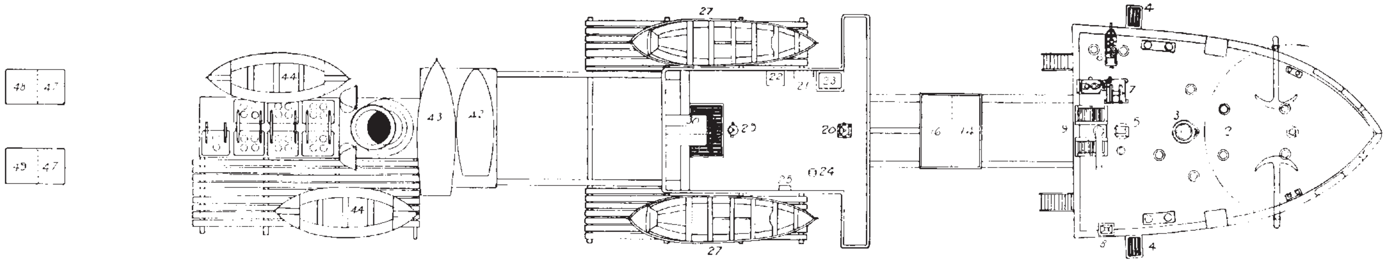
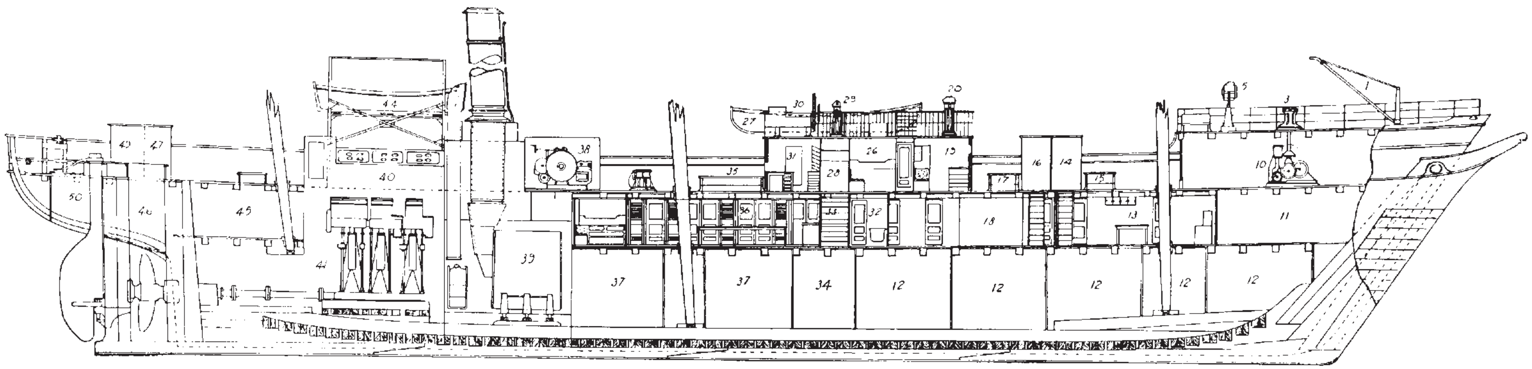
Profile and plan of Forecastle and Bridge deck



Forecastle and Bridge deck



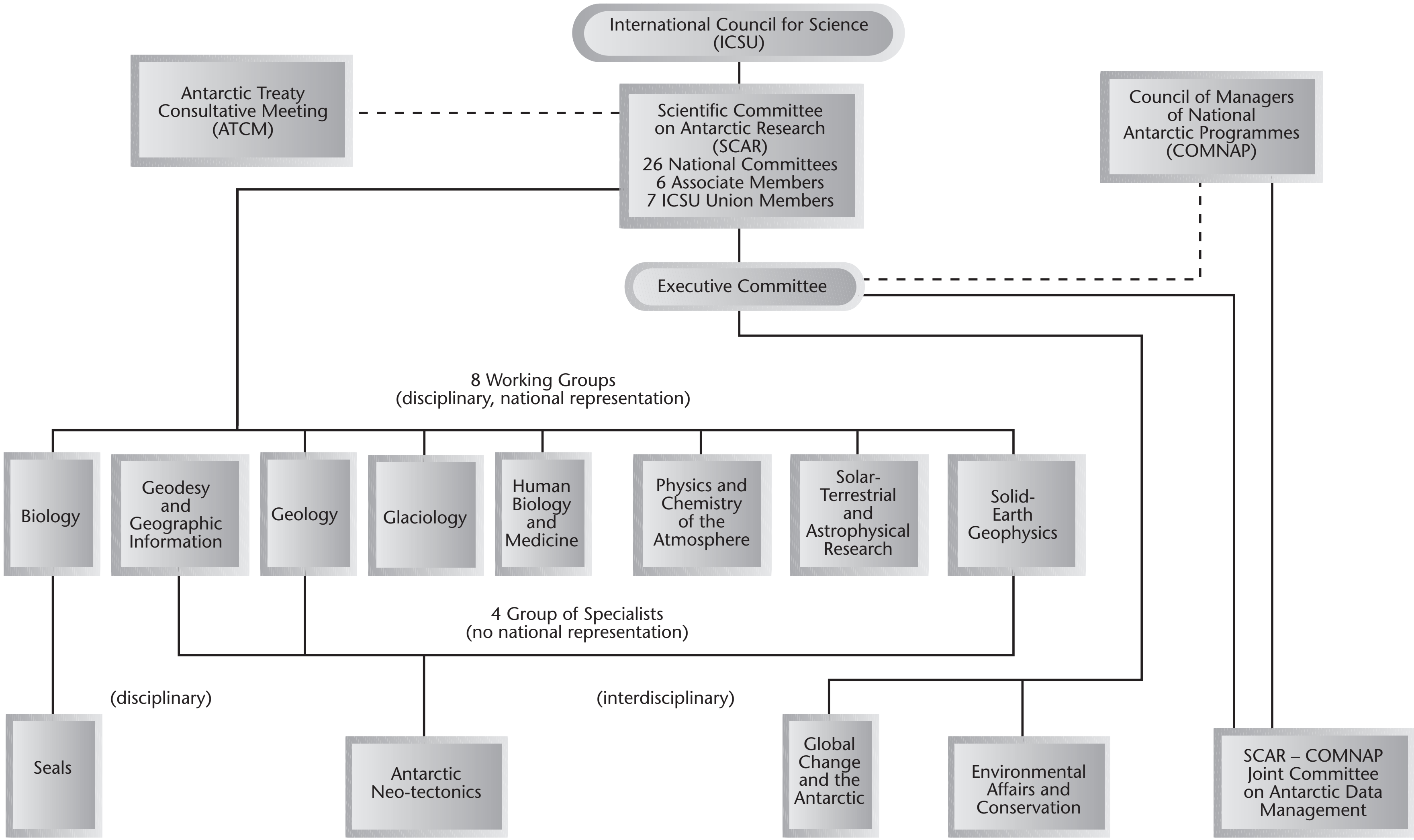
Profile

RRS *Discovery* was fitted out for marine biology and oceanography in 1925 for the Discovery Investigations

RRS *Discovery*
1. Anchor davit
2. Deck lights and ventilators
3. Capstan
4. Sounding platform
5. Searchlight
6. Lucas sounding machine
7. Deep-water hydrological machine
8. Pedestal for small harpoon gun
9. Galley skylight
10. Windlass
11. Chain locker
12. Stores
13. Galley and kitchen
14. Galley companion
15. Skylight to kitchen
16. Crew space companion
17. Skylight to crew space
18. Quarters of crew and petty officers
19. Chart house
20. Standard compass
21. Flag locker
22. Wireless accumulator box
23. Chart table
24. Engine-room telegraph
25. Voice tube to engine room
26. Deck cabin
27. Whaler
28. Wardroom entrance
29. Steering compass
30. Steam and hand steering gear
31. Deck laboratory
32. Bathroom
33. Wardroom companion
34. Freshwater tank
35. Wardroom skylight
36. Wardroom
37. Main bunker
38. Winch house and winch
39. Main boiler
40. Engine room casing and skylight
41. Engine room
42. Norwegian pram
43. Dinghy
44. Lifeboat
45. Sail locker
46. Propeller well
47. Officers' toilet
48. Armoury
49. Lamp locker
50. Rudder well

National Institute of Oceanography

Scientific Committee on Antarctic Research (SCAR)

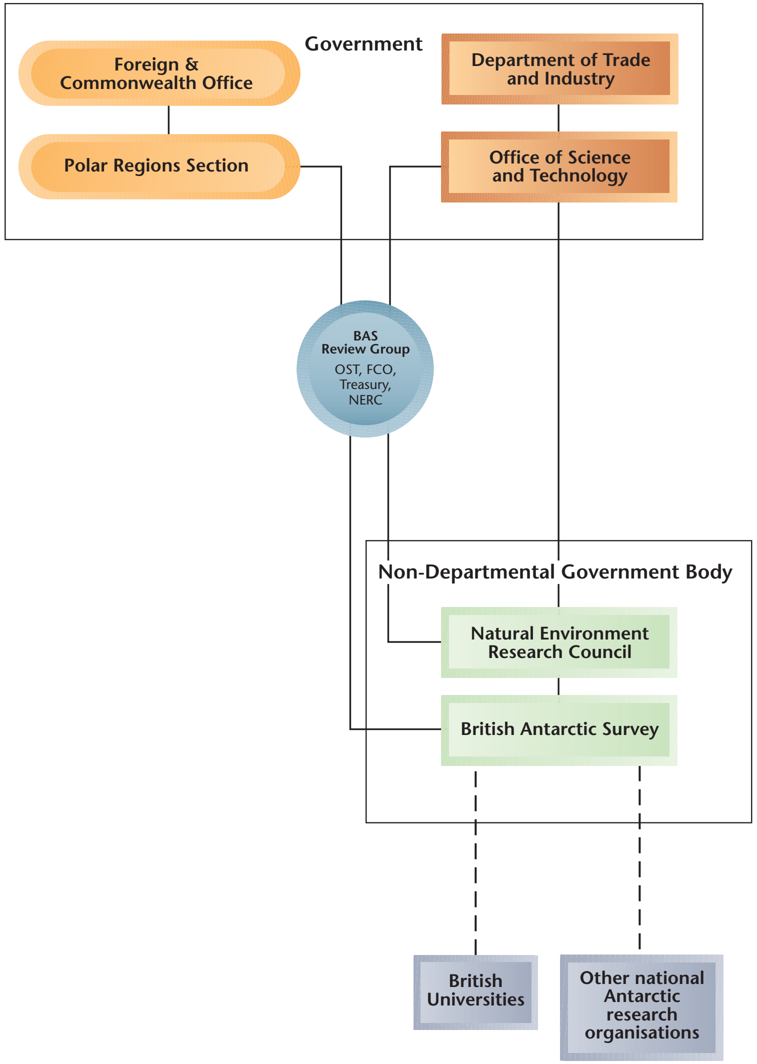


The organisation of the Scientific Committee on Antarctic Research

SCAR

The organisation of UK Antarctic research

The organisation of the British Antarctic Survey



BAS

Research stations operated by the British Antarctic Survey (1999)

Name	Position	Opened	Function	Remarks
Bird Island (South Georgia)	54°00′S, 38°03′W	1971	Studies of birds and seals	Open year round since 1983
Signy (South Orkney Islands)	60°43′S, 45°36′W	1947	Study of terrestrial and freshwater ecosystems	Summer only since 1996
Rothera (Adelaide Island)	67°34′S, 68°08′W	1976	Centre for studies in glaciology, geosciences and biological sciences	Runway supports air operations over a wide area throughout the Antarctic Peninsula
Halley	75°35′S, 26°30′W	1956	Centre for studies of the Earth's atmosphere from ground level to its outer limits	Station is built on the floating Brunt Ice Shelf

The BAS Bird Island Research Station on South Georgia

BAS

Recent scientific achievements by BAS

Resource S4

General

In 1997, BAS was awarded a major prize for its contribution to science and environmental protection. The International St Francis Prize for the Environment commemorates St Francis of Assisi's regard for nature.

Ice and climate

BAS glaciologists predicted the disintegration of an ice shelf and are watching the predictions come true. They devised a mathematical model of the flow and fracture of ice to predict that Larsen B Ice Shelf would become critically unstable.

BAS glaciologists have deduced that the more 'continental' Antarctic ice shelves will thicken as the climate warms. This non-intuitive result is based on oceanographic measurements made beneath Ronne Ice Shelf using access holes made by a hot-water drill. The study showed that the formation of sea ice drives the currents beneath the ice shelf. This implies that if there were to be less sea ice in a warmer Southern Ocean, there would be less melting at the base of the ice shelf.

In 1998, remote sensing scientists at University College London, who used satellites to map the Antarctic ice sheet, reported that between 1992 and 1996 the elevation of the interior of the continent fell by less than 1 cm a year. They argued that the contribution of Antarctica's inland ice to sea level rise this century has been very small indeed.

In 1997, BAS scientists showed that the thinning of the Antarctic ozone hole starts earlier in the year than had previously been thought. They showed that the depletion process starts in winter at the sunlit edge of Antarctica. This is important because ozone-poor air from the edge of the ozone hole regularly passes over South America, resulting in larger than normal doses of damaging UV radiation.

In 1995, ten years after first discovering the springtime ozone hole over Antarctica, BAS scientists showed that ozone depletion now extends into late summer and causes lower temperatures in the stratosphere.

Upper atmospheric sciences

In 1998, BAS scientists were reported to have discovered that 'the sky was falling in'. In reality, they had found that the height of the Earth's upper atmosphere (the thermosphere) had fallen by 8 kilometres in 38 years. The long-term decrease in altitude is attributed to increasing concentrations of greenhouse gases. It confirms that as the lower atmosphere warms, the upper atmosphere is cooling.

In 1997, BAS scientists and international collaborators predicted the occurrence of a major space weather storm. On 6 January 1997 they observed a magnetic storm, produced by a major disturbance on the Sun, heading towards the Earth. On January 10–11 the storm disrupted radio communications and permanently damaged a $200 million TV satellite.

BAS has developed Automatic Geophysical Observatories which are unmanned stations designed to collect and store environmental data at locations where permanently manned activities are impractical.

Geoscience

BAS geologists have identified in Antarctica the longest Cretaceous sedimentary succession in the southern hemisphere. It contains a history of environmental and biological change over the last 100 million years.

BAS geologists contributed to the ambitious international Cape Roberts Drilling Project to study climate change on geological time scales by drilling into the sea bed. Drilling was conducted from sea ice 1.7 m thick above 200 m of water, more than 15 km offshore. Exciting facts in the development of the world's largest ice sheet are emerging.

Terrestrial and freshwater life sciences

BAS biologists have documented an 'explosion' in the numbers of flowering plants in the Antarctic Peninsula over the last 30 years. The species are almost at their limit of distribution and have benefited from recent warmer summers, with increased moisture ensuring better germination and seed setting.

BAS

Wing of BAS Twin Otter aircraft showing aeromagnetic sensing aerials

BAS biologists, with international partners, are planning to study the lake discovered beneath the Antarctic ice sheet at Vostok, near the centre of Antarctica. The water in the lake could be hundreds of thousands to millions of years old. The lake is the most isolated aquatic environment on Earth and may well contain unique life-forms of micro-organisms and biomolecules. The scientific challenge is how to study the lake without polluting it.

Marine life sciences

BAS ornithologists have revolutionised studies of the foraging of albatrosses and other species by attaching miniature recorders to the birds and using satellite telemetry. They have charted the decline in populations of the wandering albatross mostly because of entrapment on the fishing lines of commercial fishing boats.

BAS biologists have analysed a 90 year record of sea ice from the South Orkney Islands which confirms an overall decline in the duration of sea ice. Most of the decline was concentrated in the early 1950s. Subsequently a cyclical pattern has emerged – now recognised as the Antarctic Circumpolar Wave.

An eminent scientist's views on scientific trends

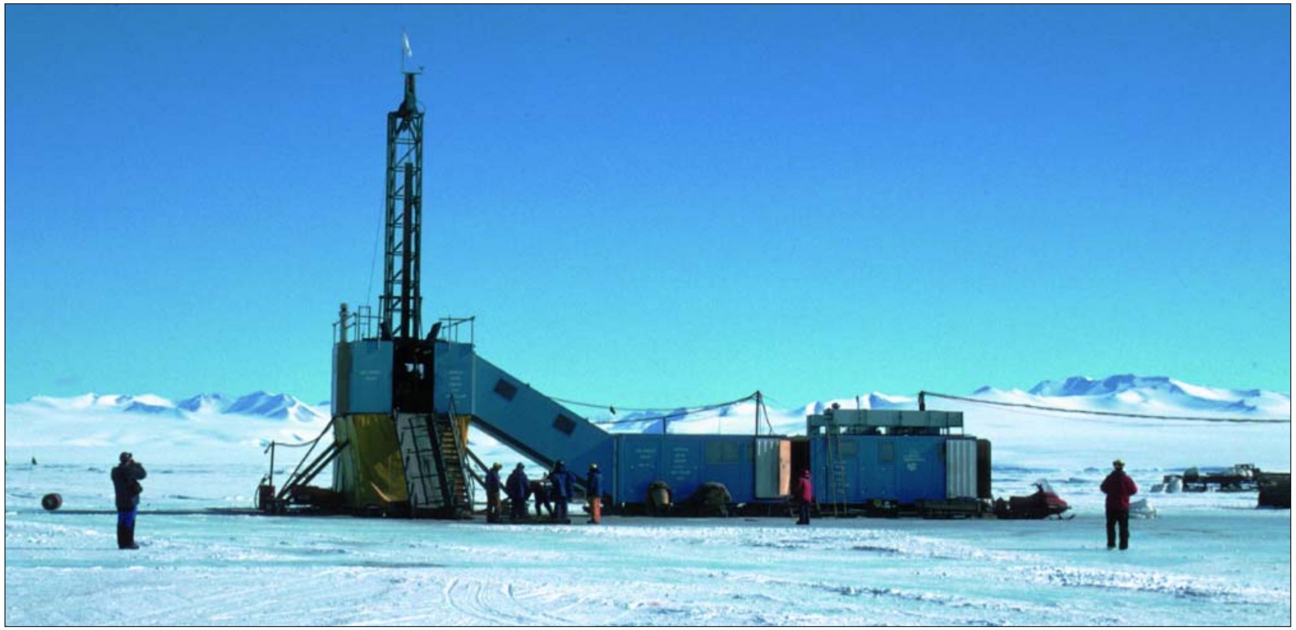
Buller's albatross

The study of the Buller's albatross is an example of how science and technology is changing so rapidly that even scientists are sometimes left blinking in amazement. It might illustrate why we are so enthusiastic about the present rate of these changes.

Buller's albatross is a species that roams the oceans around and south of New Zealand. It is being intensively studied, because of its vulnerability to the Southern Ocean squid fishery. We have put satellite transmitters onto its feathers so we can track it over the Southern Ocean. Data are gathered by a French satellite for tracking the birds, a US satellite for Sea Surface Temperatures, and then these data are downloaded to the National Institute for Water and Atmospheric Research and finally read in a cosy room in Christchurch, New Zealand – all in real time. The internet provides access to global climate models for winds. Computer Global Positioning Systems (GPS) allows positioning and computer Geographic Information Systems (GIS) allows overlaying. Soon, we will be able to download fishing fleets in relation to our individual albatross.

The lessons

- Joint national and international programmes, and multidisciplinary science.
- Remote sensing at a local and global scale to put individual scientists in the big picture.
- Miniaturisation of electronics.
- The internet allowing access to ancillary data from international research programmes.
- Use of GPS and GIS.
- Ability to carry out complex remote research programmes from the office.



Dr J. Smellie/BAS

Drilling at Cape Roberts is on sea ice some 15 km offshore in the south west Ross Sea

Trends in science

I went through the last 40 issues of the journal *Science* covering over 700 original papers to get an idea of the proportions of new leading-edge science which could be attributed to various topic headings. As a check, I went through the last 20 issues of the journal *Nature* to see if the proportions were similar – they were.

The 20th century has seen a massive increase in our understanding of how Planet Earth functions. The early part of the 21st century will focus on understanding the human body, how it functions at the smallest detail, and how we can control these functions by altering our genetic make-up.

	Per cent of total papers in the survey	
Science area	**Science**	**Nature**
Life sciences	**60**	**62**
Genetics/molecular biology	23	27
Medicine	14	19
Other life science	22	16
Physical sciences	**19**	**16**
Materials science/nanotechnolgoy	5	4
Other physics and chemistry	14	12
Environmental science	**13**	**16**
Global change	6	5
Other (geology, oceanography, etc)	7	11
Astrophysics/astrobiology	**8**	**6**

So what has this got to do with Antarctica?

Global change

A hundred million years ago temperatures were 6–7°C higher than they are now. When we look in the future, global models show the rate of change is 10,000 times faster than it has been in the last 100 million years. Instead of millions of years we are looking at centuries. Global change is real, happening now and Antarctica has a part to play in this.

Astrophysics

The South Pole is the only place in earth where certain fundamental astronomical observations can take place. It is the principal area of the world that provides meteorites for studies of worlds other than our own and it provides analogues for other parts of the solar system.

Lake Vostok, up to 500 m deep and 3.5 km down below the ice surface at the bottom of the East Antarctic Ice Sheet may be a model for Europa, an icy moon of Jupiter, which may have an ocean of water or slush covered by ice.

Environmental security

Catastrophes, and even armed conflict, may result from worldwide abuse of the environment and overpopulation – e.g. the international outrage over the Indonesian fires, and the heated politics over concepts such as global carbon taxes and the liability issues relating to sea level rises that could engulf whole nations in the Pacific. The huge carbon-emitting industries, ozone-depleting substance industries, and the giant international insurance industries are now asking questions that can be tackled by science in Antarctica. Industrial research and development funding is increasing in the developed nations.

Global change illustrates these trends

The polar regions are sensitive indicator areas of change where early detection of global change trends can be picked up. The ice provides a wonderful medium for recording changes in the Earth's atmospheric composition and therefore climate change in the recent past (tens of thousands of years) and pollution in the very recent past (decades). The sedimentary layers of part of Antarctica are similarly unique.

The Cape Roberts Drilling Project is essentially a geological and geophysical programme to map the earth's history. It links in with global change scenarios and will provide information of the state of the marine and the atmospheric environment at almost any stage over the last 100 million years.

There is the realisation that the Southern Ocean and the ice are intimately linked. This linkage influences world climate. For instance, biologically generated aerosols from phytoplankton generated in the Southern Ocean have been shown to affect cloud formation; the Southern Ocean itself is an enormous global CO_2 buffer, and a sink for ozone-depleting substances such as methyl bromide.

Antarctic science trends

1. There is a marked trend for greater multidisciplinary science in oceanography, atmospheric chemistry, sea ice physics, earth science and glaciology.

The big changes to the way we do science and to the results of the research will occur through interactions of geology, climate, ice-sheet and tectonic modelling. In 1997, for the first time links were demonstrated between Antarctica and the large climate events elsewhere on the planet such as El Niño in the Pacific and the North Atlantic Oscillation (NAO). This is really exciting stuff and demonstrates the role of the polar regions in influencing our planet on a grand scale.

Research linked to the global change area where Antarctica will continue to be important in the foreseeable future, is in the areas of atmospheric physics and chemistry. Work on ozone depletion is at the forefront of this. Atmosphere-ocean interactions in the Southern Ocean linking biology, physics and chemistry of the oceans and atmosphere, geology and geophysics will give us indications of past rates of change and climatic conditions from which we can plan future scenarios.

2. An exciting development which heralds a new type of research, is the 'All the world's a lab' concept. (See Buller's albatross.)

Scientists on oceanographic vessels will discuss data with international collaborators in their home institutions as it is downloaded. Precision instrumentation provided by several countries will be cost effectively deployed by one nation and then remotely adjusted and used by researchers in other nations.

I see a trend of increasing commitment to large programmes with 'big picture' goals.

3. Science and the environmental consequences of doing the science.

It will be harder to justify doing science in the Antarctic in the future for environmental reasons alone. The demand to reduce the human 'footprint' in Antarctica is increasing. More Antarctic science will be done in the next 20 years, but there may be fewer scientists down there.

This is a summary of the views of Dr Clive Howard-Williams, NZ National Institute for Water and Atmospheric Research Ltd., as expressed in Tetley, G. (Ed.) (1998) Antarctica 2010; a Notebook – Proceedings of the Antarctic Futures Workshop 28–30 April 1998. Antarctica New Zealand, Christchurch.

Science in Antarctica

From the earliest days of discovery, Britain has made significant and distinguished contributions to Antarctic exploration and research. Nearly all the British scientific research in the Antarctic is now carried out by the British Antarctic Survey (BAS). This worksheet explains key episodes in the history of science in Antarctica, and how Antarctic research is currently organised in the UK.

The voyages of Captain James Cook (1772–75)

Captain James Cook was the first to circumnavigate the Antarctic continent in 1772–75 but did not sight it. Cook described an inhospitable region 'doomed by Nature… to lie for ever buried under everlasting snow and ice'. His expedition provided the first scientific information about the Southern Ocean and set the scene for later explorers and scientists.

Expeditions to Antarctica in the 19th century all had geographical discovery and science as their principal objectives. A Russian naval expedition led by Bellingshausen is acknowledged with having made the first sighting of the landmass in 1820. The British naval expedition of Sir James Clark Ross explored Antarctica between 1840 and 1843, discovering the Ross Sea, Ross Ice Shelf and Victoria Land.

The 'heroic age' (1895–1915)

The 'heroic age' saw a remarkable development in the scientific study and geographical exploration of Antarctica. In 1895, the International Geographical Congress in London adopted a resolution to encourage Antarctic exploration. This led to fifteen major national expeditions visiting Antarctica in the next two decades. The Norwegian Borchgrevink was the first to establish an overwintering land station in 1899 at Cape Adare at the western end of the Ross Sea.

The expeditions of Scott, Shackleton, Nordenskjöld and Charcot between 1901 and 1916 extended geographical exploration and important studies in glaciology, meteorology, geology and biology were begun. The attainment of the South Pole was a powerful incentive for these expeditions. In many cases, major science programmes were undertaken alongside attempts to reach the South Pole. For example, there was a massive yield of knowledge from Scott's two expeditions to the Antarctic, but none from Amundsen's.

Royal Geographical Society

Scientific work during the Trans-Antarctic Expedition, 1957

The mechanical age (1916–58)

The decades after the First World War saw increasing use of new technical and mechanical equipment in Antarctica, such as aircraft, motor transport, radios and aerial photography. The American explorer Byrd was the first to fly over the South Pole in 1928. He showed that aircraft could be flown over very long distances in Antarctica, and be used for ferrying people and equipment into the field.

The Discovery Investigations (1925–32)

The Discovery Investigations carried out scientific research on whale and marine biology in the Southern Ocean. The studies were funded by royalties from the whaling industry at South Georgia. Scott's former expedition ship RRS *Discovery* was refitted as a research vessel for the investigations. A shore laboratory was also used at Grytviken on South Georgia. The early work on whale biology was later extended to oceanography, krill, fish, birds and seals and most significantly to marine food chains. This work was a major scientific achievement and has had a strong influence on the development of the science of oceanography.

Task 1 The RRS *Discovery* is illustrated in Resource S1. Analyse the plans of the ship and produce a classification of the spaces shown. Group each of the facilities into one of the following categories of use:
- scientific investigations
- support for scientific investigations
- navigation and powering the ship
- living accommodation
- safety and security
- communications
- other purposes

Those of you interested in the ship can visit it at Discovery Point, Dundee, Scotland.
You might carry out a similar exercise on the data provided in Resource LW3 for the RRS *James Clark Ross*.

The modern age (1958–today)

The modern age of international exploration of Antarctica began in the 1950s. The first successful crossing of the Antarctic was completed by the Commonwealth Trans-Antarctic Expedition of 1955–1958 led by Sir Vivian Fuchs.

The International Geophysical Year (IGY) (1957/58)

The International Geophysical Year concentrated research in Antarctica. It brought 12 countries into the region on a massive scale. They operated 47 stations south of latitude

60°S, and over 5000 personnel were deployed. They carried out research in meteorology, magnetism and glaciology as well as studies of the upper atmosphere. The pursuit of science enabled countries such as the USA and USSR, and the UK and Argentina, to put aside their political differences for the sake of international cooperation. The tremendous success of the IGY paved the way for the Antarctic Treaty, which ensures freedom of scientific investigation in Antarctica and also the free exchange of scientists and data.

Task 2 With reference to Worksheet 5 on the Antarctic Treaty System, indicate how the achievements of science and the IGY were reflected in the Antarctic Treaty and subsequent agreements made by the Treaty nations.

The Scientific Committee on Antarctic Research (SCAR)

To coordinate and manage the international research effort in Antarctica the Scientific Committee on Antarctic Research (SCAR) was established in 1958 with its headquarters at the Scott Polar Research Institute in Cambridge. It has a small budget financed by a levy on all national Antarctic research organisations in proportion to their level of Antarctic activity. It has a number of working groups and groups of specialists (shown in Resource S2) which develop new science programmes and provide expert advice to Antarctic Treaty meetings. SCAR is very influential in Antarctic affairs, which reflects the scientific distinction of its membership and the authority of the scientists within their national scientific communities.

Antarctic research in the United Kingdom

Different nations organise their Antarctic research in different ways. The system in the UK is relatively simple and is shown in Resource S3. The BAS is responsible for almost all of the British government's scientific research in the Antarctic. The Survey is based in Cambridge and is one of the research institutes of the Natural Environment Research Council (NERC). It is funded through NERC from the Office of Science and Technology, which is part of the Department of Trade and Industry. BAS operates three permanently-occupied research stations: two in the Antarctic and one on South Georgia (see Resource S3). The stations are supplied annually from the UK by the Survey's two Royal Research Ships, *James Clark Ross* and *Bransfield*. BAS also has a fleet of four de Havilland Twin Otter aircraft and one de Havilland Dash 7 which are used for ferrying scientists and their equipment, as well as supplies. The Royal Navy Ice Patrol Vessel HMS *Endurance* also provides logistical support to BAS.

BAS

A BAS scientist checking meteorological equipment

Developing research programmes

In Britain, research programmes are determined by international scientific priorities but individual projects are agreed through a process of peer and merit review. This means scientists in a particular discipline have to justify their investigations to other scientists in the same field. This ensures that research programmes are academically of the highest quality and utilise the unique features of Antarctica in answering questions of global importance. Resource S4 shows some of the recent research highlights from work carried out by BAS.

Task 3 Form yourselves into small groups, charged with prioritising Antarctic research in BAS. Each of you should prepare the case for a particular research project, summarise it and then present it to the rest of your group. Reference to the resources in this worksheet and others in the pack should assist you. The group should then prioritise the overall BAS science programme by identifying three key projects. This should be achieved through negotiation. As a group you should provide a written justification for your selection. This can be reported back to the rest of the class. Discuss the different priorities between groups.

Future science

As societies evolve their scientific priorities change. There is an emphasis at present for science to be applied to key strategic issues and to be of direct value to society. It is possible that some areas of theoretical or 'blue skies' research could suffer as a result.

Task 4 You may have identified this issue in the previous exercise. If you have not, review all the scientific programmes that were suggested in Task 3 and comment on those which you think are likely to benefit from this new emphasis.

In 1998, an eminent scientist from New Zealand produced a paper that speculated on the issues that he thought would influence Antarctic research in 2010. A summary of this is produced in Resource S5.

Task 5 Read this and other resources in the pack and answer the following essay title: 'Antarctic research programmes should reflect global priorities related to sustainable development'.
Discuss the adequacy of this as a framework for commissioning future research.