Nanyang Girls' High School
Secondary One Integrated Curriculum 2016
Subject / Unit / Lesson Organiser

• **Subjects:** Biology, Chemistry and Physics	
• **Unit:** The Nature and Practice of Science	• **Number of Hours / Lessons:** Six (6)

• **Interdisciplinary Macroconcept(s):**

Communication and Evidence

• **Interdisciplinary Enduring Understanding(s):**

Effective communication is essential for progress.
Reliable evidence is essential to making good decisions (reaching valid conclusions).

• **Interdisciplinary Essential Question(s):**

What makes communication effective? What different forms can communication take? Why are clarification and reflection important in communication?
What is reliable evidence? What different forms can evidence take? How can evidence be interpreted?

• **Disciplinary Enduring Understanding(s):**

Science is a human endeavour.
Scientific knowledge is tentative and is subject to change (based upon new evidence).
Science explains the natural world through the interpretation and communication of empirical evidence.

• **Disciplinary Essential Questions(s):**

Why do humans want to understand the natural world?
What questions about the natural world is science unable to answer? (Can science ever understand everything about the natural world? Is humanity intelligent enough to understand everything about the natural world?)

Part One: Instructional Purpose
• **Enduring Understanding(s) for the Unit:** Science is a *body of knowledge* about the natural world. Science is a *way of thinking* about the natural world. Science is a *range of practical and theoretical methods* that are used to understand the natural world. The body of scientific knowledge is built-up over time by the work of many people (as exemplified by our knowledge of atomic structure).
• **Essential Question(s) for the Unit:** How do scientists think and communicate (as compared with experts in other disciplines)? What constitutes scientific evidence (and to what extent is it the same as evidence used in other disciplines)? To what extent does science transcend culture and society? To what extent is scientific knowledge empirically based? To what extent is scientific knowledge discovered? To what extent is scientific knowledge invented? How are observations and inferences different from each other? Is there really such a thing as the *Scientific Method*? Is science purely objective? To what extent do scientists use their imagination and creativity?
• **What new knowledge will the students gain?** The unit will set the background to the students' journey through the science curriculum for the next four years and beyond. One objective of the unit is to erase any misconceptions that the students might have about science. Popular media (television, radio, magazines, the internet, movies and especially advertisements) often distort and misrepresent science, generating misconceptions about science in the mind of the student. By the end of the unit students will know: What is science, as compared to protoscience, pseudoscience and non-science? How reliable scientific knowledge is. How scientific knowledge is generated. The limits of scientific knowledge.
• **What new skills will the students develop?** Students will develop the skills that are necessary to designing a scientific experiment. Note: O' and A' Level sciences require students to design experiments that answer specific questions in a given context. Students will understand that an experiment is a systematic investigation that attempts to prove or disprove a hypothesis. Experimental results are measurable and objective and it should be possible to replicate the results under identical conditions. Students will learn how to construct a

hypothesis or problem statement as well as identify independent, dependent and control variables. Students will learn how to write a clear step-by-step method for the experiment as well as how to interpret and present the results.

- **How will the students be challenged to think?**

Critical thinking – activities will require students to understand the logical connections between ideas and solve problems in a systematic manner, *e.g.* the "*curiosity cubes*" activity in which students experience what it is to think like a scientist.
Creative thinking – students will have to take responsible risks and consider the same information from different points of view, e.g. the "*scrambled sentence*" activity in which students experience how scientists incorporate information from new discoveries into existing theories.
Understand (Blooms) – students should be able to explain certain concepts and transfer their knowledge to new situations.
Analyse (Blooms) – students will be encouraged to compare, contrast, examine and question their own ideas as well as the ideas of others.
Create (Blooms) – students will be required to design a simple experiment.

- **What 21st Century Competencies will the students develop?**

Collaboration – Students will work in small groups to solve meaningful problems using critical and creative thinking skills. Where relevant, each member of the group will be assigned a specific role.
Communication – Students will share their ideas with their peers both individually and as a group (class presentation). Presentations may be purely verbal or may include a visual component (use of whiteboard, classroom visualiser, iPad or laptop computer).
Critical thinking – activities will require students to understand the logical connections between ideas and solve problems in a systematic manner, *e.g.* the "*curiosity cubes*" activity in which students experience what it is to think like a scientist.
Creative thinking – students will have to take responsible risks and consider the same information from different points of view, e.g. the "*scrambled sentence*" activity in which students experience how scientists incorporate information from new discoveries into existing theories.
Processing information – students will organise, interpret and present information in different forms.

- **Curriculum of Connections – Making meaningful connections:**

Biology, chemistry and physics will not be differentiated for this unit. They will be combined together and taught under the general heading of science.
Connections can be made between science and history and language arts when studying the biographies of the famous female scientists.
Connections can be made between science and mathematics during the data manipulation and graph plotting activities on the "*Analysing Experimental Results*" worksheet.
Connections between science and other subjects can be made through the macroconcepts *communication* and *evidence*. There can be discussions about how experts in other disciplines communicate and what they accept as evidence.
Connections between science and other subjects can be made through the 16 Habits of Mind (16 HoM). Which of the 16 HoM are most commonly demonstrated by scientists, historians, mathematicians and so on?
Connections between science and other subjects can be made through the Elements of Thought (Paul's Wheel of Reason). For example, how is critical thinking in science similar to / different from that in geography, language arts and so on?

- **Curriculum of Practice – Making learning authentic and relevant:**

Students will reflect on where they encounter science in their everyday lives – is the impact of science on society always beneficial?
Students will be encouraged to think about the different careers that require a good knowledge of science – what job would they like to do?
In the presentation "*What is Chemistry*" the students will be given examples of chemistry in their everyday lives. Some examples will be positive while others will be negative to give a balanced point-of-view and provide additional areas for discussion [maybe postponed until the start of the unit on chemistry].
Students will be actively engaged in hands-on activities that give them an insight and understanding as to how scientists think and how ideas in science are developed in the light of new information.
Students will study the biographies of famous female scientists. These positive role models provide the students with an authentic insight with regards to the traits and characteristics of a scientist.

- **Curriculum of Identity – Making learning personal:**

Students will be encouraged to reflect on how science impacts their everyday lives, thus emphasising the importance of science in the development of modern civilisation.
Students will study the biographies of (up to) five famous female scientists and discuss the contributions that they made and the struggles (if any) that they faced. It is hoped that the students will identify and empathise with some characteristics of these positive role models. Through study of the biographies, students should understand that although women are underrepresented in the field of science, they are capable of making very significant contributions.
Students will consider which of the 16 Habits of Mind (16 HoM) are most clearly demonstrated by scientists and how similar these are to the 16 HoM that they exhibit themselves. Students can be asked to compare the 16 HoM common to scientists to those observed in historians, mathematicians and so on.
Students will be encouraged to write their reflections in their journals and post questions / comments / observations on a common noticeboard in their classroom.

Part Two: Assessment

- **Formative Assessment for this Unit:**

There is no formal formative assessment for this short introductory unit. However, there are many individual and group activities that students engage in that the teacher could use to estimate an individual student's level of understanding should they need to do so. Examples include the worksheets titled "*The Tale of the Other Dog*", "*Alienate This*" and "*Analysing Experimental Results*". Teachers can also gauge their students' level of understanding during question / answer sessions, class discussions and comments posted on the class noticeboard during their individual journal writing time.

• **Summative Assessment for the Unit:**

There is no formal summative assessment for this short introductory unit. Teachers may wish to set questions on the summative examinations given at the end of Semester One and / or Semester Two. In this context, students could answer questions that integrate nature of science with another topic(s) from biology, chemistry of physics, *e.g.* "*Design an experiment to investigate how different amounts of salt affect the freezing point of water*". This combines nature of science with kinetic particle theory.

Part Three: Learning Experience and Instruction

Lesson One:	**Strategies Employed**	**Questions to Ask**	**Resources / Comments**
a) Objectives: • Uncover students' ideas about science. • Discuss the question "What is science?" **b) Introduction (Hook Activity):** • People bingo. **c) Development:** • Students' perceptions of science. • Evaluation of students' knowledge about science. • Discuss criteria for science. • Students' apply criteria for science. **d) Closure:** • Reflection on Lesson One. • Preamble to Lesson Two.	• People Bingo: Each student has a bingo board with simple questions about science on. Questions can be both factual and personal. Students move about the class and find others who can answer the questions (one person allowed to answer one question). This is a good activity for verbal linguistic learners and bodily kinaesthetic learners. It also gives students in the new Sec. 1 class an opportunity to learn something about each other. • Students' perceptions of science. Asking the students what they think science is and why it is important to their lives draws on their tacit knowledge and makes the topic relevant to the students. • A brief survey will be used to capture students' perceptions about science, *e.g.* "Do scientists try to	• What is science? • In what ways are science and art similar and different? • What role does science play in society? • How does science support other disciplines? • Is science always beneficial? • What criteria / rules must something follow in order to be "scientific"? • What can and what cannot be studied by science? • Can science ever understand everything?	• Worksheet #1 People Bingo • Worksheet #2 Students' Perceptions of Science • Worksheet #3 Evaluation of Students' Knowledge about Science • Worksheet #4 Criteria for Science (CONPTT and of Sunsets, Souls and Senses) • PowerPoint #1 Criteria for Science • "*16 Habits of Mind*" cards • "*Elements of Thought*" cards • Post-It® Notes

	disprove their own ideas?" Students can check if their perceptions have changed by the end of the unit. • The essential criteria of science: consistent, observable, natural, predictable, testable, tentative. • Students will use the essential criteria of science and critical thinking skills to evaluate whether science can study angels, viruses, volcanoes, horoscopes, witchcraft (for example). • Students write individual reflections on Post-It® notes which will then be posted on a noticeboard in the classroom. Different colours could represent different things, *e.g.* blue for a question, yellow for an observation, green for a recommendation. • Brief students about the next lesson and ask them to prepare any necessary materials / work. Students should prepare the Habits of Mind and Elements of Thought cards for the next lessons.	• How / why are evidence and communication important in science?	

Lesson Two:	Strategies Employed	Questions to Ask	Resources / Comments
a) Objectives: • Uncover what science *is*. • Uncover what science is *not*. **b) Introduction (Hook Activity):** • Horoscopes. **c) Development:** • Review Lesson One – the criteria for science (what science is). • Ten myths about science. • What science is not. **d) Closure:** • Scientific discoveries. • Preamble to Lesson Three.	• How is Your Horoscope? Are horoscopes (astrology) based on good scientific principles? Students will read descriptions of the 12 star signs and choose which one best describes them. The teacher will then tell the dates associated with each description, and students will note whether there is a match between the dates for the description that they chose and their birthday. "Hits" and "misses" can be totalled for the class and even the entire level. This activity could be extended to include a discussion of the Chinese Zodiac. • Students reflect on the essential characteristics of science that were discussed in Lesson One. This could be achieved through a co-operative learning strategy such as "*Give One, Get One*". • Teacher led discussion about what science is not. Students should be able to contribute ideas based upon what they have learned so far.	• What is science? (Review) • What is the history of science? • What is the relationship between science and mathematics? • How is science portrayed in the popular media? To what extent is this accurate / believable / realistic? • What myths / misconceptions are there about science? • How is science communicated to the general public? • Is astrology a science? • What other pseudosciences are there? • Can science and religion ever be reconciled? • What role does evidence play in science?	• Worksheet #5 How is Your Horoscope? • Worksheet #6 Making Connections – Scientific Discoveries • PowerPoint #2 What Science is Not • PowerPoint #3 Ten Myths About Science

	• Teacher led discussion about myths and misconceptions about science. • Students write individual reflections on Post-It® notes. This can be repeated in other subjects. What questions and observations do students have about their different subjects? Is there a pattern? • Brief students about the next lesson and ask them to prepare any necessary materials / work.	• In science, what is a law, hypothesis, theory?	
Lesson Three **a) Objectives:** • Uncover how scientists think. • Introduction to 16 Habits of Mind. **b) Introduction (Hook Activity):** • Powers of Ten video. **c) Development:** • Making predictions about what cannot be observed directly. • Observation and inference. • How scientists make sense of new data / information. **d) Closure:** • Reflection on Lesson Three. • Preamble to Lesson Four.	**Strategies Employed** • The "*Powers of Ten*" video deals with scale in science. It moves from the nucleus of a carbon atom to the edge of the known universe. This can be used to discuss what scientists can and cannot observe, and how scientists make deductions, inferences and draw conclusions about what they cannot observe. • Curiosity Cubes: Groups of 3-4 students are given a cube. They can observe five of the six sides (not the base) and have to think critically about this evidence to identify relationships and hence	**Questions to Ask** • How do scientists think? • How do scientists see the world? (The "*Scientific Lens*"). • Do scientists have a particular personality profile? What might it be? (Relate to the 16 Habits of Mind). • How are scientists different from professionals working in other disciplines? • How can scientists try to understand things that they cannot observe directly, *e.g.*	**Resources / Comments** • "*Powers of Ten*" video (Eames 1977) • "*Curiosity Cubes*" • Worksheet #7 Alienate This • Worksheet #8 The Extra Piece (with tangram) • Worksheet #9 Scrambled Sentence (with word cards) • Post-It® Notes

	deduce what is printed on the sixth side of the cube. Note: An alternative activity is to use the "*Mystery Tubes*". • Alienate This: Students are given a scenario in which an astronaut comes across an alien creature. Students have to state whether the astronaut's comments about the creature are observations or inferences. • The Extra Piece: A group of 3-4 students are given a four piece tangram from which they have to arrange in the form of a square. Each piece of the tangram represents a piece of scientific knowledge that fit together to produce a theory. Students are then given a fifth piece of the tangram and again have to arrange the pieces in the form of a square. This models how science is tentative and how new evidence can modify existing theories. Requires critical and creative thinking skills. • The Scrambled Sentence: A group of 3-4 students are given 24 card, each with one word printed on it. The cards are spread out and placed face down. Students are	atomic structure and black holes in space (inference)? (Relate to the "*Powers of Ten*" video and using the "*Alienate This*" worksheet and "*Curiosity Cubes*" as an example). • Scientists are continuously making new discoveries. How is this new information incorporated into what they already know? (Relate to the "*Tangram*" and "*Scrambled Sentence*" worksheets). • How is it possible for different scientists, given the same data / information, to draw different conclusions? • What Habits of Mind / Elements of Thought have you used during today's lesson?	

	asked to turn over any five cards and make a sentence from the words that they can see (hypothesis one). Students turn over another five cards and incorporate them into the sentence, which may be similar to the original or completely different (hypothesis two). This continues until 20 of the words can be seen. This models the tentative nature of science and how new evidence causes scientists to change their ideas about the natural world. It also models how scientists must be creative and why, when presented with the same data, scientists can reach different conclusions. Note: not all 24 cards are turned over to model the idea that scientists "don't know what they don't know". • Students write individual reflections on Post-It® notes. This can be repeated in other subjects. Students can ask a question, summarise an important point, highlight something they are unsure about, praise another student, identify their favourite part of the lesson, make a recommendation (for example). • Brief students about the next lesson and ask them to prepare any necessary materials / work.		

Lesson Four	Strategies Employed	Questions to Ask	Resources / Comments
a) Objectives: • Describe the Scientific Method. • Study examples of experimental design. **b) Introduction (Hook Activity):** • Quotations by famous scientists. **c) Development:** • Discuss the scientific method. • Analyse / evaluate a fictitious scientific experiment. **d) Closure:** • Reflection on Lesson Four. • Preamble to Lesson Five.	• Quotations by Famous Scientists: Understanding the nature of science and how scientists think by reading quotations from experts who work in that field. • Teacher led discussion about scientific method. Although there is no single scientific method, students will be given a general idea with regards to how scientists work. Exceptions can also be discussed (*e.g.* it is not possible to conduct experiments in astronomy, and it may be unethical to conduct experiments in medicine). • The Tale of the Other Dog: Students read the story about the scientist and then answer the questions that follow. There should be a class discussion once students have completed the activity. • Students write individual reflections on Post-It® notes. This can be repeated in other subjects. After some time, this will become a habit and the students will complete it automatically. • Brief students about the next lesson and ask them to prepare any necessary materials / work.	• What Habits of Mind can you identify from the quotations? • What do you understand about the Scientific Method? • Is there really only one scientific method, or can scientists work in different ways? • What constitutes a fair test? • What is a hypothesis? • What are variables? • How is mathematics used in scientific experiments? • Are experiments conducted in other disciplines beyond biology, chemistry and physics? • Why is evidence important in science? • Why is it important for scientists to communicate with each other and with the general public? • What are the different forms / ways that scientists communicate their results?	• PowerPoint #4 Quotations by Famous Scientists • PowerPoint #5 The Scientific Method • Worksheet #10 The Tale of the Other Dog • Post-It® Notes

Lesson Five	Strategies Employed	Questions to Ask	Resources / Comments
a) Objectives: • Study examples of experimental design. • Design a simple experiment. **b) Introduction (Hook Activity):** • Simple crossword puzzle using key terms / words in science. **c) Development:** • Analyse a fictitious scientific experiment. • Design a simple experiment. **d) Closure:** • Reflection on Lesson Five. • Preamble to Lesson Six.	• The crossword puzzle is an energising activity that will appeal to students who have a passion for language arts. • Students are given the scenario and results of a fictitious experiment. Students read through the experiment and answer the questions that follow. Students are required to do some simple mathematics and plot a graph as part of the activity. There should be a brief class discussion once students have completed the worksheet. • Students will be given guidelines to design their own experiment. Students will be expected to write a hypothesis, identify variables, write a step-by-step procedure and explain how they would interpret their results. In the interest of time, students may be required to complete this activity for homework. • Students write individual reflections on Post-It® notes. This can be repeated in other subjects. • Brief students about the next lesson and ask them to prepare any necessary materials / work.	• What constitutes a fair test? • What is a hypothesis? • What are variables? • How is mathematics used in scientific experiments? • Are experiments conducted in other disciplines beyond biology, chemistry and physics? • Why is evidence important in science? • Why is it important for scientists to communicate their ideas clearly and concisely?	• Worksheet #11 Analysing Experimental Results • Worksheet #12 Experimental Design • Post-It® Notes

Lesson Six	Strategies Employed	Questions to Ask	Resources / Comments
a) Objectives: • Understand how scientists work through their biographies. • Recognise the important work done by women in the field of science. **b) Introduction (Hook Activity):** • Revision of the unit – Pictionary. **c) Development:** • Read biographies of famous female scientists. • Answer guiding questions about the scientists. • Discuss the characteristics / traits exemplified by the scientists. **d) Closure:** • Reflection on Lesson Six • Preamble to Biology, Chemistry, Physics lessons.	• Pictionary: Groups of 3-4 students write words and short statements about the nature of science on piece of paper. These are exchanged (face down) with other groups. Students in the group take turns to pick a piece of paper and must draw a visual clue of the word or statement for the other students to guess. This activity requires students to reflect upon what they have learnt and caters to verbal, visual and kinaesthetic learning styles. • Each student is given the biography of a famous female scientist to read. After reading the biographies, students form groups of five – each group containing the five different biographies (group numbers / letters can be written on the biographies in advance). Students briefly explain the history and work of each scientists. Groups identify similarities and difference between the women. The group activity can be supported by guiding questions to scaffold the discussion.	• In the media, are scientists portrayed as men or women? Why do you think this is so? • Are women equally represented in the field of science? • Why might women be underrepresented in the field of science? • What are the characteristics of famous female scientists? In what ways would their characteristics be different from their male colleagues? • How can more women be attracted into the field of science? • How have your ideas / understanding of science changed over the past two weeks? • If you were to work in the field of science, what possible jobs would you like to do? • Are women equally represented in other	• Coloured A4 paper. Dry-wipe drawing boards. • Biography #1 Barbara McClintock • Biography #2 Chien-Shiung Wu • Biography #3 Dorothy Hodgkin • Biography #4 Gertrude Elion • Biography #5 Rosalind Franklin • Post-It® Notes

	• Teacher supervises a class discussion about the past, present and future roles of women in science. Guiding questions are provided in the column on the right. • Students write individual reflections on Post-It® notes. This can be repeated in other subjects. Students should reflect on how their understanding of science has changed over the course of the unit and should be encouraged to ask any questions that they still have. • Brief students about the next lesson and ask them to prepare any necessary materials / work.	disciplines? In which disciplines are women over represented? Why? • How do the characteristics of scientists differ from experts in other disciplines? (Relate this to the 16 Habits of Mind).	

• **Note:** Ensure alignment / agreement between concepts, enduring understandings and essential questions used at the various levels:

Interdisciplinary → Disciplinary → Unit → Lesson.

• Options to include in the individual lesson plans (Yang and Ricks, 2013):

1. **Key Point** – The central objective of the lesson (the main idea that the teacher wants her students to understand).
2. **Difficult Point** – The cognitive difficulty that students might encounter as they try to learn the key point.
3. **Critical Point** – Pedagogy employed to overcome the Difficult Point, leading students to understand the Key Point.