ANTARCTIC SCIENCE

UNITED STATES ANTARCTIC PROGRAM

The United States Antarctic Program (USAP), which is managed by the National Science Foundation, supports research into almost every major scientific discipline. It maintains three year-round research stations and two research vessels. There are also up to 30 or more field camps each year where scientists conduct activities from drilling ice cores to studying lakes buried deep below the ice sheet.

Antarctica may seem remote, but it is an integral part of the Earth's climate system. Several major studies suggest the West Antarctic Ice Sheet will collapse in the coming centuries, leading to significant sea-level rise. That would have a profound effect on nations around the world, as they attempt to address future coastal changes, as well as a cascade of other problems likely to occur from the collapse. Scientists are racing against the clock to learn as much as they can from this unique continent before further changes occur.

LOCKHEED MARTIN

BIOLOGY

Penguins may have become synonymous with Antarctica, but of the estimated 19 species of penguins in the world, the emperor and Adélie are found the farthest south. Other species, such as chinstrap, gentoo and macaroni, breed around the Antarctic Peninsula and islands off the continent, where conditions are less harsh. As the world warms from climate change, emperor and Adélie penguins may lose colonies, while other subantarctic species may find better conditions for life farther south.

There is more to Antarctica than just penguins. Whales and seals are two groups of marine mammals found throughout the Southern Ocean. The waters are also rich with mostly endemic, or native, groups of fish that have evolved over millions of years with unique adaptations like anti-freeze proteins that allow them to live in subfreezing conditions. Scientists are attempting to exploit these traits, such as developing techniques to preserve human organs for transplants.

Antarctica's largest terrestrial critter isn't a penguin or whale. These larger fauna, or animals, spend only part of their lives on land. The title goes to a bug called *Belgica antarctica*, a flightless midge, or fly, that measures less than a centimeter (half-inch) long. It's a hardy insect, able to survive losing nearly all its moisture and freezing temperatures that would kill similar species. Further down the scale of size are microorganisms like bacteria capable of living within and under the ice itself.

74° 38.85' S, 165° 23.15' E

IN FOCUS CAPE WASHINGTON EMPEROR PENGUIN COLONY

In the region of the Ross Sea, Cape Washington is one of the largest emperor penguin colonies in the world. It is home to more than 20,000 breeding pairs, as well as a nursery and hatchery for silverfish, a herring-sized fish that is a key species in the Ross Sea food web. Emperor penguins are the largest penguin species and the only one to breed during the Antarctic winter. The seabirds reside there from April to January of each year.

GLACIOLOGY

Less than one percent of Antarctica is not covered by ice. The continent, including its ice shelves, is approximately 14 million square kilometers (5.4 million square miles). Sea ice more than doubles the size of the continent in winter, covering more than 18 million square kilometers (7 million square miles) of the Southern Ocean. If all the continental ice were to melt, sea level around the world would go up by about 60 meters (200 feet), which is enough to flood low-lying coastal areas from Florida to Bangladesh. That's why scientists are particularly interested in learning as much as possible about how ice moves and melts.

One of the best records of past climate can be found in Antarctic ice. Snow that falls each season eventually becomes compressed into ice, creating a distinctive layer within the ice sheet. Scientists use specially designed drills to extract ice cores, which provide a vertical timeline of past climate, similar to the way tree rings record past environmental conditions.

It's easy to forget that under Antarctica's ice sheet is a continent as diverse as any other landmass – but it is difficult to explore. Scientists have developed sophisticated techniques to investigate subglacial lakes and other extreme environments below the ice that may harbor life, despite the fact there is no light or ready source of food for these microorganisms. Such studies also provide insights into environments on other planets.

75° 14.25' S, 99° 14.65' W

IN FOCUS PINE ISLAND GLACIER, WEST ANTARCTICA

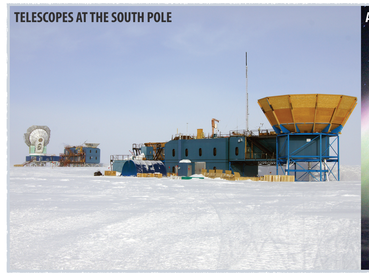
Pine Island Glacier is one of the main glaciers in West Antarctica. A glacier is like a river of ice. In this case, the glacier connects the ice sheet that sits on the land to an ice shelf that floats on the Amundsen Sea. Chunks of the ice shelf occasionally break off from the front to form icebergs. Like melting ice cubes in a glass of water, ice that is already in the ocean will not raise sea level as it melts. The ice shelf acts like a cork in a bottle, preventing the glacier from moving directly off the land and into the ocean, which would raise sea level. When ice shelves thin, weaken or break apart, the glaciers then flow faster, just like removing the cork from a bottle. Recent research suggests that Pine Island Glacier ice shelf has reached such a state.

ASTROPHYSICS, PARTICLE PHYSICS, AND SPACE WEATHER

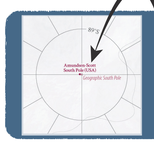
Antarctica's polar plateau reaches nearly three miles high in places, and the atmosphere above it is cold, dry, and stable – perfect conditions for researchers using telescopes to explore the universe by observing ancient light left over from the Big Bang. These telescopes aid in our understanding of the universe, from the moment it burst into existence to the forces that continue to speed its expansion nearly 14 billion years later.

The clarity and vastness of Antarctic ice makes it an ideal medium through which to study one of the world's tiniest particles. Neutrinos are nearly without mass and fly through the universe, the planet, and even people, at nearly the speed of light. Experiments embedded in the ice sheet are studying these strange particles as they make rare collisions in the ice, which can tell scientists about highly energetic events in the universe, such as the explosion of a star, known as a supernova.

The sun's influence on Earth goes beyond warm summer days. Solar storms can disrupt satellite communications or increase radiation in outer space that could endanger astronauts. Space weather is especially pronounced at the polar regions, so scientists have installed instruments to monitor changes in the Earth's upper atmosphere. Solar storms also create the colorful displays known as auroras that can only be seen near high latitudes.



90° S, 0° E



IN FOCUS AMUNDSEN-SCOTT SOUTH POLE STATION

Amundsen-Scott South Pole Station is located at the geographic South Pole at the bottom of the planet. Located at an elevation of 9,301 feet, the U.S. research station was originally established in 1956-57 to study solar activity from the sun, which is expressed most powerfully in the polar regions. It has become the premiere site for telescopes and other experiments that study the universe. What makes the South Pole an ideal location for observing the universe is the minimal amount of moisture in the air. Water vapor absorbs the sorts of signals that scientists "see" with telescopes. Sitting on Earth's axis of rotation has distinct advantages, too. The same sky is visible all winter; it doesn't sweep from east to west, which enables astronomers to make prolonged observations of the sky.

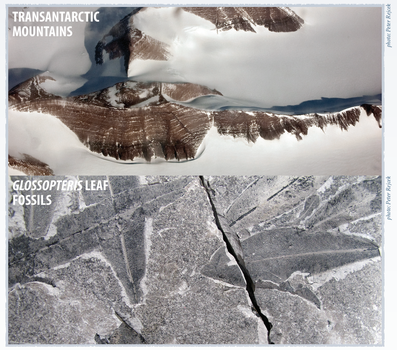
EARTH SCIENCES

Most of Antarctica is an ice-covered desert. While less than one percent of the continent is free of ice, it does contain two mountain ranges: the 3,000-kilometer-long (1,800-mile-long) Transantarctic Mountains, which nearly bisect the continent into east and west, and the 1,700-kilometer-long (1,050-mile-long) range along the spine of the Antarctic Peninsula. The McMurdo Dry Valleys are the largest relatively ice-free region on the continent and encompass about 15,000 square kilometers (5,800 square miles) of mountains, valleys, lakes and glaciers reserved for scientific research.

More than 99% of Antarctica is covered with ice and all that white ice makes the continent an ideal place to search for meteorites. To date, U.S. researchers have recovered more than 20,000 rocks from space, including meteorites from Mars and the moon.

The story of a hidden mountain range may sound like myth, but the Gamburtsev Subglacial Mountains, about the size of the European Alps, are located entirely under the East Antarctic Ice Sheet more than a half-kilometer (one-third mile) below the surface. Research on this unique feature is offering new insights into mountain-building and other geological and glaciological processes.

Further back in time, before Antarctica turned into an icy wasteland, dinosaurs once walked upon the continent. There were also forests with plants that had adapted to surviving four-month-long winters of total darkness due to the extreme southerly location of Antarctica. The fossils of these animals and plants can be found in the few places where rock pokes through the ice, offering scientists a view into the evolution of life that goes back more than 250 million years.



77° 31.65' S, 167° 9.65' E

IN FOCUS MOUNT EREBUS, ROSS ISLAND

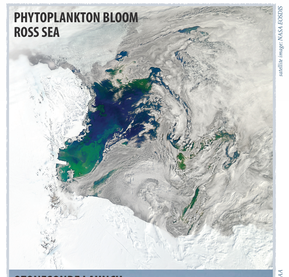
Mount Erebus on Ross Island is one of the world's most famous volcanoes thanks to a rare lava lake. Researchers are not just interested in the lava lake, but also the "plumbing" below that feeds the magma, as well as the gases that are emitted from the volcano. Scientists also study the ice caves and other structures, called fumaroles, created by vents around the crater. Erebus is not the only active volcano in Antarctica: Scientists have found volcanoes more than a kilometer below the surface of the ice sheet by using instruments that detect earthquakes to image rocks below the ice. The instrument is sort of like an X-ray machine, but it uses sound waves.

OCEANOGRAPHY AND ATMOSPHERIC SCIENCES

The Antarctic Circumpolar current is the only ocean current that circles the entire world, linking the Atlantic, Pacific, and Indian oceans into one global system by transporting heat and salt from one ocean to another. Understanding what factors influence this ocean current is critical to understanding and predicting future changes to the Earth's ecosystem.

The Southern Ocean is the world's most biologically productive ocean thanks to the upwelling of nutrients thousands of meters below to the surface. Its productivity is limited by the low availability of micronutrients, such as iron, that aid in the growth of phytoplankton, which are microscopic planet cells that absorb carbon dioxide from the atmosphere like terrestrial plants.

Since the discovery of the annual ozone hole over Antarctica in the 1980s, the manmade chemicals that destroy ozone in the stratosphere have been mostly phased out – an example of how the nations of the world can work together on global problems like climate change. Ozone in the layer of the atmosphere between 20 and 50 kilometers above the Earth protects human health by blocking harmful ultraviolet radiation from reaching the surface. Scientists predict the ozone hole will stop occurring by the end of the 21st century.



59° 55.15' S, 62° 19.3' W

IN FOCUS DRAKE PASSAGE

The Drake Passage, a stretch of sea between the tip of South America and the Antarctic Peninsula, has some of the roughest water in the world. It represents the narrowest point through which the world's largest ocean current, the Antarctic Circumpolar Current, circles the Antarctic continent. Scientists believe that the Antarctic Circumpolar Current formed tens of millions of years ago after the Drake Passage opened. In turn, the ocean currents influenced the Antarctic climate, eventually leading to the development of its huge ice sheets. However, those theories remain hotly debated and the Drake Passage is an active area of research today.

PIONEERS AND PROTECTORS OF ANTARCTIC SCIENCE

The first crossing of the Antarctic Circle is believed to be by Captain James Cook, who saw icebergs in the area in the 1770s. The continent was first sighted around 1820 by whalers and explorers.

The modern era of scientific exploration and discovery started with the 1957-1958 International Geophysical Year, which included research by 12 nations at 67 research stations in Antarctica. The Antarctic Treaty entered into force in 1961, and about 50 nations have signed the agreement to designate the area south of 60 degrees south latitude as a zone of peace and scientific research.

0 — 1820 — 1917 — 1957-58 — 1961 — 1991 — TODAY

Belief in the existence of a vast southern continent had been around since at least the ancient Greeks, more than 2,000 years ago.

Expeditions to the southern continent peaked with the Heroic Age of Exploration, which began in the late 19th century and ended around 1917 with the conclusion of Ernest Shackleton's famous *Endurance* adventure. In 1911-12, Norwegian Roald Amundsen and Briton Robert Falcon Scott both attempted to be the first to reach the South Pole. Amundsen's team beat Scott's team to the Pole, arriving about one month sooner. Today the South Pole station is named for these two great explorers.

Conservation of the continent and its fragile ecosystem has become increasingly part of the strategy of managing Antarctica, not just for preserving its inherent beauty but also because it serves as one of the last pristine natural laboratories on Earth. In 1991, the Protocol on Environmental Protection to the Antarctic Treaty was signed to promote conservation and protection of the continent.

photos (left to right): UK Telegraph, Peter Rejcek, Dr. Charles Bentley, Maggie Knuth

COMMON QUESTIONS ABOUT ANTARCTICA

Isn't Antarctica only flat ice?
Geographically, Antarctica is divided into three major sections: the Antarctic Peninsula, East Antarctica and West Antarctica. Antarctica has two major ice sheets, divided by the Transantarctic Mountains. Although there are high mountains, less than one percent of the continent is exposed rock, including an area called the McMurdo Dry Valleys, which is the largest relatively ice-free area on the continent.

What are differences between Antarctica and the Arctic?
Antarctica and the Arctic are both cold and remote, but those are superficial similarities. Besides being on different poles, Antarctica is a continent surrounded by ocean, while the Arctic is essentially an ocean surrounded by land. One big difference is that penguins live in Antarctica, while polar bears are only found in the Arctic.

Who owns Antarctica?
No one owns Antarctica, although several countries have made territorial claims in the past that have been temporarily suspended by international treaty. Antarctica is protected by the Antarctic Treaty to prevent natural resource exploitation and to preserve it for scientific research.

How many people live in Antarctica?
Antarctica has no indigenous population, with only about 4,000 people living and working around the continent during the austral summer, October through February. That number drops down to about 1,000 during the winter. These people are not permanent residents and are mainly scientists, workers, or tourists.

ANTARCTICA, THE FROZEN CONTINENT …

14,000,000 km²

… is **1.75x** the size of the continental United States

… holds about **70%** of the Earth's fresh water

25,000,000 km²

30,000,000 km²

… holds about **90%** of the Earth's ice

… holds the lowest recorded temperature on Earth of **-89.2°C**

ANTARCTIC GLOSSARY

ablation	removal of material from a glacier through melting, evaporation, or calving
albedo	proportion of light or radiation that is reflected by a surface, typically of a planet
aurora	natural electrical phenomenon characterized by the appearance of streamers of red or green light in the sky
austral	relating to the south or southern hemisphere
benthic	pertaining to the bottom of the ocean or other waterbody
crevasse	deep, open crack in a glacier or ice sheet
cyanobacteria	phylum of bacteria that obtain their energy through photosynthesis
fast ice	sea ice that extends from and is attached to the shore
firn	granular snow, especially on the top of glaciers, where it has not yet been compressed into ice
fumarole	opening in the earth's crust, typically near volcanoes, which emits steam and gasses
grounding line	boundary between the floating ice shelf and the ice that is resting on bedrock
hypothermia	condition of having an abnormally low body temperature
ice floe	small sheet of floating and moving ice in the sea
ice shelf	thick, floating platform of ice flowing from land onto the sea
jamesway hut	portable and easy-to-assemble hut, usually arched, designed for cold weather
katabatic winds	high-velocity winds that drop from a higher elevation
krill	small, shrimplike crustacean in the ocean
nematode	worms having long, cylindrical bodies that inhabit a broad range of environments, including cold
nunatak	exposed peak of rock or mountain projecting through and above the surface of inland ice or snow
ozone hole	region of marked thinning of the ozone (O_3) layer in high latitudes attributed to chemical action of pollutants
polynya	stretch of open water surrounded by ice
rookery	area where penguins or seals breed, nest, and raise young
sastrugi	parallel, wavelike ridges of snow formed by high winds
sea ice	frozen sea water, floating on the surface
serac	block or column, often unstable, of ice on a glacier
skua	large, brown predatory seabird related to gulls
traverse	overland route to transport goods or people
ventifact	rocks that have been eroded, grooved, or polished by wind-driven sand or ice crystals