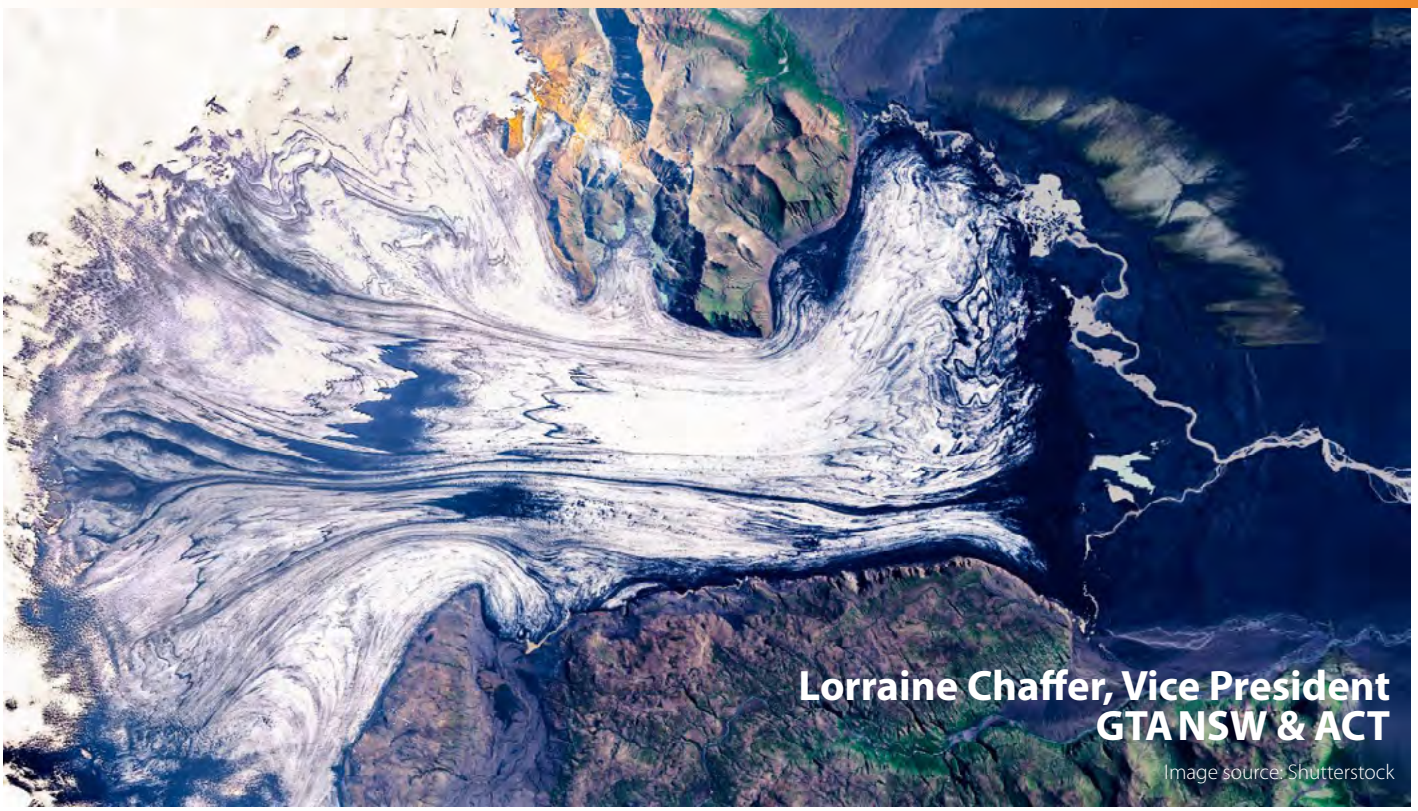


Lorraine Chaffer, Vice President
GTA NSW & ACT

Image source: Shutterstock

EXPLORING THE CRYOSPHERE

INTRODUCTION: 'When I don't know what my students know'

The topic *"Biophysical Interactions"* in Year 11, is about investigating the biophysical processes and interactions that underpin environmental functioning, and the importance of understanding these processes for sustainable management. The topic is foundational learning for Year 12, explicitly for Ecosystems at Risk but also for evaluating the ecological sustainability of economic activities and urban places.

With the implementation of the new K–10 Geography Syllabus, there is significant overlap in content, conceptual understanding, the investigation of biophysical processes and issues currently studied in Stage 6. See Figure 1. Students also study components of the biophysical environment in Science, and potentially in electives subjects such as Elective Geography 7–10, Agricultural Technology 7–10 and Marine and Aquaculture Technology 7–10.

The expectation is that students would undertake a deeper examination of biophysical processes in year 11. Due to variations in how extensively and deeply biophysical processes are investigated in Stage 5, particularly the Environmental Change and Management topic, the problem becomes determining the level prior knowledge and understanding.

A more long-time issue is teaching students you did not teach in Stages 4 and 5 and having confidence in the knowledge, understanding and skills they bring with them into Stage 6. It is important to minimise the reuse of resources and stimulus and reteaching what is known.

Often Biophysical Interactions is taught with a study of each component of the biophysical environment, followed by an investigation of the biophysical interactions in one environment and an issue within that environment. I call this the textbook approach. It is very linear and promotes reteaching or repeating prior learning and inquiry.

STAGE 4 & 5 BIOPHYSICAL TOPICS	STAGE 6 BIOPHYSICAL INTERACTIONS
Water in the World – processes in the hydrosphere and atmosphere – atmospheric /hydrologic hazard **Landforms and landscapes** – processes shaping the lithosphere – geomorphic hazard **Sustainable Biomes** – factors and processes affecting the biosphere (biomes) – biomes used to produce food, fibres and industrial products **Environmental change and management** (biophysical / human interactions in ONE environment)	**The biophysical environment** The nature and functioning of the four components: the atmosphere, hydrosphere, lithosphere and biosphere **in a specific biophysical environment**. The interactions between, and the human impacts on, the functioning of the atmosphere, hydrosphere, lithosphere and biosphere. **Biophysical processes and issue**s A case study investigating **ONE issue in ONE of the biophysical components**, to illustrate how an understanding of biophysical processes contributes to sustainable management in the environment.

Figure 1: Overlap between Stages 4, 5 and 6 topics

The challenges include:

- assessing prior knowledge and understanding to avoid reteaching content
- using resources and case studies not used in Stages 4 and 5.
- starting the year with interesting and challenging investigations to excite and engage

This requires careful programming and lesson development for Geography years 7–12.

Exploring the cryosphere

- It's interesting and topical
- There are plentiful resources, including visual stimulus
- The cryosphere can be used to assess student prior learning about the hydrosphere.
- Links between the cryosphere and the atmosphere, lithosphere and biosphere provide opportunities to assess student understanding of these components of the biophysical environment and interactions between them.
- The cryosphere is undergoing immense change and lends itself to a case study of ONE ISSUE in a component of the biophysical environment e.g. climate change, melting ice caps and retreating glaciers and future water supplies.

A topic plan

A. Create a list of essential knowledge and understanding for each component of the biophysical environment. This will be used in *Step 2* below. See figure 2

B. Design a sequence of learning using the cryosphere as an introductory case study and stimulus. See figure 3.

C. Examine links between the cryosphere, atmosphere, lithosphere, hydrosphere and biosphere.

D. Complete the sequence of learning in Figure 3 for each subsequent sphere. This could be based on other microstudies or stories e.g. *'Miracle in the storm'* for atmosphere; *'Madagascar: a biodiversity hotspot'* for Biosphere; *'Diving between earth's plates'* for Lithosphere.

E. Apply knowledge and understanding of biophysical processes and interactions to:
   - A study of ONE ENVIRONMENT
   - A study of ONE ISSUE in one biophysical component.* This issue may be one that arose in Step 3 and selected for deeper class investigation e.g. climate change, deforestation, dam building, coastal erosion

**Note:* The environment study and / or issue could also be integrated into the sequence of learning where relevant.

Essential knowledge and understanding: Hydrosphere

- Hydrological cycle – processes, volumes, storages, flows
- Global distribution of water
- Open (local) and closed (global) water cycles including the concept of a water budget.
- Factors influencing the hydrologic cycle at different scales.
- Interactions with other components of the biophysical environment
- Human interactions and impacts
- Contemporary issues

Figure 2: Sample list of knowledge and understanding considered essential at Stage 6 level.
Note: This list will be influenced by the environment selected for study in Year 11 Biophysical Interactions and Case Studies selected for Year 12 topics

Sample sequence of learning: Cryosphere / hydrosphere

Step 1: Teacher creates a focus inquiry question and student activities to determine knowledge and understanding about the cryosphere and subsequently, the hydrosphere. This could be stimulus based and differentiated. Students work in small groups to complete activities.

Step 2: As a class create a KWNR chart

- Class populates the **Know** column with known facts and concepts revealed through investigating the cryosphere.
- Students populate the **Want to know** column with their own questions linked to the case study or story.
- Teacher populates the **Need to Know** column. (tick known content)

Step 3: Students complete investigations to answer selected *'Want to know'* questions. Share findings with the class.

Step 4: Explicit teaching and inquiry learning activities to cover remaining 'Need to know' syllabus content about the cryosphere / hydrosphere.

Step 5: Revisit the KWNR Chart to complete the **Reflect** column.

Step 6: Answer the key inquiry question

Step 7: Discuss potential SGP topics that investigate the hydrosphere in the local area.

Figure 3: Sample sequence of learning

KNOW Knowledge and understanding about the cryosphere and hydrosphere	**WANT** My questions about the cryosphere	**NEED** Syllabus requirements (Teacher input) Hydrosphere	**REFLECT** What did I learn?

Figure 4: KWNL chart. What I KNOW, WANT to know, NEED to know, REFLECT. See full page template in Edition 3 Supplement

INVESTIGATING THE CRYOSPHERE

Aim

The following activities illustrate the use of steps 1 – 5 in a sequence of learning about the cryosphere and hydrosphere.

The aim is to stimulate student interest in Earths natural systems through an investigation of the cryosphere while using the activities to unlock the knowledge and understandings students already have from their studies in Stages 4 and 5.

Key inquiry question: How vital is the cryosphere to Earth's natural systems?

Contributing questions:

- *What is the cryosphere? (Features and characteristics)*
- *Where is the cryosphere? (On a world map).*
- *How does the cryosphere change over time? (Temporal change - seasonal, yearly, decadal, over millennia; Spatial change)*
- *Does the cryosphere have critically important interactions with Earth's other biophysical components?*
- *What biophysical processes are unique to the cryosphere?*
- *How have humans altered the cryosphere? What is the impact of change?*
- *Explain how the cryosphere interacts with the hydrosphere, atmosphere, lithosphere and biosphere?*

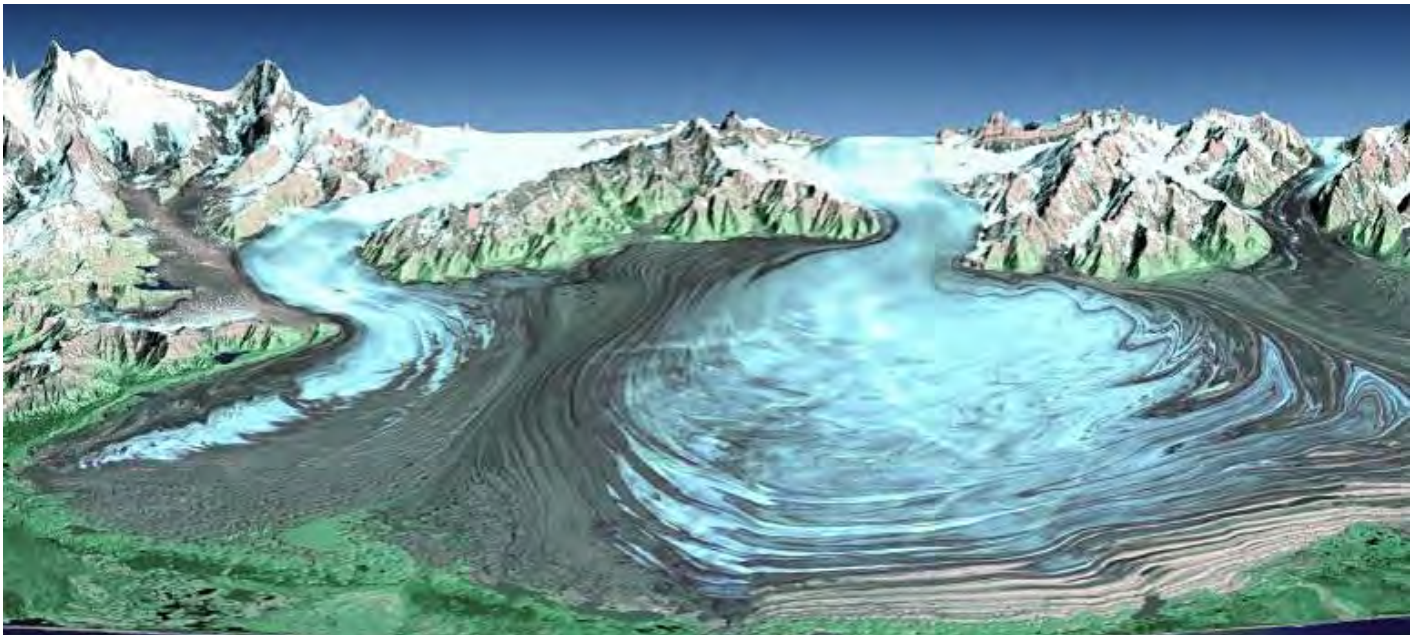
ACTIVITY 1: Features of the cryosphere (Group and class activity)

Use one or more stimulus items such as **Source A** and other visuals on the PPT.

Use a variety of geographical tools such as photographs, simulations, maps and diagrams.

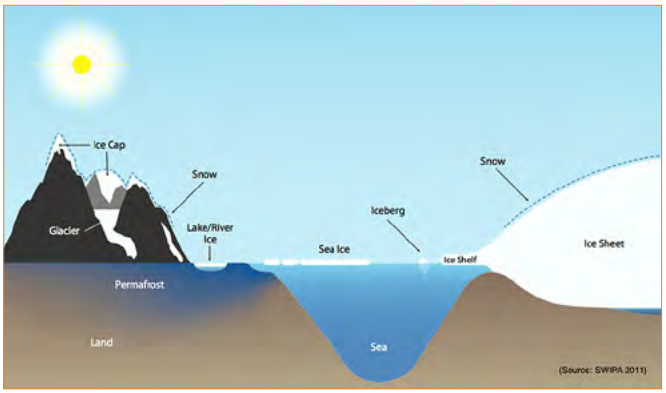
- Group brainstorming / mind mapping - What is the cryosphere? What are its features and characteristics?
- Class discussion and KWNR Chart (See Supplement):
  - Record all responses into the KNOW column.
  - Encourage students to challenge the correctness of responses
  - Use **Source B** to confirm features of the cryosphere
  - Discuss a range of biophysical processes in the cryosphere such as formation of snow, glaciation, glacier advance and retreat, permafrost, iceberg calving, sea ice formation.
- Students suggest content for the REFLECT column. They may also make notes.
- Students start a glossary of key terms and concepts.

Source A: Cryosphere time lapse



Source: Scitechdaily – https://scitechdaily.com/ice-in-motion-incredible-time-lapse-satellite-footage-captures-decades-of-change/

Source B: Features of the cryosphere



Source: https://globalcryospherewatch.org/about/cryosphere.html

ACTIVITY 2: Mapping spatial patterns / peer assessment (Group Activity)

- Students map where they believe features of the cryosphere would be located on a world map. (Where is the cryosphere found?)

  On Map 1: Create a colour key and shade where you would expect to find each feature:
  - Ice cap
  - Ice shelf
  - Sea ice
  - Glacier
  - Permafrost

  On Map 2: Select a colour to represent snow. Shade the areas on the map that would generally receive snow during a year.

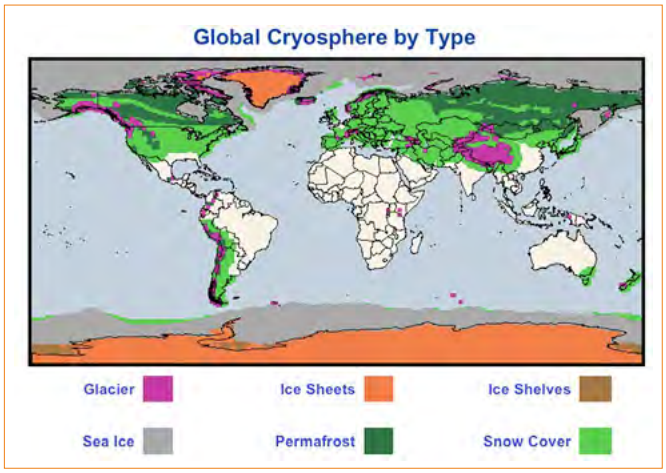
  See Supplement for world maps

- Peer assessment:
  - ONE student from each group shares maps with a nearby group for feedback.
  - The student reports back to their group who may choose to adjust the maps.
  - Each group swap maps with a different group for peer assessment.
  - Use **Source C** as the criteria for assessment. Display using the PPT

Allocate 1 mark for each correctly located feature to a maximum of 20 marks.

- Class discussion of the spatial patterns shown in Source C. Identify locations such as poles, equator, continents, mountain ranges, oceans, hemispheres
- Students write a paragraph describing the global distribution of the cryosphere.
- Students add information to the REFLECT column. They may also make notes.

Source C: Spatial distribution of the cryosphere

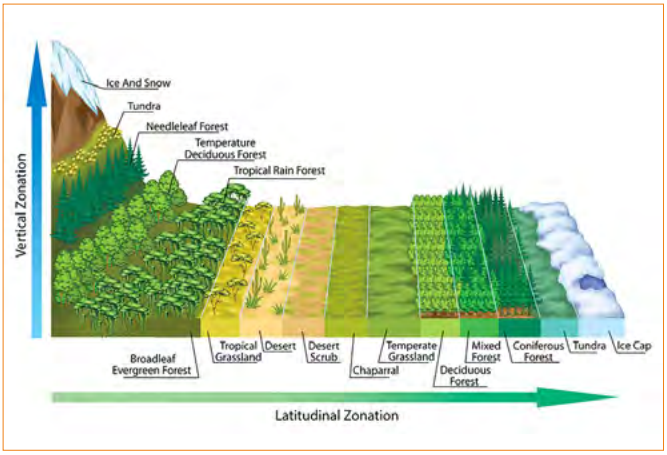


Source: https://globalcryospherewatch.org/about/cryosphere.html

ACTIVITY 3: Factors explaining cryosphere distribution

- Discussion: What factors explain the distribution of the cryosphere.
  - Use **Source D** to assist students struggling to get started.
  - Add correct responses to the Know column of the KWNR Chart
  - Some explicit teaching or directed questioning may be needed here to link prior learning
- Remind students that they studied the hydrosphere in Stage 4 Water in the World and biosphere in Stage 5 Sustainable Biomes. Make use of Geography Bulletin 52, Edition 2 Snapshot to revisit processes linked to biomes and water.
- Students write a paragraph explaining the distribution of the cryosphere using geographical concepts e.g. climate, latitude, altitude, insolation, atmosphere

Source D: Factors explaining the location of the cryosphere



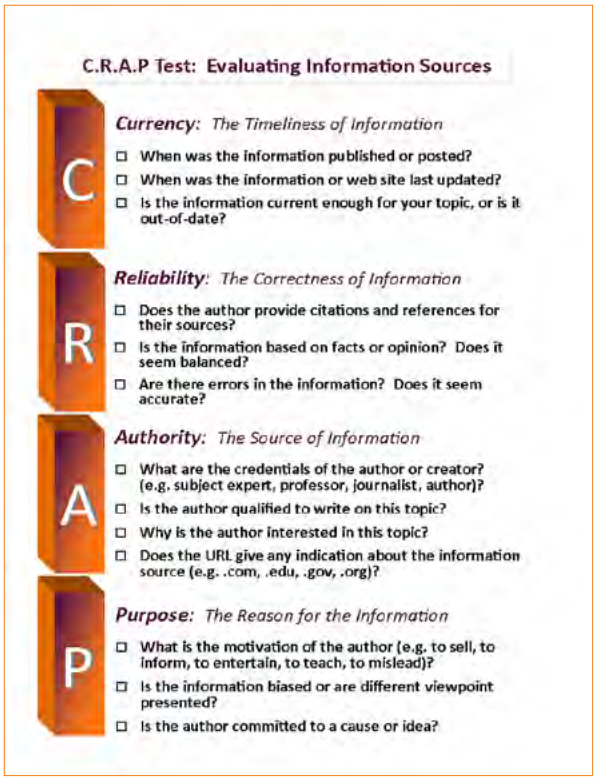
Source: Shutterstock

ACTIVITY 4: Investigation

Students contribute questions for the WANT to know column in the KWNR Chart.

- Individually or in pairs students select ONE question to research for ONE lesson.
  - Use websites to answer the selected question.
  - Evaluate two websites using **Source E**, the Information Evaluation Rubric or CRAP Test. (See Supplement for evaluation template).
  - Give an 'Explain in 1 minute' presentation to the class including a CRAP or NOT CRAP assessment of the two selected websites.
- Class identifies components of the CRAP TEST that match the concepts of validity, reliability and usefulness used in the Stage 6 Geography Syllabus
- In the absence of student questions, have a range of questions prepared that you can suggest. These should create deeper knowledge about the cryosphere. For example:
  - How do icecaps form?
  - What is glacial melt and why is it important?
  - Is the cryosphere fresh or saltwater?
  - How thick are icecaps, glaciers and sea ice?
  - How does soil freeze?
  - Is the cryosphere a source of freshwater for human use?

Source E: Evaluating Information Sources



Source: https://library.maryvillecollege.edu/crap-test

ACTIVITY 5: Change over time

> *"Large, continental ice sheets in the Northern Hemisphere have grown and retreated many times in the past. We call times with large ice sheets "glacial periods" (or ice ages) and times without large ice sheets "interglacial periods." The most recent glacial period occurred between about 120,000 and 11,500 years ago. Since then, Earth has been in an interglacial period called the Holocene. Glacial periods are colder, dustier, and generally drier than interglacial periods. These glacial–interglacial cycles are apparent in many marine and terrestrial paleoclimate records from around the world."*
>
> Source: https://www.ncdc.noaa.gov/abrupt-climate-change/Glacial-Interglacial%20Cycles

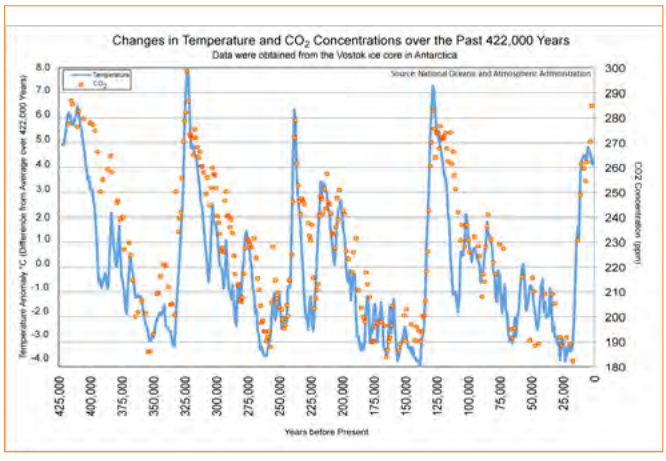
Time-lapse videos of Earth's glaciers and ice sheets as seen from space, static pictorial records and simulations provide insights into how the planet's frozen regions have changed over time.

Graphs and tables provide statistical data from scientific and research organisations that are used to identify changes and trends and to project / extrapolate possible futures.

- Use stimulus such as the visualisations shown in **Source F** and **Source G** and others on the PPT to examine changes to the cryosphere over time. Include reference to glacial and interglacial cycles, human induced change and evidence of change.

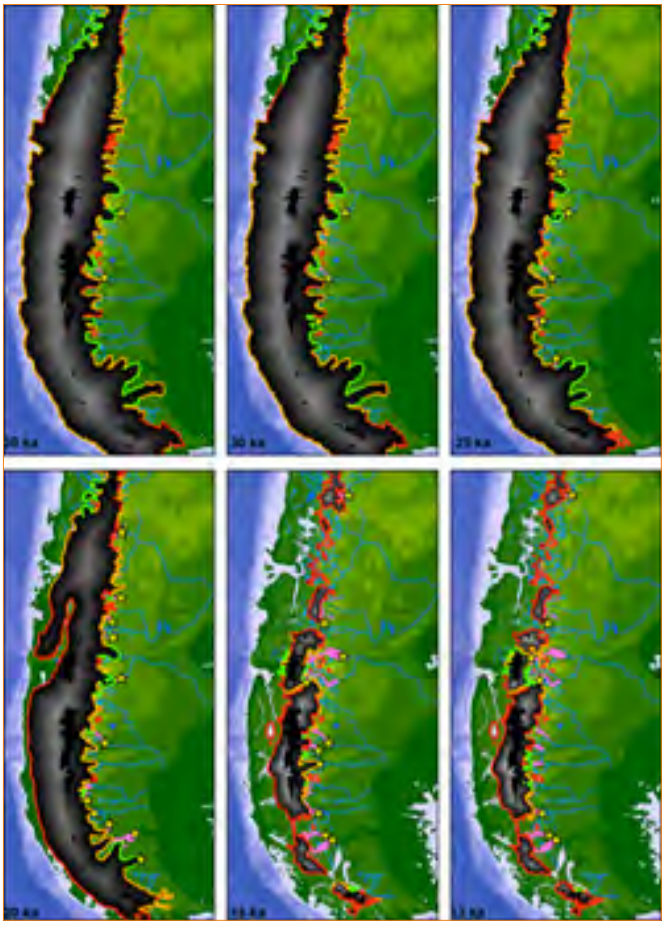
NOTE: Retreating glaciers and ice sheets could be the selected ISSUE for study and completed at this point.

Source F: Glacial and Interglacial cycles



Source: Georgia State University School of Geosciences – http://sites.gsu.edu/geog1112/lab-6-part-5/

Source G: GIF – Recession of Patagonian glaciers and ice-dammed lakes



Source: http://www.antarcticglaciers.org/glacial-geology/patagonian-ice-sheet/patice/patice_2020_02_28__1000-2/

Use the Graphic News stimulus items if selecting this issue. See *Stage 6 Skills*

- Antarctica's Doomsday Glacier Explained
- Mont Blanc Glacier on the verge of collapse
- Impact of global crisis on global ice

ACTIVITY 6: Biophysical Interactions

Activity 5 leads nicely into a broader review of biophysical interactions through the lens of the cryosphere. Start with the opening question 'How is a changing cryosphere impacting on other components of the biophysical environment'. Impacts could include fresh water supply (hydrosphere) natural hazards and sea levels (Hydrosphere, Atmosphere, lithosphere), biodiversity and ecosystems (Biosphere).

When examining interactions between the cryosphere and other spheres you will be testing student knowledge and understanding from Stages 4 and 5. Use resources that challenge thinking and avoid comprehension activities. Develop questions that require students to draw on what they remember or can predict based on their understanding.

Fill gaps in knowledge, understanding and skills as you go.

a. Interactions within the hydrosphere - precipitation, runoff, storages and flows of water
b. Interactions with the atmosphere – water cycle, weather, albedo effect
c. Interactions with the biosphere – biomes, ecosystems and biodiversity.
d. Interactions with the lithosphere – geomorphic processes, glaciation, isostacy, permafrost

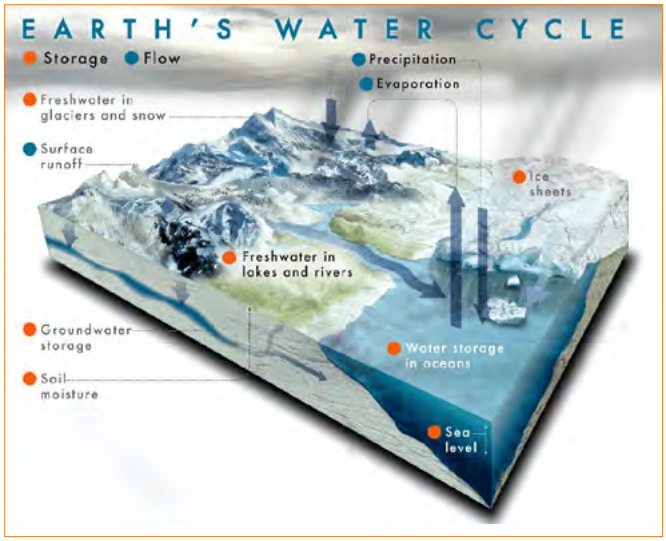
Suggested activities:

- **Cryosphere / Hydrosphere / Atmosphere interactions**

Refer to **Source H** to complete a range of activities such as:

- Match volumes of water with letters on an image
- Identify and explain interactions between the atmosphere and cryosphere
- Predict the impact of cryosphere loss on global water security.
- Complete a Futures Wheel / Consequence Chart with the statement 'If all Earth's ice melted?' in the centre *See Supplement.*
- Discuss responses then watch 'If all Earth's ice melted' – https://www.youtube.com/watch?v=VbiRNT_gWUQ and using media reports.

Source H: Global water cycle



Source: NASA Climate Kids – https://climatekids.nasa.gov/water-cycle/

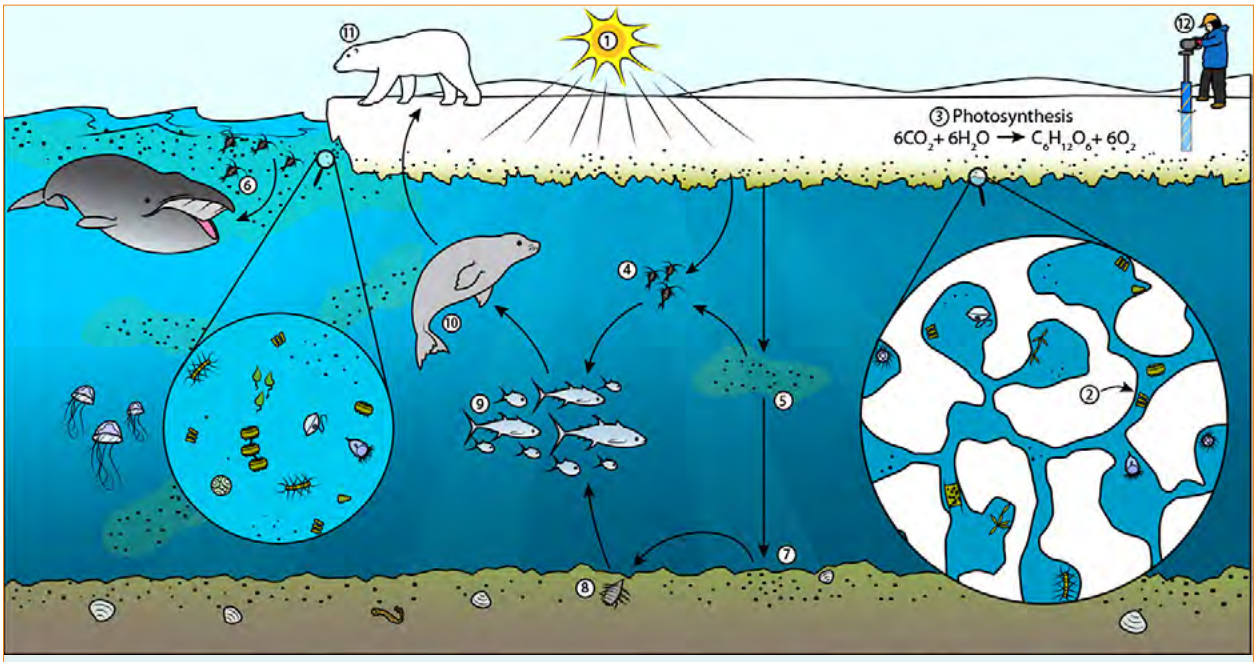
See Edition 3 Supplement for suggested activities.

- **Cryosphere and Biosphere**
  Remind students that they studied the biosphere in Stage 5 Sustainable Biomes.
  - Use *Geography Bulletin 52, Edition 2* Snapshot 1 Biomes and their productivity to revisit processes in the biosphere.
  - Students continue to build their glossary of key terms and concepts.
  - Refer to **Sources D**, Snapshot 1 and **Source I** to discuss cryosphere / biosphere interactions. Use the following questions to guide discussions:
    'Which biomes are strongly connected with the cryosphere'?
    'Does the cryosphere affect biome productivity?'
    'Does the cryosphere limit biodiversity in an environment or ecosystem?'
  - List arguments to support or reject the following statement:
    'Ice as important to the arctic ecosystem as soil is to a forest'

- **Cryosphere and Lithosphere**
  Refer to **Sources B, C and H** to discuss cryosphere / lithosphere connections
  Use focus questions such as:
  - How much of Earth's land is covered by the cryosphere?
  - How does the lithosphere influence the cryosphere?
  - How does the cryosphere affect the lithosphere?

ACTIVITY 7: Drawing conclusions and making judgements

- Complete the *Test your recall. Stop the bus activity* based on contributing questions. *See Supplement*
- Revisit the Key inquiry question 'How vital is the cryosphere to Earth's natural systems?'
- In **Source J** the cryosphere is identified separately to the hydrosphere. Is this justified?



Sunlight (1) shines on the microscopic algae (2) in the sea ice. The sea ice algae convert carbon dioxide (CO2) to sugars through a process called photosynthesis (3).

The algae in the ice are eaten by small animals like copepods (4). Some of the algae in the ice are not eaten and melt out of the ice and sink into the water (5) where they can be eaten by the small animals (4) or whales (6). Some of the algae are heavy and sink to the sea floor (7) where they can be eaten by bottom-feeding animals such as isopods (8; which are crustaceans, like the copepods).

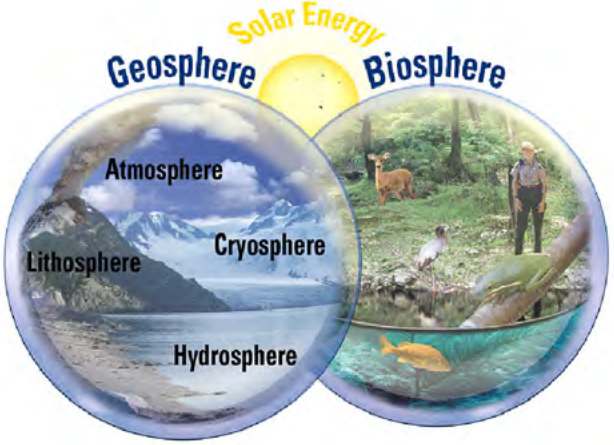
The small animals in the water (4) and on the seafloor (8) might in turn be eaten by fish (9). The fish are the food choice of seals (10). Seals are a preferred food of polar bears (11), which inhabit the area and roam on top of the ice in search of food.

Sea ice algae are the main basis of the marine food web in the late winter and spring in the Arctic. The scientist is drilling a hole through the ice (12) to collect an ice core.

Source https://askabiologist.asu.edu/explore/frozen-life

- Teacher populates the NEED to know column of the KWNR Chart in relation to the Hydrosphere.
  - Tick content covered during the cryosphere activities.
  - Use explicit teaching and inquiry learning activities to cover remaining 'Need to know' syllabus content about the cryosphere / hydrosphere.

Source J: The Earth System



The Earth System has two primary components: the geosphere and the biosphere. The geosphere has four subcomponents: lithosphere (solid Earth), atmosphere (gaseous envelope), hydrosphere (liquid water), and cryosphere (frozen water)

Source: https://www.geographyrealm.com/what-are-the-earths-systems/

In Source J the cryosphere is identified separately to the hydrosphere. Is this justified?

ACTIVITY 8: Biophysical Interaction

- Complete KWNR Charts for the Atmosphere, Lithosphere and Biosphere
  - Students complete the KNOW, WANT and REFLECT columns based on the retrieval of knowledge and understanding during the study of the Cryosphere
  - Teacher populates the NEED to know column with predetermined content
- Use explicit teaching and inquiry learning activities to cover remaining 'Need to know' syllabus content.

OR

- Undertake an investigation using a case study or story as stimulus. Use stimulus such as:
  - 'Miracle in the storm' – Atmosphere *See Supplement*
  - 'Madagascar: a biodiversity hotspot' – Biosphere
  - 'Where in the world can you dive between earth's plates?' Lithosphere.

  Resources for these studies can be found in the *PPT*, *Supplement* and *Resource list. Source K*

OR

- Investigate the biophysical interactions in ONE environment drawing on knowledge and understanding gained from Activities 1 – 8.

  Resource List See Supplement.

Source K: Biophysical Interactions – Investigation options

1. 'Where in the world can you dive between earth's plates?

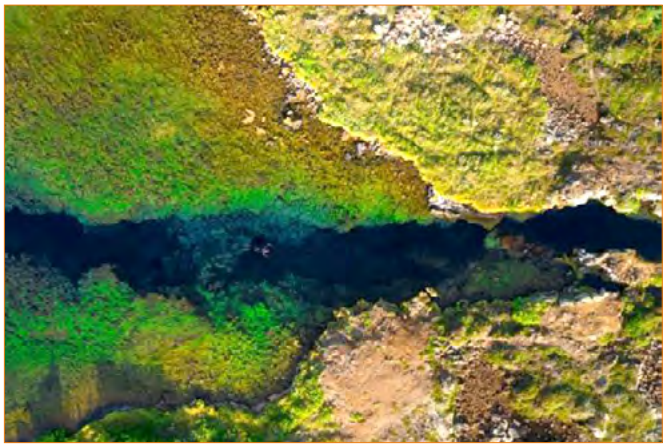


Image source: Shutterstock,

1. 'Where in the world can you dive between earth's plates? (continued)

Images: L Chaffer

2. Biosphere: Madagascar a biodiversity hotspot

Photo source: Shutterstock. Map: Retrieved from https://sites.google.com/a/lincoln.edu.gh/biodiversity-hotspots-lcs-ess/madagascar-indian-ocean-islands

3.Atmosphere: Miracle in a storm

"I wanted to fly around the clouds, but I got sucked 20 metres per second up into it and started to spiral," she told smh.com.au. "After 40 minutes or an hour, I woke up and I was 6900 metres. "I was still flying but I realised I didn't have the brakes in my hand. "I saw my hands and the gloves were frozen, and I didn't have the brakes, and the glider was still flying on its own. "I was thinking I can't do anything, so I only have to wait and hope that the clouds were bringing me out somewhere"

https://www.smh.com.au/national/ewa-sucked-into-storm-and-lives-to-tell-20070217-gdphms.html

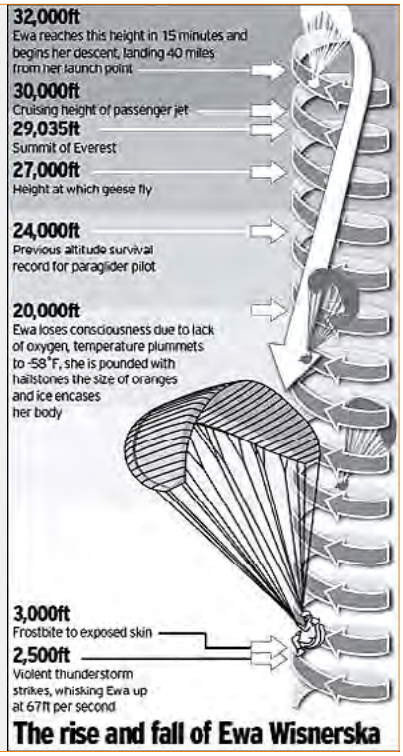


Image retrieved from Telegraph UK
Illustration retrieved from https://www.telegraph.co.uk/news/worldnews/1542962/Paraglider-survived-in-storm-at-32000-ft.html