Polar and Deep Sea Ecosystems
Essential Questions

1. Describe the challenges for life in Polar Ecosystems and where the most productive areas are in both the Arctic and Antarctic.
2. How does the deep ocean get most of its nutrients? What are the stages of a Whale Fall?
3. How is life able to exist around Hydrothermal vents? Be sure you describe what powers the production of sugars and some of the organisms that make up the food web.
The Arctic

- The Arctic Circle
  - a shallow unbroken continental shelf ring
  - Except the upper North Atlantic
- Deep basin holds sea in ring.
- Mostly covered by permanently frozen ice cap
Polar Ecosystems

- **Challenges**
  - reduced sunlight under ice
  - water barely above freezing

- Life fairly scarce under permanent ice cap.

- Special adaptations for organisms
  - antifreezing compounds in blood
  - extremely low metabolisms
Most Productive Area

- Edge of the cap during the warmer months.
- Melting water sinks down to bottom of continental shelf.
- This churns up nutrients from the shelf bottom.
Antarctic

- More extreme climate than the Arctic
- Land, not a frozen-over sea
- Has its own continental shelf.
Winter

- Sea ice surrounding Antarctica almost doubles continent
  - Adds an area about the size of North America.
- Forms cold salty water.
  - Sinking, it mixes with deep ocean water to form the most dense water in the ocean, the Antarctic Bottom Water.
Melting of ice sheet causes an explosion of bioproductivity.

Winds blow water away
- causes upwelling of Deep Water

Nutrient-rich deep water reaches the surface, at about 65° to 70° south latitude.
- The Northern-most part of the Antarctic Ocean

The largest nutrient-rich area on Earth.
Antarctic Divergence — northern limit of Antarctic seas

- Supports massive phytoplankton blooms
  - November through end of southern summer
- The copepod and krill (crustaceans) populations are larger than any other populations found in any other ecosystem.
- Single krill swarms estimated higher than 100 million tons
  - more than the world’s annual commercial fish catch.
Deep Sea Ecosystem

- Beyond the continental shelves, the sun’s light and warmth never reach the bottom
  - the average temp is 2°C (35.6°F).
- No sunlight = no photosynthesis
- No primary productivity in most of the deep ocean.
Most areas get nutrients from **Marine Snow**
- the constant fall of sediment, dead organisms, fecal pellets, and other nutrients from the productive shallow waters above
- These nutrients are moved around ocean by ocean conveyor belt and brought to surface by upwelling
Organisms of the deep

- Deep ocean rich in nutrients from snow
  - Spreads out evenly
- Few multicelld organisms
  - Brittle stars, sea cucumbers
- Most are meiofauna
Whale Falls

- **Flat Abyssal Plains**
  - Depth ~3,000 to 4,000 meters (9,842.5 to 13,123.4 feet)
  - Usually fairly barren, not much life
- Exceptions: Whale Falls
- Dead whale ecosystem goes through stages
Stages of Whale Fall

- Massive amount of nutrients
- **Stage 1: Scavengers**
  - Hagfish, crabs, large sleeper sharks
  - Consume soft tissue
  - Lasts for several months
- **Stage 2: Worms, Small crustaceans, bacteria**
  - feed on the remaining soft tissue
  - Bacteria create H$_2$S as by-product
- **Stage 3: Decay of skeleton**
  - Chemosynthetic bacteria live on H$_2$S
  - create a food source for tubeworms, crustaceans, gastropods, and bivalves.
  - The bacteria appear to be the same as those in hydrothermal vents.
- Usually found at least a mile deep long the mid-ocean ridges
  - First ones discovered in 1977

- Cold sea water seeps into fractures of crust around tectonic plate edges
  - heated by the hot magma under the sea floor.

- Superheated water is forced back up to the sea floor carrying dissolved minerals

- The minerals grow into a chimney
  - black smoker or white smokers
  - depends on the minerals present
Physical conditions

- **Tremendous pressure** - 300 atmospheres
  - We feel one atm. right now.

- **Extreme Temps**
  - highest measured vent temp is 403°C
  - highest temp at which living tube worms have been observed is 100°C
  - bottom water is about 2°C - up to 20°C near some vents.

- **Chemicals** - hydrogen sulfide (H₂S), the source of energy that fuels vent food webs
  - most plentiful compound in vent emissions
  - toxic to most living things

- **pH** - very acidic with a pH as low as 2.8
  - very unhealthy for most living things.
Organisms around Hydrothermal vents

- Wide variety
- **Chemosynthesizing bacteria***
  - intake $\text{H}_2\text{S}$ to use to make sugars
  - Base of ecosystem - *producers*
- Amphipods and Copepods
- Limpets, shrimp, crabs, tube worms, fish, and octopii.
- Most advanced stages
  - mussels, a variety of worms, anemones, crabs, as well as many of the earlier colonists.