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| Student Worksheet |
| Radiocarbon dating Aboriginal and Torres Strait Islander cultures and histories |
| Information Processing |
| In this resource, students learn about our growing understanding of Aboriginal and Torres Strait Islander histories and cultures using radiocarbon dating.  Students will:   * learn about radiocarbon dating and its applications to cultural heritage materials. * analyse and interpret different texts and videos to better understand Aboriginal and Torres Strait Islander cultures. * build literacy and numeracy capabilities using cloze passages, writing a glossary, interpreting graphs, answering comprehension questions, and making a timeline and a map to summarise the research stories.   **The activities address these Australian Curriculum Science Understanding and Inquiry Skills:**  **Students learn:**   * all matter is made of atoms that are composed of protons, neutrons and electrons; natural radioactivity arises from the decay of nuclei in atoms (ACSSU177)   + investigating how radiocarbon and other dating methods have been used to establish that Aboriginal Peoples have been present on the Australian continent for more than 60,000 years (OI.6) * to communicate scientific ideas and information for a particular purpose, including constructing evidence-based arguments and using appropriate scientific language, conventions and representations (ACSIS174)   General capabilities:   * Literacy * Numeracy   Cross curriculum priorities:   * Aboriginal and Torres Strait Islander Histories and Cultures   **These activities are suitable for students in Years 9-10.** |
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# Suggested Teaching Strategy - Jigsaw reading

**Purpose**

* To actively engage students in understanding the content of a particular text.
* To provide students with the opportunity to work together in small groups to accomplish shared goals

**Description**

This document provides five texts (activities 2 – 6) on the same topic “Radiocarbon dating Aboriginal and Torres Strait Islander cultures and histories”, each with a different focus. The texts and corresponding questions stand alone as complete units but are related to the topic under discussion.

Students work in groups, which can be similar or mixed ability, to process information for one text, and by doing so learn the content of that text. They then convey/ teach this content to other students, providing their part of the “jigsaw”.

**Implementation**

1. All students should complete Activity 1- Radiocarbon dating.
2. Organise the class into groups of five students. Tell students these are their “home” groups.
3. Within these groups, number students 1, 2, 3, 4, 5. These students will be responsible for conveying the information from their “expert” group activity to the rest of their home group. If there are more than five students in a home group, two students will have the same “expert” number. These students will share the “expert” role for that numbered activity.
4. Group all the 1s, 2s, 3s, 4s and 5s together as “expert” groups. Each group will be provided with the text(s) and questions for one of the activities (Activities 2-6). The texts provided can vary in reading level and can be matched to the level of each “expert” group.
5. Students in “expert” groups process the source(s) of information for their activity. They read, highlight key points, discuss and clarify so that each member of the group understands the content. They jointly answer the questions provided for the activity, with each member of the group recording the answers on their own activity sheet.
6. Students now return to their “home” groups, which contain members from each of the “expert” groups.
7. Each “expert” student takes turns teaching the content of their activity to the “home” group. The home group students record the important points learned from each “expert” in order to answer the questions for that activity. In this way all students will complete the questions for activities 2 to 6.
8. All students should then complete activity 7 to fit the jigsaw parts together.

# Activity 1: Radiocarbon dating

Radiocarbon dating is a well-known method for determining the age of materials up to the age of ~ 50,000 years.

Radiocarbon dating analyses may be carried out on diverse natural materials such as lake sediments, groundwater and surface waters, tree rings, ice-cores, corals, soils and air.

ANSTO scientists use radiocarbon dating to determine the age of ancient artefacts and to shed light on lives of the first people in Australia.

This dating method works by measuring the ratio of different isotopes of carbon in a sample using a particle accelerator. Isotopes are atoms of the same element, having the same number of protons, but different numbers of neutrons.

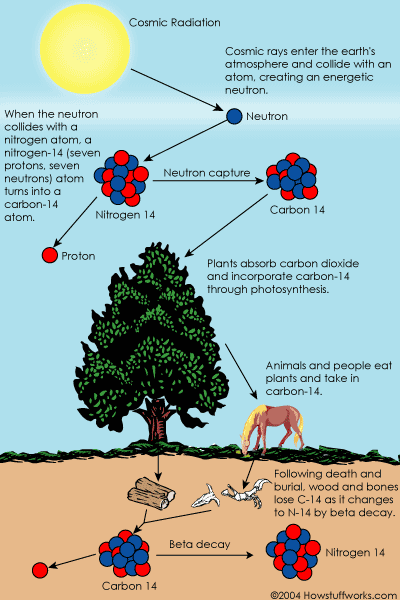
There are three main isotopes of carbon on earth:

Carbon-12 (99% of all carbon on earth)

Carbon-13 (almost 1% of all carbon on earth)

Carbon-14 (trace amounts only)

Carbon-12 and carbon-13 are both stable isotopes, but carbon-14 is unstable and undergoes radioactive decay.

As you can see in the diagram on the left, carbon-14 atoms are constantly being formed in the Earth’s upper atmosphere when cosmic radiation collides with atoms and makes free neutrons. These neutrons then collide with nitrogen-14 (14N) atoms to make carbon-14 (14C) atoms. Atoms of 14C combine with oxygen to make carbon dioxide, which is incorporated into plants during photosynthesis. 14C moves into other living organisms when plants are eaten.

The ratio of 14C to carbon-12 (12C) in an organism remains relatively constant while it is alive, but begins to decrease once the organism dies. Once dead, there is no new 14C incorporated into the organism and 14C continues to decay.

By measuring the 14C : 12C ratio in a biological artefact, such as a piece of bone or wood, we can calculate the age of the artefact.

1. Use the word bank below to complete the following paragraphs:

**seven (7) trace stable most**

**radioactive nucleus six (6) age**

**ratio decays carbon-14 eight (8)**

Carbon-12 is the \_\_\_\_\_\_ abundant carbon isotope. It is \_\_\_\_\_\_\_\_\_ and contains 6 protons and 6 neutrons in its \_\_\_\_\_\_\_\_\_. Carbon-13 makes up almost 1% of all carbon on earth. It is also stable and contains 6 protons and \_\_\_ neutrons in its nucleus. Carbon-14 is found in \_\_\_\_\_\_\_ amounts. It is unstable and \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_, and its nucleus contains \_\_\_ protons and \_\_\_ neutrons.

Living things contain carbon-14 and carbon-12 in a \_\_\_\_\_\_ that is the same as in the atmosphere at the time. When the organism dies, the ratio of carbon-14 to carbon-12 decreases, as carbon-14 \_\_\_\_\_\_\_ away.

Using carbon dating, scientists can calculate how much \_\_\_\_\_\_\_\_\_\_\_ decay has occurred by measuring the ratio of carbon-14 to carbon-12 in the sample. The extent of carbon-14 decay will reveal the \_\_\_\_\_\_ of the sample.

A graph of the decay of carbon-14 over time is below:

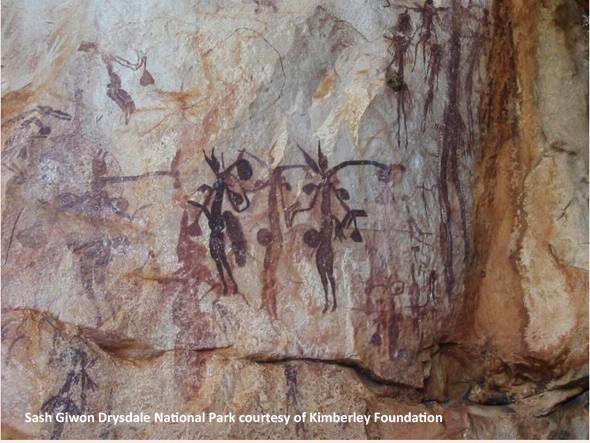
**Example**: A scientist calculates that an artefact contains only 50% of the original amount of carbon-14 it contained when it died. The scientist would use a graph like the one above to calculate that the artefact is approximately 6000 years old.

Use the graph of carbon-14 decay to solve these science puzzles:

1. Carbon-dating was performed on an artefact that was found to have 25% of the original carbon-14 remaining in it. How old is the artefact?

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1. Nuclear techniques are applied to analyse and date rock art, tools, ochres and animal remains, shedding light on the culture of the first people in Australia. An accelerator scientist at ANSTO performed radiocarbon dating and found that an artefact that was 30,000 years old. What percentage of the original carbon-14 remains in the artefact today?

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1. Accelerator scientists at ANSTO date Aboriginal rock art (pictured right) using mud wasp nests to collect evidence of Aboriginal Australians civilisations. The oldest dates suggested that the rock art was 16,000 years old. What percentage of the original carbon-14 remains in the mud-wasp nests today?

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1. Carbon dating is most useful for determining the age of objects up to about 50,000 years old. Refer to the graph to explain why carbon dating is less accurate for objects older than this?

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# Activity 2: Dating the Warratyi Rock Shelter in the Flinders Ranges

Read the following article and answer the questions below:

[1]. ANSTO. (2016). Cutting-edge nuclear techniques help prove Australia's oldest Aboriginal site. News article. <https://www.ansto.gov.au/news/cutting-edge-nuclear-techniques-help-prove-australias-oldest-aboriginal-site>

1. Complete the glossary table below to define the following terms:

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| **Term** | **Definition** |
| Artefacts |  |
| Collocated |  |
| Megafauna |  |
| Non-destructive |  |
| Ochre |  |

1. Where is the site located and who are the traditional owners of the land?

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1. Describe two major findings of this research project and what they tell us about Aboriginal and Torres Strait Islander history and culture.

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1. Why do scientists repeat research that is undertaken by other scientists in other laboratories?

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# Activity 3: Using mud wasp nests to date Aboriginal rock art

Read the two articles and watch the video to answer the questions below.

[2]. University of Melbourne. (2020). Wasp nests used to date Kimberley rock art. News article. <https://about.unimelb.edu.au/newsroom/news/2020/february/wasp-nests-used-to-date-ancient-kimberley-rock-art>

[3]. ANSTO. (2020). Dating Aboriginal rock art using mud wasp nests. News article. <https://www.ansto.gov.au/news/dating-aboriginal-rock-art-using-mud-wasp-nests>

[4]. ANSTO. (2020). Mud wasp building nest helps date Aboriginal rock art. Video. <https://youtu.be/ZstN2zU_Ctc>

1. What are the traditional Aboriginal names for the lands where these rock paintings are found? What is the European name for their location?

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1. What is characteristic of the Gwion Gwion style of rock paintings?

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1. What is the estimated age of the rock paintings?

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1. Explain why it is difficult to date the pigment used in Aboriginal rock paintings.

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1. Radiocarbon dating of mud wasp nests was used as an indirect method of dating the rock paintings. Create a flow chart to show the series of events that enable mud wasp nests to be used to date rock art.

HINT: Describe, in the steps of the flow chart, how the charcoal from ancient bushfires ends up in fossilised mud wasp nests near the rock art and how this is used to date the paintings.

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# Activity 4: Evidence of early occupation of Australia’s coasts at Barrow Island in Northwest Australia

Read the following article and watch the embedded video to answer the questions below:

[5]. ANSTO. (2017). Indigenous Australia. News article. <https://www.ansto.gov.au/news/indigenous-australia>

1. What artefacts were radiocarbon dated and how old were they?

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1. Who are the traditional owners of these lands?

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1. What new information does this study contribute to our understanding of Aboriginal and Torres Strait Islander histories and cultures?

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# Activity 5: World Heritage Listing for Budj Bim Cultural Landscape supported by ANSTO research

Read the following articles and answer the questions below:

[6]. ANSTO (2019). Research supported World Heritage Listing for Aboriginal site. News article. <https://www.ansto.gov.au/news/research-supported-world-heritage-listing-for-aboriginal-site>

[7]. Barras, C. (2020). Is an Aboriginal tale of an ancient volcano the oldest story ever told? Science Magazine. <https://www.sciencemag.org/news/2020/02/aboriginal-tale-ancient-volcano-oldest-story-ever-told>

1. Describe the eel traps at Budj Bim.

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1. Who are the traditional owners of the Budj Bim Cultural Landscape?

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1. Which component of the Budj Bim eel traps were ANSTO scientists able to date using radiocarbon dating? What is the estimated age of the Budj Bim eel traps?

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1. UNESCO has recognised this site as having “outstanding universal value”. How do the Budj Bim eel traps challenge some of the earlier European notions of Aboriginal and Torres Strait Islander cultures?

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1. The Gunditjmara people have lived in the Budj Bim Landscape for a lot longer than 6,600 years. Explain why their oral traditions describing an ancient volcanic eruption may represent the oldest scientific observation ever made?

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# Activity 6: Earliest evidence of Aboriginal occupation in Kakadu National Park

Read the following article and watch the video to answer the questions below:

[8]. ANSTO. (2017). Nuclear science helps prove earliest Aboriginal occupation. News article. <https://www.ansto.gov.au/news/nuclear-science-helps-prove-earliest-aboriginal-occupation>

[9]. Davidson, H. and Wahlquist, C. (2017). Australian dig finds evidence of Aboriginal habitation up to 80,000 years ago. The Guardian. Video. <https://www.theguardian.com/australia-news/2017/jul/19/dig-finds-evidence-of-aboriginal-habitation-up-to-80000-years-ago>

1. What is the name of the site and who are the traditional owners of the land?

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1. What artefacts were found during the archaeological dig?

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1. How has this research changed our understanding of Aboriginal and Torres Strait Islander histories and cultures?

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1. Explain the role of the traditional owners in the project and why it could not have proceeded without their participation.

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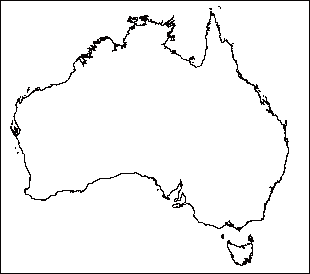
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# Activity 7: Bringing it all together

1. Label the map of Australia below with the following information about each research project:

* Name of site
* Artefacts found
* Age of artefacts
* Traditional owners of the land
* A sentence to describe the significance of the research for our understanding Aboriginal and Torres Strait Islander cultures

Use the AIATSIS map of Indigenous Australia as a guide (<https://aiatsis.gov.au/explore/articles/aiatsis-map-indigenous-australia>)



2. Create a **timeline** to show the length of time that the Aboriginal and Torres Strait Islander peoples have been living continuously in Australia. Plot the five research projects above on the timeline and include other significant events in Aboriginal and Torres Strait Islander histories from your own research and knowledge. Ensure your timeline is to scale.

**Years before present**

**Present day**

1. Traditional owners must give scientists permission before these research projects can begin, and may also have strict conditions for how scientists are allowed to interact with their cultural sites.

Evaluate why it is important for scientists to obtain permission from the traditional owners of the land before commencing science research together with Aboriginal and Torres Strait Islander cultures, using examples from the texts above.

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