 Module 6: Technologies - A continuous cycle

Year 12 Investigating Science

Duration – 7 weeks

This document references the [Investigating Science Stage 6 Syllabus](https://syllabus.nesa.nsw.edu.au/investigating-science-stage6/) © 2017 NSW Education Standards Authority (NESA) for and on behalf of the Crown in right of the State of New South Wales.

Rationale

The rapid development of new technologies has enhanced industrial and agricultural processes, medical applications and communications. Students explore the dynamic relationship between science and technology where the continuing advancement of science is dependent on the development of new tools and materials. They also examine how advances in science inform the development of new technologies and so reflect the interdependence of science and technology. Students consider experimental risks as they engage with the skills of Working Scientifically. They investigate the appropriateness of using a range of technologies in conducting practical investigations, including those that provide accurate measurement.

Inquiry question

How have developments in technology led to advances in scientific theories and laws that, in turn, drive the need for further developments in technology?

Outcomes

Working scientifically skills

* INS11/12-1 develops and evaluates questions and hypotheses for scientific investigation
* INS11/12-2 designs and evaluates investigations in order to obtain primary and secondary data and information
* INS11/12-3 conducts investigations to collect valid and reliable primary and secondary data and information
* INS11/12-4 selects and processes appropriate qualitative and quantitative data and information using a range of appropriate media
* INS11/12-5 analyses and evaluates primary and secondary data and information
* INS11/12-6 solves scientific problems using primary and secondary data, critical thinking skills and scientific processes
* INS11/12-7 communicates scientific understanding using suitable language and terminology for a specific audience or purpose

While all Working Scientifically outcomes have been presented in this sample unit of work, teacher judgement should be used about which skill descriptors students will be working towards and engaging with.

Knowledge and understanding

* INS12-13 describes and explains how science drives the development of technologies

Assessment overview

* Oral presentation assessment task: What comes first, science or technology? Weighting: 20 %
* Yearly/trial examination
* Formative assessment throughout unit.

Content

Year 12 - Questioning and Predicting Year 12

Students:

* develop and evaluate inquiry questions and hypotheses to identify a concept that can be investigated scientifically, involving primary and secondary data
* modify questions and hypotheses to reflect new evidence

Year 12 - Planning Investigations Year 12

Students:

* assess risks, consider ethical issues and select appropriate materials and technologies when designing and planning an investigation
* justify and evaluate the use of variables and experimental controls to ensure that a valid procedure is developed that allows for the reliable collection of data
* evaluate and modify an investigation in response to new evidence

Year 12 - Conducting Investigations Year 12

Students:

* employ and evaluate safe work practices and manage risks
* use appropriate technologies to ensure and evaluate accuracy
* select and extract information from a wide range of reliable secondary sources and acknowledge them using an accepted referencing style

Year 12 - Processing Data and Information Year 12

Students:

* select qualitative and quantitative data and information and represent them using a range of formats, digital technologies and appropriate media
* apply quantitative processes where appropriate
* evaluate and improve the quality of data

Year 12 - Analysing Data and Information Year 12

Students:

* derive trends, patterns and relationships in data and information
* assess error, uncertainty and limitations in data
* assess the relevance, accuracy, validity and reliability of primary and secondary data and suggest improvements to investigations

Year 12 - Problem Solving Year 12

Students:

* use modelling (including mathematical examples) to explain phenomena, make predictions and solve problems using evidence from primary and secondary sources
* use scientific evidence and critical thinking skills to solve problems

Year 12 - Communicating Year 12

Students:

* select and use suitable forms of digital, visual, written and/or oral forms of communication
* select and apply appropriate scientific notations, nomenclature and scientific language to communicate in a variety of contexts
* construct evidence-based arguments and engage in peer feedback to evaluate an argument or conclusion

Part 1 - Technology influencing science

| Content | Teaching & learning activities | Resources |
| --- | --- | --- |
| * using examples, assess the impact that developments in technologies have had on the accumulation of evidence for scientific theories, laws and models, including but not limited to:
	+ computerised simulations and models of the Earth's geological history
 | Understanding Earth's geological history from models and simulationsAn exploration into the discovery of Earth’s geological historyStudents to undertake a case study of the Grand Canyon (or other geographically contextual landmark) using a variety of sources.* Teacher selects a short video to watch to engage students and prepare questions to answer.
* Students write about how, for example, the canyon was formed. They should feel free to present their work in any format for example; poster, a poem, 3D model, creative writing (for example; from the perspective of a water droplet viewing all the changes as it passes through the water cycle), flow chart, timeline.

(Note – within the body of their presentation, student must find a way to integrate their understanding of how changing technologies resulted in different findings. This could be achieved by simply annotating with word/thought bubbles. | * [Travel Through Deep Time with this Interactive Earth](https://www.smithsonianmag.com/science-nature/travel-through-deep-time-interactive-earth-180952886/)
* YouTube – [Plate Tectonics in action](https://www.youtube.com/watch?v=Cm5giPd5Uro)
* [Geologic Time](https://serc.carleton.edu/NAGTWorkshops/time/visualizations/geotime.html)
* Layered Earth Geology – [Earth Science simulation](https://layeredearth.com/layered-earth-geology-earth-science-simulation-software-curriculum-education-middle-school-high-school.html)
* [Plate Tectonic Animation](http://earthguide.ucsd.edu/eoc/teachers/t_tectonics/t_tectonics.html) – Earth-guide Online Classroom
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| IQ: How have developments in technology led to advances in scientific theories and laws that, in turn, drive the need for further developments in technology?* using examples, assess the impact that developments in technologies have had on the accumulation of evidence for scientific theories, laws and models, including but not limited to:
	+ X-ray diffraction and the discovery of the structure of deoxyribonucleic acid (DNA)
 | DNA from X-ray diffractionExplainStudents to watch DNA Secrets of Photo 51 videoStudents to read about key steps towards DNA model and with the option of doing their own research, students are to construct a timeline on the importance of technologies in developing the structure of DNA and how models have been changed over time. The timeline should incorporate several features. Each feature is to be represented either above or below the line and each should be written/typed in a different colour.The features of the timeline should include:* Names of scientists (for example; Watson, Crick, Franklin)
* Time periods
* Models used/created along the way
* Technologies used (for example; X-ray diffraction)
* Major discoveries (outlined briefly)
* Problems/Limitations which had to be overcome (briefly described)

Draw vertical/horizontal (as the case may be) lines through the timeline to show when models were refined or altered.ElaborateStudents should research the developments in technologies since X-ray diffraction (for example, electron microscopy) and briefly outline how one of these technologies has contributed to a greater understanding of DNA.Students should add this information to their timelineEvaluateOptional task:Using their timeline as a source of evidence, students write an extended response:Assess the impacts of changing technologies to the development of new scientific ideas and models. | [DNA Secrets of Photo 51 video](https://www.youtube.com/watch?v=Vw8Wrr-ykFc)Developments in technologies since X ray diffraction resources:* [DNA and electron microscopes](https://www.newscientist.com/article/dn22545-dna-imaged-with-electron-microscope-for-the-first-time/)

Other resources* [Structure of DNA](http://ib.bioninja.com.au/higher-level/topic-7-nucleic-acids/71-dna-structure-and-replic/structure-of-dna.html)
* [Discovery of the structure of DNA – Khan Academy (article)](https://www.khanacademy.org/science/biology/dna-as-the-genetic-material/dna-discovery-and-structure/a/discovery-of-the-structure-of-dna)
* YouTube – [Diffraction of Light and the Discovery of DNA Structure](https://www.youtube.com/watch?v=fsYZqiaDsSY)
* [The Discovery of the double helix structure of DNA – Khan Academy (video)](https://www.khanacademy.org/science/biology/dna-as-the-genetic-material/dna-discovery-and-structure/v/the-discovery-of-the-double-helix-structure-of-dna)
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| IQ: How have developments in technology led to advances in scientific theories and laws that, in turn, drive the need for further developments in technology?Students:* using examples, assess the impact that developments in technologies have had on the accumulation of evidence for scientific theories, laws and models, including but not limited to:
	+ technology to detect radioactivity and the development of atomic theory
 | Technology to detect radioactivity and the development of the atomic theoryEngageStudents to recall the model of the atom, draw a diagram of what the atom looks likeExplainStudents research a Wilson cloud chamber. Teacher explains what the tracings show. Teacher guides discussion: the thick lines must have been due to bigger particles, the helium nuclei and the thinner lines due to beta particles. Link back to how this shows the difference in the particles-beta particles are electrons.Students research the photographic film badges worn by workers in the Nuclear Industry-teacher to explain why the film darkens, the darkening is due to the atoms decaying and emitting ionising energy.Teacher to explain how a Geiger Muller counter/scintillation counter works brieflyElaborateUsing the Discovery of radioactivity resource, students to tabulate the Scientists discovery and their contribution to the development of the atomic theory.Teacher explain how these developments in knowledge led to more understanding about the structure of the atom-Use Rutherford’s Gold foil experiment to explain how we know the charges on the subatomic particles and where they are found.Students should reflect on how the technology led to new information about the structure of atoms.EvaluateStudents should reflect on what they have learnt about the link between technology and new knowledge. | Other resources* [What is radiation - ANSTO](https://www.ansto.gov.au/education/nuclear-facts/what-is-radiation)
* [Rutherford’s Nuclear World: the Story of the Discovery of the Nucleus](https://history.aip.org/exhibits/rutherford/sections/alpha-particles-atom.html)
* [Discovery of radioactivity](https://www.britannica.com/science/atom/Discovery-of-radioactivity)
* [Detecting radiation](http://www.bbc.co.uk/schools/gcsebitesize/science/aqa_pre_2011/radiation/radioactiverev6.shtml)
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Part 2 - Science influencing the development of technology

| Content | Teaching & learning activities | Resources |
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| IQ: How have developments in technology led to advances in scientific theories and laws that, in turn, drive the need for further developments in technology?Students:* using examples, assess the impact that developments in technologies have had on the accumulation of evidence for scientific theories, laws and models, including but not limited to:
	+ the Hadron collider and discovery of the Higgs boson
 | The Higgs boson and the Large Hadron Collider (LHC) Engage* Students read news article LHC could kill us all
* Group brainstorm - What do I know about the LHC?
* Group brainstorm - What do I know about the Higgs boson
* Important definitions.

Explore* Students watch the LHC rap video and list some of the key instruments in the LHC and what they do.
* What is the Higgs boson? Watch Higgs boson videos
* What about the Higgs boson led to the LHC? Watch Higgs to LHC videos

Explain/ elaborate* Student research task - create a tourism pamphlet or an information sheet for those visiting the LHC. Details should include:
	+ What does it do?
	+ What technology were required to build the LHC
	+ When were key discoveries made?
	+ What are the key upcoming events
	+ What countries are involved
	+ How to get there.

EvaluateWhat are the future technologies being implemented?What lessons can be learnt for new colliders?Sample HSC question - Assess the impact that hypothesis of the Higgs Boson had on the developments of technologies such as the Large Hadron Collider | News article: [LHC could kill us all](http://blogs.nature.com/news/2008/03/more_physics_nonsense_the_lhc.html)LHC [rap song and video](https://www.youtube.com/watch?v=j50ZssEojtM&feature=youtu.be)YouTube – [4 Discoveries made by the Large Hadron Collider](https://www.youtube.com/watch?v=83FbDC3jcmE)YouTube –[The Higgs Boson Simplified through Animation](https://www.youtube.com/watch?v=L6AN6UwTTjU)YouTube – [The Large Hadron Collider Project](https://www.youtube.com/watch?v=2PI7spY1bPg)Higgs boson videosYoutube - [Minute Physics 1 - What is the Higgs Boson?](https://www.youtube.com/watch?v=9Uh5mTxRQcg&feature=youtu.be)Higgs to LHC videosYoutube - Minute Physics 2 [Why did we need the LHC to 'discover' the Higgs Boson](https://www.youtube.com/watch?v=6guXMfg88Z8&feature=youtu.be)Other resources* Website: [The Higgs boson – CERN](https://home.cern/topics/higgs-boson)
* Article: [How the Higgs Boson was found](https://www.smithsonianmag.com/science-nature/how-the-higgs-boson-was-found-4723520/)
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| IQ: How have developments in technology led to advances in scientific theories and laws that, in turn, drive the need for further developments in technology?Students:* using examples, assess the impact that developments in scientific theories, laws and models have had on the development of new technologies, including but not limited to:
	+ the laws of refraction and reflection on the development of microscopes and telescopes
 | The laws of reflection and refraction leading to microscopes and telescopesEngageLook at some samples under a microscope. Examine interesting mirrors or refraction illusionsExploreRecount the phenomena of reflection and refraction from Stage 5. Find some cool optical illusions or pictures that use these phenomena and share with the class.ExplainDo practical investigation on reflection and reflectionElaborateWhat are the limits of microscopes and telescopes? Students can construct a timeline of important developments or people in the development of microscopes and telescopes using Timeline resource EvaluateSample HSC question - Assess the impact that understandings of reflection and refraction have had on the developments of microscopes and telescopes | Timeline resource - [Molecular Expressions: Science, Optics and you](https://micro.magnet.fsu.edu/optics/timeline/people/) |
| IQ: How have developments in technology led to advances in scientific theories and laws that, in turn, drive the need for further developments in technology?Students:* using examples, assess the impact that developments in scientific theories, laws and models have had on the development of new technologies, including but not limited to:
	+ radioactivity and radioactive decay on the development of radiotherapy and nuclear bombs
 | Nuclear science and the development of radiotherapy and nuclear bombsEngage/ExploreStudents to define what radiotherapy is and why it is used.Students to research what nuclear bombs have been used- hint for them to search ‘ Little Boy’, ‘Fat Boy’’, Hiroshima, Nuclear testing in the Pacific, Manhattan projectPossibility to hold class debate: The Good and the Bad of nuclear technology or assign groups to report back to class.ExplainTeacher to explain how atoms which decay produce charged particles-helium nuclei and electrons-these ionise/ destroy cells, teacher to explain the alpha particle being the biggest will cause the most ionising but due to its size will not penetrate as far. Gamma radiation will penetrate the furthest.ElaborateStudents to tabulate the properties of radioactivity: alpha, beta, gamma and ionising ability and penetrating power for each type of radiation.EvaluateStudents to summarise the positive and negative aspects of the uses of radioisotopes used in radiotherapy.Students to write a letter to their Local MP, explaining why Australians should be opposed to the use of Nuclear bombs. | Other resources1. [Basic Nuclear Science information](http://www2.lbl.gov/abc/Basic.html)
2. [Half-life](http://www.bbc.co.uk/schools/gcsebitesize/science/add_ocr_gateway/radiation/radioactivityrev1.shtml)
3. [Radiation: Effects and Sources – ANSTO](http://www.ansto.gov.au/cs/groups/corporate/documents/document/mdaw/mdu2/~edisp/acs106214.pdf)
4. [Radioactive Fallout – Worldwide effects of Nuclear War](http://www.atomicarchive.com/Docs/Effects/wenw_chp2.shtml)
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| IQ: How have developments in technology led to advances in scientific theories and laws that, in turn, drive the need for further developments in technology?Students:* using examples, assess the impact that developments in scientific theories, laws and models have had on the development of new technologies, including but not limited to:
	+ the discovery of the structure of DNA and the development of biotechnologies to genetically modify organisms
 | Unlocking DNA and genetic technologiesEngageRecall the structure of DNA and how it unzips and replicates itself.Define what genetic modification means.Are students aware of any GM foods they eat or products they use? ExploreUsing playdough, make round plasmids of DNA, model how a section could be spliced, re-inserted into another plasmid and then that circular piece of DNA would replicate with the new sequence in it.ExplainStudents to discuss the following question: 1. Identify the scientific model and/or theory which led to further scientific research into a named biotechnology and explain how the model and/or theory “opened the door” to this development. (Students to recall X ray diffraction and the structure of DNA and how modelling DNA leads to ideas of splicing and genetic manipulation).
2. How have advances in technology led to even further technological advances? (Students should be able to cite specific examples eg. X ray diffraction leads to discovery of DNA and DNA modelling, which in turn leads to biotechnologies)

Using fermentation as an example of biotechnology, or development of antibiotics, summarise how organisms are modified genetically to produce useful products. ORStudents to research their own application of genetic modification for example; gene splicing in embryos.ElaborateBuilding on the example of antibiotics (or any other chosen example) students discuss how we constantly learn more about genetics for example; micro-organisms (in the case of antibiotics) and this leads to better understanding and new technologies.EvaluateHold a class debate: Should GM be on labels for consumers? ORHold a class debate on any issues concerning the ethics of gene modification technologies. | 1. [Genetically Modified Organisms (GMOs)](https://www.nature.com/scitable/topicpage/genetically-modified-organisms-gmos-transgenic-crops-and-732)
2. [Recombinant DNA Technology and Transgenic Animals](https://www.nature.com/scitable/topicpage/recombinant-dna-technology-and-transgenic-animals-34513)
3. [DNA double helix: discovery that led to 60 years of biological revolution](https://www.theguardian.com/science/2013/apr/25/dna-double-helix-60-years-biological-revolution)
4. [Modern Biotechnology – Science Learning Hub](https://www.sciencelearn.org.nz/resources/1206-modern-biotechnology)
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| IQ: How have developments in technology led to advances in scientific theories and laws that, in turn, drive the need for further developments in technology?Students:* using examples, assess the impact that developments in scientific theories, laws and models have had on the development of new technologies, including but not limited to:
	+ Newton's laws and the technology required to build buildings capable of withstanding earthquakes
 | Newton's laws and earthquake-proofing buildingsEngageRecall Newton’s Laws of motion. Students should try and refute 'Derek's 3 incorrect laws of motion' ExploreUsing the resources list the features that help to make buildings earthquake proof. Teacher could also use Slinky springs to demonstrate compression and transverse waves, relate these to p, r, s and l earthquake waves. Show how each type of wave causes different damage to buildings.ExplainRelate each design feature to Newton’s Laws. Teacher to make clear that these design features absorb resonance. How do they minimise damage from the forces generated by activity beneath Earth’s surface.ElaborateImagine if their school was in an earthquake zone, what changes would be needed to their school buildings.EvaluateUsing Newton’s Laws how would their suggested changes to their school design be an improvement? | [Derek's 3 incorrect laws of motion video](https://www.youtube.com/watch?v=Yf0BN0kq7OU&feature=youtu.be)Resource list:1. [Can you build an Earthquake proof building – Imagination station](https://www.imaginationstationtoledo.org/educator/activities/can-you-build-an-earthquake-proof-building)
2. [Faultline: Earthquake Engineering](https://www.exploratorium.edu/faultline/damage/building.html)
3. [10 Technologies That Help Buildings Resist Earthquakes](https://science.howstuffworks.com/innovation/science-questions/10-technologies-that-help-buildings-resist-earthquakes.htm)
4. [Earthquake Proof and Resistant Building Structures](http://www.reidsteel.com/steel-buildings/resilient-steel-structures/earthquake-resistant-building/)
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Part 3 - The Australian context

| Content | Teaching & learning activities | Resources |
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| Students:* investigate scientists' increasing awareness of the value of Aboriginal and Torres Strait Islander peoples' knowledge and understanding of the medicinal and material uses of plants and, in partnership with communities, investigate the potential for ethical development of new drug treatments and synthetic chemicals through the bio harvesting of plants from Country and place
 | EngageAsk if students are aware of any examples of how plants are used by Aboriginal and Torres Strait Islander peoples. Using aspirin as an example of a medicine that came from plants-discuss with students how plants are being used to look for new ways of treating disease. ExploreUsing the resource summarise what plants Aboriginals have been reported to use medicinally. Schools should make contact with local community members or Aboriginal Education consultants to gain local perspective.ExplainResearch what steps are taken in the development of drugs. Read the guidelines posted on the TGA website.ElaborateTeacher to lead discussion on how the pharmaceutical industry and materials experts could cooperate with Aboriginal and Torres Strait islander peoples to share their knowledgeStudents to write a proposal to ……. company explaining how the local Aboriginal community could share their knowledge of ... to allow the development of new …EvaluateStudents to brainstorm what they have learnt about Aboriginal and Torres Strait Islander people’s knowledge and understanding in this area. | [Aboriginal use of plants for medicine](http://www.australiangeographic.com.au/topics/history-culture/2012/05/bush-medicine-aboriginal-remedies-for-common-ills/) This resource is generalised and uses examples from all over Australia.[Therapeutic Goods Administration Website](https://www.tga.gov.au/standards-guidelines-prescription-medicines)  |