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ANTARCTICA: A Journey of Discovery

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ANTARCTICA

A Journey of Discovery

Photo: Jeffrey Kietzmann

the COLDEST windiest driest place on Earth

Photos National Science Foundation, Office of Polar Programs

SOUTH ATLANTIC OCEAN

INDIAN OCEAN

Weddell Sea

Larsen Ice Shelf

Ronne-Filchner Ice Shelf

Queen Maud Land

South Pole

Transantarctic Mountains

EAST ANTARCTICA (East Antarctic Ice Sheet)

WEST ANTARCTICA (West Antarctic Ice Sheet)

Ross Ice Shelf

Wilkes Land

Ross Sea

Victoria Land

SOUTH PACIFIC OCEAN

Land of Fire...

VOLCANOES

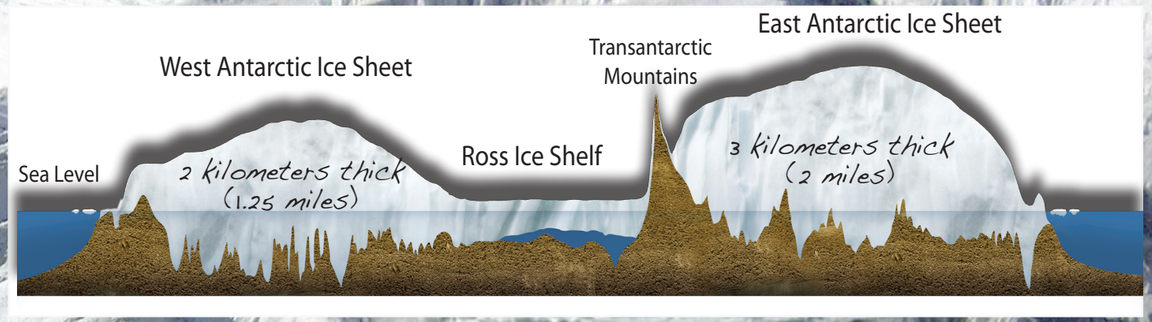
Mt. Erebus on Ross Island, Antarctica is one of the largest and the furthest south active volcano in the world. It often belches steam from its crater, but in 1984 rocks from inside the volcano violently erupted and flew almost 2 miles from the vent. In recent years it has only thrown a few long distance rock projectiles from its active, bubbling lava lake.
Antarctica has other active volcanoes, including one recently discovered completely buried under the West Antarctic Ice Sheet!

DRY VALLEYS

Nestled between ridges of the Transantarctic Mountains are several valleys that have been almost completely dry for millions of years. The main valleys, Taylor, Wright and Victoria, are so dry that when the snow does fall, it usually sublimates (changes directly from its frozen state to a gaseous state) without melting first!

TRANSANTARCTIC MOUNTAINS

The **Transantarctic Mountains** (TAM) cross the entire length of the continent between the Ross Sea and the Weddell Sea. The summits, or nunataks, and the Dry Valleys are some of the few places not covered by snow and ice in Antarctica.



...and Ice

Photos National Science Foundation, Office of Polar Programs

A Slice of Ice

Only the peaks of mountains are visible through the Antarctic Ice Sheet. These peaks are called nunataks.

Ice Sheets

Ice sheets are broad, thick expanses of ice covering a huge area of land for a long time. Earth's largest ice sheet today covers the Antarctic continent.

Glaciers

Glaciers form when snow accumulates over time, turns to ice, and begin to flow outward under the pressure of its own weight across the underlying topography.

Glaciers move ice through the Transantarctic Mountains.

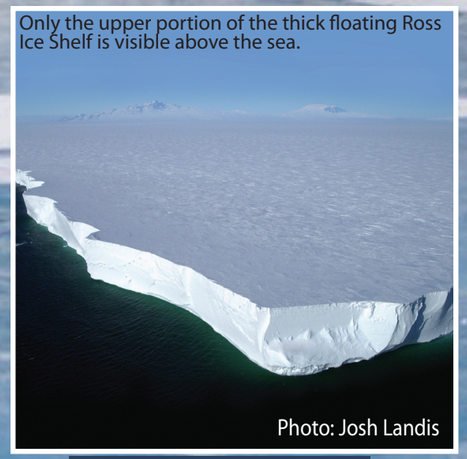
Ice Streams

Ice streams are regions of ice sheets that move much faster than the ice around it. They account for most of the ice that feeds into the Ross Ice Shelf.

Ice Caps

Ice caps are ice masses that cover less than 31,000 mi^2 (50,000 km^2). Larger ice masses are ice sheets. The term 'polar ice cap' refers to any high latitude region on a planet or satellite that is covered by ice, regardless of its size.

Background photo: Joe Mastroianni



Only the upper portion of the thick floating Ross Ice Shelf is visible above the sea.

Photo: Josh Landis

Ice Shelves

Ice shelves are bodies of ice that extend out from land and float in the ocean. Ice shelves form where an ice sheet reaches sea level and extends across the water.

Icebergs

Icebergs are pieces of ice that have broken loose from glaciers or ice shelves. From Antarctica, icebergs drift north to warmer seas where they melt.

Photo: Mike Usher

Sea Ice

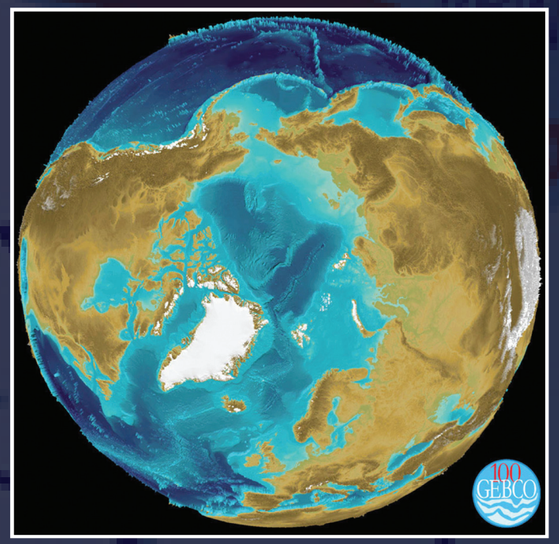
Thin **sea ice** forms by freezing the surface of ocean water. Around Antarctica the sea ice extent increases dramatically each winter, then decreases again as the sea ice melts away in the summer.

Photos National Science Foundation, Office of Polar Programs

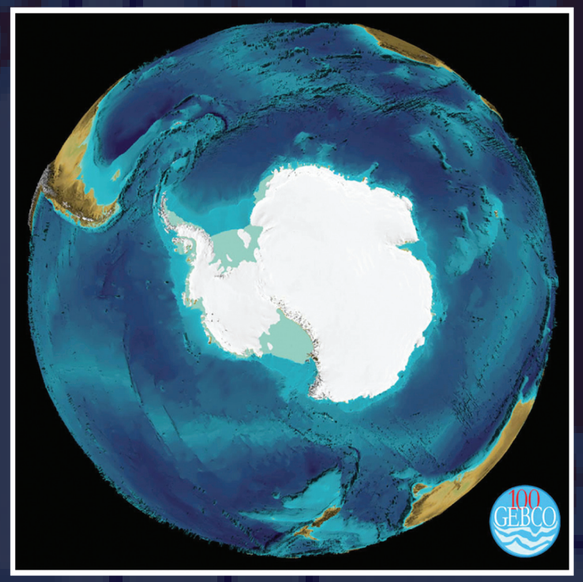
Polar Perspectives

At first glance the tremendous cold and extremes of day and night in both the Arctic and Antarctic make us think that the Polar Regions are very similar. It is true that both Poles are intensely cold and have a lot of ice, but in many ways they are quite different. One of the main differences between the Arctic and Antarctic is that the Arctic is an ocean surrounded by land, while Antarctica is a land mass covered by ice and surrounded by the Southern Ocean.

The **Arctic** and **Antarctic Circles** are defined as 66°33′ N or 66°33′ S, which is the latitude where at least one day each year the sun does not sink below the horizon. At higher latitudes in both the northern and southern hemispheres, the sun never rises above the horizon on some winter days, nor sets for an equal number of days in the summer.

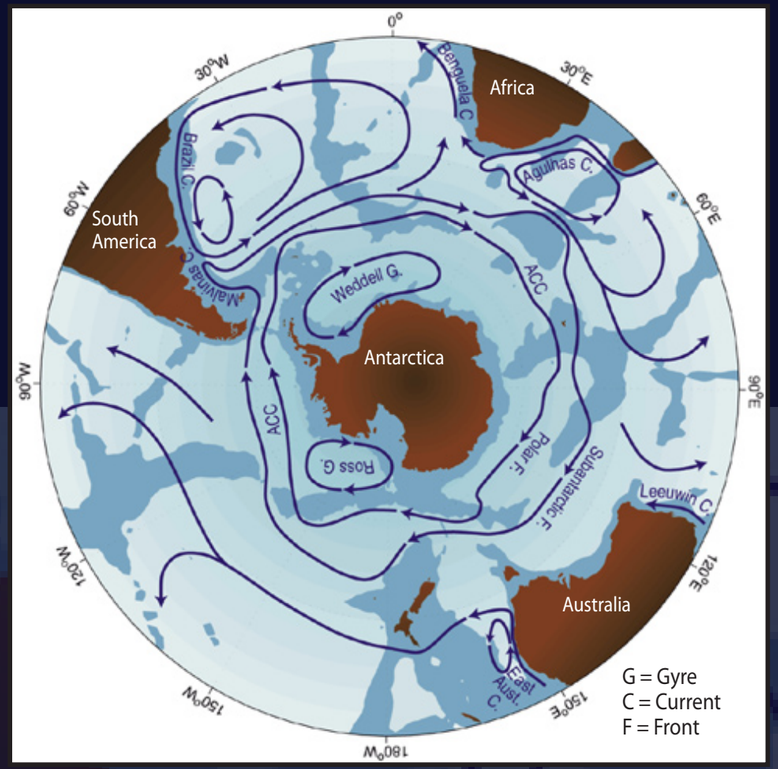


Arctic Ocean surrounded by northern lands.
Photo: GEBCO



Southern Ocean surrounding Antarctica.
Photo: GEBCO

The Antarctic Circumpolar Current (ACC) System



The earliest visitors to Antarctica, the whalers and explorers, noticed that strong currents set their ships on an eastward course. This happens at the latitude where the relatively warm, southward flowing, subantarctic waters meet the cold, northward flowing polar waters. This area, known as the **Antarctic Convergence**, or Polar Front is where Antarctic waters sink beneath subantarctic waters. These are waters rich in nutrients due to mixing and upwelling. The Polar Front, and the Subantarctic Front to the north, are boundaries between water masses that are part of the **Antarctic Circumpolar Current** (ACC) system. The eastward flowing ACC is the longest continuous current in the world, penetrates through the water column to the seafloor, and is an important part of the global "ocean conveyor belt." It also isolates Antarctica from the rest of the world and plays an important role in Earth's climate.

The Weddell and Ross Gyres are currents that flow southward along the Antarctic margin and then loop back to the north. They play an important role in the transport of heat towards the continental margin and under the ice shelves in some areas. This southward heat transport contributes to the production of bottom waters that flow northward away from Antarctica as part of the lower limb of the "ocean conveyor belt".

Getting to Antarctica

1

Thinking about going to Antarctica? Here are the steps to a smooth trip if you plan to work in the US Antarctic Program (**USAP**). First, you have to make sure you are physically ready to endure the harsh conditions of the coldest place on Earth. After you have passed the USAP physical tests and some online courses to prepare you, get ready for the trip of a lifetime!

To begin the adventure, you need to get your Extreme Cold Weather (**ECW**) gear at one of the two departure locations for Antarctica. If you are headed to McMurdo or South Pole Stations, you get ready for your flight from Christchurch, New Zealand. Headed to Palmer? You will embark on a ship from Punta Arenas, Chile.

2

3

Flying to Antarctica is an interesting experience. Instead of a regular passenger plane, people are seated in the cargo area of a C-17 or C-130 plane. These cargo planes are piloted by the US Air National Guard, and they can only land when the weather is clear. Sometimes, they have to "**boomerang**" back to New Zealand and wait for the weather to improve. Depending on the time of year, planes may land on one of three runways: the **sea ice** runway, Williams Field (Willy Field), the snow runway on the **ice shelf** or Pegasus, the blue ice runway on ice shelf.

4

Once landed, people are transported across the ice shelf or sea ice via Ivan the Terra Bus. Equipped with special wheels, Ivan is ideal for transporting a large number of people to McMurdo Station situated on the tip of Ross Island.

At McMurdo, the new arrivals are assigned a dorm room and get accustomed to their new surroundings. They are introduced to the rules applying to where they will be living, and are quickly signed up for **Survival School** and other important classes to help them do their jobs well, and be safe.

From Punta Arenas, Chile, USAP participants travel aboard a US icebreaker for the four day journey across the rough waters of the Drake Passage. Sea ice and storms can slow the journey and make for an uncomfortable trip. Passengers get quickly oriented to Palmer Station because it is the smallest of the US Antarctic bases.

5

Photos National Science Foundation, Office of Polar Programs

Transportation

...on the Ice...

Transportation in Antarctica must be able to withstand extremely low temperatures as well as battering winds. The rugged terrain requires ingenuity in creating machines for safe travel. In the past, explorers and scientists used dog sleds, but today the Antarctic Treaty outlaws dogs because they are not a species native to the continent. Skis, snowshoes, as well as vehicles with interesting tracks and tires help transport people over ice, snow and land. Novel techniques have been developed to transport people and equipment to conduct work in this extreme environment.

...in the Water...

Specially designed icebreaking vessels cut through frozen seas to supply Antarctic stations with food and equipment. Planes are equipped with either skis or wheels to land on ice runways. Helicopters are used to transport researchers to nearby field camps, and Twin Otter aircraft are used to take teams into more remote locations.

Left: Gentoo penguins watch a research vessel near Petermann Island. Photo: Christine Hush

...and Above

Right: a group of people fly to Antarctica in a C-17 cargo plane.
Photo: USAF Tech. Sgt. Shane A. Cuomo

Left: a helicopter pilot flies over McMurdo Station.
Photo: Joe Mastrolianni

Photos National Science Foundation, Office of Polar Programs

Background photo: Zee Evans

Surviving at 80° Below

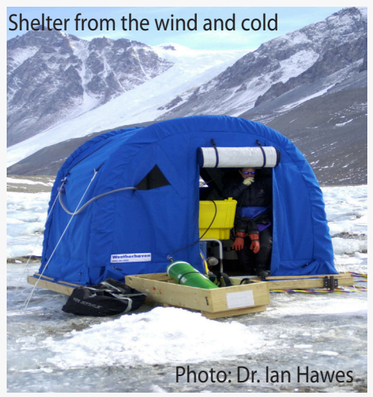
If you like ice and cold, then Antarctica is the place for you! But how long could you survive in the extremes of the Ice Continent? Not long if you were not dressed appropriately which is why the clothing system, called Extreme Cold Weather **(ECW)** gear, is your first and most important line of defense. Layers of long underwear, heavy shirts, vests and wind pants help keep people warm. Don't forget to wear a hat because you lose a lot of heat from your head. But the best friend of US Antarctic Program participants is *Big Red,* the down-filled hooded parka.

To stay alive at -80°C (-112° F), you must pay close attention to your face, feet and hands. People lose a lot of heat through these body parts. Visitors also must protect their eyes from the bright sunlight, which reflects off of the ice. Sunglasses or goggles are needed to prevent a condition called snow-blindness, which is painful and is like sunburning your eyeballs!

Weather conditions can change very rapidly in the Antarctic, therefore survival gear must be carried at all times. Plenty of food and water, plus a means to heat them are essential. In addition, a proper shelter is extremely important. A tent is one of the best options, however if there is a blizzard, one could dig a snow trench or build a snow shelter called a "**quinzee**." A quinzee is built by putting all of the team's gear in a pile, and then covering it with a thick layer of snow. After packing the snow down, a tunnel is dug into the base, and the gear is pulled out leaving an insulated snow cave. It might not be what you would call "warm," but it provides protection for the inhabitants against the wind and freezing temperatures.


"Bunny Boots"
Photo: Brien Barnett


Building a quinzee requires much teamwork
Photo: Louise Huffman


Shelter from the wind and cold
Photo: Dr. Ian Hawes


When traveling away from the base, a radio is a necessity
Photo: Emily Stone

Photos National Science Foundation, Office of Polar Programs

McMurdo Station

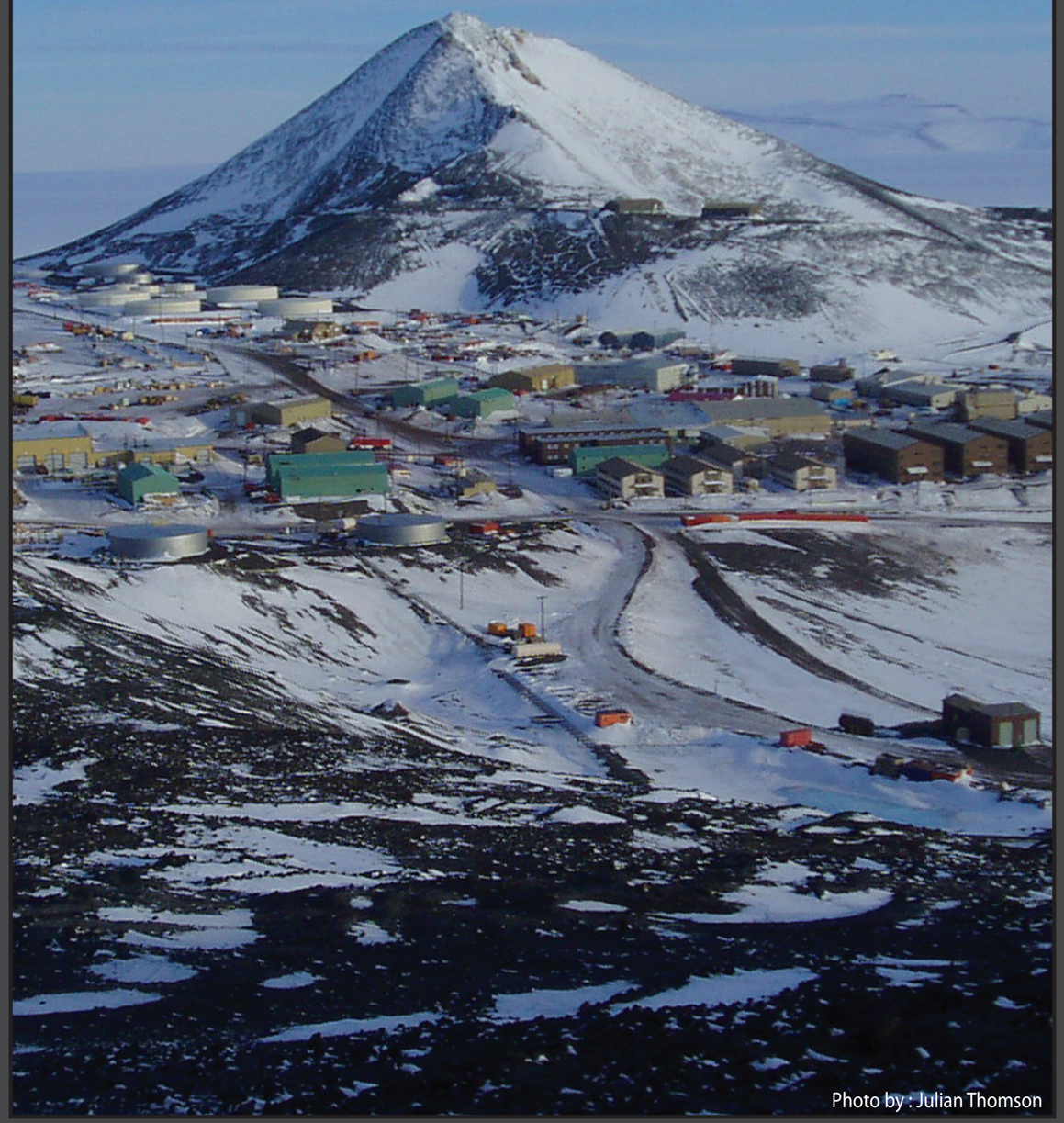
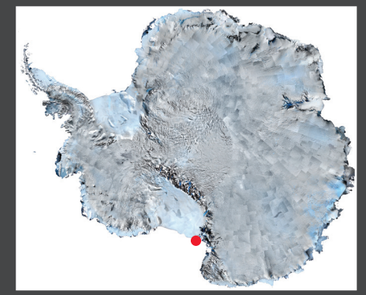


Photo by : Julian Thomson



McMurdo Station is the main logistics center and research base on the continent of Antarctica. The largest year-round coastal research station also services two ocean-going vessels equipped for ice-breaking, science investigations and logistical support. Imagine yourself as part of a science team flying in for a season on the Ice. It is a clear day and as you approach from the air you can see many buildings as well as the streets, water and sewer lines, telephone and power lines, creating the look of a small town. Hoping for a smooth landing? Hold on! Your plane will be landing on an ice runway over McMurdo Sound.

McMurdo Station is built on volcanic rock near Hut Point Peninsula on Ross Island; this is the southernmost solid ground accessible by ship. The harbor is within a protected area of McMurdo Sound with a view of Robert Falcon Scott's historic hut. A prominant landmark behind McMurdo Station is Observation Hill (Ob Hill), which is a popular climbing and hiking trip for visitors.

Photos: Robyn Waserman

Transportation around McMurdo may also look unique – trucks haul gear and supplies, but you will also see snowmobiles and large tracked vehicles for moving over the ice. As you find your way around the station, you will meet other scientists, researchers and support personnel who work here many months of the year. McMurdo is the operational hub of the US Antarctic Program, and all disciplines of research are carried out from this logistics center. The population of McMurdo varies from 160 in the winter months to over 1,100 people at peak summer season.

Meteorology, upper atmosphere physics, biology, glaciology, seismology and geology are some of the scientific disciplines engaged in research near McMurdo Station.

Photos National Science Foundation, Office of Polar Programs

Landsat image mosaic of Antarctica (LIMA)

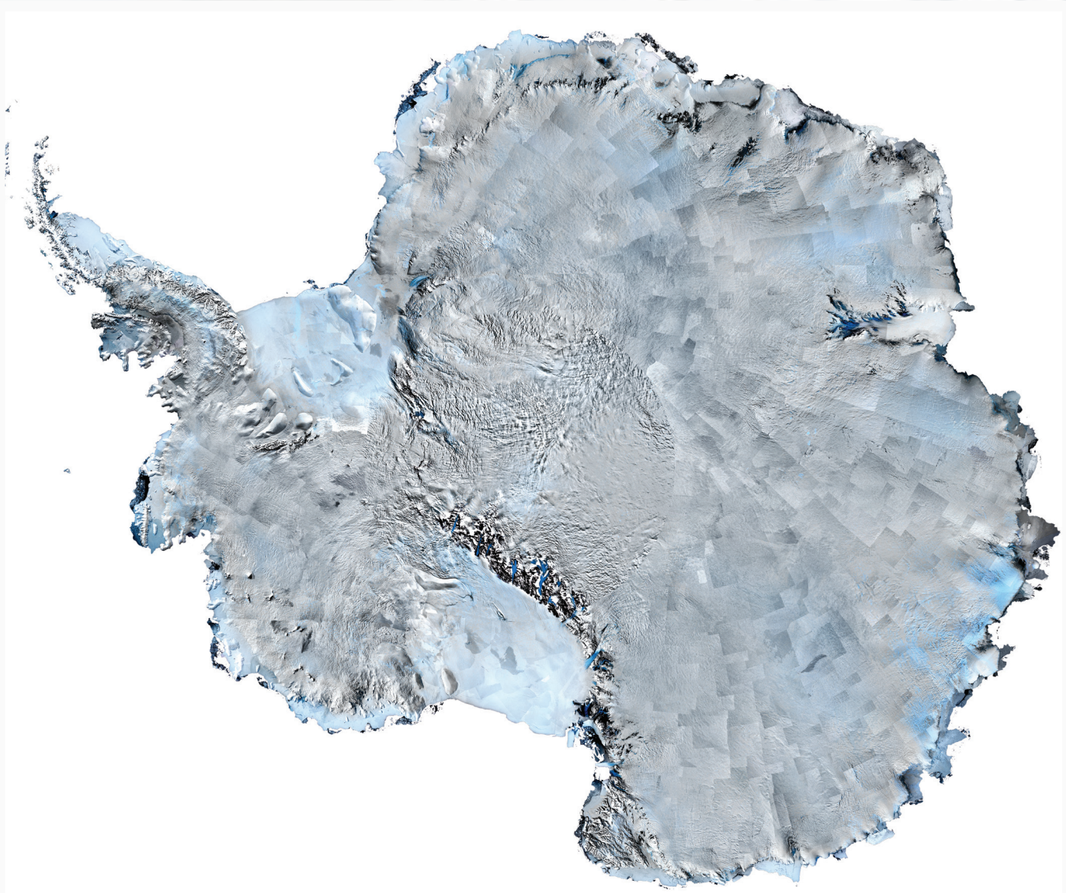


Image: USGS, BAS, NASA with funding from **NSF**

We are used to taking a photograph and immediately seeing the image in the LCD screen of the camera, but how would you take a photograph of a continent larger than the US and Mexico together? Impossible you say? You would be right! Instead, scientists solved the problem by creating **LIMA** (Landsat Image Mosaic of Antarctica). They took over 1100 images from the Landsat and MODIS satellites and using a computer graphics technique, 'knitted' them together to form a photo mosaic image of the entire continent (see image on opposite page).

The Landsat Program began in 1972, with the launch of the first Landsat satellite. The satellite captured millions of photographs to create digital images that are used by researchers all over the world. From 1999-2003, scientists collected thousands of pictures from the satellite and then hand-picked ones to weave together into a complete mosaic image of the entire continent.

Many variables were involved in choosing each image. The selected pictures had to show each land area without cloud cover. Also, because of melt in the summer, especially around coastal areas, it was important to choose pictures that were taken around the same date and time and with the same sun angle.

The LIMA mosaic image is an extremely important record of Antarctica's ice sheets today and will provide the baseline for future comparisons.

Look closely to see the lines of the individual tiles that were "knitted" together to form this image of the Ross Island region.

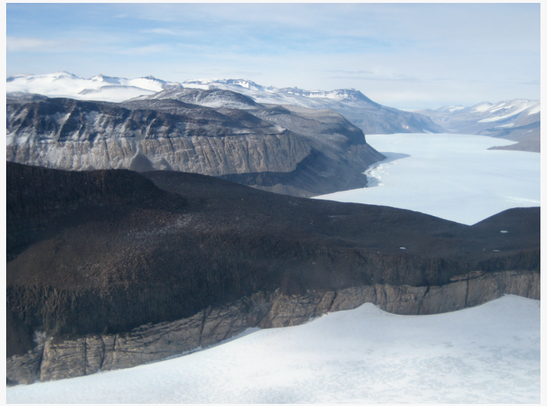
Graphic: AGIC Antarctic Geospatial Information Center

Photos National Science Foundation, Office of Polar Programs

Plate Tectonics

Continental Drift

Fossils of plants and vertebrates discovered in Antarctica helped to confirm the theory of continental drift. This theory suggested that a large southern continent called Gondwanaland contained the landmasses that would one day separate and become South America, Australia, India, Africa and Antarctica.



Most of the geological record of Antarctica until about 242 million years ago is displayed in the rock sequences seen above in the **Beacon Supergroup**.

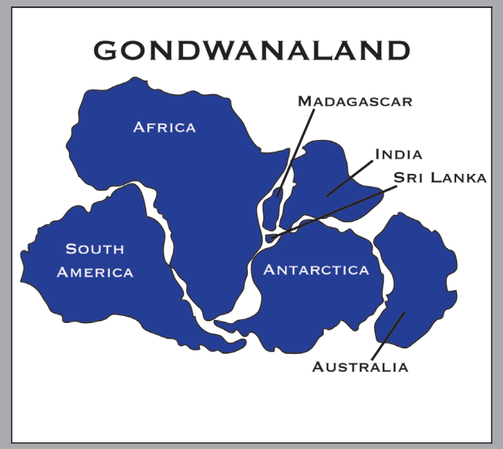
Photos: Joanna Hubbard

Seafloor Spreading

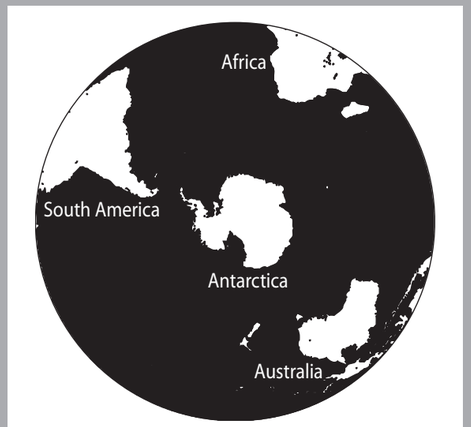
Australia separated from Antarctica about 45 million years ago. At that time, these two continents shared a similar community of animal and plant life because of their close proximity to each other. In a process called seafloor spreading, the continents broke away and drifted apart. Through this process new ocean crust was created. Gateways opened to the south of Africa, Australia and South America, leaving Antarctica alone over the Pole. A strong ocean current flowed around the continent keeping it isolated and cold. Life on each continent evolved and adapted independently after the continental separation according to their changing climate.

An aerial view of the Beardmore Glacier, taken in 1956 by US Navy pilot Jim Waldron.

Supercontinent



Present Day



Geology of Antarctica

Antarctica has a dynamic geologic history, with active volcanoes and rifting fault-lines running through West Antarctica. The rocks of East Antarctica are at least 3 billion years old, and the rocks of West Antarctica are relatively new – only 700 million years old.

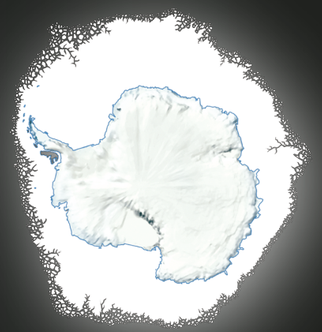
ANDRILL (ANtarctic geological DRILLing) is a scientific project that is collecting rock cores from beneath the ice off the coast of Antarctica. By deciphering the clues found in the sedimentary layers of the rocks, scientists are learning how the ice sheet has responded to past changes in climate.

Here are the layers of sediment found in a core sample. The lower the layer, the older it is!

Photos: Julian Thomson

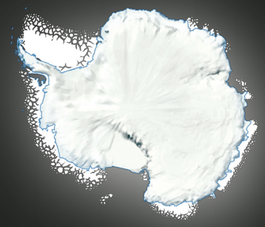
From Past to Present

Antarctica has been over the south polar region for at least the last 100 million years. Its climate history over the last 40 million years has been one of increasing cold, with substantial periods of ice growth and retreat. Take a look at Antarctica's climate history below!



Today

5 Million Years Ago



15-10 Million Years Ago

35-30 Million Years Ago

50-40 Million Years Ago

Dry Valleys

In 1903 when Robert Falcon Scott and his team discovered and named Taylor Valley, he called this area the "Valleys of the Dead" because he did not see any living creatures – no plants, trees, or animals – just sand and rocks and a petrified seal. Because of the hard work of many dedicated scientists, we now know that there is a lot of life in the **Dry Valleys**, it's just really tiny (microscopic). In the **Dry Valleys**, most life is found in the areas that have liquid water, which is why they are often referred to as "Ecosystems waiting for water".

Photo: Karen Cozzetto

The McMurdo **Dry Valleys** are the largest ice-free region in Antarctica. They are a 45-minute helicopter ride from the largest research station in Antarctica, McMurdo Station. This area is a polar desert that receives less than 2 in (5 cm) of precipitation a year, mainly as snow. Large fingers of ice, known as glaciers, flow down from the mountain peaks into the valleys. For 6-14 weeks a year these glaciers melt because of the sun's rays hitting the glacier surface. During this time, small meltwater streams form and flow into the permanently ice-covered lakes in the bottom of the valleys.

Photos National Science Foundation, Office of Polar Programs

Although the lakes do not contain fish, they have lots of other forms of life that are difficult to see without a microscope, including plankton, rotifers, tardigrades, bacteria, and Archaea. There are even bacteria living in the ice covering the lakes.

Walking across the glaciers you may encounter some of the most fascinating habitats for life on Earth! Cryoconites form when sand grains blow on top of the white surface of the glacier, attracting the sun's heat, and causing a small pool of water to develop. Bacteria and other organisms attached to that sand grain will grow and form a whole community in the small pool of water.

Algae growing in a cryoconite hole on top of the Canada Glacier

Photo: Jenny Baeseman

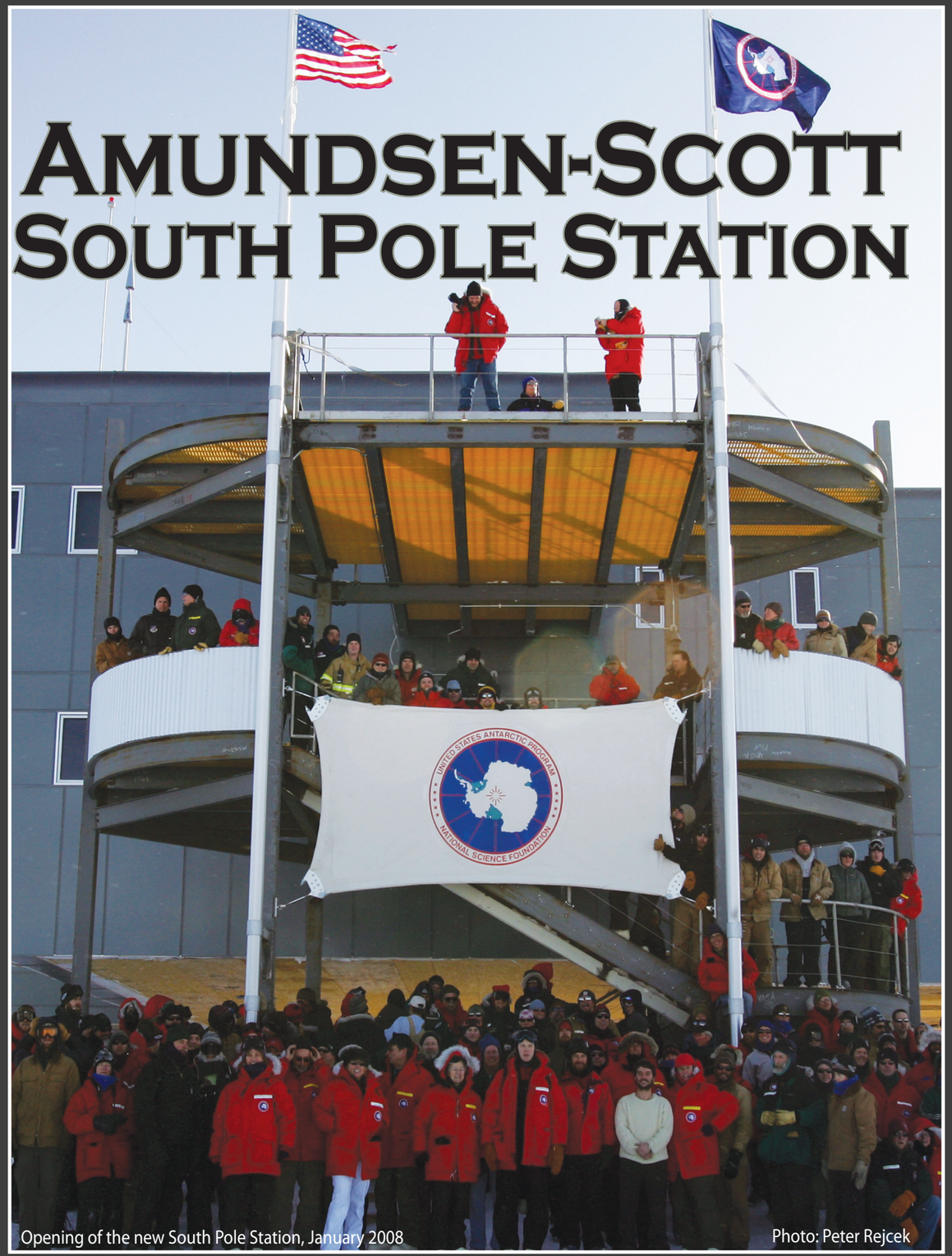
Photo: Jenny Baeseman

Perhaps some of the most striking colors in the Dry Valleys are the orange and black bacterial mats growing on the bottom of some streams. These mats live through very harsh conditions. For much of the year there is no water in the stream because it is so dry it evaporates. Organisms living in the stream need to be able to survive without water. Many of the mats naturally freeze-dry or dehydrate themselves so they look like dried sponges. Within 20 minutes of receiving liquid water, they are rehydrated. That's less than the time it takes you to get ready to go to school. This is how they survive the harsh dry and dark Antarctic winters.

Recently, some of these mats that have been freeze-dried for over 26,000 years have been rehydrated and brought back to life. This helps us to understand the survivial mechanisms of organisms on this planet, as well as predict how organisms on other planets might survive as well.

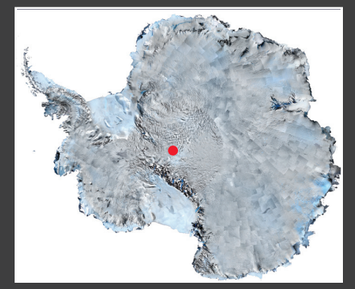
Photos National Science Foundation, Office of Polar Programs

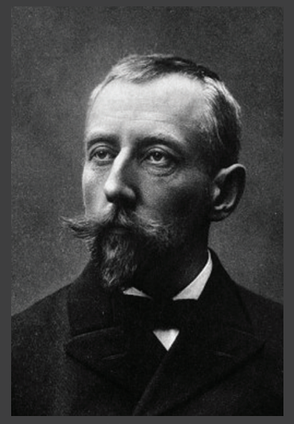
Amundsen-Scott South Pole Station



Opening of the new South Pole Station, January 2008 Photo: Peter Rejcek

The Amundsen-Scott South Pole Station is the southernmost research base on Earth. It was named for the two polar explorers, Roald Amundsen of Norway and Robert Falcon Scott of Great Britain, who raced to be the first to set foot on the South Pole in 1911. It was first built as a science research base in preparation for the International Geophysical Year (**IGY**) in 1956. Fifty two years later, in 2008, the new South Pole Station was dedicated.





Roald Amundsen

Robert Falcon Scott

About 150 scientists and support personnel, called *Polies*, live there during the summer, but the population of the station drops to about 50-80 in the winter. Winter-over crews experience extreme isolation from mid-February until the first early "Win-fly" (winter fly-in) flights in late September to October.

South Pole Station is built on the 9000 ft (2750 m) thick polar ice sheet. It is drifting along on the flowing ice at about 30 feet (9 m) per year. The geographical South Pole marker has to be relocated each New Year's Day for accuracy.

South Pole Station from the air

Photo: Scot Jackson

Photos National Science Foundation, Office of Polar Programs

Glow of the ***Aurora Australis*** over
Amundsen-Scott South Pole Station

Photo National Science Foundation, Office of Polar Programs
Photo: Chris Danals

Science In the Air


Long Duration Balloon

Photo: Melanie Conner

Antarctica provides the perfect science lab for studying a wide range of atmospheric phenomena. Antarctica's weather systems circle the continent and drive storms across the Southern Ocean. Seasonal melting and formation of sea ice affects the weather around the globe. Weather stations in Antarctica collect data daily, and meterological observations are sent out to surrounding countries to use in weather forecasting. Atmospheric scientists work at research stations across the continent. Observations of seasonal temperatures, atmospheric pressure, wind speed and direction, solar radiation, precipitation and evaporation are made to better understand our global weather and climate patterns.

Photos National Science Foundation, Office of Polar Programs

Meteorology, Aeronomy and Astrophysics

Aeronomy (the study of the upper region of the atmosphere) is an expensive and growing atmospheric science. Due to global warming and ozone depletion, this has become a major field of study, and Antarctica is vital to the research. Researchers can monitor and measure the ozone layer by launching special helium-filled balloons that have detectors on board. There are also satellites that can look through the atmosphere from above and report measurements of the concentration of ozone to scientists. Ground lasers can look upward from the Earth to measure the formation of statospheric clouds that contain the ozone-depleting gases.

One of the best places for an astrophysicist to study the stars is at the South Pole! Researchers are interested in unraveling the mysteries of the universe. In addition, the pristine environment of Antarctica allows for research into natural electromagnetic wave spectra. Naturally-occuring electromagnetic (radio) signals emanate from lightning storms, aurora (the Northern and Southern Lights), and most importantly, the Earth's magnetic-field (the Magnetosphere). The low interference from human-produced signals, makes Antarctica the best place for measuring and collecting electromagnetic wave data.


Racer Rock weather station

Photo: Jeff Kietzmann

Background photos: Brien Barnett

Earth's Sunscreen

If you stay out in the sun for too long without protection, you will get sunburned. Mixed in with the light from the sun are several kinds of light that you can't see. One of those kinds of light is called ultra-violet radiation. This is the light responsible for causing your sunburn.

The ozone layer high up in the stratosphere wraps the Earth in a protective blanket. It protects all living things by filtering and reflecting some of the ultraviolet radiation from the sun. Too much ultraviolet radiation can damage DNA (deoxyribonucleic acid) and cause problems like glaucoma (an eye disease) and skin cancer. Over-exposure can also have a damaging effect on our environment.

The Ozone Layer

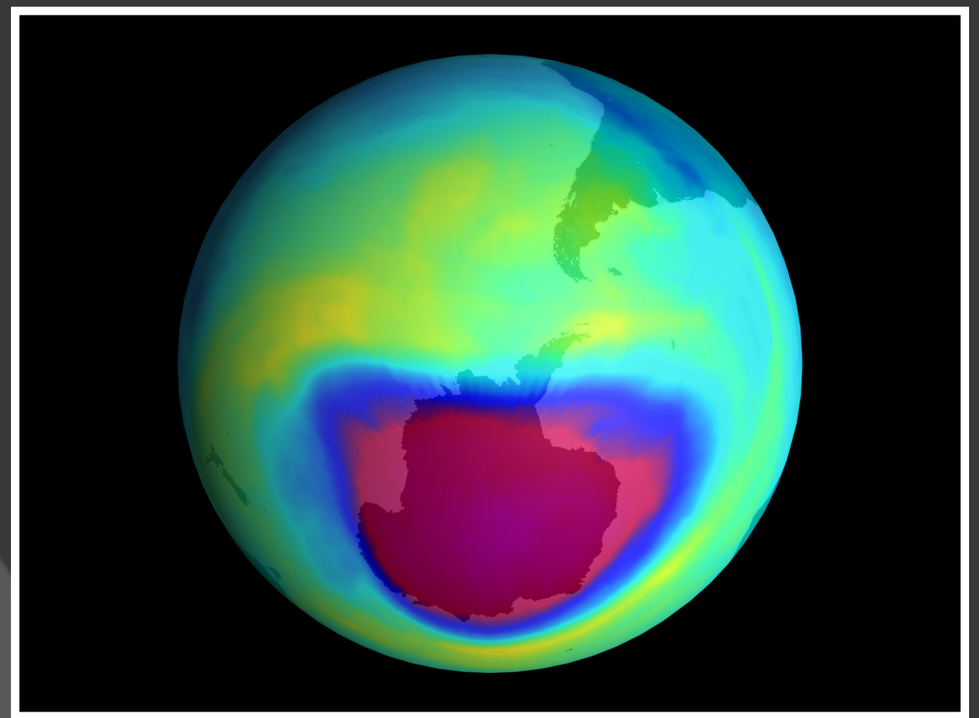


Photo: Greg Shirah, NASA GSFC Scientific Visualization Studio, NASA's Earth Observatory

Antarctica is an excellent laboratory for monitoring the health of the Earth. In 1985, scientists discovered a "hole" in the ozone layer over Antarctica and found that chemicals used by all of us were causing this ozone depletion.

The ozone hole forms over Antarctica because of seasonal atmospheric circulation patterns and photo-chemical (a chemical reaction induced by light) reactions that destroy ozone. Polar stratospheric clouds that form in the Antarctic winter provide surfaces for chemical reactions that lead to ozone depletion.

Chlorofluorocarbons (CFCs) which were used in air conditioning, cooling units, refrigerators, and as aerosol spray propellants prior to the 1980's were identified as contributing to the depletion of ozone. CFCs have been outlawed and there is some evidence that the hole in the ozone over Antarctica may be recovering.

This experience is a good lesson for human beings. Our activities can be dangerous to the planet, so we need to help take care of Earth; it is our only home.

Photos National Science Foundation, Office of Polar Programs

Science Under The Ice

When speaking of **neutrinos**, scientist Wolfgang Pauli said, "I have done a terrible thing; I have invented a particle that cannot be detected." He didn't really "invent" neutrinos, but rather "conceived" of them. In science classes, we learn that the world is made of protons, neutrons and electrons that switch their identities back and forth in nuclear reactions. Because of the work of Pauli and many others, we know that neutrinos also play a role in these reactions.


Photo: Ethan Dicks

Neutrino detector lowered into an ice hole

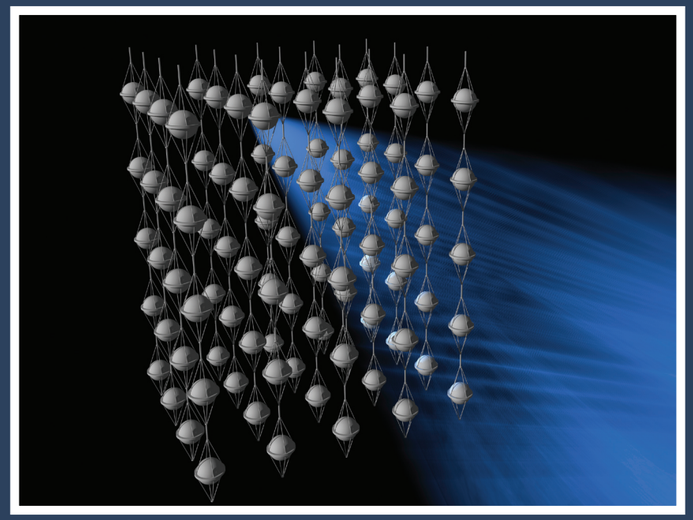


Illustration of a **neutrino's** path through photo-multipliers

For many years, neutrinos were believed to have no mass, but now we know they do, because a creative group of scientists designed an ingenious plan for detecting the undetectable. Neutrinos are all around us, but the most interesting ones come from space and millions of them bombard the Earth each day along with other subatomic particles. Neutrinos are the only subatomic particles tiny enough to travel from the North Pole, through the Earth, and out through the South Pole. When a neutrino interacts with the nucleus of a molecule of water or ice, a muon is formed that emits a measureable light called the "Cherenkov Effect." As it speeds through the ice, the muon travels in the same direction as the neutrino that created it.

Photos National Science Foundation, Office of Polar Programs

AMANDA (the Antarctic Muon and Neutrino Detector Array) was the first attempt at the South Pole to track the paths of neutrinos. Light detectors (photo-multipliers) were lowered into the extremely clear ice. The conditions at the South Pole are ideal for detecting the flashes of light from the collisions of these fast-moving particles. This project was so successful that it has been expanded and renamed IceCube.

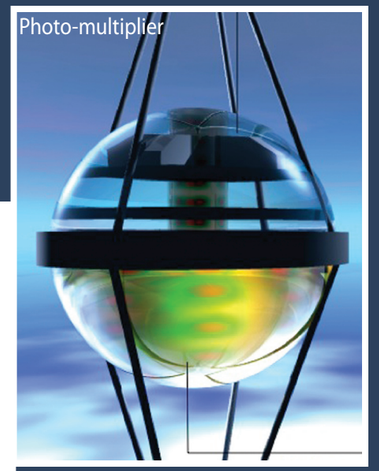


Photo-multiplier

For IceCube, the area near the South Pole Station containing these strings of light detectors was increased to a one square km (0.62 miles). The optical sensors reach a depth of 4760-8040 ft (1,450-2,450 m), increasing their reach from AMANDA's maximum depth of 4600-6560 ft (1,400-2000 m). The number of detectors increased from 677 optical modules in AMANDA, to 5160 in IceCube.

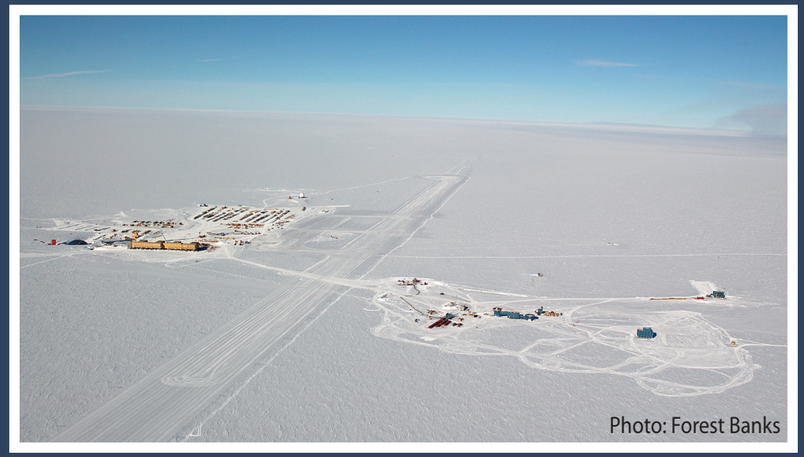


Photo: Forest Banks

Understanding these cosmic messengers may provide understanding of the origins of the universe!

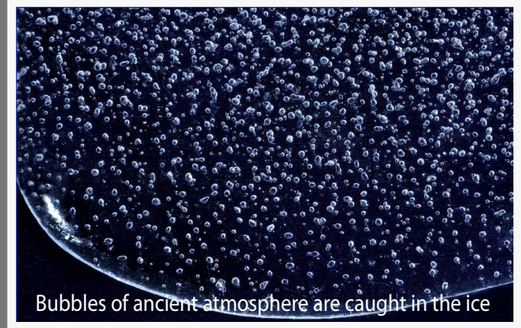
Ice Core Research

Ice core drilling allows scientists to study ice that fell as snow nearly a million years ago. Collecting and analyzing these samples is a highly specialized science. It requires work in the most extreme environments on Earth and careful, thorough data collection on miles and miles of ice cores.

In Antarctica, the snow seldom melts. The ice piles up in layers year after year, burying clues about the climate at the time the snow fell. By collecting ice cores, scientists can find evidence of the past. Climate conditions, chemistry of the atmosphere, and the presence of manmade pollution are all things that can be learned by studying the mysteries trapped in the bubbles of the ice cores. In fact, ice cores reveal that "greenhouse gases" like carbon dioxide correlate with rises and falls in temperature over hundreds of thousands of years.

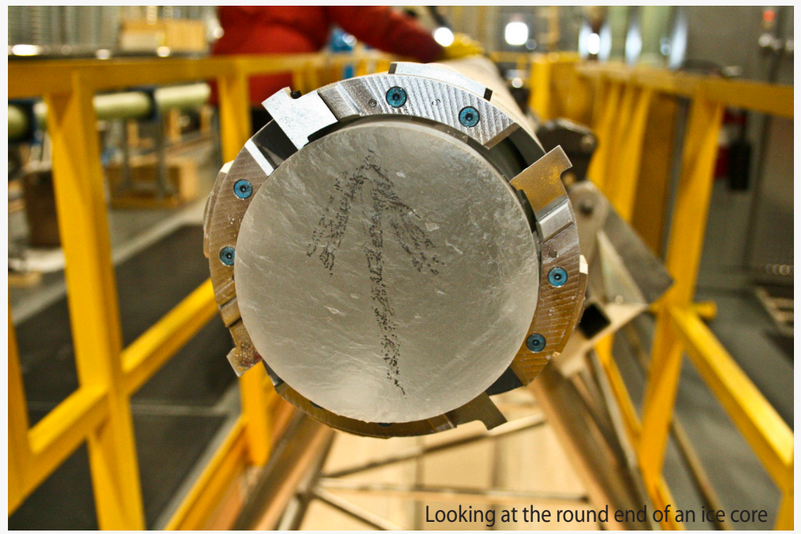
The first deep ice cores were drilled in the late 1960's. Data collected over the history of ice coring research has given us a record of the climate and chemical make-up of the atmosphere that dates back to more than 800,000 years ago. Today, scientists are also able to send instruments down the borehole left by the extricated core to learn about the insides of ice sheets and glaciers. Such research is critical for studying how melting ice at the Poles may affect sea level around the world.

Slicing a thin section of the ice core



Bubbles of ancient atmosphere are caught in the ice

Photos above: British Antarctic Survey

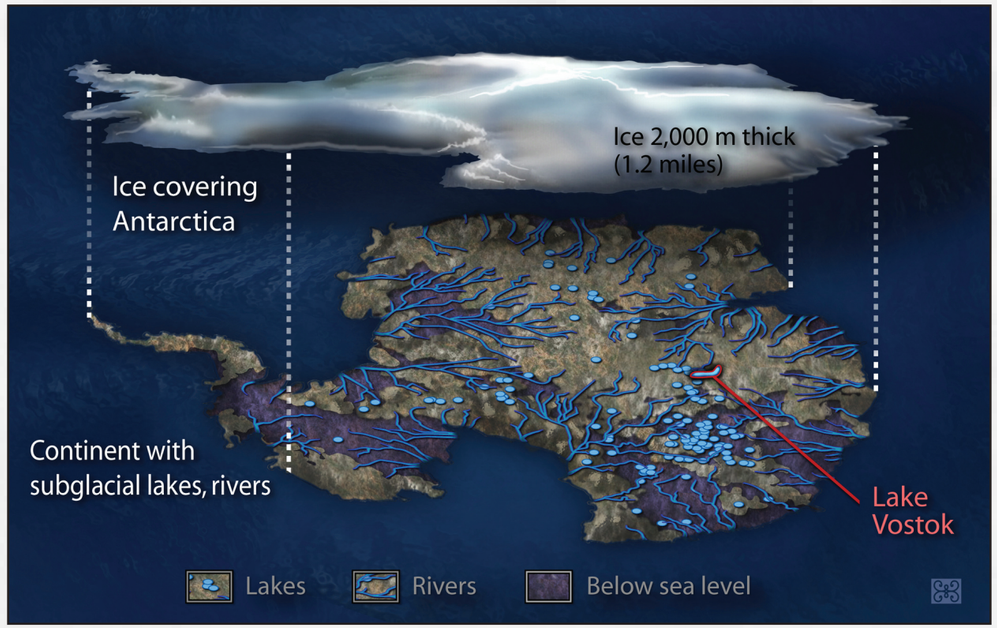


Looking at the round end of an ice core

Photo above and left: Scripps Institution of Oceanography UC San Diego

Radar Mapping and Subglacial Lakes

What mysteries lie beneath the huge ice sheet that blankets Antarctica? Today, multiple satellites flying high above the Earth gather images of what lies beneath the ice layers. Fixed-wing aircraft equipped with radar systems and other geophysical instruments also fly over the ice and record data along survey lines. Researchers use these pictures to study the topography of Antarctica and its hidden secrets. Studies have revealed shallow swamp-like features, lakes and a huge, connected water system flowing among the sub-glacial environments.

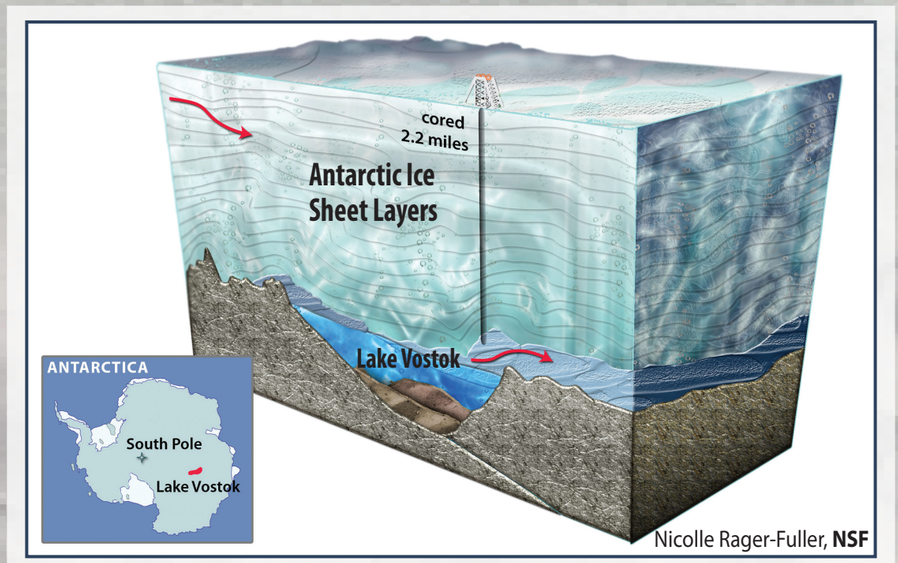


Zina Deretsky, **NSF**

By using ice-penetrating radar to collect these images, scientists have discovered over 145 sub-glacial lakes, including one under the South Pole. The largest of these lakes is Lake Vostok, located under the Russian base, Vostok Station. It is roughly the size of Lake Ontario in North America, and even though it rests below more than two miles of ice, the water is not frozen! Evidence indicates that a huge watershed of rivers and streams, flowing under the ice sheet, connects the lakes. There is also evidence of life in these lakes—microbes that thrive in extreme cold and dark.

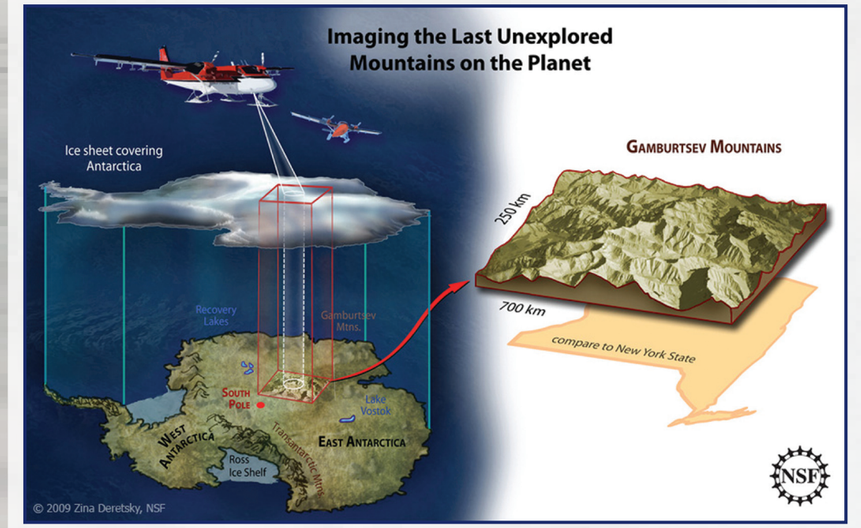
The buried Antarctic lakes, which are sealed off by tons of ice above, may have been isolated from Earth's evolutionary processes for tens of thousands of years. How might the organisms living there be different from the ones we know? Will knowledge gained from these unique environments and the life in them, help us understand environments on other planets and moons in our solar system?

Photos National Science Foundation, Office of Polar Programs



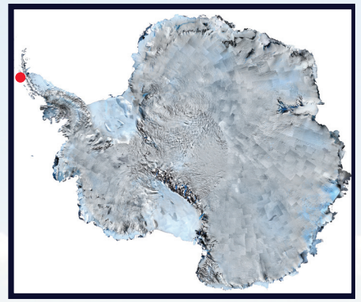
Nicolle Rager-Fuller, **NSF**

Another exciting project using radar imaging is the AGAP (Antarctic Gamburtsev Province) research program. The Gamburtsev Mountain Range is as high as the European Alps, but is completely covered by the East Antarctic Ice Sheet. Using Twin Otter aircraft equipped with ice-penetrating radar, laser altimetry, gravimeters and magnetic sensors, the top to the bottom of the ice sheet is imaged along flight lines. Seismometers are also deployed on the ice surface to measure movements of the ice and earthquake activity to interpret structures from the bottom of the ice sheet deep into the earth.



Early results from AGAP show very prominent peaked mountains that may indicate a relatively young range for these features. This actually raises more questions than it answers. How could mountains have formed in the middle of the continent? Could this be a range that formed from the collision of two landmasses in the distant past? If so, then they have remained remarkably preserved with very little erosion. Could two pieces of Antarctica have collided more recently, indicating that the continent is more dynamic than previously thought? Could a volcanic plume beneath East Antarctica have formed the Gamburtsev Mountains? Future scientists will unravel these mysteries. Today's students will have the opportunities to answer big questions if they choose to become scientists!

Palmer Station



Palmer Station is a research facility on Anvers Island on the west coast of the Antarctic Peninsula. If you were visiting this station you would most likely be coming in by ship as there is no permanent landing field and no regular service by airplanes. Since the climate is influenced by a polar-maritime air mass, Palmer has the mildest climate of the three US research stations. Ships can access the station year round with tour ships and sailing yachts visiting during the summer months. Vehicles for transport around the station area consist of Zodiac boats, snowmobiles and all-terrain vehicles.

Palmer Station has a population as few as 10 in the winter months and up to 44 scientists and support staff during the summer science season. The two major research buildings and three smaller ones are built on solid rock. People are housed at Palmer station in dorms with shared bathrooms and everyone helps with household duties.

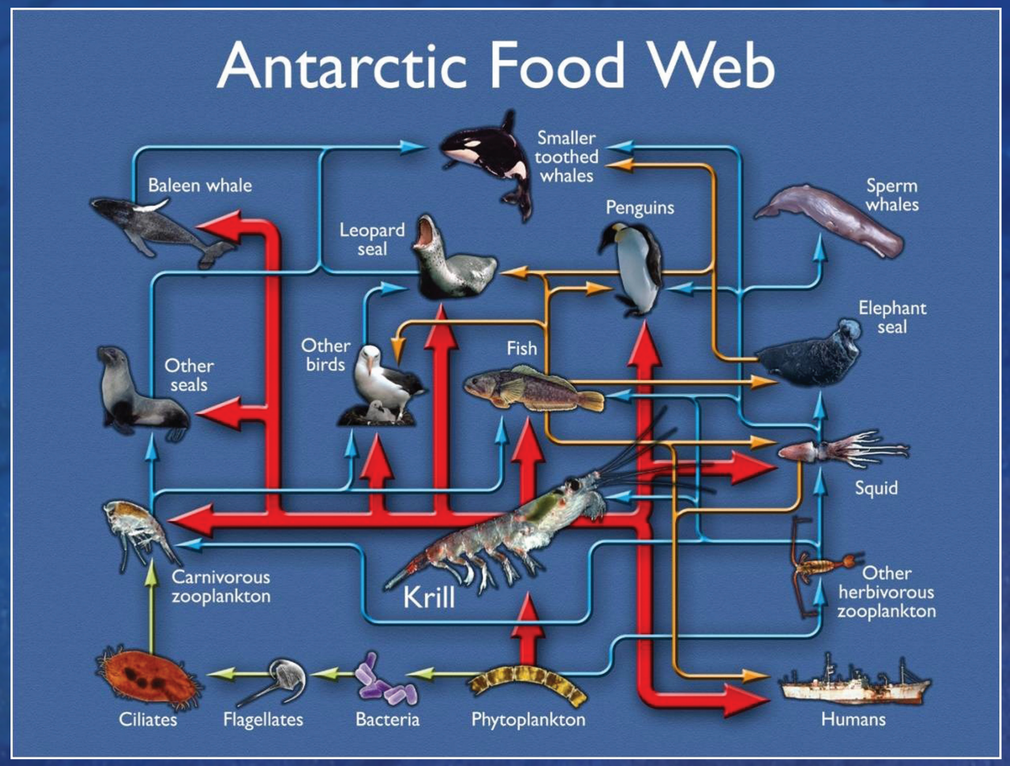
Palmer Station is an important location for marine scientific research. There are a lot of birds, seals and other wildlife within the marine ecosystem. Research vessels can pursue work on and in the water and have Palmer Station for support logistics. There is a large science laboratory and seawater aquarium for studying the marine ecosystem.

Photo National Science Foundation, Office of Polar Programs
Photo: Jeffrey Kietzmann

Science
In the Water

Antarctica, surrounded by the Southern Ocean, has a marine ecosystem unlike any in the world. Oceanographers are studying the marine environment to gain a better understanding of the complex relationship between the ocean-atmosphere system and climate change. The waters surrounding Antarctica have a remarkable effect on the waters of the world and are responsible for exchanges in mass, heat and salt among all of the oceans.

For most of the year, the icy waters are warmer than the land. A variety of marine animals live in these waters. Algae, or phytoplankton, at the bottom of the food chain, feed the krill that are vital for survival of many animals that live in the ocean. Without krill, all Antarctic animals, including whales and seals, would be endangered. We don't know much about how the rich seafloor communities are fed, and this is one of the key ecological questions in the Antarctic.



Graphic: Lloyd Peck and the British Antarctic Survey

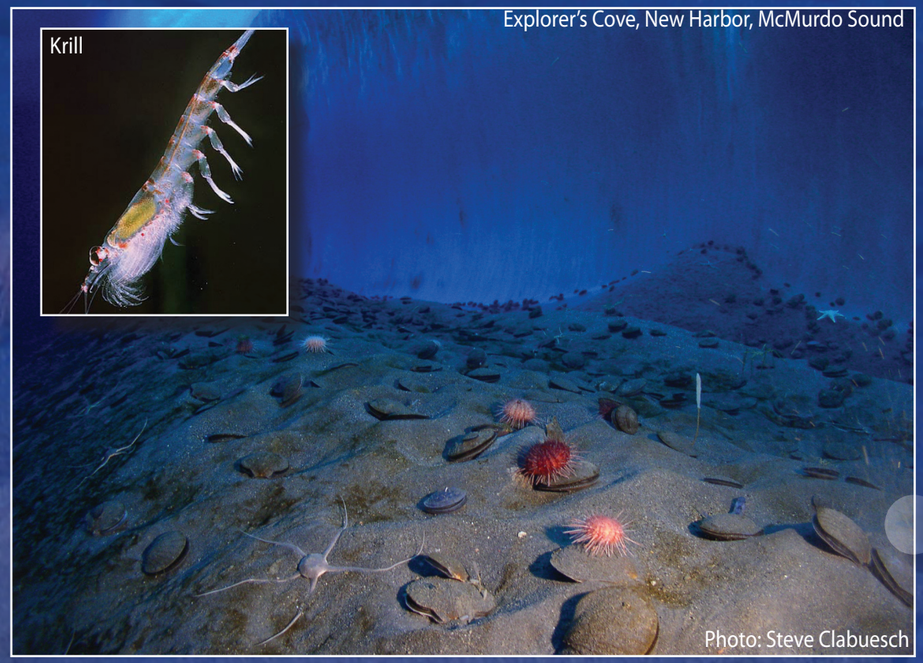

Giant sea sponge in McMurdo Sound

Photo: Rob Robbins


Photo: Henry Kaiser

Some sea creatures in Antarctica grow to extremely large sizes. Sea stars, jellyfish, and sea spiders are examples of these undersea giants. Scientists are studying the question of why these creatures are so much larger than their temperate ocean cousins. The frigid waters of the Southern Ocean hold more dissolved oxygen than the warmer waters near the Equator. Could this fact affect the size of the sea creatures of the Antarctic? Or do animals' metabolisms slow in the cold waters? Or perhaps the right questions have not been asked yet.

The health of any ocean depends on certain key factors. The extremely cold Southern Ocean waters allow more oxygen to dissolve in the sea, which allows marine life to thrive. This, along with the upwelling of water masses that bring nutrients up from the deeper levels of the ocean, feed the microscopic algae near the surface. Researchers are developing new methods for studying the complexity of the ocean's biosphere, including the marine food chain. Dissolved oxygen and nutrients are key factors to the abundance of life in the Southern Ocean surrounding Antarctica. The microscopic algae, the fish, seals, whales, birds and humans all depend on the ocean's health!



Explorer's Cove, New Harbor, McMurdo Sound

Photo: Steve Clabuesch

Photos National Science Foundation, Office of Polar Programs

Background photo: Melanie Conner

Antarctic Birds

All Antarctic animals evolved in a place where people were not present. Because of this, the animals have no land predators; they are not afraid of people. This makes it easy for scientists to get up close and study them with relative ease.


Skua

Photo: Ariana Owens

Skuas, large seagull-like birds, have adapted well to the extreme cold of Antarctica.They are fearless hunters of fish and penguin chicks and scavenge what they can find on the ice. Scientists have to be wary of them when outside with food and scientific samples. More than one researcher has been surprised by a skua trying to steal his or her lunch!


Albatross hunting for food

Photo: Dave Munroe

Several species of albatross live within the Polar Front. The largest is the wandering albatross with a wing span of up to 11 feet (3.4 m). These birds soar over the waves of the Southern Ocean looking for squid and fish and make their nests on the rocky southern islands.


Giant Petrel at Humble Island

Photo: Jeffrey Kietzmann

Seven species of petrels make the Southern Ocean and Antarctica their breeding grounds. The snow petrel breeds further south than any bird in the world except skuas, sometimes as far inland as 215 miles (346 km).

Penguins, another species of bird found in Antarctica, all live south of the equator. They must guard their nests and eggs carefully from skuas, the skillful hunters. Seven species of penguins live south of the Antarctic Convergence: Adélie, chinstrap, emperor, gentoo, king, macaroni, and rockhopper.


Gentoos

Photo: Jon Brack


King

Photo: Mike Usher


Adeliè Penguin showing her egg

Photo: Louise Huffman

Only two species, the Adélie and emperor penguins, are found exclusively living on the ice near the continent of Antarctica. From these ice floes they make foraging (feeding) trips in open ocean searching for krill, squid and small fish.The others can be found making rocky nests on the subantarctic islands and on the Antarctic peninsula.

Due to global climate change, the sea ice in northern parts of Antarctica is disappearing and along with it, the Adélies. Sea ice provides a place for Adélie penguins to rest between foraging (feeding) trips in open ocean and without their ice floe homes, these birds must relocate to other areas where the sea ice remains. In an emperor penguin breeding colony, the sea ice must remain strong enough to support the chicks until they have reached fledgling weight and molted to their adult and waterproof feather coat. With global climate change some areas can no longer support the chicks long enough and these colonies are decreasing.

Can penguins adapt to the rapid changes in their environment? Future scientists will search for answers to questions such as this.


Macaroni, Chinstrap and Adélie penguins

Photo: Phillip Spindler


Adelies on sea ice at Beaufort Island

Photo: Jean Pennycook


Emperors on sea ice

Photo: Jean Pennycook

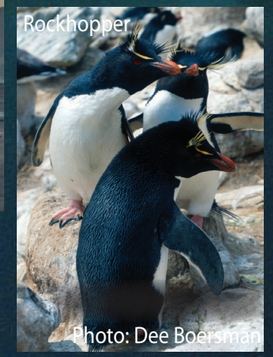

Rockhopper

Photo: Dee Boersma

Photos National Science Foundation, Office of Polar Programs

Marine Mammals

Antarctica is a natural laboratory for biologists to learn about marine mammals in the southernmost part of the world. No terrestrial mammals are native to Antarctica, but many species of seals and whales live in the waters surrounding the continent.

There are only six types of seals that live in Antarctica: crabeater seals, leopard seals, Ross seals, Weddell seals, Antarctic fur seals and southern elephant seals. These six species make up the majority of the world's seal population. Crabeater, leopard, Ross, Weddell and southern elephant seals are true seals; that means they have no external ears. The Antarctic fur seal is an eared seal with a small, visible ear flap.


A scientist tagging seals

Photo: Steven Profaizer


Weddell seals playing together

Photo: James Hebrlee


A Weddell seal and her pup

Photo: Steven Profaizer

Photos National Science Foundation, Office of Polar Programs

Unlike whales which breed in the water, seals must return to land to breed. Like whales, all seals feed at sea and their diets consist of krill, fish and squid.

Whales, dolphins and porpoises are all members of the Order Cetacea. Killer (orca) whales and sperm whales are the only toothed whales inhabiting Antarctic waters. They both eat fish and squid, and orcas also eat birds and other marine mammals, swallowing them whole. There are six baleen whales: blue, fin, humpback, minke, sei, and southern right whales. Baleen whales have comb-like structures, instead of teeth, for filtering krill and fish from the water.


A scientist takes pictures of killer whales

Photo: Donald LeRoi


Killer whale swimming among floating ice in the Ross Sea
Photo: Donnald LeRoi

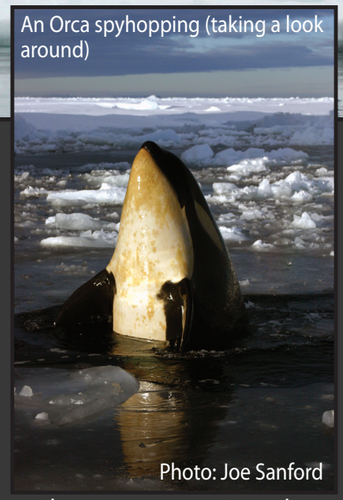

An Orca spyhopping (taking a look around)

Photo: Joe Sanford

All Antarctic whale species migrate long distances from northern warmer waters where they raise their young during the Southern Hemisphere's winter and back to the nutrient-rich Southern Ocean during the summer months. Recently, scientists have discovered what they believe to be at least one new species of dwarf killer whale in the Antarctic waters. Its migration patterns and behaviors are just beginning to be studied.

Both whales and seals were hunted to the verge of extinction, but populations are beginning to recover because of international regulations. Today, the Convention for the Conservation of Antarctic Seals is protecting seals from hunting, and the oceans around Antarctica have been declared a whale sanctuary. Whaling activities are closely monitored by the International Whaling Commission (IWC) .

Historical Exploration

A quick map study of the names of Antarctic mountain peaks, glaciers, and seas is like reading the table of contents of a history of exploration in Antarctica. The men and more recently, the women, who have explored the vast wilderness of the ice continent each has a breathtaking story to tell and have left their mark on the landscape and collective history of the continent.

Who discovered Antarctica? The answer to that question is not an easy one. The first visitors to the Antarctic probably arrived accidentally when their ships were blown off course and they discovered icebergs and penguins. Whalers, seal hunters and commercial fishermen were the next to arrive in the frozen seas around the continent, but the first explorer to seek scientific knowledge was James Cook in 1774. He sailed within 75 miles of the continent and concluded that any land there could not be fertile and that further exploration was unnecessary. The seal trade proved profitable, so these routes continued to push further and further south until sadly, breeding grounds and colonies were depleted and almost pushed to extinction.

The race to the South Pole began in earnest at the turn of the century, and the story of Antarctic exploration might best be told through the lives of three men: Robert Falcon Scott and Ernest Shackleton from the United Kingdom, and Roald Amundsen from Norway. From 1901 to 1922, the three men led various expeditions to try to reach the South Pole and to explore the region.

Scott led the first expedition in 1901, and reached a point about 463 miles from the Pole. Shackleton was sent home from this expedition with scurvy, a painful disease afflicting sailors who do not get enough vitamin C. This humiliation fueled Shackleton's obsession to make his mark in the history of Antarctic exploration.

In 1908, Shackleton raised enough money to lead his own expedition and surpassed Scott's record by coming within 97 nautical miles of the Geographic Pole.

Ernest Shackleton

Had we lived I should have had a tale to tell of the hardihood, endurance and courage of my companions which would have stirred the heart of every Englishman. These rough notes and our dead bodies must tell the tale.
-Robert F Scott

Map created by Rita Thomas

On October 19, 1911, Roald Amundsen left his base camp at the Bay of Whales with four companions and his dogsleds for a dash to the bottom of the world. Scott and his team left two weeks later from Ross Island. Amundsen arrived there on December 14, 1911, beating Scott to the South Pole. Scott's team finally made it to the South Pole, but they must have felt devastatingly disappointed when they were greeted by a Norwegian flag planted in the ice, proving they had lost the race to be the first to step foot there.

Scott's team was in bad shape. They struggled back through bad weather as their health deteriorated. Hungry and sick, a terrible blizzard trapped them in their tents where they eventually froze to death.

Today, new materials and improvements in clothing design make working in Antarctica easier than in the past, but the terrain and climate persist in posing challenges. Modern exploration continues in an effort to study and understand Antarctica's role in Earth's climate and ocean systems.

1773 — James Cook and the crew of the HMS Resolution and Adventure are first to cross the Antarctic Circle.

1819-1821 — Thaddeus von Bellingshausen circumnavigates the South Pole on Octover 31, 1819.

1821 — John Davis and his crew are believed to be the first to set foot on the Antarctic continent.

1823 — James Weddell sails furthest south and discovers what is now the Weddell Sea.

1837-40 — James Sebastien Cesar Dumont d'Urville discovers and names Adelie Land after his wife.

1840 — Charles Wilkes leads the United States Exploring Expedition to Antarctica, but does not land.

1839-43 — James Clark Ross and his ships *Erebus* and *Terror* explore Antarctica and discover the Ross Sea, and establish the Soulth Magnetic Pole to be far inland.

1901-04 — Scientific discoveries are made on the British National Expedition "Discovery" to the Ross Sea, led by Robert Falcon Scott.

1911 — Robert Scott arrives at Ross Island ready to make a second attempt at the race to the South Pole in November.

December 14, 1911 Roald Amundsen wins the race to the South Pole. After leaving a letter to the king of Norway, he and his men turn back and return to The Bay of Whales and their base.

1912 — January 17, 1912 Robert Scott and his men reach the Pole only to find that Amundsen had been there first. Scott and his men never made it back. They all perished on the return.

1915 — Ernest Shackleton's transcontinental expedition spends 10 months on the ice when his ship the *Endurance* becomes trapped in ice.

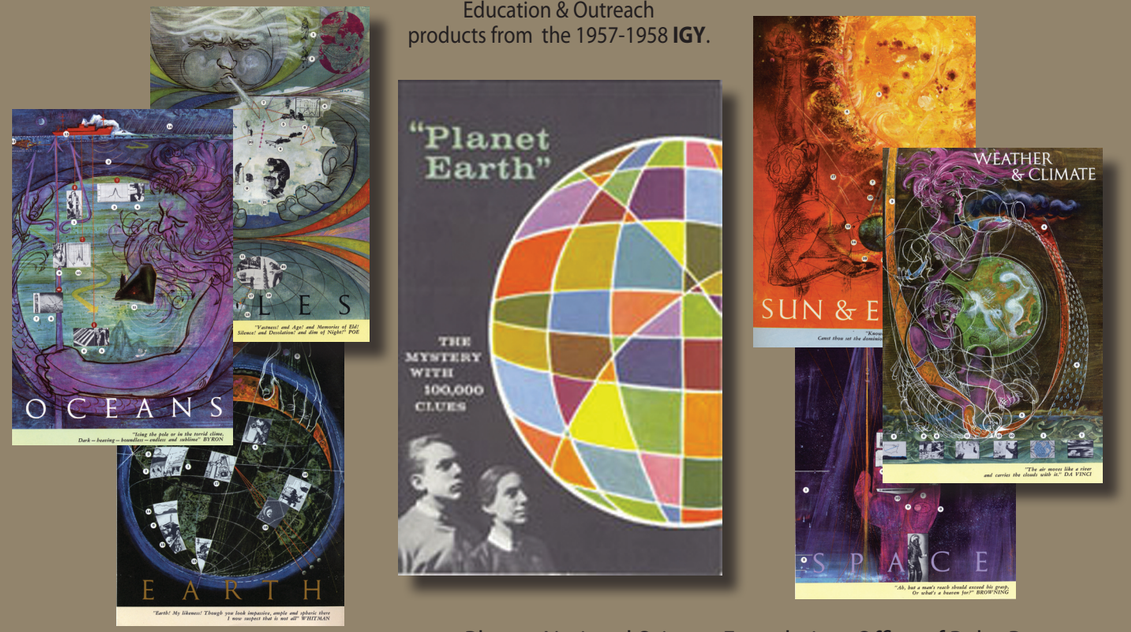
Exploration Today
IGY to IPY

Modern exploration of Antarctica began in earnest during the International Geophysical Year (**IGY**) from July 1957 to December 1958. It was actually the third International Polar Year (**IPY**) following ones held in 1882-1883 and 1932-1933. Scientists from 46 countries originally agreed to participate in the IGY, but eventually 67 countries became involved.

Some of the most amazing science the world had seen was conducted during the **IGY** with activities that spanned the globe from the North to the South Poles. After the IPY of 1932 and with post-World War II technologies, the scientists of the IGY were involved in unprecedented research and discoveries, including the launch of the first artificial satellites.

International cooperation during the IGY was truly remarkable. Scientists took part in cutting-edge research including studies of aurora, cosmic rays, geomagnetism, glaciology, gravity, ionospheric physics, longitude and latitude determination, meteorology, oceanography, rocketry, seismology and solar activity. Amazing discoveries came out of the IGY, including the confirmation of continental drift (which when combined with the concept of seafloor spreading became the theory of plate tectonics), a description of the mid-ocean ridge system, and the discovery of the Van Allen radiation belts surrounding Earth. Another accomplishment following the IGY was the establishment of the Antarctic Treaty that protects the continent as a place of peace and science.

The 4th International Polar Year, from March 2007-March 2009, celebrated the 50th anniversary of the IGY. 228 large, international science projects focused their studies on the Polar Regions with more than 50,000 participants. One of the main themes was a focus on investigating Earth's shrinking ice and snow worldwide, but especially the rapid changes in the polar regions.



Education & Outreach products from the 1957-1958 **IGY**.

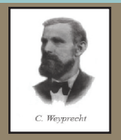
Photos National Science Foundation, Office of Polar Programs

A major difference between the IPY and the IGY was the study of the human dimension: What is it like living in the Arctic? What are the impacts of global climate changes on human beings? Another theme of the IPY included understanding the global linkages and interactions between the Poles and the rest of the planet. Additionally, an important difference with this IPY was the inclusion of education and outreach to make science accessible to all people. One such project includes the publication of this book!

It is an exciting time, as discoveries arising from data collected during the IPY will continue to be revealed for many years to come.

The First IPY

1850 **1874**



Captain Carl Weyprecht led an Arctic expedition searching for the NW Passage. He was instrumental in creating the concept for the First Polar Year.

1882-33

11 Nations
14 Stations

1900

The Second IPY

1932-33

40 Nations
Both Poles

1950

IGY-The Third IPY

1957-58

67 Nations
50 Antarctic Stations

2000

The Fourth IPY

2007-08

63 Nations
Over 200 Large Projects

April 6, 2009 Historic joint session of Antarctic Treaty Consultative Meeting and Arctic Council.

Antarctic Treaty

Antarctica is protected by a unique treaty based on international cooperation, unmatched anywhere else in the world. It is probably the only place where two people from countries with opposing political agendas can come together to work side-by-side with a common goal of peace and science for the "progress of all mankind."

As a result of cooperation during the International Geophysical Year (**IGY**), a treaty was drawn up and signed in 1961 by 12 nations interested in preserving Antarctica for peaceful purposes. Today, the 46 Antarctic Treaty nations represent about two-thirds of the world's human population.

Photo by: AFP

Historic joint session of Antarctic Treaty Consultative Meeting and Arctic Council

Antarctica benefits from the Treaty's protection in many ways. Military activity is prohibited, except in support of the science. Military ships, aircraft and personnel help move scientists and their equipment to the science bases and beyond to field camps.

Photo: Bill Meurer

Scientists gather around the South Pole marker

Even though many countries have made overlapping territorial claims on the continent, the Antarctic Treaty does not recognize or deny any existing claims, but it also does not allow new claims to be made while the treaty is in effect.

The Treaty requires that all information be shared freely and that freedom of scientific investigations shall continue as it did during the IGY.

The Protocol on Environmental Protection to the Antarctic Treaty was signed October 4, 1991. It requires that all scientists and support personnel live within strict guidelines that protect the environment from negative human impact. A committee meets annually to consult on environmental protection of the continent.

Each country is called upon to self-regulate their behavior and to devise strategies for resolving disputes. The Antarctic Treaty stands as a model for international cooperation.

New South Pole Station

Photo: Nick Powell

Photos National Science Foundation, Office of Polar Programs

Antarctic Artists and Writers

The **USAP**'s Antarctic Artists and Writers Program was created to support opportunities for professionals in the Arts and Humanities to have direct experiences visiting Antarctica. Artists and writers are able to make observations, gather information, and then use this knowledge to paint, sculpt, photograph, write or document the history of this very special place. Scientists focus on studies of astrophysics, atmospheric, earth, ocean sciences and biology. Artists and writers bring their different perspectives to understanding the culture, heritage and science of Antarctica to populations of people around the world.

Photo: Peter Rejcek

Photo: Michael Bartalos

Once professionals are chosen through a competitive process, funds are used to support the artists and writers in Antarctica. They live at a US Antarctic Program station, or visit research sites and remote field camps. The goal is for artists and writers to share their experience with the public to increase our understanding of Antarctica through the arts and humanities.

Photo: Homero Campos

Photo: Kristan Hutchison

Many of the books used in classrooms, libraries and science centers, as well as photos documenting the beauty of Antarctica, came about through this program. Some other products representing Antarctica through the arts are documentary films, multi-media presentations and musical compositions using natural sounds and materials. In this way, Antarctic scientists, artists and writers work together to teach others about the unique qualities of the Antarctic continent and document the historical heritage of this region that is inaccessible to most people.

Careers On Ice

Working to increase our understanding of the Antarctic is one of the most exciting jobs a person can have. Many people who work in Antarctica have said that they have "ice in their veins" and their passion for the coldest continent is what makes them feel this way.

How do you get involved in Antarctic science? You could be a researcher who asks the major science questions and works to find the answers. There are many ways you could do this: being a professor at a University, working at a research laboratory, or working as a laboratory technician that helps conduct the science experiments.

Lots of other people work in Antarctica in addition to the researchers. The US Antarctic Program employs hundreds of people to help support Antarctic science. These people help to ensure that the communication satellites work so scientists can talk with their home institutions and around the world. There are also people that help to coordinate all the logistics, such as flights to and around Antarctica, making sure field camps are supplied with food and equipment, and helping to figure out the best way to collect scientific data in cold remote regions of our planet. Lots of people also work as carpenters, chefs, medical technicians, search and rescue field experts, janitors, firefighters, mechanics, large equipment operators, and general assistants that help with all the other things needed to run field camps and the larger stations.

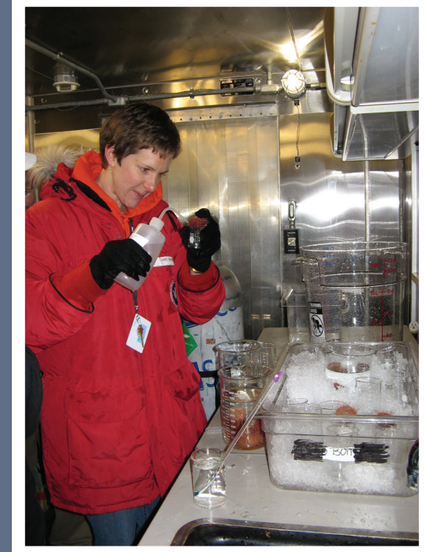


Photo: Elaine Hood

Photo: Kristan Hutchinson

Photo: Melanie Conner

Photos National Science Foundation, Office of Polar Programs

Outside of the US Antarctic Program, there are other careers you could have that help to increase our understanding of Antarctica. You could help to protect Antarctica's pristine environment by working with policy makers who create laws that describe the protocols governing how people conduct their work in Antarctica. Many people also work as educators who help to share the science conducted on the frozen continent with everyone around the world. Tourism companies also hire people to help with various expeditions. There are also great jobs at the National Science Foundation that ensure the scientists have funding to conduct their research and find ways for people to work together on common projects in Antarctica.

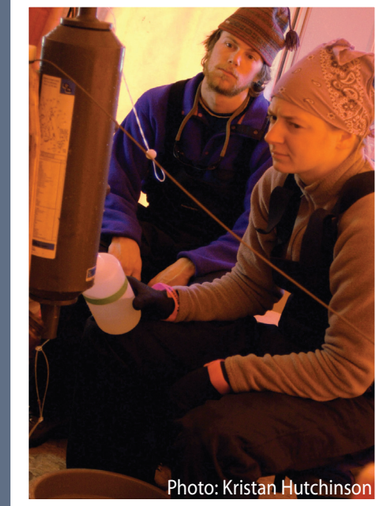


Photo: Kristan Hutchinson

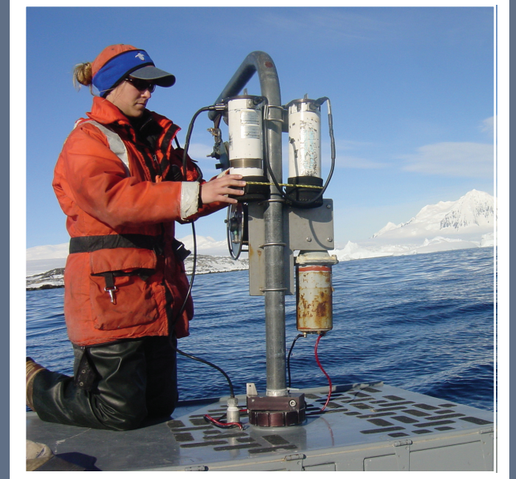


Photo: Jeffrey Kietzmann

If you are a graduate student or new PhD scientist interested in working in Antarctica, you can learn more by getting involved with the Association of Polar Early Career Scientists (APECS). This organization is a group of over 2000 researchers from all different countries who are just starting their careers working on lots of different aspects of polar science.

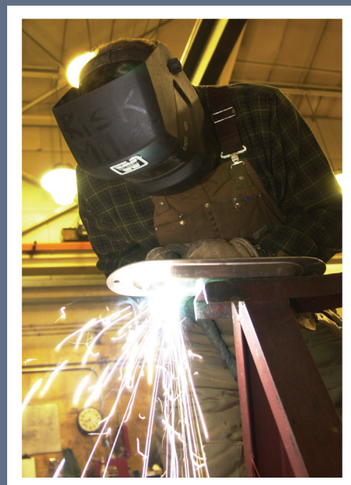


Photo: Melanie Conner

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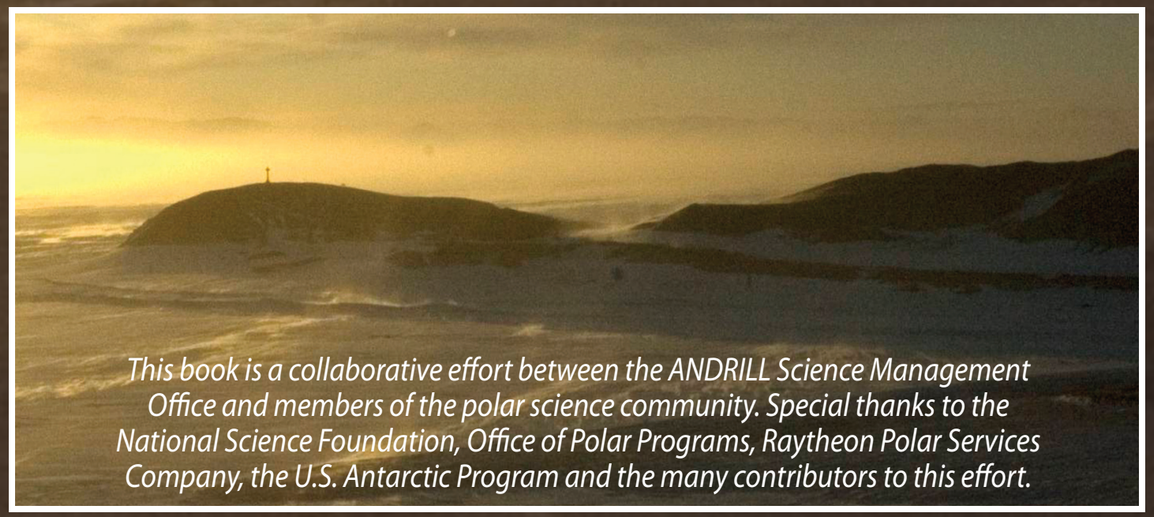

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Photos: Julian Thomson

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