KEMENTERIAN
PENDIDIKAN
MALAYSIA

KURIKULUM STANDARD SEKOLAH MENENGAH

Biologi

Dokumen Standard Kurikulum dan Pentaksiran

Tingkatan 4 & 5

(EDISI BAHASA INGGERIS)

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Bahagian Pembangunan Kurikulum
MEI 2019

Terbitan 2018

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CONTENT

RUKUN NEGARA

BAHAWASANYA Negara kita Malaysia mendukung cita-cita hendak:
Mencapai perpaduan yang lebih erat dalam kalangan seluruh masyarakatnya;
Memelihara satu cara hidup demokratik;
Mencipta satu masyarakat yang adil di mana kemakmuran negara
akan dapat dinikmati bersama secara adil dan saksama;
Menjamin satu cara yang liberal terhadap tradisi-tradisi
kebudayaannya yang kaya dan berbagai corak;
Membina satu masyarakat progresif yang akan menggunakan
sains dan teknologi moden;

MAKA KAMI, rakyat Malaysia, berikrar akan menumpukan seluruh tenaga dan usaha kami untuk mencapai cita-cita tersebut berdasarkan atas prinsip-prinsip yang berikut:

KEPERCAYAAN KEPADA TUHAN
KESETIAAN KEPADA RAJA DAN NEGARA
KELUHURAN PERLEMBAGAAN
KEDAULATAN UNDANG-UNDANG
KESOPANAN DAN KESUSILAAN

FALSAFAH PENDIDIKAN KEBANGSAAN

“Pendidikan di Malaysia adalah suatu usaha berterusan ke arah lebih memperkembangkan potensi individu secara menyeluruh dan bersepadu untuk melahirkan insan yang seimbang dan harmonis dari segi intelek, rohani, emosi dan jasmani, berdasarkan kepercayaan dan kepatuhan kepada Tuhan. Usaha ini adalah bertujuan untuk melahirkan warganegara Malaysia yang berilmu pengetahuan, berketerampilan, berakhlak mulia, bertanggungjawab dan berkeupayaan mencapai kesejahteraan diri serta memberikan sumbangan terhadap keharmonian dan kemakmuran keluarga, masyarakat dan negara”

Sumber: Akta Pendidikan 1996 (Akta 550)

DEFINISI KURIKULUM KEBANGSAAN

3. Kurikulum Kebangsaan

(1) Kurikulum Kebangsaan ialah suatu program pendidikan yang termasuk kurikulum dan kegiatan kokurikulum yang merangkumi semua pengetahuan, kemahiran, norma, nilai, unsur kebudayaan dan kepercayaan untuk membantu perkembangan seseorang murid dengan sepenuhnya dari segi jasmani, rohani, mental dan emosi serta untuk menanam dan mempertingkatkan nilai moral yang diingini dan untuk menyampaikan pengetahuan.

Sumber: Peraturan-Peraturan Pendidikan (Kurikulum Kebangsaan) 1997
[PU(A)531/97.]

FALSAFAH PENDIDIKAN SAINS KEBANGSAAN

Selaras dengan Falsafah Pendidikan Kebangsaan, pendidikan sains di Malaysia memupuk budaya Sains dan Teknologi dengan memberi tumpuan kepada perkembangan individu yang kompetitif, dinamik, tangkas dan berdaya tahan serta dapat menguasai ilmu sains dan keterampilan teknologi.

Sumber: Kementerian Sains, Teknologi dan Inovasi (MOSTI)

KATA PENGANTAR

Kurikulum Standard Sekolah Menengah (KSSM) yang dilaksanakan secara berperingkat mulai tahun 2017 akan menggantikan Kurikulum Bersepadu Sekolah Menengah (KBSM) yang mula dilaksanakan pada tahun 1989. KSSM digubal bagi memenuhi keperluan dasar baharu di bawah Pelan Pembangunan Pendidikan Malaysia (PPPM) 2013-2025 agar kualiti kurikulum yang dilaksanakan di sekolah menengah setanding dengan standard antarabangsa. Kurikulum berasaskan standard yang menjadi amalan antarabangsa telah dijelmakan dalam KSSM menerusi penggubalan Dokumen Standard Kurikulum dan Pentaksiran (DSKP) untuk semua mata pelajaran yang terdiri daripada Standard Kandungan, Standard Pembelajaran dan Standard Prestasi.

Usaha memasukkan standard pentaksiran di dalam dokumen kurikulum telah mengubah lanskap sejarah sejak Kurikulum Kebangsaan dilaksanakan di bawah Sistem Pendidikan Kebangsaan. Menerusinya murid dapat ditaksir secara berterusan untuk mengenal pasti tahap penguasaan mereka dalam sesuatu mata pelajaran, serta membolehkan guru membuat tindakan susulan bagi mempertingkatkan pencapaian murid.

DSKP yang dihasilkan juga telah menyepadukan enam tunjang Kerangka KSSM, mengintegrasikan pengetahuan, kemahiran dan nilai, serta memasukkan secara eksplisit Kemahiran Abad Ke-21 dan Kemahiran Berfikir Aras Tinggi (KBAT). Penyepaduan tersebut dilakukan untuk melahirkan insan seimbang dan harmonis dari segi intelek, rohani, emosi dan jasmani sebagaimana tuntutan Falsafah Pendidikan Kebangsaan.

Bagi menjayakan pelaksanaan KSSM, pengajaran dan pembelajaran guru perlu memberi penekanan kepada KBAT dengan memberi fokus kepada pendekatan Pembelajaran Berasaskan Inkuiri dan Pembelajaran Berasaskan Projek, supaya murid dapat menguasai kemahiran yang diperlukan dalam abad ke-21.

Kementerian Pendidikan Malaysia merakamkan setinggi-tinggi penghargaan dan ucapan terima kasih kepada semua pihak yang terlibat dalam penggubalan KSSM. Semoga pelaksanaan KSSM akan mencapai hasrat dan matlamat Sistem Pendidikan Kebangsaan.

Dr. MOHAMED BIN ABU BAKAR
Pengarah
Bahagian Pembangunan Kurikulum
Kementerian Pendidikan Malaysia

INTRODUCTION

As articulated in the National Education Philosophy, education in Malaysia is an on-going effort towards nurturing the potential of individuals in a holistic and integrated manner, to develop individuals who are intellectually, spiritually, emotionally and physically balanced. The primary and secondary school curriculum standard and assessment for sciences are developed with the aim of fostering such individuals.

Moving towards a developed nation, Malaysia should create a scientific, progressive, inventive and visionary community as well as benefiting the latest technologies. This community must be able to contribute to the advancement of science and the sustainability of technological civilisation. To achieve this, we need to develop critical, creative, innovative and competent citizens who practice the culture of Science, Technology, Engineering and Mathematics (STEM).

The national science curriculum encompasses core science and elective science subjects. The core science subject is being offered in primary, lower secondary and upper secondary schools, while the eective sciences are being offered in upper secondary schools such as are Biology, Physics, Chemistry and Additional Science.

Secondary core science subject is designed to develop science literacy and high order thinking skills as well as the ability to apply science knowledge, in decision-making and solving real-life problems among pupils.

Elective science subjects are aspired to sharpen and reinforce pupil's knowledge and skills in STEM. These subjects enable pupils to pursue high education with lifelong learning skills. These pupils are anticipated to pursue career in STEM and be able to actively participate in community development and nation-building.

Pupils taking KSSM Biology will have the knowledge and skills to enable them to solve problems and make decisions in everyday life related to Biology based on scientific attitudes and values. They will also be able to further their studies and undertake biology related career. KSSM Biology intends to develop individuals who are dynamic, viable, fair, practice STEM culture and responsible towards community and environment.

AIMS

KSSM Biology aims to develop science-literate pupils through learning experiences in understanding the biology related concepts, developing skills, using various strategies and applying the knowledge and skills based on scientific attitudes and values as well as understanding the impact of science and technological developments in society. These pupils can communicate, make decisions based on scientific evidences, and able to further their education and careers in the STEM field.

OBJECTIVES

Biology KSSM enables pupils to achieve the following objectives:

1. Strengthen interest and passion for biology.
2. Reinforce and enrich scientific knowledge, skills, attitudes and values in biology through scientific investigation.
3. Enhance the ability to think logically, rationally, critically and creatively through processes of understanding and applying biology in decision-making and problems solving.
4. Acknowledge that the knowledge of biology is temporary and evolving.
5. Practise the usage of biology language and symbols and equip pupils with skills in delivering phyiscs related ideas in the relevant context.
6. Develop mindset about chemical concepts, theories and laws, open-mindedness, objectiveness and proactiveness.
7. Realize social, economic, environmental and technological implications in biology and caring for the environment and society.
8. Appreciate biology and its application in helping to explain phenomena and solve real worls problems.

KSSM FRAMEWORK

KSSM Biology is built based on six pillars, which are Communication; Spiritual, Attitude and Value; Humanity; Personal Development; Physical Development and Aesthetic; and Science and Technology. The six pillars are the main domain that support each other and are integrated with critical, creative and innovative thinking. This integration aimed at developing human capital who is knowledgeable, competent, creative, critical, innovative and embraces noble values based on religion as illustrated in Figure 1.

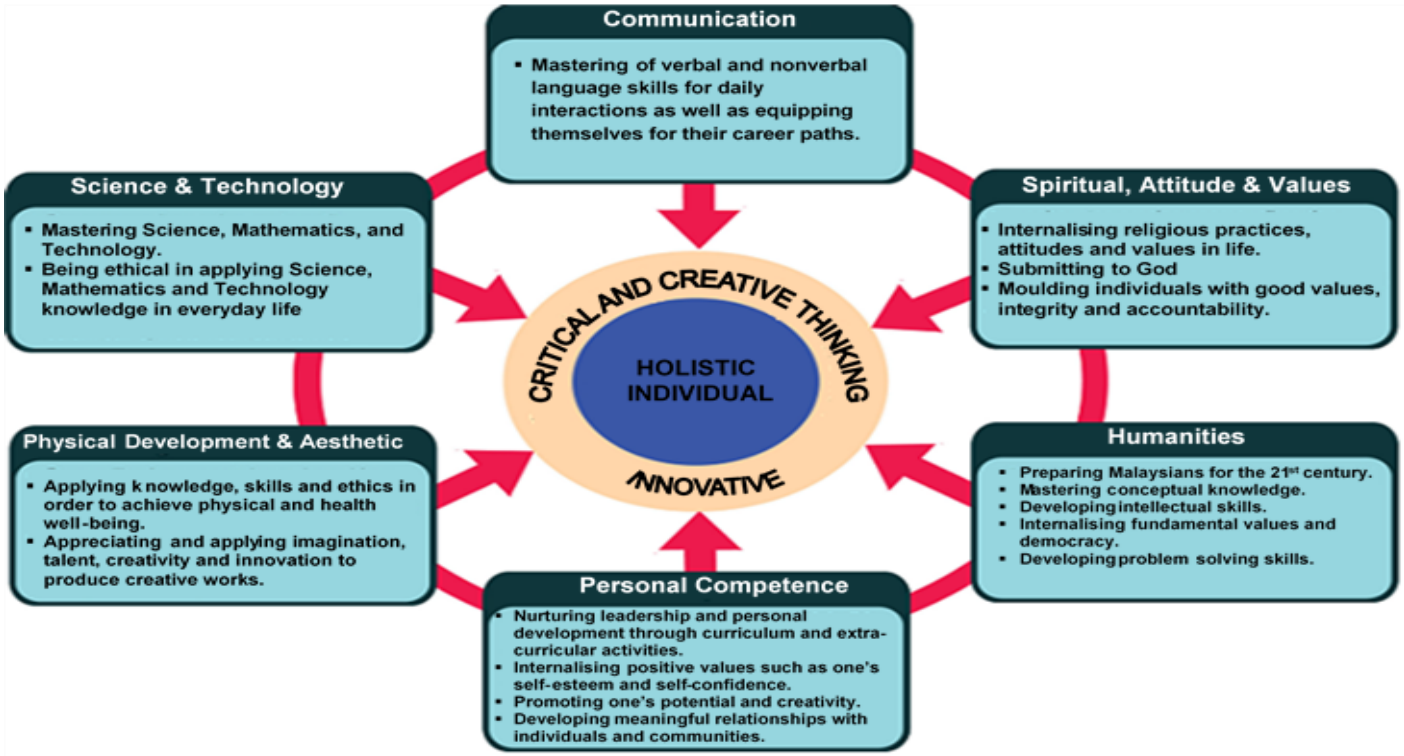

Figure 1: KSSM Framework

FOCUS

KSSM Biology focuses on thoughtful learning based on the three domains, which are knowledge, skills and values. The development of these domains will be experienced by pupils through inquiry method in order to nurture thoughtful science individual (Figure 2). The inquiry approach includes pupil-centred learning, constructivism, contextual learning, problem-based learning, mastery learning as well as related strategies and methods.

The curriculum also aims to prepare pupils to face rapid technological development and various challenges of the 21st century like The Industrial Revolution 4.0. The group of pupils that have gone through this curriculum will be the STEM human resource who will be able to contribute towards national development.

Thoughtful Science

According to Kamus Dewan (4th Edition), 'fikrah' or in English language 'thoughtful' means the ability to think and reflect. In the context of science curriculum, thoughtful science refers to the quality desired to be produced by the National Science Education System. Thoughtful science learners are those who can understand scientific ideas and are able to communicate in scientific language; can evaluate and apply scientific knowledge and skills in science and technology contextually, responsibly and ethically. Thoughtful science also intends to produce creative and critical individuals that can communicate and collaborate to face the challenges of the 21st century demands, in which the country's progress is highly dependent upon the capacity and quality of its human resources.

Thoughtful Learning

Thoughtful learning is a process of acquiring and mastering skills and knowledge which can develop pupils mind to optimum level.

Thoughtful science can be achieved through thoughtful learning when pupils are actively engaged in the teaching and learning processes (T&L). In this process, the thoughtful learning activities designed by teachers are to dig the pupils' minds and encourage them to think, to conceptualize, solve problems and make wise decisions. Hence, thinking skills should be practised and cultured among pupils.

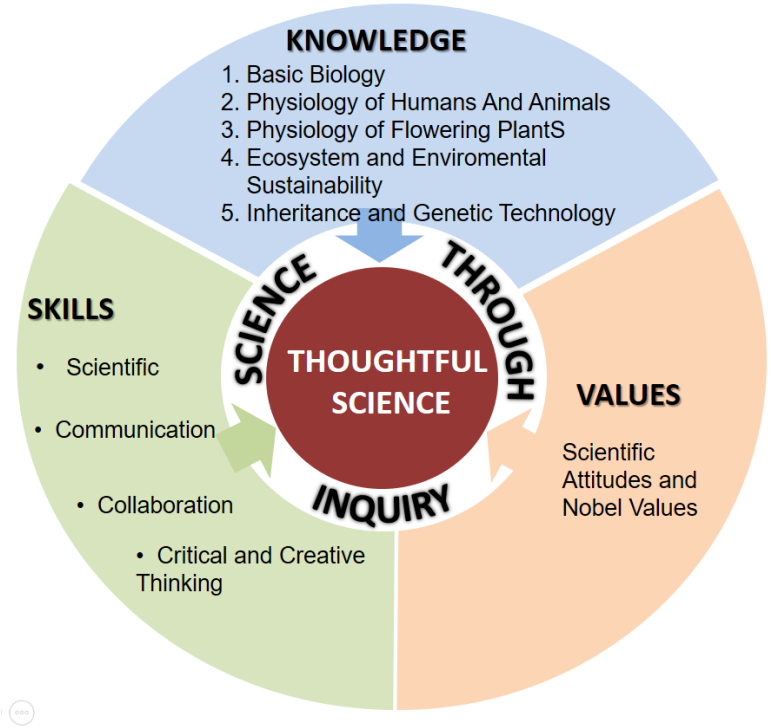

Figure 2: The Conceptual Framework for Biology Curriculum

Critical Thinking Skills

Critical thinking skills is the ability to evaluate an idea in a logical and rational manner to make reasonable judgement with justifications and reliable evidences.

A brief description of each critical thinking skills is as in Table 1:

Table 1: Critical Thinking Skills

CRITICAL THINKING SKILLS	DESCRIPTION
Attributing	Identifying characteristics, features, qualities and elements of a concept or an object.
Comparing and Contrasting	Finding similarities and differences based on criteria such as characteristics, features, qualities and elements of objects or events.
Grouping and Classifying	Separating and grouping objects or phenomena into groups based on certain criteria such as common characteristics or features.

CRITICAL THINKING SKILLS	DESCRIPTION
Sequencing	Arranging objects and information in order based on the quality or quantity of common characteristics or features such as size, time, shape or number.
Prioritising	Arranging objects or information in order based on their importance or urgency.
Analysing	Processing information by breaking it down into smaller parts in order to deeply and thoroughly understand them in details and their interrelationship.
Detecting Bias	Identify/ Investigate views or opinions that have the tendency to support or oppose something.
Evaluating	Assessing considerations and decisions using knowledge, experiences, skills, values and giving justification.
Making Conclusions	Making a statement about the outcomes of an investigation based on a hypothesis.

Creative Thinking Skills

Creative thinking skill is the ability to produce or create something new and valuable by using genuine imaginative skill and unconventional thinking. A brief description of each creative thinking skill is as in Table 2.

Table 2: Creative Thinking Skills

CREATIVE THINKING SKILLS	DESCRIPTION
Generating Ideas	Prompting thoughts or opinions related to something.
Relating	Making connections in certain situations or events to find relationship between a structure or pattern.
Making Inference	Making initial conclusion and explaining an event using data collection and past experiences.
Predicting	Forecasting an event based on observations and previous experiences or collected data.

CREATIVE THINKING SKILLS	DESCRIPTION
Making Generalisation	Making general statement about certain matter from a group of observations on samples or some information from that group.
Visualising	Forming perception or making mental images about a particular idea, concept, situation or vision.
Synthesising	Combining separate elements to produce an overall picture in the form of writing, drawing or artefact.
Developing Hypothesis	Making a general statement about the relationship between the manipulated variable and responding variable to explain an observation or event. This statement or conjecture can be tested to determine its validity.
Developing Analogy	Forming an understanding about a complex or abstract concept by relating it to simple or concrete concept with similar characteristics.
Inventing	Producing something new or modifying something which is already in existence to overcome problems in a systematic manner.

Thinking Strategy

Thinking strategy is structured and focused high-level thinking which involves critical and creative thinking and reasoning skills in every steps taken to achieve the intended goal or solution to a problem. Description of each thinking strategy is as in Table 3.

Table 3: Thinking Strategy

THINKING STRATEGY	DESCRIPTION
Conceptualising	Making generalisations towards building of meaning, concept or model based on inter-related specific common characteristics.

Making Decisions	Selecting the best solution from several alternatives based on specific criteria to achieve the intended aims.
Problem Solving	Finding the right solutions in a systematic manner for situations that are uncertain or challenging or unanticipated difficulties.

Table 3 shows an overall picture of the thinking skills and thinking strategies. Further information on thinking skills and thinking strategies(TSTS) can be found in Buku Panduan Penerapan Kemahiran Berfikir dan Strategi Berfikir dalam Pengajaran dan Pembelajaran Sains (Curriculum Development Centre, 1999).

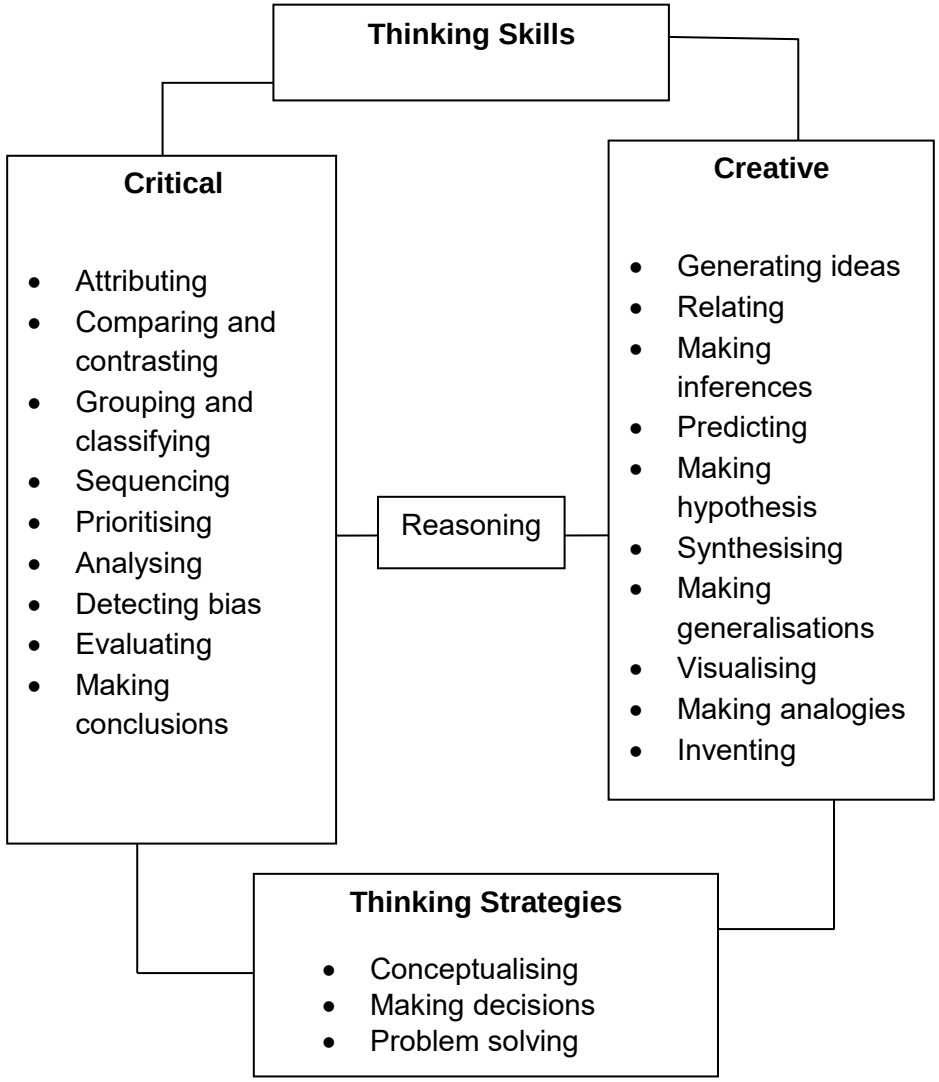

Figure 3: TSTS KSSM in KSSM Biology

Scientific Skill

KSSM Biology emphasizes on inquiry and problem solving. In the process of inquiry and solving problem, scientific skills and thinking skills are used. Scientific skills are important skills used during scientific activities such as conducting experiments and projects.

Scientific skills consist of science process skills and manipulative skills.

Science Process Skills

Science Process Skills (SPS) are skills required in the process of finding solutions to a problem or making decisions in a systematic manner. SPS are mental processes which promote critical, creative, analytical and systematic thinking. Mastery of SPS together with attitude and appropriate knowledge to guarantee the ability of pupils to think effectively. Thus, good command of SPS with positive attitude and sound knowledge will ensure effective thinking among pupils. Table 4 describes each of the SPS.

Table 4: Science Process Skills

SCIENCE PROCESS SKILLS	DESCRIPTION
Observing	Using the senses of sight, hearing, touch, taste or smell to gather information about objects and phenomena.
Classifying	Using observations to group objects or phenomena according to similarities and differences.
Measuring and Using Numbers	Making quantitative observations using numbers and tools with standard units to ensure an accurate measurement.
Inferring	Using collected data or past experiences to draw conclusions and make explanations of events.
Predicting	Making forecast about future events based on observations and previous experiences or collected data.

SCIENCE PROCESS SKILLS	DESCRIPTIONS
Communicating	Using words or graphic symbols such as tables, graphs, diagrams or models to explain actions, objects or events.
Using Space-Time Relationship	Describing changes in parameter such as location, direction, shape, size, volume, weight or mass with time.
Interpreting Data	Giving rational explanations about an object, event or pattern derived from collected data.
Defining Operationally	Giving meaning to a concept by describing what must be done and what should be observed.
Controlling Variables	Managing manipulated variable, responding variable and fixed variable. In a scientific investigation, the manipulated variable is changed to observe its relationship with the responding variable. At the same time, the other variables are kept the same.
	Making a general statement about the

SCIENCE PROCESS SKILLS	DESCRIPTIONS
Hypothesising	relationship between the manipulated and responding variable to explain an observation or event. This statement or conjecture can be tested to determine its validity.
Experimenting	Planning and conducting an investigation under controlled conditions to test a hypothesis, collecting and interpreting data until a conclusion can be obtained.

<u>Manipulative Skills</u>

Manipulative skills are psychomotor skills that enable pupils to carry out practical works in science. It involves the development of hand-eye coordination. These manipulative skills are:

- Use and handle science apparatus and substances correctly.
- Handle specimens correctly and carefully.
- Draw specimens, apparatus and substances accurately.
- Clean science apparatus correctly.
- Store science apparatus and substances correctly and safely.

Relationship between Science Process Skills and Thinking Skills

Accomplishment in Science Process Skills require pupils to master the related thinking skills. Table 5 shows these relationships.

Table 5: Relationship between Science Process Skills and Thinking Skills

SCIENCE PROCESS SKILLS	DESCRIPTION
Observing	Attributing Comparing and contrasting Relating
Classifying	Attributing Comparing and contrasting Grouping and classifying
Measuring and Using Numbers	Relating Comparing and contrasting
Making Inferences	Relating Comparing and contrasting Analysing
	Making Inferences
Predicting	Relating Visualising
Using Space - Time Relationship	Sequencing Prioritising
Interpreting data	Comparing and contrasting Analysing Detecting bias Making conclusion Making Generalisation Evaluating
Defining operationally	Relating Developing analogy Visualising Analysing

SCIENCE PROCESS SKILLS	DESCRIPTION
Controlling variables	Attributing Comparing and contrasting Relating Analysing
Hypothesising	Attributing Relating Comparing and contrasting Generating ideas Developing hypothesis Predicting Synthesising
Experimenting	All thinking skills
Communication	All thinking skills

Teaching and Learning based on Thinking Skills and Scientific Skills

KSSM Biology emphasizes thoughtful learning based on thinking skills and scientific skills. In this curriculum, the intended Learning Standard (LS) is written by integrating the aspired knowledge and skills for pupils to acquire and master. Teachers should emphasize on the acquisition and proficiency of pupils' knowledge and skills along with attitudes and scientific values in T&L.

The embedding of SPS in KSSM Biology has somewhat fulfills the aspirations of 21st century education and indirectly encourages and uplifts the development of pupils' high order thinking skills.

Science Process Skills Standard

The Science Process Skills Standard is a general recommended and specific accomplishment which must be met by pupils in each level of schooling. Each statement refers to the minimum standard of pupils' achievement based on schooling levels and cognitive development.

The science process skills at level 1 and 2 stated in the Learning Standard which must mastered as a basis for further study at the secondary level as shown in Table 6.

Table 6: Science Process Skills Standard

NO	SCIENCE PROCESS SKILLS	Level 1 (Year 1-3)	Level 2 (Year 4 – 6)	Level 3 (Form 1 – 3)	Level 4 (Form 4 – 5)
1	**Observing**	• Use sensory organs involved to make observation about phenomena or changes that occur.	• Use sensory organs to make observation qualitatively and quantitatively with appropriate tools to describe the phenomena or changes that occur.	• Make relevant and precise observation qualitatively and quantitatively to identify trends or sequences on objects or phenomena. • Use correct tools skillfully to make observations.	• Make observation qualitatively and quantitatively to make generalization based on trends or sequences. • Present advance findings analytically.

NO	SCIENCE PROCESS SKILLS	Level 1 (Year 1-3)	Level 2 (Year 4 – 6)	Level 3 (Form 1 – 3)	Level 4 (Form 4 – 5)
2	**Classifying**	• Collect/segregate evidences/data/objects /phenomena based on observed characteristics.	• Compare/identify the similarities and differences based on given categories based on common characteristics.	• Compare/identify the similarities and differences to determine the criteria of category for evidence/ data/ objects/ studied phenomena	• To identify characteristics used to segregate, choose and explain in detail about objects or the phenomena studied.
3	**Measuring and Using Numbers**	• Measure using correct tools and standard units.	• Measure using correct techniques, tools with standard units.	• Measure using correct techniques and tools with standard units and record systematically and completely. • Convert basic quantity units correctly. • Use correct derived units.	• Show ways to measure using tools and standard units with correct techniques and record in tables systematically and completely. • Use complex derived units correctly.
4	**Inferring**	• State a reasonable explanation for an observation.	• Make reasonable pre-assumption for an observation using the information given.	• Make more than one reasonable early conclusions for an incident or an	• Generate multiple possibilities to explain a complex situation. • Explain the relation and

NO	SCIENCE PROCESS SKILLS	Level 1 (Year 1-3)	Level 2 (Year 4 – 6)	Level 3 (Form 1 – 3)	Level 4 (Form 4 – 5)
				observation using information given.	trends between observed variables with measurements used in investigation.
5	**Predicting**	• Describe a possibility for an incident or data.	• Make a reasonable prediction about an incident based on observations, past experiences or data.	• Perform simple development or trend analysis based on obtained data to predict the future of an object or phenomena.	• Perform simple development or trend analysis based on obtained data to predict the future of an object or phenomena. • Test the prediction made.
6	**Communicating**	• Record ideas or information in any form.	• Record and present ideas and information systematically in suitable form.	• Present experimental findings and observation data in various form such as simple graphics, pictures or tables.	• Present experimental findings and observation data in various complex form using graphics, pictures or tables to show the relationship between the associated patterns.

NO	SCIENCE PROCESS SKILLS	Level 1 (Year 1-3)	Level 2 (Year 4 – 6)	Level 3 (Form 1 – 3)	Level 4 (Form 4 – 5)
7	**Using Space Time Relationship**	(Not stated explicitly in the Learning Standard)	• Arrange a phenomenon or incident chronologically.	• Arrange a phenomenon or incident chronologically. • Interpret and explain the meaning of mathematical relations.	• Use, analyse and interpret numbers and numerical relationship efficiently when solving problems and conducting investigations.
8	**Interpreting Data**		• Choose relevant ideas about objects, incidents or patterns in data to come up with an explanation.	• Give rational explanations by interpolating and extrapolating the collected data.	• Analyse data and suggest ways to improve. • Detect and explain anomaly in collected sets of data.
9	**Defining Operationally**		• Describes an interpretation by stating what is being done and observed in a specific aspects of a situation.	• Describes the most appropriate interpretation of a concept by stating what is being done and observed in a situation.	• Describe the interpretation made about the selection of tools or methods of what is being observed.

NO	SCIENCE PROCESS SKILLS	Level 1 (Year 1-3)	Level 2 (Year 4 – 6)	Level 3 (Form 1 – 3)	Level 4 (Form 4 – 5)
10	**Controlling Variables**	(Not stated explicitly in the Learning Standard)	• Determine the responding and constant variables after the manipulated variable is determined in an investigation.	• Determine all types of variable, which are responding variables, manipulated variables and fixed variables.	• Change the fixed variable to the manipulated variable and state the new responding variable.
11	**Hypothesising**		• Make a general statement that can be tested about the relationship between the variables in an investigation.	• Make a relationship between the manipulated variable and the responding variable to build a hypothesis which can be tested.	• Explain an expected result from the designed scientific investigation.
12	**Experimenting**		• Carry out experiment, collect data, interpret data and make conclusions to test the hypothesis and write report.	• Carry out experiment, build hypothesis, design methods and determine appropriate apparatus, collect data, analyse, summarise and write report.	• Trigger new question and plan an experiment to test new hypothesis from the question.

Scientific Attitudes and Noble Values

Science learning experiences can inculcate scientific attitudes and noble values in pupils. These attitudes and values are instilled through the following:

1. Interest and curious about the environment.
   - Seek information from teachers, friends or other people.
   - Do own reading.
   - Collect materials or specimens for research purposes.
   - Carry out own research.

2. Honest and accurate in recording and validating data.
   - Describe and record real observations.
   - Record information objectively (not affected by feelings of illusions).
   - Explain information rationally.
   - Cite the sources of used information.

3. Flexible and open-minded.
   - Accept others' opinions.
   - Agree tp cogent evidence.
   - Be open-mided.

4. Diligent and persistent when carrying out a task.
   - Preservere and determined.
   - Ready to repeat experiments.
   - Do the task wholeheartedly.
   - Ready to accept critics and challanges.
   - Strive to overcome problems and challenges.

5. Systematic, confident and ethical.
   - Conduct activities orderly and timely.
   - Arrange tools and materials in order.
   - Optimistic about the task.
   - Brave and ready to venture something new.
   - Dare to defend something done.

6. Collaborate.
   - Help friends and teachers.
   - Carry out activities and experiments together.
   - Selflessness.
   - Fair and equitable.

7. Be responsible for the safety of oneself, others, and the environment.
    - Take care of oneself and friends' safety.
    - Preserve and conserve the environment.

8. Compasionate.
    - Love all living things.
    - Be prudent and respectful.

9. Appreciate the contributions of science and technology.
    - Use the creation of science and technology wisely.
    - Utilise public facilities created by science and technology responsibly.

10. Thankful to God.
    - Always be satisfied with the gift of God.
    - Use the gift of God wisely.
    - Be thankful to God.

11. Appreciate and practise clean and healthy living.
    - Maintain cleanliness and good health.
    - Always be conscious of personal hygiene and clean environment.

12. Realise that science as a means to understand nature.
    - Express how science is used to solve problems.
    - State the implications of using science to solve a problem or issue.
    - Communicate through correct scientific language.

The inculcation of scientific attitudes and noble values generally occurs through the following stages:

- Aware and understand the importance and the need of scientific attitudes and noble values.
- Focus on these attitudes and noble values.
- Internalise and practise these scientific attitudes and noble values.

Sound lesson plan is required for effective inculcation of scientific attitudes and noble values during teaching and learning. Thus, before planning each lesson, teachers should examine the Learning Standard, including Performance Standard fto foster scientific attitudes and noble values in the lesson.

21st CENTURY SKILLS

One of the aspirations in KSSM is to develop pupils with 21st century skills, while focusing on thinking skills as well as life and career skills strongly rooted in noble values and practices. 21st century skills aim to prepare pupils with the characteristics specified in Table 7: Pupils' Profile. These features enable them to compete globally. Achieving CS and LS in KSSM Biology contributes to the acquisition of 21st century skills among pupils.

Table 7: Pupils' Profile

PUPIL'S PROFILE	DESCRIPTION
Resilient	Able to face and overcome difficulties and challenges with wisdom, confidence, tolerance and empathy.
Communicator	Able to voice out and express their thoughts, ideas and information confidently and creatively in verbal and written, using multi-media and technology.
Thinker	Able to think critically, creatively and innovatively; solve complex problems and make ethical decisions. Think about learning and about being learners themselves. Generate questions and are receptive towards perspective, values and individual traditions and society. Confident and creative in handling new learning areas.
Team Player	Cooperate effectively and harmoniously with others. Share collective responsibility while respecting and appreciating the contributions of each member in the team. Acquire interpersonal skills through collaborative activities, which in turn mould pupils into better leaders and team members.
Curious	Develop natural curiosity to explore strategies and new ideas. Learn skills that are needed to carry out inquiry and research, as well as display independent learning traits. Enjoy

PUPIL'S PROFILE	DESCRIPTION
	continuous life-long learning experiences.
Principled	Honest and have integrity, equity with just and respect for individuals, groups and community. Responsible for their actions, and as well as the consequences.
Informative	Knowledgeable, have wide, deep and balanced understanding across various disciplines. Explore and gain knowledge on local and global issues effectively and efficiently. Understand ethical issues/ laws related to the information gained.
Caring/ Concern	Show empathy, compassion and respect towards the needs and feelings of others. Committed to serve the society and ensure sustainability of the environments.
Patriotic	Portray love, support and respect towards the country.

HIGHER ORDER THINKING SKILLS

Higher Order Thinking Skills (HOTS) is explicitly stated in the curriculum to encourage teachers to incorporate them in teaching and learning, hence stimulating structured and focused thinking among pupils. Descriptions of the focused four levels of HOTS are shown in Table 8.

Table 8: Thinking Levels in HOTS

THINKING LEVEL	DESCRIPTION
Applying	Using knowledge, skills and values to take actions in different situations.
Analysing	Breaking down information into smaller parts to enhance understanding and make relationship between the parts.
Evaluating	Using knowledge, experience skills and values to consider, make decisions and give justifications.
Creating	Producing ideas, products or methods and innovatively.

HOTS are the ability to apply knowledge, skills and values in reasoning and reflecting to solve problems, make decisions, to innovate and create something. HOTS include critical thinking, creative thinking, reasoning and thinking strategy.

Critical thinking skill is the ability to evaluate an idea in a logical and rational manner to make a reasonable judgement with justifications and reliable evidences.

Creative thinking skill is the ability to produce or create something new and valuable by using genuine imaginative skill and unconventional thinking.

Reasoning skill is the ability of an individual to consider and evaluate logically and rationally.

Thinking strategy is a way of thinking that is structured and focused to solve problems.

HOTS can be applied in classrooms through activities in the form of reasoning, inquiry learning, problem solving and projects. Teachers and pupils need to use thinking tools such as thinking maps and mind maps, including high level questioning to stimulate thinking processes among pupils.

TEACHING AND LEARNING STRATEGIES

Teaching and learning strategies in KSSM Biology emphasise on thoughtful learning. Thoughtful learning is a process that helps pupils acquire knowledge and master skills which assist them to develop their minds to optimum level. Thoughtful learning can take place through various learning approaches such as inquiry, constructivism, science, technology and society, contextual learning and mastery learning space. Learning activities should therefore be geared towards activating pupils' critical and creative thinking skills and not be confined to routine methods. Pupils should be made explicitly aware of the thinking skills and thinking strategies which are employed in their learning.

More higher order questions and problems posed to pupils encourages them to enhance their critical and creative thinking skills. Pupils actively involved in the teaching and learning where the acquisition of knowledge, mastery of skills and inculcation of scientific attitudes and noble values are integrated.

The learning approaches that can be applied by teachers in the classroom are as follows:

Inquiry Approach

Inquiry approach emphasises learning through experiences. Inquiry generally means to find information, to question and to investigate a phenomenon. Discovery is the main characteristic of inquiry. Learning through discovery occurs when the main concepts and principles of science are investigated and discovered by pupils themselves. Through activities such as experiments, pupils investigate a phenomenon and draw conclusions by themselves. Teachers then lead pupils to understand the science concepts through the results of the inquiry. Thinking skills and scientific skills are thus developed further during the inquiry process. However, the inquiry approach may not be suitable for all teaching and learning situations. Sometimes, it may be more appropriate for teachers to present concepts and principles directly or through guided inquiry.

Constructivism

Constructivism is a learning theory which suggests that learners construct their own knowledge and understanding of the world through experiences and reflecting on those experiences. The important elements of constructivisme are:

- Teachers have to consider pupils' prior knowledge.
- Learning is the result from pupils' own effort.
- Learning occurs when pupils restructure their ideas through relating original ideas to new ones.
- Pupils have the opportunities to cooperate, share ideas and experiences and reflect on their learning.

Contextual Learning

Contextual learning is a method of instruction that enables pupils to apply new knowledge and skills to real-life situations. In this context pupils do not just obtain knowledge theoretically, but allowing pupils to make connections and make relevance of science learning with their lives. A contextual approach is used when pupils learn through investigation similar to inquiry approach.

Mastery Learning

Mastery learning ensures all pupils acquire and master the intended learning objectives. This approach is based on the principle that pupils are able to learn if given the opportunities. Pupils should be allowed to learn at their own pace, with the incorporation of remedial and enrichment activities as part of the teaching-learning process.

Problem/ Project Based Learning

Problem/ project based learning (PBL) is a student-centered pedagogy where pupils learn through prompting solving issues/ problems. The issues or problems are provided by teachers. Teachers can provide issues, problems or projects from various sources such as newspapers, magazines, journals, books, textbooks, and cartoons, videos, television, films and others to suit the teaching and learning.

Real world and relevant problem or project is used as a platform to encourage pupils to the intended the concepts and principles. PBL promotes the development of critical thinking skills, problem solving abilities, and communication skills.

PBL provides students the opportunity to work in a team, collaborate on inquiring and evaluating research materials, analysing data, justifying and making decision, and nurturing life-long learning among pupils.

For effective PBL, the provided issue of problem should;

- encourage pupils to understand the concept clearly an deeply.
- Require pupils to justify and support their decisions.
- meet the intended and previous related content/ learning standards.
- Be suitable to the capabilities of the pupils to ensure they can work together to complete the task.
- Be open and captivating enough to motivate and enhance pupils' interest.

STEM APPROACH

STEM approach is the teaching and learning (T&L) method which applies integrated knowledge, skills and values of STEM through inquiry, problem solving or project in the context of daily life, environmentand, as well as local and global community, as shown in Diagram 4.

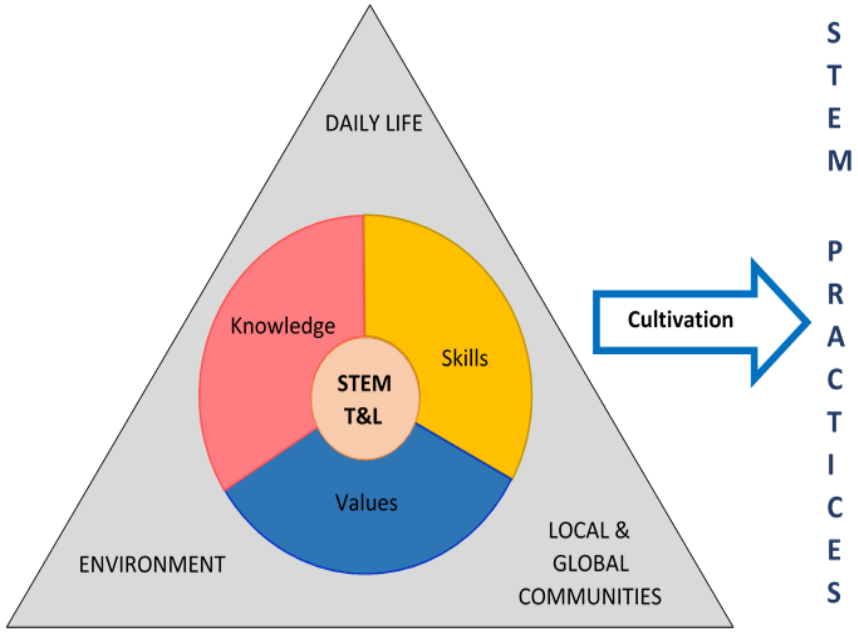

Diagram 4: STEM Teaching and Learning Approach

STEM T&L which is contextual and authentic can encourage in depth learning amongst pupils. Pupils can work in groups or individually based on the nature of the T&L activities. The STEM practices that are encouraged during STEM T&L are as follows:

1. Questioning and identifying problems,
2. Developing and using models,
3. Planning and carrying out investigations,
4. Analyzing and interpreting data,
5. Using mathematical thinking and computational thinking,
6. Developing explanations and designing solutions,
7. Engaging in debates and discussion based on evidence, and
8. Acquiring information, evaluating and communicating about the information.

Computational thinking is a cognitive process involved in formulating problems and solutions which can be represented in a form that can be effectively executed by humans and/ or computers. Computational thinking helps pupils to solve complex problems easily through organizing, analysing and presenting data or ideas in a logical and systematic way.

Varied T&L activties can elevate pupils' interest towards science. Interesting science lessons will motivate pupils to study which will then show favourable influence on their performance. The T&L activities should correspond to the intended curriculum content, pupils' ability and multiple intelligences, as well as resources and facilities available.

Some T&L activities encouraged in science are as follows:

Scientific Investigation/ Experiment

A scientific investigation/ experiment is commonly used in science lessons. The hypothesis is tested by pupils through an investigation to discover certain scientific concepts of principle. Carrying out scientific investigation/ experiment encourages pupils to cultivate thnking skills, science process skills and manipulative skills.

In general, the procedures to conduct a scientific investigation/ experiment are shown in Diagram 5.

With the introduction of KSSM Biology, pupils are given the opportunity to design scientific investigation/ experiments beside the usual teacher-guided scientific investigations/ experiments. Pupils are expected to plan and design the experiment, collect and analyse data, interpret and display results, and finally share and present their report and findings.

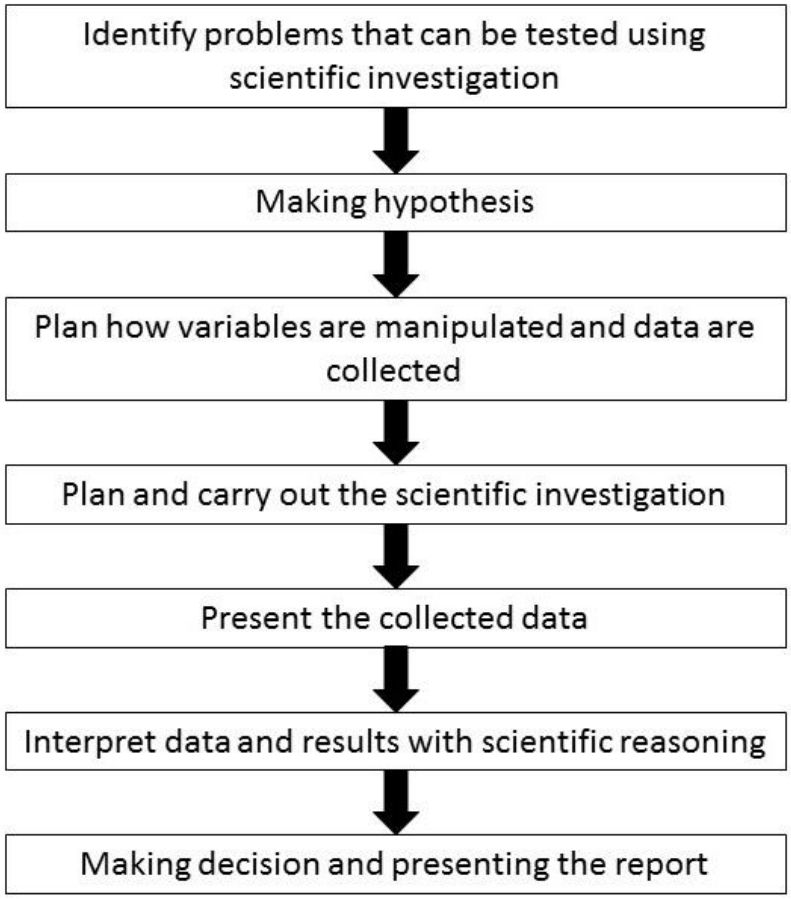

Diagram 5: Steps to carry out anscientific investigation/ experiment

Simulation

Simulation is an activity that imitates the real situation. Simulations can be carried out through role-play, games or using model. In role-playing, pupil act out a particular role spontaneously based on a certain pre-determined conditions. Whereas in gaming, pupils is required to follow procedures. Pupil plays games in order to learn a particular principle or to understand the process of decision making. While in modelling, an object/ replica is used to represent the real thing/ process. Pupils will be able to visualise the actual situation, thus understand the concepts and principles to be learned.

Project

Activities carried out by individuals or groups of students to achieve certain goals. Project takes a long time and usually reach out with the formal learning time. Pupils' reports, artifacts or other forms of project outcomes need to be presented to teachers and fellow pupils. Project work promotes problem solving skills, time management skills and self-study.

Visits and Use of External Resources

Science learning is not limited to schools only. Science learning can take place at the zoos, museums, science centers, research institutes, mangrove swamps and factories too. Visits to such places can make learning more effective, fun and meaningful. Learning through visits can be impacted by careful planning. To optimise learning, students must carry out activities or perform assignments during the visit and held discussion after the visit.

The Use of Technology

Technology is a highly effective and powerful tool to increase interest in science learning. Through the use of technologies such as television, radio, video, computers and the internet, science T&L can be more exciting and effective. Animation and computer simulation can be used as an effective tool to learn difficult and abstract science concepts. Computer simulations and animation can also be displayed in the form of coursewareor through website. Software applications such as word processors, graphic presentation software and electronic spreadsheets are valuable tools that can be employed to analyse and present data.

The use of other technologies such as data loggers and computerized user interface in experiments and projects can be of effective assistants in science teaching and learning.

Good management of activities and two-ways interactions between teacher-pupils and pupils-pupils during T&L further liberate their thinking skills to a higher level.

ELEMENTS ACROSS THE CURRICULUM

Elements Across Curriculum is a set of value-added elements applied in the teaching and learning process other than those specified in the standard content. The application of these elements is aimed at strengthening the human capital skills and competency besides preparing pupils for the challenges of the present and the future. The elements are explained below:

1. Language

- Using correct instruction language in all subjects.
- Emphasising promunication correct sentences structure, grammar and terminologies in T&L in order to assist pupils to communicate effectively and organise their thoughts clearly and systematically.

2. Environmental Sustainability Awareness

- Developing awareness, nurturing the love and care for the environment through teaching and learning.
- Promoting knowledge and awareness on the importance of the environmental ethics and sustainability for pupils to appriciate.

3. Noble Values

- Instilling noble values in all subjects to ensure that pupils are aware of their importance and gradually practice them.
- Practising noble values which encompass the aspects of spirituality, humanity and citizenship in relation to pupils' daily life.

4. Science and Technology

- Raising the pupils' interest in the science and technology to improve scientific and technological literacy.
- Using technology in teaching and learning can contribute and assist efficient and effective learning.
- Integration of science and technology in the teaching and learning enhances knowledge, skills and values in all subjects for examples:

(i) knowledge of science and technology principles, concepts and facts related to science and technology;
(ii) Process skills (process of thought and specific manipulative skills);
(iii) Scientific attitudes and values
(iv) Technological knowledge and skills.

5. Patriotism

- Nurturing patriotism in all subjects, extracurricular activities and community services,
- Developing the spirit of love for the country as well as encouraging the feelings of 'truly proud to be Malaysians' amongst pupils.

6. Creativity and Innovation

- Giving time and opportunity in all subjects for pupils to be creative and innovative through extracting and generating or creating new/ original ideas.
- Exploiting and fostering pupils' creativity and innovativeness to see and realise their full potential.
- Integrating elements of creativity and innovation in teaching and learning to ensure human capital meet the challenges of 21st Century.

7. Entrepreneurship

- Incorporating the characteristics and practices of enterpreneurship, gradually shaping a culture amongst pupils,
- Fostering entrepreneured characteristics through activities which promote diligence, honesty, trustworthiness and responsibility as well as developing creative and innovative mindset to drive ideas into the economy.

8. Information and Communication Technology (ICT)

- Incorperating information and communication technology (ICT) in the lessons to ensure pupils have the ability to apply and strengthen their basic knowledge and skills in ICT,
- Uitilizing ICT to motivate pupils to be creative, stimulates interesting and fun T&L and improve the quality of learning,
- Integrating ICT in teaching appropriate topics to further enhance pupils' understanding of the content subject.

9. Global Sustainability

- Discussing Global Sustainability directly or indirectly in related subjects, prompt and develop sustainable thinking (responsive towards the environment, being responsible, creative and resourceful) with the concept of living within global resources without damaging its present or future environment,
- Educating global sustainability prepares pupils to face challenges on complex interconnected global issues.

10. Financial Education

- Incorporating Financial Education to build future generations who are financial literate, capable of making wise financial decisions and practise ethical financial management and skills.
- Exploring financial management and skills directly or indirectly in T&L through topics related to finance e.g simple and compound interest, foreign exchange, budgeting credit-debit, saving and financial safety.
- Simulating financial management activities to prepare pupils with knowledge, skills and values which are relevant and useful to their living.

CLASSROOM ASSESSMENT

Classroom Assessment is the process of obtaining information on student development planned, implemented and reported by the teacher concerned. This process is ongoing to enable teachers to determine the Student Mastery Level.

Classroom Assessment can be implemented by teachers formatively and summatively. Assessment is formatively implemented at the same time with the T&L process, while summative assessments are implemented at the end of a learning unit, term, semester or year. Teachers should plan, construct valuation items or instruments, administer, examine, record and report levels of mastery based on DSKP.

In order to ensure that assessments help to improve the ability and mastery of the pupils, the teacher should implement the assessments that have the following characteristics:

- Use various assessment methods such as observation, oral and writing.
- Use various assessment strategies that can be implemented by teachers and pupils.
- Take into consideration the various levels of knowledge and skills learned.
- Allow pupils to show various learning capabilities.
- Assess the pupil's mastery level on Learning Standard and Performance Standards.
- Follow up actions for recovery and consolidation purposes.

Performance Standard of KSSM Biology

Classroom Assessment for KSSM Biology is evaluated from three main domains which are knowledge, skills and affective domains (for nobles' values).

Knowledge and science process skills integrated in learning area are assessed based on the stated Performance Standards (PS). PS aims to gauge the achievement of students mastering the specific knowledge, skills and values. Assessment of scientific skills can be carried out continuously, periodically or in clusters throughout the year. Therefore, it is important for teachers to use professional judgment in determining the pupils' performance levels. There are 6 performance levels with their general descriptors shown in Table 9.

Table 9: General Descriptors of Performance Level in Science subjects for KSSM Biology

PERFORMANCE LEVEL	DESCRIPTORS
1	Recall knowledge and basic skills of science.
2	Understand the knowledge and skills of science and explain the understanding.
3	Apply knowledge and science skills to carry out simple tasks.
4	Analyze information about knowledge and science skills in the context of problem solving.
5	Evaluate to make judgement about the science knowledge and skills in context problem solving and decision-making to carrying out a task.
6	Invent by applying the knowledge and skills in context problem solving and decision-making or carrying out an assignment in a new situation creatively and innovatively, giving due consideration to the social values/ economy/ culture of the community.

Teachers can refer to **Appendix** to view the relationship between the key verbs of each Performance Level in Performance Standards and verbs in the Learning Standard with examples of student activity that can be implemented.

All the investigations/ experiments/ activities listed in each theme in Table 10 are **COMPULSORY**. Investigations/ experiments/ activities are conducted using inquiry approach.

Table 10: List of Investigations/ Experiment/ Activity in each Theme

THEME	EXPERIMENTS	
BASIC BIOLOGY	1.4.1	Design an experiment to solve a problem using scientific investigation methods
	2.1.1	Prepare slides of animal and plant cells.
	3.2.2	Conduct experiments to investigate the movement of substances across a selectively permeable membrane by using: (i) visking tubing (ii) simple osmometer
	3.3.4	Design an experiment to investigate the effects of different concentrations of solution on animal and plant cells.
	3.4.1	Conduct an experiment to determine the concentration of cell sap of a plant tissue.
	5.2.9	Design and conduct experiments to study the effects of temperature and pH on the activities of amylase and pepsin.

THEME	EXPERIMENTS	
	7.2.3	Conduct an experiment to investigate aerobic respiration.
	7.3.4	Conduct an experiment to investigate fermentation in yeast.
PHYSIOLOGY OF HUMANS AND ANIMALS	9.2.5	Conduct experiments to investigate digestions of starch, proteins and lipids in food samples.
	9.6.1	Conduct an experiment to investigate the energy values in food samples.
	9.6.2	Conduct an experiment to determine the contents of vitamin C in fruit juices or vegetables.
	13.2.5	Conduct an experiment to investigate the effects of the different volume intake of water on urine formation.
PHYSIOLOGY OF FLOWERING PLANTS	16.2.3	Conduct an experiment to Identify zone of cell division, zone of cell elongation and zone of cell differentiation in a seed radicle.
	16.3.3	Conduct an experiment to study the growth curve of a plant.
	17.2.3	Conduct an experiment to compare stomatal distribution on upper and lower epidermis of monocotyledon and eudicotyledon leaves

THEME	EXPERIMENTS	
	17.3.3	Conduct experiments to study the effects of environmental factors on the rate of transpiration using a potometer.
	17.4.8	Conduct experiments to study effects of environmental factors on the rate of photosynthesis.
	19.4.3	Conduct experiments to study the effectiveness of phytoremediation plants in controlling: (i) water pollution. (ii) soil pollution.
	20.3.2	Conduct an experiment to compare the effects of presence of a phytohormone on fruit ripening.
ECOSYSTEM AND ENVIRONMENTAL SUSTAINABILITY	25.1.3	Conduct an experiment to compare the levels of Biochemical Oxygen Demand (BOD) in different water samples.
INHERITANCE AND GENETIC TECHNOLOGY	27.2.2	Conduct an experiment to study continuous and discontinuous variation in humans.

Reporting on scientific skills assessments is done twice a year. Table 11 can be used as guidance on making professional judgment for the reporting.

Table 11: General Statement for Scientific Skills Performance Level in KSSM Biology

PERFOMANCE LEVEL	DESCRIPTOR
1	• Poorly planned scientific investigation. • Inappropriate materials and apparatus used in the scientific investigation. • No data collected and recorded. • No or unclear explanation of the scientific investigation.
2	• Plan the correct strategy and procedure in the scientific investigation with guidance. • Use suitable material and apparatus. • Collect and record incomplete or irrelevant data. • Make an interpretation and conclusion not based on the collected data.
3	• Plan and carry out the correct strategy and procedure in the scientific investigation with guidance. • Use correct material and apparatus. • Collect and record relevant data. • Organize data in numerical or visual form with some error. • Make an interpretation and conclusion based on the collected data. • Write an incomplete scientific investigation report.
4	• Plan and carry out the correct strategy and procedure in the scientific investigation. • Handle and use the correct material and apparatus to get an accurate result. • Collect relevant data and record in a suitable format. • Organize the data in the numerical or visual form with no error. • Interpret the data and make an accurate conclusion based on the aim of the scientific investigation.

PERFOMANCE LEVEL	DESCRIPTOR
	• Write a complete report on the scientific investigation
5	• Carry out a scientific investigation and writing a complete report. • Collect, organize and present data in numerical or visual form well. • Interpret data and make conclusions accurately with scientific reasoning. • Identify the trend, pattern and relevant data.
6	• Justify the outcome of the scientific investigation relating to theory, principle and law of science in the reporting. • Evaluate and suggest ways to improve to the scientific investigation methods and further inquiry investigation if needed. • Discuss the validity of the data and suggest ways to improve the method of data collection.

Assessment of scientific attitudes and values can be implemented throughout the year. Table 12 can be used as guide for teachers in making a professional judgment.

Table 12: General Interpretation of the Performance Level in Scientific Attitudes and Values of KSSM Biology

PERFOMANCE LEVEL	DESCRIPTOR
1	• State how science is used to solve problems. • State the implication of using science to solve problems or certain issues. • Use science language to communicate. • Document the source of information used.
2	• State how science is used to solve problems. • State the implication of using science to solve problems or certain issues. • Use science language to communicate. • Document the source of information used.
3	• State how science is used to solve problems. • State the implication of using science to solve problems or certain issues. • Use limited science language to communicate. • Document a few sources of information used.

PERFOMANCE LEVEL	DESCRIPTOR
4	• Determine how science is used to solve problems or certain issues. • Determine the implication of using science to solve problems or certain issues. • Always use sufficient science language to communicate.
5	• Conclude how science is used to solve problems or certain issues. • Conclude the implication of using science to solve problems or certain issues. • Always use good science language to communicate. • Document all the sources of information used.
6	• Conclude how science is used to solve problems or certain issues. • Discuss and analyse the implication of using science to solve problems or certain issues.

PERFOMANCE LEVEL	DESCRIPTOR
	• Use science language consistently to communicate clearly and accurately. • Document all the sources of information used. • Become a role model to other pupil.

The Overall Performance Level

Overall Performance Level of KSSM Biology is to be determined at the end of each year. This Overall Performance Level includes aspects of knowledge, skills and values. Teachers need to assess pupils collectively and holistically by looking at all aspects of the learning process. Teachers' professional judgment should be employed in all assessment processes, particularly in determining the overall performance level. Professional judgments can be made based on knowledge and experience of teachers, teacher-pupil interactions, and discussions with committee members of relevant departments. Table 13 shows the overall performance level descriptors of KSSM Biology.

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Table 13: Overall Mastering Level KSSM Biology Statement

PERFOMANCE LEVEL	DESCRIPTOR
1 (Know)	Pupils have the basic knowledge of biology or can use the basic skills or give response towards basic knowledge in the field of Biology.
2 (Know and understand)	Pupils show understanding by explaining something learned in the form of communication in the field of Biology.
3 (Know, understand and do)	Pupils use knowledge to carry out skills on situation in the field of Biology.
4 (Know, understand and can do it with manners)	Pupils use knowledge and performing a civilised skill that is in accordance with the procedure or analytically and systematically in the field of Biology.
5 (Know, understand and can do it with good manners)	Pupils use knowledge and apply skills to new situation by following procedures or systematically and consistently and positively in the field of Biology.
6 (Know, understand and can do it with civilized manner)	Pupils are able to utilize existing knowledge and skills to be used in a new systematic, positive, creative and innovative situation in the production of new ideas and can be emulated in the field of Biology.

CONTENT ORGANISATION

Form 4 and Form 5 Biology KSSM consist of five themes: Fundamentals of Biology, Physiology Humans and Animals, Physiology Flowering Plants, Ecosystem and Nature Sustainability also Inheritance and Genetic Technology. Each theme is divided into several fields of learning as shown in Table 14.

Table 14:Theme and Field of Biology Form 4 and 5.

Theme	Learning Field	
	Form 4	Form 5
Fundamentals of Biology	1.0 Introduction to Biology and Laboratory Rules 2.0 Biology and Cell Organisation 3.0 Movement of Substances Across a Plasma Membrane 4.0 Chemical Composition in a Cell 5.0 Metabolism and Enzymes 6.0 Cell Division 7.0 Cellular Respiration	
Physiology of Humans and Animals	8.0 Respiratory System in Humans and Animals 9.0 Nutrition and Human Digestive System 10.0 Transport in Humans and Animals 11.0 Immunity in Humans 12.0 Coordination and Response in Humans 13.0 Homeostasis and Human Urinary System 14.0 Support and Movements in Humans and Animals 15.0 Sexual Reproduction, Development and Growth in Humans and Animals	
Physiology of Flowering Plants		16.0 Organisation of Plant Tissues and Growth 17.0 Leaf Structure and Function 18.0 Nutrition in Plants 19.0 Transport in Plants 20.0 Responses in Plants 21.0 Sexual Reproduction in Flowering Plants

		22.0 Adaptations of Plants in Different Habitats
Ecosystem and Environmental Sustainability		23.0 Biodiversity 24.0 Ecosystem 25.0 Environmental Sustainability
Inheritance and Genetic Technology		26.0 Inheritance 27.0 Variation 28.0 Genetic Technology

The recommended minimum teaching hours for KSSM Biology is 96 hours per year as stipulated in *Surat Pekeliling Ikhtisas Kementerian Pendidikan Malaysia Bilangan 9 Tahun 2016.*

The Learning Area in each theme describes the span of development, knowledge, skills and values through its Content Standard and Learning Standard. The Content Standard has one or more Learning Standards which collectively form a concept or idea based on the Learning Area.

T&L needs to be holistic and integrated in order to deliver the scientific concept or principle from a few Learning Standards to suit pupils' ability.

Teachers need to examine Content Standards, Learning Standards and Standard Performance during the intended T&L activities. Teachers need to prepare activities which would actively prompt pupils to exercise their analytical, critical, innovative and creative thinking.

The application of technology in activity, investigation or experimental-based T&L will promote and strengthen pupils' understanding.

KSSM Biology focuses on the mastery of knowledge, skills and values that are appropriate to the pupils' development. Each Learning Area contains Content Standard, Learning Standard and Standard Performance as described in Table 15.

The Remarks column gives additional information to the Content Standard and Learning Standard. It also includes suggestions on activities to be performed and/ or notes related to Learning Standard and sometimes limitations to the Learning Standard.

Table 15: Interpretation of Content Standards, Learning Standards and Performance Standards

CONTENT STANDARDS	LEARNING STANDARDS	PERFORMANCE STANDARDS
Specific statements about what pupils should know and can do during the schooling period encompassing the knowledge, skills and values.	A predetermined criteria or indicator of the quality in learning and achievement that can be measured for each content standard.	A set of general criteria which reflects the levels of pupils' achievement that they should show as a sign that a certain topic has been mastered by pupils.

In providing learning environments and activities which are suitable and relevant to the pupils' abilities and interests, teachers need to use their creativity and wisdom. The list of proposed activities is not absolute. Teachers are advised to use various resources such as books and the internet in providing T&L activities suitable to their pupils' ability and interest.

Content Standard,
Learning Standard
and Performance Standard
Form Four

THEME

FUNDAMENTALS OF BIOLOGY

LEARNING AREA

1.0 Introduction to Biology and Laboratory Rules

2.0 Cell Biology and Organisation

3.0 Movement of Substances across a Plasma Membrane

4.0 Chemical Composition in a Cell

5.0 Metabolism and Enzymes

6.0 Cell Division

7.0 Cellular Respiration

Theme 1: **FUNDAMENTALS OF BIOLOGY**

This theme aims to provide basic scientific understanding regarding biology through inquiry and scientific investigation. This theme includes knowing the branches and careers in field of biology. This theme also emphasises on cell as a basic unit of life, role of plasma membrane in cell physiology, chemical compositions in a cell, cell division and cellular respiration.

Learning Area

1.0 Introduction to Biology and Laboratory Rules
- 1.1 Fields and Careers in Biology
- 1.2 Safety and Rules in Biology Laboratory
- 1.3 Communicating in Biology
- 1.4 Scientific Investigation in Biology

2.0 Cell Biology and Organisation
- 2.1 Cell Structure and Function
- 2.2 Living Processes in Unicellular Organisms
- 2.3 Living Processes in Multicellular Organisms
- 2.4 Levels of Organisation in Multicellular Organisms

3.0 Movement of Substances Across a Plasma Membrane
- 3.1 Structure of Plasma Membrane
- 3.2 Concept of Movement of Substances Across a Plasma Membrane
- 3.3 Movement of Substances Across a Plasma Membrane in Living Organisms
- 3.4 Movement of Substances Across a Plasma Membrane and its Application in Daily Life.

4.0 Chemical Compositions in a Cell
- 4.1 Water
- 4.2 Carbohydrates
- 4.3 Proteins
- 4.4 Lipids
- 4.5 Nucleic Acids

1.0 INTRODUCTION TO BIOLOGY AND LABORATORY RULES

CONTENT STANDARD	LEARNING STANDARD	NOTE
1.1 Fields and Careers in Biology	Pupils are able to: 1.1.1 State the meaning of biology. 1.1.2 List the fields of study in biology, careers and development in related fields. 1.1.3 Generate ideas about development in biology fields and contribution of technology in biology to humanity. 1.1.4 Give examples of careers related to the fields of biology.	**Suggested activities:** Gather information and perform multimedia presentation/ poster about fields of study in biology (botany, ecology, etc) and development that is related to the latest fields of biology (biotechnology, nanobiotechnology, bioinformatics, etc.) Find information and design poster/ multimedia presentation/ exhibition related to the contributions of biologists and the development of technology in biology in daily life. Carry out role-playing activities about careers in the latest fields of biology.

CONTENT STANDARD	LEARNING STANDARD	NOTE
1.2 Safety and Rules in Biology Laboratory	Pupils are able to:	
	1.2.1 Explain self protective equipments and their functions.	**Note:** Emphasis is given to the functions of gloves, laboratory coats and shoes, eye wash, surgical masks, hand wash, fume chamber, lamina flow cabinet, biology safety cabinet, emergency sprinkler station and others.
	1.2.2 Identify and justify substances that can be disposed into the sink.	**Note:** The categories of substances that can be disposed into the sink are: (i) substances that have pH values between 5 and 9. (ii) liquids or solutions with low concentration and harmless.
	1.2.3 Identify and justify substances that cannot be disposed into the sink.	**Note:** Categories of substances that cannot be disposed into the sink are: (i) solid wastes (chemical substances, glass,rubber). (ii) substances that have pH values less than 5 and more than 9. (iii) organic solvents. (iv) chemical substances (acids, grease, oil, oil paint, hydrogen peroxide). (v) toxic substances. (vi) heavy metals. (vii) organic wastes (microorganisms, carcasses). (viii) radioactive wastes. (ix) volatile substances. (x) reactive substances.

CONTENT STANDARD	LEARNING STANDARD	NOTE
	1.2.4 Describe methods in managing biological wastes.	**Suggested activity:** Gather information and perform multimedia presentation about biological wastes and identify the Standard Operating Procedure to manage the waste substances.
	1.2.5 Communicate about steps to manage accidents in a laboratory.	**Note:** Emphasis is given to accidents involving the spillage of chemical substances and mercury*. **Suggested activity:** Find information on steps in managing laboratory accidents that have been set by agencies: (i) *Malaysian Biosafety and Biosecurity Association* (MBBA). (ii) *National Institute for Occupational Safety and Health* (NIOSH). Steps in managing spillage of chemical substances and mercury are as follows: (i) inform the teacher / laboratory assistant. (ii) make the spillage area as a prohibited area. (iii) stop the spillage of chemical substances from spreading using sand (sprinkle sulphur powder to cover mercury spillage*). (iv) scoop the chemical substance spillage. (v) dispose safely. * Contact the fire department for mercury spillage.

CONTENT STANDARD	LEARNING STANDARD	NOTE
	1.2.6 Conclude safety practices in a Biology laboratory.	**Note:** Discuss the safety in a biology laboratory regarding attire ethics, safety symbols, laboratory safety rules, emergency aids, fire related safety regulations, handling of glass items, chemical substances, living specimens and others. Discuss the importance of scientific attitudes and noble values when conducting scientific investigations scientifically.
1.3 Communicating in Biology	Pupils are able to: 1.3.1 Communicate by constructing tables based on experimental data.	**Note:** Titles in a table must consist of manipulated variable and responding variable with correct units. Example of a title in a table: Temperature/ °C or Temperature (ºC). Numerical values cannot be written as fractions.

CONTENT STANDARD	LEARNING STANDARD	NOTE
	1.3.2 Plot a suitable graph based on the data from an experiment.	**Note:** Responding variables are represented by the vertical axis (y-axis) and manipulated variables are represented by the horizontal axis (x-axis). Scales on the axes must be uniform. Mark reading on the graph with suitable symbols such as the points with suitable symbols such as 'x'. Methods of drawing line graph, bar charts and histograms need to be discussed. Title of a graph: "Graph of (responding variable) against (manipulated variable)".
	1.3.3 Sketch biological drawings based on observations.	**Note:** Pupils have prior knowledge about using a light microscope in Form 1. Characteristics of biological drawings: (i) large and accurate using a sharp pencil. (ii) not shaded artistically. (iii) lines drawn must be clear and not broken. (iv) with labels (straight label lines without crossing). (v) with titles. Plan drawings and detailed drawings need to be discussed.

CONTENT STANDARD	LEARNING STANDARD	NOTE
	1.3.4 Identify body planes, sections and directional terms in organisms.	**Note:** Body planes consist of frontal plane, sagittal plane and horizontal plane. Sections include cross/ transverse section and longitudinal section. Direction refers to anterior, posterior, superior, inferior, dorsal, ventral and lateral.
1.4 Scientific Investigation in Biology	Pupils are able to: 1.4.1 Design an experiment to solve a problem using scientific investigation methods.	**Note:** Acquiring biological knowledge scientifically through systematic investigation is emphasised. Emphasis is given to science process skills.

PERFORMANCE STANDARDS

INTRODUCTION TO BIOLOGY AND LABORATORY RULES

PERFORMANCE LEVEL	DESCRIPTOR
1	**Recall** the knowledge and basic scientific skills of biology and laboratory rules.
2	**Understand** and able to explain biology and laboratory rules.
3	**Apply** knowledge and skills about biology and laboratory rules to carry out simple task.
4	**Analyse** information about biology and laboratory rules and apply science skills in the context of **problem solving.**
5	**Evaluate** to make judgement about biology and laboratory rules and apply science skills in the context of **problem solving and decision making** to carry out a task.
6	**Create** using knowledge and scientific skills related to biology and laboratory rules in the context of **problem solving and decision making** or carrying out an assignment in a new situation creatively and innovatively giving due consideration to the social values/ economy/ culture of the community.

2.0 CELL BIOLOGY AND ORGANISATION

CONTENT STANDARD	LEARNING STANDARD	NOTE
2.1 Cell Structure and Function	Pupils are able to:	
	2.1.1 Prepare microscope slides of animal and plant cells.	**Note:** Pupils have prior knowledge about animal and plant cells in Form 1.
	2.1.2 Identify the structures of animal and plant cells based on observations through a light microscope.	**Suggested activity:** 1. Prepare slides of animal and plant cells. 2. Observe, draw and label diagrams of animal and plant cells: plasma membrane, cytoplasm, cell wall, vacuole and nucleus observed by using a light microscope. Animal cells: human cheek cells and chicken blood cells. Plant cells: onion epidermal cells, leaf cells of *Hydrilla* sp., epidermal cells of spider lily, etc.
	2.1.3 Analyse the components of animal and plant cells as seen on micrographs.	**Suggested activity:** Gather information and carry out a multimedia presentation about components in animal and plant cells as seen on micrographs. (i) cell wall. (ii) plasma membrane.

CONTENT STANDARD	LEARNING STANDARD	NOTE
	2.1.4 State the main functions of components of animal and plant cells as seen on micrographs.	(iii) cytoplasm. (iv) nucleus and nuclear membrane. (v) mitochondrion. (vi) rough endoplasmic reticulum. (vii) smooth endoplasmic reticulum. (viii) Golgi apparatus. (ix) lysosome. (x) ribosome. (xi) centrioles. (xii) chloroplast. (xiii) vacuole.
	2.1.5 Compare and contrast components of animal and plant cells.	**Suggested activity:** Construct a graphic organiser/ table to compare and contrast components in animal and plant cells.
2.2 Living Processes in Unicellular Organisms	Pupils are able to: 2.2.1 Conceptualise living processes in unicellular organisms such as *Amoeba* sp. and *Paramecium* sp..	**Note:** Living processes: respiration, nutrition, movement, reproduction, growth, excretion and response.
	2.2.2 Deduce living processes in unicellular organisms as seen through a light microscope.	**Suggested activity:** Gather and discuss information on living processes in *Amoeba* sp. and *Paramecium* sp. by using multimedia presentation. Conduct an experiment by using a light microscope to study the living processes in unicellular organisms.

CONTENT STANDARD	LEARNING STANDARD	NOTE
2.3 Living Processes in Multicellular Organisms	Pupils are able to:	
	2.3.1 Correlate the uniqueness of specialised cell structures with their functions in multicellular organisms.	**Note:** Specialised cells: epithelial cell, muscle cell, nerve cell, red blood cell, white blood cell, sperm cell, mesophyll cell, xylem vessel, sieve tube element, root hair cell and guard cell.
	2.3.2 Identify specialised cells in multicellular organisms.	**Suggested activity:** Observe prepared slides of animal and plant tissues through a light microscope. Gather information and carry out a multimedia presentation to explain the importance of cell specialisation in multicellular animals and plants.
	2.3.3 Analyse the density of certain organelles with the functions of specialised cells in multicellular organisms.	**Note:** The following examples are discussed: (i) density of mitochondrion with its function in sperm cells, muscle cells and meristematic cells. (ii) density of chloroplast with its function in palisade mesophyll cells and spongy mesophyll cells. (iii) density of rough endoplasmic reticulum and Golgi apparatus with their functions in pancreatic cells and goblet cells. (iv) density of smooth endoplasmic reticulum and Golgi apparatus with their functions in liver cells.

CONTENT STANDARD	LEARNING STANDARD	NOTE
	2.3.4 Describe the effects of deficiency, absence or failure in the function of an organelle of certain cells in multicellular organisms.	**Note:** Give examples of effects of deficiency, absence or failure in the function of organelles such as lysosome, mitochondrion, chloroplast and ribosome in certain cells. **Suggested activity:** Gather information related to deficiency, absence or failure in the function of an organelle in multicellular organisms such as: (i) Tay-Sachs disease. (ii) mitochondrial dysfunction.
2.4 Levels of Organisationin Multicellular Organisms	Pupils are able to: 2.4.1 Make a sequence of levels of organisation in multicellular organisms. 2.4.2 Identify cells, tissues or organs in an organ system. 2.4.3 Communicate about organ systems in multicellular organisms with their main functions.	**Note:** Pupils have prior knowledge about the levels of organisation in multicellular organisms in Form 1. Organ systems involved are respiratory system, digestive system, circulatory system, lymphatic system, nervous system, integumentary system, endocrine system, skeletal system, muscular system, urinary system and reproductive system.

PERFORMANCE STANDARDS

CELL BIOLOGY AND ORGANISATION

PERFORMANCE LEVEL	DESCRIPTOR
1	**Recall** the knowledge and basic scientific skills of cell biology and organisation.
2	**Understand** and able to explain cell biology and organisation.
3	**Apply** knowledge and skills about cell biology and organisation to carry out simple task.
4	**Analyse** information about cell biology and organisation and apply science skills in the context of **problem solving.**
5	**Evaluate** to make judgement about cell biology and organisation and apply science skills in the context of **problem solving and decision making** to carry out a task.
6	**Create** using knowledge and scientific skills related to cell biology and organisation in the context of **problem solving and decision making** or carrying out an assignment in a new situation creatively and innovatively giving due consideration to the social values/ economy/ culture of the community.

3.0 MOVEMENT OF SUBSTANCES ACROSS A PLASMA MEMBRANE

CONTENT STANDARD	LEARNING STANDARD	NOTE
3.1 Structure of Plasma Membrane	Pupils are able to: 3.1.1 Justify the necessity of movement of substances across a plasma membrane.	**Suggested activity:** Carry out group discussions and gather information about substances required by cells and waste products eliminated from cells.
	3.1.2 Describe the components of a plasma membrane and its function based on the fluid mosaic model.	**Note:** Emphasis is given to: (i) phospolipid bilayer. (ii) cholesterol. (iii) pore/ channel protein. (iv) carrier protein. (v) glycoprotein. (vi) glycolipid. **Suggested activity:** Research on history of development of plasma membrane models.
	3.1.3 Draw and label the components of a plasma membrane based on the fluid mosaic model.	**Suggested activity:** Draw a model of a plasma membrane with its related components.
	3.1.4 Describe the permeability of a plasma membrane.	**Note:** Discuss the characteristics and properties of the phospholipid bilayer.

CONTENT STANDARD	LEARNING STANDARD	NOTE
3.2 Concept of Movement of Substances Across a Plasma Membrane	Pupils are able to: 3.2.1 State the characteristics of substances that are able to move across a plasma membrane in these aspects: (i) size of molecules. (ii) polarity of molecules. (iii) ionic charge. 3.2.2 Conduct experiments to study the movement of substances across a selectively permeable membrane by using: (i) Visking tubing. (ii) simple osmometer. 3.2.3 Describe by using examples movement of substances across a plasma membrane: (i) passive transport. (ii) active transport. 3.2.5 Compare and contrast passive transport and active transport.	**Suggested activity:** Conduct an experiment to show that small molecules (example: glucose) are able to move across a selectively permeable membrane while large molecules (example: starch) are not. **Suggested activity:** Conduct an experiment to study the movement of substances across a visking tubing using simple osmometer. Design a simple osmometer. **Note:** The concept of water potential is used in osmosis. Types of passive transport: (i) simple diffusion. (ii) osmosis. (iii) facillitated diffusion.

CONTENT STANDARD	LEARNING STANDARD	NOTE
3.3 Movement of Substances Across a Plasma Membrane in Living Organisms	Pupils are able to: 3.3.1 Explain by using examples the process of passive transport in organisms.	**Note:** Emphasis is given to passive transport in organisms such as: (i) gaseous exchange between an alveolus and a blood capillary. (ii) reabsorption of water in kidney. (iii) absorption of water by a plant root hair cell. (iv) absorption of fructose in a villus.
	3.3.2 Explain by using examples the process of active transport in organisms.	**Suggested activity:** Discuss carrier proteins involved in active transport, such as the sodium-potassium pump and the proton pump. Examples of active transport in organisms: (i) .absorption of glucose and amino acids in a villus. (ii) reabsorption of glucose in a kidney. (iii) transport of sucrose from a green leaf to phloem tissue. (iv) absorption of mineral ions by a plant root hair cell.
	3.3.3 Define: (i) hypotonic solution. (ii) hypertonic solution. (iii) isotonic solution.	**Suggested activity:** Carry out experiments to show the process of osmosis by using Visking tubing, egg membrane or plant tissue.

CONTENT STANDARD	LEARNING STANDARD	NOTE
	3.3.4 Design an experiment to study the effects of different concentrations of solution on animal and plant cells. 3.3.5 Communicate about the effects of hypotonic, hypertonic and isotonic solutionson cell based on movement of water molecules: (i) animal cell. (ii) plant cell.	**Note:** The terms 'normal', 'shrink' and 'burst' are used to show the conditions of an animal cell. The phenomena involved are crenation and haemolysis/ lysis. The terms 'turgid' and 'flaccid' are used to show the conditions of a plant cell. The phenomena involved are plasmolysis and deplasmolysis. **Suggested activity:** Draw and label: (i) plant cells that undergo plasmolysis and deplasmolysis. (ii) red blood cells that undergo haemolysis and crenation.

CONTENT STANDARD	LEARNING STANDARD	NOTE
3.4 Movement of Substances Across a Plasma Membrane and its Application in Daily Life.	Pupils are able to: 3.4.1 Conduct an experiment to determine the concentration of cell sap of a plant tissue. 3.4.2 Correlate the concentration of cell sap in a plant tissue with the phenomenon of plant wilting. 3.4.3 Explain by using examples the application of the concept of movement of substances across a plasma membrane in daily life.	**Note:** Discuss the concentration of cell sap in a plant tissue with phenomenon of plant tissues. **Note:** Examples of application of the concept in the movement of substances across a plasma membrane in daily life: (i) isotonic drinks for athletes. (ii) rehydrating drinks for diarrhoea patients. (iii) saline solution in the medical field. (iv) liposome in the field of medicine, cosmetic industry, etc... **Suggested activity:** Gather and discuss information on excessive use of fertilisers that causes plant wilting. Apply the concept of movement of substances across a plasma membrane to produce food products by using local raw materials and market the products in school: (i) prservation of coloured egg. (ii) smoked banana with different colours. (iii) coloured cabbage. (iv) pickled fruits and vegetables. (v) salted fish.

CONTENT STANDARD	LEARNING STANDARD	NOTE
	3.4.4 Communicate about reverse osmosis in water purification.	**Suggested activity:** Gather information about reverse osmosis through various media and present the findings.

PERFORMANCE STANDARDS

MOVEMENT OF SUBSTANCES ACROSS A PLASMA MEMBRANE

PERFORMANCE LEVEL	DESCRIPTOR
1	**Recall** the knowledge and basic science skills of movement of substances across a plasma membrane.
2	**Understand** and able to explain movement of substances across a plasma membrane.
3	**Apply** knowledge and skills about movement of substances across a plasma membrane to carry out simple task.
4	**Analyse** information about movement of substances across a plasma membrane and apply science skills in the context of **problem solving.**
5	**Evaluate** to make judgement about movement of substances across a plasma membrane and apply science skills in the context of **problem solving and decision making** to carry out a task.
6	**Create** using knowledge and scientific skills related to movement of substances across a plasma membrane in the context of **problem solving and decision making** or carrying out an assignment in a new situation creatively and innovatively giving due consideration to the social values/ economy/ culture of the community.

4.0 CHEMICAL COMPOSITION IN A CELL

CONTENT STANDARD	LEARNING STANDARD	NOTE
4.1 Water	Pupils are able to: 4.1.1 Describe the properities water molecule. 4.1.2 Correlate the properties of water with its importance in the cell.	**Note:** Pupils have prior knowledge about the properties of water in Form 2. The properties of water to be discussed: (i) polarity. (ii) specific heat capacity of water. (iii) cohesion force. (iv) adhesion force.
4.2 Carbohydrates	Pupils are able to: 4.2.1 List the elements of carbohydrate. 4.2.2 Explain the types of carbohydrates: (i) monosaccharides. (ii) disaccharides. (iii) polysaccharides.	**Note:** Pupils have prior knowledge about the classes of food and food tests in Form 2. Detailed molecular structure of carbohydratesis not needed. **Suggested activity:** Carry out discussion and presentation on the following: (i) elements in carbohydrates (ii) types of carbohydrates, which are monosaccharides (glucose, fructose, galactose), disaccharides (maltose, sucrose, lactose) and polysaccharides (starch, glycogen and cellulose).

CONTENT STANDARD	LEARNING STANDARD	NOTE
		Suggested activity: Design an experiment to determine the presence of reducing sugar and non-reducing sugar (sucrose).
	4.2.3 Conceptualise the formation and breakdown of: (i) disaccharides. (ii) polysaccharides. 4.2.4 Write and explain the word equation for the formation and the breakdown of disaccharides. 4.2.5 Justify the importance of carbohydrates in cell.	**Note:** Glucose is the monomer of polysaccharides. Only a simple explanation on condensation and hydrolysis reactions is required.
4.3 Proteins	Pupils are able to: 4.3.1 List the elements of proteins. 4.3.2 Conceptualise the formation and the breakdown of dipeptides and polypeptides.	**Note:** Amino acid is the monomer of polypeptides. **Suggested activity:** Gather information and present the following: (i) elements in proteins, such as carbon, hydrogen, oxygen, sulphur, nitrogen and phosphorus. (ii) the formation and the breakdown of dipeptides and polypeptides.
	4.3.3 Write and explain the word equation for the formation and the breakdown of dipeptides. 4.3.4 Justify the importance of proteins in a cell.	

CONTENT STANDARD	LEARNING STANDARD	NOTE
4.4 Lipids	Pupils are able to: 4.4.1 List the elements in lipids. 4.4.2 Explain the main types of lipids. 4.4.3 Describe the formation and the breakdown of a triglyceride. 4.4.4 Write and explain the word equation for the formation and the breakdown of a triglyceride.	**Notes:** Types of lipids: (i) fat. (ii) wax. (iii) phospholipids. (iv) steroids (cholesterol, testosterone, oestrogen and progesterone). **Suggested activity:** Carry out discussion and presentation on: (i) elements in lipids. (ii) components of triglyceride. (iii) formation and breakdown of triglyceride. Construct thinking tools (example: mind maps, tree maps) to compare saturated fats and unsaturated fats.
	4.4.5 Justify the importance of lipids in cell and multicellular organisms.	

CONTENT STANDARD	LEARNING STANDARD	NOTE
4.5 Nucleic acids	Pupils are able to: 4.5.1 List the elements in nucleic acids. 4.5.2 Explain the structure of nucleotides: (i) nitrogenous base. (ii) ribose or deoxyribose sugars. (iii) phosphate. 4.5.3 Describe the structure of the nucleic acids: (i) deoxyribonucleic acid (DNA). (ii) ribonucleic acid (RNA). 4.5.4 Justify the importance of nucleic acids in cells: (i) carrier of herediritary information. (ii) production of proteins.	**Note:** Nucleotide is a monomer of nucleic acids. **Suggested activity:** Draw a molecular structure of DNA in an uncoiled form. Build a model of DNA. **Suggested activity:** Conduct a computer simulation/ multimedia presentation to explain the structure of the nucleic acids.
	4.5.5 Describe the formation of chromosomes from DNA and proteins.	

PERFORMANCE STANDARDS

CHEMICAL COMPOSITION IN A CELL

PERFORMANCE LEVEL	DESCRIPTOR
1	**Recall** the knowledge and basic scientific skills of chemical composition in a cell.
2	**Understand** and able to explain chemical composition in a cell.
3	**Apply** knowledge and skills about chemical composition in a cell to carry out simple task.
4	**Analyse** information about chemical composition in a cell and apply science skills in the context of **problem solving.**
5	**Evaluate** to make judgement about chemical composition in a cell and apply science skills in the context of **problem solving and decision making** to carry out a task.
6	**Create** using knowledge and scientific skills related to chemical composition in a cell in the context of **problem solving and decision making** or carrying out an assignment in a new situation creatively and innovatively giving due consideration to the social values/ economy/ culture of the community.

5.0 METABOLISM AND ENZYMES

CONTENT STANDARD	LEARNING STANDARD	NOTE
5.1 Metabolism	Pupils are able to: 5.1.1 Define metabolism. 5.1.2 State the types of metabolism in a cell: (i) anabolism. (ii) catabolism.	
5.2 Enzymes	Pupils are able to: 5.2.1 Define enzymes. 5.2.2 Reason out the necessity of enzymes in metabolism. 5.2.3 Describe the naming of enzymes with the addition of *–ase* to their substrates. 5.2.4 Characterise the general properties of enzymes.	**Note:** Pupils have prior knowledge about fundamentals of enzymes in Form 2. Emphasis is given to the fact that not all enzymes are synthesised from proteins. **Suggested activity:** Gather information and present about the naming of enzymes according to the conventional and the *International of Biochemistry and Molecular Biology* (IUBMB) methods.

CONTENT STANDARD	LEARNING STANDARD	NOTE
	5.2.5 Communicate about the involvement of specific organelles in the production of: (i) intracellular enzymes. (ii) extracellular enzymes.	**Suggested activity:** Carry out a multimedia presentation about the production of intracellular and extracellular enzymes.
	5.2.6 Explain the mechanism of enzyme action using the 'lock and key' hypothesis.	
	5.2.7 Interpret energy diagrams to explain the mechanism of enzyme action.	
	5.2.8 Correlate the mechanism of enzyme action with the change in the following factors: (i) temperature. (ii) pH. (iii) substrate concentration. (iv) enzyme concentration.	**Note:** Explanation about the effects of change in temperature is based on kinetic energy, structural changes, effective collision frequency and denaturation. Explanation about the effects of change in pH is based on structural changes and denaturation.
	5.2.9 Design and conduct experiments to study the effects of temperature and pH on the activities of amylase and pepsin.	**Note:** Catalase enzyme from liver (chicken) or potato may also be used.

CONTENT STANDARD	LEARNING STANDARD	NOTE
5.3 Application of Enzymes in Daily Life	Pupils are able to: 5.3.1 Explain by using examples the application of enzymes in daily life.	**Suggested activity:** Discuss the use of enzyme immobilisation technology in industries. Examples of the uses of enzymes in bio-detergent, fish processing, leather production, medicine, lactose-free milk and fruit juices.

PERFORMANCE STANDARDS

METABOLISM AND ENZYMES

PERFORMANCE LEVEL	DESCRIPTOR
1	**Recall** the knowledge and basic scientific skills of metabolism and enzymes.
2	**Understand** and able to explain metabolism and enzymes.
3	**Apply** knowledge and skills about metabolism and enzymes to carry out simple task.
4	**Analyse** information about metabolism and enzymes and apply science skills in the context of **problem solving.**
5	**Evaluate** to make judgement about metabolism and enzymes and apply science skills in the context of **problem solving and decision making** to carry out a task.
6	**Create** using knowledge and scientific skills related to metabolism and enzymes in the context of **problem solving and decision making** or carrying out an assignment in a new situation creatively and innovatively giving due consideration to the social values/ economy/ culture of the community.

6.0 CELL DIVISION

CONTENT STANDARD	LEARNING STANDARD	NOTE
6.1 Cell Division	Pupils are able to: 6.1.1 Describe: (i) karyokinesis (nuclear division). (ii) cytokinesis (cytoplasmic division). 6.1.2 Describe the terms haploid, diploid, chromatin, homologous chromosomes, paternal chromosome and maternal chromosome.	**Note:** Characterise briefly the events that occur in nuclear and cytoplasmic divisions.
6.2 Cell Cycle and Mitosis	Pupils are able to: 6.2.1 Describe the phases in a cell cycle: (i) interphase. (ii) G_1 phase. (iii) S phase. (iv) G_2 phase. (v) M phase. (vi) mitosis. (vii) cytokinesis.	**Suggested activity:** Gather information and perform a simulation activity about mitosis.

CONTENT STANDARD	LEARNING STANDARD	NOTE
	6.2.2 Arrange the stages of mitosis in the correct order.	**Note:** Characterise the events that occur in each stage of mitosis. **Suggested activity:** Draw and label the stages of mitosis in the correct order (Prophase, Metaphase, Anaphase and Telophase). Observe prepared slides of each stage of mitosis through a light microscope. Design a three dimensional model of the stages of mitosis.
	6.2.3 Communicate about the cell structure of each stage of mitosis and cytokinesis by using labelled diagrams. 6.2.4 Compare and contrast mitosis and cytokinesis in animal and plant cells.	**Suggested activity:** Make an illustration by using multimedia to differentiate mitosis and cytokinesis in animal and plant cells.

CONTENT STANDARD	LEARNING STANDARD	NOTE
	6.2.5 Discuss the necessity of mitosis in: (i) development of embryo. (ii) growth of organisms. (iii) healing of wounds on the skin. (iv) regeneration. (v) asexual reproduction.	**Suggested activity:** Gather and present information on the application of mitosis in the fields of agriculture and medicine: (i) tissue culture. (ii) meat culture. (iii) stem cell therapy. Organise visits to study about tissue culture at: (i) Forest Research Institute Malaysia (FRIM). (ii) Malaysian Palm Oil Council (MPOC). (iii) Malaysian Agricultural Research and Development Institute (MARDI). (iv) Malaysian Rubber Board (MRB). (v) Higher Learning Institutions.
6.3 Meiosis	Pupils are able to: 6.3.1 State the meaning of meiosis. 6.3.2 Identify types of cells that undergo meiosis.	

CONTENT STANDARD	LEARNING STANDARD	NOTE
	6.3.3 State the necessity of meoisis in: (i) the formation of gametes. (gametogenesis). (ii) producing genetic variation. (iii) maintaining diploid chromosomal numbers from one generation to another.	**Note:** Define meiosis. **Suggested activity:** Gather information and discuss the necessity of meiosis.
	6.3.4 Explain the stages of meiosis in the correct order: (i) Meiosis I. (ii) Meiosis II.	**Suggested activity:** Conduct different simulation activities to explain changes that occur in each stage of meiosis I and meiosis II.
	6.3.5 Draw and label the cell structure in each stage of meiosis I, meiosis II and cytokinesis.	
	6.3.7 Compare and contrast meiosis and mitosis.	**Suggested activity:** Construct thinking tools to: (i) compare and contrast meiosis I and meiosis II. (ii) compare and contrast meiosis and mitosis.
6.4 Issues of Cell Division on Human Health	Pupils are able to: 6.4.1 Explain the effects of abnormal mitosis on human health: (i) tumour. (ii) cancer.	**Suggested activity:** Research on diseases such as tumour and cancer due to uncontrolled mitosis.

CONTENT STANDARD	LEARNING STANDARD	NOTE
	6.4.2 Evaluate the effects of abnormal meiosis on Down Syndrome individuals.	**Suggested activity:** Discuss with examples disorders caused by abnormal meiosis.

PERFORMANCE STANDARDS

CELL DIVISION

PERFORMANCE LEVEL	DESCRIPTOR
1	**Recall** the knowledge and basic scientific skills of cell division.
2	**Understand** and able to explain cell division.
3	**Apply** knowledge and skills about cell division to carry out simple task.
4	**Analyse** information about cell division and apply science skills in the context of **problem solving.**
5	**Evaluate** to make judgement about cell division and apply science skills in the context of **problem solving and decision making** to carry out a task.
6	**Create** using knowledge and scientific skills related to cell division in the context of **problem solving and decision making** or carrying out an assignment in a new situation creatively and innovatively giving due consideration to the social values/ economy/ culture of the community.

7.0 CELLULAR RESPIRATION

CONTENT STANDARD	LEARNING STANDARD	NOTE
7.1 Production of energy through cellular respiration	Pupils are able to: 7.1.1 Justify the necessity of energy in metabolic processes. 7.1.2 Identify the main substrate used in energy production. 7.1.3 List the types of cellular respiration: (i) aerobic respiration. (ii) anaerobic respiration. (iii) fermentation.	**Suggested activity:** Conduct group discussions on the necessity of energy in metabolic processes. **Note:** Glucose is the main substrate for cellular respiration that is produced from: (i) digestion of carbohydrates in humans and animals. (ii) photosynthesis in plants.

CONTENT STANDARD	LEARNING STANDARD	NOTE
7.2 Aerobic respiration	Pupils are able to: 7.2.1 Conceptualise energy production from glucose during aerobic respiration in cells. 7.2.2 Write a word equation for aerobic respiration in cells. 7.2.3 Conduct an experiment to study aerobic respiration.	**Note:** Explanation includes the breakdown of glucose (glycolysis) that occurs in the cytoplasm and the production of carbon dioxide and ATP in mitochondria.
7.3 Fermentation	Pupils are able to: 7.3.1 State the factors that cause fermentation to occur in cells.	**Note:** Fermentation occurs in human muscle cells, certain types of bacteria, yeast and plants. **Suggested activity:** Study fermentation process by using *Lactobacillus.* Apply the concept of fermentation to produce food products and market the products in school. Pupils may conduct this as a co-curricular activity.

CONTENT STANDARD	LEARNING STANDARD	NOTE
	7.3.2 Explain by using examples energy production from glucose during fermentation in: (i) human muscle cells. (ii) *Lactobacillus.* (iii) yeast. (iv) plants such as paddy. 7.3.3 Write and explain word equations for: (i) lactic acid fermentation. (ii) alcohol fermentation. 7.3.4 Conduct an experiment to study fermentation in yeast. 7.3.6 Compare and contrast aerobic respiration and fermentation.	

PERFORMANCE STANDARDS

CELLULAR RESPIRATION

PERFORMANCE LEVEL	DESCRIPTOR
1	**Recall** the knowledge and basic scientific skills of cellular respiration.
2	**Understand** and able to explain cellular respiration.
3	**Apply** knowledge and skills about cellular respiration to carry out simple task.
4	**Analyse** information about cellular respiration and apply science skills in the context of **problem solving.**
5	**Evaluate** to make judgement about cellular respiration and apply science skills in the context of **problem solving and decision making** to carry out a task.
6	**Create** using knowledge and scientific skills related to cellular respiration in the context of **problem solving and decision making** or carrying out an assignment in a new situation creatively and innovatively giving due consideration to the social values/ economy/ culture of the community.

THEME

PHYSIOLOGY OF HUMANS AND ANIMALS

LEARNING AREA

8.0 Respiratory System in Humans and Animals

9.0 Nutrition and Human Digestive System

10.0 Transport in Humans and Animals

11.0 Immunity in Humans

12.0 Coordination and Response in Humans

13.0 Homeostasis and Human Urinary System

14.0 Support and Movements in Humans and Animals

15.0 Sexual Reproduction, Development and Growth in Humans and Animals

Theme 2

PHYSIOLOGY OF HUMANS AND ANIMALS

The purpose of this theme is to give an understanding about physiological processes that occur in humans and animals. Humans and animals carry out physiological processes which are respiration, nutrition, sensitivity, excretion, movement, reproduction and growth. This theme will emphasise on the understanding about organ functions in each physiological process. The understanding of this theme will contribute towards the knowledge about personal care and the development of science and technology.

Learning area:

8.0 Respiratory Systems in Humans and Animals
- 8.1 Types of Respiratory System
- 8.2 Mechanisms of Breathing
- 8.3 Gaseous Exchange in Humans
- 8.4 Health Issues Related to the Human Respiratory System

9.0 Nutrition and Human Digestive System
- 9.1 Digestive System
- 9.2 Digestion
- 9.3 Absorption
- 9.4 Assimilation
- 9.5 Defaecation
- 9.6 Balanced Diet
- 9.7 Health Issues Related to the Digestive System and Eating Habits

10.0 Transport in Humans and Animals
- 10.1 Types of Circulatory System
- 10.2 Circulatory System of Humans
- 10.3 Mechanism of Heart Beat
- 10.4 Mechanism of Blood Clotting
- 10.5 Blood Grouping in Humans
- 10.6 Health Issues Related to the Human Circulatory System

15.0 Sexual Reproduction, Development and Growth in Humans and Animals
- 15.1 Reproductive System of Humans
- 15.2 Gametogenesis in Humans
- 15.3 Menstrual Cycle
- 15.4 Development of Human Foetus
- 15.5 Formation of Twins
- 15.6 Health Issues Related to the Human Reproductive System
- 15.7 Growth in Humans and Animals

8.0 RESPIRATORY SYSTEMS IN HUMANS AND ANIMALS

CONTENT STANDARD	LEARNING STANDARD	NOTE
8.1 Types of Respiratory System	Pupils are able to: 8.1.1 Identify respiratory structures in: (i) insects. (ii) fish. (iii) amphibians. (iv) humans. 8.1.2 Describe the adaptation of respiratory structures and their functions for gaseous exchange in: (i) animals. (ii) humans. 8.1.3 Compare and contrast respiratory structures in humans and animals.	Note: Pupils have learned about the respiratory organs and breathing in humans in Form 3. **Suggested activity:** Conduct an experiment to study the effects of an increase in total surface area on the rate of difussion as an analogy in gaseous exchange. Conduct experiments to study respiratory structures in animals. **Suggested activity:** Construct thinking tools to compare respiratory structures in humans and animals.
8.2 Mechanisms of Breathing	Pupils are able to: 8.2.1 Compare and contrast breathing mechanisms in humans and animals.	**Suggested activity:** Construct a model to show the actions of diaphragm muscle during breathing in humans. Design a model to show the antagonistic actions of intercostal muscles during breathing in humans.

CONTENT STANDARD	LEARNING STANDARD	NOTE
8.3 Gaseous Exchange in Humans	Pupils are able to: 8.3.1 Communicate about external and internal respirations: (i) gaseous exchange between lungs and blood. (ii) transport of respiratory gases from lungs to tissues. (iii) gaseous exchange between blood and tissues. (iv) transport of respiratory gases from tissues to lungs.	**Note:** Pupils have learned about the transport of oxygen in humans in Form 3. Concepts of partial pressure of oxygen and partial pressure of carbon dioxide are used to explain gaseous exchange.
8.4 Health Issues Related to the Human Respiratory System	Pupils are able to: 8.4.1 Narrate the effects of *Chronic Obstructive Pulmonary Disease* (COPD) on the human respiratory system: (i) asthma. (ii) chronic bronchitis. (iii) emphysema.	**Suggested activity:** Carry out a presentation on COPD.

PERFORMANCE STANDARD

RESPIRATORY SYSTEMS IN HUMANS AND ANIMALS

PERFORMANCE LEVEL	DESCRIPTOR
1	**Recall** the knowledge and basic scientific skills of respiratory systems in humans and animals.
2	**Understand** and able to explain respiratory systems in humans and animals.
3	**Apply** knowledge and skills about respiratory systems in humans and animals to carry out simple task.
4	**Analyse** information about respiratory systems in humans and animals and apply science skills in the context of **problem solving.**
5	**Evaluate** to make judgement about respiratory systems in humans and animals and apply science skills in the context of **problem solving and decision making** to carry out a task.
6	**Create** using knowledge and scientific skills related to respiratory systems in humans and animals in the context of **problem solving and decision making** or carrying out an assignment in a new situation creatively and innovatively giving due consideration to the social values/ economy/ culture of the community

9.0 NUTRITION AND HUMAN DIGESTIVE SYSTEM

CONTENT STANDARD	LEARNING STANDARD	NOTE
9.1 Digestive System	Pupils are able to: 9.1.1 Identify structures of the human digestive system.	**Note:** Pupils have been introduced to the human digestive system in Form 1. Human digestive system structures that will be discussed: Mouth, salivary glands, oesophagus, stomach, liver, gall bladder, pancreas, small intestine and large intestine. **Suggested activity:** Draw and label structures of salivary, gastric and intestinal glands seen on prepared slides by using a light microscope.
9.2 Digestion	Pupils are able to: 9.2.1 Describe the types of digestion: (i) physical digestion. (ii) chemical digestion. 9.2.2 Analyse the process and products of carbohydrate digestion in the mouth.	**Note:** Pupils have been introduced to physical and chemical digestions in Form 1. Physical digestion: mastication and peristalsis. Chemical digestion: enzyme actions.

CONTENT STANDARD	LEARNING STANDARD	NOTE
	9.2.3 Analyse the process and products of protein digestion in the stomach.	**Note:** Cells in a gastric gland: (i) chief cells (secrete pepsinogen). (ii) parietal cells (secrete hydrochloric acid). (iii) goblet cells (secrete mucus).
	9.2.4 Describe digestions of carbohydrates, proteins and lipids in the small intestine.	**Note:** Emphasis is given to the digestion of carbohydrates, proteins and lipids in the small intestine. (i) liver: produces bile. (ii) gall bladder: stores and secretes bile. (iii) pancreas: secretes trypsin, pancreatic amylase and lipase. (iv) ileum: secretes mucus, maltase, sucrase, lactase and erepsin.
	9.2.5 Conduct experiments to study digestions of starch, proteins and lipids in food samples.	
9.3 Absorption	Pupils are able to: 9.3.1 Identify the structure of a villus in the ileum.	**Note:** Emphasis is given to the structure of a villus in the ileum: (i) epithelial cells. (ii) goblet cells. (iii) blood capillaries. (iv) lacteals. (v) intestinal glands.

CONTENT STANDARD	LEARNING STANDARD	NOTE
	9.3.2 Communicate about the adaptations of ileum and villus in the absorption of digested food.	**Note:** Adaptations of ileum and villus in absorption have been introduced to pupils in Form 1. Emphasis is given to the adaptations of ileum and villus in the absorption of digested food: (i) fructose by facilitated diffusion. (ii) glucose and galactose by active transport . (iii) amino acids by active transport. (iv) vitamins by active transport. (v) water by osmosis. (vi) fatty acids and glycerol by simple diffusion. **Suggested activity:** Gather information about the absorption of alcohol and drugs and present the findings.
9.4 Assimilation	Pupils are able to: 9.4.1 Describe the roles of the circulatory system in assimilation of digested food. 9.4.2 Discuss the functions of liver in assimilation of digested food: (i) metabolisms of digested food (carbohydrates and proteins). (ii) storage of nutrients. (iii) detoxification.	**Suggested activity:** Gather information and explain the assimilation of lipids. Research on various functions of the liver and produce a scrap book.

CONTENT STANDARD	LEARNING STANDARD	NOTE
9.5 Defaecation	Pupils are able to: 9.5.1 Explain the functions of the large intestine: (i) absorption of water and vitamins. (ii) formation of faeces.	**Note:** Pupils have been introduced to defaecation in Form 1. Emphasis is given to the production of vitamins by microorganisms and absorption by the large intestine.
9.6 Balanced Diet	Pupils are able to: 9.6.1 Conduct an experiment to study the energy values in food samples. 9.6.2 Conduct an experiment to determine the contents of vitamin C in fruit or vegetables juices. 9.6.3 Justify the modification of diets for individuals that: (i) experience obesity. (ii) experience a specific disease - diabetes mellitus. - cardiovascular. - cancer.	**Notes:** Pupils have been introduced to balanced diet in Form 1. **Suggested activity:** Investigate the effects of temperature on the contents of vitamin C in fruit or vegetable juices by conducting experiments. **Note**: Pupils have been introduced to the importance of a balanced diet and factors affecting energy requirement of individuals in Form 1. **Suggested activity:** Plan a meal based on the Malaysian Healthy Plate for different individuals.

CONTENT STANDARD	LEARNING STANDARD	NOTE
9.7 Health Issues Related to Digestive System and Eating Habits	Pupils are able to: 9.7.1 Predict the effects of modifying digestive organs on human health. 9.7.2 Outline health issues related to defecation. 9.7.3 Correlate health issues that are related to eating habits.	 **Suggested activity:** Discuss on health issues that are related to defecation. **Suggested activity:** Conduct case study on the health issues that are related to humans' eating habits. Examples of health issues that are related to eating habits: (i) type 2 diabetes. (ii) obesity. (iii) gastritis. (iv) acid reflux. (v) muscle dysmorphia. (vi) aneroxsia nervosa. (vii) bulimia nervosa. (viii) pica.

PERFORMANCE STANDARDS

NUTRITION AND HUMAN DIGESTIVE SYSTEM

PERFORMANCE LEVEL	DESCRIPTOR
1	**Recall** the knowledge and basic scientific skills of nutrition and human digestive system.
2	**Understand** and able to explain nutrition and human digestive system.
3	**Apply** knowledge and skills about nutrition and human digestive system to carry out simple task.
4	**Analyse** information about nutrition and human digestive system and apply science skills in the context of **problem solving.**
5	**Evaluate** to make judgement about nutrition and human digestive system and apply science skills in the context of **problem solving and decision making** to carry out a task
6	**Create** using knowledge and scientific skills related to nutrition and human digestive system in the context of **problem solving and decision making** or carrying out an assignment in a new situation creatively and innovatively giving due consideration to the social values/ economy/ culture of the community

10.0 TRANSPORT IN HUMANS AND ANIMALS

CONTENT STANDARD	LEARNING STANDARD	NOTE
10.1 Types of Circulatory System	Pupils are able to: 10.1.1 Justify the necessity of transport systems in complex multicellular organisms. 10.1.2 Identify substances that are transported by the transport system: (i) substances required by a cell. (ii) waste products of a cell. 10.1.3 Conceptualise types of circulatory system in complex multicellular organisms. (i) open circulatory system. (ii) closed circulatory system. 10.1.4 Compare and contrast circulatory systems in complex multicellular organisms: (i) insects. (ii) fish. (iii) amphibians. (iv) humans.	**Suggested activity:** Design an experiment to study the effect of the change in the total surface area/volume (TSA/V) ratio on the rate of diffusion.

CONTENT STANDARD	LEARNING STANDARD	NOTE
10.2 Circulatory System of Humans	Pupils are able to: 10.2.1 Describe components of the human circulatory system: (i) heart. (ii) blood vessel. (iii) blood. 10.2.2 Explain the composition of blood: (i) blood plasma. (ii) blood cells. 10.2.3 Compare and contrast the types of blood vessels: (i) artery. (ii) vein. (iii) capillary.	**Note:** Pupils have learned the human blood circulation in Form 3. Emphasise the types of blood vessels: (i) artery. (ii) arteriole. (iii) capillary. (iv) venule. (v) vein.

CONTENT STANDARD	LEARNING STANDARD	NOTE
	10.2.4 Label the structure of a human heart and associated blood vessels: (i) aorta. (ii) vena cava. (iii) pulmonary artery and pulmonary vein. (iv) coronary artery and coronary vein. (v) semilunar valve. (vi) bicuspid valve and tricuspid valve. (vii) septum. 10.2.5 Describe the functions of parts of the heart.	
10.3 Mechanism of Heart Beat	Pupils are able to: 10.3.1 Describe the human heart beat mechanism: (i) sinoatrial node (pacemaker) . (ii) atrioventricular node. (iii) bundle of His. (iv) Purkinje fibres.	**Suggested activity:** Production of “lub-dub” sound by the heart is discussed.

CONTENT STANDARD	LEARNING STANDARD	NOTE
	10.3.2 Communicate about forces that cause the blood to circulate in humans: (i) pumping of the heart. (ii) contraction of skeletal muscles.	
10.4 Mechanism of Blood Clotting	Pupils are able to: 10.4.1 Justify the necessity for blood clotting mechanism. 10.4.2 Describe blood clotting mechanism. 10.4.3 Describe health issues related to blood clotting: (i) thrombosis. (ii) embolism. (iii) haemophilia.	**Suggested activity:** Watch a video on blood clotting mechanism. **Suggested activity:** Gather and present information about thrombosis, embolism and haemophilia.
10.5 Blood Grouping of Humans	Pupils are able to: 10.5.1 Describe ABO blood group. 10.5.2 Correlate ABO blood group with blood donation.	**Note:** Emphasis is given to antigen A, antigen B, anti-A antibody and anti-B antibody.

CONTENT STANDARD	LEARNING STANDARD	NOTE
	10.5.3 Describe Rhesus factor. 10.5.4 Reason out incompatibility of Rhesus factor in pregnancies.	**Note:** Antigen D and anti-D antibody are discussed.
10.6 Health Issues Related to the Human Circulatory System	Pupils are able to: 10.6.1 Justify the necessity for a healthy circulatory system. 10.6.2 Communicate about cardiovascular diseases.	**Suggested activity:** Conduct a case study on practices in taking care of the circulatory system. **Suggested activity:** Gather information and discuss about treatments for heart failure. Examples of cardiovascular diseases: (i) arteriosclerosis. (ii) atherosclerosis. (iii) hypertension. (iv) angina. (v) myocardial infarction. (vi) stroke.
10.7 Lymphatic System of Humans	Pupils are able to: 10.7.1 Synthesise the process of formation of tissue fluid and lymph.	

CONTENT STANDARD	LEARNING STANDARD	NOTE
	10.7.2 Compare and contrast the contents of lymph and: (i) tissue fluid. (ii) blood. 10.7.3 Describe components of the lymphatic system: (i) lymph. (ii) lymphatic capillaries. (iii) lymphatic vessels. (iv) lymph nodes. (v) lymphatic organs. 10.7.4 Justify the necessity of the lymphatic system: (i) complements the blood circulatory system. (ii) transports lipid soluble substances. (iii) body defence.	**Note:** Lymphatic organs: spleen, tonsils, thymus gland, appendix and bone marrow.
10.8 Health Issues Related to the Human Lymphatic System	Pupils are able to: 10.8.1 Describe health issues related to the lymphatic system.	**Suggested activity:** Gather information and discuss the causes of oedema. (i) filariasis. (ii) parasitic infection. (iii) plasma protein deficiency. (iv) pregnancy. (v) bedridden patients.

PERFORMANCE STANDARD

TRANSPORT IN HUMANS AND ANIMALS

PERFORMANCE LEVEL	DESCRIPTOR
1	**Recall** the knowledge and basic scientific skills of transport in humans and animals.
2	**Understand** and able to explain transport in humans and animals.
3	**Apply** knowledge and skills about transport in humans and animals to carry out simple task.
4	**Analyse** information about transport in humans and animals and apply science skills in the context of **problem solving.**
5	**Evaluate** to make judgement about transport in humans and animals and apply science skills in the context of **problem solving and decision making** to carry out a task.
6	**Create** using knowledge and scientific skills related to transport in humans and animals in the context of **problem solving and decision making** or carrying out an assignment in a new situation creatively and innovatively giving due consideration to the social values/ economy/ culture of the community

11.0 IMMUNITY IN HUMANS

CONTENT STANDARD	LEARNING STANDARD	NOTE
11.1 Body Defence	Pupils are able to: 11.1.1 Define: (i) immunity. (ii) antigen. (iii) antibody. 11.1.2 Describe the three lines of body defence in humans: (i) first line of defence - physical - chemical (ii) second line of defence - fever - inflammation - phagocytosis (iii) third line of defence - antibody - memory cell	**Note:** Pupils have been introduced to the three lines of body defence in Form 2.
11.2 Actions of Antibodies	Pupils are able to: 11.2.1 Discuss the actions of antibodies on foreign antigens: (i) neutralisation. (ii) agglutination. (iii) precipitation. (iv) opsonisation. (v) complement fixation.	**Suggested activity:** Design games to show antigen-antibody reactions.

CONTENT STANDARD	LEARNING STANDARD	NOTE
11.3 Types of Immunity	Pupils are able to: 11.3.1 Communicate about the types of immunity: (i) passive immunity. (ii) active immunity. 11.3.2 Compare and contrast passive immunity and active immunity.	
11.4 Health Issues Related to Immunity	Pupils are able to: 11.4.1 Describe health issues related to Acquired Immuno Deficiency Syndrome (AIDS).	**Suggested activity:** Carry out a study on health issues related to immunity in humans: (i) Systemic Lupus Erythematosus (SLE). (ii) allergy.

PERFORMANCE STANDARD

IMMUNITY IN HUMANS

PERFORMANCE LEVEL	DESCRIPTOR
1	**Recall** the knowledge and basic scientific skills of immunity in humans.
2	**Understand** and able to explain immunity in humans.
3	**Apply** knowledge and skills about immunity in humans to carry out simple task.
4	**Analyse** information about immunity in humans and apply science skills in the context of **problem solving.**
5	**Evaluate** to make judgement about immunity in humans and apply science skills in the context of **problem solving and decision making** to carry out a task.
6	**Create** using knowledge and scientific skills related to immunity in humans in the context of **problem solving and decision making** or carrying out an assignment in a new situation creatively and innovatively giving due consideration to the social values/ economy/ culture of the community

12.0 COORDINATION AND RESPONSE IN HUMANS

CONTENT STANDARD	LEARNING STANDARD	NOTE
12.1 Coordination and Response	Pupils are able to: 12.1.1 Make a sequence and describe components in human coordination: (i) stimulus. (ii) receptor. (iii) integration centre. (iv) effector. (v) response. 12.1.2 Identify and describe external and internal stimuli 12.1.3 List the types of sensory receptors based on the stimuli involved: (i) chemoreceptor. (ii) mechanoreceptor. (iii) photoreceptor. (iv) thermoreceptor. (v) baroreceptor. (vi) nocireceptor. 12.1.4 Justify the necessity to respond to external and internal stimuli.	**Suggested activity:** Conduct a role play activity to explain coordination and response.

CONTENT STANDARD	LEARNING STANDARD	NOTE
12.2 Nervous System	Pupils are able to: 12.2.1 Construct an organisational chart and explain the structures of the human nervous system: (i) central nervous system - brain - spinal cord (i) peripheral nervous system - sensory receptor - cranial nerve - spinal nerve 12.2.2 Explain the functions of parts of in the central nervous system related to coordination and response. (i) brain - cerebrum - cerebellum - medulla oblongata - hypotalamus - pituitary gland (ii) spinal cord 12.2.3 Communicate about the functions of parts of the peripheral nervous system in coordination and response.	**Note:** Peripheral nervous system that are discussed: (i) somatic nervous system. (ii) autonomic nervous system.

CONTENT STANDARD	LEARNING STANDARD	NOTE
12.3 Neurones and Synapse	Pupils are able to: 12.3.1 Draw and label structures of a sensory neurone and a motor neurone: (i) dendrite. (ii) axon. (iii) cell body . (iv) myelin sheath. (v) node of Ranvier. 12.3.2 Analyse the functions of each type of neurone in impulse transmission. 12.3.3 Explain the structure and function of synapse. 12.3.4 Explain the transmission of impulse across a synapse.	**Note:** Emphasis is given to sensory neurone, relay neurone and motor neurone. **Suggested activity:** Design a simulation model of the nervous coordination using electrical circuit.

CONTENT STANDARD	LEARNING STANDARD	NOTE
12.4 Voluntary and Involuntary Actions	Pupils are able to: 12.4.1 Compare and contrast voluntary and involuntary actions. 12.4.2 Describe the reflex actions involving: (i) two neurones. (ii) three neurones. 12.4.3 Draw a reflex arc.	**Note:** Discuss the spinal reflex only.
12.5 Health Issues Related to the Nervous System	Pupils are able to: 12.5.1 Communicate about the health issues related to the nervous system.	**Suggested activity:** Carry out research on health issues that are related to the nervous system: (i) mutliple sclerosis. (ii) Alzheimer. (iii) Parkinson. (iv) Lou Gehrig/ Amyotrophic Lateral Sclerosis (ALS). (v) Attention Deficit Hyperactivity Disorder (ADHD). (vi) autism. (vii) cerebral palsy. (viii) epilepsy. Carry out research on traditional methods (acupuncture and others) in health treating issues related to the nervous system.

CONTENT STANDARD	LEARNING STANDARD	NOTE
	12.5.2 Describe the effects of drug and alcohol abuse on human coordination and response.	
12.6 Endocrine System	Pupils are able to: 12.6.1 State the role of endocrine glands in humans. 12.6.2 Identify and label the endocrine glands in humans. 12.6.3 Analyse the functions of hormones secreted by each endocrine glands: (i) hypothalamus - gonadotropin releasing hormone (GnRH) (ii) anterior lobe of pituitary - growth hormone (GH) - follicle stimulating hormone (FSH) - luteinising hormone (LH) - thyroid stimulating hormone (TSH) - adrenocorticotropic hormone (ACTH)	**Note:** Emphasis is given to the endocrine gland in humans. (i) hypothalamus. (ii) pituitary. (iii) thyroid. (iv) pancreas. (v) adrenal. (vi) ovaries. (vii) testes.

CONTENT STANDARD	LEARNING STANDARD	NOTE
	(iii) posterior lobe of pituitary - oxytocin hormone - antidiuretic hormone (ADH) (iv)thyroid - thyroxine hormone (v) pancreas - insulin hormone - glucagon hormone (vi)adrenal - adrenaline hormone - aldosterone hormone (vii) ovary - oestrogen hormone - progesterone hormone (viii) testis - testosterone hormone	
	12.6.4 Discuss involvements of the nervous system and endocrine system in a "fight or flight" situation. 12.6.5 Compare and contrast the nervous and the endocrine system.	**Note:** Examples of "fight or flight" situations: excited, frightened or stressed.
12.7 Health Issues Related to the Endocrine System	Pupils are able to: 12.7.1 Predict the effects of hormonal imbalances on human health.	**Note:** Examples of hormonal imbalances on human health are: (i) dwarfism.

CONTENT STANDARD	LEARNING STANDARD	NOTE
		(ii) gigantism. (iii) hyperthyroidism. (iv) hypothyroidism. (v) diabetes mellitus. (vi) diabetes insipidus.

PERFORMANCE STANDARD

COORDINATION AND RESPONSE IN HUMANS

PERFORMANCE LEVEL	DESCRIPTOR
1	**Recall** the knowledge and basic scientific skills of coordination and response in humans.
2	**Understand** and able to explain coordination and response in humans.
3	**Apply** knowledge and skills about coordination and response in humans to carry out simple task.
4	**Analyse** information about coordination and response in humans and apply science skills in the context of **problem solving.**
5	**Evaluate** to make judgement about coordination and response in humans and apply science skills in the context of **problem solving and decision making** to carry out a task.
6	**Create** using knowledge and scientific skills related to coordination and response in humans in the context of **problem solving and decision making** or carrying out an assignment in a new situation creatively and innovatively giving due consideration to the social values/ economy/ culture of the community

13.0 HOMEOSTASIS AND HUMAN URINARY SYSTEM

CONTENT STANDARD	LEARNING STANDARD	NOTE
13.1 Homeostasis	Pupils are able to: 13.1.1 Explain the meaning of homeostasis. 13.1.2 Justify the neccesity to maintain physical and chemical factors in the internal environment. 13.1.3 Describe the involvement of various organ systems in maintaining an optimal internal environment. 13.1.4 Apply the knowledge of homeostasis concept in regulation of: (i) body temperature. (ii) blood sugar level. (iii) partial pressure of carbon dioxide. (iv) blood pressure.	**Note:** Pupils have been introduced to the concept of homeostasis in humans in Form 1. **Note:** Regulation of partial pressure of carbon dioxide in blood is correlated with the respiratory control centre and cardiovascular control centre.
13.2 Urinary System	Pupils are able to: 13.2.1 Identify the structure and functions of a kidney.	**Suggested activity:** Build models of :

CONTENT STANDARD	LEARNING STANDARD	NOTE
	13.2.2 Draw, label and explain the structure of a nephrone and collecting duct.	(i) kidney. (ii) nephrone. (iii) collecting duct.
	13.2.3 Describe the formation of urine: (i) ultrafiltration. (ii) reabsorption. (iii) secretion.	**Note:** Emphasis is given to substances that are reabsorbed: water, glucose, amino acid and salt.
	13.2.4 Synthesise the concept of homeostasis by using negative feedback mechanism in osmoregulation.	**Suggested activity:** Gather information and discuss about haemodialysis. Carry out activities to raise funds for a haemodialysis centre.
	13.2.5 Conduct an experiment to study the effects of different volumes of of water intake on urine formation.	
13.3 Health Issues Related to the Urinary System	Pupils are able to: 13.3.1 Describe health issues that are related to the urinary system.	**Suggested activity:** Gather information and perform multimedia presentation about health issues that are related to the urinary system such as kidney stones.

PERFORMANCE STANDARD

HOMEOSTASIS AND HUMAN URINARY SYSTEM

PERFORMANCE LEVEL	DESCRIPTOR
1	**Recall** the knowledge and basic scientific skills of homeostasis and human urinary system.
2	**Understand** and able to explain homeostasis and human urinary system.
3	**Apply** knowledge and skills about homeostasis and human urinary system to carry out simple task.
4	**Analyse** information about homeostasis and human urinary system and apply science skills in the context of **problem solving.**
5	**Evaluate** to make judgement about homeostasis and human urinary system and apply science skills in the context of **problem solving and decision making** to carry out a task.
6	**Create** using knowledge and scientific skills related to homeostasis and human urinary system in the context of **problem solving and decision making** or carrying out an assignment in a new situation creatively and innovatively giving due consideration to the social values/ economy/ culture of the community

14. SUPPORT AND MOVEMENT IN HUMANS AND ANIMALS

CONTENT STANDARD	LEARNING STANDARD	NOTE
14.1 Types of Skeleton	Pupils are able to: 14.1.1 List the types of skeleton in humans and animals: (i) hydrostatic skeleton. (ii) exoskeleton. (iii) endoskeleton. 14.1.2 Justify the necessity of skeletons in humans and animals.	**Suggested activity:** Conduct brainstorming activity to explain the importance of skeletons in humans and animals.
14.2 Musculoskeletal System of Humans	Pupils are able to: 14.2.1 Identify bones that form the human skeletal system: (i) axial skeleton. (ii) appendicular skeleton. 14.2.2 Characterise types of vertebrae in the backbone: (i) cervical vertebrae (including atlas and axial). (ii) thoracic vertebrae. (iii) lumbar vertebrae. (iv) sacral vertebrae. (v) caudal vertebrae.	**Suggested activity:** Observe a model of human skeletal to identify bones that form the human skeletal system.

CONTENT STANDARD	LEARNING STANDARD	NOTE
	14.2.3 Compare and contrast the types of vertebrae. 14.2.4 State types of joints in the human skeletal system. (i) immovable joints. (ii) slightly moveable joints. (iii) freely moveable joints. 14.2.5 Draw, label and explain the human forearm hinge joint structure: (i) bones. (ii) cartilages. (iii) skeletal muscles. (iv) tendons. (v) ligaments. (vi) sinovial membrane. (vii) sinovial fluid.	**Note:** Discuss examples of freely moveable joints such as hinge joint and ball-and-socket joint. **Suggested activity:** Conduct a dissection on a chicken wing to observe the structures of the bones, cartilages, skeletal muscles, tendons and ligaments.
14.3 Movement and Locomotion	Pupils are able to: 14.3.1 Explain the movement mechanisms in: (i) human forearm. (ii) human leg (walking). 14.3.2 Describe briefly the locomotion mechanisms in animals.	**Note:** Emphasis is given to the concept of antagonistic muscle concept. **Note:** Animals that should be emphasised: (i) earthworms. (ii) fish. (iii) grasshoppers (jump). (iv) bird (flight).

CONTENT STANDARD	LEARNING STANDARD	NOTE
		Suggested activity: Invent a model that shows the mechanism of movements in animals.
14.4 Health Issues Related to the Human Musculoskeletal System	Pupils are able to: 14.4.1 Describe health issues related to thehuman musculoskeletal system: (i) osteoporosis. (ii) osteomalacia. (iii) rickets. (iv) arthritis. (v) scoliosis. 14.4.2 Justify practices to maintain a healthy musculoskeletal system.	**Suggested activity:** Conduct research on treatments to help individuals that have health issues related to the human musculoskeletal system. Construct a walking aid for an individual with muscle injury or joint pains. **Suggested activity:** Discuss the effects of using electronic gadgets exessively on body postures. **Note:** Practices to maintain a healthy musculo skeletal system: (i) exercise. (ii) balanced diet. (iii) correct body posture. (iv) suitable clothes.

PERFORMANCE STANDARD

SUPPORT AND MOVEMENT IN HUMANS AND ANIMALS

PERFORMANCE LEVEL	DESCRIPTOR
1	**Recall** the knowledge and basic scientific skills of support and movement in humans and animals.
2	**Understand** and able to explain support and movement in humans and animals.
3	**Apply** knowledge and skills about support and movement in humans and animals to carry out simple task.
4	**Analyse** information about support and movement in humans and animals and apply science skills in the context of **problem solving.**
5	**Evaluate** to make judgement about support and movement in humans and animals and apply science skills in the context of **problem solving and decision making** to carry out a task.
6	**Create** using knowledge and scientific skills related to support and movement in humans and animals in the context of **problem solving and decision making** or carrying out an assignment in a new situation creatively and innovatively giving due consideration to the social values/ economy/ culture of the community

15.0 SEXUAL REPRODUCTION, DEVELOPMENT AND GROWTH IN HUMANS AND ANIMALS

CONTENT STANDARD	LEARNING STANDARD	NOTE
15.1 Reproductive System of Humans	Pupils are able to: 15.1.1 Characterise the anatomy of: (i) male reproductive system. (ii) female reproductive system.	**Note:** Pupils have been introduced to the human reproductive system in Form 1.
15.2 Gametogenesis in Humans	Pupils are able to: 15.2.1 Justify the necessity of gametogenesis. 15.2.2 Describe gamete formation: (i) spermatogenesis. (ii) oogenesis. 15.2.3 Identify the structure of: (i) sperm - head - middle piece - tail (ii) Graafian follicle - secondary oocyte - follicular cells	**Note:** The hormones in spermatogenesis: FSH, LH and testosterone. The hormones in oogenesis: FSH, LH, oestrogen and progesterone.

CONTENT STANDARD	LEARNING STANDARD	NOTE
	15.2.4 Compare and contrast between spermatogenesis and oogenesis.	
15.3 Menstrual Cycle	Pupils are able to: 15.3.1 Analyse the changes in the levels of hormones involved during: (i) menstruation. (ii) folicle development. (iii) thickening of the endometrium. (iv) ovulation. (v) corpus luteum formation. 15.3.2 Correlate the changes in the levels of hormones involved with: (i) pregnancy. (ii) miscarriage. 15.3.3 State the meaning of premenstrual syndrome and menopausal syndrome.	**Note:** Pupils have been introduced to the menstrual cycle in Form 1. The hormones that are discussed: FSH, LH, oestrogen and progesterone. **Suggested activity:** Determine the ovulation day if the menstrual cycle is not 28 days (irregular). **Suggested activity:** Discuss the andropause syndrome.
15.4 Development of Human Foetus	Pupils are able to: 15.4.1 Describe fertilisation process and the formation of zygotes.	**Note:** Pupils have been introduced to fertilisation and pregnancy in Form 1.

CONTENT STANDARD	LEARNING STANDARD	NOTE
	15.4.2 Make a sequences and explain the early development of an embryo until implantation: (i) two-celled embryo. (ii) morula. (iii) blastocyst. 15.4.3 Explain the role of human chorionic gonadotropin (HCG) hormone in the early stages of pregnancy. 15.4.4 Communicate about the roles of following structures in the development of a foetus: (i) placenta. (ii) umbilical cord. 15.4.5 Justify the necessity for separate foetal and maternal blood circulatory systems.	**Note:** Pupils have learned the importance and functions of the placenta and umbilical cord in Form 1.
15.5 Formation of Twins	Pupils are able to: 15.5.1 Describe the processes in the formation of twins: (i) identical twins. (ii) fraternal twins.	

CONTENT STANDARD	LEARNING STANDARD	NOTE
	15.5.2 Compare and contrast between identical and fraternal twins. 15.5.3 Correlate cellular division with the formation of conjoined twins.	**Suggested activity:** Gather information on the lives of conjoined twins and surgeries that can be done.
15.6 Health Issues Related to the Human Reproductive System	Pupils are able to: 15.6.1 State the meaning of impotency. 15.6.2 Communicate about causes of human impotency.	**Note:** Pupils have been introduced to impotency and prevention of pregnancies in Form 1. **Suggested activity:** Debate on the advantages and disadvantages of the contribution of science and technology in human reproduction.
15.7 Growth in Humans and Animals	Pupils are able to: 15.7.1 Explain the meaning of growth in organisms. 15.7.2 Determine parameters to measure growth in humans and animals.	

CONTENT STANDARD	LEARNING STANDARD	NOTE
	15.7.3 Describe the growth of insects with exoskeleton: • complete metamorphosis. • incomplete metamorphosis.	**Suggested activity:** Conduct a project and gather data to study metamorphosis in insects.
	15.7.4 Analyse the growth phases on sigmoid growth curves of humans and animals. 15.7.5 Analyse the staircase-shaped growth curve of animals with exoskeletons.	**Note:** The phases in a sigmoid growth curve: (i) lag phase. (ii) rapid growth phase. (iii) slow growth phase. (iv) stationary phase. (v) senescense (vi) death phase.

PERFORMANCE STANDARD

SEXUAL REPRODUCTION, DEVELOPMENT AND GROWTH IN HUMANS AND ANIMALS

PERFORMANCE LEVEL	DESCRIPTOR
1	**Recall** the knowledge and basic scientific skills of sexual reproduction, development and growth in humans and animals.
2	**Understand** and able to explain sexual reproduction, development and growth in humans and animals.
3	**Apply** knowledge and skills about sexual reproduction, development and growth in humans and animals to carry out simple task.
4	**Analyse** information about sexual reproduction, development and growth in humans and animals and apply science skills in the context of **problem solving.**
5	**Evaluate** to make judgement about sexual reproduction, development and growth in humans and animals and apply science skills in the context of **problem solving and decision making** to carry out a task.
6	**Create** using knowledge and scientific skills related to sexual reproduction, development and growth in humans and animals in the context of **problem solving and decision making** or carrying out an assignment in a new situation creatively and innovatively giving due consideration to the social values/ economy/ culture of the community.

Content Standard,
Learning Standard
and Performance Standard
Form Five

THEME 3

PHYSIOLOGY OF FLOWERING PLANTS

LEARNING AREA

16.0 Organisation of Plant Tissues and Growth

17.0 Leaf Structure and Function

18.0 Nutrition in Plants

19.0 Transport in Plants

20.0 Responses in Plants

21.0 Sexual Reproduction in Flowering Plants

22.0 Adaptations of Plants in Different Habitats

Theme 3: **PHYSIOLOGY OF FLOWERING PLANTS**

This theme aims to give a basic understanding of plant physiological processes. This theme introduces tissue organisation, growth, leaf structure and function, nutrition, transport, response, sexual reproduction in flowering plants and adaptations of plants in different habitats.

Learning Area:

16.0 Organisation of Plant Tissues and Growth
- 16.1 Organisation of Plant Tissues
- 16.2 Meristematic Tissues and Growth
- 16.3 Growth Curves

17.0 Structure and Function of leaf
- 17.1 Structure of a Leaf
- 17.2 Main Organ for Gaseous Exchange
- 17.3 Main Organ for Transpiration
- 17.4 Main Organ for Photosynthesis
- 17.5 Compensation Point

18.0 Nutrition in Plants
- 18.1 Main Inorganic Nutrients
- 18.2 Uptake of Water and Mineral Salts
- 18.3 Diversity in Plant Nutrition

19.0 Transportation in Plants
- 19.1 Vascular Tissues
- 19.2 Transport of Water and Mineral Salts
- 19.3 Translocation
- 19.4 Phytoremediation

16.0 ORGANISATION OF PLANT TISSUES AND GROWTH

CONTENT STANDARD	LEARNING STANDARD	NOTES
16.1 Organisation of Plant Tissues	**Pupils are able to:** 16.1.1 Communicate about the types of plant tissue and their main functions.	**Note:** Types of tissue and main functions: (i) meristematic tissues. (ii) permanent tissues: - epidermal tissue - ground tissue - vascular tissue **Suggested activity:** Gather information and carry out a presentation about the uses of plant tissues in everyday life.
16.2 Meristematic Tissues and Growth	**Pupils are able to:** 16.2.1 Identify the types and parts of tissue involved in growth. 16.2.2 Describe positions of zone of cell division, zone of cell elongation and zone of cell differentiation in shoots and roots.	**Notes:** Types of meristematic tissue: (i) apical meristems (tips of shoots and tips of roots). (ii) lateral meristems (vascular cambium and cork cambium).

CONTENT STANDARD	LEARNING STANDARD	NOTES
	16.2.3 Identify zone of cell division, zone of cell elongation and zone of cell differentiation in a seed radicle.	**Suggested activity:** Prepare a microscope slide: (i) zone of cell division. (ii) zone of cell elongation. (iii) zone of cell differentiation.
	16.2.4 Describe types of growth: (i) primary. (ii) secondary.	
	16.2.5 Justify the necessity of primary growth and secondary growth.	**Suggested activity:** Gather information about the necessity of primary growth in terms of height, support and transport and secondary growth for additional support and transport.
	16.2.6 Compare and contrast primary growth and secondary growth in eudicotyledon plants.	Gather information about types of monocotyledon plants that undergo anomalous secondary growth and present the findings.
	16.2.7 Assess the economic importance of plants that have undergone secondary growth.	**Suggested activity:** Gather information about types and uses of timber in Malaysia from agencies such as: (i) Forestry Department of Peninsular Malaysia / Sabah / Sarawak. (ii) Malaysian Timber Industry Board (MTIB).

CONTENT STANDARD	LEARNING STANDARD	NOTES
16.3 Growth Curves	**Pupils are able to:**	
	16.3.1 Describe types of plants based on their life cycles.	**Suggested activity:** Gather information about: (i) annual plants. (ii) biennial plants. (iii) perennial plants. Identify the types of plants in school based on their life cycles using ICT.
	16.3.2 Analyse growth curves of: (i) annual plants. (ii) biennial plants. (iii) perennial plants.	**Suggested activity:** Gather information about growth curves.
	16.3.3 Conduct an experiment to study the effects of factor on the growth curve of a plant.	Design an experiment to study the effects of sound on plant growth. Design an auxanometer to measure the rate of plant elongation.

PERFORMANCE STANDARD

ORGANISATION OF PLANT TISSUES AND GROWTH

PERFORMANCE LEVELS	DESCRIPTOR
1	**Recall** the knowledge and basic science skills of organisation of plant tissues and growth.
2	**Understand** and able to explain the organisation of plant tissues and growth.
3	**Apply** knowledge and skills about organisation of plant tissues and growth to explain events or phenomena to carry out simple task.
4	**Analyse** information about organisation of plant tissues and growth and apply science skills in the context of **problem solving.**
5	**Evaluate** to make judgement about organisation of plant tissues and growth in the context of problem solving and apply science skills in the context of **problem solving and decision making** to carry out a task.
6	**Create** using knowledge and scientific skills related to organisation of plant tissues and growth in the context of **problem solving and decision making** or carrying out an assignment in a new situation creatively and innovatively giving due consideration to the social values/ economy/ culture of the community

17.0 LEAF STRUCTURE AND FUNCTION

CONTENT STANDARD	LEARNING STANDARD	NOTES
17.1 Structure of Leaf	**Pupils are able to:** 17.1.1 Describe external structures of a leaf: (i) lamina. (ii) petiole. 17.1.2 Identify internal structures of a leaf lamina: (i) upper epidermis. (ii) palisade mesophyll. (iii) spongy mesophyll. (iv) lower epidermis. (v) vascular bundle.	**Suggested activity**: Collect specimens and prepare a herbarium according to leaf structures. **Suggested activity**: Draw and label a cross-sectional diagram of a leaf as seen through the light microscope. Observe prepared microscope slides of cross-sections of monocotyledon and eudicotyledon leaves.
17.2 Main Organ for Gaseous Exchange	**Pupils are able to:** 17.2.1 Justify the necessity of gaseous exchange in plants.	

CONTENT STANDARD	LEARNING STANDARD	NOTES
	17.2.2 Explain the mechanism of stomatal opening and closing based on: (i) the uptake of potassium ions. (ii) changes in sucrose concentration.	**Suggested activity**: Prepare a microscope slide to observe and describe the condition of guard cells of spider lily plants or any other plant. Design a model to relate the mechanism of stomatal opening and closing to uptake of potassium ions and changes in sucrose concentration.
	17.2.3 Conduct an experiment to compare stomatal distribution on upper and lower epidermis of monocotyledon and eudicotyledon leaves.	**Suggested activity**: Design a microbalance to compare water loss from the upper and lower epidermis of a leaf.
	17.2.4 Predict with explanation the effect of water deficiency in plants on stomatal opening and closing.	
17.3 Main Organ for Transpiration	**Pupils are able to:** 17.3.1 Justify the necessity of transpiration in plants.	
	17.3.2 Describe environmental factors that affect rate of transpiration: (i) light intensity. (ii) temperature. (iii) air movement. (iv) relative air humidity.	**Suggested activity**: Conduct an experiment to determine the rate of transpiration in a plant. Gather and interpret data on the effects of light intensity, temperature, air movement and relative air humidity on rate of transpiration.

CONTENT STANDARD	LEARNING STANDARD	NOTES
	17.3.3 Conduct experiments to study the effects of environmental factors on rate of transpiration using a potometer.	**Suggested activity**: Design experiments to study the effects of pollution levels, leaves positions and plant locations on rate of transpiration in plants.
17.4 Main Organ for Photosynthesis	**Pupils are able to:** 17.4.1 Justify the necessity of photosynthesis in plants.	**Suggested activity**: Carry out a group discussion and make multimedia presentation about the history of the discovery of photosynthesis.
	17.4.2 Relate the adaptations of internal structure of a leaf to photosynthesis.	Conduct a study on adaptations of plants to optimize photosynthesis: (i) mosaic arrangement of leaves (ii) orientation of eudicotyledon leaves
	17.4.3 Identify structures of a chloroplast: (i) granum. (ii) thylakoid. (iii) stroma.	Conduct an investigation to separate photosynthetic pigments in a leaf using paper chromatography.
	17.4.4 Relate light-dependent and light-independent reactions in photosynthesis.	**Suggested activity**: Carry out a discussion to gather information about light-dependent and light-independent reactions in photosynthesis based on: (i) materials required. (ii) sites of reactions. (iii) products of reactions.

CONTENT STANDARD	LEARNING STANDARD	NOTES
	17.4.5 Write a chemical equation to represent the process of photosynthesis. 17.4.6 Compare and contrast light-dependent and light-independent reactions in photosynthesis. 17.4.7 Explain environmental factors that affect the rate of photosynthesis: (i) light intensity. (ii) temperature. (iii) concentration of carbon dioxide. 17.4.8 Conduct experiments to study effects of environmental factors on the rate of photosynthesis. 17.4.9 Analyse the effects of different light intensities and colours of light on the rates of photosynthesis.	**Suggested activity**: Design an indoor greenhouse. **Suggested activity**: Design an experiment to identify the best colour of light for maximum rate of photosynthesis in an aquatic plant. **Suggested activity**: Prepare a proposal on ways to increase agricultural yields for countries with four seasons based on the factors affecting the rate of photosynthesis.
17.5 Compensation Point	**Pupils are able to:** 17.5.1 Describe compensation point.	

CONTENT STANDARD	LEARNING STANDARD	NOTES
	17.5.2 Compare and contrast photosynthesis and cellular respiration in plants.	
	17.5.3 Analyse light intensity and attainment of compensation point using a graph.	**Suggested activity**: Carry out a discussion on the attainment of compensation point for plants that grow in direct sunlight and in shade.
	17.5.4 Predict the effect on plant growth if the rate of photosynthesis and the rate of cellular respiration remain at its compensation point.	**Suggested activity**: Conduct a study to verify the prediction about the effect on plant growth if the rates of photosynthesis and cellular respiration remain at its compensation point.

PERFORMANCE STANDARD

LEAF STRUCTURE AND FUNCTION

PERFORMANCE LEVELS	DESCRIPTOR
1	**Recall** the knowledge and basic science skills of organisation of leaf structure and function.
2	**Understand** and able to explain organisation of leaf structure and function.
3	**Apply** knowledge about organisation of leaf structure and function to explain events or phenomena of nature and conduct a simple task.
4	**Analyse** information about organisation of leaf structure and function and apply science skills in the context of **problem solving.**
5	**Evaluate** to make judgement about organisation of leaf structure and function and apply science skills in the context of **problem solving and decision making** to carry out a task.
6	**Create** using knowledge and scientific skills related to organisation of leaf structure and function in the context of **problem solving and decision making** or carrying out an assignment in a new situation creatively and innovatively giving due consideration to the social values/ economy/ culture of the community.

18.0 NUTRITION IN PLANTS

CONTENT STANDARD	LEARNING STANDARD	NOTES
18.1 Main Inorganic Nutrients	**Pupils are able to:**	
	18.1.1 Identify macronutrients and micronutrients required by plants.	**Note:** Main inorganic nutrients for plants: (i) Macronutrients (carbon, oxygen, hydrogen, nitrogen, potassium, calcium, magnesium, phosphorus and sulfur). (ii) Micronutrients (chlorine, iron, manganese, boron, zinc, copper, nickel and molybdenum).
	18.1.2 Justify the necessity of macronutrients and micronutrients in plants.	**Suggested activity**: Conduct an experiment to investigate effects of macronutrient ratios on plant growth. **Suggested activity**: Conduct an experiment to investigate effects of nitrogen: phosphorus: potassium (N: P: K) ratios on the growth of an identified plant. (Example: corn)
18.2 Organ for Water and Mineral Salts Uptake	**Pupils are able to:**	
	18.2.1 Describe the root structure for water and mineral salts uptake.	**Suggested activity**: Observe prepared microscope slides of cross sections of monocotyledon and eudicotyledon roots.
	18.2.2 Justify root adaptations for water and mineral salts uptake.	

CONTENT STANDARD	LEARNING STANDARD	NOTES
18.3 Diversity in Plant Nutrition	**Pupils are able to:** 18.3.1 Describe nutritional adaptations of plants.	**Suggested activity**: Gather information about plants: (i) carnivorous. (ii) parasitic. (iii) epiphytic. Conduct a field study on the effects of habitat change on plant growth: (i) carnivorous. (ii) parasitic. (iii) epiphytic.

PERFORMANCE STANDARD

NUTRITION IN PLANTS

PERFORMANCE LEVELS	DESCRIPTOR
1	**Recall** the knowledge and basic science skills of nutrition in plants.
2	**Understand** and able to explain the nutrition in plants.
3	**Apply** knowledge and skills about nutrition in plants to carry out simple task.
4	**Analyse** information about nutrition in plants and apply science skills in the context of **problem solving.**
5	**Evaluate** to make judgement about nutrition in plants and apply science skills in the context of **problem solving and decision making** to carry out a task.
6	**Create** using knowledge and scientific skills related to nutrition in plants in the context of problem solving and decision making or conduct an activity/ a task in a new situation creatively and innovatively by considering social/ economy/ culture of society.

19.0 TRANSPORT IN PLANT

CONTENT STANDARD	LEARNING STANDARD	NOTES
19.1 Vascular Tissues	**Pupils are able to:** 19.1.1 Justify the necessity of transport in plants. 19.1.2 Relate structural adaptations of xylem vessels and tracheids to transport water and mineral salts. 19.1.3 Relate the structural adaptations of sieve tubes and companion cells to the transportation of organic substances.	**Suggested activity:** Carry out an activity to observe the structure of xylem in a longitudinal section of a celery stalk. Study the role of xylem tissue in the transport of water and mineral salts in stems of herbaceous plants.
19.2 Transport of Water and Mineral Salts	**Pupils are able to:** 19.2.1 Describe factors involved in the pathway of water and mineral salts from soil to shoots: (i) root pressure. (ii) capillary action. (iii) transpirational pull.	**Suggested activity:** Conduct an experiment to study the effect of root pressure on water transport. Conduct an experiment to study the effect of transpirational pull on water transport. Produce multi coloured flowers by applying the concept of water transport in xylem and market them in school.

CONTENT STANDARD	LEARNING STANDARD	NOTES
	19.2.2 Explain guttation in plants. 19.2.3 Compare and contrast guttation and transpiration in plants. 19.2.4 Predict the condition of plants that do not undergo transpiration and guttation.	**Suggested activity:** Watch videos and use thinking tools to compare and contrast guttation and transpiration.
19.3 Translocation	**Pupils are able to:** 19.3.1 Define translocation. 19.3.2 Justify the necessity of translocation in plants. 19.3.3 Describe pathways of translocation in plants.	**Suggested activity:** Conduct an experiment to study the role of phloem tissue in the transport of organic substances. **Note:** Translocation pathways from green leaves to other organs such as: (i) roots. (ii) shoots. (iii) stems. (iv) fruits.

CONTENT STANDARD	LEARNING STANDARD	NOTES
19.4 Phytoremediation	**Pupils are able to:** 19.4.1 Define phytoremediation.	
	19.4.2 Explain the uses of phytoremediation in life.	**Suggested activity:** Gather information about phytoremediation.
	19.4.3 Conduct experiments to study the effectiveness of phytoremediation plants in controlling: (i) water pollution. (ii) soil pollution.	**Suggested activity:** Conduct an experiment to identify the most effective phytoremediation aquatic plant.

PERFORMANCE STANDARD

TRANSPORT IN PLANTS

PERFORMANCE LEVELS	DESCRIPTOR
1	**Recall** the knowledge and basic science skills of organisation of transport in plants.
2	**Understand** and able to explain transport in plants.
3	**Apply** knowledge and skills about transport in plants to carry out simple task.
4	**Analyse** information about transport in plants and apply science skills in the context of **problem solving.**
5	**Evaluate** to make judgement about transport in plants and apply science skills in the context of **problem solving and decision making** to carry out a task.
6	**Create** using knowledge and scientific skills related to transport in in the context of **problem solving and decision making** or carrying out an assignment in a new situation creatively and innovatively giving due consideration to the social values/ economy/ culture of the community.

20.0 RESPONSE IN PLANTS

CONTENT STANDARD	LEARNING STANDARD	NOTES
20.1 Types of Responses	**Pupils are able to:** 20.1.1 Describe types of plant responses: (i) tropism. (ii) nastic.	**Suggested activity:** Compare and contrast tropism and nastic responses in plants using thinking tools.
20.2 Phytohormone	**Pupils are able to:** 20.2.1 Describe phytohormone. 20.2.2 State the functions of phytohormones: (i) auxins. (ii) gibberellins. (iii) cytokinins. (iv) abscisic acid. (v) ethylene. 20.2.3 Make inferences on effects of auxins on growth response. 20.2.4 Explain the roles of auxins in plant responses. (i) phototropism. (ii) geotropism.	**Suggested activity:** Conduct a study on the discovery of phytohormones and present the findings. Gather information about: (i) functions of phytohormones. (ii) effects of auxins on growth response. (iii) roles of auxins in plant responses. **Suggested activity**: Design an experiment to study the responses of radicle and plumule of a seedling towards gravitational pull.

CONTENT STANDARD	LEARNING STANDARD	NOTES
20.3 Application of Phytohormones in Agriculture	**Pupils are able to:** 20.3.1 Justify uses of phytohormones in agriculture. 20.3.2 Conduct an experiment to compare the effects of presence of a phytohormone on fruit ripening.	**Suggested activity**: Prepare a plant rooting hormone. Conduct a study on the effects of auxins:cytokinin ratios on plant growth in tissue culture and present the findings.

PERFORMANCE STANDARD

RESPONSE IN PLANTS

PERFORMANCE LEVELS	DESCRIPTOR
1	**Recall** the knowledge and basic science skills of responses in plants.
2	**Understand** and able to explain responses in plants.
3	**Apply** knowledge and skills about responses in plants to carry out simple task.
4	**Analyse** knowledge about responses in plants and apply science skills in the context of **problem solving.**
5	**Evaluate** to make judgement about responses in plants and apply science skills in the context of **problem solving and decision making** to carry out a task.
6	**Create** using knowledge and scientific skills related to responses in plants in the context of **problem solving and decision making** or carrying out an assignment in a new situation creatively and innovatively giving due consideration to the social values/ economy/ culture of the community.

21.0 SEXUAL REPRODUCTION IN FLOWERING PLANTS

CONTENT STANDARD	LEARNING STANDARD	NOTES
21.1 Structure of a Flower	**Pupils are able to:** 21.1.1 Identify structures of a flower. 21.1.2 Compare and contrast male and female structures in a flower.	**Suggested activity**: Dissect a flower, draw and label the structures and state the function of peduncle, sepal, petal, carpel (stigma, style, ovary) and stamen (filament and anther).
21.2 Development of Pollen Grains and Embryo Sac	**Pupils are able to:** 21.2.1 Describe the formation of pollen grains in an anther. 21.2.2 Describe the formation of embryo sac in an ovule.	**Suggested activity**: Prepare and observe microscope slides of pollen grains of various plants, and describe their shapes. Use thinking tools to show stages in the formation of: (i) pollen grains from a pollen mother cell. (ii) embryo sac from an embryo sac mother cell.
21.3 Pollination and Fertilization	**Pupils are able to:** 21.3.1 Describe pollination. 21.3.2 Describe the formation of pollen tube and the formation of male gametes.	**Suggested activity**: Conduct activities to observe the germination of pollen grains and the formation of pollen tubes in a sugar solution through the light microscope.

CONTENT STANDARD	LEARNING STANDARD	NOTES
	21.3.3 Explain double fertilization in the formation of diploid zygote and triploid nucleus. 21.3.4 Justify the importance of double fertilization for the survival of flowering plants.	**Suggested activity**: Use thinking tools to explain double fertilization which includes: (i) formation of two male nuclei from a generative nucleus. (ii) formation of triploid endosperm nucleus. (iii) formation of zygote.
21.4 Development of Seeds and Fruits	**Pupils are able to:** 21.4.1 Describe double fertilization and development of seeds and fruits. 21.4.2 Relate the structure of seeds to ovules.	**Suggested activity**: Observe the structures of fruits such as mangoes and legumes, and relate the structures of flowers to fruits: (i) seeds from ovules. (ii) seed coats from integuments. (iii) fruits from ovaries.

CONTENT STANDARD	LEARNING STANDARD	NOTES
	21.4.3 Relate the structure of fruit to ovary.	Carry out a multimedia presentation on the development of fruits from flowers. Collect specimens to study types of fruits: (i) simple. (ii) aggregates. (iii) multiple. (iv) accessories.
21.5 Importance of Seeds for Survival	**Pupils are able to:** 21.5.1 Justify the importance of seeds for plant survival.	**Suggested activity**: Gather information and carry out a presentation about human actions on the production of seeds in plants. Examples: notching of tree trunks.

PERFORMANCE STANDARD

SEXUAL REPRODUCTION IN FLOWERING PLANTS

PERFORMANCE LEVELS	DESCRIPTOR
1	**Recall** the knowledge and basic science skills of sexual reproduction in flowering plants.
2	**Understand** and able to explain sexual reproduction in flowering plants.
3	**Apply** knowledge and skills about sexual reproduction in flowering plants to carry out simple task.
4	**Analyse** information about sexual reproduction in flowering plants and apply science skills in the context of **problem solving.**
5	**Evaluate Evaluate** to make judgement about sexual reproduction in flowering and apply science skills in the context of **problem solving and decision making** to carry out a task.
6	**Create** using knowledge and scientific skills related to sexual reproduction in flowering plants in the context of **problem solving and decision making** or carrying out an assignment in a new situation creatively and innovatively giving due consideration to the social values/ economy/ culture of the community.

22.0 ADAPTATIONS OF PLANTS IN DIFFERENT HABITATS

CONTENT STANDARD	LEARNING STANDARD	NOTES
22.1 Adaptations of Plants in Different Habitats	**Pupils are able to:**	
	22.1.1 Classify plants based on habitats.	**Note:** Classification of plants based on habitats: (i) mesophytes. (ii) hydrophytes. (iii) halophytes. (iv) xerophytes. **Suggested activity:** Gather information about classification of plants based on habitats.
	22.1.2 Describe the adaptive features of mesophytes, hydrophytes, halophytes and xerophytes in terms of: (i) uptake of water and mineral salts. (ii) gaseous exchange. (iii) support. (iv) photosynthesis.	**Suggested activity:** Conduct visits to botanical gardens/ herbal gardens/ agricultural parks to observe adaptive features of plants in different habitats. Conduct a case study on adaptive features of plants in different climates.

STANDARD PERFORMANCE

ADAPTATIONS OF PLANTS IN DIFFERENT HABITATS

PERFORMANCE LEVELS	DESCRIPTOR
1	**Recall** the knowledge and basic science skills of adaptations of plants in different habitats.
2	**Understand** and able to explain adaptations of plants in different habitats.
3	**Apply** knowledge and skills about adaptations of plants in different habitats to carry out simple task.
4	**Analyse** information about adaptations of plants in different habitats and apply science skills in the context of **problem solving.**
5	**Evaluate** to make judgement about adaptations of plants in different and apply science skills in the context of **problem solving and decision making** to carry out a task.
6	**Create** using knowledge and scientific skills related to adaptations of plants in different habitats in the context of **problem solving and decision making** or carrying out an assignment in a new situation creatively and innovatively giving due consideration to the social values/ economy/ culture of the community.

THEME 4

ECOSYSTEM AND THE ENVIRONMENTAL SUSTAINABILITY

LEARNING AREA

23.0 Biodiversity
24.0 Ecosystem
25.0 Environmental Sustainability

Theme 4: **ECOSYSTEM AND ENVIRONMENTAL SUSTAINABILITY**

This theme aims to give an understanding of biodiversity, ecosystem and environmental sustainabilty. This theme encompasses studies on biodiversity, population ecology and practices in preserving, conserving and restoring ecosystems. It also emphasises applications of green technology.

Learning area:

23.0 Biodiversity
- 23.1 System of Classification and Naming of Organisms
- 23.2 Biodiversity
- 23.3 Microorganisms and Viruses

24.0 Ecosystem
- 24.1 Community and Ecosystem
- 24.2 Population Ecology

25.0 Environmental Sustainability
- 25.1 Threats to the Environment
- 25.2 Preservation, Conservation and Restoration of Ecosystems
- 25.3 Environmental Sustainability Practices
- 25.4 Green Technology

23.0 BIODIVERSITY

CONTENT STANDARD	LEARNING STANDARD	NOTES
23.1 Classification System and Naming of Organisms	**Pupils are able to:** 23.1.1 Explain the necessity of classification system and naming of organisms	
	23.1.2 Describe the hierarchical classification of organisms into six kingdoms: (i) Archaebacteria. (ii) Eubacteria. (iii) Protista. (iv) Fungi. (v) Plantae. (vi) Animalia.	**Note:** Hierarchy of taxa from kingdom to species.
	23.1.3 Describe the main features of organisms in each kingdom.	**Suggested activity:** Gather information and present the main features of organisms in every kingdom. **Note:** Examples of organisms in each kingdom: (i) Archaebacteria: Sulfur Bacteria. (ii) Eubacteria: *Thermus Aquaticus* (Taq). (iii) Protista: Protozoa, algae and slime mold. (iv) Fungi: Yeast and multicellular fungi (mushroom). (v) Plantae: seedless plants and plants with seeds.

CONTENT STANDARD	LEARNING STANDARD	NOTES
		(vi) Animalia: invertebrates and vertebrates.
	23.1.4 Describe the naming of organisms according to the Binomial Nomenclature System.	**Suggested activity:** Gather information and carry out a presentation about the history of classification systems. Conduct a field study in school to name plants according to the Binomial Nomenclature System.
	23.1.5 Construct dichotomous keys to classify organisms.	
23.2 Biodiversity	**Pupils are able to:**	
	23.2.1 Synthesise the concept of biodiversity based on diversities of: (i) ecosystem. (ii) species. (iii) genetic.	**Suggested activity:** Conduct a field study at a botanical garden/ agricultural park and carry out a presentation on diversity of *in situ* species.
	23.2.2 Describe the meaning of phylogenic tree.	**Suggested activity:** Construct a phylogenic tree for each kingdom.
	23.2.3 Justify the importance of biodiversity on the environment and humans.	**Suggested activity:** Discuss the effects of loss of biodiversity on the environment and humans.

CONTENT STANDARD	LEARNING STANDARD	NOTES
23.3 Microorganisms and Viruses	**Pupils are able to:**	
	23.3.1 Identify the main characteristics of microorganisms and viruses: (i) bacteria. (ii) protozoa. (iii) algae. (iv) fungi. (v) viruses.	**Suggested activity:** Debate on the status of a virus as a non-living thing. Prepare and observe microscope slides of bacteria (from yogurt), fungi (yeasts) and algae (spirogyra).
	23.3.2 Describe the roles of microorganisms in nitrogen cycle.	**Suggested activity:** Conduct activities to study the role of nitrogen fixing bacteria in plants.
	23.3.3 Explain the roles of microorganisms as: (i) producers. (ii) decomposers. (iii) symbions. (iv) parasites.	
	23.3.4 Define the terms: (i) pathogens. (ii) vectors.	**Suggested activity:** Design an eco-friendly vector trap/ repellent.

CONTENT STANDARD	LEARNING STANDARD	NOTES
	23.3.5 Explain the effects of pathogens on human health.	**Suggested activity:** Gather information and carry out a presentation about pathogenic diseases caused by: (i) viruses (e.g.: *Human papilloma virus*). (ii) bacteria (e.g.:*Salmonella* sp.). (iii) protozoa (e.g.:*Plasmodium* sp.). (iv) fungi (e.g.:*Tinea* sp.).

STANDARD PERFORMANCE

BIODIVERSITY

PERFORMANCE LEVELS	DESCRIPTOR
1	**Recall** the knowledge and basic science skills of biodiversity.
2	**Understand** and able to explain biodiversity.
3	**Apply** knowledge and skills about biodiversity to carry out simple task.
4	**Analyse** information about biodiversity and apply science skills in the context of **problem solving.**
5	**Evaluate** to make judgement about biodiversity and apply science skills in the context of **problem solving and decision making** to carry out a task.
6	**Create** using knowledge and scientific skills related to biodiversity in the context of **problem solving and decision making** or carrying out an assignment in a new situation creatively and innovatively giving due consideration to the social values/ economy/ culture of the community.

24.0 ECOSYSTEM

CONTENT STANDARD	LEARNING STANDARD	NOTES
24.1 Community and Ecosystem	**Pupils are able to:** 24.1.1 Define the terms: (i) species. (ii) population. (iii) community. (iv) habitat. (v) niche. (vi) ecosystem.	
	24.1.2 Identify biotic and abiotic components in an ecosystem.	**Suggested activity:** Gather information about biotic and abiotic components. Identify biotic and abiotic components in the school field or pond.
	24.1.3 Explain autotrophic and heterotrophic nutritions.	**Note:** Types of autotrophic nutrition: (i) photoautotrophic. (ii) chemoautotrophic. Types of heterotrophic nutrition: (i) saprotrophic. (ii) holozoic. (iii) parasitic.

CONTENT STANDARD	LEARNING STANDARD	NOTES
	24.1.4 Communicate about biotic components according to trophic levels.	**Suggested activity:** Classify biotic components into three groups: (i) producers. (ii) consumers. (iii) decomposers.
	24.1.5 Describe energy flow in a food chain.	Construct a food chain and a food web for biotic components in the school field or pond.
	24.1.6 Describe ecological pyramids: (i) pyramid of numbers. (ii) pyramid of biomass. (iii) pyramid of energy.	Draw, label and discuss inverted pyramids of numbers and biomass.
	24.1.7 Analyse types of interactions between biotic components: (i) parasitism. (ii) commensalism. (iii) mutualism. (iv) saprophytism. (v) competition. (vi) predation.	**Suggested activity:** Analyse the interactions between organisms from videos watched. Conduct an experiment to study the effects of intraspecific and interspecific competitions between organisms.

CONTENT STANDARD	LEARNING STANDARD	NOTES
	24.1.9 Explain a mangrove ecosystem in terms of: (i) biotic components. (ii) abiotic components. (iii) adaptations of mangrove trees. (iv) colonisation and succession. (v) its importance.	**Suggested activity:** Conduct studies and carry out a presentation on the importance of a mangrove ecosystem as in: (i) charcoal industry. (ii) cottage industry (e.g.: production of *atap nipah*, cockles, shrimps, crabs and palm sugar).
24.2 Population Ecology	**Pupils are able to:** 24.2.1 Describe factors affecting population distribution. 24.2.2 Analyse data to estimate population size of organisms using: (i) quadrat sampling technique. (ii) capture-mark-release-recapture technique.	**Note:** Parameters involved in quadrat sampling: (i) frequency. (ii) density. (iii) cover. **Suggested activity:** i. Conduct a field study to estimate plant population size in the school field. ii. Conduct a field study to estimate animal population size. iii. Conduct a field study to the effects of abiotic components on the population of an organism.

STANDARD PERFORMANCE

ECOSYSTEM

PERFORMANCE LEVELS	DESCRIPTOR
1	**Recall** the knowledge and basic science skills of ecosystem.
2	**Understand** and able to explain ecosystem.
3	**Apply** knowledge and skills about ecosystem to carry out simple task.
4	**Analyse** information about ecosystem and apply science skills in the context of **problem solving.**.
5	**Evaluate** to make judgement about ecosystem and apply science skills in the context of **problem solving and decision making** to carry out a task.
6	**Create** using knowledge and scientific skills related to ecosystem in the context of **problem solving and decision making** or carrying out an assignment in a new situation creatively and innovatively giving due consideration to the social values/ economy/ culture of the community.

25.0 ENVIRONMENTAL SUSTAINABILITY

CONTENT STANDARD	LEARNING STANDARD	NOTES
25.1 Threats to Environment	**Pupils are able to:** 25.1.1 Describe the meaning of environmental sustainability. 25.1.2 Analyse threats to environment: (i) climate change. (ii) deforestation. (iii) pollutions. (iv) loss of biodiversity. (v) human population explosion. (vi) global warming. (vii) eutrophication.	**Suggested activity**: Discuss the threats of climate change to humans and the environment. Outline solutions to overcome problems caused by deforestation. Design an experiment to investigate the effects of water pH or temperature on the seed germination. Gather information about effects of air, light, and sound pollutions on humans and wildlife. Study and present the findings about the yearly development of United Nations Climate Change Conferences (COP). Debate on the necessity of development and the importance of environmental sustainability initiatives. Study the impact of human population explosion on the environment.

CONTENT STANDARD	LEARNING STANDARD	NOTES
	25.1.3 Conduct an experiment to compare the levels of Biochemical Oxygen Demand (BOD) in different water samples.	Prepare an action plan to reduce the levels of air and water pollution in school for the next ten years.
25.2 Preservation, Conservation and Restoration of Ecosystem	**Pupils are able to:** 25.2.1 Define the terms: (i) preservation of ecosystem. (ii) conservation of ecosystem. (iii) restoration of ecosystem. 25.2.2 Justify the necessity of: (i) preservation of ecosystem. (ii) conservation of ecosystem. (iii) restoration of ecosystem.	**Suggested activity**: Conduct a collaborative activity with other organisations to propose measures to preserve, conserve and restore the environment of a local area. **Note:** *In situ* and *ex situ* conservation and restoration of ecosystems. **Suggested activity**: Conduct a mini project to restore a mangrove ecosystem. Gather information from the Department of Wildlife and National Park (PERHILITAN) and present the findings about protected and totally protected organisms in Malaysia.

CONTENT STANDARD	LEARNING STANDARD	NOTES
25.3 Practices in Environmental Sustainability	25.3.1 Generate ideas related to practices that contribute to environmental Sustainability.	**Suggested activity**: Discuss initiatives to overcome environmental sustainability issues. Conduct studies on: (i) Sustainable Development Goals (SDGs). (ii) efforts by local authorities in support of Local Agenda 21 (LA 21). Construct a model city based on SDGs goals. Conduct an activity/ campaign to plant trees in school/ residential area. Practice buying goods with sustainable product logos. Conduct activities to upcycle waste materials.
	25.3.2 Discuss the status of food security in Malaysia.	**Suggested activity**: Gather information and carry out a presentation on steps to increase global food security.

CONTENT STANDARD	LEARNING STANDARD	NOTES
25.4 Green Technology	25.4.1 Define green technology.	**Suggested activity**: Gather information and present the findings about the four pillars of the National Green Technology policy: (i) energy. (ii) environment. (iii) economy. (iv) social.
	25.4.2 Justify the use of green technology in environmental sustainability.	**Suggested activity**: Build a green wall or vertical garden in school using solid wastes. Recycle kitchen wastes and expired food to produce natural fertilizers or plant growth inducer. Produce eco-enzyme as cleaning agents from fruit wastes. Produce foliar fertilizer as vegetable growth inducer from kitchen wastes. Produce flour as natural plasticine from banana peel. Produce biogas from solid organic wastes. Outline an action plan to overcome the energy consumption issues and the social responsibility in sustaining the environment of a local area.

CONTENT STANDARD	LEARNING STANDARD	NOTES
	25.4.3 Communicate about applications of social science to solve environmental problems and challenges.	**Suggested activity**: Problem-based learning: Conduct a collaborative study with local residents to identify and solve an environmental issue.

STANDARD PERFORMANCE

ENVIRONMENTAL SUSTAINABILITY

PERFORMANCE LEVELS	DESCRIPTOR
1	**Recall** the knowledge and basic science skills of sustainability of the environment.
2	**Understand** and able to explain sustainability of the environment.
3	**Apply** knowledge and skills about sustainability of the environment to carry out simple task.
4	**Analyse** information about sustainability of the and apply science skills in the context of **problem solving.**
5	**Evaluate** to make judgement about sustainability of the environment and apply science skills in the context of **problem solving and decision making** to carry out a task.
6	**Create** using knowledge and scientific skills related to the environment in the context of **problem solving and decision making** or carrying out an assignment in a new situation creatively and innovatively giving due consideration to the social values/ economy/ culture of the community.

THEME 5

INHERITANCE AND GENETIC TECHNOLOGY

LEARNING AREA

26.0 Inheritance

27.0 Variation

28.0 Genetic Engineering and Biotechnology

Theme 5: **INHERITANCE AND GENETIC TECHNOLOGY**

This theme aims to provide an understanding of inheritance, variation and genetic technology. Genetic and environmental factors play important roles in creating variation in a species. This theme also emphasises the application of genetic knowledge in the fields of genetic engineering and biotechnology.

Learning area:

26.0 Inheritance
- 26.1 Monohybrid Inheritance
- 26.2 Dihybrid Inheritance
- 26.3 Genes and Alleles
- 26.4 Inheritance in Humans

27.0 Variation
- 27.1 Types and Factors of Variation
- 27.2 Variations in Humans
- 27.3 Mutation

28.0 Genetic Technology
- 28.1 Genetic Engineering
- 28.2 Biotechnology

26.0 INHERITANCE

CONTENT STANDARD	LEARNING STANDARD	NOTES
26.1 Monohybrid Inheritance	**Pupils are able to:** 26.1.1 Describe the meaning of a monohybrid cross. 26.1.2 Explain a monohybrid cross based on Mendel's experiments. 26.1.3 Differentiate terms related to inheritance: (i) genes and alleles. (ii) characteristics and traits. (iii) phenotypes and genotypes. (iv) dominant alleles and recessive alleles. (v) dominant traits and recessive traits. (vi) homozygotes and heterozygotes. (vii) pure breeds and hybrids. (viii) parental generation and filial generations.	**Suggested activity**: Gather and present information about the history of Mendel's discovery. **Suggested activity**: Conduct activities to illustrate a monohybrid cross using coloured buttons/ beans. Present an analogy to illustrate a monohybrid cross. Construct a cross diagram to show the relationship among genes, traits, characteristics, alleles, genotypes, phenotypes, homozygotes and heterozygotes.

CONTENT STANDARD	LEARNING STANDARD	NOTES
	26.1.4 Construct monohybrid cross diagrams.	**Note:** Monohybrid cross diagrams include: (i) phenotypes and genotypes of parental generation. (ii) meiosis. (iii) gametes. (iv) fertilization. (v) genotypes and phenotypes of filial generations. (vi) genotypic and phenotypic ratios of filial generations.
	26.1.5 Determine genotypic and phenotypic ratios of filial generations in a monohybrid cross. 26.1.6 Describe Mendel's First Law .	**Note:** Genotypes and phenotypes of filial generations can be represented by using a Punnett square.
26.2 Dihybrid Inheritance	**Pupils are able to:** 26.2.1 Describe the meaning of a dihybrid cross. 26.2.2 Explain a dihybrid cross based on Mendel's experiments. 26.2.3 Construct a dihybrid cross diagram. 26.2.4 Determine genotypic and phenotypic ratios of filial generations in a dihybrid cross.	**Note:** Genotypes and phenotypes of filial generations can be represented by using a Punnett square.

CONTENT STANDARD	LEARNING STANDARD	NOTES
	26.2.5 Describe Mendel's Second Law.	**Suggested activity**: Gather and present information about Mendel's Second Law.
26.3 Genes and Alleles	**Pupils are able to:** 26.3.1 Describe the meaning of locus. 26.3.2 Relate alleles and loci to genes in a chromosome.	 **Suggested activity**: Make an analogy to relate alleles and loci to genes in a chromosome.
26.4 Inheritance in Humans	**Pupils are able to:** 26.4.1 Identify types of human chromosomes: (i) autosomes. (ii) sex chromosomes. 26.4.2 Analyse and describe human karyotypes.	 **Note:** Discuss karyotypes of males, females and individuals with different chromosomal numbers.

CONTENT STANDARD	LEARNING STANDARD	NOTES
	26.4.3 Match paternal and maternal chromosomes of humans in a drawing/ micrograph to build a complete karyotype of an individual.	
	26.4.4 Relate Mendel's Laws to human inheritance.	**Note:** Examples of human inheritance are: (i) ABO blood groups. (ii) Rhesus factor (Rh). (iii) thalassemia. (iv) ability to roll the tongue. (v) types of earlobe. (vi) sex determination. (vii) sex-linked inheritance (colour blindness, haemophilia). **Suggested activity**: Conduct a Ishihara test to identify inheritance of colour blindness among pupils.
	26.4.5 Analyse human inheritance by constructing inheritance cross diagrams.	**Suggested activity:** Construct a cross diagram to determine genotypic and phenotypic ratios.
	26.4.6 Analyse human inheritance by studying family pedigrees.	**Suggested activity**: Construct a family pedigree based on phenotypic and genotypic information among family members.

STANDARD PERFORMANCE

INHERITANCE

PERFORMANCE LEVELS	DESCRIPTOR
1	**Recall** the knowledge and basic science skills of inheritance.
2	**Understand** and able to explain the inheritance.
3	**Apply** knowledge and skills about inheritance to carry out simple task.
4	**Analyse** information about inheritance and apply science skills in the context of **problem solving.**
5	**Evaluate** to make judgement about and apply science skills in the context of **problem solving and decision making** to carry out a task.
6	**Create** using knowledge and scientific skills related to in the context of **problem solving and decision making** or carrying out an assignment in a new situation creatively and innovatively giving due consideration to the social values/ economy/ culture of the community.

27.0 VARIATION

CONTENT STANDARD	LEARNING STANDARD	NOTES
27.1 Types and Factors of Variation	**Pupils are able to:** 27.1.1 Describe the meaning of variation.	
	27.1.2 Justify the necessity of variation for the survival of species.	**Suggested activity**: Make reflection on the statement "*It is not the strongest of the species that survives, nor the most intelligent that survives. It is the one that is most adaptable to change....*". -Charles Darwin Gather and present information about variation among various animals and plants.
	27.1.3 Describe the types of variation: (i) continuous variation. (ii) discontinuos variation.	
	27.1.4 Compare and contrast continuous and discontinuous variations.	
	27.1.5 Relate causes of variation to types of variation: (i) genetic factors. - crossing over - independent assortment of chromosomes - random fertilization - mutation	**Suggested activity:** Gather and present information about the effects of envionmental factors on sex determination in reptiles and certain fishes.

CONTENT STANDARD	LEARNING STANDARD	NOTES
	(ii) enviromental factors. - temperature - light - pH 27.1.6 Describe variation caused by interactions between genetic and environmental factors.	
27.2 Variation in Humans	**Pupils are able to:** 27.2.1 Relate variation to human inheritance. 27.2.2 Conduct an experiment to study continuous and discontinuous variation in humans.	**Note:** Examples of continuous variation: height, body weight. Examples of discontinuous variation: fingerprint patterns. **Suggested activity**: Conduct an experiment to study the levels of tongue sensitivity to ptc (phenylthiocarbide) solution in humans.
27.3 Mutation	**Pupils are able to:** 27.3.1 Describe the terms: (i) mutagen. (ii) mutation. (iii) mutant.	

CONTENT STANDARD	LEARNING STANDARD	NOTES
	27.3.2 Describe the types of mutagen: (i) physical agents. (ii) chemical agents. (iii) biological agents.	**Suggested activity**: Make a video/ comic about a mutant superhero inspired by pupils.
	27.3.3 Describe with examples types of mutations: (i) gene mutation. (ii) chromosomal mutation.	**Note:** Examples of gen mutation: sickle cell anaemia and albinism. Examples of chromosomal mutation: Down syndrome, *Cri du Chat* syndrome, Turner syndrome, Klinefelter syndrome, and Jacob syndrome. **Suggested activity**: Gather and present information about the inheritance of haemophilia in society.
	27.3.4 Relate mutations of somatic cells and gametes to variation.	**Suggested activity**: Study and present the impact of disastrous events such as: (i) nuclear accidents in Fukushima and Chernobyl. (ii) usage of Agent Orange during the Vietnam War.

STANDARD PERFORMANCE

VARIATION

PERFORMANCE LEVELS	DESCRIPTOR
1	**Recall** the knowledge and basic science skills of variation.
2	**Understand** and able to explain variation.
3	**Apply** knowledge and skills about variation to carry out simple task.
4	**Analyse** information about variation and apply science skills in the context of **problem solving.**
5	**Evaluate** to make judgement about variation and apply science skills in the context of **problem solving and decision making** to carry out a task.
6	**Create** using knowledge and scientific skills related to variation in the context of **problem solving and decision making** or carrying out an assignment in a new situation creatively and innovatively giving due consideration to the social values/ economy/ culture of the community.

28.0 GENETIC TECHNOLOGY

CONTENT STANDARD	LEARNING STANDARD	NOTES
28.1 Genetic Engineering	**Pupils are able to:** 28.1.1 Describe the terms: (i) genetic engineering. (ii) genetically modified organisms (GMOs). 28.1.2 Explain the application of genetic engineering in the production of: (i) genetically modified organisms (GMOs). (ii) genetically modified foods (GMF). (iii) insulin.	**Note:** Examples of GMF: genetically engineered rice, oil palm, pineapple, corn and soybean **Suggested activity**: Gather and present information about GMOs and GMF that are available. Debate the pros and cons of GMOs and GMF productions.
28.2 Biotechnology	**Pupils are able to:** 28.2.1 Explain the meaning of biotechnology.	**Suggested activity:** Gather and present information about classification in the field of biotechnology. Visit organisations such as FRIM, MPOB, MARDI, MRB and higher education centres to gather information about Yellow biotechnology.

CONTENT STANDARD	LEARNING STANDARD	NOTES
	28.2.2 Describe applications of biotechnology in life.	**Note:** Examples of biotechnology applications: (i) gene therapy. (ii) DNA profiling. (iii) production of insect/ herbicide tolerant plants. (iv) cleaning of oil spills. (v) production of microbial metabolites. (vi) nanobiotechnology. (vii) bioinformatics. **Suggested activity:** Design an entrepreneurial proposal to produce a product using biotechnology. Discuss the Clustered Regularly Interspace Short Palindromic Repeats (CRISPR) technology. Design products using inexpensive, discarded and biodegradable materials to overcome oil spill problems in aquatic ecosystems.
	28.2.3 Justify the importance of biotechnology in life.	**Suggested activity:** Debate on the effects of biotechnology on humans, animals and the environment. Discuss applications of artificial intelligences in biological fields in the Industrial Revolution 4.0 era (IR 4.0).

STANDARD PERFORMANCE

GENETIC TECHNOLOGY

PERFORMANCE LEVELS	DESCRIPTOR
1	**Recall** the knowledge and basic science skills of genetic technology.
2	**Understand** and able to explain genetic technology.
3	**Apply** knowledge and skills about genetic technology to carry out simple task.
4	**Analyse** information about genetic technology and apply science skills in the context of **problem solving.**
5	**Evaluate** to make judgement about genetic technology and apply science skills in the context of **problem solving and decision making** to carry out a task.
6	**Create** using knowledge and scientific skills related to genetic technology in the context of **problem solving and decision making** or carrying out an assignment in a new situation creatively and innovatively giving due consideration to the social values/ economy/ culture of the community.

Appendix 1

RELATIONSHIP BETWEEN VERBS IN EACH PERFORMANCE LEVEL IN STANDARD PERFORMANCE AND VERBS IN STANDARD OF LEARNING WITH EXAMPLES OF PUPIL'S ACTIVITIES

KEY VERBS PERFORMANCE STANDARD		PERFORMANCE STANDARD VERBS	EXAMPLES OF PUPILS' ACTIVITIES
PERFORMANCE LEVEL	VERB		
1	**Recall** (Recall or identify specific information)	Recognise Recall List Identify Name State Tell etc.	Quiz Definition Fact Worksheet Work Test Label List Workbook Reproduce
2	**Understand** (Translate material or ideas from one form to another; interpret material or ideas, estimate trends)	Elaborate Give examples Summarise Translate Choose Explain etc.	Memorisation Summary Collection Explanation Show and explain Example Quiz Label List Framework

KEY VERBS PERFORMANCE STANDARD		PERFORMANCE STANDARD VERBS	EXAMPLES OF PUPILS' ACTIVITIES
PERFORMANCE LEVEL	VERB		
3	**Apply** (Using knowledge, skills, and values in different situations to carry out things)	Show Adjust Use Illustrate Build Complete Check Classify Demonstrate Draw Sketch Predict Prepare Produce Reuse Execute Role play etc.	Illustration Simulation Carve Demonstration Performance Interview Show Diary Journal
4	**Analyse** (Break down the information to small sections to understand in depth as well as to interrelate between the relevant section)	Break down Differentiate Examine Compare Detect Investigate Categorise	Questionnaire Data Abstract Report Graph Checklist Chart

KEY VERBS PERFORMANCE STANDARD		PERFORMANCE STANDARD VERBS	EXAMPLES OF PUPILS' ACTIVITIES
PERFORMANCE LEVEL	VERB		
		Display Evaluate Test Predict Making inference Interpret etc.	Guidelines
5	**Evaluate** (Make judgments and decisions using knowledge, experience, skills and values as well as justification)	Consider Choose Make decisions Give reasons Argue Confirm Suggest Assess Make conclusion Defend Support Determine priorities Predict Make justification etc.	Debate Forum Report Evaluation Investigation Decision Conclusion Speech

KEY VERBS PERFORMANCE STANDARD		PERFORMANCE STANDARD VERBS	EXAMPLES OF PUPILS' ACTIVITIES
PERFORMANCE LEVEL	VERB		
6	**Invent** (Generate creative and innovative ideas, products or methods)	Upgrade Change Plan Build Suggest Generate Develop Prepare Rearrange Combine Assemble Summarise Produce Invent Sketch etc.	Film Story Project Plan Games Song Media Advertisement Drawing

Note: A verb can be categorized at different Performance Level based on the context of the determination Learning Standard.

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ACKNOWLEDGEMENT

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This curriculum document is published in Bahasa Melayu and English language. If there is any conflict or inconsistency between the Bahasa Melayu version and the English version, the Bahasa Melayu version shall, to the extent of the conflict or inconsistency, prevail.

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