Syllabus for CCVX Preliminary Examination in Biology

This document sets out the general learning outcomes of the programme for the Physics Preliminary Examination of the Centrale Commissies Voortentamen (Central Committees for Preliminary Examinations), starting with the November 2017 Preliminary Examination.

This specification is based on the learning outcomes of the programme for the Central Examination and School Examination as held for Biology in VWO secondary schools from May 2016. The Preliminary Examination tests knowledge of the syllabus for both the Central Examination and the School Examination.

As long as this list is on the site of the CCVX, this list is automatically up to date.
If the syllabus for the Preliminary Examination differs from that of the current programme for the Central Examination or School Examination, the CCVX programme always applies.

Date: 21 September 2017

1. The CCVX Preliminary Examination in Biology

The Preliminary Examination is a written examination.
It lasts three hours.

The syllabus comprises the following domains:

- Basic Knowledge of Chemistry and Physics
- Domain A Skills
- Domain B Self-Regulation
- Domain C Self-Organization
- Domain D Interaction
- Domain E Reproduction
- Domain F Evolution

The Biology Preliminary Examination relates to the Basic Knowledge of Chemistry and Physics and the Domains B-F in conjunction with the skills in Domain A, except for those aspects that do not by their nature lend themselves to written examination, including skills that expressly require a computer workstation.

For examples of examination questions see the specimen examinations on the CCVX website (www.ccvx.nl) and past written examinations. The type of questions will not differ from those based on the Dutch “College voor Toetsing en Examens” (CvTE) current interpretation of the learning outcomes.

The following specification of the syllabus for the CCVX Biology Preliminary Examination lists:
- the domains and subdomains being tested
- a single general learning outcome for each subdomain
- the general learning outcomes, supplemented by specimen contexts and specific concepts.

The specimen contexts are intended as minimum requirements; they are certainly not designed to exclude other possible specimen contexts.

2. The Syllabus for the Preliminary Examination

Basic Knowledge of Chemistry and Physics

This basic knowledge is not tested directly or in isolation from a biological case in the Preliminary Examination.

Chemistry
The following topics are assumed to be known for biology:

- Atom, molecule, ion, proton
- Atomic mass
- Molecular formula, structural formula
- Reagents
- Reaction equation, equilibrium reactions, catalyst
- Water-soluble or fat-soluble (hydrophilic, hydrophobic), saturation
- Acids and bases, pH, indicators
- Reducing agent and oxidizing agent
- Amino acids, proteins, peptide binding
- Fats, glycerol, saturated/unsaturated fatty acids
- Carbohydrates: monosaccharides, disaccharides and polysaccharides
- Hydrogen and sulfur bridges
- Methane, alcohol (ethanol)
- Names and formulas of the following substances: ammonia, calcium, iron, potassium, carbon dioxide, magnesium, sodium chloride, nitrogen and water
- Quantities and units: concentration (mol/L or g/L), percentage by mass, percentage by volume, ppm.

Physics
The following topics are assumed to be known for biology:

- Mass, density, weight
- Solid, liquid and gas phase
- Rates, frequencies
- Types of energy
- Radioactive isotopes and ionizing radiation, half-life
- Electromagnetic spectrum
- Specific heat, heat capacity, heat of combustion

Domain A - Skills

The skills are divided into three categories:

Subdomains A1-A4:	General Skills
Subdomains A5-A9:	Scientific, Mathematical and Technical Skills
Subdomains A10-A15:	Specific Biological Skills

Subdomain A1 - Using Information Skills
The candidate is able is search for, judge, select and process information systematically.

Subdomain A2 - Communication
The candidate is able to communicate effectively on subjects in the respective area in writing, verbally and digitally in the public domain.

Subdomain A3 - Reflecting on Learning

The candidate is able to reflect on his interests, motivation and learning process in acquiring subject knowledge and technical skills.

Subdomain A4 - Studies and Professions
The candidate is able to describe how scientific knowledge is used in studies and professions and based on that, among other things, to put his interest in studies and professions into words.

Subdomain A5 - Research
The candidate is able in particular contexts to analyse problems using relevant concepts and theory, translate them into specific research, conduct that research and draw conclusions from the results, using consistent arguments and relevant arithmetical and mathematical skills.

Specification:
The candidate is able, using consistent arguments and relevant arithmetical and mathematical skills, to:

1. recognize and specify a scientific problem
2. express a scientific problem as one or more research questions
3. identify relationships between a research question and scientific knowledge
4. formulate a hypothesis and expectations for a research question
5. draw up a work plan for a scientific study to answer one or more research questions
6. carry out relevant observations and collect measuring data to answer a research question
7. process measuring data and present them in a way that helps to answer a research question
8. from data collected in a study draw conclusions relating to that study's research question(s)
9. evaluate how a study was conducted and its conclusions, using the concepts of validity and reliability
10. present a scientific study
11. Recognizing that approaches other than an experimental approach are possible
12. Interpreting the nature of research findings, using the concepts of uncertainty and probability.

Subdomain A6 - Design
The candidate is able in particular contexts to prepare, implement, test and evaluate a technical design based on a set problem, using relevant concepts, theory and skills and valid, consistent arguments.

Specification:
The candidate is able, using relevant concepts, theory and skills and valid, consistent arguments, to:

1. analyse and describe a technical design problem
2. draw up a schedule of requirements and preferences
3. identify relationships between scientific knowledge and the functions and properties of a design
4. produce several versions of the functions and properties of a design
5. put forward a reasoned design proposal for a design, taking the schedule of requirements, priorities and criteria into consideration
6. build a prototype of a design
7. test and evaluate a design process and product, taking the schedule of requirements into consideration
8. put forward proposals to improve a design
9. present a design process and product.

Subdomain A7 - Modelling

The candidate is able in particular contexts to analyse a relevant problem, reduce it to a workable problem, translate it into a model, generate and interpret model results, and verify and assess the model, using consistent arguments and relevant arithmetical and mathematical skills.

Specification:
The candidate is able, using consistent arguments and relevant arithmetical and mathematical skills, to:

1. identify and select relevant parameters and relationships in a problem situation
2. reduce a scientific problem to a researchable question by making assumptions and simplifications
3. select a model for a scientific problem that is suitable to study it
4. make reasoned estimates of values and margins of error for model parameters based on data
5. formulate verifiable expectations for the behaviour of a model
6. compute a model with a suitable time increment
7. evaluate a model based on results, expectations and measuring data, taking any margins of error in model parameters into consideration
8. present a model study.

Subdomain A8 - Scientific Instruments
The candidate is able in particular contexts to use scientifically relevant instruments, paying attention to risks and safety where necessary; this relates to instruments for data collection and processing, scientific language, scientific conventions, symbols, formulas and arithmetical calculations.
Specification:
The candidate is able to:

1. obtain and select information from written, oral and audiovisual sources, including using IT:
   - extract data from graphs, tables, drawings, simulations, charts and diagrams
   - look up parameters, units, symbols, formulas and data in suitable tables
2. analyse information, data and readings, reproduce and organize them in graphs, drawings, charts, diagrams and tables, including using IT
3. indicate what techniques and apparatus are used to measure the most important scientific parameters
4. handle materials, instruments, organisms and the environment responsibly
5. use a number of scientifically relevant arithmetical/mathematical skills to solve scientific problems:
   - calculate numbers in fractions and powers
   - calculate ratios, percentages and averages
   - calculate area and volume
   - convert formulas
   - draw graphs, taking the place of the dependent and independent variable into consideration
   - read a logarithmic graph
   - recognize linear and exponential relationships
   - read graphs (without formulas) in terms of graphical progression and trends
6. identify relationships from data in tables and graphs.

Subdomain A9 - Evaluation and Judgment
The candidate is able in particular contexts to give a reasoned judgment of a situation in nature or a technical application, distinguishing between scientific arguments, normative social considerations and personal views.

Specification:
The candidate is able to:

1. give a reasoned judgment of a situation in which scientific knowledge plays an important role, or make a reasoned choice between alternatives in questions of a scientific nature
2. distinguish between scientific arguments, normative social considerations and personal views
3. cite sources for facts
4. assess the reliability of information and determine its value as regards answering the respective question.

Subdomain A10 - Perception
The candidate is able in particular contexts to put into words feelings and meanings evoked by engaging with nature or objects that occur in nature, paying attention to the feelings and meanings experienced by other people.

Subdomain A11 - Thinking in terms of Form and Function
The candidate is able in particular contexts to argue from the given form of biological objects at different levels of organization to the associated function and vice versa.

Subdomain A12 - Ecological Thinking
The candidate is able in sustainability contexts to argue what the effects of internal or external changes in a community or ecosystem are.

Subdomain A13 - Evolutionary Thinking
The candidate is able in particular contexts to argue how biological phenomena at different levels of organization can be explained, using theory on evolutionary mechanisms.

Subdomain A14 - Systems Thinking
The candidate is able in particular contexts to distinguish between different levels of organization, examine relationships within and between levels of organization, and explain how biological units at different levels of organization maintain themselves and develop.

Subdomain A15 - Developing and Applying Knowledge
The candidate is able in particular contexts to analyse how scientific and technological knowledge is developed and applied.

Subdomain A16 - Contexts
The candidate is able to use the skills listed under Domain A and Domains B-F at least in scientific contexts, in professional contexts requiring scientific training and in social environment contexts.

Domain B - Self-Regulation
Biology, the theory of life, studies life at different levels. At each level there are systems with their own organization, known as ‘biological units’: molecules, cells, organs, organisms, populations and ecosystems. Each biological unit is a complex dynamic system, designed to deal with its environment effectively. Each biological unit is a complex system that regulates itself.
Biological units at any level of organization maintain themselves by taking in substances or energy from their environment, repairing damage to themselves, defending themselves against attackers and harmful substances, and adapting to or changing the environment. Parts of a biological unit may be specialized to perform particular functions. Biological units may get together to form a new higher-level biological unit with its own organizational structure.
The candidate is able in a particular context to:
- recognize biological units and describe their characteristics. These biological units are molecules, cells, organs, organisms, populations and ecosystems
- explain that energy and matter are taken in, processed and released, describing the relationships within and between the various biological units

- argue from a given form of a biological unit to an associated function and vice versa.

Subdomain B1 - Protein Synthesis
The candidate is able at least in health and food production contexts to explain how self-regulation takes place at molecular level, using the concepts of DNA and protein synthesis.

Specimen contexts:
Health and healthcare: Human geneticists at university hospitals are doing experimental DNA research to enable Duchenne muscular dystrophy patients to produce functional dystrophin.
Food production: Biotechnologists at the Bureau for Genetically Modified Organisms (Bureau GGO) are assessing applications for the use of genetically modified crops in order to ensure that they are safe for humans and the environment.
Food production: Food technologists at a food production company are changing DNA and thus protein synthesis in order to produce healthier products (functional foods).

B1.1 - DNA
Specification:
The candidate is able in a particular context to:
1. describe the structure of DNA and RNA and explain the differences
2. list the functions of DNA, mRNA, tRNA and rRNA and describe how they relate to their structure
3. explain how the base sequence in DNA can be identified.

Specific concepts:
Nucleic acids, helical structure, base pairing, nucleotide, single-strand and double-strand DNA, chromosomes, nucleosomes, histones, nucleic DNA, mitochondrial and chloroplast mtDNA, cDNA, RNA, genetic code, plasmid, primer, PCR, sequences, restriction enzyme, repetitive DNA.

B1.2 - Protein Synthesis
Specification:
The candidate is able in a particular context to:
1. explain how proteins are produced, based on the relationship between triplet code and amino acid
2. describe the process of transcription and translation
3. explain how the amino acid sequence (primary structure) of a protein determines its structure and mechanism
4. explain how proteins determine the structure and mechanism of biological units.

Specific concepts:
Amino acid, primary, secondary, tertiary and quaternary structure, protein, peptide binding, transcription, translation, mRNA, tRNA, rRNA, cytoplasm, ribosome, Golgi apparatus, rough endoplasmic reticulum, triplet code, codon, anticodon, coding strand, reading direction, template/matrix strand, DNA polymerase, start codon, stop codon, plasmid.

Subdomain B2 - Metabolism in Cells
The candidate is able at least in health and nutrition contexts to explain how the metabolism of cells of prokaryotes and eukaryotes takes place, using the concepts of homeostasis, transport, assimilation and dissimilation.
Specimen contexts:
Health and healthcare (social environment context): Members of a family who may have a hereditary mitochondrial disorder such as MERRF taking part in a study at a university hospital to ascertain whether they have the mutated gene in order to prepare for possible consequences.
Nutrition: Microbiologists at food producers developing microbial tests for food ingredients to enable them to be tested quickly for dangerous microorganisms.

B2.1 - Homeostasis

Specification:
The candidate is able in a particular context to:

1. describe the characteristics of bacteria
2. describe a eukaryotic cell as an independently functioning unit, recognize the parts of cells and list their functions
3. explain that cells maintain themselves by means of chemical reactions
4. explain that dynamic equilibrium in a cell is maintained in a complex network of cell processes that have a variety of functions
5. explain how the principle of homeostatic feedback is implemented in a cell.

Specific concepts:
Prokaryote, eukaryote, virus, bacterium, plasmid, cell nucleus, nucleolus, nuclear pore, chromosome, cell wall, cell membrane, vacuole, cytoplasm, groundplasm, cytoskeleton, centrioles, mitochondrion, rough endoplasmic reticulum, Golgi apparatus, ribosome, lysosome, chloroplast, chlorophyll, plastid, cilia, flagella, feedback, receptor protein, effector, cascade, ion pump, dynamic equilibrium.

B2.2 - Transport

Specification:
The candidate is able in a particular context to:

1. describe types of active and passive transport and how they relate to the properties of the substances being transported and the structure and properties of membranes
2. explain that the effects of osmosis are different in plant and animal cells
3. explain that cell contents differ from the cell environment at all times because of the presence of a selectively permeable cell membrane
4. recognize the role of the cytoskeleton in transport processes.

Specific concepts:
Diffusion, osmosis, semi-permeable membrane, selective permeability, phospholipids, hydrophobic, hydrophilic, receptor protein, ion transport, ion pump, isotonic, hypotonic, hypertonic, plasmolysis, turgor, osmotic pressure, osmotic value, water potential, active transport, passive transport, endocytosis and exocytosis, cytoplasmic flow, motor protein, cytoskeleton.

B2.3 - Assimilation and Dissimilation

Specification:
The candidate is able in a particular context to:

1. describe that cells absorb and release water, that substances in the cells are processed in chemical reactions (produced and broken down) which are catalysed by enzymes
2. describe that there are different types of energy: chemical energy (as in ATP), light energy, kinetic energy and heat, and describe that these types can be converted into one another
3. describe the photosynthesis process in cells with chloroplasts
4. describe assimilation processes in plants and animals and explain that these processes result in the production of building materials, fuels, reserve substances and enzymes
5. describe dissimilation processes, distinguishing between anaerobic and aerobic dissimilation
6. explain assimilation and dissimilation processes (and the constituent reactions) using reaction equations
7. describe where and how enzymes catalyse reactions such as assimilation and dissimilation processes and how they are influenced by temperature and pH
8. explain how the metabolism of microorganisms is used in biotechnology
9. explain the differences between photosynthesis and chemosynthesis and explain under what conditions both these processes can take place.

Specific concepts:
Autotroph, heterotroph, photosynthesis, C assimilation, chloroplast, light and dark reaction, chemosynthesis, combustion, aerobic, anaerobic, glycolysis, citric acid cycle, oxidative phosphorylation, fermentation, alcohol, lactic acid, methane, ADP and ATP, NAD, NADP, building materials, fuels, reserve substances, enzymes, phospholipids, extracellular matrix, carbohydrates (monosaccharides, disaccharides and polysaccharides, starch, glycogen, cellulose), fat (fatty acids and glycerol), protein, amino acids, DNA, recombinant DNA, pH.

Subdomain B3 - Metabolism in Organisms
The candidate is able at least in health and food production contexts to explain how metabolism takes place in organisms and argue how disorders of metabolism can develop and how they can be tackled, using the concepts of organ, photosynthesis, respiration, digestion, excretion and transport.

Specimen contexts:
Health and healthcare (social environment context): Members of a family in which obesity is the rule rather than the exception are discussing whether they should take part in a trial of an appetite-inhibiting substance in order to learn how to achieve and maintain healthy weight.
Food production: Plant scientists at a university hospital are studying the optimum growing conditions for crops in order to advise growers on how to optimize crops and crop protection.

B3.1 - Organs
Specification:
The candidate is able in a particular context to:
1. describe how groups of cells perform a joint function by virtue of their organization in a tissue, organ or organ system
2. describe the characteristics and functions of human organ systems for transport, respiration, food processing and excretion
3. recognize the differences and similarities between organs and organ systems in humans and various animal species
4. explain the differences in gas exchange, absorption and transport in prokaryotes, plants and animals
5. explain how organ systems interrelate and argue how an organ malfunction affects cooperation between organs.

Specific concepts:
Heart, heart valves, artery, blood vessel, capillary, lymph system, stomata, tracheids and sieve tube elements, root hairs, lungs, trachea, bronchi, alveoli, gills, oesophagus, stomach, duodenum, pancreas, liver, gall bladder, small intestine, large intestine, rectum, intestinal villi, circular and longitudinal muscles, kidneys, nephron, sweat glands.

B3.2 - Photosynthesis
Specification:
The candidate is able in a particular context to:
1. describe that organisms are autotrophic because of photosynthesis
2. list the conditions for the photosynthesis process in plants
3. describe the importance of photosynthesis as a basis for the continued assimilation and dissimilation of the organism.

Specific concepts:
Autotroph, heterotroph, organic/inorganic substances, chloroplasts, net photosynthesis reaction, continued assimilation, limiting factors.

B3.3 - Respiration
Specification:
The candidate is able in a particular context to:

1. describe the structure, mechanism and function of gas exchange organs in eukaryotes, in particular in humans
2. structure the relationship between the structure of gas exchange organs and explain their function and the relationship between structure and mechanism
3. explain how pulmonary ventilation comes about and is regulated
4. explain how the absorption, transport and release of CO_2 and O_2 take place and what role haemoglobin and myoglobin play
5. describe the relationship between gas exchange in plants and photosynthesis and dissimilation.

Specific concepts:
Gas exchange, ventilation movements, lung capacity, vital capacity, dead space, diffusion, Fick principle, CO_2 concentration, O_2 concentration, haemoglobin and HCO_3^- buffers, dissimilation, assimilation, limiting factor.

B3.4 - Digestion
Specification:
The candidate is able in a particular context to:
1. describe the structure, mechanism and function of digestive organs in eukaryotes, in particular in humans
2. describe the relationship between the structure of digestive organs and their function and explain the relationship between structure and mechanism
3. describe where and how nutrients are digested and absorbed and explain how factors can influence this.

Specific concepts:
Mechanical and chemical digestion, intestinal peristalsis, nutrients, digestive juices, bile, digestive enzymes for carbohydrates, proteins, fats, vitamins, pH, temperature, products of digestion, emulsification, absorption, intestinal bacteria.

B3.5 - Excretion
Specification:
The candidate is able in a particular context to:
1. describe the structure, mechanism and function of excretory organs in eukaryotes, in particular in humans
2. describe the relationship between the structure of excretory organs and their functions and explain the relationship between structure and mechanism
3. explain the role of the liver, kidneys, lungs and skin in excretory processes.

Specific concepts:
Water regulation, ultrafiltration, reabsorption, renal ultrafiltrate, osmotic value, ADH, urea, urine, HCO_3^- buffers, bile salts, bile pigments, sweat.

B3.6 - Transport
Specification:
The candidate is able in a particular context to:
1. describe the structure, mechanism and function of the circulation with the heart and blood vessels in eukaryotes, in particular in humans
2. describe the relationship between the structure of the heart and blood vessels and their functions and explain the relationship between structure and mechanism
3. explain the embryonic circulation in humans and list the differences from and similarities with the postnatal circulation
4. describe the function of the components of blood, blood plasma, tissue fluid and lymph and explain the production of tissue fluid and lymph
5. describe the relationship between the vascular system and the lymph system

6. describe the transport of water, salts and assimilation products in plants and argue the relationship with photosynthesis, dissimilation and storage of substances.

Specific concepts:
Open and closed circulation, single and double circulation, large circulation, small circulation, embryonic circulation, blood plasma, tissue fluid, lymph, bone marrow, blood composition, red blood cells, white blood cells, platelets, heart rate, stroke volume, sinoatrial node, AV node, bundle of His, blood pressure, diastole, systole, oxygen transport and carbon dioxide transport, nutrients and waste products, Bohr effect, buffer substances, HCO_3^-, haemoglobin, myoglobin, coagulation, cholesterol, counterflow principle, filtration pressure, colloid osmotic pressure, evaporation flow, cohesion, adhesion, root pressure.

Subdomain B4 - Self-Regulation of Organisms
The candidate is able at least in sports and nutrition contexts to explain how self-regulation takes place in eukaryotes and argue how disorders of self-regulation can develop and how they can be tackled, using the concepts of homeostasis, hormonal regulation and neural regulation.

Specimen contexts:
Sport: An exercise physiologist at a national training centre is studying blood values to optimize an athlete's performance in consultation with him.
Nutrition: Doctors and medical biologists and psychobiologists are doing behavioural research in a trial to ascertain the possible effect of foods on neural and hormonal regulation in ADHD.

B4.1 - Homeostasis
Specification:
The candidate is able in a particular context to:
1. describe the importance of the lungs, liver, kidneys, nervous and hormonal system to homeostasis in humans
2. describe the relationship between the structure of the liver, lungs, skin and kidneys and homeostasis
3. infer a regulation cycle from a description of the regulation of body processes and explain the principles of a regulation cycle
4. describe the interrelationships in the regulation of body processes
5. argue how the dynamic equilibrium can become disturbed and how it can be regulated.

Specific concepts:
Nervous system, hormonal system, receptors, internal and external environment, regulation cycle, positive and negative feedback, dynamic equilibrium, receptors in cell membranes and cytoplasm, osmotic value, pH, temperature, chemical composition, O_2 concentration, CO_2 concentration, haemoglobin and HCO_3^- buffers, glucose level, water regulation, chemical and pressure receptors in the aorta.

B4.2 - Hormonal regulation
Specification:
The candidate is able in a particular context to:
1. predict the functioning of a regulation cycle in the hormonal system
2. describe the functioning of hormone glands and the specific functioning of their hormones and infer how the target organs respond to them
3. describe the relationship between hormonal regulation and the maintenance of homeostasis
4. explain the relationship between the hormonal system and the senses, musculature and nervous system.

Specific concepts:

Hormone glands, pituitary gland, hypothalamus, thyroid gland, kidneys, adrenal glands, ovaries, testes, pancreatic islets, exocrine, endocrine, target organs, receptor, hormone level, insulin, glucagon, adrenaline, thyroid hormone, digestive hormones, EPO.

B4.3 - Neural Regulation

Specification:
The candidate is able in a particular context to:

1. describe the structure and mechanism of the nervous system and signal processing
2. explain the functioning of a regulation cycle in the nervous system
3. describe the relationship between the functioning of the nervous system and the functioning of an organism
4. explain the relationship between the nervous system and the senses, musculature and hormonal system.

Specific concepts:
Central nervous system, peripheral nervous system, large and small brain, centres in the cerebral cortex, white matter, grey matter, brainstem, spinal cord, autonomic (vegetative) nervous system, animal nervous system, orthosympathetic and parasympathetic, sensory, relay and motor neurons, Schwann cells, myelin sheath, synapse, Na/K pump, impulse conduction, saltatory conduction, reflex arc, neurotransmitter, resting potential, action potential, stimulation threshold, refractory period, excitatory, inhibitory, stimuli, mechanical, chemical, temperature, light, touch and pain receptors.

Subdomain B5 - Defence in Organisms

The candidate is able at least in healthcare and food production contexts to describe how organisms defend themselves against other organisms, viruses and allergens, and argue what problems can occur and how they can be tackled, using the concept of defence.

Specimen contexts:
Health and healthcare: Virologists at the RIVM (National Institute for Public Health and the Environment) are doing annual research into the types of influenza viruses expected in order to issue a recommendation on the composition of the influenza vaccine so as to prevent influenza in people with lowered resistance.
Food production: Microbiologists at the Food and Consumer Product Safety Authority are studying whether vegetables in the Netherlands are contaminated with the intestinal bacterium EHEC, a variant of the E. coli bacterium in order to prevent a food poisoning epidemic
Health and healthcare (social environment context): Based on newspaper reports, discussing the use of antibiotics in livestock farming in order to reach a considered opinion on the matter.

B5.1 - Defence

Specification:
The candidate is able in a particular context to:

1. explain the structure, mechanism and function of organs and cells involved in the human defence system and explain how they relate to one another
2. describe the functioning of the specific and non-specific immune response and explain the response to self and non-self substances and cells
3. recognize the defence mechanisms of plants.

Specific concepts:
Skin and mucous membranes, blood, lymph, spleen, lymph nodes, humoral and cellular response, macrophages, T and B cells, mediators, antigens and antibodies, self, non-self, MHCI and MHCII receptors, natural and artificial immunity, active and passive immunity, vaccination, transplantation, blood transfusion, ABO system, rhesus factor, donor, acceptor, mechanical and chemical defences in plants.

Subdomain B6 - Movement of the Organism

The candidate is able at least in health and sport contexts to explain how humans and animals move and how this can be optimized, using the concepts of movement, neural regulation and perception.

Specimen contexts:
Health: Health insurers are offering activity programmes to reduce the likelihood of cardiovascular disease
Sport: Analysis of skating movements has resulted in an effective skate design, the clap skate.

The candidate is able in particular contexts to:
1. list the structure, mechanism and function of the main organs involved in movement (muscles, senses and nerves) in humans and animals and explain the relationship between form and function
2. explain the design and effects of training and rehabilitation programmes for humans and animals.

Specific concepts:
Striated and smooth muscles, muscle fibre, muscle cell, tendon, reflex arc, antagonist, tone, strength training, endurance training, warming up, cooling down, endurance, doping, motor protein, muscle tension, actin, myosin, neural regulation, muscle spindle, tendon spindle.

Subdomain B7 - Perception by Organisms
The candidate is able at least in health and sport contexts to explain how organisms perceive, using the concepts of organ, perception and neural regulation.

Specimen contexts:
Health or healthcare: An optician is collecting information in his practice on different types of lenses to enable him to give good advice to customers wishing to correct their myopia.
Sport: Trainers and physiotherapists at a national training centre are studying the effects of various types of start training for athletes in order to reduce the number of false starts in competitive sport.

The candidate is able in particular contexts to:
1. describe the functioning of a sense in general and explain what role the brain centres play
2. describe and explain the structure of the eye
3. describe the relationship between adequate stimulus and response
4. recognize the principles of a regulation cycle in the functioning of the senses
5. describe the relationship between the senses and the musculature, nervous system and hormonal system
6. describe the relationships between the use of the senses and the functioning of an organism.

Specific concepts:
Central nervous system, peripheral, large and small brain, centres of sensation, movement and vision in the cerebral cortex, brainstem, spinal cord, optic chiasm, sensory, relay and motor neurons, impulse conduction, adaptation, habituation, reflex arc, pupil, retina, rods, cones, macula, blind spot, adequate stimulus, mechanical, chemical, light, temperature, touch and pain receptors.

Subdomain B8 - Regulation of Ecosystems
The candidate is able at least in sustainability contexts to explain how ecosystems regulate themselves, using the concepts of energy flow, cycle, dynamics and equilibrium; the candidate is able to argue what effects can occur if self-regulation of ecosystems and the Earth system is

disturbed, and is able to argue what measures we can take to influence the self-regulation of ecosystems and the Earth system.

Specimen contexts:
Sustainability: Environmental biologists and ecologists on a Sustainability Committee are informing the Minister about the environmental aspects of importing soya from Brazil as pig feed in order to promote sustainability.

B8.1 - Energy Flows

Specification:
The candidate is able in a particular context to:

1. describe the energy flows in an ecosystem, explain what factors influence them and what the causes and effects of disturbance are
2. describe energy flow models and explain what processes and organisms are involved
3. argue what measures we can take to influence energy flows.

Specific concepts:
Producer, consumer, decomposer, trophic levels, phototroph, chemotroph and autotroph, heterotroph, organic/inorganic substances, BPP, NPP, productivity, fossil fuel, biofuel, biomass.

B8.2 - Cycles

Specification:
The candidate is able in a particular context to:

1. explain the role of producers, consumers and decomposers in the carbon and nitrogen cycles and quantify the relationships
2. show cycles of elements in an ecosystem, explain what factors influence the various steps and what the causes and effects of disturbance are
3. argue what measures we can take to influence nutrient cycles and thus the Earth system.

Specific concepts:
Photosynthesis, dissimilation, nitrification/denitrification, ammonification, nitrogen fixation, organic/inorganic substance, leaching, eutrophication, biomass, greenhouse effect.

B8.3 - Dynamics and Equilibrium

Specification:
The candidate is able in a particular context to:

1. describe what is meant by an ecosystem and what components it comprises
2. explain what role competition within and between populations plays in the dynamics (maintenance and development) of an ecosystem
3. explain what role biotic and abiotic factors play in the dynamics within an ecosystem
4. argue what measures we can take to influence the self-regulation of ecosystems.

Specific concepts:
Niche, microclimate, biodiversity, migration, introduced species.

Domain C - Self-Organization

Biological units can be regarded as systems with an organization. Biological units differ from non-living systems in that they are the only product of their organization: in other words there is no separation between producer and product. They organize themselves.

New structures (higher-order biological units) can be created through self-organization. The higher level of organization displays new properties that the lower-level biological unit does not have, known as ‘emergent properties’.

Take the biological clock in humans, for example: some clock cells are active during the daytime, others at night, and yet others peak in the morning. All together they have a property that the individual cells do not have: the biological clock is able to register day length and time of year. Thus the whole is more than the sum of the parts.
The candidate is able in a particular context to:

- explain that biological units from cellular level to population level have self-organizing ability
- argue that biological units have new emergent properties compared with biological units at the next lower level.

Subdomain C1 - Self-Organization of Cells
The candidate is able at least in health and food production contexts to describe how cells develop and argue how developmental disorders can occur and how they can be tackled, using the concepts of gene expression and cell differentiation.

Specimen contexts:
Health or healthcare: Biologists at a transplant centre are growing stem cells and inducing them to differentiate into specialized cells in order to replace damaged tissue in the human body and thus cure people.
Food production: Biologists and plant scientists in public-private partnerships are working on plant improvement to change the proportions of active ingredients (in amylopectin potatoes) in order to make processing more energy-efficient and simpler.

C1.1 - Gene Expression
Specification:
The candidate is able in a particular context to:

1. show that DNA in eukaryotes is non-coding for the most part and that genes consist largely of introns
2. describe the process of gene expression up to and including protein synthesis
3. describe that genes express depending on the circumstances
4. explain that different types of cells produce different proteins
5. explain the interrelationship between gene expression and the functioning of an organism.

Specific concepts:
Chromosome, gene, DNA, RNA, protein, phenotype, genetic code, start codon, stop codon, transcription factor, activator, RNA polymerase, splicing, introns, exons, nucleosomes, non-coding RNA, cDNA, knockout gene.

C1.2 - Cell Differentiation
Specification:
The candidate is able in a particular context to:

1. describe that virtually all the cells of a multicellular organization have the same genome
2. describe how cells with different forms and functions develop through differentiation
3. describe that cell differentiation is the result of switching genes on and off
4. describe the properties of stem cells and explain the purposes for which stem cells can be used
5. explain that a cell is capable of apoptosis and that this can play a role during the development of a multicellular organism.

Specific concepts:
Genome, stem cells, cell type, extracellular matrix, apoptosis, lysosome, pluripotent, totipotent.

Subdomain C2 - Self-Organization of Organisms

The candidate is able at least in health and food production contexts to describe how organisms develop, explain how developmental disturbances can occur and argue how these can be prevented or tackled, using the concept of life cycle.

Specification:
The candidate is able in particular contexts to:
1. describe the life cycles of plants, insects and mammals in general terms
2. recognize the phases in development from a zygote to the birth of a baby
3. explain the influence of nutrition, stimulants and stress on prenatal development
4. relate internal and external factors to the physical development of a human being during his life
5. explain the influence of biotic and abiotic factors on the development of crops.

Specimen contexts:
Food production: Vegetable growers are intervening at various stages of the life cycle of food crops in order to maximize output.
Health or healthcare: Researchers have discovered a relationship between malnutrition during embryonic development and glucose metabolism in later life, for example among people who were in utero during the 1944-45 'Hunger Winter' famine.

Specific concepts:
Reproductive cells, fertilization, sperm, germ, egg, larva, pupa, imago, complete and incomplete metamorphosis, morula, blastula, amnion, chorion, embryo, foetus, placenta, amniotic fluid, umbilical cord, congenital abnormality, hereditary disease, cancer and its causes, prevention.

Subdomain C3 - Self-Organization of Ecosystems
The candidate is able at least in sustainability and world-view contexts to describe how ecosystems can develop and argue what measures we take that influence the self-organization of ecosystems and the Earth system, using the concepts of dynamics and equilibrium.

Specimen contexts:
Sustainability: Biologists, landscape architects and engineers at the Ministry of Infrastructure and the Environment are doing research into the development of nature and ways of building with nature to protect the coast.
Sustainability: An aquatic ecologist at a research institute is studying the food relationships in the Oostvaardersplassen nature reserve in order to come up with a sustainable management plan.
World view: Biologists working for the Planning Department of a municipality are doing research into public attitudes to nature in order to take them into account in land use plans.

C3.1 - Dynamics and Equilibrium
Specification:
The candidate is able in a particular context to:
1. describe the development of an ecosystem
2. describe successive changes in an ecosystem and explain how transitions occur
3. list differences between ecosystems based on differences in populations (biotic factors) and abiotic factors
4. describe the dynamics in an ecosystem
5. recognize that an ecosystem can be in different equilibrium states
6. argue what measures we take that influence the self-organization of ecosystems and the Earth system.

Specific concepts:

Succession, pioneer species, climax ecosystem, ecotone ('gradient ecosystem'), indicator species, biodiversity, gene pool, competition, capacity, tolerances, introduced species, turning point.

Domain D - Interaction

Biological units are influenced by their environment, which can be both biotic and abiotic. They can respond to these influences by adapting, moving or displaying other responses.
Conversely, they also influence their biotic and abiotic environment.
Interaction refers to the open nature of biological systems.
The candidate is able in a particular context to:

- argue that a biological unit at any level of organization is constantly interacting with the environment, including other biological units
- argue what effects internal or external changes in a biological unit have on that unit and on biological units at higher and lower levels of organization
- describe the complexity of relationships in and between biological units and between biological units and their abiotic environment.

Subdomain D1 - Molecular Interaction

The candidate is able at least in health and food production contexts to explain how molecular regulation takes place, using the concepts of gene regulation and interaction with biotic and abiotic factors.

Specimen contexts:
Health or healthcare: Biologists, chemists and doctors in a university partnership studying gene expression to enable targeted chemotherapy to be used on cancer patients to cure them.
Food production: Plant improvement scientists at a plant improvement company are using GMO to change molecular processes so as to make plants drought-resistant or salt-tolerant to enable them to be grown on the edges of deserts and in brackish deltas and thus tackle the problem of hunger.

D1.1 - Gene Regulation and Interaction with Biotic and Abiotic Factors

Specification:
The candidate is able in a particular context to:

1. list gene regulation mechanisms and explain their importance
2. explain that cells use proteins for their functioning
3. explain that biotic and abiotic factors influence protein variation
4. explain that gene expression is a dynamic process regulated by various factors, including epigenetic ones
5. explain that mutagenic factors disturb gene regulation.

Specific concepts:
Genome, structural genes, regulator genes, recombinant DNA, proto-oncogenes, enzymes, virus, iRNA, promotor, operator, repressor, suppressor, epigenetic, cisgenic, transgenic.

Subdomain D2 - Cellular Interaction

The candidate is able at least in health contexts to describe how cellular interaction takes place, using the concepts of cell communication and interaction with biotic and abiotic factors.

Specimen contexts:
Health or healthcare: Biologists at a research institute are doing research on C. elegans into cell communication and the effects of biotic and abiotic factors in order to develop knowledge of cell communication by studying this model organism with a view to possibly curing people with abnormal cell communication.

D2.1 - Cell Communication and Interaction with Biotic and Abiotic Factors

Specification:
The candidate is able in a particular context to:

1. describe how cells receive and process signals, how cells respond to signals, and relate these processes to one another
2. recognize how cells communicate with one another over short and long distances via neurons and hormones
3. distinguish between responses in cell plasma and responses that promote gene expression
4. infer what effects cell communication has on other levels of organization.

Specific concepts:
Signal substances, second messenger, synapse, cell junctions, receptor, response, signal cascade, Na/K pump.

Subdomain D3 - Behaviour and Interaction
The candidate is able at least in communication, health and safety contexts to explain how the behaviour of organisms and populations develops, describe what the function of behaviour is and how it develops, using the concepts of behaviour and interaction with biotic and abiotic factors.

Specification:
The candidate is able in particular contexts to:

1. explain how behaviour refers to actions and reactions
2. describe the dynamic relationship between an organism and its environment
3. describe factors in the internal environment, such as hormones, the biological clock, changes in metabolism, impulses from areas of the brain
4. explain that behaviour is partly inherited
5. describe how the behaviour of an individual organism mirrors the various life stages of the organism
6. explain intimidating behaviour, territorial behaviour, social behaviour, feeding behaviour and reproductive behaviour as examples of functional behaviour and relate these types of behaviour to chances of survival
7. explain how behaviour evolves under the influence of selection pressure
8. describe behaviour by listing behavioural elements and develop this into an action protocol and/or ethogram
9. explain why populations such as a school of fish or flock of birds display behaviour that has added value compared with the behaviour of the individual organisms
10. describe behavioural biology as a branch of biology concerned with the differences and similarities in behaviour between species and the evolutionary background
11. describe the differences and similarities between anthropoids and humans, in particular as regards communication, moral awareness and empathy
12. explain the relationship between behavioural research and other areas of research in molecular biology, neurophysiology, behavioural ecology, cognitive psychology, evolutionary research, genetic and epigenetic research
13. apply the results of behavioural research and explain the implications for society.

Specimen contexts:
Communication: Communicators are looking for ways of incorporating supernormal stimuli in public education campaigns.
Health or healthcare: Psychologists are looking for the hereditary component of behaviour using research into twins.
Safety: Researchers have demonstrated a link between drug use and traffic behaviour.

Specific concepts:

Internal factors, external factors, behaviour system, ethogram, genes, congenital, hereditary, acquired, classical and operant conditioning, habituation, imprinting, reflex, survival, communication, social behaviour, intimidating behaviour, territorial behaviour, instinct, nature/nurture.

Subdomain D4 - Sexuality
The candidate is able at least in health and communication contexts to argue how issues relating to human sexuality can be approached, using the concepts of behaviour and interaction with biotic and abiotic factors.

Specification:
The candidate is able in particular contexts for example to:
1. argue what role sexuality plays in reproduction and in maintaining relationships
2. explain the role of sexuality at different life stages
3. relate sexual behaviour to reproductive behaviour
4. select the right contraceptives and describe their effective use
5. explain diversity in sexual orientation
6. relate acceptance of sexual diversity to his own opinions and cultural aspects
7. explain the relationship between sexual behaviour and sexually transmitted diseases
8. describe how you can make your wishes known and guard and respect boundaries
9. explain the role of hormones and the nervous system in aspects of relationships and sexuality.

Specimen contexts:
Health or healthcare: Epidemiologists at RIVM (the National Institute for Public Health and the Environment) are carrying out a Chlamydia screen on hundreds of thousands of young people aged 16-29 to decide whether a national screening programme should be introduced.
Communication: Staff of a public education organization are devising a campaign to reduce transgressive sexual behaviour in young people, focusing on attitude and skills as well as knowledge.

Specific concepts:
Sexuality, bisexual, homosexual, heterosexual, coming out, contraceptives, arousal, orgasm, gender, sexually transmitted diseases, AIDS, transsexuality, reproductive stimulus, adolescence, hormonal regulation, life stage.

Subdomain D5 - Interaction in Ecosystems
The candidate is able at least in sustainability and food production contexts to describe what relationships exist between populations and ecosystems and argue how issues relating to them can be approached, using the concepts of food relationship and interaction with biotic and abiotic factors.

Specimen contexts:
Food production: Agriculturalists and greenhouse technologists are studying ways for a tomato grower to manage the greenhouse cycle in order to reduce energy consumption and increase productivity so as to make crops competitive and reduce dependency on a particular product.
Sustainability: Schoolchildren are measuring their ecological footprints and discussing how they could each actually reduce their ecological footprint.

D5.1 - Food Relationships
Specification:
The candidate is able in a particular context to:
1. describe food relationships between organisms
2. list the relationships in a food chain
3. recognize food chains in a food web
4. explain how toxic substances accumulate in a food chain.

Specific concepts:
Trophic levels, predation, grazing, signal substances, symbiosis, parasitism, mutualism, commensalism.

D5.2 - Interaction with Biotic and Abiotic Factors

Specification:
The candidate is able in a particular context to:

1. describe changes in abiotic and biotic factors and the interactions between them in an ecosystem
2. describe what role biotic and abiotic factors play in the maintenance and development of an ecosystem
3. explain how toxic substances accumulate in a food chain
4. describe the role of competition within and between populations in an ecosystem
5. describe what is meant by sustainable development, in particular sustainable energy and food production
6. argue how issues relating to sustainable development can be approached.

Specific concepts:
Microclimate, niche, indicator species, limiting factor, tolerance, optimum, persistent, biodegradable.

Domain E - Reproduction

Biological units such as cell organelles, cells and organisms replicate themselves.
The candidate is able in a particular context to:

- describe the relationships between replication taking place at the various levels of organization.

Subdomain E1 - DNA Replication

The candidate is able at least in safety and health contexts to describe how hereditary material is reproduced, using the concept of DNA replication.

Specimen contexts:
Safety: Forensic researchers are examining DNA evidence for the purpose of criminal investigation.
Health or healthcare: Researchers at the Mauritsklinieken in the Netherlands have demonstrated that skin burns due to sunlight at a young age are directly linked to the development of skin cancer in later life.

Specification:
The candidate is able in particular contexts for example to:

1. explain the process of DNA replication, describing continuous and discontinuous replication and leading and lagging strand
2. explain what can go wrong in DNA replication and describe the consequences
3. describe how DNA (from the same species or other species) can be incorporated (naturally and artificially) and the consequences
4. explain that the DNA replication process underlies human, animal and plant reproduction

Specific concepts:
Nucleotides, double strand, base pairs, free DNA nucleotides, chromatids, DNA polymerase, S phase, Okazaki fragment, operon model, coding strand, template strand, 3’ and 5’ end.

Subdomain E2 - Cell Life Cycle

The candidate is able at least in energy, health and food production contexts to describe how cells reproduce and argue how disorders can be prevented or tackled, using the concept of cell cycle.

Specification:
The candidate is able in particular contexts for example to:

1. describe the importance of cell division in growth, healing and reproduction
2. describe that division takes place under the influence of adjacent cells
3. describe how cells divide in a controlled manner, passing through various phases of the cell cycle
4. describe in what phase normal cell division differs from reduction division and relate this to the function of each type of division
5. describe how the phases of the cell cycle are regulated and what can go wrong with that regulation
6. describe how daughter cells grow and develop after division
7. relate the uncontrolled division of cells to the development of tumours
8. explain that tumours can be benign or malignant
9. argue that errors in DNA can remain uncorrected where there is uncontrolled cell division
10. describe how normal cells age and explain that they can divide approximately fifty times before dying naturally
11. explain the role of telomeres in cell ageing
12. recognize the role of tissue culture in food production and medical research.

Specimen contexts:
Energy: Staff at Wageningen University are trying to culture algae experimentally enabling them to be used as raw material for energy production.
Health or healthcare: Staff at a cancer research centre are using cell cultures to identify the carcinogenic properties of various substances.
Food production: Staff at a seed producer's laboratory are studying how to optimize seed yields from crops.

Specific concepts:
Unicellular, multicellular, reproductive cells, somatic cell, chromosome, mitosis, reduction division (meiosis), chromatid, replication, spiralization, spindle apparatus, microtubules, meiosis I, meiosis II, diploid, haploid, telomeres, cytoskeleton, prophase, metaphase, anaphase, telophase, cell cycle, RNA interference, G0 phase, microDNA, telomerase, apoptosis.

Subdomain E3 - Reproduction of Organisms
The candidate is able at least in energy, health and food production contexts to explain how characteristics are passed on and describe how eukaryotes and prokaryotes reproduce, using the concepts of reproduction and hereditary characteristics.

Specimen contexts:
Energy: Biologists and biophysicists at an algae test facility are doing cell biology and physics research into influencing algal reproduction in order to optimize cultivation for energy generation and oil production
Health or healthcare: A class of schoolchildren are producing their own information leaflet on sexuality and STDs with the aim of reducing STDs and helping to detect them at an early stage.
Food production: Biologists working for Greenpeace are producing literature to educate the public by drawing attention to possible disadvantages of genetically modified organisms.

E3.1 - Reproduction
Specification:
The candidate is able in a particular context to:

1. describe sexual and asexual reproduction, explaining genetic variation in prokaryotes and eukaryotes
2. describe the structure, formation, development and function of gametes and the zygote
3. describe the structure and mechanism of the human reproductive organs and the role played by hormones

4. comment on views on intervention in the reproductive process of organisms using ethical and biological arguments.

Specific concepts:
Life cycle, sexual and asexual reproduction, reproductive organs of eukaryotes, gametes, spore, mitosis, meiosis, haploid, diploid, polyploid, fertilization, ovum, sperm cell, follicle, corpus luteum, zygote, mitosis, polar body, embryo, placenta, sex hormones, FSH, LH, oestrogen, progesterone, testosterone, hCG, menstrual cycle, contraception, artificial insemination, in vitro fertilization, embryonic development, clones.

E3.2 - Hereditary Characteristics

Specification:
The candidate is able in a particular context to:

1. explain that a phenotype develops from the interaction of genotype and environmental factors, and recognize differences from epigenetic inheritance
2. list the differences between autosomes and sex chromosomes and explain that sex chromosomes determine sex in humans
3. infer the frequency of genotypes and genotypes of offspring from pedigrees or cross diagrams in the case of monohybrid and dihybrid crosses, for both independent and linked inheritance, for both autosomal and X-chromosome genes, multiple alleles and lethal factors
4. explain that mitochondrial inheritance and epigenetics can result in a pattern of inheritance that does not comply with Mendel's laws
5. comment on views on intervention in the inheritance of prokaryotic and eukaryotic organisms using ethical and biological arguments.

Specific concepts:
Genome, autosomes, X and Y chromosomes, genotype, phenotype, allele, gene, monohybrid and dihybrid cross, complete/incomplete dominance, recessive, intermediate, multiple alleles, lethal factor, linked genes, pedigree, mitochondrial DNA, epigenetics, methylation.

Domain F - Evolution

Biological units interact with one another at all levels of organization, influenced by biotic and abiotic factors and competing for space, light, food, etc. The chances of surviving and producing offspring are greatest for biological units that are most compatible with the conditions, that can adapt the conditions or that can seek out the best conditions.
Evolution shows how chance, mutation, recombination, variation, adaptation and selection pressure have created the current biodiversity.

The candidate is able in a particular context to:

- explain how the biodiversity of life has come about
- explain that the existence of the universal genetic code is regarded as a scientific argument for the common origin and kinship of all life
- argue the role of adaptations in biological units
- argue from a given form of a biological unit to an associated function, and explain that a particular functionality may have developed in different ways during evolution
- explain how the theory of evolution was developed and argue how it interacts with science, society and beliefs.

Subdomain F1 - Selection

The candidate is able at least in health and food production contexts to explain how variation in populations comes about, using the concepts of DNA, mutation, genetic variation, recombination and population.

Specimen contexts:

Health or healthcare: Doctors in Japan are using sequencing to study mutations caused by different doses of radiation in order to give the best advice on protection when working with radiation.
Food production: A plant improvement scientist and taxonomists at a Genetic Resources Institute are developing new varieties of food crops using knowledge of taxonomy and improvement techniques and looking for genetic resources to make food crops pest-resistant or improve their flavour.

F1.1 - DNA
Specification:
The candidate is able in a particular context to:
1. explain that DNA acts as a universal carrier of genetic information
2. explain that the same genetic information can occur in different organisms
3. explain how the degree of kinship between species can be ascertained using data obtained from DNA analysis.

Specific concepts:
DNA, genetic code, genotype, phenotype.

F1.2 - Mutation
Specification:
The candidate is able in a particular context to:
1. describe what types of mutation exist
2. explain what can cause mutation
3. explain that mutation can affect the phenotype
4. explain that mutation takes place regardless of the possible effect on the chances of survival or reproduction of the cell or organism.

Specific concepts:
Chromosome, mutagenic substance, mutagenic radiation, point mutation, deletion, insertion, genome mutation, gene, allele, genetic modification, DNA repair system.

F1.3 - Recombination
Specification:
The candidate is able in a particular context to:
1. explain how reproductive cells with a unique combination of genes are created in sexual reproduction by recombination of chromosomes and parts of chromosomes.

Specific concepts:
Meiosis, homologous chromosomes, autosomes, sex chromosomes, karyotype, haplotype, genome, linked genes, crossover.

F1.4 - Genetic Variation
Specification:
The candidate is able in a particular context to:
1. explain how genetic variation in a population is increased by mutation and recombination
2. explain how desired gene combinations can be created through genetic modification.

Specific concepts:
Mutation, recombination, phenotype, genotype, gene pool, genetic modification.

Subdomain F2 - Speciation
The candidate is able at least in health and world-view contexts to explain how new species can come into being, using the concepts of population, variation, selection and speciation.

Specimen contexts:

Health or healthcare: A bacteriologist at a hospital is engaged in continuous research into how populations of resistant bacteria change in the context of infection prevention.
World view: Evolutionary biologists at the Naturalis Biodiversity Center are studying genetic kinship, using characteristic analysis of plants and DNA/RNA analysis, and using the data to construct phylogenetic pedigrees in order to improve understanding of plant evolution.

F2.1 - Population
Specification:
The candidate is able in a particular context to:
1. describe what is meant by a population
2. explain how frequencies of genotypes and phenotypes in populations change over time and space
3. explain that populations have emergent properties.

Specific concepts:
Population, genotype, phenotype, emergent property.

F2.2 - Variation
Specification:
The candidate is able in a particular context to:
1. describe what is meant by genetic variation in a population
2. explain how gene frequencies in a population can change as a result of random mutations, genetic drift and gene flow
3. quantify links between gene frequencies and frequencies of genotypes in successive generations using the Hardy-Weinberg principle.

Specific concepts:
Adaptation, fitness, natural selection, genetic drift, gene flow, allele frequency, Hardy-Weinberg principle.

F2.3 - Selection
Specification:
The candidate is able in a particular context to:
1. explain that adaptation in populations is due to selection of organisms
2. explain that selection pressure produces adaptations that increase the reproductive success of the species
3. describe the similarities and differences between natural and artificial selection.

Specific concepts:
Adaptation, fitness, selection pressure, species, natural selection, sexual selection, island theory, founder effect, bottleneck effect.

F2.4 - Speciation
Specification:
The candidate is able in a particular context to:
1. describe that species are groups of individuals reproductively isolated from one another
2. explain that populations diverge as a result of genetic drift, mutation and selection
3. explain that species develop through reproductive isolation
4. explain how the kinship and descent of species can be shown in a cladogram.

Specific concepts:
Species, sex, cladogram, clade, taxon, homology, analogy, genetic drift. coevolution, sympatric and allopatric speciation.

Subdomain F3 - Biodiversity

The candidate is able at least in sustainability and world-view contexts to explain changes in the diversity of populations and ecosystems within the Earth system and argue how these changes are influenced, using the concept of biodiversity.

Specification:
The candidate is able in particular contexts to:

1. describe how biodiversity can be approached at different levels of organization: at the level of species (organisms), genes and ecosystems
2. explain how the existence of humans depends on biodiversity: food supply, production of pharmaceuticals, raw material and fuel production, water treatment, decomposition of toxins, contributing to a stable climate
3. explain what factors threaten biodiversity, what role humans play and what measures can be taken to conserve species
4. explain changes in biodiversity over time, including using the concept of natural selection.

Specimen contexts:
Sustainability: Members of a group campaigning for the conservation of rare mammals are drafting an objection to a construction project that would harm the habitat of an endangered mammal species.
World view: Members of a nature conservation association are discussing the assertion in Bas Haring's book Plastic Panda's that species extinction is not a problem, in order to evaluate their policy.

Specific concepts:
Species, species composition, intensified greenhouse effect, red list, indicator species, distribution area, fragmentation, eutrophication, pedigree, adaptation, kinship, introduced (exotic) species, indigenous species, invasive species.

Subdomain F4 - The Genesis of Life
The candidate is able at least in world-view contexts to describe what theory explains the presence of life on Earth, using the concept of the genesis of life.

Specification:
The candidate is able in particular contexts to:

1. describe to what period the first living organisms on Earth date back
2. describe theories on how the first organic molecules developed on Earth
3. describe theories on how the first living cells developed on Earth
4. describe what implications various theories on the genesis of life on Earth may have for questions of belief.

Specimen contexts:
World view: Documentary makers are interviewing scientific celebrities studying the genesis of life, in order to give viewers an understanding of various theories on the subject.

Specific concepts:
Self-organization, primeval soup, archaea, chemical evolution, Miller-Urey experiment, endosymbiotic theory, black smokers.