**Year 9 Earth Sciences and Biology:**

**Changes in the Earth and Ecosystems over Time.**

**Acknowledgement**

This teaching sequence was developed by students in the Issues in Science and Environmental Education (ESS439) unit in trimester 1, 2017.  Peta White lead the unit and had support from colleagues Kieran Lim, John Cripps Clark, Ian Bentley, Russell Tytler, Jorja McKinnon, and Connie Cirkony who supported the students in the initial sequence design.  Research scientists were invited from the Faculty of Science and the Built Environment and contributed their research and ideas as the basis for the students to then develop teaching sequences that result in contemporary science practices being infused into secondary school science.  All sequences were edited by Mary Vamvakas prior to publishing.

Thanks to the following students for their efforts in generating this innovative teaching sequence: **Chuong Ly and Virginia Vuong**

**KEY OUTCOMES**

The purpose of this teaching and learning sequence is to have our students to recognise the importance in understanding our past to appreciate the nuances of the present and to give us the knowledge to make predictions for the future. [Dr Liz Weldon’s](http://www.deakin.edu.au/about-deakin/people/liz-weldon) research highlights this with the analysis of fossils from 250-260 million years ago and tracking trends in our past to allow us to get an insight to whether contemporary issues are abnormal or not. The teaching and learning sequence delivers this by examining the movement of tectonic plates in the past that have created the mountain ranges and volcanoes we know today, and to predict what the Earth’s terrain will look like in the future. The union between different fields of sciences, in line with Dr Weldon’s research, will also be illustrated in the learning sequence to overcome the misconception that each science stands alone and that you must learn and approach them separately. A final goal is also for students to appreciate the *nature* *and development* of science with ‘scientific knowledge, including models and theories, iscontestable and is refined over time through a process of review by the scientific community’ (ACARA, 2016). The Earth is dynamic, and our students will understand that we make assumptions and create theories based on the current knowledge and facts, and we adjust them as necessary with new evidence.

**TEACHING AND LEARNING SEQUENCE**

This sequence combines aspects of year 9 Earth and Space sciences with Biological sciences and introduces students to a field called Biogeography, which is the study of the distribution of flora and fauna over time and space. The four out of five teaching and learning lessons start from exploring the whole world, broadly, with each lesson zooming in a little more for students to finally discover specific marine ecosystems in Australia. Each lesson embraces the research of Dr Liz Weldon. The summative assessment (see appendix 4) is an ongoing project throughout the sequence and the fifth, and last, lesson is for students to complete the task. This last lesson is also a safety net for teachers to overflow from previous lessons and allows for some flexibility. The sequence is planned in a way such that students have the learning scaffolded from one lesson to the next, as well as within the lessons to approach the activities.

The unit on ecosystems, as outlined by the Australian Curriculum, will be cut in half. The elaborations focusing on ecosystems as a whole and how they are related to Australia’s plate movement will be explored in this sequence. It is intended that the exploration of the complexities within ecosystems will be the next sequence of learning.

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| **Lesson 1: The puzzle pieces of the world** |
| Learning Intentions:Understand the importance of palaeontology.* Describe how [Dr Liz Weldon’s](http://www.deakin.edu.au/about-deakin/people/liz-weldon) research is utilised to understand the trends of today.

Recognise the major tectonic plates on a world map.* Accurately drawing the major plates on a map.
* Plate boundaries are positioned in volcanic and earthquake hotspots.
* Show that Australia sits in the middle of a plate

Understand the role of heat energy and convection currents in the movement of tectonic plates.* Illustrate/describe the convection current in relation to the movement of the plates.
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| Teaching inputs and student activities:* Show video of Dr Liz Weldon. Provide questions to ensure students are engaged and receive the key messages. Example questions include:
* What are some of the key skills palaeontologists like Dr Liz Weldon would need to help them in their work?
* Describe three different tasks that Dr Weldon undertakes as part of her role as a palaeontologist.
* Other than Science what other subject areas assist Dr Weldon in her job. Explain using examples.
* How old are the fossils that Dr Weldon studies? List some examples of the fossils she studies.
* THINK PAIR SHARE: Teacher to provide key words and concepts (e.g. tectonic plates, ecosystem, fossils, fault line) of the learning sequence and use as a diagnostic tool. Students to keep record of their ideas and to update them, if necessary, when the concepts are elaborated in the sequence.
* Teacher to give brief overview of the teaching and learning sequence and introduce the summative task. **See link in resources**.
* Interactive website to show the major plates of the world.
* Students to draw plates on a world map. This will be revisited in lesson two as they develop a deeper understanding on the plate boundaries. (World map should be copied on A3 to allow annotations from Lesson 2 Role Plays)
* Students to view video “Causes of Tectonic Plate Movement” and write a brief summary of how tectonic plates move.
* Colourful convections: this activity can be demonstrated by only the teacher if time and/or resources are limited. Otherwise, students will work in pairs. This activity creates the opportunity for students to make predictions on how they believe the plates of the earth move.
* Teacher will mention how brachiopods, as explained in Weldon’s research, are affected by how convection currents cause plate movements. This idea will be explored further in lessons three and four.
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| Resources:Dr Liz Weldon Video: <https://video.deakin.edu.au/media/t/0_0hgoo3u2>Summative task (Appendix 4). [https://deakin365-my.sharepoint.com/personal/cqly\_deakin\_edu\_au/\_layouts/15/guestaccess.aspx?docid=123821b981f554434a600043411f8163c&authkey=ATpK0m2TMD2eKY1LPV4PCLQ](https://l.facebook.com/l.php?u=https%3A%2F%2Fdeakin365-my.sharepoint.com%2Fpersonal%2Fcqly_deakin_edu_au%2F_layouts%2F15%2Fguestaccess.aspx%3Fdocid%3D123821b981f554434a600043411f8163c%26authkey%3DATpK0m2TMD2eKY1LPV4PCLQ&h=ATNZDRZFJspH6mb3_57zCEWVxljcdKawe0Jn93iOwYmoSbCVEb08QfW5szpnixOvKEIGOBi0F5eOfy2gLd1Edhf0ADbNAYAXEMAK74EvqQTJ9laVt3IcFMK-gWwlQjMRxUt4lA)World Map copied on A3: <http://www.outline-world-map.com/outline-transparent-world-map-b1b>World plates:<https://www.learner.org/interactives/dynamicearth/platesboundarieschallenge/>The major plates will be the requirement for this lesson. Students can revisit this site for the next lesson or for their summative assessment.Causes of Tectonic Plate Movement: <https://www.youtube.com/watch?v=KYt4Muz6hSQ>Convection currents practical: <https://www.youtube.com/watch?v=RCO90hvEL1I> |
| Assessments:The Think Pair Share activity will allow the teacher to determine prior knowledge to gauge the students’ current position within the prospective learning material.The world map activity will portray the students’ familiarity with the countries on a map in conjunction with any volcanic and earthquake hotspots they know.The predictions the students make will draw upon what they already know, as well as the material covered during the lesson. This will illustrate the students’ ability to infer by pondering, making connections and questioning what they know. |

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| **Lesson 2: The plates** |
| Learning intentions:To know the different types and effects of moving plate boundaries.* Divergent, transform and convergent (oceanic-oceanic, continental-continental, oceanic-continental) plate boundaries.
* Occurrences of volcanic activity and earthquakes are in response to constructive and destructive plate boundaries.
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| Teaching inputs and student activities:* Tectonic plate boundaries role play (Appendix 1)
	+ Students watching role plays to annotate various plate boundaries on their World Map

 Teacher will lead a debrief/discussion on:* How the students’ knowledge on plate movement and boundaries have developed over the two lessons. (*Students to update their prediction from previous lesson*).
* What other ways could these plate boundaries have been represented to still convey the dynamic nature of the plates?
* Touch on how water flow can be affected and changed due to plate movements.
* Teacher to elaborate further on summative task.
* Time is given for students to work on this task.
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| Resources: Role Play instructions: (Appendix 1)The teacher will explicitly name the types of plate boundaries. The students can collaborate within their small groups to find their own resources for research. |
| Assessments:The role-play and narration itself is quite simple but a successful one will be the result of translating a complex concept into some simple actions by collaborating with peers.Monitor understanding from the reflections of progression from lessons 1 and 2. |

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| **Lesson 3: Australia – past to present** |
| Learning intentions:Identify why Australia does not have active volcanoes or large earthquakes.* Explain this in relation to Australia’s tectonic plate stability and extreme age.

Understand that Australia’s land mass has moved over time and has experienced the changing climates of this planet. |
| Teaching inputs and student activities:* Students to brainstorm and create a mind map, in pairs, on Australia’s stability.
* Students will be provided with some of Dr Liz Weldon’s research and will be asked to engage with some of the data and answer relevant questions (see Appendix 2)
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| Resources:Worksheet on Dr Liz Weldon’s research: [http://www.sciencedirect.com.ezproxy-](http://www.sciencedirect.com.ezproxy-b.deakin.edu.au/science/article/pii/S1871174X16300762)[b.deakin.edu.au/science/article/pii/S1871174X16300762](http://www.sciencedirect.com.ezproxy-b.deakin.edu.au/science/article/pii/S1871174X16300762) (see Appendix 2) |
| Assessments:Confirming/understanding that Australia sits within a plate.Assess ability to work independently and engage with a scientific report. |

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| **Lesson 4: Ecosystems in Australia** |
| Learning intentions:Define ecosystem and identify some different ecosystems in Australia. Explain how Australian ecosystems can change in the long term.* Long term effects such as continental drift and climate change. Explain how Australian ecosystems can change in the short term.
* Short term effects such as natural disasters and seasonal changes
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| Teaching inputs and student activities:* The teacher will facilitate a simulation (see Appendix 3) of some of Australia’s marine ecosystems over a period of the past 260 million years.
* Class discussion:

– how did the simulation show us, in conjunction with climate change, Australia’s plate movement? Teacher to guide the discussion in the direction of these long-term effects to the short-term effects. The teacher should also prompt and guide thinking about the different types of ecosystems in Australia.* Students to create an A4 poster illustrating and mapping the connections they learnt from the simulation and discussion.
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| Resources: (Appendix 3) |
| Assessments:Collaborating with peers to connect new concepts and activity. Ability to independently draw conclusions. |

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| **Lesson 5: Completing the summative task (revisit previous lessons if necessary)** |
| Learning intentions:To complete and submit the project. |
| Teaching inputs and student activities:This lesson is available for the teacher to elaborate on any of the previous lessons. Students are expected to submit their completed project by the end of the lesson.If there are students who submit prior to the end of the lesson, they can choose one of the ecosystems of most interest (discussed in the previous lesson) to start researching. |
| Resources: (Appendix 4)[https://deakin365-my.sharepoint.com/personal/cqly\_deakin\_edu\_au/\_layouts/15/guestaccess.aspx?docid=123821b981f554434a600043411f8163c&authkey=ATpK0m2TMD2eKY1LPV4PCLQ](https://l.facebook.com/l.php?u=https%3A%2F%2Fdeakin365-my.sharepoint.com%2Fpersonal%2Fcqly_deakin_edu_au%2F_layouts%2F15%2Fguestaccess.aspx%3Fdocid%3D123821b981f554434a600043411f8163c%26authkey%3DATpK0m2TMD2eKY1LPV4PCLQ&h=ATNZDRZFJspH6mb3_57zCEWVxljcdKawe0Jn93iOwYmoSbCVEb08QfW5szpnixOvKEIGOBi0F5eOfy2gLd1Edhf0ADbNAYAXEMAK74EvqQTJ9laVt3IcFMK-gWwlQjMRxUt4lA) |
| Assessments: Summative taskTime management skills in a work-dedicated lesson |

**SCAFFOLDING FOR LEARNING**

The structure, design and order of activities for scaffolding should be evident in the teaching and learning sequence table. Edgar’s (1946) “cone of experience” is essential as the increase in participation could lead to higher education attainment as a result of the participation being closely representing reality. Activities that scaffold students’ learning until they are comfortable enough to approach tasks independently have been provided. A wide range of activities, and activities completed in different group sizes are aimed to allow every student to an experience where they are approaching new learning material from their preferred learning method.

**INFUSION OF CONTEMPORARY SCIENCE**

Dr Liz Weldon’s research is used as the main resource for lesson three and is the inspiration for the marine ecosystem simulation in lesson four. The first two lessons should have the teacher making suggestions about brachiopods, relating to the video and also lesson three and four.

**ASSESSMENTS**

The first two lessons of the sequence require the teacher to be engaged and observant throughout the activities as to assess prior knowledge and understanding of the new concepts. The formative assessments are frequent near the start as to have as many opportunities to gauge and assist student understanding before they move on to more independent tasks. The summative assessment allows some flexibility for students to complete tasks they deem most interesting or most suited to their learning style.

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**Appendices**

Appendix 1

Tectonic plate boundaries role play activity:

* The teacher will separate students into five groups and each group will be allocated a different plate boundary.
* Within each group, the students will research (on devices if available, or from handouts developed by the teacher) either the divergent, transform or convergent (oceanic-oceanic, continental-continental, oceanic-continental) plate boundary.
* The jigsaw activity will have each group using their research to role-play their plate boundary whilst narrating:

o An outline of how and where the plates move

o The constructive and/or destructive nature of the plate movement at the boundary

o Two examples in the world of their plate boundary.

* The group researching and role-playing oceanic-oceanic convergent plates will be prompted to identify how convection currents play a role in plate movement.
* **Students not performing the role play will be required to annotate and add to their world map from the previous lesson.**

Appendix 2

**Analysing Dr Liz Weldon’s Research**

Worksheet on Dr Liz Weldon’s research: [http://www.sciencedirect.com.ezproxy-](http://www.sciencedirect.com.ezproxy-b.deakin.edu.au/science/article/pii/S1871174X16300762)

[b.deakin.edu.au/science/article/pii/S1871174X16300762](http://www.sciencedirect.com.ezproxy-b.deakin.edu.au/science/article/pii/S1871174X16300762)

The Geological Time Scale shown is used by geologists and palaeontologists to describe the timing and relationships of events that have occurred during Earth's history from 4500 million years (Myr) ago to now. The scale is divided into time intervals as a hierarchy that includes **eons, eras** and **periods**.

It is interesting to note that the first multicellular animals appeared in the fossil record about 620 Myr ago.

**1. Locate 620 Myr on the Geological time scale on your right and mark it with an X.**

Dr Liz Weldon’s research paper focused on Brachiopod fossils found from the Mississippian (Early Carboniferous), to Early Triassic Periods.

**2. Locate these Periods on the Geological Time Scale on the right. What time period in Million years does this represent?**

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**3. The first modern human appeared about 190,000 years ago. During what era, eon, period and epoch did humans appear?**

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The figure below represents part of the Geological Time Scale taken from Dr Weldon’s research paper “Fig. 4. Environmental changes from the Carboniferous to the Griesbachian”.

This figure represents the time range that Dr Weldon was studying the Brachiopod fossils.



Study the diagram and research the internet to answer the following questions. Note the sea-level changes curve shows increasing transgression (greatest change) of sea-level and the bottom graph shows % oxygen (O18) levels in the water. *Note more O18molecules in the water is interpreted to mean the Earth is cooling down* during this time, and there is more ice at the poles. (<https://timescavengers.blog/introductory-material/what-is-paleoclimatology/proxy-data/carbon-oxygen-isotopes/> )

1. Research what is meant by a glacial interval.
2. At times when the sea levels are high would the global temperature be higher or lower and what effect would this have on oxygen levels in the sea?
3. During the Permian–Triassic Periods there was mass extinction of organisms and the environment was highly stressful. What evidence from the diagram supports this conclusion? Explain.
4. Marine organisms with a small body size require fewer food resources and oxygen to sustain their metabolism and to make calcium carbonate shells. Would these types of organisms have a high or low chance of survival during the time period outlined in question 3 above? Explain.

Appendix 3

**Seasonal Change and Marine Diversity Simulation.**

**What will you need?**

* 20-30 students
* Marine card: Unique marine species printed on a piece of paper, mostly consisting of warm marine organism while the rest are cold environment marine species. Each piece of paper will have a temperature range in which the species can exist.
* Marked area. OPTIONAL: duct tape, to create a marked area.

**Things to consider when selecting organisms for simulation**

30oC is hot, while 5oC is considered cold (European Commission 2007)

Increase is depth = colder environments. Therefore, when selecting warm marine environment organisms, select organisms that live in the least depth marine environments eg. Great barrier reef (Marine bio)

<https://www.coolantarctica.com/Antarctica%20fact%20file/wildlife/antarctic_animal_adaptations2.php>

<http://www.enchantedlearning.com/biomes/coralreef/coralreef.shtml>

**Student and Teacher Actions/Inputs**

1. Teachers will hand out the one marine card to each student in the classroom. Teachers are to direct students to go inside the marked area.
2. Teachers tell students that he/she will yell out a number indicating the temperature of the environment at the time, and students are to move out of the marked area if the number is not in their temperature range.
3. Teachers remind students to keep a mental count of how many students present/ amount of diversity in the marked area after number is called out and to also observe the space of the marked area.
4. Teachers will call out numbers starting with higher numbers and gradually decreasing.
5. Students will observe that higher temperature environments have higher diversity (but low abundance), but colder environments have lower diversity (and higher abundance) of each individual organism. While students will observe diversity, they will not be able to observe abundance.

**Potential Questions**

1. What did you observe with the higher temperatures in terms of marine diversity?
2. What did you observe with lower temperatures in terms of marine diversity?
3. What was the relationship between temperature, marine diversity and the space in the marked area?
4. Give us some examples of high and low temperature marine environments. Does this simulation represent the real world?
5. While you have been able to observe species diversity in your simulation, you have not observed species abundance in each environment. Research and explain the effect of water temperature on abundance of each species in the warm and cold marine environments. The following link may be of help <http://www.gma.org/comparing_oceans.html>

Appendix 4

[https://deakin365-](https://l.facebook.com/l.php?u=https%3A%2F%2Fdeakin365-my.sharepoint.com%2Fpersonal%2Fcqly_deakin_edu_au%2F_layouts%2F15%2Fguestaccess.aspx%3Fdocid%3D123821b981f554434a600043411f8163c%26authkey%3DATpK0m2TMD2eKY1LPV4PCLQ&h=ATNZDRZFJspH6mb3_57zCEWVxljcdKawe0Jn93iOwYmoSbCVEb08QfW5szpnixOvKEIGOBi0F5eOfy2gLd1Edhf0ADbNAYAXEMAK74EvqQTJ9laVt3IcFMK-gWwlQjMRxUt4lA)

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