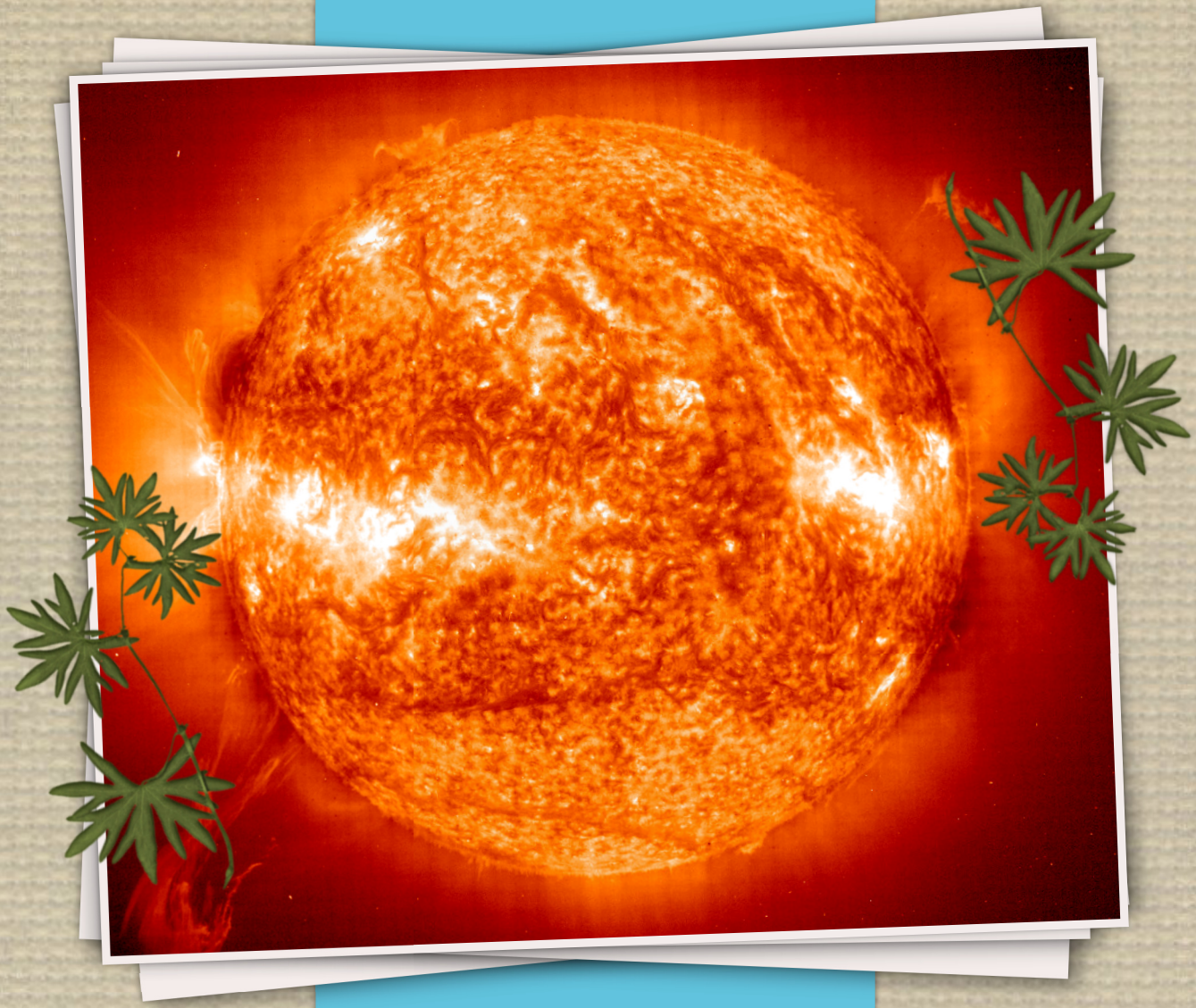
Investigating Science

Year 11 Dot Point Notes



The absence of evidence is not evidence of absence.

The plural of anecdote is not evidence.

"We live in a society exquisitely dependent on science and technology, in which hardly anyone knows anything about science and technology." Carl Sagan

Module 1: Cause and Effect – Observing

Outcomes

A student:

- develops and evaluates questions and hypotheses for scientific investigation INS11/12-1
- conducts investigations to collect valid and reliable primary and secondary data and information INS11/12-3
- selects and processes appropriate qualitative and quantitative data and information using a range of appropriate media INS11/12-4
- identifies that the collection of primary and secondary data initiates scientific investigations INS11-8

Related Life Skills outcomes: SCLS6-1, SCLS6-3, SCLS6-4, SCLS6-8

Content Focus

Observation instigates all scientific experimentation. Investigative scientific processes can only be applied to phenomena that can be observed and measured. Detailed observations motivate scientists to ask questions about the causes and the effects of phenomena they observe. In this way, science continues to progress and enhance the lives of individuals and society by encouraging a continued search for reason and understanding.

Students explore the importance of observation and the collection of quantitative and qualitative data in scientific investigations. They conduct their own practical investigation, either individually or collaboratively, which is used to demonstrate the importance of making detailed and accurate observations, determining the types of variables and formulating testable scientific hypotheses.

Working Scientifically

In this module, students focus on developing hypotheses that arise from their observations and evaluate these in order to gather, select and process appropriate qualitative and quantitative data. Students should be provided with opportunities to engage with all Working Scientifically skills throughout the course.

Content

Role of Observations

Inquiry question: How does observation instigate scientific investigation?

Students:

- carry out a practical investigation to record both quantitative and qualitative data from observations, for example:
  - burning a candle floating in a closed container
  - the behaviour of slaters in a dry/wet or light/dark environment
  - the Bernoulli effect
  - strata in rock cuttings

Students:

- discuss and evaluate the characteristics of observations made compared to inferences drawn in respect of the practical investigation

Students:

- research how observation has instigated experimentation to investigate cause and effect in historical examples, including but not limited to:
  - Archimedes observing the displacement of water
  - Alexander Fleming's observations of the effect of mould on bacteria
  - Galileo's observations of the movement of Jupiter's moons

Students:

- assess ways in which Aboriginal and Torres Strait Islander Peoples use observation to develop an understanding of Country and Place in order to create innovative ways of managing the natural environment, including but not limited to:
  - firestick farming
  - knowledge about plants for medicinal purposes

Observations

Inquiry question: What are the benefits and drawbacks of qualitative and quantitative observations?

Students:

- carry out a practical activity to qualitatively and quantitatively describe, for example:
  - microscopic images of a variety of cells
  - geological strata in rock faces and road cuttings
  - an object falling due to gravity
  - characteristics of acids and bases

Students:

- analyse the quantitative data from the following information sources, including but not limited to:
  - digital images and hand-drawn diagrams of cells
  - geological succession obtained from rock strata
  - graphs of results obtained from observations of an object falling due to gravity
  - data showing the pH of acids and bases

Students:

- evaluate the differences between qualitative and quantitative observations and data and where these are used

Observations as Evidence

Inquiry question: How does primary data provide evidence for further investigation?

Students:

- use data gathered to plan a practical investigation to:
  - pose further questions that will be investigated
  - discuss the role of variables
  - determine the independent and dependent variables
  - formulate a hypothesis that links the independent and dependent variables
  - describe at least three variables that should be controlled in order to increase the validity of the investigation

Students:

- develop a method to collect primary data for a practical investigation by:
  - describing how to change the independent variable
  - determining the characteristics of the measurements that will form the dependent variable
  - describing how the data will be collected
  - describing how the controlled variables will be made consistent
  - describing how risks can be minimised

Students:

- evaluate how observation is limited by the observational tools available, including but not limited to:
  - observing the Universe
  - digital versus analogue technologies

Observing, Collecting and Recording Data

Inquiry question: How does the collection and presentation of primary data affect the outcome of a scientific investigation?

Students:

- carry out the planned practical investigation, above, to collect primary data

Students:

- apply conventions for collecting and recording observations to qualitatively and quantitatively analyse the primary data, including but not limited to:
  - tabulation
  - graphing
  - visual representations
  - digital representations

Students:

- compare the usefulness of observations recorded in the initial practical activity with the primary data gathered in this planned practical investigation

Conclusions Promote Further Observations

Inquiry question: How do conclusions drawn from the interpretation of primary data promote further scientific investigation?

Students:

- draw conclusions from the analysis of the primary data collected in the practical investigation

Students:

- evaluate the process of drawing conclusions from the primary data collected

Students:

- assess the findings of the scientific investigation in relation to the findings of other related investigations

Students:

- assess the need to make further observations by gathering data about other phenomena arising from the practical investigation

Module 2: Cause and Effect – Inferences and Generalisations

Outcomes

A student:

› develops and evaluates questions and hypotheses for scientific investigation INS11/12-1
› designs and evaluates investigations in order to obtain primary and secondary data and information INS11/12-2
› selects and processes appropriate qualitative and quantitative data and information using a range of appropriate media INS11/12-4
› examines the use of inferences and generalisations in scientific investigations INS11-9

Related Life Skills outcomes: SCLS6-1, SCLS6-2, SCLS6-4, SCLS6-9

Content Focus

Scientific inquiry follows on from humans making inferences and generalisations from commonly held understandings. Such inferences and generalisations have led to a wide range of investigations being performed throughout history, culminating in breakthroughs in scientific understanding. Many hypotheses, when found to be correct, have generated further inquiry and created the need to develop new technologies for further observation.

Students consider primary and secondary-sourced data and its influence on scientific investigations. In this module, students engage in gathering primary and secondary-sourced data to assist them in conducting and reporting on investigations, and to further develop their understanding of the central roles of scientific questioning and collaboration in the pursuit of scientific truth.

Working Scientifically

In this module, students focus on designing and evaluating investigations, drawing inferences, making generalisations, and developing and testing hypotheses through the collection and processing of data. Students should be provided with opportunities to engage with all Working Scientifically skills throughout the course.

Content

Observations and Inferences

Inquiry question: What inferences can be drawn from observations?

Students:

- investigate the practices of Aboriginal and Torres Strait Islander Peoples that relate to observations and inferences, including but not limited to:
  - leaching of toxins in bush tucker
  - locating sources of freshwater within bodies of salt water

Students:

- conduct a collaborative practical investigation and collect a range of qualitative and quantitative primary data from one of the following:
  - growth of plants
  - reactions of calcium carbonate
  - the 'life' of different batteries under different circumstances
  - water quality of a pond or local stream

Students:

- make inferences and conclusions derived from the primary data collected in this collaborative practical investigation

Using Secondary-sourced Data

Inquiry question: How is secondary-sourced data used in practical investigations?

Students:

- collect qualitative and quantitative secondary-sourced data to validate the inferences and conclusions drawn from the practical investigation carried out above, based on one or more of the following:
  - the effect of soil salinity on plant growth
  - chemical reactions in cave formation
  - energy storage
  - methods of water monitoring

Students:

- discuss how secondary-sourced data adds to the inferences and conclusions drawn from primary data

Students:

- evaluate the usefulness of considering secondary-sourced research before undertaking an investigation to collect primary data, in order to:
  - make inferences
  - develop inquiry questions
  - construct suitable hypotheses
  - plan suitable investigations
  - avoid unnecessary investigation

Observing Patterns

Inquiry question: How does humans' ability to recognise patterns affect the way they interpret data?

Students:

- describe patterns that have been observed over time throughout the Universe and in nature using, for example:
  - animal migration
  - movement of comets
  - formation and shape of snow crystals
  - elements exhibiting certain properties

Students:

- interpret data in order to propose a hypothesis based on an irregular pattern observed over time in the Universe and in nature using, for example:
  - the Aurora Australis
  - fractals in nature
  - the behaviour of unstable isotopes

Students:

- examine the human tendency to observe patterns and misinterpret information, for example:
  - pareidolia
  - optical illusions

Students:

- discuss how the tendency to recognise patterns, even when they may not exist, can lead to misinterpretation of data

Students:

- discuss the role and significance of outliers in data

Developing Inquiry Questions

Inquiry question: How can hypotheses and assumptions be tested?

Students:

- gather secondary-sourced data describing historical instances of long-standing assumptions that have been updated by scientific investigation, including but not limited to:
  - spontaneous generation and the investigations that led to the proposal of the germ theory
  - radioactivity: including the work of Henri Becquerel and Marie Curie
  - phlogiston theory
  - human influences on atmospheric pollution

Students:

- propose an inquiry question, construct a hypothesis and conduct an investigation that tests a common assumption, for example:
  - washing with antibacterial soap kills more germs than washing with normal soap
  - the Sun rises in the East and sets in the West
  - what goes up must come down

Students:

- use appropriate representations to analyse the data

Generalisations in Science

Inquiry question: What generalisations and assumptions are made from observed data?

Students:

- make generalisations to describe any trends found in the data

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Students:

- draw conclusion based on generalisations

Peer Review

Inquiry question: What role do peers play in scientific investigation?

Students:

- assess the input that collaborative teams and alternative perspectives have had on the development of hypotheses and research questions that have contributed to the development of, for example:
  - particle accelerators
  - periodic table
  - study of bioastronomy
  - geological uniformitarianism

Students:

- assess the scientific community's current understanding of scientific mysteries and outline why this understanding remains incomplete, including but not limited to:
  - origins of life on the Earth
  - the idea that feynmanium is the last chemical on the periodic table that could exist
  - the expanding Universe and Hubble constant

Students:

- evaluate biases that may have affected the scientific thinking of European settlers about Aboriginal and Torres Strait Islander Peoples' ecological understanding and knowledge of Country and Place in relation to agricultural practices and the biological and natural resources of Australia

Module 3: Scientific Models

Outcomes

A student:

› designs and evaluates investigations in order to obtain primary and secondary data and information INS11/12-2
› conducts investigations to collect valid and reliable primary and secondary data and information INS11/12-3
› selects and processes appropriate qualitative and quantitative data and information using a range of appropriate media INS11/12-4
› develops, and engages with, modelling as an aid in predicting and simplifying scientific objects and processes INS11-10

Related Life Skills outcomes: SCLS6-2, SCLS6-3, SCLS6-4, SCLS6-10

Content Focus

Scientific models are developed as a means of helping people understand scientific concepts and representing them in a visual medium. Models are used to make predictions. They may include physical and digital models, which can be refined over time by the inclusion of new scientific knowledge.

Students recognise that many scientific models have limitations and are modified as further evidence comes to light. For this reason, scientific models are continually evaluated for accuracy and applicability by the global scientific community through the process of peer review. Students construct and evaluate their own models, which are generated through practical investigation.

Working Scientifically

In this module, students focus on designing and evaluating investigations to collect valid and reliable primary and secondary qualitative and quantitative data, and apply scientific modelling. Students should be provided with opportunities to engage with all Working Scientifically skills throughout the course.

Content

Models to Inform Understanding

Inquiry question: What is a scientific model?

Students:

- examine the types of models that may be used in science, including:
  - diagrams
  - physical replicas
  - mathematical representations
  - analogies
  - computer simulations

Inquiry question: What makes scientific models useful?

Students:

- examine the use of scientific models, including but not limited to:
  - epidemic models
  - models of the Universe
  - atomic models
  - climate models

Students:

- outline how models have been used to illustrate, simplify and represent scientific concepts and processes

Students:

- explain how scientific models are used to make predictions that are difficult to analyse in the real world due to time frames, size and cost

Students:

- assess the effectiveness of models at facilitating the understanding of scientific processes, structures and mathematical relationships through the use of:
  - diagrams
  - physical replicas
  - mathematical representations
  - analogies
  - computer simulations

Students:

- evaluate how scientific models draw on a growing body of data from a wide range of disciplines and technologies to refine predictions and test new hypotheses

Types of Models

Inquiry question: When should a particular model be used?

Students:

- explain why new evidence can challenge the use of existing scientific models and may result in those models being contested and refined or replaced, including but not limited to the development of:
  - epidemic models
  - models of the Universe
  - atomic models
  - climate models

Students:

- compare the limitations of simple and complex scientific models

Constructing a Model

Inquiry question: How can a model be constructed to simplify understanding of a scientific concept?

Students:

- investigate a scientific concept or process that can be represented using a model, by:
  - planning a model with reference to the scientific literature
  - constructing a model using appropriate resources to represent the selected scientific concept
  - demonstrating how the model could be used to make a prediction
  - presenting and evaluating the model through peer feedback

Module 4: Theories and Laws

Outcomes

A student:

› analyses and evaluates primary and secondary data and information INS11/12-5
› solves scientific problems using primary and secondary data, critical thinking skills and scientific processes INS11/12-6
› communicates scientific understanding using suitable language and terminology for a specific audience or purpose INS11/12-7
› describes and assesses how scientific explanations, laws and theories have developed INS11-11

Related Life Skills outcomes: SCLS6-5, SCLS6-6, SCLS6-7, SCLS6-10

Content Focus

The term 'science' comes from the Latin *scientia*, which means 'a knowledge based on demonstrable and reproducible data'. Reproducible data is used by scientists to develop theories and laws to explain and describe phenomena. Theories provide a coherent understanding of a wide range of phenomena. A law is usually a statement that can be expressed as a mathematical relationship. It describes phenomena in nature, with no exceptions, at a point in time. Testing scientific theories drives scientific breakthroughs and questions current understandings.

Students examine how complex models and theories often require a wide range of evidence, which impacts on society and the environment. In this module, students engage in practical and secondary investigations that are related to major theories or laws and their application.

Working Scientifically

In this module, students focus on analysing and evaluating data to solve problems and communicate ideas about the development of theories and laws. Students should be provided with opportunities to engage with all Working Scientifically skills throughout the course.

Content

Introduction to Scientific Theories and Laws

Inquiry question: What are the differences and similarities between scientific theories and laws?

Students:

- collect primary data to investigate the law of conservation of mass

Students:

- collect secondary-sourced data to investigate the theory of plate tectonics

Students:

- compare the characteristics of theories and laws

Development of a Theory

Inquiry question: What leads to a theory being developed?

Students:

- gather secondary-sourced data to investigate the supporting evidence and development of theories, including but not limited to:
  - germ theory
  - oxygen theory of combustion

Students:

- gather secondary-sourced data to investigate how aspects of a theory can be disproved through the collection of evidence, including:
  - Geocentric Theory (of the solar system)
  - Theory of Inheritance of Acquired Characteristics
  - Dalton's atomic theory
  - Steady State Theory of the Universe (in cosmology)

Development of Laws

Inquiry question: What leads to the acceptance of a scientific law?

Students:

- gather secondary-sourced data to investigate and assess the evidence that supports scientific laws, including but not limited to:
  - Newton's Second Law of Motion
  - Avogadro's Law
  - law of superposition
  - Mendel's Law of Dominance

Students:

- design and collect primary data to show that results can be predicted by laws, including but not limited to:
  - Ohm's Law
  - law of conservation of energy

Application of Theories and Laws in Science

Inquiry question: How are theories and laws used in science?

Students:

- investigate how the law of conservation of energy is applied in different science disciplines through primary and secondary-sourced research, including but not limited to:
  - Chemistry
  - Physics
  - Human Biology
  - Earth and Environmental Science

Students:

- demonstrate, using evidence and examples, how diverse phenomena have been unified into specific theories, for example:
  - atomic theory
  - theory of evolution
  - Big Bang theory
  - plate tectonic theory

Students:

- gather secondary-sourced data to investigate how scientific investigations of nuclear reactions and decay changed the way in which the law of conservation of mass and law of conservation of energy are interpreted