with providing accurate and helpful feedback to students and teachers on the kind of learning taking place and the nature of students' strengths and weaknesses in order to help develop students' understanding and capabilities. Formative assessment can also help to improve teaching quality, as it can provide information to monitor progress towards meeting the course aims and objectives.

- Summative assessment gives an overview of previous learning and is concerned with measuring student achievement.

The Diploma Programme primarily focuses on summative assessment designed to record student achievement at, or towards the end of, the course of study. However, many of the assessment instruments can also be used formatively during the course of teaching and learning, and teachers are encouraged to do this. A comprehensive assessment plan is viewed as being integral with teaching, learning and course organization. For further information, see the IB *Programme standards and practices* document.

The approach to assessment used by the IB is criterion-related, not norm-referenced. This approach to assessment judges students' work by their performance in relation to identified levels of attainment, and not in relation to the work of other students. For further information on assessment within the Diploma Programme please refer to the publication *Diploma Programme assessment: principles and practice*.

To support teachers in the planning, delivery and assessment of the Diploma Programme courses, a variety of resources can be found on the OCC or purchased from the IB store (http://store.ibo.org). Additional publications such as specimen papers and markschemes, teacher support materials, subject reports and grade descriptors can also be found on the OCC. Past examination papers as well as markschemes can be purchased from the IB store.

Methods of assessment

The IB uses several methods to assess work produced by students.

Assessment criteria

Assessment criteria are used when the assessment task is open-ended. Each criterion concentrates on a particular skill that students are expected to demonstrate. An assessment objective describes what students should be able to do, and assessment criteria describe how well they should be able to do it. Using assessment criteria allows discrimination between different answers and encourages a variety of responses. Each criterion comprises a set of hierarchically ordered level descriptors. Each level descriptor is worth one or more marks. Each criterion is applied independently using a best-fit model. The maximum marks for each criterion may differ according to the criterion's importance. The marks awarded for each criterion are added together to give the total mark for the piece of work.

Markbands

Markbands are a comprehensive statement of expected performance against which responses are judged. They represent a single holistic criterion divided into level descriptors. Each level descriptor corresponds to a range of marks to differentiate student performance. A best-fit approach is used to ascertain which particular mark to use from the possible range for each level descriptor.

Analytic markschemes

Analytic markschemes are prepared for those examination questions that expect a particular kind of response and/or a given final answer from students. They give detailed instructions to examiners on how to break down the total mark for each question for different parts of the response.

Marking notes

For some assessment components marked using assessment criteria, marking notes are provided. Marking notes give guidance on how to apply assessment criteria to the particular requirements of a question.

Inclusive assessment arrangements

Inclusive assessment arrangements are available for candidates with assessment access requirements. These arrangements enable candidates with diverse needs to access the examinations and demonstrate their knowledge and understanding of the constructs being assessed.

The IB document *Candidates with assessment access requirements* provides details on all the inclusive assessment arrangements available to candidates with learning support requirements. The IB document *Learning diversity within the International Baccalaureate programmes/Special educational needs within the International Baccalaureate programmes* outlines the position of the IB with regard to candidates with diverse learning needs in the IB programmes. For candidates affected by adverse circumstances, the IB documents *General regulations: Diploma Programme* and the *Assessment Procedures Diploma Programme* provide details on access consideration.

Responsibilities of the school

The school is required to ensure that that equal access arrangements and reasonable adjustments are provided to candidates with learning support requirements that are in line with the IB documents *Candidates with assessment access requirements* and *Learning diversity within the International Baccalaureate programmes/Special educational needs within the International Baccalaureate programmes.*

Assessment outline

First assessment 2019

Assessment component	Weighting
External assessment (3 hours)	**80%**
Paper 1 (1 hour) Short-answer and extended-response questions, based on any area of the syllabus. Assessment objectives 1 – 3 (40 marks)	**30%**
Paper 2 (2 hours) 4 questions, one on each topic. Each question is split into six parts: five short-answer and one extended response question. Assessment objectives 1 – 3 (80 marks)	**50%**
Internal assessment/individual investigation (10 hours) (24 marks) Assessment objectives 1 – 4 This component is internally assessed by the teacher and externally moderated by the IB at the end of the course.	**20%**

External assessment

External assessment details

Detailed markschemes specific to each examination paper are used to assess students. The markschemes are related to the assessment objectives and the group 4 grade descriptors.

Paper 1

Duration: 1 hour

Weighting: 30%

Marks: 40

Short-answer and extended-response questions to test objectives 1, 2, and 3.

Questions will be based on all areas of the syllabus.

All of the questions are compulsory.

Paper 2

Duration: 2 hours

Weighting: 50%

Marks: 80

Four questions to assess objectives 1, 2 and 3. Each question will cover one of the four topic areas, and be worth 20 marks. The four questions include short-answer questions and extended-response questions.

All of the questions are compulsory.

Purpose of internal assessment

Internal assessment is an integral part of the course and is compulsory for both SL and HL students. It enables students to demonstrate the application of their skills and knowledge, and to pursue their personal interests, without the time limitations and other constraints that are associated with written examinations. The internal assessment should, as far as possible, be woven into normal classroom teaching and not be a separate activity conducted after a course has been taught.

Guidance and authenticity

The work submitted for internal assessment must be the student's own work. However, it is not the intention that students should decide upon a title or topic and be left to work on the internal assessment component without any further support from the teacher. The teacher should play an important role during both the planning stage and the period when the student is working on the internally assessed work. It is the responsibility of the teacher to ensure that students are familiar with:

- the requirements of the type of work to be internally assessed
- the assessment criteria; students must understand that the work submitted for assessment must address these criteria effectively.

Teachers and students must discuss the internally assessed work. Students should be encouraged to initiate discussions with the teacher to obtain advice and information, and students must not be penalized for seeking guidance. As part of the learning process, teachers should read and give advice to students on one draft of the work. The teacher should provide oral or written advice on how the work could be improved, but not edit the draft. The next version handed to the teacher must be the final version for submission.

It is the responsibility of teachers to ensure that all students understand the basic meaning and significance of concepts that relate to academic honesty, especially authenticity and intellectual property. Teachers must ensure that all student work for assessment is prepared according to the requirements and must explain clearly to students that the internally assessed work must be entirely their own. Where collaboration between students is permitted, it must be clear to all students what the difference is between collaboration and collusion.

All work submitted to the IB for moderation or assessment must be authenticated by a teacher, and must not include any known instances of suspected or confirmed malpractice. Each student must confirm that the work is his or her authentic work and constitutes the final version of that work. Once a student has officially submitted the final version of the work it cannot be retracted. The requirement to confirm the authenticity of work applies to the work of all students, not just the sample work that will be submitted to the IB for the purpose of moderation. For further details refer to the IB publication *Academic honesty*, *The Diploma Programme: From principles into practice* and the relevant articles in *General regulations: Diploma Programme*.

Authenticity may be checked by discussion with the student on the content of the work, and scrutiny of one or more of the following:

- the student's initial proposal
- the first draft of the written work
- the references cited
- the style of writing compared with work known to be that of the student
- the analysis of the work by a web-based plagiarism detection service such as www.turnitin.com.

The same piece of work cannot be submitted to meet the requirements of both the internal assessment and the extended essay.

Group work

Each internal investigation is an individual piece of work based on different research collected. It should be made clear to students that all work connected with the writing of the internal investigation, should be their own. It is therefore helpful if teachers try to encourage in students a sense of responsibility for their own learning so that they accept a degree of ownership and take pride in their own work.

Time allocation

Internal assessment is an integral part of the food science and technology course, contributing 20% to the final assessment. This weighting should be reflected in the time that is allocated to teaching the knowledge, skills and understanding required to undertake the work, as well as the total time allocated to carry out the work.

It is recommended that a total of approximately 10 hours of teaching time should be allocated to the work. This should include:

- time for the teacher to explain to students the requirements of the internal assessment
- class time for students to work on the internal assessment component and ask questions
- time for consultation between the teacher and each student
- time to review and monitor progress, and to check authenticity.

Requirements and recommendations

While teachers are responsible for following national or local guidelines, which may differ from country to country, attention should be given to Health and safety for design and technology in schools and similar establishments – Code of practice

(http://old.n-somerset.gov.uk/NR/rdonlyres/602E0FC0-B2FC-4CD4-A4E0-DF71D6B7780F/0/BS41632007.pdf)

It is a basic responsibility of everyone involved to make safety and health an ongoing commitment. Any advice given will acknowledge the need to respect the local context, the varying educational and cultural traditions, the financial constraints and the legal systems of differing countries.

The Laboratory Safety Institute’s Laboratory Safety Guidelines...

40 suggestions for a safer lab

Steps Requiring Minimal Expense

1. Have a written health, safety and environmental affairs (HS&E) policy statement.
2. Organize a departmental HS&E committee of employees, management, faculty, staff and students that will meet regularly to discuss HS&E issues.
3. Develop an HS&E orientation for all new employees and students.
4. Encourage employees and students to care about their health and safety and that of others.
5. Involve every employee and student in some aspect of the safety program and give each specific responsibilities.
6. Provide incentives to employees and students for safety performance.
7. Require all employees to read the appropriate safety manual. Require students to read the institution's laboratory safety rules. Have both groups sign a statement that they have done so, understand the contents, and agree to follow the procedures and practices. Keep these statements on file in the department office.
8. Conduct periodic, unannounced laboratory inspections to identify and correct hazardous conditions and unsafe practices. Involve students and employees in simulated OSHA inspections.
9. Make learning how to be safe an integral and important part of science education, your work, and your life.

10. Schedule regular departmental safety meetings for all students and employees to discuss the results of inspections and aspects of laboratory safety.
11. When conducting experiments with hazards or potential hazards, ask yourself these questions:
    – What are the hazards?
    – What are the worst possible things that could go wrong?
    – How will I deal with them?
    – What are the prudent practices, protective facilities and equipment necessary to minimize the risk of exposure to the hazards?
12. Require that all accidents (incidents) be reported, evaluated by the departmental safety committee, and discussed at departmental safety meetings.
13. Require every pre-lab/pre-experiment discussion to include consideration of the health and safety aspects.
14. Don't allow experiments to run unattended unless they are failsafe.
15. Forbid working alone in any laboratory and working without prior knowledge of a staff member.
16. Extend the safety program beyond the laboratory to the automobile and the home.
17. Allow only minimum amounts of flammable liquids in each laboratory.
18. Forbid smoking, eating and drinking in the laboratory.
19. Do not allow food to be stored in chemical refrigerators.
20. Develop plans and conduct drills for dealing with emergencies such as fire, explosion, poisoning, chemical spill or vapour release, electric shock, bleeding and personal contamination.
21. Require good housekeeping practices in all work areas.
22. Display the phone numbers of the fire department, police department, and local ambulance either on or immediately next to every phone.
23. Store acids and bases separately. Store fuels and oxidizers separately.
24. Maintain a chemical inventory to avoid purchasing unnecessary quantities of chemicals.
25. Use warning signs to designate particular hazards.
26. Develop specific work practices for individual experiments, such as those that should be conducted only in a ventilated hood or involve particularly hazardous materials. When possible most hazardous experiments should be done in a hood.

Steps Requiring Moderate Expense

27. Allocate a portion of the departmental budget to safety.
28. Require the use of appropriate eye protection at all times in laboratories and areas where chemicals are transported.
29. Provide adequate supplies of personal protective equipment—safety glasses, goggles, face shields, gloves, lab coats and bench top shields.
30. Provide fire extinguishers, safety showers, eye wash fountains, first aid kits, fire blankets and fume hoods in each laboratory and test or check monthly.
31. Provide guards on all vacuum pumps and secure all compressed gas cylinders.
32. Provide an appropriate supply of first aid equipment and instruction on its proper use.
33. Provide fireproof cabinets for storage of flammable chemicals.
34. Maintain a centrally located departmental safety library:
    – "Safety in School Science Labs", Clair Wood, 1994, Kaufman & Associates, 101 Oak Street, Wellesley, MA 02482
    – "The Laboratory Safety Pocket Guide", 1996, Genium Publisher, One Genium Plaza, Schnectady, NY
    – "Safety in Academic Chemistry Laboratories", ACS, 1155 Sixteenth Street NW, Washington, DC 20036
    – "Manual of Safety and Health Hazards in The School Science Laboratory", "Safety in the School Science Laboratory", "School Science Laboratories: A Guide to Some Hazardous Substances", Council of State Science Supervisors (now available only from LSI)
    – "Handbook of Laboratory Safety", 4th Edition, CRC Press, 2000 Corporate Boulevard NW, Boca Raton, FL 33431
    – "Fire Protection Guide on Hazardous Materials", National Fire Protection Association, Batterymarch Park, Quincy, MA 02269
    – "Prudent Practices in the Laboratory: Handling and Disposal of Hazardous Chemicals", 2nd Edition, 1995
    – "Biosafety in the Laboratory", National Academy Press, 2101 Constitution Avenue, NW, Washington, DC 20418
    – "Learning By Accident", Volumes 1–3, 1997–2000, The Laboratory Safety Institute, Natick, MA 01760

(All are available from LSI.)

35. Remove all electrical connections from inside chemical refrigerators and require magnetic closures.

36. Require grounded plugs on all electrical equipment and install ground fault interrupters (GFIs) where appropriate.
37. Label all chemicals to show the name of the material, the nature and degree of hazard, the appropriate precautions, and the name of the person responsible for the container.
38. Develop a program for dating stored chemicals and for recertifying or discarding them after predetermined maximum periods of storage.
39. Develop a system for the legal, safe and ecologically acceptable disposal of chemical wastes.
40. Provide secure, adequately spaced, well ventilated storage of chemicals.
    (All are available from **LSI**.)

The Laboratory Safety Institute

Using assessment criteria for internal assessment

For internal assessment, a number of assessment criteria have been identified. Each assessment criterion has level descriptors describing specific achievement levels, together with an appropriate range of marks. The level descriptors concentrate on positive achievement, although for the lower levels failure to achieve may be included in the description.

Teachers must judge the internally assessed work against the criteria using the level descriptors.

- The aim is to find, for each criterion, the descriptor that conveys most accurately the level attained by the student, using the best-fit model. A best-fit approach means that compensation should be made when a piece of work matches different aspects of a criterion at different levels. The mark awarded should be one that most fairly reflects the balance of achievement against the criterion. It is not necessary for every single aspect of a level descriptor to be met for that mark to be awarded.

- When assessing a student's work, teachers should read the level descriptors for each criterion until they reach a descriptor that most appropriately describes the level of the work being assessed. If a piece of work seems to fall between two descriptors, both descriptors should be read again and the one that more appropriately describes the student's work should be chosen.

- Where there are two or more marks available within a level, teachers should award the upper marks if the student's work demonstrates the qualities described to a great extent; the work may be close to achieving marks in the level above. Teachers should award the lower marks if the student's work demonstrates the qualities described to a lesser extent; the work may be close to achieving marks in the level below.

- Only whole numbers should be recorded; partial marks, (fractions and decimals) are not acceptable.

- Teachers should not think in terms of a pass or fail boundary, but should concentrate on identifying the appropriate descriptor for each assessment criterion.

- The highest level descriptors do not imply faultless performance but should be achievable by a student. Teachers should not hesitate to use the extremes if they are appropriate descriptions of the work being assessed.

- A student who attains a high achievement level in relation to one criterion will not necessarily attain high achievement levels in relation to the other criteria. Similarly, a student who attains a low achievement level for one criterion will not necessarily attain low achievement levels for the other criteria. Teachers should not assume that the overall assessment of the students will produce any particular distribution of marks.

- It is recommended that the assessment criteria be made available to students.

Practical work and internal assessment

General introduction

The internal assessment, worth 20% of the final assessment, consists of one scientific investigation. The individual investigation should cover a topic that is commensurate with a standard level course.

Student work is internally assessed by the teacher and externally moderated by the IB. The performance in internal assessment at SL is marked against common assessment criteria, with a total mark out of 24.
Note: Any investigation that is to be used to assess students should be specifically designed to match the relevant assessment criteria.

The internal assessment task will be one scientific investigation taking about 10 hours and the write-up should be about 6 to 12 pages long. Investigations exceeding this length will be penalized in the communication criterion as lacking in conciseness.

The practical investigation, with generic criteria, will allow a wide range of practical activities. The investigation addresses many of the learner profile attributes well.

The task produced should be complex and commensurate with a Diploma level course. It requires a purposeful research question and the scientific rationale for it.

Some of the possible tasks include:

- a hands-on laboratory investigation
- using a spreadsheet for analysis and modelling
- extracting data from a database and analysing it graphically
- producing a hybrid of spreadsheet/database work with a traditional hands-on investigation
- using a simulation provided it is interactive and open-ended

Some tasks may consist of relevant and appropriate qualitative work combined with quantitative work.

Examples of possible investigations include:

- *To what extent do colours in foods reflect different levels of soil acidity, and how may this vary according to the location and/or context in which the food was produced?*
- *How does the use of different grain types in the production of bread impact its nutritional value?*
- *How do different methods of cooking impact protein chains in foods?*
- *To what extent can existing scientific data assist in the evaluation of different types of diets?*
- *How does fermentation change the properties of foods?*
- *How do the enzymatic or non-enzymatic processes that occur in the browning of food lead to desirable or undesirable results?*
- *How do genetically modified and 'natural' versions of the same food compare?*
- *To what extent do the chemicals introduced to foods during agricultural production, via fertilisers, pesticides and fungicides, pose a risk to the health of consumers?*

The five assessment criteria are personal engagement, exploration, analysis, evaluation and communication.

Internal assessment details

Individual investigation

Duration: 10 hours

Weighting: 20%

Assessment objectives 1 – 4

Internal assessment criteria

Individual investigation

The assessment model uses five criteria to assess the final report of the individual investigation with the following raw marks and weightings assigned:

Personal engagement	Exploration	Analysis	Evaluation	Communication	Total
2 (8%)	6 (25%)	6 (25%)	6 (25%)	4 (17%)	24 (100%)

Levels of performance are described using multiple indicators per level. In many cases the indicators occur together in a specific level, but not always. Also, not all indicators are always present. This means that a candidate can demonstrate performances that fit into different levels. To accommodate this, the IB assessment models use markbands and advise examiners and teachers to use a best-fit approach in deciding the appropriate mark for a particular criterion.

Teachers should read the guidance on using markbands shown above in the section called “Using assessment criteria for internal assessment” before starting to mark. It is also essential to be fully acquainted with the marking of the exemplars in the teacher support material. The precise meaning of the command terms used in the criteria can be found in the glossary of the subject guides.

Personal engagement

This criterion assesses the extent to which the student engages with the exploration and makes it their own. Personal engagement may be recognized in different attributes and skills. These could include addressing personal interests or showing evidence of independent thinking, creativity or initiative in the designing, implementation or presentation of the investigation.

Mark	Descriptor
0	The student’s report does not reach a standard described by the descriptors below.
1	The evidence of personal engagement with the exploration is limited with little independent thinking, initiative or creativity. The justification given for choosing the research question and/or the topic under investigation does not demonstrate personal significance, interest or curiosity. There is little evidence of personal input and initiative in the designing, implementation or presentation of the investigation.
2	The evidence of personal engagement with the exploration is clear with significant independent thinking, initiative or creativity. The justification given for choosing the research question and/or the topic under investigation demonstrates personal significance, interest or curiosity. There is evidence of personal input and initiative in the designing, implementation or presentation of the investigation.

Exploration

This criterion assesses the extent to which the student establishes the scientific context for the work, states a clear and focused research question and uses concepts and techniques appropriate to the Diploma Programme level. Where appropriate, this criterion also assesses awareness of safety, environmental, and ethical considerations.

Mark	Descriptor
0	The student's report does not reach a standard described by the descriptors below.
1–2	The topic of the investigation is identified and a research question of some relevance is stated but it is not focused. The background information provided for the investigation is superficial or of limited relevance and does not aid the understanding of the context of the investigation. The methodology of the investigation is only appropriate to address the research question to a very limited extent since it takes into consideration few of the significant factors that may influence the relevance, reliability and sufficiency of the collected data. The report shows evidence of limited awareness of the significant safety, ethical or environmental issues that are relevant to the methodology of the investigation*.
3–4	The topic of the investigation is identified and a relevant but not fully focused research question is described. The background information provided for the investigation is mainly appropriate and relevant and aids the understanding of the context of the investigation. The methodology of the investigation is mainly appropriate to address the research question but has limitations since it takes into consideration only some of the significant factors that may influence the relevance, reliability and sufficiency of the collected data. The report shows evidence of some awareness of the significant safety, ethical or environmental issues that are relevant to the methodology of the investigation*.
5–6	The topic of the investigation is identified and a relevant and fully focused research question is clearly described. The background information provided for the investigation is entirely appropriate and relevant and enhances the understanding of the context of the investigation. The methodology of the investigation is highly appropriate to address the research question because it takes into consideration all, or nearly all, of the significant factors that may influence the relevance, reliability and sufficiency of the collected data. The report shows evidence of full awareness of the significant safety, ethical or environmental issues that are relevant to the methodology of the Investigation*.

* This indicator should only be applied when appropriate to the investigation.

Analysis

This criterion assesses the extent to which the student’s report provides evidence that the student has selected, recorded, processed and interpreted the data in ways that are relevant to the research question and can support a conclusion.

Mark	Descriptor
0	The student’s report does not reach a standard described by the descriptors below.
1–2	The report includes insufficient relevant raw data to support a valid conclusion to the research question. Some basic data analysis is carried out but is either too inaccurate or too insufficient to lead to a valid conclusion. The report shows evidence of little consideration of the impact of measurement uncertainty on the analysis. The processed data is incorrectly or insufficiently interpreted so that the conclusion is invalid or very incomplete.
3–4	Appropriate and sufficient data analysis is carried out that could lead to a broadly valid conclusion but there are significant inaccuracies and inconsistencies in the analysis. The report shows evidence of some consideration of the impact of measurement uncertainty on the analysis. The processed data is interpreted so that a broadly valid but incomplete or limited conclusion to the research question can be deduced.
5–6	The report includes relevant quantitative and qualitative raw data that could support a detailed and valid conclusion to the research question. Appropriate and sufficient data analysis is carried out with the accuracy required to enable a conclusion to the research question to be drawn that is fully consistent with the experimental data. The report shows evidence of full and appropriate consideration of the impact of measurement uncertainty on the analysis. The processed data is correctly interpreted so that a completely valid and detailed conclusion to the research question can be deduced.

Evaluation

This criterion assesses the extent to which the student's report provides evidence of evaluation of the investigation and the results with regard to the research question and the accepted scientific context.

Mark	Descriptor
0	The student's report does not reach a standard described by the descriptors below.
1–2	A conclusion is outlined which is not relevant to the research question or is not supported by the data presented. The conclusion makes superficial comparison to the accepted scientific context. Strengths and weaknesses of the investigation, such as limitations of the data and sources of error, are outlined but are restricted to an account of the practical or procedural issues faced. The student has identified very few realistic and relevant suggestions for the improvement and extension of the investigation.
3–4	A conclusion is described which is relevant to the research question and supported by the data presented. A conclusion is described which makes some relevant comparison to the accepted scientific context. Strengths and weaknesses of the investigation, such as limitations of the data and sources of error, are described and provide evidence of some awareness of the methodological issues* involved in establishing the conclusion. The student has described some realistic and relevant suggestions for the improvement and extension of the investigation.
5–6	A detailed conclusion is described and justified which is entirely relevant to the research question and fully supported by the data presented. A conclusion is correctly described and justified through relevant comparison to the accepted scientific context. Strengths and weaknesses of the investigation, such as limitations of the data and sources of error, are discussed and provide evidence of a clear understanding of the methodological issues* involved in establishing the conclusion. The student has discussed realistic and relevant suggestions for the improvement and extension of the investigation.

Communication

This criterion assesses whether the investigation is presented and reported in a way that supports effective communication of the focus, process and outcomes.

Mark	Descriptor
0	The student’s report does not reach a standard described by the descriptors below.
1–2	The presentation of the investigation is unclear, making it difficult to understand the focus, process and outcomes. The report is not well structured and is unclear: the necessary information on focus, process and outcomes is missing or is presented in an incoherent or disorganized way. The understanding of the focus, process and outcomes of the investigation is obscured by the presence of inappropriate or irrelevant information. There are many errors in the use of subject-specific terminology and conventions*.
3–4	The presentation of the investigation is clear. Any errors do not hamper understanding of the focus, process and outcomes. The report is well structured and clear: the necessary information on focus, process and outcomes is present and presented in a coherent way. The report is relevant and concise thereby facilitating a ready understanding of the focus, process and outcomes of the investigation. The use of subject-specific terminology and conventions is appropriate and correct. Any errors do not hamper understanding.

*For example, incorrect/missing labelling of graphs, tables, images; use of units, decimal places.

Practical scheme of work

Rationale for practical work

Although the requirements for IA are centred on the investigation, the different types of practical activities that a student may engage in serve other purposes, including:

- illustrating, teaching and reinforcing theoretical concepts
- developing an appreciation of the essential hands-on nature of food science work
- developing an appreciation of food scientists’ use of secondary data from databases
- developing an appreciation of food scientists’ use of modelling
- developing an appreciation of the benefits and limitations of food scientific methodology

The practical scheme of work (PSOW) is the practical course planned by the teacher and acts as a summary of all the investigative activities carried out by a student.

Syllabus coverage

The range of practical work carried out should reflect the breadth and depth of the subject syllabus, but it is not necessary to carry out an investigation for every syllabus topic. However, all students must participate in the group 4 project and meet the requirements of the IA.

Planning your practical scheme of work

Teachers are free to formulate their own practical schemes of work by choosing practical activities/investigations according to the requirements outlined. Their choices should be based on:

1. subjects and levels taught
2. the needs of their students
3. available resources
4. teaching styles

Each scheme must include some complex practical activities/investigations that make greater conceptual demands on students. A scheme made up entirely of simple practical activities/investigations, such as ticking boxes or exercises involving filling in tables, will not provide an adequate range of experience for students. Teachers are encouraged to use the online curriculum centre (OCC) to share ideas about possible practical activities by joining in the discussion forums.

Flexibility

The practical programme is flexible enough to allow a wide variety of practical activities/investigations to be carried out. These could include:

- using data analysis for secondary data
- data-analysis exercises
- modelling using nutritional software
- focused scientific activities

Practical work documentation

Details of the practical scheme of work are recorded on Form 4/PSOW provided in the Handbook of Procedures. The 4/PSOW form is a record of all practical activities carried out by a class. The form is not required to moderate the individual investigations, so it is not necessary to submit this form. However, it is an essential planning and recording document for teachers to ensure that a suitable range of practical activities is carried out and that the appropriate hours are allocated to practical work. Teachers should maintain this form (or their own version of it including all the same information) to record the practical activities carried out by the class. A copy of the class 4/PSOW form should be retained at the school and made available to the IB, for example, during the five year school evaluation process.

Time allocation for practical work

The recommended teaching times for all Diploma Programme courses are 150 hours at SL. Students at SL are required to spend 30 hours, on practical activities (excluding time spent writing up work). The group 4 project and the food investigation are 10 hours each.

The group 4 project

The group 4 project is an interdisciplinary activity in which all Diploma Programme science students must participate. The intention is that students from the different group 4 subjects analyse a common topic or problem. The exercise should be a collaborative experience where the emphasis is on the processes involved in, rather than the products of, such an activity.

In most cases students in a school would be involved in the investigation of the same topic. Where there are large numbers of students, it is possible to divide them into several smaller groups containing representatives from each of the science subjects. Each group may investigate the same topic or different topics—that is, there may be several group 4 projects in the same school.

Summary of the group 4 project

The group 4 project is a collaborative activity where students from different group 4 subjects work together on a scientific or technological topic, allowing for concepts and perceptions from across the disciplines to be shared in line with aim 10—that is, to "develop an understanding of the relationships between scientific disciplines and their influence on other areas of knowledge". The project can be practically or theoretically based. Collaboration between schools in different regions is encouraged.

The group 4 project allows students to appreciate the environmental, social and ethical implications of science and technology. It may also allow them to understand the limitations of scientific study, for example, the shortage of appropriate data and/or the lack of resources. The emphasis is on interdisciplinary cooperation and the processes involved in scientific investigation, rather than the products of such investigation.

The choice of scientific or technological topic is open but the project should clearly address group 4 aims 7, 8 and 10.

Ideally, the project should involve students collaborating with those from other group 4 subjects at all stages. To this end, it is not necessary for the topic chosen to have clearly identifiable separate subject components. However, for logistical reasons, some schools may prefer a separate subject "action" phase (see the following "Project stages" section).

Project stages

The 10 hours allocated to the group 4 project, which are part of the teaching time set aside for developing the practical scheme of work, can be divided into three stages: planning, action and evaluation.

Planning

This stage is crucial to the whole exercise and should last about two hours.

- The planning stage could consist of a single session, or two or three shorter ones.
- This stage must involve all group 4 students meeting to "brainstorm" and discuss the central topic, sharing ideas and information.
- The topic can be chosen by the students themselves or selected by the teachers.
- Where large numbers of students are involved, it may be advisable to have more than one mixed subject group.

After selecting a topic or issue, the activities to be carried out must be clearly defined before moving from the planning stage to the action and evaluation stages.

A possible strategy is that students define specific tasks for themselves, either individually or as members of groups, and investigate various aspects of the chosen topic. At this stage, if the project is to be experimentally based, apparatus should be specified so that there is no delay in carrying out the action stage. Contact with other schools, if a joint venture has been agreed, is an important consideration at this time.

Action

This stage should last around six hours and may be carried out over one or two weeks in normal scheduled class time. Alternatively, a whole day could be set aside if, for example, the project involves fieldwork.

- Students should investigate the topic in mixed-subject groups or single-subject groups.
- There should be collaboration during the action stage; findings of investigations should be shared with other students within the mixed/single-subject group. During this stage, in any practically based activity, it is important to pay attention to safety, ethical and environmental considerations.

Note: Students studying two group 4 subjects are not required to do two separate action phases.

Evaluation

The emphasis during this stage, for which two hours are probably necessary, is on students sharing their findings, both successes and failures, with other students. How this is achieved can be decided by the teachers, the students or jointly.

- One solution is to devote a morning, afternoon or evening to a symposium where all the students, as individuals or as groups, give brief presentations.
- Alternatively, the presentation could be more informal and take the form of a science fair where students circulate around displays summarizing the activities of each group.

The symposium or science fair could also be attended by parents, members of the school board and the press. This would be especially pertinent if some issue of local importance has been researched. Some of the findings might influence the way the school interacts with its environment or local community.

Addressing aims 7 and 8

Aim 7: “develop and apply 21st century communication and collaboration skills in the study of and participation in food science and technology activities”

Aim 7 may be partly addressed at the planning stage by using electronic communication within and between schools. It may be that technology will be used in the action phase and certainly in the presentation/evaluation stage (for example, use of digital images, presentation software, websites, digital video and so on).

Aim 8: “understand how the science of food and new technologies promote intellectual, physical and emotional balance that contributes to a person’s well-being”

Addressing the international dimension

There are possibilities to illustrate the international nature of the scientific endeavour and the increasing cooperation required to tackle global issues involving science and technology. An alternative way to bring an international dimension to the project is to collaborate with a school in another region.

Types of project

While addressing aims 7, 8 and 10 the project must be based on science or its applications. The project may have a hands-on practical action phase or one involving purely theoretical aspects. It could be undertaken in a wide range of ways:

- designing and carrying out a laboratory investigation or fieldwork
- carrying out a comparative study (experimental or otherwise) in collaboration with another school
- collating, manipulating and analysing data from other sources, such as scientific journals, environmental organizations, science and technology industries and government reports
- designing and using a model or simulation

- contributing to a long-term project organized by the school

Logistical strategies

The logistical organization of the group 4 project is often a challenge to schools. The following models illustrate possible ways in which the project may be implemented.

Models A, B and C apply within a single school, and model D relates to a project involving collaboration between schools.

Model A: mixed-subject groups and one topic

Schools may adopt mixed-subject groups and choose one common topic. The number of groups will depend on the number of students.

Model B: mixed-subject groups adopting more than one topic

Schools with large numbers of students may choose to do more than one topic.

Model C: single-subject groups

For logistical reasons some schools may opt for single-subject groups, with one or more topics in the action phase. This model is less desirable as it does not show the mixed subject collaboration in which many scientists are involved.

Model D: collaboration with another school

The collaborative model is open to any school. To this end, the IB provides an electronic collaboration board on the OCC where schools can post their project ideas and invite collaboration from other schools. This could range from merely sharing evaluations for a common topic to a full-scale collaborative venture at all stages.

For schools with few Diploma Programme (course) students it is possible to work with non-Diploma Programme or non-group 4 students, or undertake the project once every two years. However, these schools are encouraged to collaborate with another school. This strategy is also recommended for individual students who may not have participated in the project, for example, through illness or because they have transferred to a new school where the project has already taken place.

Timing

The 10 hours that the IB recommends be allocated to the project may be spread over a number of weeks. The distribution of these hours needs to be taken into account when selecting the optimum time to carry out the project. However, it is possible for a group to dedicate a period of time exclusively to project work if all/most other schoolwork is suspended.

Year 1

In the first year, students' experience and skills may be limited and it would be inadvisable to start the project too soon in the course. However, doing the project in the final part of the first year may have the advantage of reducing pressure on students later on. This strategy provides time for solving unexpected problems.

Year 1–Year 2

The planning stage could start, the topic could be decided upon, and provisional discussion in individual subjects could take place at the end of the first year. Students could then use the vacation time to think about how they are going to tackle the project and would be ready to start work early in the second year.

Year 2

Delaying the start of the project until some point in the second year, particularly if left too late, increases pressure on students in many ways: the schedule for finishing the work is much tighter than for the other options; the illness of any student or unexpected problems will present extra difficulties. Nevertheless, this choice does mean students know one another and their teachers by this time, have probably become accustomed to working in a team and will be more experienced in the relevant fields than in the first year.

Selecting a topic

Students may choose the topic or propose possible topics and the teacher then decides which one is the most viable based on resources, staff availability and so on. Alternatively, the teacher selects the topic or proposes several topics from which students make a choice.

Student selection

Students are likely to display more enthusiasm and feel a greater sense of ownership for a topic that they have chosen themselves. A possible strategy for student selection of a topic, which also includes part of the planning stage, is outlined here. At this point, subject teachers may provide advice on the viability of proposed topics.

- Identify possible topics by using a questionnaire or a survey of students.
- Conduct an initial “brainstorming” session of potential topics or issues.
- Discuss, briefly, two or three topics that seem interesting.
- Select one topic by consensus.
- Students make a list of potential investigations that could be carried out. All students then discuss issues such as possible overlap and collaborative investigations.

A reflective statement written by each student on their involvement in the group 4 project must be included on the coversheet for each internal assessment investigation. See the *Assessment Procedures Diploma Programme* document for more details.

Glossary of command terms

Command terms for food science and technology

Students should be familiar with the following key terms and phrases used in examination questions, which are to be understood as described below. Although these terms will be used frequently in examination questions, other terms may be used to direct students to present an argument in a specific way.

Assessment objective 1

Define	Give the precise meaning of a word, phrase, concept or physical quantity.
Draw	Represent by means of a labelled, accurate diagram or graph, using a pencil. A ruler (straight edge) should be used for straight lines. Diagrams should be drawn to scale. Graphs should have points correctly plotted (if appropriate) and joined in a straight line or smooth curve.
Label	Add labels to a diagram.
List	Give a sequence of brief answers with no explanation.
Measure	Obtain a value for a quantity.
State	Give a specific name, value or other brief answer without explanation or calculation.

Assessment objective 2

Annotate	Add brief notes to a diagram or graph.
Apply	Use an idea, equation, principle, theory or law in relation to a given problem or issue.
Calculate	Obtain a numerical answer showing the relevant stages in the working.
Describe	Give a detailed account.
Distinguish	Make clear the differences between two or more concepts or items.
Estimate	Obtain an approximate value.
Identify	Provide an answer from a number of possibilities.
Outline	Give a brief account or summary.

Assessment objective 3

Analyse	Break down in order to bring out the essential elements or structure.
Comment	Give a judgment based on a given statement or result of a calculation.
Compare	Give an account of the similarities between two (or more) items or situations, referring to both (all) of them throughout.
Compare and contrast	Give an account of similarities and differences between two (or more) items or situations, referring to both (all) of them throughout.
Construct	Display information in a diagrammatic or logical form.
Deduce	Reach a conclusion from the information given.
Demonstrate	Make clear by reasoning or evidence, illustrating with examples or practical application.
Derive	Manipulate a mathematical relationship to give a new equation or relationship.
Design	Produce a plan, simulation or model.
Determine	Obtain the only possible answer.

Discuss	Offer a considered and balanced review that includes a range of arguments, factors or hypotheses. Opinions or conclusions should be presented clearly and supported by appropriate evidence.
Distinguish	Make clear the differences between two (or more) concepts or objects
Evaluate	Make an appraisal by weighing up the strengths and limitations.
Explain	Give a detailed account including reasons or causes.
Justify	Give valid reasons or evidence to support an answer or conclusion.
Predict	Give an expected result.
Sketch	Represent by means of a diagram or graph (labelled as appropriate). The sketch should give a general idea of the required shape or relationship, and should include relevant features.
Suggest	Propose a solution, hypothesis or other possible answer.