Schola Europaea / Office of the Secretary-General

Pedagogical Development Unit

Ref.: **2019-05-D-27-en-2**
Orig.: **EN**

Biology Syllabus – S4-S5

Approved by the Joint Teaching Committee by means of Written Procedure WP 2019/31 on 16 July 2019

Entry into force on 1 September 2019 for S4
on 1 September 2020 for S5

Table of Contents

1. General Objectives

The European Schools have the two objectives of providing formal education and of encouraging pupils' personal development in a wider social and cultural context. Formal education involves the acquisition of competences (knowledge, skills and attitudes) across a range of domains. Personal development takes place in a variety of spiritual, moral, social and cultural contexts. It involves an awareness of appropriate behaviour, an understanding of the environment in which pupils live, and a development of their individual identity.

These two objectives are nurtured in the context of an enhanced awareness of the richness of European culture. Awareness and experience of a shared European life should lead pupils towards a greater respect for the traditions of each individual country and region in Europe, while developing and preserving their own national identities.

The pupils of the European Schools are future citizens of Europe and the world. As such, they need a range of competences if they are to meet the challenges of a rapidly changing world. In 2006 the European Council and European Parliament adopted a European Framework for Key Competences for Lifelong Learning. It identifies eight key competences which all individuals need for personal fulfilment and development, for active citizenship, for social inclusion and for employment:

1. Literacy competence
2. Multilingual competence
3. Mathematical competence and competence in science, technology and engineering
4. Digital competence
5. Personal, social and learning to learn competence
6. Civic competence
7. Entrepreneurship competence
8. Cultural awareness and expression competence

The European Schools syllabuses seek to develop all of these key competences in all pupils.

2. Didactic Principles

Biology is compulsory for all pupils in S4 and S5: The course builds upon the groundwork laid in Integrated Science in S1-3, particularly the study of ecology that makes up the second half of S3. The course aims to give pupils an understanding of the structure and function of living things, from cells to organisms, and of the theory of evolution that frames scientists' understanding of the history and current state of life on earth. In the fourth year, the course is organised around a series of themes - cells, and the common challenges faced by all multicellular organisms - that allow teachers to choose examples from many taxonomic groups, thereby giving an overview of biological diversity. In the fifth year, the syllabus includes a compulsory two-day field trip, intended to allow teachers to integrate themes of biodiversity, conservation, and sustainable development with the study of evolution and inheritance, the main subjects of the S5 syllabus.

In years 6 and 7, pupils have the choice of continuing biology to the baccalaureate level at an advanced level. Moreover, pupils who do not choose any advanced science (whether biology, chemistry, or physics) for the baccalaureate cycle are required to take the 2-period biology course, providing a generalist overview for non-scientists.

Pupils should acquire the competences and cross-cutting concepts enumerated in sections 3.1 and 3.2 of this syllabus primarily by carrying out exploratory activities: observing, measuring, designing experiments and apparatuses, searching for explanations, discussing with peers and teachers, creating abstractions, models, hypotheses, and theories, and creating lab reports, presentations, and other work products. Under their teacher's active guidance, pupils should actively carry out a maximum of these activities themselves.

This approach to science and mathematics learning is referred to as ***inquiry-based learning*** (IBL). An overview of IBL can be found in the *PRIMAS* guide to inquiry-based learning in maths and science classes.[1] A useful and practical way to construct inquiry-based lessons is the “5E” lesson plan model.[2]

The study of biology is central to pupils’ developing understanding of themselves as living beings in the world. Accordingly, teachers should make links during the course to human health issues—individual, social, and global—wherever appropriate. They should likewise make links wherever appropriate to issues connected with biodiversity, conservation, sustainable development, and climate change. Teachers are encouraged to coordinate with relevant extracurricular organizations and opportunities, such as school clubs and outside resources. Finally, teachers should avail themselves, throughout the science curricula in years S1-7, of the opportunity offered by the European Schools Science Symposium.

3. Learning Objectives

Learning is not just acquiring more content knowledge. Content in a school context is used to give pupils competences, to prepare them for society and work. This syllabus rests on a three-cornered foundation. Content topics are used to learn general key competences, to acquire specific scientific and mathematical competences, and to connect across disciplines with cross-cutting concepts, as modelled in the Next Generation Science Standards from the United States National Science Teachers Association.[3] The aim is to prepare pupils for lifelong learning. The boldface verbs used in the Learning Objectives column in section 4 refer to these competences and cross-cutting concepts.

3.1. Competences[4]

The competences to be acquired by students are listed below. Consultation of Bloom’s Taxonomy of Measurable Verbs is advisable when evaluating competences.

1. **Knowledge and comprehension**
   The student displays comprehensive knowledge of facts and a thorough command and use of concepts and principles in science.

2. **Application**
   The student makes connections between different parts of the syllabus and applies concepts to a wide variety of unfamiliar situations and makes appropriate predictions.

3. **Analysis**
   The student is capable of detailed and critical analysis and explanations of complex data.

4. **Experimental work**
   The student formulates hypotheses, plans and carries out investigations using a wide range of techniques while being aware of ethical issues.

---

[1] https://primas-project.eu/wp-content/uploads/sites/323/2017/11/primas_final_publication.pdf
[2] The framework of 5E lesson plans is described at http://ngss.nsta.org/designing-units-and-lessons.aspx
[3] See http://ngss.nsta.org/About.aspx
[4] The competences described in this chapter are defined with reference to the highest level expected to be achievable by pupils in the second cycle (see chapter 5.1, “Attainment Descriptors”).

5. **Digital and information competences**
   The student can consistently independently find, and assess the reliability of, information on scientific subjects, on- and offline. S/he can independently use appropriate software for science tasks.

6. **Communication (oral and written)**
   The student communicates clearly using scientific vocabulary correctly. S/he demonstrates excellent presentation skills.

7. **Teamwork**
   The student works constructively as a team member, shows initiative, and can act as a team leader.

Globally, students should develop awareness of the environment and learn to act as responsible citizens with respect to it.

3.2. Cross-cutting Concepts

Certain cross cutting concepts are shared by all mathematics and science. This list is adapted from the U.S.A. “Next Generation Science Standards”.[5]

1. **Patterns**
   Patterns in forms and events guide organisation and classification, and prompt questions about the factors that influence them.

2. **Cause and effect**
   Events have causes, sometimes simple, sometimes multifaceted. A major activity of science is investigating and explaining causal relationships and the mechanisms by which they are mediated. Such mechanisms can then be tested across given contexts and used to predict and explain events in new contexts.

3. **Quantification**
   Scientists try, whenever they can, to turn data into numbers, because doing so allows them to use the great toolbox of mathematics to explain, interpret, and create new avenues of inquiry.

4. **Representing data**
   Scientists choose among many ways to represent data and conclusions, including graphs, mathematical models, drawings from observation, preservation of specimens, etc.

5. **Scale, proportion, and quantity**
   In considering phenomena, it is critical to recognise what is relevant at different measures (e.g., size, time, or energy) and to recognise how changes in scale, proportion, or quantity affect a system’s structure or performance.

6. **Systems and system models**
   A system is an organised group of related objects or components; models can be used for understanding and predicting its behaviour.

[5] See http://ngss.nsta.org/CrosscuttingConceptsFull.aspx

7. **Energy and matter**
   Tracking fluxes of energy and matter into, out of, and within systems helps understand the system's behaviour.

8. **Structure and function**
   The way in which an object is shaped or structured determines many of its properties and functions.

9. **Stability and change**
   For both designed and natural systems, conditions that affect stability factors that control rates of change are critical elements to consider and understand.

10. **History and nature of science**
    Scientists have developed the rules for scientific investigation over centuries, including: scientists must explain their methods of investigation, share their data, and let other scientists critique their conclusions (the principle of peer review). Scientists' choices about what and how to investigate, how to explain results, and how to act on their understanding, are informed by their societal contexts. Scientific explanations (theories) are always provisional and subject to rejection or revision on the basis of new evidence and interpretation.

4. Content

4.1. Topics

S4: **4.1. Introduction to Biology** - The scientific domain of biology as the study of living things.

4.2. Cells – The cell theory as a fundamental organising principle of biology. Intracellular organisation. The principle of *Omnis cellula a cellula*. The vast array of cell forms and functions. Observation of cells and organelles under the light microscope.

4.3. Levels of Organisation in Living Things – An overview of the composition of living things, from atoms to the differentiated tissues, organs, and systems of multicellular organisms. Reproduction in multicellular organisms.

Themes 4.4 to 4.6 explore the theme of maintaining the homeostasis, *sensu lato*, of multicellular organisms. This entails solving fundamental problems: *communication* among the cells and parts of the organism; *transport* of cell products and raw materials; and *control* of the cells making up the self. (A fourth, recognition of self vs. not-self for *defence,* is not treated in this syllabus.)

These themes may be taken in any order, at the teacher's discretion. In each section, one example should be taken from the highest relevant taxonomic level that includes humans (e.g., renal urinary system ➛ vertebrates), so that pupils gain an overall understanding of their own physiology. At least one further example should be drawn from an additional major taxonomic group, so that pupils acquire an appreciation of biodiversity and of the many different solutions to these fundamental problems that have evolved over the history of life on earth.

4.4. Communication – An overview of the two systems evolved to communicate within the parts of the organism: hormones (all multicellular organisms) and nervous systems (animals only).

4.5. Transport – Multicellular organisms must take in resources and energy to function, transport nutrition and cell products within the organism, and dispose of waste products.

4.6. Control – Multicellular organisms must manage the tension between the selfish interest of individual cells and the adaptive good of the whole organism.

S4 *or* S5:

4/5.0. Human Sexuality – 4 periods of open-ended discussion and education on the theme of human sexuality.

Teachers may schedule this theme at their discretion at any appropriate time in S4 or S5, taking into account the development and needs of an individual class. Teachers must take care that the theme is covered before the end of the S4-5 cycle.

S5: **5.0. Field Trip** – A compulsory 2-day field trip to study ecological diversity, evolution, and topics related to human impact on nature and sustainable development. It picks up themes from Integrated Science content section 3.2 and allows teachers to link them with the topic of evolution that provides the *leitmotif* of the S5 syllabus.

Teachers may schedule the field trip at their discretion during the S5 year according to their own course planning and school logistical issues. Content from the field trip may be covered in the relevant semester examination.

5.1. Evolution – The history of life on earth, leading to the framing theory that makes sense of everything in biology, natural selection, constructed from its components: variation, inheritance, the struggle for existence, and time.

5.2. Mendelian Inheritance – A simple model that allows us to treat inheritance quantitatively, leading to the beginnings of a more sophisticated understanding.

5.3. Chromosomal Inheritance – Establishing the physical location of genes on chromosomes, showing that the events of meiosis correspond to Mendelian predictions. Sex determination in mammals and other organisms.

5.4. Molecular Inheritance – DNA as the universal molecule encoding genes. Its structure, function, and replication. Issues raised by our ever-increasing ability to manipulate DNA directly. A synthesis of the themes of evolution and genetics in discussion of eugenics and current issues raised by the application of genetic knowledge to human beings.

4.2. Tables

All parts in this syllabus are framed to put pupils at the centre of the action, emphasized by the column headings:

Theme	***Subject content*** ***Pupils will learn about…***	***Learning objectives (and limits)*** ***Pupils will be able to…***	***Activities*** ***Pupils may do…***
The syllabus proposes organisation around a set of "Themes." This organization of themes should be understood as the default. The subsections are to be understood as thematic rather than pedagogical. While being sure to introduce all learning objectives within a theme, teachers are free to follow the order of their choice.	A broad overview of the scientific content belonging to the overall theme given in the first column. Content may be broken down into subsections as appropriate.	The roadmap for lesson planning, structured around the skills and subject knowledge that pupils should acquire as part of the syllabus. (Parentheses) indicate limits on the objectives, usually to specify the maximum level of technical knowledge required. Learning objectives are framed around **verbs in bold**. Lessons should be designed so that pupils themselves carry out the action of these verbs.	"Suggested activities/*pupils may do*" provides a list of possible classroom activities the teacher may use to meet the learning objectives. The suggested activities are neither prescriptive nor exhaustive: teachers are free to use some but not all them, and to use other activities instead of or in addition to these. Teachers must, however, always put hands-on student activity at the centre of biology. Teaching should be through inquiry-based (IBL) approaches whenever possible.

Theme	*Subject content* ***Pupils will learn about…***	*Learning objectives (and limits)* ***Pupils will be able to…***	*Activities* ***Pupils may do…***
4.1. Introduction to biology *The scientific domain of biology as the study of living things.*	**4.1.1. What is "alive"?** …the subject domain of biology …competing definitions of "life" …the common ancestry of all life on Earth	**explain** that biology is the study of living things **recognise** that "life" has no set, accepted definition on which all scientists agree **discuss** the relative merits of different scientific definitions of "life" **give an overview** of the highest level taxonomic groups of organisms: bacteria, archaea, major groups of eukaryotes (limited to: plants, animals, fungi, protists) **know** that all these groups have fundamental things in common leading scientists to the conclusion that they have all evolved from a single common ancestor	• research and present definitions of life by reputable scientists (e.g., Aristotle, Henri Bergson, Erwin Schrödinger, Lynn Margulis, Edward Trifonov, Gerald Joyce, Daniel Koshland, Manfred Eigen, Carol Cleland…) • discuss aspects of question already covered in Integrated Science
4.2. Cells *The cell theory as a fundamental organising principle of biology. Intracellular organisation. The principle of* Omnis cellula a cellula. *The vast array of cell forms and functions. Observation of cells and organelles under the light microscope.*	**4.2.1. The cell theory** …cells as the basic unit of life on earth …the shared attributes of all cells	**know** that the cell theory is fundamental to modern biology: - cells are the fundamental units of organisation, structure, and function of living things on earth - all cells derive from pre-existing cells **deduce** the four basic attributes possessed by all cells: - a boundary between inside and outside - instructions for the cell to build and maintain itself - machinery to execute the instructions - a means to convert energy into useful forms	• create 2- and 3-D generalised cell models in various media

	4.2.2. Cell structure and function …the great variety of cells …organelles visible with the light microscope …cell division as the origin of new cells …chromosomes as the bearers of the cell's instructions	**prepare** microscope mounts of a variety of cells **draw** plant, animal, and fungal cells **from observation**, using stains on fresh material and/or prepared slides as appropriate to highlight organelles and structures visible under the light microscope (e.g., cell membrane, cell wall, nucleus, chromosomes, plastids) **recognise** that cells come in many forms, with varied structures, according to taxonomic group and function within an organism **relate** the structure and function of the following organelles to the generalised features of all cells in 4.2.1: cell membrane, cell wall (for plants, fungi, and some bacteria), nucleus containing chromosomes, and plastids (for plants) **observe** that not all cells possess all possible organelles, within and across species **represent** bacterial, plant, fungal, and animal cells and their structures in the form of simplified, idealised diagrams **identify** structures studied in this syllabus and their functions in schematic representations of bacterial, plant, and animal cells **observe** cell division for reproduction and/or growth **know** that chromosomes are the bearers of the information needed to make and run cells – relate to cell theory	• construct comparative table/model of different types of cells • exhibition of drawings from observation • observation of commercial slides of polytene chromosomes (e.g., *Drosophila* or *Chironomus*)
	4.2.3. Single-celled organisms …the majority of living things on earth	**know** that single-celled microorganisms make up most of life on earth **observe** a variety of single-celled microorganisms under the microscope	• e.g., pond water, hay infusions, yeast cultures, yogurt/sauerkraut… • make bacterial cultures

4.3. Levels of organisation in living things *An overview of the composition of living things, from atoms to the differentiated tissues, organs, and systems of multicellular organisms. Reproduction in multicellular organisms.*	**4.3.1. Levels of organisation from chemical elements to multicellular organisms** …the chemical elements of which organisms are composed …the principal categories of molecules in organisms …levels of organisation in multicellular organisms	**know** the four principal elements of which organisms are composed (H, O, C, N), and some of the important elements found in lesser quantities (e.g., ions of Ca, P, K, S, Na, Cl, Mg, Fe …) **know** that H_2O is the main molecule in organisms **know** the principal categories of macromolecules of which organisms are composed: proteins, lipids, nucleic acids, and carbohydrates, and which of the four principal elements each contains (no molecular formulas or structures required) **organise** thinking about multicellular organisms in terms of hierarchies of organisation: (atoms→molecules→organelles→cells→ tissues→organs→systems→organisms) **deduce** that multicellular organisms differentiate cells for different functions	• experiments to show presence of carbohydrates/lipids/proteins • microscopic and macroscopic observations of tissues, organs, organisms • create diagrams or maps of levels of organisation • observation of cell division in fresh or commercially prepared slides (e.g., root tip squashes)
	4.3.2. Reproduction in multicellular organisms …asexual and sexual modes of reproduction	**deduce** that reproduction of multicellular organisms is more complicated than just cell division **know** that multicellular organisms may reproduce either asexually or sexually **know** that the offspring produced sexually by two parents possess a new and unique set of instructions derived from both **deduce** that asexual reproduction leads to identical offspring **name** and **describe** at least two types of asexual reproduction in different taxonomic groups, (e.g., budding, offsets, stolons, parthenogenesis…) **experiment** with asexual reproduction in some group of organisms	• experiment with asexual propagation of plants (e.g., cuttings, layering, stolons) • experiment with sexual propagation of plants (controlled pollination) • coordinate with a garden club • observe and/or research the role of insects in flowering plant reproduction (and the crises in bee populations) • observe asexual reproduction in animals (e.g., *Hydra,* aphids) • sprout mushrooms from commercially available hyphae

Themes 4.4 to 4.6 explore the theme of maintaining the homeostasis,* sensu lato, *of multicellular organisms. *This entails solving fundamental problems: communication among the cells and parts of the organism; transport of cell products and raw materials; and control of the cells making up the self. (A fourth, recognition of self vs. not-self for defence, is not treated in this syllabus.)* *These themes may be taken in any order, at the teacher's discretion.* *In each section, one example should be taken from the highest taxonomic level that includes humans (e.g., renal urinary system ➛ vertebrates), so that pupils gain an overall understanding of their own physiology. At least one further example should be drawn from an additional major taxonomic group, so that pupils acquire an appreciation of biodiversity and of the many different solutions to these fundamental problematics that have evolved over the history of life on earth.*			
4.4. Communication *An overview of the two systems evolved to communicate within the parts of the organism: hormones (all multicellular organisms) and nervous systems (animals only).*	**4.4.1. Chemical communication** …the communication system universal to multicellular organisms …how hormones may have multiple targets and effects	**know** that all multicellular organisms use chemical signals to communicate among cells, tissues, organs, and systems **know** that a given hormone may have multiple targets and effects **describe** and **analyse** examples of hormonal communication in at least two taxa	• experiment with application of plant hormones (e.g., rooting hormones on cuttings) • research and present hormones or hormone systems from different taxa (e.g., insulin/glucagon or auxin/gibberellin) • research environmental endocrine disruptors due to human pollution • discuss effects of modification of hormonal controls (e.g., endocrine disorders, hormonal contraception)
	4.4.2. Nervous system …a system of communication unique to animals …a simple model for neurons, nerves, and nervous systems …the action of mind-altering drugs on neurotransmission in the brain	**know** that nervous systems evolved only in the kingdom Animalia **know** basics of nervous system, limited to: - basic structure of neuron only (no Schwann cells, no biochemical details) - binary, all-or-nothing nature of signal in neurons - one-way signalling in nerves, entailing afferent and efferent neurons - basic structure of nerves only - central/peripheral nervous system only (no discussion of autonomic/sympathetic/parasympathetic systems) **describe, analyse,** and **compare and contrast** nervous systems of organisms from at least two taxa (e.g., medusozoans, cephalopods, insects, vertebrates…)	• experiment with reflexes (e.g., myotatic reflexes, pupil of eye…) • research the action of mind-altering drugs • microscopic observation of neurons, nerves, brain slices • describe/depict nervous communication from stimulus to response for a given situation • simple experiments or research on behaviour in different taxa (e.g., insects, cephalopods…) • study cnidarian nervous systems to discuss relationship between communication systems, organisms, and colonial "organisms"

	…similarities and differences between hormonal and nervous communication	**know** that mind-altering drugs interfere with or stimulate neurotransmission in the brain **discuss** issues and questions related to mind-altering drugs **compare** and **contrast** hormonal and nervous system communication	• invite expert on drugs (possible to coordinate with school nurse, psychologist)
4.5. Transport *Multicellular organisms must take in resources and energy to function, transport nutrition and cell products within the organism, and dispose of waste products.*	**4.5.1. Absorption and uptake** …how organisms take in the materials and energy they need	**deduce** that multicellular organisms must have specialised means to absorb/uptake necessary materials and energy **know** that, while plants are autotrophs that must only absorb light energy and inorganic compounds (H_2O, CO_2, and minerals), animals and fungi are heterotrophs that must take up O_2 and complex organic molecules **analyse** absorption/uptake systems in vertebrates (e.g., gills/lungs, digestive tract): **analyse** absorption/uptake systems in at least one other taxon (e.g., xylem, leaf structure in vascular plants; haustoria in fungi; spiracles/tracheae in insects…) - schematic only (key concept: surface area), no detailed anatomic study - no biochemical details	• controlled experiments with plants (e.g., water absorption, nutrients) • observe microscopic mounts of, e.g., lungs, gills, intestines • plasmolysis (observation only) • osmosis (with simple explanation) • celery in water with food colouring
	4.5.2. Transport within the organism …different types of transport/circulatory systems	**describe** and **analyse** transport systems in at least two different taxa (e.g., closed circulatory systems of vertebrates, cephalopods; open circulatory systems of insects and molluscs other than cephalopods; water vascular systems in echinoderms, cnidaria; xylem/phloem in vascular plants…) - schematic only, no detailed anatomic study - no biochemical details	• build a model, representation, or map of vertebrate circulation, to be added to with each subsection of 4.5 (e.g., differences in blood contents before and after passing through lungs, digestive system, etc.) • heart/lung dissection • microscopic observation of red blood cells, capillaries • insect dissection • microscopic observation of plant transport structures
	4.5.3. Waste disposal …how plants dispose of oxygen …how heterotrophs	**know** that, as autotrophs, plants primarily have only to dispose of the waste O_2 from photosynthesis **know** that animals and fungi must excrete CO_2, excess nitrogen, and waste organic molecules resulting from metabolism **describe** and **analyse** waste disposal systems from at least	• kidney dissection • chemical analysis of urine • compare/contrast chemical analyses of urine, blood • discuss concept of “waste” in biological contexts and relate to human contexts • add role of kidney and liver to model of

	must dispose of CO_2 and complex organic molecules	two taxa (e.g., urinary system in vertebrates, Malpighian tubules in insects, oxygen disposal in plants…) - schematic only, no detailed anatomic study - no biochemical details	vertebrate circulation
4.6. Control *Multicellular organisms must manage the tension between the selfish interest of individual cells and the adaptive good of the whole organism.*	**4.6.1. Control of the self** …the competing interests of individual cells and the organism as a whole …cancers as failure to control "selfish" cells …risk factors for cancer in humans	**deduce** that cells within multicellular organisms have "selfish" incentives to maximise resource use, grow, and divide, at the expense of the whole organism (cf. 4.2) **deduce** that multicellular organisms must have evolved both intracellular and organism-level controls to prevent rogue cells from taking over by excessive metabolism and/or cell division **know** that cancers occur when these controls at the level of cells and organisms fail, allowing certain cells to multiply uncontrolled **research, describe, analyse,** and/or **compare** and **contrast** control systems in at least two taxa **know** that most cancers occur randomly **know** that certain factors and behaviours make human cancers more likely, notably tobacco use, chemical exposures, air pollution, and radiation including sunburn	• construct flow chart or other depiction of the steps leading to failure of the self-control systems in an organism (cancer) • tobacco awareness • research SPFs of sunblock • research and engage in awareness campaigns regarding environmental carcinogens of human origin

Theme 4/5.0 provides the opportunity for open-ended discussion and education on the theme of human sexuality. Teachers may schedule this theme at their discretion at any appropriate time in S4 or S5, taking into account the development and needs of an individual class. *Teachers must take care that the theme is covered before the end of the S4-5 cycle.*			
4/5.0. Human Sexuality *Puberty and human sexuality, organised around the needs and particular interests of pupils.*	**4/5.0.1 Sexuality and relationships** (…review of topics previously covered in Integrated Science) …discussion of sexuality and relationships, taking into account student needs and interests	(Teachers should ensure that all pupils have met all the learning objectives of IS 1.4.1-3, reviewing and updating as necessary) **pose questions** and **discuss** issues concerning sex and relationships (e.g., anatomy, contraception, the experience of the menstrual cycle, protection against sexually transmitted infections, media depictions, pornography, sexual identity, sexual preferences, pleasure, consent, respect for others...)	(see IS 1.4.2 for suggestions) • present different forms of contraception • discuss realism of media depictions of sexual activities and relationships, including pornography • invite outside experts • provide opportunities for boys and girls to discuss and pose questions separately • provide opportunities to pose questions anonymously • coordinate with school nurse and/or psychologist

Theme 5.0 is a compulsory 2-day field trip to study ecological diversity, evolution, and topics related to human impact on nature and to sustainable development. It picks up themes from Integrated Science content section 3.2 and allows teachers to link them with the topic of evolution that provides the leitmotif *of the S5 syllabus. Teachers may schedule the field trip at their discretion during S5 according to their own course planning and school logistical issues. Content from the field trip may be covered in the relevant semester examination.*			
5.0 Field Trip *Study in the field of biodiversity, evolution, and topics related to the human impact on nature and to sustainable development.*	**5.0.0. Field trip** …biodiversity, ecology, and evolution in the field …threats to biodiversity due to climate change and other human and natural causes …sustainable development approaches to preserving biodiversity	**explore** aspects and raise awareness of biodiversity, ecology, evolution, systematics, climate change, and sustainable development in the context of a field trip	• identify the different components of a landscape • measure abiotic factors and research changes over historical time • take samples (e.g., herbarium specimens), respecting protection of biodiversity • look for fossils • use taxonomic keys and field guides • measure variation of a chosen character in a natural population • characterise the ecosystem • identify specific adaptations • draw food chains and food networks (e.g., bioaccumulation) • presentation/discussion with scientists • discuss how the research area may be under threat from climate change and/or other human and natural causes • debates about conservation, biodiversity, and sustainability issues • involve students in organisation of the field trip to promote sustainable development considerations in everyday life • school awareness/action campaign linked to research area before and/or after return

5.1. Evolution *The history of life on earth, leading to the framing theory that makes sense of everything in biology, natural selection, constructed from its components: variation, inheritance, the struggle for existence, and time.*	**5.1.1. History of life on earth and evidence for evolution** …the history of life on earth …the distinction between evolution as fact and the theory of evolution explaining it …the overwhelming evidence of the fact of evolution …how to construct a phylogeny	**construct** a timeline for the history of life on earth, to scale, marking major geological eras, the appearance of major taxa, and major extinction events, including the current Holocene extinction **distinguish** between evolution as a historical fact and the theory of evolution that proposes mechanisms for its occurrence **explain** why scientists are sure that current living things are descended with modification from earlier forms **analyse** at least three categories of consilient evidence pointing to the fact of evolution **construct** a phylogeny for real or invented organisms on the basis of multiple data sets	• research and present groups of extinct organisms (e.g., dinosaurs) • discuss the meaning of a "theory" in science: an explanatory framework that encompasses a broad array of phenomena and is supported on a foundation of facts, observations, experiments, and reasoning • an exercise to reconstruct a phylogeny for real or invented organisms (e.g., Caminalcules or computer models), on the basis of multiple data sets • analyse and discuss a phylogeny of humans
	5.1.2. Variation in populations …variation as a universal characteristic of natural populations …the normal distribution …the importance of the Law of Large Lumbers	**demonstrate** the existence of variation in biological characters in populations **graph** variation and **recognise** the results in terms of a statistical normal distribution (qualitative treatment of variance only) **analyse** the need for a large data set to reach reliable results – statistical Law of Large Numbers (qualitative only, no tests for confidence interval)	• have pupils line up in the classroom by variation for a number of different characters (e.g., height, shoe size, earlobe length, eye colour, fingerprints...) to demonstrate the independence of variation among characters • measure and graph variation for some human character (e.g., handspan) in the school population. Contrast small and large data sets to illustrate Law of Large Numbers • measure variation for some character in another type of organism (plant/animal)
	5.1.3. Inheritance …tendency of offspring to inherit their parents' place in the normal distribution	**observe** that offspring tend to resemble their parents, and thus fall into the same range of the distribution for a given character (qualitative treatment only – qualitative resemblance of offspring to parents is sufficient to construct the theory of natural selection) **deduce** that offspring will tend to be in the same place in the distribution for a given character as their parents	• have pupils list ways in which they resemble their own parents • discuss other everyday observations about inheritance (e.g., dog, cat, horse, or flower breeding)

	5.1.4. Struggle for existence …the discrepancy between ideal growth of populations and of resources …the Malthusian argument as applied to natural populations and to humans	**graph** population curves in the event of unconstrained reproduction for asexually and sexually reproducing populations **deduce** a simple equation to describe exponential growth (e.g., $y=2^x$) **analyse** the Malthusian argument that populations will inevitably increase faster than resources **propose** and **graph** some hypotheses for changes in resources over time (qualitative only) **analyse** the consequence of the discrepancy between population and resource growth curves **discuss** whether Malthus's argument still applies to humans and **relate** to issues of sustainable development	• model population growth under various conditions of fertility and constraints • experiment with limiting factors in bacterial growth • introduce Thomas Malthus's argument in *An Essay on the Principle of Population* (1798) and discuss arguments among economists, political scientists, and historians about whether he got it right
	5.1.5. Evolution by natural selection …the explanatory framework that best explains the history of life	**deduce** the mechanism of natural selection outlined by Charles Darwin in the *Origin of Species* (1859): *if* - there is variation in a population, - variations are inherited by offspring, - there is a struggle for existence because populations outstrip resources, thus organisms in certain parts of the distribution reproduce disproportionately; *then* - distributions of characters will shift from generation to generation, and - given time, lineages can change profoundly **model** natural selection within simple parameters **construct a simple model** for speciation by geographical separation and **relate** to the origins of biodiversity	• model the action of natural selection • discuss analogy with artificial selection (making clear that there is no "selector" in natural evolution and no predetermined goal) • research important thinkers in the history of evolutionary theory • model, research, or experiment with the development of antibiotic resistance in bacteria or pesticide resistance in insects
5.2. Mendelian Inheritance *A simple model that allows us to treat inheritance quantitatively, leading to the beginnings of a more sophisticated understanding.*	**5.2.1. A particulate model of inheritance** …Mendel's model for studying inheritance quantitatively …monohybrid dominant/recessive crosses	**explain** that Gregor Mendel set up an experimental model system that usefully oversimplified inheritance **analyse** the important characteristics of a useful model organism in biology **analyse** the results of F1 and F2 monohybrid crosses and **deduce** the existence of alleles inherited from each parent via gametes (cf. 4.3.2). **predict** the results of a given monohybrid cross using a Punnett square	• analyse monohybrid transmission P/F1/F2 using statistically significant data sets • analyse Mendel's own crosses and data • coin-flip model of inheritance: pupils pair up as "parents" heterozygous for a given trait, flip coins to determine gametes, and create "families" of offspring

	…the importance of sample size …the test cross …pedigree analysis	**demonstrate** that ratios of offspring in small sample sizes are unlikely to conform to predicted Mendelian ratios **compare** results from a few offspring with a larger data set to see the effect of the Law of Large Numbers **analyse** a test (back) cross to determine genotype **analyse** pedigrees to deduce genotypes **discuss** the consequences of genetic diagnoses for individuals and families **know** and **use** standard terminology for Mendelian genetics: gene, allele, dominant, recessive, genotype, phenotype, heterozygous, homozygous	• invite a genetic counsellor to discuss issues of diagnosis and communication with patients and families about genetic illnesses
	5.2.2. More complex phenotypes from monohybrid crosses …codominance, incomplete dominance, and polygenic characters	**analyse** F1/F2 cross results not conforming to dominant-recessive model: codominance, incomplete dominance **analyse** situations involving multiple alleles in a population **know** that most characters result from the interaction of many genes (no epistasis required)	• derive phenotypes from genotypes for ABO blood groups • give examples of polygenic characters
5.3. Chromosomal Inheritance *Establishing the physical location of genes on chromosomes, showing that the events of meiosis correspond to Mendelian predictions.* *Sex determination in mammals and other organisms.*	**5.3.1. Meiosis** …the physical location of genes: chromosomes …correspondence of meiosis to Mendelian predictions …consequences of errors in meiosis	**know** that chromosomes are the bearers of genes **recognise** chromosomes in a karyotype **recognise** that meiosis corresponds to the expectation for alleles from Mendel's model of inheritance: importance of chromosome pairing, reducing division, giving the law of independent assortment (gene linkage not required, no detailed treatment of stages of meiosis 1/2 required) **deduce** that errors in meiosis can give rise to problems such as Down syndrome, illustrated with karyotypes	• examination of prepared slides of meiosis • hands-on modelling of events of meiosis, e.g., with "sockosomes" or chromosomes made in a fab lab • research the history of chemical dyes and stains that made the discovery of meiosis possible (1870s) • research Theodor Boveri's demonstrations that chromosomes were the bearers of genetic information

	5.3.2. Sex determination …the XY chromosomal sex determination in mammals …detecting sex-linked characters in humans …sex determination in other taxa	**know** the XY chromosomal sex determination system in mammals **use** standard terminology for chromosomal genetics: hemizygous, locus, autosomal, sex-linked **analyse** a pedigree showing an X-linked recessive character **analyse** a pedigree to determine whether a character is autosomal or sex-linked (X-linked recessive only) **describe** one other system of sex determination	• analyse karyotypes • research Nettie Stevens's discovery of the existence of sex chromosomes, T.H. Morgan's discovery of sex linkage • research and/or look at sex determination in other groups, e.g., ZW chromosomes in birds, temperature dependence in crocodilians, haplodiploidy in hymenopterans, fish that change sex, chromosomal systems in dioecious plants…
5.4. Molecular Inheritance *DNA as the universal molecule encoding genes. Its structure, function, and replication. A synthesis of the themes of evolution and genetics in discussion of eugenics and current issues raised by the application of genetic knowledge to human beings.*	**5.4.1. DNA structure and function as code for proteins** …DNA as the molecule of inheritance …the double helix …an introduction to protein structure and the many roles of proteins …the universal codon system	**know** that DNA is the component of chromosomes actually carrying the genetic code (no epigenetics required) **draw** and **label** a simplified, schematic representation of the DNA molecule (double helix, sugar-phosphate backbone, four bases ATGC) **extract** DNA from cells **explain** that DNA codes for the amino acid sequence of proteins, which are manufactured by ribosomes (no details of RNA transcription/translation required) **know** that proteins are complex molecules comprising strings of amino acids that fold up into complex shapes that determine their function (no biochemical details required) **know** that proteins are the key macromolecules of cellular biochemistry, playing many roles **describe** several roles played by proteins in organisms (e.g., structure, enzymes, transport, hormones, signalling…) **use** a DNA codon wheel or table to give an amino acid sequence from a given DNA sequence **know** that the DNA code is universal to organisms on earth (cf. 5.1.1)	• research the Watson/Crick model of DNA and conflicts over credit and attribution (role of Rosalind Franklin's crystallography data) • construct model of DNA molecule • view computer/video models of chromosome structure and basic protein structure, types, and function

	5.4.2. DNA replication …a simple model of DNA replication …a simple model of mutation …how mutation introduces new variations into populations	**explain** and/or **model** a basic schema for DNA replication (no directionality or Okazaki fragments) **construct a basic model** of mutation due to substitutions during replication causing mis-sense, same-sense, or non-sense mutations, with corresponding changes to protein structure and function **know** some common causes of mutation: statistical bad luck, radiation, mutagenic chemicals (cf. 4.6.1). **recognise** that mutations add alleles to a population, increasing variation, on which natural selection works and brings about evolution	• construct model of DNA replication • research causes of mutation • study the effect of non-sense mutations to deduce the stop codons • identify the first amino acid coded by each gene to identify the start codon • school informational campaign about environmental exposure to carcinogens of human origin • use sickle cell anaemia as a case study to consolidate syllabus sections 5.1-5.4: phenotype to pedigrees to alleles to gene to mutation; link to heterozygote advantage, geographical distribution, natural selection, genetic testing
	5.4.3. Uses and abuses of evolutionary theory and genetics …the troubling history of the eugenics movement …current issues in human reproduction, genetics, genetic testing, and genetic engineering	**know** the definition of eugenics **describe** eugenics as a political movement to apply biology to human evolution and its consequences **recognise** that modern prenatal testing raises issues related to eugenics **discuss** issues related to genetic testing within families **know** about the existence of DNA manipulation techniques and **discuss** their social, ethical, and legal implications	• research the history of eugenics laws and their application in particular countries • coordinate with ethics/religion, history teachers to discuss history of eugenics and related current issues • research and discuss CRISPR-Cas9 • research and discuss potential and actual treatment of genetic diseases, intervention in human reproduction, rewriting the human genome, genetic manipulation techniques in agriculture…

5. Assessment

Assessments must be oriented around the **Key Competences for the European Schools** (see section 1), the **attainment descriptors** for biology (see sections 3.1 and 5.1), and the **cross-cutting concepts** shared by all the mathematics and science syllabuses (see section 3.2). Teachers must incorporate assessment of all of these in each year's teaching. Assignment of semester grades must likewise be based on the descriptors.

Pupils must be assessed in a broad variety of ways throughout the year, to give a wide-ranging picture of each pupil's attainments, strengths, and areas for further work. Both formative and summative assessments must be used, ranging from quick and simple (e.g., short quizzes, oral assessments by teacher during the course of an activity, brief presentations by pupils of work in progress) to more complex and time-demanding (e.g., laboratory reports, tests requiring pupils to apply learned content in new situations, group presentations of a project). **Practical work should make up a very substantial component of the course.**

In S4-5, A and B marks are assigned, in whole and half marks. The A mark synthesises the results of both formative and summative work throughout a semester. Examinations should not test pupils only on factual knowledge and comprehension, but also substantially assess application, analysis, and written communication skills, in accordance with the attainment descriptors (see section 5.1). In S5, the field trip may be used as a source in composing the relevant semester exam in which the field trip was taken.

Assessments over the course of a year must include tasks requiring pupils to:

- **design and carry out their own investigation**
- **write a laboratory report including abstract/methods/results/conclusions**
- **use mathematical techniques**
- **make and use models of phenomena and/or systems**
- **do substantial writing**
- **practice digital literacy skills**
- **integrate historical, social, civic, cultural, and/or ethical aspects of science**
- **present their work to classmates, parents, or the public**
- **practice skills and content in structured exercises (e.g., worksheets, problem sets)**
- **demonstrate mastery of subject content, including ability to apply content to new situations**
- **demonstrate mastery of practical skills (e.g., making a microscope mount and bringing it into focus, dissection, drawing from observation)**
- **work in teams**
- **carry out self and peer evaluation**
- **engage in debates and class discussions**

Teachers should make an annual assessment plan that provides a weighting of different assessment activities and ensures that all the competences are assessed within each school year of the cycle.

5.1. Attainment descriptors – Biology S4-S5

Globally, students should develop awareness of the environment and learn to act as responsible citizens with respect to it.

	A - 9.0-10 ***Excellent***	**B - 8.0-8.9** ***Very good***	**C - 7.0-7.9** ***Good***	**D - 6.0-6.9** ***Satisfactory***	**E - 5.0-5.9** ***Sufficient***	**F - 3.0-4.9** ***Failed/Weak***	**Fx - 0-2.9** ***Failed/ Very Weak***
Knowledge	Displays comprehensive knowledge of facts…	Displays a very broad knowledge of facts…	Displays a broad knowledge of facts…	Displays a reasonable knowledge of facts and definitions…	Recalls main names, facts and definitions…	Displays little recall of factual information…	Displays very little recall of factual information…
Comprehension	…and a thorough command and use of concepts and principles in science.	…and a good command and use of concepts and principles in science.	…and good understanding of main concepts and principles in science.	…and understanding of basic concepts and principles in science.	…but understands only basic concepts and principles in science.	…and a limited understanding of concepts and principles in science.	…and shows very little understanding of scientific principles and concepts.
Application	Makes connections between different parts of the syllabus and applies concepts to a wide variety of unfamiliar situations and makes appropriate predictions.	Makes some connections between different parts of the syllabus and applies concepts and principles to unfamiliar situations.	Is capable of using knowledge in an unfamiliar situation.	Is capable of using knowledge in a familiar situation.	Can use basic knowledge in a familiar situation.	Is unable correctly to apply basic knowledge to solve problems.	Is entirely unable to apply even basic knowledge to solve problems.
Analysis	Is capable of detailed and critical analysis and explanations of complex data.	Analyses and explains complex data well.	Produces good analysis and explanations of simple data.	Produces basic analysis and explanations of simple data.	Given a structure can analyse and explain simple data.	Can use data only with significant guidance.	Fails to use data adequately.
Experimental Work	Formulates hypotheses, plans and carries out investigations using a wide range of techniques while being aware of ethical issues.	Plans and carries out investigations using appropriate techniques, being aware of safety issues.	Follows a written procedure safely and makes and records observations, presenting them using different techniques.	Follows a written procedure safely and records observations.	Follows a written procedure safely and makes basic observations	Has difficulty following instructions without supervision.	Is not able to safely follow a written procedure.

Digital and Information Competences[6]	Can consistently independently find, and assess the reliability of, information on scientific subjects, on- and offline. Can independently use appropriate software for science tasks.	Can usually independently find, and assess the reliability of, information on scientific subjects, on- and offline. Can use appropriate software for science tasks with some assistance.	Can often independently find, and assess the reliability of, information on scientific subjects, on- and offline. Can use appropriate software for science tasks with assistance.	With aid, can find, and assess the reliability of, information on scientific subjects, on- and offline. Can use appropriate software for science tasks given structured assistance.	Can retrieve information on scientific subjects when directed to reliable sources, on- and offline. Can follow structured instructions to use appropriate software for science tasks.	Generally unable to find, or to assess the reliability of, information on scientific subjects, on- and offline. Has great difficulties using appropriate software for science tasks even with assistance.	Unable to find, or to assess the reliability of, information on scientific subjects, on- or offline. Unable to use appropriate software for science tasks even with assistance.
Communication (oral and written)	Communicates clearly using scientific vocabulary correctly. Demonstrates excellent presentation skills.	Communicates clearly using scientific vocabulary correctly. Demonstrates very good presentation skills.	Communicates clearly most of the time using scientific vocabulary correctly. Demonstrates good presentation skills.	Uses basic scientific vocabulary, and descriptions show some structure. Demonstrates satisfactory presentation skills.	Uses basic scientific vocabulary, but descriptions may lack structure or clarity. Demonstrates satisfactory presentation skills	Generally produces descriptions that are insufficient or incomplete with a poor use of scientific vocabulary. Lacks acceptable presentation skills.	Has very poor communication and presentation skills.
Teamwork	Works constructively as a team member, shows initiative, and can act as a team leader.	Works constructively in a team.	Works well in a team.	Works satisfactorily in a team.	Participates in teamwork.	Needs assistance when working in a team.	Does not work in a team.

[6] *This competence is part of the European Digital Competence Framework (https://ec.europa.eu/jrc/en/digcomp).

SYNOPSIS

Grade A - 9.0-10.0 - Excellent

The student: displays comprehensive knowledge of facts and a thorough command and use of concepts and principles in science. Makes connections between different parts of the syllabus and applies concepts to a wide variety of unfamiliar situations and makes appropriate predictions. Is capable of detailed and critical analysis and explanations of complex data. Can consistently independently find, and assess the reliability of, information on scientific subjects, on- and offline. Formulates hypotheses, plans and carries out investigations using a wide range of techniques while being aware of ethical issues. Can independently use appropriate software for science tasks. Communicates clearly using scientific vocabulary correctly. Demonstrates excellent presentation skills. Works constructively as a team member, shows initiative, and can act as a team leader.

Grade B - 8.0-8.9 - Very good

The student: displays a very broad knowledge of facts and a good command and use of concepts and principles in science. Makes some connections between different parts of the syllabus and applies concepts and principles to unfamiliar situations. Analyses and explains complex data well. Plans and carries out experiments using appropriate techniques, being aware of safety issues. Can usually independently find, and assess the reliability of, information on scientific subjects, on- and offline. Can use appropriate software for science tasks with some assistance. Communicates clearly using scientific vocabulary correctly. Demonstrates very good presentation skills. Is able to draw, describe and analyse different kinds of graphs. Works constructively in a team.

Grade C - 7.0-7.9 - Good

The student: displays a broad knowledge of facts and good understanding of main concepts and principles in science. Is capable of using knowledge in an unfamiliar situation. Produces good analysis and explanations of simple data. Follows a written procedure safely and makes and records observations, presenting them using different techniques. Can often independently find, and assess the reliability of, information on scientific subjects, on- and offline. Can use appropriate software for science tasks with assistance. Communicates clearly most of the time using scientific vocabulary correctly. Demonstrates good presentation skills. Is able to draw, describe and analyse simple graphs. Works well in a team.

Grade D - 6.0-6.9 - Satisfactory

The student: displays a reasonable knowledge of facts and definitions and understanding of basic concepts and principles in science. Is capable of using knowledge in a familiar situation. Produces basic analysis and explanations of simple data. Follows a written procedure safely and records observations. With aid, can find, and assess the reliability of, information on scientific subjects, on- and offline. Can use appropriate software for science tasks given structured assistance. Uses basic scientific vocabulary, and descriptions show some structure. Demonstrates satisfactory presentation skills. Is able to draw, describe and read simple graphs. Works satisfactorily in a team.

Grade E - 5.0-5.9 - Sufficient

The student: recalls main names, facts and definitions but understands only basic concepts and principles in science. Can use basic knowledge in a familiar situation. Given a structure can analyse and explain simple data. Follows a written procedure safely and makes basic observations. Can retrieve information on scientific subjects when directed to reliable sources, on- and offline. Can follow structured instructions to use appropriate software for science tasks. Uses basic scientific vocabulary, but descriptions may lack structure or clarity. Demonstrates satisfactory presentation skills. Is able to draw and describe simple graphs. Participates in teamwork.

Grade F - 3.0-4.9 - Failed/Weak

The student: displays little recall of factual information and a limited understanding of concepts and principles in science. Is unable correctly to apply basic knowledge to solve problems. Can use data only with significant guidance. Has difficulty following instructions without supervision. Is generally unable to find, or to assess the reliability of, information on scientific subjects, on- and offline. Has great difficulties using appropriate software for science tasks even with assistance. Generally produces descriptions that are insufficient or incomplete with poor use of scientific vocabulary. Lacks acceptable presentation skills. Has difficulty drawing and describing simple graphs. Needs assistance when working in a team.

Grade Fx - 0-2.9 - Failed/Very weak

The student: displays very little recall of factual information and shows very little understanding of scientific principles and concepts. Is entirely unable to apply even basic knowledge to solve problems. Fails to use data adequately. Is not able to safely follow a written procedure. Is unable to find, or to assess the reliability of, information on scientific subjects, on- or offline. Is unable to use appropriate software for science tasks even with assistance. Has very poor communication and presentation skills. Has difficulty drawing and describing simple graphs without assistance. Does not work in a team.

6. Annex 1 – Operators used in learning objectives in 4.2, by attainment descriptor

Knowledge	**Fachkenntnisse**	**Connaissances**
draw and label (e.g., a schema or diagram)	*skizzieren/zeichnen und beschriften*	*dessiner et légender*
give overview	*einen Überblick geben*	*présenter une vue globale*
identify	*identifizieren*	*identifier*
know	*wissen*	*savoir/connaître*
name	*nennen*	*nommer*
Comprehension	**Verständnis**	**Compréhension**
describe	*beschreiben*	*décrire*
distinguish	*unterscheiden/abgrenzen*	*distinguer*
explain	*erklären*	*présenter/expliciter/préciser*
recognise	*verstehen*	*comprendre/constater*
Application	**Anwendung**	**Application**
construct	*entwerfen*	*concevoir (modèle)*
discuss	*diskutieren/erörtern*	*argumenter/discuter*
relate	*verknüpfen*	*relier/mettre en relation*
use	*anwenden*	*utiliser/exploiter*
Analysis	**Bewertung**	**Analyse**
analyse	*analysieren/untersuchen/auswerten*	*étudier/interpréter*
compare	*vergleichen*	*comparer*
compare/contrast	*Gemeinsamkeiten, Ähnlichkeiten und Unterschiede ermitteln*	*comparer*
construct (a model)	*ein Modell entwerfen*	*concevoir un modèle*
deduce	*ableiten*	*déduire*
derive	*eine Gleichung ableiten/aufstellen*	*dériver*
discuss	*diskutieren/erörtern*	*argumenter/discuter*
model	*entwickeln*	*modéliser*
organise	*zusammenhängend darstellen*	*hiérarchiser/construire*
predict	*vorhersagen*	*prévoir/anticiper*
relate	*verknüpfen*	*relier/mettre en relation*
represent	*darstellen*	*représenter*
Experimental Work	**Experimentelle Arbeit**	**Travail expérimental**
demonstrate	*zeigen*	*démontrer*
draw (from observation)	*zeichnen*	*dessiner/esquisser*
experiment	*Experimente durchführen*	*expérimenter, effectuer*
explore	*erkunden/untersuchen*	*explorer, étudier*
extract	*extrahieren*	*extraire, prélever*
graph	*graphisch darstellen*	*représenter graphiquement*
model	*modellieren/entwickeln*	*modéliser*
observe	*beobachten*	*observer/constater*
predict	*vorhersagen*	*prévoir*
prepare	*entwickeln/herstellen*	*préparer*
propose (a hypothesis)	*eine Hypothese aufstellen*	*formuler une hypothèse*
Digital and Information Competences	***ICT und Medienkompetenz***	***Compétences numériques et information***
analyse	*analysieren/auswerten/untersuchen*	*analyser*
graph	*graphisch darstellen*	*représenter graphiquement*
model	*entwickeln*	*modéliser*
research	*untersuchen*	*rechercher*
Communication (oral and written)	**Kommunikation (mündlich und schriftlich)**	**Communication (orale et écrite)**
discuss	*diskutieren*	*discuter/argumenter*
pose questions	*Fragen stellen/hinterfragen*	*poser des questions*
Teamwork	**Teamarbeit**	**Travail en groupe**
discuss	*diskutieren*	*échanger*