Live From Antarctica 2

Passport to Knowledge

electronic field trips to scientific frontiers
via interactive television and on-line networks

made possible, in part, by
the National Science Foundation, NASA, and public television

Dear Educator,

Remote... alien... distant... *Terra Australis Incognita*, the "unknown southern land"... the "last place on Earth"....

For most of human history, and still for most people today, Antarctica is a blank, a great white continent covered with ice, unconnected to daily life back in the industrial world. Scientists know differently: the southern oceans are the planet's air conditioner; the Antarctic ice is a litmus paper sampling pollutants in Earth's atmosphere; the polar ozone hole is an indicator of possible global climate change. We are all connected, whether we know it or not, to Antarctica.

Now, for the first time, modern telecommunications allows us to jump the physical barriers of storm-tossed seas and vast ice-sheets, and links us directly to the men and women who know this astonishing place best. *LFA 2* will take students along, on board the Research Vessel *Polar Duke*, across the Drake Passage—some of the roughest seas on Earth—to Palmer Station on Anvers Island, off the Antarctic Peninsula. Palmer is the jewel of NSF's U.S. Antarctic Program, populated even at the height of the season by less than 50 researchers—joined this year by 6 intrepid videographers and telecommunications specialists. Through their efforts, students here in the States will be able to interact directly with scientists on ship and on the tiny islands where Adelie penguins, seals and skuas make their homes. This will be the first time Palmer has ever been connected by video to the outside world, and NASA's Advanced Communications Technology Satellite team are traveling with us to experiment with innovative telecommunications devices operating under extreme conditions.

Our three live programs will combine pre-taped sequences showing the daily life of the researchers, with "You Are There" live interactions in which scientists let students look over their shoulders, in real time, at the creatures and conditions they're studying, and answer live and e-mail questions. It's ambitious, incredibly exciting... and yes, we have contingency plans!

This Guide is your "passport" to sharing this unprecedented experience with your students. It provides all an educator needs to know to implement *Live From Antarctica 2* successfully in a wide variety of grades and subject areas. Most importantly, it provides Activities which will allow your students to simulate, in class or at home, the research they'll see on camera or on-line. The Guide and videos also point students to the on-line resources which allow them to come to know the researchers much more personally than would be possible through textbooks or any other medium.

Perhaps one or more of the students who watch with you, log on to read the latest *Field Journal*, or experiment with plants or phytoplankton, will one day venture south in actuality, and contribute to a new generation of discovery.

We're privileged to be working with NASA, NSF and public television to bring this incredible opportunity to you, and we also thank you for your commitment to the future.

Sincerely,

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Executive Producer

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Project Director

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Please note: affiliations cited for identification purposes only.

Table of Contents

What's unique about *Passport to Knowledge* electronic field trips?

- the most current content, including real time images and data
- a direct connection to places inaccessible to students through any other means
- participation by some of the world's foremost scientists and researchers
- hands-on discovery Activities designed to simulate "real world" science
- interactive opportunities for students to question experts, and receive individual answers
- collaborative opportunities for teachers to work with other teachers, and students with other students
- support for educators via the *Passport to Knowledge* Information Hotline, 1-800-626-LIVE (626-5483) and on-line

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Live From Antarctica 2 is an integrated multimedia project, which uses

on-line resources

print materials

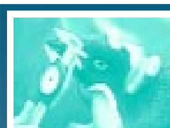
live interactive video and tape

Each medium is used to contribute what it does best. Participants in previous *Passport to Knowledge* projects report their students benefited most when all three components were used in complementary ways. However, flexibility in local implementation strategies and a wide range of choices are also hallmarks of every *PTK* Module.

On-line . . . .

The Internet breaks down the walls of the classroom and brings the world and world-class researchers *to any school, any place, any time.*

• ***Field Journals*** and ***Biographies*** provide behind-the-scenes and "beyond the screen" anecdotes which personalize the scientific process in ways no textbook or broadcast TV program can



My parents were in "business," and yet five of their six children went into biology. I don't know why I am facinated by biology and can't be bothered to balance my checkbook. I think people should strive to find a career in which they do well, and more importantly, what they like.
— Carol Vleck

• On-line opportunities facilitate direct, individual interactions with leading scientists and their support teams through ***Researcher Q&A***

• Images of Antarctica, weather reports, ship's logs and project ***Updates*** will be available over the Internet in close to real time: *LFA 2* can be experienced as an expedition or "electronic field trip", and as a learning experience with direct relevance to the curriculum

• Teachers share curriculum ideas and implementation challenges with other teachers via on-line mail lists, such as ***discuss-lfa***

• *Passport to Knowledge* provides opportunities for meaningful participation for those with access only to text and e-mail, as well as those with full access to the World Wide Web

• For the first time, this *Passport to Knowledge* Module will provide three customized pathways through the *Live From Antarctica 2* Web site for Teachers, Students and "Parents & Public". Check out the "Continuous Construction" site at:

http://quest.arc.nasa.gov/antarctica2

Print . . . .

This Guide and associated print materials provide all an educator needs to implement this unique learning experience successfully in a science class, or interdisciplinary team teaching environment. The Guide (also accessible on-line) provides a teacher-friendly, easy-to-use introduction to the entire project, and is co-packaged with copy masters of Student Worksheets and other Blackline Masters to support the Activities, an original full-color poster and various NSF publications designed to enhance the sense of taking an *actual* field trip to Ahtarctica.

• Hands-on ***Activities*** simulate the most significant aspects of the research seen on-camera or on-line, and illuminate key science concepts

ENGAGE

Review Electromagnetic Spectrum/ light wavelengths/nanometers with the class.

Place chemical equation for photosynthesis on blackboard. Ask students if they know what these symbols represent. Some students may easily recognize symbols for water and carbon dioxide.

• Many Activities suggest adaptations beyond *PTK's* primary target of middle school classes, up and down in grade level

- Many of the Activities also suggest ways to connect across the disciplines, beyond science, as indicated by the ***icons*** to be found throughout this Guide.

math social studies lang. arts art computers

- Each activity retains the pedagogically-sound ENGAGE, EXPLORE, EXPLAIN, EXPAND format of previous *Passport to Knowledge* Guides.
- ***Opening*** and ***Closing Activities*** help teachers create anticipatory set, and reinforce and assess student learning outcomes at the conclusion of the experience
- A ***Teacher's Kit*** provides more extensive materials, including this Guide and its co-packaged materials, an oversized USGS map of Antarctica with detail of the Palmer Peninsula, videos from NSF designed to orient field teams visiting Antarctica, backgrounders on the continent from the first *Passport to Knowledge Live From Antarctica* field trip, UV filter materials to support Activity 3.2, 5 copies of NSF's "Your Stay at United States Antarctic Program Stations", and 5 copies of the Childrens' Television Workshop/NSF color brochure, "Antarctica." (To order the *LFA 2* Teacher's Kit, fill in and return the form enclosed with this Guide.)

Video . . . .

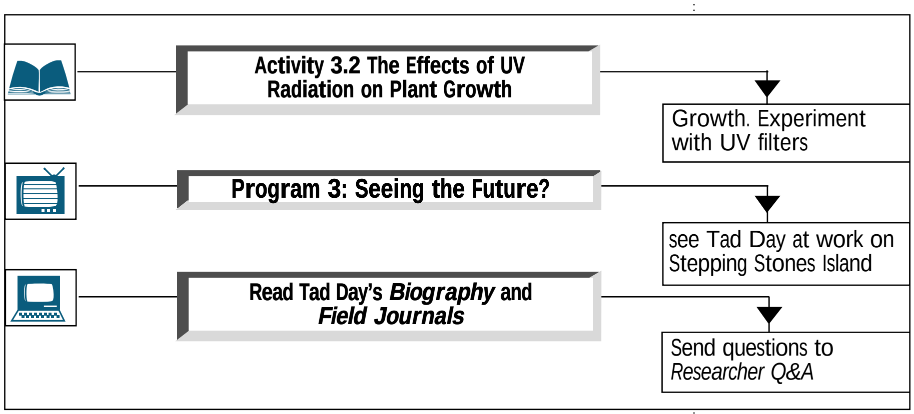
Television provides the *sights* and *sounds*, the *people, places* and *processes* which set a living context around the text.

- ***Personal portraits*** of the researchers and their lives humanize the hard work of doing science and demystify high-tech careers
- Cutting-edge telecommunications connects students to remote or inaccessible locations
- Graphics and dynamic visuals simplify complex concepts
- Live, ***two-way*** exchanges between students and researchers symbolize the interactive possibilities universally available via the Internet

Teachers rate the *live* component of the *Live From...* videos highly, although most teachers use them on *tape*: there's no contradiction. The excitement of the original live interactions is maintained while teachers gain flexibility by using the video on tapes.

How the Components work together—an example

Activity 3.2 "The effects of UV Radiation on Plant Growth" invites students to undertake experiments which directly parallel what researcher Tad Day will be doing, on camera, at Stepping Stones Island during Program 3. Tad has worked with *LFA 2* to create this Activity. His biography and field work notes can be read on-line, where you can also find references to his other publications on plants and UV-B. The combination of TV, the printed hands-on Activities and on-line resources should make your students truly feel as if they were "co-investigators" with a scientist engaged in significant research in the real world. And if you have questions about how best to implement the Activity, or have stories to share about your students' successes or failures, you can post messages to *discuss-lfa* and connect with fellow teachers geographically dispersed across the nation, and even across the planet.



A Note on Assessment

Live From Antarctica 2 like every *Passport to Knowledge* Module, is very different from traditional instruction with its reliance on textbooks and dittos for facts and background. But evaluation has shown us that teachers and students certainly feel they are indeed *learning* a great deal while experiencing the excitement of these unique "electronic field trips to scientific frontiers". In line with the new National Science Education Standards, we also hope that students not only discover:

1. *content more current* than found in any textbook, but also develop;
2. a more accurate understanding of the *scientific method* and the *process of research*;
3. are exposed to and have a chance to practice *research skills using computers and telecommunications*, and:
4. grow *more positive attitudes* towards science and high technology.

But how do we, and you, their teacher, know we're achieving these goals? First, by returning the pre-paid postcard included with this Guide you'll receive an Evaluation Survey, customized to your specific circumstances (e.g., grade level, school size) from the nationally-respected Center for Children and Technology of EDC (Education Development Center, Inc.) which is the Project Evaluator for *Passport to Knowledge*. If other teachers borrow your Guide, please have them copy and return the "postcard" printed at the bottom of this page.

Second, based on positive experiences with *previous Live From...* projects, we suggest that students keep *Antarctic Logbooks*, recording daily what they learn through the hands-on Activities, and their responses to the videos and what they read or do on-line. Blackline Master A.1 provides some suggestions for how these *Logbooks* might be designed and used. Student Worksheet A.2 provides a sample student *Learning Log*. But we are finding more and more teachers now use such "portfolio assessment" in addition to quizzes and tests, and we're as interested in learning how *you* assess your students' learning as having you follow our formats. Please send exemplary student work (*Logbook* pages, journals, computer databases, videos, photos, etc.) to us on-line, using the procedures you'll find at the *LFA 2* Web site, or mail hard copies to the address below. We wish you luck in implementing *Live From Antarctica 2*, and hope it's both an instructive and enjoyable experience for you and your students!

We encourage you to share your students' achievements with us on-line. Some of it may be published, thereby validating your students' efforts and perhaps motivating others.

To submit materials on-line, see: Student Gallery on the *LFA 2* web site

To submit hard copies, send original materials (make a copy for your records) to:

Passport to Knowledge, **P.O.Box 1502, Summit, NJ 07902-1502**

To contact EDC directly with questions or suggestions specifically about Assessment, call:

1-212-807-4200 (ask for *"Passport to Knowledge)"*

REGISTRATION FORM

Reply to: EDC, 96 Morton Street
7th Floor, New York, NY 10014

- Name ___________________________
- School Address _____________________
- work telephone number ________________
- e-mail address ____________________
- Grade level (Please check only one.)
  ___ lower elementary ___ upper elementary ___ middle school ___ high school ___ other
- Subject taught (Please check only one.) ___ generalist ___ science specialist ___ other specialist
- Number of classes in which you will use *Live From Antarctica 2*? ___
- Describe the size of the area in which your school is located? (Please check only one.)
  ___ rural ___ suburban ___ small city ___ medium/large city (over 1,000,000)
- Which previous *Passport to Knowledge* modules have you participated in? ___ *Live From Antarctica* ___ *Live From the Stratosphere* ___ *Live From the Hubble Space Telescope* ___ *Live Fom Mars* ___ None
- How often have you used on-line curriculum projects other than *Passport to Knowledge modules*?
  ___ Many times ___ A few times ___ Once ___ Never
- Are you planning to team-teach this curriculum? __ Yes __ No

Copy this card

NSF's Objectives in Antarctica, and *PTK's* Goals for *Live From Antarctica 2*

Here's how NSF's Office of Polar Programs describes the United States Antarctic Research Program:

The United States Antarctic Research Program aims to increase understanding of the Antarctic region and its relationship to the rest of the planet. This research is the major focus of the "United States Antarctic Program", the comprehensive name for United States Government-sponsored activities in Antarctica. The Foundation funds and manages the Antarctic program in support of the range of United States interests and the Nation's adherence to the Antarctic Treaty.

What follows are objectives for science programs most directly involved in research at Palmer Station or on board the *Polar Duke*.

Marine Biology

The oceans around Antarctica make up one of the world's most productive regions. Objectives are to understand the structure and function of Antarctic marine ecosystems; to determine the major features and adaptations of organisms; and to add to knowledge of their distribution, abundance, and dynamics.

Physical and Chemical Oceanography

The southern ocean has a central role in the world ocean…making the southern ocean a major source of the world's intermediate and deep water masses. Huge changes in the extent of sea ice (varying annually between 4 and 20 million square kilometers) also influence energy transfer. The Antarctic Circumpolar Current, the world's largest ocean current, has a major effect on general oceanic circulation. Research objectives are…to investigate the relationship between oceanic and atmospheric circulation systems and the physical basis for biological productivity; and to investigate the relationship of the southern ocean and climate.

Atmospheric Sciences

Antarctica, the world's largest and most intense area of cold, has an active relationship with regional and perhaps global weather and climate patterns…Conditions in Antarctica have proved a harbinger of natural and human-induced global atmospheric change. Research objectives are to improve understanding of physical processes of the atmosphere, to determine the relationship between events and conditions in the Antarctic atmosphere and global events, and to determine the region's role in past and present global climate.

Terrestrial Biology

The meager biota of terrestrial Antarctica are of special interest, owing to adaptations to the extreme environment. The simplicity of these terrestrial ecosystems provides opportunities for analysis that is more difficult or impossible in the complex systems of the lower latitudes. Research objectives are to understand features and adaptations of organisms and to gain further knowledge of their distribution, abundance, and dynamics.

For more see NSF's full statement of USAP Objectives at:

http://www.nsf.gov/od/opp/antarct/antarct.htm

PTK goals for *Live From Antarctica 2*

1. to provide students, through state-of-the-art telecommunications, with a sense of real connectedness to the science and scientists at work in the Antarctic
2. to provide teachers with an easy-to-use suite of integrated multimedia tools—video, print and on-line—with which to bring Antarctica to life in their classroom
3. to provide materials embodying the National Science Education Standards, for both *content* and *process*
4. to show careers in science and science support as exciting, rewarding and open to all prepared to study hard and achieve, at school and as lifelong learners
5. to document significant student learning outcomes facilitated by *Live From Antarctica 2*

Passport to Knowledge and Live From Antarctica 2 are…
Real Science,
Real Scientists,
Real Locations,
Real Time..

Activity A.1

Putting Antarctica On the Map

Teacher Background

Although Antarctica is certainly "of this world," it's so distant and alien that some students may perceive it as "out of this world!" There are many misconceptions and much misinformation about this remote, frozen continent. The main purpose of this Opening Activity is to begin a process of discovery and exploration to enable your students to sort out Antarctic fact from fiction. Who lives here? Are there indigenous peoples? Are there cities? Where are the research stations? Who "owns" Antarctica? Who or what sets the rules for this vast continent of more than 5.4 million square miles, but fewer than 3,000 seasonal residents? Are there mountains? Volcanoes? Deserts? Rivers? Valleys? If so, *where* are they? What mammals, birds, and fish are considered "native" to Antarctica? And... are there any polar bears? (Just checking!)

Today, we know geography is more than making maps and memorizing the names of the states and their capitals. Geography seeks to identify, analyze, and explain how regions change over space and time, how physical processes influence ecosystems and how human processes contribute to changes in those ecosystems. (See Blackline Master #1, *The Five Themes of Geography*.)

Objective

Students will assess what they already know about Antarctica, and begin to identify, research and position new Antarctic features on a map of the continent.

Materials

- paper to cover a 4 x 4 ft. bulletin board
- overhead projector
- transparency of the Antarctic continent made from Blackline Master #2 (supplied)
- markers, crayons, pens
- atlases, encyclopedias, CD-ROMs, access to on-line research sources
- individual outline maps of Antarctica for students made from Blackline Master #2

Engage

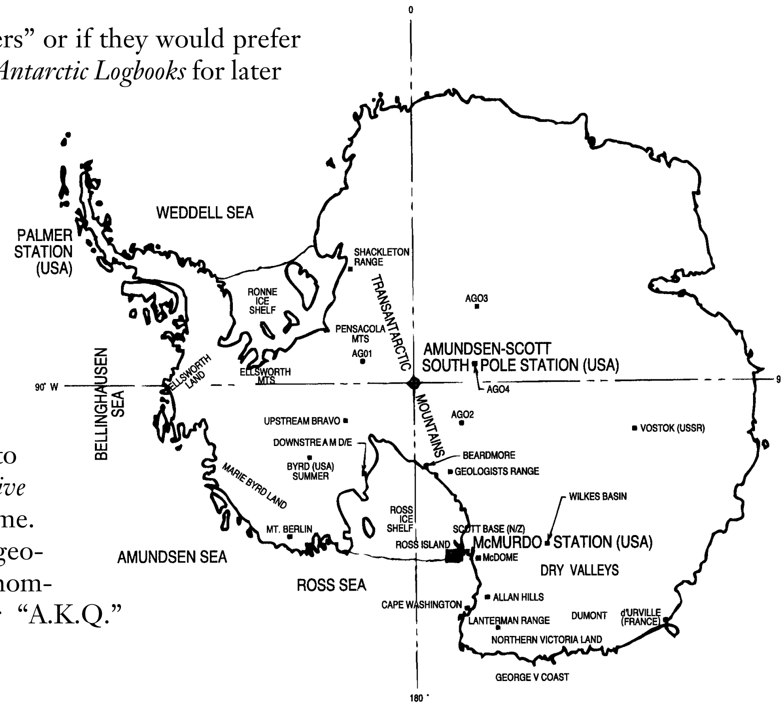
Ask students to brainstorm about Antarctica. Here's a ten item "pop quiz" to test their knowledge of this vast (as large as North America and Mexico combined) and mysterious (visited to date by fewer humans than would fill a sports stadium!) continent. Have them write a *true* or *false* answer to each statement as you read it aloud:

1. Antarctica is the largest continent. *(F)*
2. There are cities in Antarctica. *(T: McMurdo in summer swells to over 1,500 people)*
3. You will find polar bears in Antarctica. *(F)*
4. Antarctica doubles in size and shrinks each year. True or False, and Why? *(T: The ice sheet grows and melts from winter to summer.)*
5. Antarctica is a continent covered by ice and snow, just like the Arctic. *(T: for Antarctica. F: for the Arctic, which is ice over water, and is not a continent)*
6. Daylight lasts for six months at the South Pole. *(T)*
7. There are rivers and volcanoes in Antarctica. *(T)*
8. There is water under nearly all the ice. *(F)*
9. Penguins live only in Antarctica. *(F: Penguins live elsewhere south of the equator, including coasts of South America, Southern Africa, and islands north of Antarctica.)*
10. Antarctica is a territory of the United States. *(F)*

VOCABULARY

cartographer
geography
Gondwanaland
iceberg
IGY: International Geophysical Year
geographic South Pole
magnetic South Pole
geomagnetic South Pole
peninsula (esp. Antarctic Peninsula)
physical features
Polar Plateau
region

Check the test and ask students if their scores are “keepers” or if they would prefer a re-test at a later date. Ask students to file the quiz in their *Antarctic Logbooks* for later reference. Re-administer the pop quiz at the end of *Live From Antarctica 2* and let students compare their results.



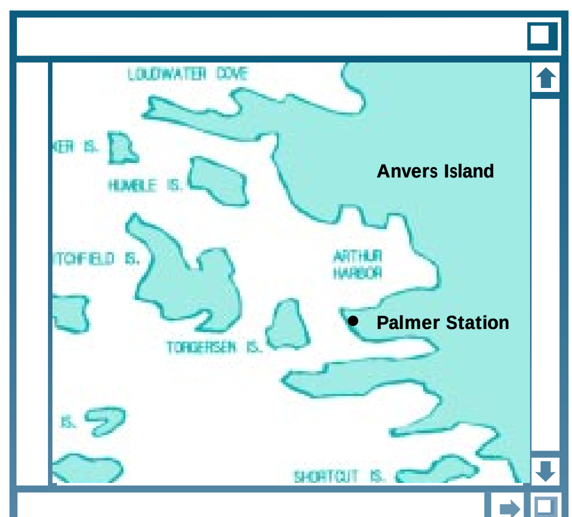
Note: the NSF booklet *Facts About the USAP* and the CTW/NSF *Antarctica* brochure co-packaged with this Guide contain geographic information which can be used with this Activity. NSF’s *Facts…*is also on-line at the *LFA 2* site. Blackline Master #3 is a simplified map with a limited number of place names. The *LFA 2* Kit also includes an oversize USGS map packed with data.

Explore

Discuss whether it’s a frustrating to miss answers to straightforward questions. Explain that participating in *Live From Antarctica 2* can keep this from happening a second time. Encourage them in the coming weeks to see how many geographical features—physical, political, human, animal, economic, cultural and others—they can locate to boost their “A.K.Q.” (“Antarctic Knowledge Quotient”).

Procedure

1. Make a map transparency of Antarctica from Blackline Master #2. Project it onto a 4’ x 4’ piece of paper and trace the outline of the continent. Place it where it can be permanently displayed during the *Live From Antarctica 2* unit. (Perhaps in a school corridor, where others can enjoy the ongoing discovery process?)
2. On lined chart paper next to the map, list the places and features found on the reverse of Blackline Master #2.
3. Have students form teams of 2–3. Distribute copies of Student Worksheet #A.1 “North Pole, South Pole, My State” to each team to set up a kind of “Antarctic Geography Scavenger Hunt”, and (at your discretion) Blackline Master #4, “Contrasting Poles,” which is a summary of key differences between the Arctic and Antarctic. Have students use all available research tools to “fill in the blanks”, and share their findings with the class, transferring the places, features and creatures from the list onto the outline of the continent. Add new places, features and creatures that can be found in the videos or on-line.



Expand/Adapt/Connect #1

In the picture book, *Where’s Waldo?*, readers try to locate Waldo as he wanders among crowds in various places around the world. *LFA 2*’s video producer in the Antarctic is Deane Rink: you can find his informative *Field Journals* on-line. This is his fifth visit to Antarctica to make TV documentaries. He’s visited just about every research station operated by the USAP and many bases of other nations. He’ll be posting special *“Where’s Deane Been?”* Challenge Questions on-line during the course of the project, with clues as to what locations he’s referencing. After completing the map exercise outlined in this Activity, and throughout *LFA 2*, use Deane’s postings to review students’ new knowledge of Antarctica’s geography by tracking Deane’s travels around the frozen continent.

Deane has visited and worked in: McMurdo Station, the McMurdo Dry Valleys, Amundsen-Scott South Pole Station, what was the Soviet Union’s Vostok Base, Palmer Station, Rothera, and King George’s Island, as well as field sites in the Allan Hills (searching for meteorites) and Central West Antarctica. Have students work up “clues” for this game of “20 Geo-Questions.” (no on-line access necessary).

Procedure

1. Divide the class into two teams. Team “A” agrees upon a sequence of 5 locations on the Antarctic continent that Deane has visited, writes them down, and gives a folded copy of the itinerary to the teacher.
2. Team “B” has 20 chances to track Deane by asking careful questions that will pinpoint his present location and future direction (e.g. north, northeast, etc.). (Assume for the sake of this Activity, that he’s got a “Magic Helo” with no fuel limits, which can take him anywhere, in any sequence, in any direction, rather than the real path he had to follow.)

Some examples of questions:

•Is Deane visiting an American research station on a peninsula?

•Is Deane eating Thanksgiving dinner near Lake Hoare? (read his *Field Journals* in *LFA 1*)

•Is Deane visiting the most populated settlement on the continent?

Expand/Adapt/Connect #2

Once students have enough new knowledge to feel confident, they can give the pop quiz to parents or younger students and then play *Where’s Deane Been?* as a mentoring/learning experience.

Have students search for Antarctic maps on the Internet. (Check the *LFA 2* Home Page as a place to start.) Have teams research and report to the whole class on the use of space-age technology (satellites, etc.) to create maps of Antarctica, the seasonal sea-ice surrounding it, the ozone hole, even the life-forms which live in the oceans. How does this technology work to create maps that track climate? Wildlife populations?

Using maps of Antarctica, have students work in teams to take measurements:

- Palmer Station to McMurdo Station
- Punta Arenas, Chile to Palmer Station
- Palmer Station to Los Angeles

Have some go on-line and read Deane’s *Field Journals* to see his actual travel path to the Antarctic in 1996–97 (LA, Aukland [NZ], Christchurch, McMurdo, South Pole, McMurdo, Christchurch, LA, Miami, Santiago [Chile], “P.A.”, Palmer!)

Using the map’s scale, convert measurements to miles and/or kilometers. Record distances on the class chart and compare. How do you account for the variations? *(Maps with smaller scales lead to bigger errors.)* What’s the range of error?

Most scientific research uses the metric system, e.g. NSF’s *Facts...* packaged with this Guide. Review metric measurement for temperature (Celsius rather than Fahrenheit) and distance (kilometers rather than miles). Have students practice using appropriate conversion formulas (see Glossary for C/F formulas) and post a temperature chart illustrating Celsius/Fahrenheit temperatures.

SUGGESTED URLS

Key Antarctic facts:

World Factbook 1995
http://cliffie.nosc.mil/~NATLAS/wfb/

Overview of Antarctic ecosystem:

ICAIR (International Center for Antarctic Information and Research)
http://www.icair.iac.org.nz/tourism/visitor.html

Maps: Australian Antarctic Division’s Map Collection
http://www.antdiv.gov.au/aad/sci/human/dm/maps/maps.html

Website for the National Council for Geographic Education
http://multimedia2.freac.fsu.edu/ncge/

The Real "Old Antarctic Explorers"

Teacher Background

NSF's researchers and their ASA science support teams refer to people who have returned season after season to live and work on "the Ice" as OAE's—Old Antarctic Explorers. This Activity will help your students get to know the *true* OAE's.

Long before anyone journeyed south, the Ancient Greeks had a name for the land they believed to be there: "Antarktikos"—the land "opposite the Bear," Arktos being the constellation of the Great Bear (Big Dipper) above the North Pole.

But who *really* discovered Antarctica? Was anyone already there, waiting to be "discovered"? What motivated individuals to explore the region? The answer to these questions aren't always so easy, since different sources don't always agree on dates, and some of the "firsts" are disputed!

The history of Antarctica is marked by an *Age of Discovery* when early explorers like Captain James Cook, and whaling and sealing captains like Nathaniel Palmer and Admiral Von Bellingshausen ventured into the icy waters and first sighted and identified the coast of the continent.

During the *Age of Competition* Ernest Shackleton, Robert Scott, Douglas Mawson, Roald Amundsen and others set off on grand races in search of the magnetic and geographic South Poles. Finally, in the *Age of Scientific Exploration* men like Admiral Richard E. Byrd, Sir Edmund Hillary and, more recently, representatives of the signatory nations to the Antarctic Treaty, ensured that guidelines were put in place to preserve the fragile continent for future peaceful purposes and scientific exploration, and to protect it from exploitation.

Objective

Students will research information about exploration in Antarctica, and create a visual display which synthesizes and communicates their work.

Materials

- *Live From Antarctica 2* Student Log Sheet
- sources (print, on-line)
- paper, markers, rulers, etc.
- computer and timeline software (optional)

Engage

Ask students what they already know about the *history* of Antarctica. Can they think of any "big names" linked to the continent? Who/what was there waiting to be "discovered"? Read a sample diary entry from an early Antarctic explorer (see the sidebar, and read *Journal Entries* from the Heroic Age found on-line at the *LFA 2* Web Site.) Where do these fit in the continent's history?

Explore

Procedure

1. Have students work individually or in pairs to gather basic information about Antarctica's history. This can be done on-line, in the library/media center, then shared with the class by listing facts on a chalkboard or poster.
2. Working in any configuration desired, have students construct a visual display (timeline, display, chart, poster, computer-generated presentation, HyperCard stack, series of cartoons, etc.) that chronologically sequences key events in Antarctic history. Information should include exploration, government/ownership issues, founding and abandoning bases.
3. Have students add their individual work to their *Antarctic Logbooks*, as well as contribute it to the class chart.

A Journal Sample

Two of the most famous journal entries in the entire history of Antarctic exploration come from the very first expeditions to reach the South Pole. The contrasting fates of the Norwegian party, led by Roald Amundsen, and the British, led by Robert Falcon Scott, are embodied in the emotions and words written upon reaching 90 degrees South, first by Amundsen, on December 17, 1911 at 3:00 p.m.

So we arrived and were able to plant our flag at the geographical South Pole. God be thanked! …I had decided that we would all take part in the historic event; the act itself of planting the flag. It was not the privilege of one man, it was the privilege of all those who had risked their lives in the fight and stood together through thick and thin. It was the only way I could show my companions my gratitude at this desolate and forlorn place.

One month later, on January 17, 1912, Scott and his 5-man party arrived at the Pole. The glory he sought for himself and for his country had been pre-empted.

Bowers' sharp eyes detected what he thought was a cairn…We marched on, found that it was a black flag tied to a sledge bearer…The Norwegians have forestalled us and are the first to the Pole. It is a terrific disappointment, and I am very sorry for my loyal companions...The Pole. Yes, but under very different circumstances than we expected... Great God! this is an awful place and terrible enough for us to have laboured to it without the reward of priority... Now for the run home and a desperate struggle. I wonder if we can do it.

All Scott's party died on the journey back, after terrible hardships. But even in their final struggle, they chose not to abandon the scientific samples they'd collected, and exhibited a stubborn heroism that reaches out across the years to all who read their words today.

Expand/Adapt/Connect

Have students research territorial claims in Antarctica, and add them to the map begun in Activity A.1. Have students add the locations of the major research sites of various nations. Why do you suppose they are located where they are? Debate/discussion topic: If you were in charge of starting a new research station, where would you place it and why?

Use the Internet to research the Antarctic Treaty and its impact on current and future development of Antarctic resources. Which nations have ratified the Treaty? What are some of the major concerns on both sides of the ratification issue?

Have students research the role of women and minorities in exploring Antarctica. (Be sure to check out information on the relatively high percentage of females in the current USAP, part of the *LFA 2* Web site.)

Have students prepare a properly-formatted bibliography of sources used to create their visual display.

Students can conduct a simulated interview with one of the OAE's. This can be a newspaper article, skit, video or radio newscast or "chat show". Share with class and include in *Logbook*.

Have students look for imagery or emotion laden words used to describe Antarctica, (e.g. "awful," as in Scott's comment at the Pole: "Great God, this is an awful place.") They can record these words in *Logbooks*, and on a class vocabulary list, important resources if your students utilize the *LFA 2* poetry unit.

Create an "Antarctic Hall of Fame".

Make and distribute copies of the "Old Antarctic Explorers" Hall of Fame Candidates (Blackline Master #5). Have students pick names by lot, and research 3 *key things* for which their OAE is best known.

Have students create a framed portrait, and design a symbol which best communicates the accomplishment for which s/he is remembered.

Please note: you might wish to involve the art, social studies and/or language arts teachers. Save student work for an "Antarctic Expo" open house display, as suggested later in this Guide, or submit their work on-line, following guidelines you can find on the *LFA 2* site.

Have students go on-line and search for *today's* explorers, who have mounted non-governmental expeditions to the Antarctic (e.g. Will Steger, Jean-Claude Etienne, Norman Vaughn, the Scandinavian woman who skied solo to the South Pole, etc.). NSF officially provides no support or encouragement for such expeditions, since when they go wrong (e.g., a recent team lost members and Skidoos down a crevasse field they'd been crossing in unwise fashion—"line abreast" rather than "line ahead"), it's NSF that has to deploy rescuers, putting them at needless risk and expending precious resources. Have students debate whether individual expeditions, even if privately sponsored, are a good or bad idea.

SUGGESTED URLS

Images and background information on several expeditions. Prepared by Donal Manahan, professor at USC and USAP member.
http://arts.usf.edu/~marsh/history.html

Virtual Antarctica provides historical overview of exploration and links to contemporary adventurers.
http://www.terraquest.com/va/history/history.html

ICAIR provides images of Shackleton and Scott's ships, and more historical data—with a Kiwi twist.
http://www.icair.iac.org.nz/history/

All you need to know about the Antarctic Treaty, including a copy of the Treaty itself.
http://www.icair.iac.org.nz/treaty/

Careers in Antarctic Science and Science Support

Teacher Background

The United States Antarctic Program (USAP) supports an extensive and diverse scientific community. More than 3,000 people work on research vessels or at the main stations and field camps as part of ongoing research projects. Just about every state in the U.S. is represented, and in the past year researchers came from 19 other countries to work with USAP. Their average age was 36; 30% were female; 5% were minorities.

Palmer Station itself is a small, highly interdependent research community, with a very distinct and unique character, different from McMurdo or South Pole. Its research projects focus on marine and terrestrial biology, Long-Term Ecological Research studying sea-ice variability and the marine food chain, ozone depletion, UV radiation and other important topics, for which it's one of the best sites on the planet. Palmer is normally reached only by sea, except in cases of extreme emergency, when a small ski-equipped plane *may* be able to land on a nearby glacier. The safety of each individual and the existence of the community as a whole depends on strict adherence to the rules which you can read in the co-packaged NSF/ASA booklet *Your Stay at United States Antarctic Program Stations*, pp. 29–40. You and your students can read about the 2 mile boating limit and "house-mouse" cleanup duties, check out mealtimes, laundry service, and begin to get a sense of how research is supported. Of course, the best way to appreciate this is through the *LFA 2* videos and on-line resources. However, Activity A.3 may sharpen your students' eyes and ears to what they are seeing and/or reading, and help establish a productive anticipatory set.

Objectives

Students will demonstrate their understanding of the roles and responsibilities of USAP participants in Antarctica.

Students will problem-solve an emergency situation specific to the operation of Palmer Station.

Engage

Share the overview of life at Palmer Station provided in the Teacher Background section and in the *Your Stay…* booklet.

Share a *Field Journal* entry from researchers currently working at Palmer. (It's OK to download an on-line journal from your home Internet account to read to your class, if school access is still limited. See sidebar for an example of how such journals convey the personal dimension of what it's like to work on this distant continent.)

Explore

What is a *community*? Identify several types of communities (class, school, family, sports team, Scouts, Young Astronauts, citizens of a nation.) What characteristics do they share? Remind students that Palmer Station is a highly interdependent *scientific research* community. Does it meet the definitions for *community* as discussed? How does the Palmer community govern itself and spend its spare time in such a remote and isolated outpost? What about special holidays and events? How is the need for relaxation or privacy handled?

Please note: if you use Closing Activity B.2, "New Palmer", you may find your students' "Before" and "After" responses particularly revealing.

Maria Vernet, marine biologist:

While at Palmer we have a working day that is more similar to work in the States, (but) work on the ship is very different. At the station we wake up for breakfast, and continue to work until mealtime although sometimes we miss lunch (if for example we got delayed in the sampling). But we are usually back for dinner. There is a quota of daily exercise, either walking up the glacier or going to the gym. Sometimes there is skiing, early in the season. At night there are other social activities like watching movies, playing ping-pong, getting together with friends or developing pictures… On weekends it is possible to visit nearby penguin rookeries, with permission.

On the ship there are no activities besides a very small gym and sauna. There are movies but usually there is not much time (or energy) left to watch them. So we find entertainment while we work, like listening to music or having people (who are) not on watch visit (and sometimes help) in the lab. The highlight of the cruise is the camaraderie that develops between people working very hard towards a common goal. There is also beautiful scenery, particularly when we sample in the channels. And every day is different because we never sample in the same place.

VOCABULARY

botanist
climatologist
community
developmental biologist
ecologist
geologist
glaciologist
isolation
LTER
marine biologist
meteorologist
oceanographer
ornithologist

Join the "A" Team

Materials

- chalkboard
- paper
- pencils/pens
- Blackline Master #6

Procedure

1. Ask students to brainstorm a list of jobs which make life possible in such a remote outpost. Record responses on the chalkboard or overhead projector.
2. Have students organize tasks into categories (see below):
   - *Facility Site Managers* plan for and deliver food supplies; operate station store; provide medical service, fire management; monitor waste disposal, water usage; develop emergency plans
   - *Communication* Team plans for personal and professional communication needs: on-line and satellite links; HAM Radio; mail
   - *Transportation* Team handles logistics of getting there and getting around while on site: water, land, and air (only in emergency.)
   - *Scientific Investigators* handle tasks from field research to technical assistance in the Biolab.
   - Are there jobs that don't fit these general groupings? Which job(s) appeal to different students? Why?
3. Share copies of Blackline Master #6, *Careers on the "A" Team*. Have students choose a job at Palmer. Research career information in the library, or on-line via the *LFA 2* Web site, or in discussion with parents or other adults. Write a one-page report that describes the education necessary to work in that position. What special interests might motivate an individual to choose this career? Share reports with the class, add to Logbooks, and consider posting them on-line to *LFA 2*.

SUGGESTED URLS

Check out the Journals and Biographies available on-line at both our Live From Antarctica sites:

http://quest.arc.nasa.gov/antarctica/team/
http://quest.arc.nasa.gov/antarctica2/team/

NSF's Antarctic research objectives are detailed here:

http://www.nsf.gov/nsf/nsfpubs/nsf9491/nsf9491h.htm#UnitedSt

The LTER Project's work at Palmer Station: overview, history and related links:

http://www.crseo.ucsb.edu/lter/lter.html

Emergency!

Materials

- 1 *Emergency!* card per team (Blackline Master #7)
- 1 per team: *Antarctic Safety Rules* (Blackline Master #8)

Note: If you have easy on-line access, check out the USAP *Field Manual.* It's like an Antarctic "Scouts' Handbook." It teaches you how to build igloos, operate radios, tie knots…and even comments that you may need to change your underpants if you get your Skidoo stuck in a crevasse!

Engage

As your students can see on the *LFA 2* poster co-packaged with this Guide, Antarctica is an extremely beautiful continent. But here, Nature rules, not humans. Even the smartest science teams are just temporary visitors and must show "the Ice" due respect. The continent is unforgiving of ignorance or breaches of safety procedures, and will punish foolhardy behavior. Every year or so, one or more USAP participants dies because they took a supposed "short cut" across unflagged snow or ice. Venturing out in the field without the proper equipment, or when the weather is turning, can be fatal.

Explore

Procedure

1. Divide the class into teams of 3–4 students. Distribute one *Emergency!* card and one copy of the *Antarctic Safety Rules* to each team.
2. Have teams read the emergency situation described on their card, review the safety rules on the sheet provided, and come up with a plan of action to avert a tragedy.
3. Students can share situations and solutions with the entire class. Debrief with feedback. What other possible solutions might have worked?
4. Have students write a journal entry as if they were caught in the situation explored by their team. Share it with their team, or with the entire class, and place a copy in their *Logbook*.

Expand/Adapt/Connect

Read/share the on-line *Biographies* and *Field Journals*. Ask students what they found most interesting about these individuals. What kind of education was required for their jobs? Were they always "good" students as children? What special, personal, non-academic interests led them to pursue their current careers?

Getting There: Planning is Half the Battle!

Teacher Background

Antarctica is one of the last frontiers on Earth. If you arrive without a key piece of equipment, or if it breaks and you have no spare, it will very probably be impossible to recover. So USAP participants need months of careful preparation before they set out on their journey south. NSF and ASA provide detailed guidelines (which you can find on-line) and a great deal of expertise, but each individual science team is largely responsible for its own logistics. If your students think attention to detail is only required when doing schoolwork, this Activity will make them think again. The Antarctic sets tougher tests than any teacher can, and you *really* don't want to receive a failing grade on "the Ice!"

(Ed. note: as in previous "electronic field trips", we provide this type of Opening Activity because it sets a real-world context for the learning experiences which follow. Students, especially in younger grades, enjoy such simulations because they are fun and open-ended. They relate directly to what's seen in the videos and on-line. However, this Guide provides more choice of Activities than any teacher, with limited time, is likely to be able to implement. Please be sure to consider the "hard science" and technology Activities which follow as you make your selection. These curriculum-related Activities are also fun and informative.)

Objective

Students will plan, prioritize, coordinate and review travel and logistics details by simulating the preparations researchers make in order to do science in Antarctica.

Materials

- notebook
- copies of the "Take to Antarctica/Don't Take to Antarctica" Blackline Master #9
- on-line access (optional)
- NSF booklet, *Your Stay at United States Antarctic Program Stations*, co-packaged with Guide

Engage

Getting to Antarctica is not as simple as calling a travel agent, getting a ticket, throwing a few things in a suitcase, and going. In some ways, preparing for a trip to Antarctica is like preparing for a space mission: you must take what you need with you, and you'll be bringing just about everything back with you!

Present students the following challenge: their research team is applying for permission to travel to Palmer Station. They must submit a comprehensive proposal to the National Science Foundation which outlines their plans to get the researchers to "the Ice" and to successfully operate there.

SUGGESTED URLS

Students plan a trip to Antarctica in this lesson from the Gulf of Maine Aquarium
http://octopus.gma.org/surfing/antarctica/cold.html

Geologist James E. Lundy's Fall of 1995 trip aboard the R/V Nathaniel B. Palmer
http://piano.geo.utexas.edu/~jiml/palmer.html

A contrasting, tourist's eye view, of a trip to Antarctica via the cruise ship Marco Polo
http://http2.sils.umich.edu/Antarctica/Story.html

Terraquest's Clothing and Equipment checklist might help students define what they need to pack.
http://www.terraquest.com/va/expedition/equipment.html

Explore/Explain

Have student teams research and meet all requirements necessary to travel to Antarctica. New members of science teams are sometimes amazed at the detail with which Navy doctors check out teeth X-rays and treadmill stress tests to reduce the likelihood of subsequent medical emergencies. Personal comfort in Antarctica is important to keep you safe, warm and positive in outlook. Environmental protection is also critical. As students plan, have them use the basic backpacker's rule of thumb: *pack it in*, *pack it out!*

USAP participants are only allowed to bring two pieces of check-in baggage weighing no more than 70 lb. each and one carry-on. (Their heavy scientific equipment will have been shipped ahead.) What items might be needed during a (let's say) 6 week stay in Antarctica?

Procedure

1. Brainstorm with students what pre-planning/items are part of any trip. What additional requirements/special concerns are there for international travelers? List all suggestions.
2. Explain that USAP has strict requirements for anyone setting foot on the Antarctic continent. These fall into four broad categories which should be posted on the board:

✔ Program Requirements (passports, visas, and permits)
✔ Equipment
✔ Packing
✔ Personal Matters

3. Have student teams:

A. organize the relevant items from the brainstorming list under the above headings (or student-generated equivalents)

B. use on-line resources and the booklet *Your Stay at United States Antarctic Program Stations* to expand and reorganize information into a six-week "To Do" timeline so that all members of the team will be ready to leave on the *Polar Duke* from Punta Arenas, Chile on the scheduled departure date, January 4, 1997. Assign a "start task" date and anticipated completion date for each task.

C. students should secure two letters of reference supporting their desire to be part of the science or science support team. Letters must testify to their character, skills, educational background, ability to solve problems, etc. One letter must be written by a parent or adult; the second can come from a classmate or friend.

D. make a packing list that includes:

✔ medication, toiletry and personal hygiene articles
✔ inner clothing/work clothes/special gear
✔ electric power adapters; batteries and supplies
✔ sunscreen and sunglasses (discuss why these are essential)

E. consider the need for special clothing as insulating systems that minimize heat loss in a sub-zero environment. Explain *insulation*, *conduction*, *convection*, *radiation* and *infiltration*.

Expand/Adapt/Connect

Bring in leftover packaging from a fast food meal or school lunch and have the students discuss why these materials would not be acceptable in Antarctica. Discuss the impact of packaging choices on the environment and actions that can be taken to reduce waste at home and in school. Have students research and list projects in your community that are environmentally friendly. What impact have students had on environmental change?

Have students bring in one object labeled "biodegradable" and another which is organic. List all objects on board and categorize them. Save the list for later use. Have students select several objects from each list to test (they must all fit in a 5 gallon bucket). Place sand in the bucket and bury these objects in the sand. Make small drainage holes in bottom of the bucket, cover it with a screen and place it outdoors in a secure location. Once a month, bring the bucket into the classroom and spread the contents out on a plastic sheet. Examine contents. *What has changed? Have any of the biodegradable objects changed? How long does this process take?*

As students view the videos and/or read the on-line materials, have them add travel excerpts to their own *Logbooks*, as if they were traveling to Antarctica and back.

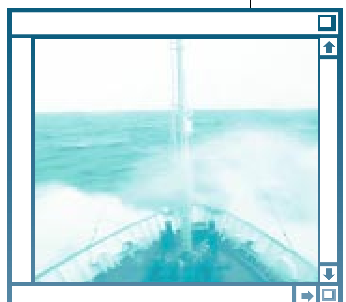
Continue to add to the class Vocabulary Chart words that are suggestive of the unique qualities of Antarctica. These words can be used in journal activities or in a poetry unit.

With all the difficulty of living and working in a cold, inhospitable place like Antarctica, discuss the advantages and disadvantages of doing research via satellite, using telecommunications instead of physical presence (this is already being partly done in support of astronomy at the South Pole). List what you can learn about Antarctica from satellites. What kind of information can you only get by being on site yourself?

List URLs that other students can use to explore issues confronting researchers in Antarctica.

Oceans, Ice & Life

Getting to Antarctica, the most remote continent on Earth, is a challenge in itself. We set sail from the once-rich trading city of Punta Arenas, Chile, aboard the R/V (Research Vessel) *Polar Duke*, across the Drake Passage — 650 miles of the roughest seas on the planet. En route for Anvers Island, site of America's Palmer Station, lifeboat drill reminds us that danger is ever-present, and that we might need to survive for several days at sea, in a closed metal tube that resembles a submarine. Leaving Tierra del Fuego and Cape Horn behind, "the Duke" sails south. For two storm-tossed days, food is on no-one's "to do" list, and simple survival is job #1. Then, we make first land-fall at King George's Island, seeing the Polish and Chilean bases, off-loading mail and supplies and tending to automated weather stations. Now with the Antarctic Peninsula to port, we sail South once more. Whales sport in front of majestic mountains, glaciers and icebergs. Then the *Polar Duke* slips into Arthur Harbor, and ties up beside Palmer Station to unload some of its researchers, and refresh others before their science cruise continues.



This first program begins our electronic field trip with an adventurous voyage south through some of the most spectacular scenery in the entire continent. But the *Duke* is much more than a ferry to get scientists to a destination, and the chilly waters provide more than an endurance test. The *Duke* is a 67 meter long, ice-strengthened research tool, its crew of 14 outnumbered by up to 23 researchers. Below decks, on the voyage south to Palmer, and then on down towards the British base at Rothera, its onboard laboratories will be put to work analyzing the unique creatures of these waters, from the microscopic to the immense, helping its crew and researchers better understand the intricate interaction of oceans, ice and life.

Robin Ross from U.C. Santa Barbara tracks krill, tiny shrimp-like creatures, which feed on the algae, and form the next rung up on the marine food ladder. David Karl from the University of Hawaii contrasts the productivity of these cold waters with the tropics closer to home. On shore, operating out of Palmer proper, Bill Fraser tracks the silverfish which sea-birds eat and the consequences of skua attacks on baby penguins. All these scientists collaborate with team leader Ray Smith on what's known as the Palmer Long-Term Ecological Research project (LTER), patiently accumulating data, year after year, to gain some understanding of when and why which species flourish or die back. They've found clues and causes in the interaction of Antarctica's extreme seasons, the growth of the ice sheet which annually doubles the continent's area, and in how much the ocean blooms with phytoplankton on which the larger creatures feed. It's some of the most challenging and significant science being done anywhere on Earth, for Antarctica's extremes and the relative simplicity of its marine food chain throws into high contrast the secrets of time, life and death—the engines of Darwinian evolution. Their analyses involve the contents of birds stomachs and the latest data from orbiting satellites, high above Earth. Their work takes them out on stormy seas during the southern summer, and then keeps them busy poring over disks full of data back home in the United States; their dedication, a testament to the human ability to find order and patterns in the diversity and complexity of nature.

But sometimes humans and nature conflict. The LTER project began partly as a response to the wreck of the Argentine supply and cruise ship, *Bahia Paraiso*. In January 1989, it spilled 200,000 gallons of diesel and jet fuel into some of the most pristine waters on Earth. Within four days of the accident, 100 square kilometers of ocean surface were covered by an oil slick. Underwater video shows the wreck today, and we see how well the marine creatures have been recovering. This was the most severe oil spill ever in polar waters, and the scientists are committed to understanding its consequences to help prevent a recurrence. As more and more cruise ships visit these waters, the *Bahia* wreck raises questions about the impact of tourism on the unique natural laboratory of the Antarctic. The challenge of understanding life and death in the southern oceans is symbolized by the contrast of the active science on board the *Polar Duke* and the sad sight of the *Bahia Paraiso*.

"Oceans, Ice & Life" will originate live from on board the *Polar Duke*. We'll take a walking tour of this unique vessel, from bridge to engine room, and meet its Chilean and Norwegian crew and the scientists who are sampling the marine food chain in Arthur Harbor. A second live camera will be on shore with researchers at Palmer Station. Pre-taped reports will show highlights of the passage from South America, and introduce the key features of this unique continent. Live guests will include members of the LTER team, many of whom have contributed to the development of lessons to be found in this Teacher's Guide. (See Activities 1.5, Phytoplankton, and 3.2, Plants and UV-B.

Life On, Under and In . . . the Ice

Teacher Background

Robin Ross, a member of the Palmer LTER team, wrote this personal overview of their research goals, which serves as a general introduction to this set of Activities: students will meet Robin and the LTER team throughout all three 3 videos, and on-line.

"The Palmer LTER (Long-Term Ecological Research) program was established in 1990 to study the polar marine ecosystem in the area west of the Antarctic Peninsula. In the Southern Ocean one of the dominant physical factors structuring the ecosystem is the annual advance and retreat of sea ice, one of the largest physical phenomena in the world's oceans.

The Palmer LTER includes researchers working on many different aspects of this ecosystem, from the growth and movement of sea ice to sea bird reproduction. With my colleague and husband, Langdon Quetin, I am responsible for research on "prey". Prey for the upper level predators like penguins includes large zooplankton (unable to swim against currents) and micronekton (small animals able to swim against some currents). In the Southern Ocean, Antarctic krill is one of the most important prey items. In fact it is a keystone species, the organism upon which many Antarctic predators depend. The analogy is to building an arch with a keystone in the center of the arch which keeps the entire structure from collapsing. Our working hypotheses center on the effects of physical factors (e.g. sea ice and oceanic circulation) on zooplankton and krill distributions, abundances, and "recruitment" within the LTER region. All krill born in one summer belong to that year's "class", similar to the year of a group of students when they graduate from high school. To us recruitment refers to how successful a particular year's class is after their first year of life: a strong year's class is one with many survivors to age 1, and a weak year's class would have few survivors to year 1.

…One strong interest is to work with our colleagues to look at the effect of the year-to-year changes we see in zooplankton community composition and abundance (including krill) both up and down the food web, i.e. on the food supply of the krill (primarily phytoplankton), and on their predators (penguins). The concept of broadening the horizons of all aspiring oceanographers and educating them in other aspects of oceanography besides their own specialty was important, and provided an appreciation of other disciplines. As a result we learned to interact knowledgeably with our colleagues, a skill essential to multi-disciplinary teams asking questions about how entire ecosystems function."

The Activities suggested for program 1 simulate:

1. important environmental conditions studied in and around Palmer Station
2. model several key biological responses to them, and;
3. show how some of the ship-based research tools used by the scientists work.

Ice Facts

Near Antarctica, sea ice retreats to four million square kilometers during summer, but grows to cover 19 million kilometers (7,334,000 square miles) during winter. As the air temperature begins dropping in March, the ocean temperature drops to -1.8°C and starts freezing at the incredible rate of 5.75 square kilometers (2.2 square miles) per minute. This thin ice coating covers an area nearly twice the size of the United States. The ice grows to more than a meter thick as winter progresses. Satellite imagery is helpful in monitoring sea ice extent and temperature.

Cool Talk from Antarctica

Ice: Water frozen solid occurs in its greatest variety in the coldest place on Earth. At least 78 different forms have been identified, including bullet ice, grease ice, green ice, pancake ice, and fraxil ice.

Fast Ice: Ice attached to the coast

Glacier: A mass of slow-moving, thick ice that has built up over many years on land

Iceberg: A large block of ice that has broken off from a glacier

Pack ice: Drifting sea ice

Polynya: An area of open water surrounded by ice

South Pole: The term is not interchangeable with Antarctica. In fact, there are three "South Poles":

1. **Geographic South Pole:** the Earth's spin axis, at exactly 90 degrees South latitude (the Amundsen-Scott South Pole Station is located here);
2. **Geomagnetic South Pole:** (near Russia's Vostok station), which is the locus of the *aurora australis* and Earth's magnetic lines of force that loop outward from the polar regions and meet over the equator at an altitude of several Earth radii.
3. **Magnetic South Pole:** (just off the coast, near the French station, Dumont d'Urville), which is where compass needles point.

Wind Chill Factor: The effect of wind blowing away the warmed air near the body, making one feel as if the temperature is really colder

Austral summer: The period from August through February, when the sun shines 24 hours per day

from "Antarctica: Continent of Ice", by Guy G. Guthridge, *Odyssey*, January 1994

Modeling Krill Behavior: How do brine shrimp react to physical stimuli?

In this Activity students will simulate aspects of the Antarctic ice ecosystem, and see how simple life forms respond, modeling links between environmental factors and biological responses. Although brine shrimp are different from krill and silverfish, students should recognize the parallels with the work done by the Palmer LTER team.

Objective

Students will conduct a controlled experiment with brine shrimp eggs in order to draw conclusions about this organism's response to variations in light levels and water temperature.

Materials (for each group of 3/4 students)

- aluminum foil
- balance
- bar magnet
- brine shrimp eggs from a local tropical fish store
- cover glass and slide
- glass rod
- graduated cylinder
- ice cubes
- light source
- medicine droppers
- microscope or hand lens
- petri dish
- plastic bag
- salt solution
- *Activity 1.1.1* Student Worksheet
- *Krill to Kill?* Blackline Master #10

Please note: as we've suggested in previous *Passport to Knowledge* field trips, if the materials for any Activity are beyond the resources ordinarily available to you, consider enlisting a local high school science teacher, for whom such simple items are more likely to be available.

Engage

Any organism must respond to changes in their environment in order to get food, avoid predators, and successfully breed—in short, to survive. In the Antarctic, the LTER group has confirmed that some of the most important factors are as expected: the seasonal cooling and warming of the continent. But their work in the last few years has also begun to show the precise mechanisms by which the (relatively) hotter/colder cycle works, by affecting the size of the ice-sheet, the time when it appears from year to year, and how it affects the amount of light and dark penetrating down into the ocean. In this experiment, students can observe how brine shrimp react to changes in their environment, which somewhat parallel the above phenomena.

Ensure that students understand brine shrimp are "stand-ins" for the krill they'll see in the videos. Review with students the *Krill to Kill?* Blackline Master #10, so they understand something of the actual life cycle of krill and the conditions they face.

Explore

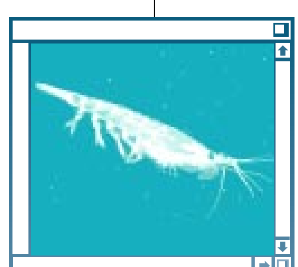
Procedure

1. Organize class in research teams, hand out Activity 1.1.1 Student Worksheet, "How Do Brine Shrimp React to Physical Stimuli?", review materials list, and lab procedures. Have students complete their hands-on investigation.
2. When all groups have finished their investigations, have research teams share their results and discuss. *Were all results the same? What might account for any differences? Which variables were difficult to control?*

Expand/Adapt/Connect

Referring to the krill data sheet, could students replicate the entire life cycle of krill in the pack ice by freezing brine shrimp in the lab? Why or why not? Explain. Response should go into their assessment portfolios.

Sea ice is easily tracked by satellite and infrared imagery. Link from the *LFA 2* Web site to other sites, such as those maintained by the Palmer LTER group, NOAA and NASA, to see how the ice grows and retreats with the seasons.



Fish With Nature's Anti-freeze?

Teacher Background

The temperature of the Southern Ocean rarely rises above 2°C. McMurdo Sound averages –1.87 degrees, and ranges between –1.4 and –2.15°C. Arthur Harbor is relatively similar in size of temperature fluctuation. From December through February, temperatures don't increase much, ranging from –1.9°C to –1.8°C. In such sub-freezing conditions, why don't fish freeze when their blood is much like fresh water? Is it possible for fish to be cooled below the freezing point of water, and yet for their bodily fluids to remain liquid?

Under special experimental conditions, fish have been observed functioning in ice-free cold salt water at a temperature of –6°C! Research (largely pioneered by Art DeVries, who appeared in the first *Live From Antarctica* series), has found that these fish have eight types of anti-freeze molecules which bathe the interior surface of their skin, acting as a barrier to ice propagating in from outside. When the anti-freeze molecules are not present, ice filters through their skin at these temperatures and crystallizes (freezes) their blood and tissues.

Objective

Students will experiment with lowering the freezing point of a substance, thus causing it to remain liquid at a temperature when it is normally solid. Students will compare their findings with facts about Antarctic ice-fish, which have bodily fluids that remain liquid at temperatures below freezing.

Materials

- 600 ml beaker or glass jar
- alcohol burner
- goggles
- laboratory balance/lab scale
- sodium thiosulfate (regular photographer's hypo)
- stir rod
- test tube (app. 20 by 150 mm)
- test tube and holder
- water
- *Activity 1.1.2* Student Worksheet, "Fish with Nature's Anti-Freeze"

Explore

Procedure

1. Hand out Activity 1.1.2 Student Worksheet. Review appropriate safety measures and procedures. Organize research teams and complete lab.
2. At completion of hands-on Activity, compare results and conclusions.

Explain

The chemically super-saturated solution begins to crystallize around the "seed" (the sodium thiosulfate crystal dropped in, step 8) immediately and continues to do so until all the chemical—which is normally solid at room temperature—has changed state. The test tube was heated to dissolve the solid (touch the test tube, to feel heat being released). This is very similar to what happens to water. Heat is added to melt ice, and heat is given off when water solidifies back into ice. The reaction takes place below our body temperature so we cannot feel it.

Fish, with blood containing sugars and salts, have a *freezing plateau* below that of fresh water (probably app. –0.8°C.) Antarctic fish have the ability to supercool (–2.2°C) under ice in McMurdo Sound without crystallizing (freezing). Thus, they can live under pack ice where salt water is below the freezing temperature of fresh water, but *only so long as no ice enters their body*. They crystallize if they cool by as little as 0.1°C when an ice crystal penetrates the skin and seeds the reaction.

VOCABULARY
(for both Activities 1.1.1 and 1.1.2)

aurora australis
adaptation
Antarctic Convergence
calving
glaciologist
lichen
metabolism
nunataks
nutrients
pack ice
permanent ice shelves
permafrost
polynyas
rookery

Extend/Adapt/Connect

1. Have students freeze an apple at home and bring it to class to thaw. Place it next to an apple that has not been frozen, and observe it over the next 2-3 days. What happens? Which apple rots faster? Why? *(the cell walls of the frozen apple broke when liquid in the apple cells expanded upon freezing, thus accelerating rotting)*
2. Why do farmers put barrels of rainwater in fruit storage cellars on cold nights? *(the latent heat given off when the water keeps the fruit above its freezing point)*

Expand/Adapt/Connect

Post a "Super Scientist Challenge Question" each day for extra credit. Students can respond in their *Logbooks* or turn in their written explanation at the end of the class.

Why do we put salt on roads in winter? *Salt on roads mixes with ice and water on roads. More heat must be removed from the mixture of ice and water for it to reach its freezing temperature than from pure water. This happens because the molecules have to overcome adhesion of water to the salt molecules in order to arrange themselves in the ice crystal lattice. We put salt on roads because the water remains liquid at a lower temperature. Below –5° or so, everything freezes.*

Why do we put salt in ice when making old fashioned ice cream? And do we put the salt in, or outside, the container? *The cream inside the container is not pure water—thus its freezing temperature is lower than the freezing temperature of water. If we just pack ice around the metal canister of cream, the ice may be above the freezing temperature of the cream. In order to make the cream freeze, liquid on the outside of the container must be colder than the cream inside the container. The ice outside the container must melt so that the salt can be added. (Since salt lowers the freezing temperature to –5° or so, the ice at zero degrees is now above the freezing temperature of the water-salt mixture). To melt the ice, heat has to be absorbed from somewhere. The ice cream maker is well insulated so the only place where the heat needed to melt the ice can come from is the metal cream container. Thus the melting of the ice (caused by the salt) draws heat from the metal canister holding the cream and lowers the temperature of the cream, so it freezes. Notice, when the ice is all melted, the cream is unable to freeze any more.*

Ed. note: OK, the next question is *not* about salt… but we think it should provoke some *warm* discussion amid all this talk of freezing!

Why did pioneer cooks not make fudge in rainy weather? *Surprisingly enough, wet air is lighter in weight than dry air. H_2O weighs less than N_2—given a uniform distribution of gas molecules. Since wet air weighs less, it does not take as much energy for water molecules to jump out of the beaker (boiling) so water boils at a lower temperature on rainy days. The glucose molecules take longer to cook at this lower temperature—and since water evaporates more easily (trying to jump out of the beaker against less pressure), dry spots appear more easily. These dry spots tend to crystallize the fudge making it grainy rather than smooth.*

Ice. When there is so *much* of one thing, how can one word possibly do it justice? As students work through the *Live From Antarctica 2* Activities, have them look for, list and characterize all the different types of ice they encounter.

Read Kurt Vonnegut's science fiction novel, *Cat's Cradle*, where a new kind of ice, "Ice-nine", ends up destroying life on Earth in a fantastic extension of the seed/crystallization phenomena.

Illustrate the life cycle of krill in relation to the ice pack ecosystem.

In Antarctica ice freezes at the rate of 2.2 square miles per minute. How great an area would this cover in one hour? *(132 sq. miles)* Twelve hours? *(1584 sq. miles)* Twenty-four hours? *(38,016 sq. miles)* On a state or national map, chart this area starting from your own town as the center point.

SUGGESTED URLS

Track the changes in the Antarctic ice sheet using NIH imaging software.
http://octopus.gma.org/surfing/antarctica/ice.html

Lessons and resources created by ICAIR's LEARNZ (Linking Education with Antarctic Research in New Zealand).
http://icair.iac.org.nz/~psommerv/web/lessonpl/learnz/learnz96/seaice.htm

University of Colorado National Snow and Ice Data Center. Education resources for teachers with links to studies on Antarctic ice and useful information about the cryosphere, climate and global change, and remote sensing.
http://www-nsidc.colorado.edu/NSIDC/coldlinks.html#EDUCATE

The Teel Family of Alaska shares their web site full of fun snow activities!
http://www.teelfamily.com/activities/snow/

Headline

NSF's Antarctic Artists and Writers Program

©Ann Hawthorne, NSF's Artists and Writers Program Participant, 1991,1994, 1996

Teacher Background

Though substantially fewer in number than researchers and their science support teams, NSF each year does send a number of men and women to Antarctica whose interests are more in *experiencing* and then *communicating* the human dimension of the continent and its living creatures. Some of these non-science visitors are media crews, reporting back via newspapers, radio and TV to the public about what their tax dollars are contributing, down at the end of the world. Others are poets, photographers, writers, and—in the 1996-97 research season— an audio recordist!

Applicants to the National Science Foundation's "Antarctic Artists and Writers Program" must develop a detailed proposal, just as scientists do, and show how they will reach a wide audience. They must also meet the health and fitness criteria set for all visitors. Successful applicants are those who are prominent in their chosen fields, and have received critical recognition for their work.

Objective

Students will write poetry and prose, and/or create images in various media, to capture some of the non-scientific aspects of the Antarctic experience, and to practice communicating what they see and hear during the Module.

Materials

- class chart of high-imagery vocabulary developed over the course of *LFA 2*
- *Logbook*/journal/computer
- various art media
- illustrated books on Antarctica, and/or magazines such as *National Geographic*

ENGAGE

What would attract you to Antarctica if you were an artist, photographer, or writer? Why?

In Antarctica mankind can view a truly primeval wilderness. It is essential to his psychic well-being that his feelings of awe, wonder, mystery, humility, his appreciation of incredible and unspoiled natural beauty on a tremendous scale not be taken from him.

CHARLES NEIDER, from "Homage to Antarctica"
NSF's Artists and Writers Program

As I was painting in Antarctica, I remember having to constantly remind myself that this was actually a part of the Earth I knew. I had the sense of another planet, of something powerful, and strangely beautiful. I think of Antarctica as a symbol of peace—an inner peace that all people can share, regardless of nationality—because the vitalizing spirit that such an expansive, magnificent landscape evokes in all of us is unaffected by culture. Antarctica is the only stretch of wilderness on this planet that belongs to people of all nations; one last peaceful expanse of earth to nurture as our paradise.

LUCIA DE LEIRIS, Artist
NSF's Artists and Writers Program

Explore

Ask students what they know about the differences between "essays" and "poems". Share the two poems by sixth graders who participated in *Live From Antarctica 1*. Ask students what sense of Antarctica the works convey.

Explain

Antarctica is a study in contrasts: summer sunlight for days on end, long months of winter darkness; unyielding yet fragile; remote yet ever-present to those who've visited just once; a place of achievement for Amundsen, an "awful" tragic place for Scott. As your students participate in *LFA 2*, have them add evocative words suggesting these contrasts to a class list.

Examine library or on-line materials that picture Antarctica. What feelings, images, moods, contrasts, do these photos suggest? What's visible? What's noticeably absent?

Procedure

Poetry tries to say in few words what essays convey in expanded form. There's often poetry waiting to be mined from within prose or journal writing. Try this technique to get started: using either excerpts from historical or contemporary writing about Antarctica, or from their own project *Logbooks*, have students highlight high-imagery words or phrases that capture the essence of the Antarctic experience. Using the highlighted text—words and phrases—as a starting point, play with their arrangement and relationship to create a new work from the prose text. As they construct their word images, have them refer to the class vocabulary chart and other reference materials. Remind them a poem does not have to rhyme, but achieves its effect from the careful placement of words.

Younger students may prefer to work on art projects in various media. One first grade teacher reported *LFA 1* inspired her students to great creativity. Remember, there's an on-line Gallery for student work!

SOLITARY CONFINEMENT

This is my sentence,
This deserted place,
This is my prize, my prison.
I am in the middle of nowhere.
The wind, ice, and everything,
All White.
Colorless, bleached white,
It goes with everything,
Except me.

SALLY SMITH, Summit Middle School, Summit, NJ

IMPRESSIONS OF ANTARCTICA

Barren place of no civilization for millions of years.
World of intense knowledge.
Snow piled up from millions of years ago.
I sit, struggling to survive the arid climate.
I stop, look around, and think,
"What am I doing on this vast, unknown continent?"
Searching for an answer, I feel a sudden gust of wind on my face.
There is something about it that makes me feel all alone, yet in the midst of a crowd.
Still searching for an answer, I am seized with a feeling of presence.
Someone is all around me but nowhere at all.
Standing in this ancient land of ice, I sense I am in the presence of God.
In this frigid, bare area, I suddenly feel warm inside.
Now I don't have to ask my question any more... it was answered.

DOMINIQUE PRADELLA, Summit Middle School, Summit, NJ

Ship Science

The R/V *Polar Duke* is essential to both science and survival at Palmer Station. But there's more to any ship than meets the eye. These two Activities allow students to conduct hands-on experiments exploring the basic principles of why ships float, and to build simple models which show how special tools on deck, using levers and pulleys, allow researchers and crew to handle heavy equipment and sample water layers deep in the ocean, as students will see during Program 1.

Activity 1.2.1 Why Ships Float

Teacher Background

Salt content differs from sea to sea, and ships often sail from one body of water to another. This is very important since ships are only stable with the right combination of cargo or ballast and ocean conditions, including salinity. Ships can become unstable in stormy waters if their center of gravity is too high in relation to their center of buoyancy. Ships can swamp and sink if they ride too low in the water. Meredith Olson, who contributed several Activities to this Guide, including this one, lives in the Pacific Northwest, and tells of several heavily-laden trawlers being lost at sea when they sailed from salty waters—where their cargo weight was safe—to waters diluted in salt content by fresh water melting from glaciers! Ice, salt, and why ships float: it's a matter of life and death.

VOCABULARY (for both Activities)

- **boom**
- **block and tackle**
- **buoyancy**
- **friction**
- **fulcrum**
- **mechanical advantage**
- **pulley**
- **resistance**
- **winch**

Objective

Students will conduct experiments demonstrating the effects of varying rates of salinity on how high out of the water a simple "ship" will float.

Materials (for each group of 3/4 students)

- ▼ 600-ml. beaker or wide mouth glass jar
- ▼ lightweight 8 in. plastic test tube
- ▼ sand (for ballast)
- ▼ wood splint (popsicle stick marked in 1 cm intervals) which fits in test tube
- ▼ metric ruler
- ▼ *Activity 1.2.1* Student Worksheet, "Why Ships Float"
- ▼ Blackline Master #11, "Facts About the R/V *Polar Duke*, and its Equipment"

Engage

Ask the class to name large bodies of both salt and fresh water. In which would floating be easier? Why? Water in the Dead Sea is about 27 percent salt. If you floated vertically, your head and shoulders would stick out above the surface. You could say your body's "water line" passed under your arm-pits. If you stretched your arms out, you'd lose balance because you'd be top heavy. Your "center of balance" would not coincide with your "center of buoyancy". And you wouldn't swim very well because you couldn't stay under water sufficiently to propel yourself.

Explore

Procedure

1. Review experimental procedure on *Activity 1.2.1* Student Worksheet. As students complete their investigations, they should add their data to class record sheet on chalkboard.
2. Debrief. Analyze class data set. Gather conclusions based on the data.

Explain/Extend

Discuss the following real-world applications:

What would happen if a ship was loaded to the fresh water line in a salty sea port and then took its cargo to a fresh water port?

Winter seas in the North Atlantic are very rough so a ship must be less heavily loaded. What is a safe load level for a trip to Antarctica? The *Polar Duke* sails from South America to Antarctica. There is ice and fresh water at the surface around Antarctica. What will happen to the *Polar Duke's* water line as it moves along its journey?

Activity 1.2.2

Pulleys, Levers and Rigging

Objective

Students will investigate how simple machines help move large loads on a ship.

Engage

How can you lower or raise something heavy with just the power of your arms pulling on a rope? Brainstorm real-world situations where large, heavy loads must be lifted, moved and lowered with a minimum of energy (fuel) expended. Explain that in these Activities, students will construct simple machines to move loads.

Explore

Materials

- string or cord
- bamboo skewers or small sticks
- tape
- small pulleys or thread spools
- spring scale
- wire coat hanger
- masking tape or duct tape
- 16d nail
- drinking straw
- scissors
- *Activity 1.2.2* Student Worksheet, “Levers, Pulleys and Rigging”

Explore/Explain

Procedure

1. Hand out materials and *Activity 1.2.2* Student Worksheet. Review directions.
2. When the lab is completed, discuss student observations and conclusions.

Do you gain mechanical advantage by using more than 3 pulleys to compound the force?

It’s rarely worth more than three pulleys to compound the force because friction starts to reduce the mechanical advantage. In addition, you can see from Figure 3 that the rope suspending the upper pulley block needs to be stronger and stronger to hold the weight of the object to be lifted plus the weight of the weights and pulley blocks.

Uses of Rigging on Ships

One of the most important early applications of block and tackle rigging was for raising, lowering, and controlling sails. Engine powered fishing and research ships depend on these mechanisms too. Instruments are often lowered into the ocean on the ends of long cables. The pressures of the sea are very strong so the machinery has to be rugged.

Read Deane Rink’s on-line, hair-raising account of his cargo-handling “experience” involving the *Duke’s* winches. After viewing the videos, write a journal entry describing a day aboard the *Duke.* Include information about the rigging, cargo and instrument-handling equipment. Place copy in *Logbook*.

Using a world map, plot a course that would take a ship such as the R/V *Polar Duke* to all the major oceans of the world. Using print or on-line sources, research basic information about these oceans, including salinity, major ocean currents and upwellings, bottom canyons, storm belts and other factors that would be critical to successful circumnavigation.

Use data from on-line or the videos to calculate the *Duke’s* average speed. How long would it take to travel to each place, and complete the entire journey?

SUGGESTED URLS

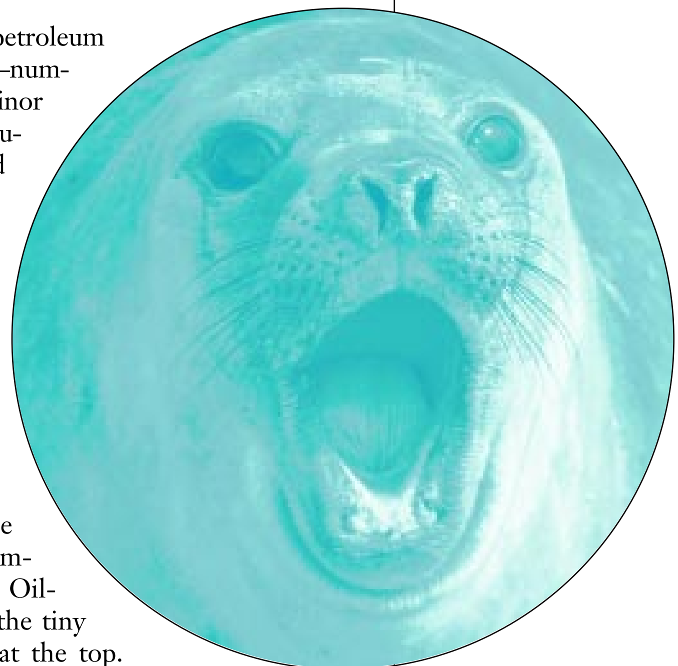
Information on the R/V’s* Polar Duke *and* Nathaniel B. Palmer, *designed for NSF researchers. Includes deck plans, meal times, safety precautions:
http://enterprise.asa.org/vessels.html

Details on the cruise ship, Marco Polo:
http://http2.sils.umich.edu/Antarctica/Marco_Polo/MarcoPolo.html

Oil and Water Don't Mix... or Do They?

Teacher Background

Oil spills—the accidental or deliberate discharge of petroleum or petroleum products into the ocean from oil rigs, tankers, or oil-fueled vessels—number in the thousands each year. While most are relatively minor (amounting to less than 1,000 gallons), catastrophic spills occur regularly. The pristine environment of Antarctica has not been spared these man-made disasters. On January 28, 1989, the *Bahia Paraiso*, an Argentine tour ship visiting Palmer, ran aground on a reef near the station and spilled 200,000 gallons of fuel oil into the harbor. Over 200 people had to be evacuated to Palmer (normal population, 45 or so!) until rescue vessels could be sent. Today the rusting overturned hulk still sits in Arthur Harbor. Fortunately, the *Bahia Paraiso* incident did not have a long term effect on the LTER project. The wreck's presence, however, serves as a warning to researchers and others about the uneasy co-existence of tourism and science in such a fragile environment.



Oil spills can impact the entire food chain. Oil-coated birds whose feathers can no longer hold air or repel water, and furred ocean mammals such as seals, die from drowning, exhaustion and freezing. Oil-impregnated water and toxic components of the spill also affect the tiny creatures at the bottom of the food chain which sustain those at the top. Techniques for dealing with oil spills at sea include the use of floating booms to keep the oil contained until it can be collected by pumps or skimmers; spraying chemical dispersants which break down the oil, and burning surface oil.

Objective

Students will investigate the effects of oil on various materials simulating the skin and/or coats of Antarctic marine organisms, and compare the ability of different techniques to clean up oil spills.

Materials (for each team of 3/4 students)

- 1 aluminum pie pan
- water
- 2 tablespoons of vegetable oil
- cup of sand
- small piece of brown fake fur (to represent elephant seal)
- feather—use sterilized feathers from a pillow (to represent a penguin or skua)
- medicine dropper
- paper towel
- cotton ball
- tweezers
- wooden toothpicks
- metric ruler
- safety goggles (one per student)
- liquid detergent
- *Activity 1.3* Student Worksheet "Oil Spill Simulation"

VOCABULARY

chemical dispersants
food chain
oil spill
pollution
toxic

Engage

Ask students to name the most famous oil spill with which they're familiar. What effects did this accident have on the environment? What can be done to deal with them?

Explore/Explain

Review with students information about the *Bahia Paraiso* oil spill. Distribute worksheets. Demonstrate Activity set-up (see Worksheet, steps 1-5). Tell students their mission is to simulate an oil spill, keep the oil from spreading in the ocean, clean it up and figure out ways to save the seals and penguins. A seal is "saved" if its fur is cleaned well enough to feel free of oil when dry. A sea bird is "saved" if the dry feather returns to its original unclumped appearance.

After completing the Activity, ask teams to report their results. Note that it can be difficult to keep the spill from spreading, clean it up, and save the sea animals, all at the same time. Compare this simulation with problems faced in the Antarctic in the *Bahia Paraiso* spill.

Expand/Adapt/Connect

Have students repeat this experiment with ice-cold water and compare and contrast the results with the room temperature water of the original activity.

Local investigation:

How does your community dispose of oil from industry and cars?

Have students research the Antarctic Conservation Act, and ASA's publications on waste disposal and waste recycling. (There are links to this from the *LFA 2* Home Page.) List additional suggestions, ideas or methods that might be used to prevent pollution of the land, ice sheets or oceans of the Antarctic. Write a letter to NSF's Office of Polar Programs giving your reasons protecting Antarctica and proposing specific laws. Post ideas, research and letters on-line!

Design a poster to help stop ocean pollution.

Marine Fuel Spill Response

http://www.nsf.gov:80/od/opp/antarct/antprog/sb12.htm

The Argentine supply ship, *Bahia Paraiso*, ran aground and sank in January 1989 near Palmer Station, Antarctica. Although few people were injured, the accident spilled about 200,000 gallons of diesel and jet fuel…The initial spill killed as much as 50% of the mollusks and marine algae in the intertidal community…Only a few hundred of the area's 30,000 adult seabirds were observed dead at the time of the spill, but adults bringing food to the nest site exposed their young to fuel-contaminated food. The most severe impact appeared to be in the cormorant colonies, where nearly 100% of the chicks died in a few months after the spill.

Continued studies on various components of the ecosystem over the past 7 years have shown different levels of impact. The intertidal community has been recovering. While the Adelie penguin colonies closest to the spill site no longer exist, changes in overall population numbers remain within the range of natural variability. Active nests of cormorants near the spill have decreased by more 60%, while those away from the spill have remained constant. A steady decline in active kelp gull nests has persisted, suggesting that the initial damage to its mollusk food source drove the bird populations down.

…Long-term studies are necessary for understanding the impact of fuel spills on different ecosystem components …Should future spills occur in the Arctic or the Antarctic, this project will provide valuable information on ecosystem impact and recovery. In recognition of its role following the spill, in 1993 the U.S. Antarctic Program received a Gold Medal Clean Seas International Award from the government of Malta "for praiseworthy efforts in conjunction with the preservation of a marine environment."

SUGGESTED URLS

Ocean Planet's information details sources, and lists accidents and cleanups
http://seawifs.gsfc.nasa.gov/OCEAN_PLANET/HTML/peril_oil_pollution.html

Details the environmental issues in Antarctica including information about oil spills
http://www.icair.iac.org.nz/~psommerv/web/informat/caring/6_caring.htm#oil

Information about U.S. Environmental Protection Agency's Oil Spill Program
http://www.epa.gov/superfnd/oerr/er/oilspill/oilhome.htm

Newton's Apple lesson on oil spill cleanups with links to related topics.
http://discovery.syr.edu/Projects/Newton/10/lessons/Oilspill.html

The Ocean in Motion!

Teacher Background

The interior of Antarctica is a lifeless desert, except for human research stations. But the coasts, especially the oceans themselves, are rich with life. To appreciate the research done at Palmer and on board the *Polar Duke*, it helps to understand some pretty astonishing and sometimes counter-intuitive phenomena.

When we see the beautiful, deep blue colors of a tropical ocean, we assume it's teeming with life. But relatively speaking, blue waters are the deserts of the sea. The farther down light penetrates, the bluer the water seems. This means there's no microscopic life to stop the light. Murky, dark-green oceans are usually nutrient-rich oceans (full of microscopic life). The Arctic and Antarctic Oceans are, at certain seasons, more productive than any others on Earth. Because of its size, the Antarctic is, on average, the richest ocean for life. And, because of the dynamics of hot and cold water, Antarctic waters also function as a gigantic planetary Mixmaster, revitalizing sterile waters which eventually reach out across the world.

At the equator, water is warmed to great depths without any sharp separation from a cold layer underneath. Except for storm action, it doesn't cool much in winter and consequently sink and incorporate nutrients from the bottom waters, into which decaying life and dissolved mineral are mixed. In fact, rich bottom water seems to flow right from the northern to the southern oceans in one continuous, bottom-hugging layer, passing right underneath warm, equatorial regions without much intermixing.

Westerly winds drive the surface waters of the Antarctic Ocean eastward, round and round the continent. The very cold bottom layer is heavy with salt and decaying organisms. (As ice forms near the surface, more and more salt sinks to the bottom, and flows away north.) Antarctic surface water becomes less salty by dilution with heavy rains and melting ice. This lightweight water also drifts northward rather than sinking. With both surface and bottom water moving northward, bottom water from warmer regions is drawn down between the layers. This warmer, less salty, bottom water bumps against the Antarctic continent and rises, creating a continuous upwelling of nutrient-rich water throughout the year. This inflowing water has moved as a huge mass all the way from the North Atlantic in a journey which takes several thousand years.

The density of sea water depends primarily upon how much salt it contains and/or at what temperature it's measured. *Cold* sea water is more dense than *warm* sea water of the same salinity. It's important to understand how density differences, mixed layer depths, and heating, cooling and ice formation affect the mix in the water column because these factors are linked to the growth of phytoplankton—the foundation of the food chain—in the Southern Ocean, as we'll see in Activity 1.5.

If the top layer of the water column is shallow, the microscopic plants in that layer will be mixed around and will receive lots of light. If the mixed layer depth is great—600 m for example, as it was in the Ross Sea in early 1996 before the bloom started—the plants will spend part of the day in the lighted part and part of the day in the darker part of the water column and will not receive enough daylight to grow. When the difference in density between two layers of water in the water column is great, the water column is said to be "stable."

VOCABULARY

bottom water
conductivity
density
fluorescence
layers
salinity
temperature
turbidity
water column

Hot, Cold and Currents

Objective

Students will explore how changes in the salinity and temperature of water affects its density and motion.

Materials for each group of 3/4 students

- food coloring
- ice cube tray (see Procedure, Step #1—colored ice cube must be made in advance)
- large glass bowl or small aquarium tank (clear plastic bottles if large enough)
- hot tap water (43°C or 110°F)
- small bottle of ink
- salt
- test tube or cup
- Celsius or Fahrenheit thermometer
- safety goggles
- *Activity 1.4.1* Student Worksheet, "Hot, Cold and Currents"

Engage

In winter months, primary production in the Antarctic Ocean is nearly zero, which creates difficulty for the grazers who depend on primary production. But in the 5-6 months of austral spring and summer, these waters become a nutrient-rich pasture for plankton. The frigid polar waters teem with life. Part of the reason lies in the density and movement of the water column which is affected by temperature, salinity, changes in pressure (depth) and sediment suspension. We can illustrate how these factors work in some simple lab experiments.

Explore

Procedure

1. Organize students into lab teams. Hand out *Activity 1.4.1* Student Worksheets and review materials and procedures. Review lab safety rules. Complete hands-on laboratory investigations.
2. When lab is completed, have students share observations and conclusions. Reinforce relationships between sea ice and ecosystem in Antarctica.

Layers in the Water Column

Teacher Background

To understand the nutrients found in the middle layers of the southern seas, we need to be able to take samples of water at specific depths, and to bring this water to the surface without it being contaminated as it's hoisted up. This requires a device which remains open until the desired depth is reached, and then closes securely, retaining the sample.

Objectives

Students will investigate how changes in salinity and temperature affect water density.

Students will design and evaluate the effectiveness of devices to sample specific water layers.

Materials

- clear plastic drink bottles of various sizes (ends cut off)
- stoppers and plugs from plumbing stores
- rubber tubing
- plumbing clamps
- a 1-quart glass beaker or wide mouth jar
- clothespins
- blue & green food coloring
- salt
- water
- safety goggles
- *Activity 1.4.2* Student Worksheet, "Layers in the Water Column"
- clear plastic tubes

Engage

Demonstrate the making of a multi-layer system (see Procedure #1 on *Activity 1.4.2* Student Worksheet). Challenge students to create a bottom sampling device. How can they get the sampling bottle down to the desired depth, and how will they keep it open? How can they close it quickly when it's where they want it to be?

Explore

Procedure

Complete *Activity 1.4.2* lab investigation. Allow time for design teams to demonstrate their "Bottom Sampling Devices" and share observations, successes and failures!

Explain

Ocean water is sampled for chemicals and organisms. The sampling device must have certain important characteristics:

- It must gather enough water for conducting all the tests.
- The depth at which the sample was gathered must be accurately known.
- The temperature at time of collection must be known.
- It must not allow contaminants to enter as it's being brought up on deck

Mixing up the Water Column

Objective

Students will investigate the effect of water temperature on mixing in the water column.

Materials (for each team of 3/4 students)

- 2 identical wide-mouth jars (20 oz. size work well)
- 2 different food colorings in dropper-type squeeze bottles
- tap water
- safety goggles
- 30 oz. cold water pre-chilled in refrigerator
- index card slightly larger than the jar mouth
- *Activity 1.4.3* Student Worksheet, "Mixing up the Water Column"

Engage

Ask students for their predictions about how different water temperatures will affect movement in the ocean water column. List all suggestions on chalkboard.

Explore

Procedure

Complete *Activity 1.4.3* lab investigation. Allow time for clean-up!

Expand/Adapt/Connect

Is muddy water heavier or lighter than fresh water of the same temperature? Describe an experiment you could do to prove your hypothesis and carry out your experiment for the class.

Ships have long obtained their drinking water by distilling sea water. How is water distilled?

Heat a beaker of salt water on a lab stand over an alcohol burner until the water steams or boils. Arrange an aluminum foil cover to catch steam rising off the boiling water. Contour the foil so the condensing steam drips to one side and falls into a second beaker. Record your results and save to include in your assessment portfolio.

The 3 Activities in *The Ocean in Motion* stress the importance of layers in and the motion of the water column, and the nutrient-rich nature of the Antarctic ocean. Be sure to have students include a summary of their discoveries in their *Logbooks*.

Nansen: the Man, the Bottle... the Sled!

Some OAE's have left their mark on the continent, beyond their exploratory achievements. Field teams still sleep in "Scott tents," and Skidoos pull "Nansen sleds."

The Norwegian, Fridtjof Nansen (1861-1930), was a zoologist, artist and Nobel Peace Prize winner. He was the first man to cross the Greenland ice cap. He tested his theory of surface currents in the Arctic Sea by allowing a specially reinforced ship (the *Fram*) to be frozen into the pack ice so it would drift with the current. Nansen hoped the Arctic current would take the ice and the *Fram* to the North Pole. When it became obvious that the ship would not reach the Pole, Nansen and a companion set out on foot. He failed to reach the Pole by about 233 miles, but got closer than anyone had before. Years later, Nansen lent the *Fram* to Amundsen, who made it his main vessel for his successful race to the South Pole.

Nansen designed a device to obtain samples from deep down in the water column. This became the standard instrument for many decades. Made of bronze, copper and tin, it was called the *Nansen bottle*. When triggered by a weight sliding down the cable, the bottle inverts 180 degrees and tapered valves at each end close.

Today, a newer sampling device, the *Niskin bottle*, made entirely of plastic, minimizes the problem of corrosion when left in standing water and sample self-contamination from trace metals in the construction of the original Nansen bottles.

Have students be on the lookout for Nansen sleds, still in use, in the videos and on-line journals!

SUGGESTED URLS

Ocean in Commotion contains multiple links to information about why the ocean is salty, currents, density, temperature, satellite images, circulation. For older students
http://geosun1.sjsu.edu/~dreed/105/currents.html

"Why Is the Ocean Salty?" (US Geological Survey) Clear and easy to understand
http://www.ci.pacifica.ca.us/NATURAL/SALTY/salty.html

Project Athena ***activities including Tracking Drifter Buoys and Ocean Color lessons.***
http://athena.wednet.edu/curric/oceans/

Effects of Light and Dark on Phytoplankton Populations

Special thanks to Drs. Robin Ross and Langdon Quetin for input to this Activity.

Teacher Background

Each southern summer, increased light levels and nutrient-rich upwellings support blooms of phytoplankton—floating microscopic marine algae—which support vast numbers of krill, which in turn form the main food source for organisms further up the food chain: whales, seals, fish, squid and birds, including penguins.

Results from the first four field seasons of the LTER at Palmer station support the hypothesis that year to year changes in physical factors such as sea-ice extent and timing (when in the season the ice appears and disappears) impact all levels of the ecosystem. Phytoplankton abundances also vary greatly from year to year, and from place to place, depending on the specifics of the ice-sheet. The two seasons following winters with high ice coverage developed overall phytoplankton biomass during bloom periods *five times greater* than two other seasons!

Researcher Maria Vernet travels around Arthur Harbor in a Zodiac and takes water samples, as well as being part of the *Duke* team. (Have students go on-line to read her *Biography* and *Journal* describing her work days and the research.) She then exposes the phytoplankton she scoops up to various light conditions. In this Activity, students will simulate some Palmer LTER techniques and analyze the consequences.

Researcher examining krill; the contents of a penguin's stomach

Objective

Students will investigate the effect of variations in length of day on phytoplankton growth.

Bill Fraser

Ornithologist, expert on skuas, gulls and penguins, and slated as a live guest in Program 1. *LFA 2* also thanks Dr. Fraser for his input to Activity 3.3, "From Data to Death"

…I cannot recall a time when I did not have an interest in science, which in my case involves the field of ecology. I spent the first 12 years of my life in the suburbs of Buenos Aires, Argentina but, either through family or friends, was fortunate in having access to some of the great "estancias" or ranches for which that country is known. It was on those ranches that I developed a keen interest in the out-of-doors…I quickly realized that the key to becoming better at those activities was simply to know more about the species I pursued. Thus, whatever free time I had in those early years was spent either reading about the natural world or pursuing fish and game. Although I did not recognize it as such, I had, in effect, turned to ecology to understand the animals in which I was interested….

The 1996-1997 season represents my 22nd year in pursuit of these interests and seabird ecology as the focus of my research, which now involves trying to understand how variability in the marine *(the feeding habitat) and* terrestrial *(the breeding habitat) environments affect seabird populations at various space and time scales.*

VOCABULARY

algae
biomass
ecosystems
microscopic
pelagic
photosynthesis
phytoplankton
UV light

Phytoplankton “See the Light”

Materials

- 2 glass aquaria *or* two 1-liter glass jars
- 1 liter of tap water (or pond water if available)
- dried grass or hay
- medicine dropper
- grow lights
- microscope and glass slides

Engage

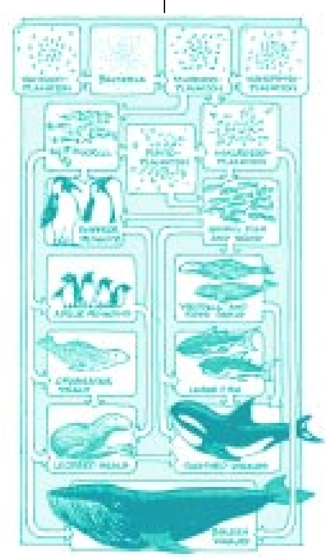
Ask students what they remember about the oxygen cycle—most early elementary students are familiar with photosynthesis as the oxygen/carbon dioxide exchange between plants and animals. There are no trees in Antarctica. So, where’s the oxygen coming from? Encourage speculation.

Explain/Explore

At the lowest end of the food web are phytoplankton, the “food” of tiny marine animals, particularly krill. Phytoplankton make their food through photosynthesis. Fueled by the energy of sunlight, they convert carbon dioxide and water into simple, sugary food. During photosynthesis, they release oxygen as a waste product. They also incorporate carbon dioxide.

Length of day and extent of sea-ice cover are both important environmental factors given the extreme seasonal cycles. Depending on the latitude, there may be enough light for the microscopic plants to grow in the winter; they only need about four hours of daylight. The amount of light that the plants receive depends on:

1. the amount of light reaching the liquid water (thickness of ice/snow cover)
2. the “mixed layer depth,” or how well the top layer of the ocean is “mixed” based on the effects of weather (wind, air temperature) and sea-ice cover (melting and freezing cycle). See Activity 1.4.3



Procedure

Create a phytoplankton culture in a hay infusion:

1. If using tap water, allow it first to age in an open container for several days.
2. Prepare a hay infusion in two identical glass aquarium tanks or a 1-liter glass jar containing equal amounts of water and an amount of fresh cut hay or grass (not cut by a gas mower).
3. Using grow lights hung over the tanks, expose one (the light treatment) to 24 hours of continuous light, and the other (dark treatment) for only four hours during the school day, with all light blocked off by opaque material during the remaining hours.
4. Record differences observable in the color of the water—greener will indicate more growth. Photos or video may be taken to keep track of color changes: be sure to indicate a descriptive “slate” with the date in the shot for later reference.
5. Record findings in a brief lab report: *conditions; variables; results; conclusions.*

(NOTE: Sometimes the plants run out of nutrients in culture so students may have to add new hay to the infusion)

Expand/Adapt/Connect

Go on-line to see Robin Ross’ suggestions for how to add “grazers” to the environments, when North American spring permits. And also to find data to compare and contrast hours of daylight as winter becomes spring, and plot this with analogous records from Palmer Station.

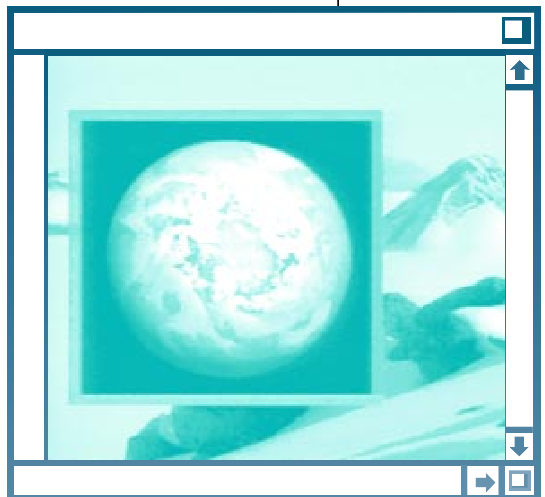
Have students plot daylight hours on maps, comparing and contrasting results from various classes participating in *LFA 2.*

The Food Web Game

Special thanks to the Gulf of Maine Aquarium, source of the original Activity
http://octopus.gma.org/surfing/human/ozonephyto.html

Materials

- pencils, index cards, string
- *Antarctic Food Web* Blackline Master #12



The inset box shows a satellite view of the hole in the ozone layer

Engage

Increases in the ozone hole will result in damaging ultraviolet-B (UV-B) rays penetrating deep into the ocean. Increases in UV rays will harm young marine life, such as floating fish eggs, fish larvae, juvenile fish, and shrimp larvae. UV-B radiation also affects phytoplankton movement: orientation (movement up or down in the water in response to the amount of light) and motility (moving through the water). Inability to properly position themselves in the water column dramatically inhibits their ability to photosynthesize. Phytoplankton are called primary producers because they photosynthesize their food from sunlight. If phytoplankton are harmed by increases in the ozone layer, how will others in the Antarctic food web be affected?

Explore

Find out what will survive UV-B radiation in Antarctica.

Procedure

1. Make cards for each item in the food web. Assign students to various items.
2. Give one end of the string to the student who is phytoplankton. Have the class discuss and decide what element eats what. Pass the free end of the string along, up the food chain to the larger predators.
3. Increase the amount of UV-B radiation in the food chain and "kill off" the phytoplankton.
4. Have students let go of the food web string as they no longer have any food to eat, and have the higher creatures pull in the free end. When the free end passes through their hands, they no longer have food to eat!
5. Discuss implications for the waters surrounding Antarctica.

Expand/Adapt/Connect

Search on-line for information about the hole in the ozone layer over Antarctica. Given what you know about the role of phytoplankton in the food web, why are scientists concerned about thinning of the ozone layer? How will increases in the ozone hole harm young marine life and affect phytoplankton movement?

Look up the number of daylight hours at different latitudes as spring goes into summer in Antarctica. Contrast length of daylight in your area with what scientists in Antarctica are experiencing. Palmer Station is at about 64 degrees S.

SUGGESTED URLS

Information about plankton, krill, fish and squid.
http://www.terraquest.com/va/science/environments/m.environments.html

excellent Antarctic Food Web lesson "Who Eats Who In the Antarctic?" by Kim Kovich
http://www.intercom.net/local/weeg/antarct7.html

AGU report on the effects of UV on phytoplankton in the Southern Ocean.
http://earth.agu.org/revgeophys/smith01/node18.html

Program 2

The Secrets of Survival

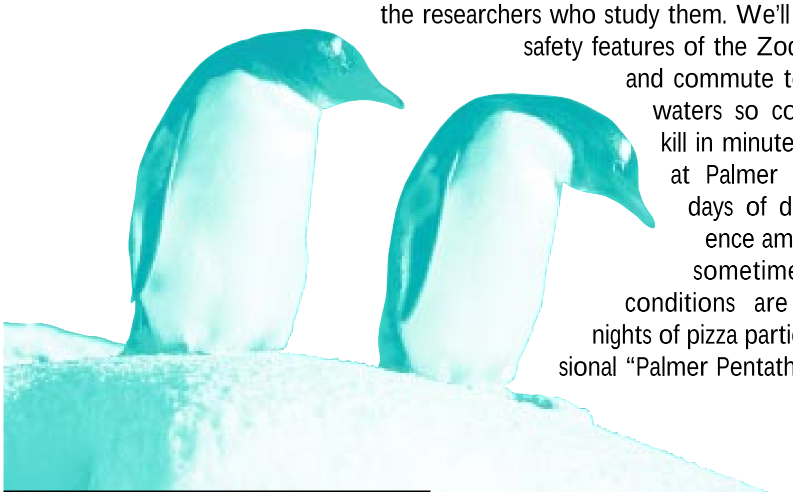
Think of Antarctica, and the most likely image will be a penguin. In this program “you are there” with the most abundant penguin species to be found in and around Palmer, the Adelie. Torgersen Island, within NSF’s 2-mile safety limit for boat trips via Zodiac inflatable, is home to some 8,000 breeding pairs, and this is the time of year when it’s make or break for the next generation. Most baby Adelies will be born in mid-December. By January, we see which will live and die, whose parents are the most successful in foraging for food, with both parents taking turns at home, and away from the nests, searching for sustenance. We’ll follow researchers Carol Vleck and Theresa Bucher as they visit Torgersen when the penguin chicks are molting, and watch them as they try to understand the physiological and behavioral bases for Adelie survival. Bucher has been studying specific individuals in this rookery since 1990, and has some insights into the “secrets of survival.”

Since *LFA 2* will have cameras at Palmer from mid-December 1996, until mid-February 1997, we’ll be able to follow the chick-rearing cycle of a typical Adelie family during the height of their breeding season. This sequence will be full of solid science, but will also take viewers on a unique “up close and personal” visit to a large penguin rookery, where the sounds (and smells) are overwhelming, where cute chicks abound, but where the nursery scenes are interrupted from time to time by lethal dive-bomb attacks from on high.

Bill Fraser studies threats to the Adelies, both natural and human. A terrestrially-based member of the LTER group we met in program 1, he studies skuas, petrels and penguins on the outlying islands near Palmer. Skuas are one of most important flying threats to baby Adelies. Fraser is also looking at how the size and seasonal onset of the sea ice has different consequences for different key species. The simplified marine food web in the Antarctic oceans and the extreme variability of seasonal climate provides a high-contrast story of survival or death, dramatically highlighting the interaction of environment and life, with implications for the rest of the planet and all its creatures.

Fraser also plans to divide Torgersen Island into two sections this research season. Visitors will be allowed in one area, but banned from the other. Then he and his research team will compare penguin breeding behavior and success in the two sections. The results are intended to help tour operators establish procedures to better protect and preserve the very creatures the tourists have paid substantial fees to see.

This program will originate live from Torgersen Island, with scenes and sounds (but none of the distinctive smells!) of the Adelies on their nests. A second live camera will show the laboratories back at Palmer Station, where the researchers bring blood samples and evidence of the penguins’ diet for analysis. Videotape sequences will compare “A Day in the Life of a Penguin Colony” with the life and work of the researchers who study them. We’ll check out the safety features of the Zodiac inflatables, and commute to work across waters so cold they could kill in minutes. We’ll see life at Palmer Station, where days of devotion to science amid extreme and sometimes dangerous conditions are enlivened by nights of pizza parties and an occasional “Palmer Pentathlon”!



Unobtrusive Observation or "The Spy Who Went Out In the Cold"

Teacher Background

The shores and oceans around Antarctica are home to about 100 fish species; six seal species, comprising two-thirds of the world's seals; several whale species, including the blue, fin, sei, humpback, sperm and right whales; more than 50 species of birds, including seven penguin species, which make up the largest percentage: the total population of birds breeding on Antarctica is estimated at over 100 million. Current and potential threats to Antarctica include exploitation of wildlife through over-fishing and hunting; an uncontrolled influx of tourists; destruction of the ozone layer and the resulting increase in ultra-violet radiation which could impact the phytoplankton upon which krill feed, and thus affect the food web of the Southern Ocean; and mining of the continent's anticipated mineral wealth (currently restricted by the Antarctic Treaty).

All researchers in Antarctica operate under the terms of the Antarctic Conservation Act, an extension of the Antarctic Treaty. The USAP has especially strict guidelines about "taking" wildlife, which is defined as anything which changes their behavior, from disturbing creatures while filming them to necessary direct contact as when obtaining blood or other physiological samples for research purposes. This Activity puts students in the shoes of researchers who need to get up close and personal with wildlife, without changing natural behavior more than is absolutely required.

VOCABULARY

austral

behavior

ecosystem

spatial/temporal measurement

Objective

Students will collect behavioral data on domestic "wildlife" and "animal behavior", exposing themselves to problems inherent in unobtrusive close observation.

Materials

- wrist or pocket watch with automatic alarm feature
- small notebook and pencil to record observations

Engage

Post the questions below and allow students 2–3 minutes to write their responses. Ask students how accurate these observations are? Are they "scientific?" "Objectively correct?" Why or why not?

- *Where were you and what were you doing at exactly 7:25 a.m. today?*
- *At 1:18 p.m. last Saturday?*
- *Who was you with?*
- *Without looking down, what color are the socks you put on this morning? Your shirt?*

Explain/Explore

Researchers interested in animal behavior train themselves to observe their surroundings with care. With some of the skills and hi-tech tools of James Bond, Agent 007, scientists are environmental spies who use whatever is available—from their senses to computers to satellites—to help them understand the creatures they're studying, without changing their behavior by the very act of studying them. Have students brainstorm real-world examples of such tracking. Some examples might include: the annual Audubon Christmas Bird Count; whale watching; one-way windows in research centers, lab schools and hospitals; hidden cameras in department stores; satellite tracking systems, sonar and radar. Once the "raw data" is collected, researchers organize and work on it until they see meaningful patterns in graphs or statistics, which allow them to make predictions about future behavior which can be tested. If the predictions are confirmed, then researchers can begin to postulate conclusions.

Procedure

1. Distribute *Activity 2.1* Student Worksheet, "Unobtrusive Observation". Allow time for students to read; discuss procedural steps and answer questions. Decide on appropriate date by which all students will have completed the assignment.
2. When all students have completed this Activity, schedule time for sharing experiences. What general conclusions can be drawn? Discuss problems students may have encountered in observing humans—what parallels can be made in regard to observing animals in their natural habitats?

Expand/Adapt/Connect

Observing and Recording Animal Behavior

1. Working in pairs, students can unobtrusively observe a preschool or kindergarten class during free play, either in class, or on the playground. Record individual differences in behavior. Are some children aggressive? Non-aggressive? Watchful? Impulsive? Social? Loners? Are there gender differences? Are there correlations of behavior with size?
2. Next, arrange for the teacher to quietly place a bag of lollipops or M&M's in a prominent place in the room where anyone can take one. Observe and note what happens in terms of traffic patterns. How does the introduction of a food cache change animal behavior?
3. Have students be on the lookout for the different sampling and observation techniques employed by the researchers seen during *LFA 2*, and write an essay on the "Perils and Pleasures of Observing Antarctic Wildlife" as part of a Closing Activity.

Have students create and compare different types of graphs showing how they use their time (sleeping, reading, eating, studying, watching TV, etc.)

SUGGESTED URLS

WhaleNet's STOP (Satellite Tagging Observation Program) whale and seal tracking via satellite
http://whale.wheelock.edu/whalenet-stuff/stop_cover.html

Australia's Antarctic Research Division: current research on seals, penguins, krill, etc.
http://www.antdiv.gov.au/aad/sci/bio/bio.html

Staying Warm in Frigid Waters: Heat Exchange

Teacher Background

We can't promise exactly how many whales students will see close-up during *LFA 2*, but we hope to record at least a few as our crew travels to Palmer. None of the researchers we'll meet this year have whales as primary research targets, but as the "top" of the Antarctic food chain they're obviously of great interest. This Activity allows students to model some key features of whale physiology in a very direct way. (See sidebar, below, for more real-world occurrences of biological counter-current heat flow.)

Whales are warm-blooded mammals who spend their entire lives in the open sea. Their transition from land-dwelling creatures to the oceans over 50 million years presented whales with great physical problems to solve. Like all mammals, their core body temperature needs to be between 35 and 38° C. But their skin is often close to the temperatures of the waters in which they swim, anywhere from –2 up to 30° C. So the degree of thermal protection they need can vary 5-fold. Going from rest to maximum activity produces another 10-fold change in metabolic heat production. A whale resting in the cold Southern Ocean may need 25 to 50 times the heat conservation of a whale swimming at high speed in tropical waters! Students will probably cite blubber as what keeps whales warm, but ironically, during times of great exertion, it also prevents them from cooling off. Metabolic heat produced from eating as much as they do—and moving enormous muscles—has to be dissipated somehow. Why don't they overheat and die? How is the whale's metabolic system uniquely adapted to the task of preventing frostbite *and* overheating?

Objective

Students will demonstrate the principle of counter-current heat exchange and illustrate their experimental data in chart form.

Materials

- 1/2 inch plastic tubes one meter long
- 1/4 inch copper tubes a meter and a half long
- short sections of flexible tubing to fit on ends of copper
- 4 funnels
- 4 foam cups
- 4 thermometers
- towels
- lab stands or pegboard walls
- safety goggles
- *Activity 2.2* Student Worksheet, "Staying Warm in Frigid Waters"

Engage

Complete the following demonstration: pour 1 cup of hot water through a 1 meter long tube, collecting it at other end of tube. Ask students if they think the water changed in any way as it traveled through the tube. Write all guesses on the board. Direct discussion to the possible cooling of the hot water. Ask how they might measure any changes in temperature.

Have students brainstorm a human system that moves a liquid through tubes throughout the body. *(circulatory system)* What functions does the circulatory system have? *(takes food and oxygen to cells, removes waste from cells, regulates body heat)* What must humans do to protect themselves from the cold? How is this different from Antarctic marine mammals?

VOCABULARY

adaptation
artery
baleen
cetacean
extremity
flipper
fluke
hypothermia
metabolism
vein

Biological Occurrences of Counter-Current Flow

Counter-current flow is widely found in fish and animals. Counter-flowing blood conserves body heat for whales, seals, cranes, herons, manatees, sloths, anteaters and armadillos. Other animals don't have counter-current arrangements even though they live in cold climates. These include ducks, geese, sea gulls, foxes and huskies.

Camels have scroll-like passages called *turbinates* in their nose which turn back upon each other creating counter-current airflow to conserve both energy and water.

The bumblebee produces lots of heat with its flight muscle. Counter-current blood flow is used to regulate heat transfer during warm weather and during vigorous wing activity. Kidneys concentrate urine by counter-flowing body fluids in the loop of Henle.

Fish gills are another fine example of counter-current efficiency. Animals which breathe air inhale 200 cubic centimeters of oxygen with each quart, but a quart of sea water has only 5 cubic centimeters of oxygen. A fish can take up 80% of that oxygen by arranging capillaries in the gill plate to allow blood to flow counter to the flow of water across them. Go to a fish monger and obtain gillrakes from fish being cleaned. You'll be able to see the folded double loop.

Explore/Explain

Explain that students will explore counter-current heat exchange.

Procedure

1. Distribute and review *Activity 2.2* Student Worksheet. Organize lab teams and answer procedural questions. Post a class data table on the chalkboard.
2. When teams have completed Part A, compare and discuss data. Continue with Part B; then compare and discuss data.

Expand/Adapt/Connect

Although rudimentary, there's artery-to-vein heat transfer in humans. This is the mechanism by which we blush or our skin flushes after exercise. The human arm has three veins nestled around deep arteries with isolated veins occurring just under the skin. Arterial blood flows outward toward the hand and venous blood returns to the body core producing counter directional flow quite similar to the model created in the classroom.

Explain

Whales and seals swim in sub-zero Antarctic water with uninsulated fins and flippers continually submerged. How do they maintain their warm body temperature?

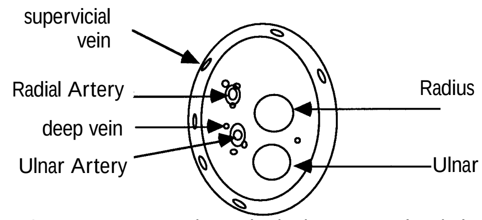
Whales and seals bypass the static insulation of blubber and produce active temperature regulation by having two alternative venous blood return systems. One pathway conserves metabolic heat at times when their environment is too cold. The other pathway allows them to dissipate heat even when they are well insulated with blubber. The cooling pathway is what we might typically expect to find with deep arteries taking warm blood to the extremity, and veins returning along the under-surface of the skin in such a way that blood cools. The heat conservation pathway is an ingenious counter current heat-exchange system consisting of deep parallel arteries and veins which allows warm outgoing arterial blood to pass its heat over to blood returning in the venous system.

The heating and cooling needs of whales change rapidly. Muscles can flatten veins and shunt blood into one system or the other. Heat is produced throughout the muscle bulk of the whale when it exercises. With movement, arterial pressure is increased. The enlarged artery pushes on the encircling veins and restricts blood flow in them. The counter-current exchanger is cut off and the blood must return through veins near the skin. Thus, heat is lost at the surface of fins and flippers. Fins and flippers are efficient cooling surfaces because they have many blood tubes and very little insulation, allowing blood to cool quickly as heat is lost in the sea.

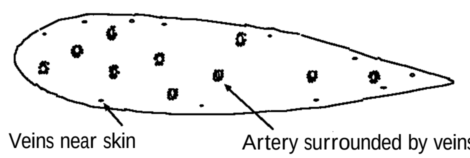
If whale blood systems have such complexity in order to provide sufficient cooling, what is the purpose of all that blubber? It appears that blubber is needed as a food storehouse while whales make their yearly, several month excursion to warmer water. It is calculated that half of a whale's blubber could provide energy for metabolism for four to six months, which is very close to the interval spent not eating.

Expand/Adapt/Connect

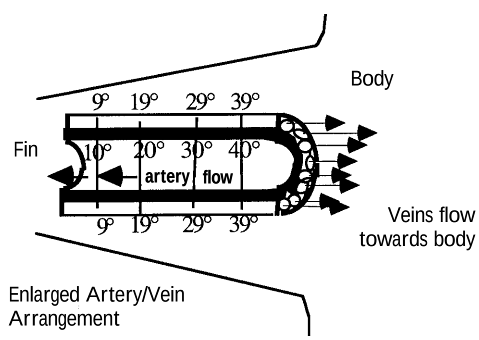
Search the internet for "marine mammals". Download articles that further explain the heat exchange concept in Antarctic marine biology.



Countercurrent exchange in the human arm just below the elbow. In cold weather, blood returns to the core through veins that run next to deep arteries. In warm weather blood returns through veins near the surface.



Cross-section through a fFuke (horizontal lobe of a whale's tail)



Enlarged Artery/Vein Arrangement

SUGGESTED URLS

ICAIR (NZ) file on Adaptation to Cold with focus on seals, whales, fish, birds, krill, etc.
http://www.icair.iac.org.nz/~psommerv/web/informat/adapt/8_adapta.htm

"How Do Survival Techniques of Antarctic Explorers and Polar Animals Compare?" Students from Worcester, MA, conduct adaptation experiments, and investigate thermal energy, conduction, insulation, and convection.
http://nis.accel.worc.k12.ma.us/WWW/Projects/Antarctica/antarctic.html

Penguin Adaptation

Teacher Background

Penguins are designed for life in the sea. Some species spend as much as 75% of their lives in the water, though they lay their eggs and raise their chicks on land. A streamlined body, paddle-like feet, insulating blubber, and feathers for waterproofing all add to their efficiency and comfort underwater. Heavy, solid bones act like a diver's weight belt, allowing them to stay submerged. Their wings, shaped like flippers, help them "fly" underwater at speeds of up to 15 mph. They also have a remarkable deep-diving ability. In addition to blubber for insulation, penguins have stiff, tightly packed feathers (up to 70 per sq. in.) which overlap to provide waterproofing, coated with oil from a gland near the tail to increase impermeability. Their distinctive black and white shading makes them nearly invisible to predators from above and below. Like most birds, penguins have little or no sense of smell (a boon for those in a crowded penguin rookery!) Like other birds, their sense of taste is also limited. Scientists suspect they may be nearsighted on land. Their vision appears to be better when they're underwater.

Penguins are considered to be the most social of birds. Rookeries may contain thousands of individuals. (As many as 24 million penguins visit the Antarctic continent!) Even at sea, they tend to swim and feed in groups. Most species of penguins build nests, but the nests may consist only of a pile of rocks or scrapings or hollows in the dirt. Emperor penguins build no nests; they hold the egg on top of their feet under a loose fold of skin called the brood patch.

Objectives

Students will investigate animal adaptations to a cold environment and incorporate key findings by designing an organism well-adapted to this environment.

Students will demonstrate the ability to predict animal behavior patterns by simulating penguin foraging activity.

Engage

Brainstorm ways in which penguins are well-adapted to cold water and icy environments. Then complete the following demonstrations:

1. Flying birds need large wingspans to hold themselves up in the air, but small wings work best for birds swimming through water. Demonstrate this with two pieces of flexible card. Try to push one, flat, through a pan of water. It's hard. Fold another piece five or six times and try pushing that through the water. The smaller, stiffer card, like a penguin's wing, works better.
2. Most birds have hollow bones to make their bodies light enough to become airborne. But the penguins' heavy, solid bones help them float lower in the water. With the help of two student volunteers, demonstrate the difference between hollow bones and solid bones using two toilet paper rolls, one empty the other stuffed with tissue paper.
3. Float an empty can in a bucket of water open end up. It floats high in the water like flying aquatic birds (ducks, for example). Add sand to another can until it sinks slightly. Now push down on both cans. The sand-filled container is easier to push down into the water. In this way, it's easier for penguins to dive into water.

VOCABULARY

adaptation
blubber
surface area
volume
foraging
predator
prey
Venn diagram

Blubber Glove!

Explore/Explain

Materials (for each team of students)

- four large, re-sealable ("ziploc") clear plastic bags
- one pound of solid vegetable shortening (such as Crisco)
- masking or duct tape
- a bucket of cold water with ice cubes
- watch with a second hand or stop watch
- weights (such as stones)

Procedure

1. Each work team of 2–4 students will need 4 bags and 2–3 cups of solid shortening. Have students take turns covering one hand with a plastic storage bag. Put a generous amount of solid shortening into another bag. Have the student put the plastic-covered hand into the bag with the shortening. Knead the shortening to make sure the hand is completely surrounded by shortening.
2. Wrap masking tape around the portion of the bag covering your wrist to seal the bag. (optional).
3. Cover the other hand with 2 bags without shortening. This is the "control."
4. Place both hands simultaneously into a bucket of ice water. Team members time and record how long each hand remains underwater until the sensation of cold is noted. Whales, Weddell seals, and penguins all have blubber. How is solid shortening like the blubber that these Antarctic animals have? What other advantages does blubber give marine animals besides warmth? *(buoyancy, food source, and heat exchange)*
5. Remove the bags from the students' hands and seal the inner bags so water won't get in. Drop weights into the outer bag of each double "glove" and put the bags gently back into the bucket of water. How much weight can each bag hold before it sinks to the bottom of the bucket?

Adapted with permission from *The Aquarium of Maine* web pages:

http://octopus.gma.org/surfing/antarctica/penguin.html

http://octopus.gma.org/antarctica/blubber.html

Create a New "Antarctic Adaptable"

Materials

- globe
- Venn diagrams
- construction paper
- two empty toilet paper rolls
- tissues
- two empty cans
- bucket of water
- sand, art supplies
- shoe box for each student
- modeling clay or play dough

Procedure

1. As a class, make a Venn diagram to show the ways that penguins are different from and similar to other birds. Next, in smaller groups, make Venn diagrams showing how penguins are both different from and similar to seals, whales, fish, and other birds.
2. Using ideas from the discussion about penguin adaptations and the Venn diagrams, have groups of students design an original marine animal that is also well-adapted for the cold
3. Make a picture of the animal or model it from playdough or clay and place it in a shoe box diorama. Label unique features which help it adapt to the cold.
4. Have students explain the rationale behind the design of their animals and habitats. Does it reflect earlier discussions?

A Penguin Foraging Simulation Game

Materials

- 1 paper cup per student, for "stomach"
- spring-type clothespins as "bills"
- various food items assigned different points based on their energy worth
- 300 1/2" metal washers (large krill) (worth 10 energy points)
- 300 M&Ms (small krill) (worth 8 energy points)
- 300 round toothpicks (Thyanoessa) (worth 5 energy points)
- 300 marbles (salps) (worth 2 energy points)
- copy for each students of the "Adelie Breeding Cycle, Diet and Foraging Facts" Blackline Master #13

Engage

Display materials for this Activity and tell students that they will be simulating the foraging behavior of penguins. Have them review the Adelie fact sheet, and discuss items which seem most of interest to your class, setting the foraging simulation in its real-world context. Explain that the washers, toothpicks, M&Ms, and marbles represent penguin food items. Then demonstrate the use of the clothespin to represent a penguin's bill! The object of the game is to capture as much "prey" (in the paper cup) as you can within a time limit. The goal is to accumulate 500 points, expending the least energy in the shortest period of time.

Explore/Explain

Many factors contribute to the chick-raising and foraging success of penguins in Antarctica, including:

- type and abundance of prey available
- the amount of time a parent has to be gone from the nest
- suitability of the general area for trying to raise a chick
- how long it takes to get enough prey to feed a chick

Procedure

1. Select an open area such as a playground, park, or gym and randomly distribute the food items over a wide but defined area.
2. Explain to the students that you are the "top predator", signaling the start and finish of each round of play. As top predator, you may "capture" penguins that are breaking the rules or exhibiting disruptive behavior. Explain to students that in nature, birds that break the rules often have behavior patterns that attract predators.
3. Give each student a clothespin bill. Explain that food items must be picked up, not (scooped) with the bill and dropped into the paper cup "stomach". As is true in many societies, throwing food items is not allowed!
4. Give students 5 minutes to forage, or stop the round before the supply is too low, but make a note of the time allowed (adjust time to skill of group).

Foraging Facts

Recent years have seen significant increases in Antarctic penguin populations. Some have argued that this is the result of reduced competition from whales who, like penguins, also feed on krill. Palmer ornithologist Bill Fraser and his research team have challenged this assumption, suggesting that "penguin populations are increasing as a result of a loss of sea ice due to environmental warming." Supporting data has come from a winter expedition to the Scotia and Weddell Seas, recent satellite images of ocean ice cover, the analysis of long-term surface temperature records and penguin demographics.

Krill are the main diet of penguins. In January 1995, Antarctic krill were scarce in the area studied by the LTER team. The main prey item available that year was *Thyanoessa*, a smaller euphausiid, which provided the penguins with much less energy per bite than the krill they favored. So that year, the Adelie penguins had very long foraging times (the hours away from the nest foraging for food for their chicks.) At one point *both* parents were observed simultaneously leaving the chicks, a previously-unknown behavior suggesting a high level of desperation.

Here are some real world "Foraging Facts":

Prey items are picked up individually, so getting a large item gives more return for effort expended than a small one if the items are of equal value per gram.

But, size is not everything. In other years (1994, for example) Palmer researchers were finding both Antarctic krill and salps. Salps are larger than krill (up to 120 mm in size, with krill around 40mm), *but* they have a much higher percentage of water and so are not as economical as food. It's like filling your stomach up with water instead of a thick vegetable and chicken soup!

Penguins are restricted in the amount of time they can spend on each foraging trip because they need to get back to their chicks. Each foraging trip must also include time for swimming to the prey, time to feed for themselves, and time to fill up their stomachs with food to bring back to the chicks in the rookery.

5. Count and record the number of food items collected and their energy point equivalents.
6. Debrief findings in the first round of play. Next, alter conditions as follows:

- How might the results of the game change if *unequal numbers of prey* are distributed in the foraging area and the time limit is removed?
- What is the expectation if *food types are not randomly distributed* in the feeding area?
- How would the game change if *time* were not a variable?
- What might happen if only one prey type was used for the experiment, but half were the same color as the feeding area and half were colored very differently? Would one prey type be chosen more than the other?
- What might happen if other predators enter the foraging area and compete with each other for food?

7. Repeat the activity, and record the results.
8. Draw conclusions: what observations can you make about foraging behavior, competition for food, and availability of prey? *The amount of food brought back to the chicks is pretty constant, so the major variables are the prey distribution/abundance, and the time spent foraging.*

Adapted with permission from the *Los Marineros Curriculum Guide*, a marine science curriculum available from the Santa Barbara Museum of Natural History at 805-682-4711, ext. 311.

Expand/Adapt/Connect

Use a globe to show that all 17 species of penguins live south of the equator. One species, the Galapagos penguin, lives on the equator in the path of the cold Peru Current. Seven kinds of penguins visit Antarctica, but only two species, the Adelie and Emperor penguins, breed exclusively on the Antarctic continent.

How are the adult Adelie penguins able to survive while sitting on the nest? *(Blubber or body fat is a primary food source.)*

Penguins are the only birds that migrate by swimming. Students can research and map their migration routes, up the west coast of South America to Tetal Point in northern Chile, or up to the east coast of South America past Argentina as far north as Rio de Janeiro in Brazil. Estimate the distances they travel. Using satellite images located on-line, students can match the migratory routes of penguins with the location of currents. What assumptions can they make about migration routes by looking at infrared imagery? (*penguins follow cold water currents*)

Research North America's own "penguins," the flightless Great Auks. Learn how Great Auks were similar to penguins. Find out why they were slaughtered (for food, their feathers, and for stuffed specimens). These birds became extinct in 1844 when two museum collectors landed on a remote island off Iceland, strangled the last surviving pair for their collection and then smashed the last egg.

SUGGESTED URLS

Information on Flightless Birds, Behavior, Breeding, Locomotion, Colonies, Adelies, Emperors, Gentoos, Chinstraps and Crested penguins

http://www.terraquest.com/va/science/penguins/penguins.html

Sounds and sights from wildlife sound recordist and NSF Artist-in-Residence, Doug Quin, including penguins, leopard and Weddell seals, and the sounds of glaciers!

http://www.webdirectory.com/antarctica/

The Adelie Penguin Monitoring Program of the Australian Antarctic Division

http://www.antdiv.gov.au/aad/sci/bio/adelie_penguins/adelie_penguins.html

Comparative Marine Biology: Seals, Seabirds, Whales and Penguins

Teacher Background

The wildlife of Antarctica is uniquely adapted to withstand the harsh conditions of this region. The seven penguin species are the Adelie, Chinstrap, Emperor, Gentoo, King, Macaroni, and Rockhopper. The six seal species are the Antarctic fur, Crabeater, Leopard, Ross, Southern Elephant and Weddell. Six species of whales belonging to the southern baleen group make their home in Antarctica for at least part of the year: Blue, Fin, Humpback, Minke, Sei, and Southern Right. Six different species of toothed whales are commonly seen in Antarctic waters: Sperm, Orca, Southern Bottlenose, Southern Four-tooth and Hourglass, and Southern Right Whale dolphins. There are more than 40 species of flying seabirds and landbirds, with Skuas, Petrels, Gulls, and Cormorants among the more common. Banding and recovery studies show that some Antarctic birds travel throughout the world.

Objective

Students will compare and contrast features of several Antarctic animals and birds.

Materials

- ▼ Daily Log Sheet to record progress, on-line exploration, questions and observations
- ▼ references, print and on-line
- ▼ Copy of "Awesome Antarctica" Blackline Master # 14
- ▼ *Activity 2.4* Student Worksheet, "Comparative Marine Biology"
- ▼ transparency of *Activity 1.5* Antarctic Food Web illustration

Engage

Have students brainstorm a complete list of Antarctic animals. Record list on chalkboard; discard any animals that are *not* found in the Antarctic! Discuss methods of grouping these animals, then rewrite list under category headings.

Explore

Procedure

1. Working in teams of 3–4, students will research a particular grouping of animals. Using the Worksheet to organize their findings, students may also want to add a section—a collection of "Weird" or "Amazing Antarctic Facts"!
2. When the research and chart are completed, teams can present their findings.
3. Additional class discussion topics:

- ways animals in Antarctica are uniquely adapted to their environment
- ways in which the wildlife in Antarctica are threatened by outside factors
- implications if any one species were removed from the food web

Expand/Adapt/Connect

Use satellite images of the Southern Hemisphere and references on migration to trace the migration routes of various species of sea animals and birds that spend at least part of the year in Antarctica.

Vocabulary

adaptation
distribution
habitat
migratory
predatory
range

SUGGESTED URLS

Information about marine and terrestrial environments and animals.
http://www.terraquest.com/va/science/science.html

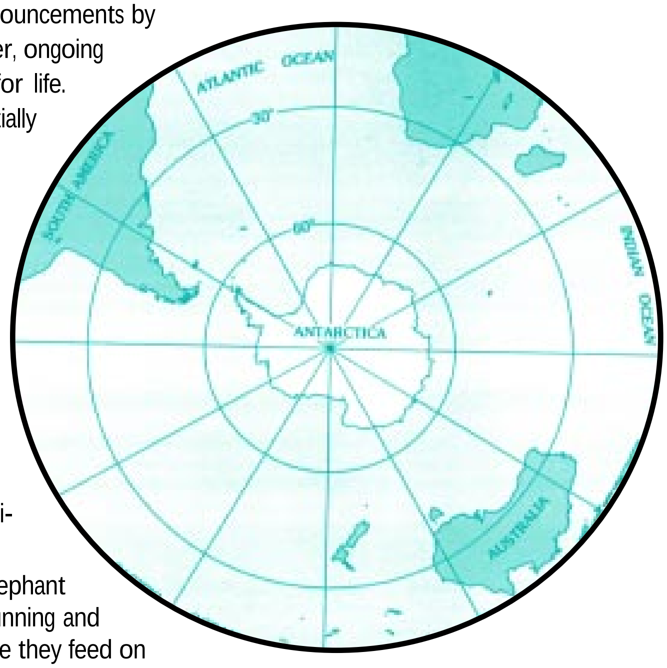
Images and background information concerning marine life.
http://www.icair.iac.org.nz/education/resource/informat/penguins/9_pengui.htm

Satellite images and pictures of Antarctica and the Southern Hemisphere
http://www-nsidc.colorado.edu/NSIDC/gallery.html

Program 3

Seeing the Future

The ozone hole and its implications for global climate change are the science stories which have most captured the attention of students, teachers and the general public. Evidence of the ozone hole lay undiscovered despite years of collected data. But the presence of NSF's U.S. Antarctic Program stations at the Pole, McMurdo and Palmer allowed rapid follow-up to the first announcements by British researchers of the existence of the hole. Now in and around Palmer, ongoing research is attempting to trace the consequences of ozone depletion for life. Antarctica is like the canary in the mine-shaft, a living detector of potentially dangerous consequences for life all around the planet.



Researcher Tad Day works on Stepping Stones Island and other sites close to Palmer, carefully studying the small plants which grow only on the Antarctic Peninsula. The relatively milder temperatures and frequent rain allow their growth. He builds tiny greenhouses for his sample plants, using filters to control the precise amount of ultraviolet radiation (UV) that falls on them. (Tad has also cooperated with *LFA 2* in the creation of Activity 3.2 which allows students back home to parallel his field research.) There's also evidence that average Antarctic temperatures have increased over the years, and Day wants to determine how these plants respond. Although much work has been done on the effects of increased UV and global climate change on animal life, this is the first high latitude study of these effects on plant life.

Languishing on some of the islands nearby Palmer are colonies of elephant seals, large lugubrious mammals whose main goal on land seems to be sunning and snoozing. These creatures are considerably more active underwater, where they feed on the penguins and fish they dwarf in size. Our video visit to the elephant seal colony will have the same kind of "You Are There" feel as did our earlier excursion to the Adelie penguin rookery.

Polly Penhale, NSF's Biology and Medicine Program Manager, who is ultimately responsible for all the science done at Palmer, will take us on a tour of the elephant seal colonies and explain how these creatures fit into the Antarctic food web. We'll see seal pups nursing and learning how to crawl and swim. We'll see how the bulls noisily mark their territory and how they conserve energy on land so they can forage more effectively at sea.

This final program weaves together the earlier videos to teach us the larger lessons aquired by looking at microscopic marine life, krill, penguins, seals and skuas. Just as with the "canary in the mine shaft," the consequences of global climate change would first be felt in the high latitudes which *LFA 2* has been visiting. Scientists, many with twenty years or more experience in the Antarctic Peninsula, will reflect upon the evidence they've seen, and show how their continuing work in Antarctica can improve our understanding of the complex planetary forces that affect us. We'll see why hi-tech tools like remote sensing satellites, as well as basic field work studying penguin droppings and half-eaten fish are both required to understand our world. Students will realize that the intense work at Palmer is "just the tip of the iceberg" of careers spent wrestling with evidence, recording results, analyzing data, revising hypotheses—the same kind of hands-on, minds-on labor encouraged and modeled by Activities in this Teacher's Guide. We hope by the end of this third program, that neither the continent nor explorers will seem remote, but rather connected, relevant and meaningful.

Live sites will include Stepping Stones Island and Palmer Station. We'll take an aerial tramway ride across Arthur Harbor to Bonaparte Point, parallel Tad Day's field work with student experiments, and contrast huge seals and microscopic plants. Computer enhanced images from space interwoven with landscapes and life forms on Earth will demonstrate the connections of high-tech to biology, and inspire students to use telecommunications to keep in touch with the science and the scientists seen in all 3 programs.

An Ozone Primer

Teacher Background

Wrapped around Earth is the atmosphere, which has evolved over the course of billions of years. Without this protective blanket of gases, life as we know it would be impossible. In comparison to the size of our planet, however, the thickness of the atmosphere is like that of the skin on an apple, and it's perhaps much more fragile than we'd like to imagine. The effects of changes in the atmosphere such as an increase in "greenhouse gases" and ozone depletion can be studied in Antarctica by looking at plants, the ice sheet, sea ice and solar radiation.

Ozone protects all living things on Earth from the damaging effects of ultraviolet light by absorbing most of the harmful ultraviolet radiation (called UV-B) from the Sun, which can be very damaging to living cells. UV-B causes some types of skin cancer and eye diseases in humans.

In 1985 British scientists published their findings on a strange and unexpected occurrence over Antarctica. They noticed that large amounts of ozone had disappeared over the continent during September (as sunlight returns after months of darkness), but that during November and December ozone levels returned to normal. Since 1985, while varying in extent from year to year, the now-notorious "ozone hole" has covered a wider area, has extended further up and down in the atmosphere, and lasted longer.

The chemical explanation of ozone depletion is as follows:

Ultraviolet light strikes a CFC molecule and causes a chlorine molecule to break away. The chlorine collides with an ozone molecule (O_3) and steals an oxygen atom to form chlorine monoxide and leave behind a molecule of ordinary oxygen. When a free atom of oxygen collides with the chlorine monoxide, the two oxygen atoms form a molecule of oxygen (O_2). The chlorine atom (Cl) is thus released, and is free to destroy more ozone.

The ozone hole appears over the Antarctic during austral spring for two main reasons.

1. During the spring, air high in the atmosphere spirals around the Pole. This is called the "polar vortex".
2. In the presence of sunlight, chlorine pollutants (chlorofluorocarbons, man-made chemicals used in refrigerators, spray cans, some plastics and fire extinguishers) in the atmosphere break down ozone molecules.

Objectives

Students will construct a Parts Per Million (PPM) model of normal atmospheric ozone.

Students will illustrate and describe chemical processes causing ozone depletion.

Students will research the latest findings on Antarctic ozone depletion, by going on-line and using other research tools.

Engage

Brainstorm with class what they know about ozone and/or the ozone hole. List the following chemical symbols on the chalkboard and ask students to match each symbol with its name.

CFCs	chlorine atom
O_2	oxygen atom
O_3	Chlorofluorocarbons
O	oxygen molecule
Cl	ozone molecule

VOCABULARY

atmosphere
atom
CFC—chlorofluorocarbon
chlorine
chlorine monoxide
depletion
fluorine
molecule
oxygen
ozone
ozone hole
troposphere
stratosphere
ultraviolet radiation

Explain/Explore

Ozone (O_3) is a special form of oxygen molecule that consists of *three* atoms of oxygen bonded together instead of the usual *two*. It's normally present in the upper atmosphere in concentrations of just 10 to 15 parts per million. This is enough to filter out most of the deadly ultraviolet radiation (UV-B) that comes from the sun. Explain that in *Activity 3.1.1*, *Parts Per Million*, students will illustrate the fraction of the upper atmosphere that consists of ozone.

Activity 3.1.1

Parts Per Million

Materials

- 12 one meter sticks (or dowels cut to one meter lengths)
- masking tape
- modeling clay
- thread

Procedure

1. Construct a cube out of the meter sticks and masking tape.
2. Roll out 10 to 15 small spheres of modeling clay, each approximately one centimeter in diameter, representing ozone molecules.
3. Using thread, suspend each sphere at a random location within the cube.
4. Calculate how many cubic centimeters there are in a cubic meter. Have students express the relation of the ozone to the cubic meter or atmosphere. *(Each sphere represents one part per million of the total volume of the cube.)*

Activity 3.1.2

Ozone Destruction: A Catalytic Process

Materials

- poster board
- crayons, markers, or colored pencils
- rulers
- protractors
- 6 sets yellow 1/5-in. round dot stickers (carbon atoms)
- 6 sets red 1/5-in. round dot stickers (chlorine atoms)
- 6 sets blue 1/5-in. round dot stickers (fluorine atoms)
- 12 small boxes white "reinforcements" (oxygen atoms), as used for file folder pages
- overhead projector
- transparency of *Activity 3.1.2*, Blackline Master # 15, *Ozone Destruction*

Engage

Pass out materials to students. Explain that they will be using colored dots to represent chemical elements. Each student will be responsible for creating a visual display of the ozone destruction (depletion) process.

Explore

Procedure

1. Use *Activity 3.1.2 Ozone Destruction* transparency to illustrate the process of ozone depletion.
2. Allow students time to create their individual poster illustrating this concept.
3. Students should explain process to a teammate.

Expand/Adapt/Connect

Go on-line and download maps of Antarctica showing the ozone hole since 1986.

Research the causes of ozone depletion on Earth. What's being done in the United States and internationally to slow the rate of ozone depletion?

- Why is ozone loss greater at the Poles? Is the loss greater in the Antarctic or Arctic region? Why? At what time of year is the loss the greatest?
- What is the difference between "good" and "bad" ozone? Where is the "bad" ozone found?

Research NASA's TOMS (Total Ozone Mapping Spectrometer). How does it work? What data has been collected so far and what does the data indicate?

How much do you weigh?

Because humans are consumers in a food web, every kilogram of our bodies was built out of nutrients from other plants and animals. Scientists estimate that the ratio of input to resulting body mass is about 1 to 10 (1:10). This means that to make 1kg of your weight, your body required about 10 kg of nutrients. Those 10 kg were made from 10 times that amount of the next item in the food chain.

An expanding and continuing ozone hole over the Antarctic could have serious results. All life in the world's oceans depends on phytoplankton. Through the process of photosynthesis, these tiny "drifting plants" convert carbon dioxide and water (see Activity 3.2) into carbohydrates, fats and proteins. If they are destroyed by UV radiation, the entire ocean food web would be upset.

As a rough and ready example of the "multiplier effects" involved in food chains, if you'd been raised on a diet of seafood, compute the number of kilograms of inputs farther down the food chain it might have taken to reach your present weight:

___kg your weight x10 > ___kg shrimp x10 >
___kg larvae x10 > ___kg phytoplankton

Try the same exercise with a beef diet:

___kg your weight x10 > ___kg beef x10 > ___kg grain

And with a vegetarian diet:

___kg your weight x10 > ___kg corn or rice

SUGGESTED URLS

EPA's Stratospheric Ozone Web site: science of ozone depletion, regulations, and many links:
http://www.epa.gov/docs/ozone/index.html

NASA Ames' resource files for teachers and students, particularly middle to high schoolers.
http://www.nas.nasa.gov/NAS/Education/TeacherWork/Ozone/Ozone.homepage.html

Includes animation of 1995 ozone hole data and links to current NOAA ozone images.
http://www.icair.iac.org.nz/environment/ozone/index.html

NASA's Facts—Fact Sheet on Ozone from modeling to monitoring projects.
http://pao.gsfc.nasa.gov/gsfc/service/gallery/fact_sheets/earthsci/ozonestu.htm

Earth Observing Systems Project at NASA, Goddard: history of TOMS (Total Ozone Mapping Spectrometer) and live image links.
http://webhost.gsfc.nasa.gov/nasamike/essays/toms/toms.htm

The Effect of UV-B on Plants

Teacher Background

The amount of potentially dangerous ultraviolet (UV) radiation reaching Earth's surface is enhanced by the austral spring depletion of stratospheric ozone, as described in Activity 3.1. Although recent research has demonstrated that increased exposure to solar UV-B radiation (between 280 and 320 nanometers) seems responsible for significant reductions in marine phyto-plankton productivity, no research has addressed how enhanced exposure to UV-B affects Antarctic vascular plants, the kind which uniquely grow along the Antarctic Peninsula. In projects conducted in other regions of the world, researchers have found that increased UV-B levels can adversely affect such plants as grasses and forbs (leafy, herb-like plants) and that these plants do not have effective systems for screening UV-B. Along with enhanced UV-B levels, there is evidence that air temperatures along the Antarctic Peninsula have increased over the past 50 years and will continue to do so. It is unclear how Antarctic plants are responding to this warming.

Dr. Thomas (Tad) Day, a botanist from Arizona State University, and his research team are attempting to determine if UV-B and warming temperatures affect photosynthesis, growth and reproduction in the only two vascular plants native to Antarctica, *Deschampsia antarctica* (a grass), called "antarctic hair grass", and *Colobanthus quitensis* (a forb), called "antarctic pearlwort". At various sites around Palmer, they'll be using filters to remove UV components from sunlight over naturally growing plants, and using different filters, transparent to UV, to warm other plants as controls.

This Activity allows your students to replicate, in class, Day's experiment, and compare and contrast their results with other students across North America, observing changes across time, as the seasons change. *Please note: you may wish to delay this Activity until spring in your region, since it must be done out-doors, where no window glass will filter UV and so interfere with the experiment.*

Our thanks to Dr. Day for his input to this Activity, and for reviewing the science.

Objective

Students will conduct an experiment which investigates the effects of UV-B exposure and warmth on seed germination and plant growth.

Materials

- 3 large boxes (copier paper boxes would work well) with lids
- * 10" x 48" sheet of special clear polyester, to screen/filter UV-B *(labeled with RED DOT)*
- * 10" x 42" sheet of clear cellulose acetate, transparent to UV-B: this is the "control" filter. *(labeled with GREEN DOT)*
- 30-40 pea or bean seeds (choose seeds that are relatively more cold tolerant)
- one bag potting soil
- metric ruler
- measuring cup
- water
- 36 seed pots
- 1 dish (for soaking seeds)
- roll of aluminum foil
- paper towels
- data sheet (student made)
- Exacto Knife
- diagram of Electromagnetic Spectrum (available in most Earth Science and Physical Science texts: see also Activities suggested in *PTK's Live from the Stratosphere*)

*** NOTE: These materials are supplied in the *Live From Antarctica 2* Teacher's KIT *only*, not with the Guide and co-packaged materials. To order *one set* of filters, mail a check for $10.00 (covering cost of filters plus shipping and handling) to:**

Passport to Knowledge, P.O. Box 1502, Summit, NJ 07902-1502

Engage

Review Electromagnetic Spectrum/light wavelengths/nanometers with class.

Place chemical equation for photosynthesis on blackboard. Ask students if they know what these symbols represent. Some students may easily recognize symbols for water and carbon dioxide.

Read Tad Day's on-line *Biography* and *Field Journal* aloud to class. Explain that students will be simulating his Antarctic research back in North America.

Explain

The equation for photosynthesis can be written as follows:

$$6CO_2 + 6H_2O + \xrightarrow{\text{sunlight}} C_6H_{12}O_6 + 6O_2$$

Photosynthesis is the process by which plants produce their own food ($C_6H_{12}O_6$). They use energy taken from sunlight to transform carbon dioxide, taken from the air, and water, taken from the soil, into carbohydrates. The rate of photosynthesis is governed by many factors, including temperature and light. In this experiment, students will filter the amount of ultraviolet light (UV-B) plants are exposed to, and observe the effect of this filtering on plant growth. They will also observe the effects of solar warmth on plant growth.

Explore

Review experimental procedure. Ask students to hypothesize possible effects of filtered UV-B light and solar warmth on seed germination and plant growth. Record all hypotheses on chart paper.

Also note that two variables will be manipulated in this experiment: the amount of ultraviolet radiation, and solar warmth. Students should discuss how best to control all other variables (seeds, water, environmental factors, etc.)

Procedure

1. Fill a small dish with room temperature water, and soak seeds for 30 minutes.
2. Line the inside of the three box lids with aluminum foil. Put 1cm depth of potting soil in each of the seed pots. Place 12 seed pots in each lid. Carefully pour sufficient water into each seed pot to saturate the soil.
3. In the *bottom* of one box, carefully cut an opening that is 9 x 16 inches. Cut holes in three sides of the box so that only a 1 1/2 inch frame remains (see Figure 1). Leave fourth side of the box uncut; this side will help strengthen the frame. Cover the openings on the box with the UV-B filter (indicated with the RED dot) and tape securely. Label this box "UV-B Filtered".

- Repeat this procedure with the second box, covering the openings with the clear cellulose acetate (GREEN dot). Label this box "Warm".
- The third set of plants won't be covered by any filter/frame; label these "Control".

4. After 30 min., carefully pour water from the small dish without spilling any seeds.

VOCABULARY

austral spring
carbohydrate
carbon dioxide
electromagnetic spectrum
forbs
grasses
hypothesis
light
nanometers
photosynthesis
radiation
ultraviolet
UV-B
wavelength

5. Tip seeds onto paper towel. Put 3 seeds onto potting soil in each seed pot. Add a dusting of soil to lightly cover the seeds. Carefully add a little more water so that this layer is also saturated.
6. Carefully place plants in sunny location outdoors. Place the *frames* over two sets of plants. Arrange plants so that uncut side of frames face NORTH. If possible, place plants in a location that is sheltered from the wind. *Note:* This experiment *must be run outdoors*; most window glass will filter UV light.
7. Plants should remain undisturbed in warm sunny location during daylight hours. Bring plants indoors at night or during inclement weather.
8. After two days check the seed pots daily for germination of seedlings. Keep pots well watered (water every 2-3 days). Record observations.
9. As soon as seeds have germinated (3-4 days or sooner), students should take daily measurements of plant height, number of leaves, total leaf area (see *Expand* section) and make any other observations (color of plants, strength of stem, etc.). Record all data on data sheet.
10. Continue monitoring plant growth for 2-3 week period.

Analysis

A. Describe what happened in each box. Did the results support original hypotheses?

B. Why was it necessary to grow plants outdoors?

C. Which variables were difficult to control?

D. How was this experiment similar to Tad Day's Antarctic research? How was it different?

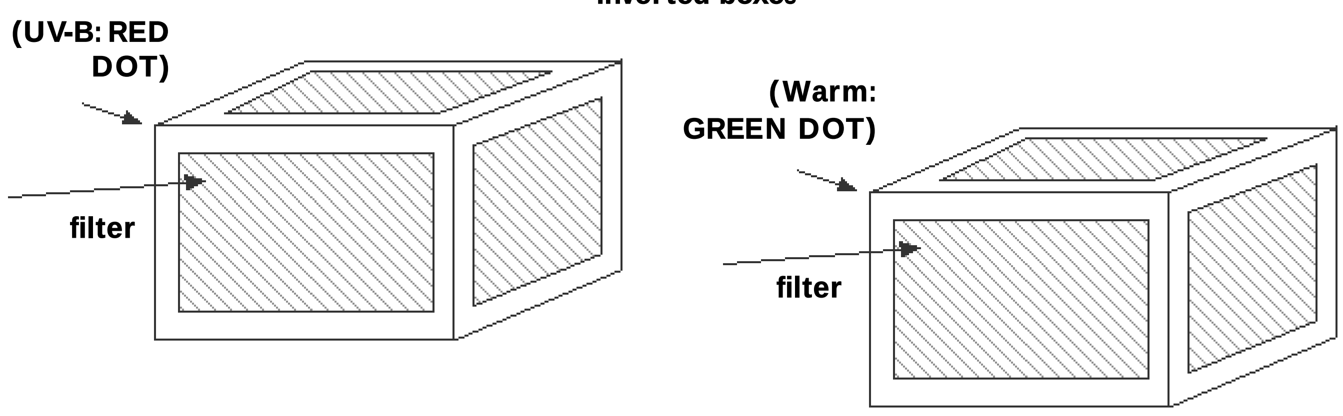
E. What conclusions can be drawn from the results?

Expand/Adapt/Connect

Students can *estimate* the Total Leaf Area for each plant by:

1. measuring the length (L) and width (W) of each leaf;
2. applying the following formula to estimate the area of the leaf: L x W x 0.7
3. totaling the areas

FIGURE 1:
inverted boxes



SUGGESTED URLS

An Ozone Depletion FAQ (Frequently Asked Questions) effects of UV on various life forms.
http://www.cis.ohio-state.edu/hypertext/faq/usenet/ozone-depletion/uv/faq.html

Tells how students can take part in EPA's on-line Ozone Depletion Art Project.
http://www.epa.gov/ozone/art/enter.html

Union of Concerned Scientist's Sound Science Initiative on Ozone Depletion
http://www.ucsusa.org/textonly/global/text.ozone.html

From Data to Death

Teacher Background

It's pretty obvious that Antarctica's unique climate and environment drive the processes which shape the life and death of the creatures who live here. But what's been happening in the past few years is an increasing understanding of exactly *what aspects* of the environment seem to have most impact on the food chain and *which* species thrive or struggle. The data which reveal these patterns aren't seen in majestic icebergs, or images of cute penguins, but in vast strings of numbers detailing myriad, individually inconsequential details about the size and distribution of creatures, temperatures, ice area, and other factors, collected over many years and then "crunched" into meaning.

Charles Darwin once wrote that the secret forces of evolution were "time and death." This Activity, bluntly called "From Data to Death", introduces students to two simplified data sets, supplied by researchers Robin Ross and Bill Fraser, and invites students to investigate the patterns hidden in them. With luck, the original researchers themselves will be looking over students' shoulders with hints and tips!

Here's some background on Robin Ross' krill data (you can find more in the Blackline Masters for this Activity, and on-line): Antarctic krill release many eggs in the ocean, but just like fish, many krill die before they reach adulthood. There's a lot of year-to-year variability in mortality rates, however, and one of the important aspects of the LTER research project is trying to understand exactly what aspects of the environment affect survival of these young krill. "Length frequency distribution", or how often a particular size occurs in the sample of krill collected, is one of the analyses routinely done on the *Polar Duke*. When measuring a krill, the LTER scientists use the following standard: total length is from the tip of the "rostrum" (the pointy bit between the eyes) and the tip of the "uropods" (near the end of the tail) and is measured in millimeters to two decimal places. Thus, krill measuring between 8.5mm and 20mm were hatched during the previous austral (January to March) summer. The year-to-year length distribution data combined with other environmental data (sea ice variability, weather, Adelie penguin and skua population statistics) provide data sets for scientists to analyze in order to better understand the structure and function of the Antarctic marine ecosystem.

Objectives

To simulate sampling techniques, students will utilize random selection to collect middle school height data.

Students will analyze, organize and graph given sets of Antarctic data.

Students will go on-line to question the Antarctic researchers, and discuss possible explanations for given sets of Antarctic data.

Materials

- transparency of krill (made from Blackline Master # 16)
- copy of Robin Ross' krill data (Blackline Master # 17) and description of sampling procedures
- copy of Bill Fraser's data (Blackline Master # 18)
- grid paper
- rulers
- markers
- computer/spreadsheet application software (optional)
- metric tape measures
- data collection sheets (student made)

VOCABULARY

bioacoustics
echosounder
larvae
random sample
receiver
transducer
variability

ENGAGE

Ask students to *estimate* the average height of all the students in their middle school. Record all guesstimates on chart paper. Then ask students how they might obtain the data necessary to *measure* the average more accurately and objectively. Discuss the difficulties of attempting to sample every student in the school.

Explain/Explore

Review with students the purposes of LTER research in the Antarctic and the specific data collection techniques used by the krill group (random sampling at specific locations around the Palmer Peninsula, use of bioacoustics, and measuring of krill body lengths). Explain that LTER scientists cannot measure every krill at each location! Instead they use a technique known as random sampling to collect a set of data that represents the total population—they measure the lengths of 100 krill at each location.

Tell students they will use this technique to gather data that represents the distribution of body heights in their school.

Procedure

1. Working in small teams, students will measure the height of *every tenth student* entering the building on a given morning. Each team will be assigned a specific entrance to monitor. Advance planning should include the following:
- cover all entrances (which ones have highest morning traffic?)
- consideration of structural factors, e.g. do all the older (taller?) students arrive early some mornings for some specific activity?
- establish standard measurement techniques
- efficient recording of data
- permission of school administration
- advance notification/explanation of event to staff and students
- compilation of data
2. After data collection has been completed, students may create simple bar graphs showing data distribution.
3. *Mean*, *median*, *mode* should all be reviewed. Students compute average.

David M. Karl

Oceanographer David Karl was on board the R/V *Polar Duke* as it took our video crew south to Palmer Station just before Christmas 1996. He'll be seen deploying sediment traps during Program 1.

I was born and raised in Buffalo, New York on the shores of polluted Lake Erie. My interest in science was sparked by my desire to do something to protect the environment and I thought that I would eventually enter the field of wildlife biology. I attended a public high school and received a good education, but in retrospect had only three meaningful courses during those 4 years: Latin, Chemistry and Algebra. My performance in high school was less than my potential, especially by comparison to my academically talented siblings. When I was 17 years old I saw the ocean for the first time and knew at that moment that I would make a career in oceanography. Everything from that time was focused on achieving that goal.

…I am currently a Professor of Oceanography at the University of Hawaii, where I enjoy teaching graduate courses and conducting research. When I am not working in the field or in the classroom, I relax by riding my Harley-Davidson motorcycle or by kayaking in the blue waters of the Pacific Ocean. My career in science has been both rewarding and exciting. I cannot imagine doing anything else, and I cannot imagine having a “real” job.

SUGGESTED URLS

Images and charts relating to the Antarctic krill population.
http://www.antdiv.gov.au/aad/sci/bio/issues_krill/issues_krill.html

Virtual Antarctica's Marine Ecosystem background file on plankton, krill, squid and fish.
http://www.terraquest.com/va/science/environments/m.environments.html#B

Data Analysis

Engage

Display transparency of krill (Blackline Master #16) on screen. Ask students to estimate the length of a krill in millimeters. Record all measurements on chalkboard; find range of measurements.

Explain/Explore

Procedure

1. Distribute Robin Ross' krill data. Review and discuss headings for each column of data. Direct students to begin analyzing the raw data with the following questions:
   - *What factors might have influenced the data collection on a given cruise?*
   - *Were the months all the same? the years?*
   - *Which cruise collected the most data? the least?*
   - *What is the smallest number? the largest?*
2. Review the life cycle of krill (See *Krill to Kill?* Blackline Master #10). Explain that krill with body lengths from 8.5mm to 20mm were born the previous austral summer. Direct students to examine the data to find the greatest incidence of these small body lengths. What might this indicate to scientists? *(successful "recruitment")*
3. Ask students how this data might be organized so that it's more easily analyzed and understood. *(numbers can be arranged from smallest to largest, data can be made into a graph)*
4. Pair students and randomly assign (pick out of a hat!) one data set for each pair. Have students work cooperatively to create a graph representing their data set accompanied by a written paragraph summarizing the data.
5. Go on-line with questions to Robin Ross during program 1, or submit via *Researcher Q&A*.

Extend/Adapt/Connect

Distribute Bill Fraser's data set, which includes krill data along with sea ice extent, length of penguin foraging trips, and the number of breeding pairs. Assign students to small data analysis teams with the following tasks:

- *What categories of data were collected?*
- *How many samples were collected?*
- *What variables are being compared?*
- *Based on this data, what inferences might be made?*
- Go on-line with questions to Bill Fraser during Program 2, or submit via *Researcher Q&A*.

Students may enter the data sets into spreadsheet or graphics programs, and create a computer-generated graph or display.

Go on-line via *discuss-lfa*, to share ideas with other teachers using this Activity.

Research and illustrate the life cycle of krill.

"Antarctic Expo" or Community Showcase

Teacher Background

Interdisciplinary teaching means that disciplines connect through a central theme, issue, process or experience and encompass all areas of instruction. Interdisciplinary teams try to teach skills with application beyond one subject, make the curriculum relevant to today's students, and teach students to think and reason. According to the National Assessment of Educational Progress, interdisciplinary teaching provides conditions under which effective learning occurs. Knowledge gained in one context becomes the basis for knowledge to be acquired in other contexts, both in and out of school. Students learn more when they use their developing critical thinking and language skills to explore and write about what they're learning, and interact with their classmates, teachers and other members of the community. *Live From Antarctica 2* provides middle schools (especially) and middle grades teaching teams with a wonderful opportunity to make learning an integrated and contextualized experience.

The interdisciplinary nature of *Live From...* Modules affords teaching teams an ideal opportunity to showcase their students' efforts to the whole school community, to students' families, and to the community at large. When schools and their stakeholder communities come together to share a unique experience and celebrate a job well-done, the benefits often extend far beyond the immediate event. Advance planning is necessary—scheduling a night on the master school calendar; securing locations (gym, concourse, halls or other public areas), and ensuring enough time for setting up and putting away computers and other displays; enlisting the help of PTA, PTO or other parent volunteers; sending out invitations; arranging for media coverage; even planning light refreshments all require a commitment of time and energy for a grand finale. However, many teachers participating in previous *Live From...* Modules have reported great success with such events, which both validate and provide closure for students' participation in these projects. Such a public presentation of knowledge gained also showcases in very specific ways the beneficial results of new learning experiences only made possible through the use of computers and telecommunications.

Objective

Students will reflect on and summarize what they've learned during the *Live From Antarctica 2* Module and develop ideas to share their experiences with others.

Materials

- individual or group projects, in any and all media
- *Antarctic Logbooks*
- binder, dividers, art tools (crayons, markers, scissors, tape, etc.)

Engage

Re-post the list of items that students could include in their individual *Antarctic Logbooks.* Have students review their *Logbooks*, and discuss how they feel about what they've learned. As they assemble their final *Logbooks* for self and teacher assessment and review, encourage students to choose examples of their work which they feel best illustrate their own individual achievements and/or challenges.

Explore

Procedure

1. Each student reviews and reorganizes selected materials from his/her *Logbook*, with special attention to those items required by the teachers.
2. Draw up a "Table of Contents" detailing the work being submitted for assessment and grading.
3. Complete a written evaluation of the electronic field trip experience, *Live From Antarctica 2.*

"Antarctic Expo"

Engage

Have students brainstorm a complete list of activities implemented during the *LFA 2* Module in all their classes. Compile list on the chalkboard. Have students identify through discussion those activities they found most meaningful, interesting, fun (or boring!) How and with whom would they like to share what they have experienced and learned? List all suggestions and discuss. If not already suggested, present the idea of organizing a major public event—an "Antarctic Expo".

Explore

Procedure

1. Assign independent Antarctic research project (see suggestions)—with individual student choice of topic, presentation mode, small group or individual work, etc.
2. Brainstorm and set-up a task/responsibility/time chart outlining all necessary tasks for the "Antarctic Expo."
3. Organize student (and parent) volunteers to work on the following committees: publicity, invitations, decorating, displays, set-up, clean-up, room, hallway, gym usage, tour guides, tech experts, hardware/software, video crew (tape showcase event)

Extend/Adapt/Connect

Design on paper, and then build an Antarctic landscape, or diorama in the gym, cafeteria, or central concourse of your school. Outline the Palmer Peninsula, or the Palmer Station area with its many small islands on floor, create a scale replica of Palmer Station, a deck of the R/V *Polar Duke*, or an outline of a Zodiac, etc. Situate "poster" or Activity stations appropriately by topic.

Involve all disciplines in the "Antarctic Expo" experience. If possible, enlist aid of Wood Shop, Home Ec., Art and Music staff and classes. Make the evening a truly interdisciplinary Antarctic experience!

Possible Topics to Explore

1. Preserving "Earth's last great science laboratory"
2. Scouts (Boy and Girl) and Teachers visiting Antarctica
3. Territorial claims in Antarctica
4. Protecting the untapped natural resources (esp. minerals, oil) in Antarctica
5. The environment: ozone layer and greenhouse effect
6. Impact of tourism in Antarctica
7. Fishing rights
8. SCAR (Scientific Committee on Antarctic Research)
9. International Geophysical Year
10. The Antarctic Treaty
11. International Polar Years (1883 and 1932)
12. Women in Antarctica
13. Writers/journalists sharing their view
14. Research Stations in Antarctica
15. The Race to the Pole
16. Ocean animals and the food chain
17. Sea birds of Antarctica
18. Ice: shelves, sheets, packs, polynas, and the 78 kinds!
19. Pollution at Winter Quarters Bay (the dumping ground for McMurdo Station until the late 70s)
20. Recycling in Antarctica, operating at 3-4 times efficiency of the best American state

Share this experience with other classes via "discuss-lfa". Also please remember to send news clippings, videos, snapshots, etc. to:

Passport to Knowledge
P.O. Box 1502
Summit, NJ 07902-1502

SUGGESTED URLS

Find more about such Closing Activities, and tips from teachers who've done similar events in the past, via the LFA 2 Website:

http://quest.arc.nasa.gov/antarctica2

Design the "Next" Palmer Station

Teacher Background

During the course of *LFA 2*, students have been exposed to a wide variety of research on board the *Polar Duke*, on Zodiacs, at Palmer itself, and on islands all around the station. They've seen trawls and dredges, miniature greenhouses, regurgitated penguin meals, and found out how you track wild creatures without interfering. Now they have a chance to dream up new and more effective ways of doing all this, with human laws (the Antarctic Treaty) and laws of Nature (climate, ice dynamics) being exactly as they are now... but with budget as no limiting factor, and with emerging and perhaps still unproven technologies as possibilities. NSF is not going through any such redesign for Palmer at the moment (as it is for the South Pole), nor does it expect to replace Palmer soon. But... this may have been one of the last seasons for the *Polar Duke*, since it's close to the end of its long-term charter. But *LFA 1* showed students were so intrigued by an Activity inviting them to redesign Amundsen-Scott South Pole Station that we decided to adapt that challenge to Palmer.

Objectives

Students will identify the key elements of a full-scale research facility/facilities, focusing on marine biology and earth science in the Antarctic.

Students will evaluate current conditions and propose a design for a new research facility/facilities (ship-based or land-based) on the Antarctic Peninsula.

VOCABULARY
site
element
hazardous waste
retrograding

Materials:

- Blackline Master #19: "Designing Palmer Station"
- art materials as needed
- on-line access if possible

Engage

Based on what they've learned and observed, brainstorm a list of the challenges faced in living and working at Palmer Station. Next, review and list the research currently undertaken there.

Continue discussion with the following questions: Are the current living conditions in place at Palmer the best that can be devised for the small support staff and scientists who live there year round? How might they be improved? Take all suggestions. Should it be land-based? Above ground or below? Water-based? Both? Can you think of any examples (real or imagined) of self-contained, fully self-sufficient habitats already tested, or in the planning and execution stages?

Explore/Explain

Explain to students that, working in small design teams, the class will design and construct a new Palmer research habitat/science laboratory that will house about 25 people over the winter and up to 75 people in austral summer. (The current base is "max'd out" at 45, and worthwhile research projects may go unsupported for logistical reasons.) The key design teams are:

- Transportation and Site Engineering Unit
- Habitat Support Unit
- Science and Technology Needs Unit
- Operations Control Center Unit
- Human Needs Unit

Designers will need to consider several things as they make design decisions:

- portable vs. permanent construction
- energy sources
- independence vs. interdependence
- idea of habitat within a habitat within a habitat …
- water: storing it, moving it, creating it
- hazard control
- waste disposal

Procedure

1. Divide class into 5 "design teams" as above. Distribute Blackline Master #19. Review and discuss design challenges, suggested work strategies and timeline for completion.
2. While groups are completing Phase 1, teacher should monitor progress, facilitating ideas, research needs, and, if possible, ensuring appropriate access.
3. Design teams should be encouraged throughout this process to talk to other teams, sharing ideas and strategies. *No group should work in isolation!*
4. Encourage students to be active participants during Phase 2 presentations: the evaluation component is meant to broker the most robust ideas, not be a contest.
5. Before beginning Phase 3, the class should come to consensus regarding the final design product. (This could be a 3-dimensional construction, a drawing, a CAD graphic, a computer-generated presentation using HyperCard, HyperStudio, Kid Pix, PowerPoint, ClarisWorks slide show and others, or any other workable idea the team agrees upon and that can be implemented in a reasonable time frame) [Note: Look for a new HyperCard plug-in that allows stacks to be served over the Web.]

Expand/Adapt/Connect

Share your team design via the *LFA 2* website Student Work gallery.

Create scale drawings of your Palmer Station design.

Investigate the use of Computer-Assisted Design (CAD) software applications to create a final design presentation.

SUGGESTED URLS

Detailed information about Palmer Station: history and projects conducted.
http://www.crseo.ucsb.edu/lter/lter.html

U.S. Long-Term Ecological Research Network: major milestones and research
http://lternet.edu/

Live From Antarctica 1's (Dec '94-Jan '95) Activities included designing a new South Pole station.
gopher://quest.arc.nasa.gov/00/interactiveprojects/Antarctica/teacherguide/program3.txt

"Antarctica: Who Needs It?"
A debate about the cost and value of the USAP

Teacher Background

As we've seen, Antarctica has provided key insights into the functioning of our planet and its creatures, as well as providing spiritual challenge and a new frontier to explore. But American research in Antarctica is only made possible by government funds, and—as all students know—balancing budgets and assigning priorities is a local and national concern. Some in Congress have suggested that the U.S. does not need 3 permanent Antarctic bases: most agree McMurdo has to stay, but some argue Palmer should be closed, and others that Amundsen-Scott should be cut back rather than refurbished, and/or "internationalized" to share costs.

This Activity uses the format of a debate, "Resolved: that Palmer Station should be Closed", to motivate students' research on the value of Antarctic science, its costs in comparison to other national activities, and the role of Palmer in such a context.

VOCABULARY
argument
debate
rebuttal

Objectives

Students will synthesize, articulate and communicate what they've learned during *LFA 2* about the unique contributions of Antarctica, and Palmer Station and its associated ship-based projects.

Students will practice and demonstrate appropriate debating skills.

Materials

- Blackline Master #20: Excerpts from the report on the USAP by the Committee on Fundamental Science, National Science and Technology Council, April 1996, detailing Palmer Station operations among other topics.
- *Antarctic Logbooks*
- notebook paper, file cards, pens/pencils
- on-line access if available
- Blackline Master #21: A Guide to Debating
- Blackline Master #22: Debate Judging Criteria

Engage

Ask students to recall the different research activities going on at Palmer Station. List them. Distribute copies of the NSTC Report (see Materials.) Note that the 1995 cost of Palmer operations—operations and science—was some $12.02 million. (This does not include the 2 ships which both support Palmer, and operate independently, which total some $21.82 million: South Pole costs were some $16.06 million, and the total USAP budget was some $195.8 million, very comparable to the cost of NASA's *Mars Pathfinder* spacecraft, featured in *PTK's Live From Mars.*) Compare this to sports star salaries, and costs of Hollywood movies, space missions, a new library in your town or region. Solicit opinions about the importance of a base such as Palmer. How important is the research? Why? What kind of research would students consider eliminating? Why? If money were no object, what research would they like to see added to the existing programs?

Explore

Procedure

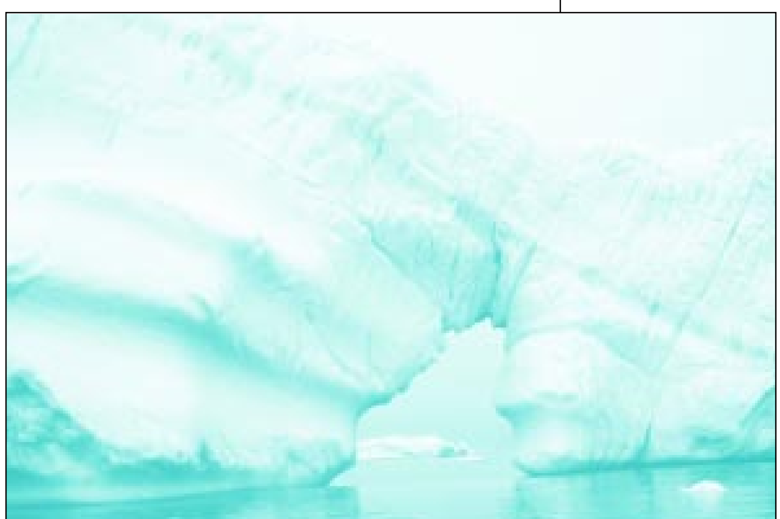
1. Explain that a formal debate is a well-organized, factually-supported argument in favor or against a stated position. Presenters do not necessarily have to believe in their position, but they must be able to argue for it and/or rebut their opponents' case with evidence, sound logic, and conviction.
2. Divide the class into debating teams of six each to brainstorm possible arguments for/against the statement, "Resolved: that Palmer Station should be Closed."
3. Distribute Blackline Masters: "A Guide to Debating" and "Debate Judging Criteria." Read, review, discuss.
4. Allow time for the teams to review the handouts and any relevant material in their *Logbooks* or to go on-line to strengthen their arguments.
5. As students prepare their arguments, invite assistance from language arts teachers or the debate team sponsor if your school has one. Interested parent volunteers might also be called upon to work with teams, listen as they practice presentations, and help them adhere to guidelines and time limits.
6. After adequate time to practice, present and judge the debates in each class.

Expand/Adapt/Connect

If this activity interested students, contact your high school English department to see if there is any organized interest in debating there. Advise the chairperson of the interest shown by your students, so the high school departments can capitalize on it in the future.

Have students write up reports on the debate, and submit to school newspapers, and the *LFA 2* Web site.

Top-scoring debate teams could be featured presenters during the "Antarctic Expo" Showcase (see Activity B.1).



SUGGESTED URLS

Also please note the special section of the LFA 2 Web site supporting this debate

NSF's site detailing research projects and goals of the U.S. Antarctic Program.
http://www.nsf.gov/od/lpa/news/publicat/nsf95138/chap7.htm#2
http://www.nsf.gov/od/opp/antarct/antprog/chiii.htm

Facilities, Logistics, and Support for NSF-supported research stations in Antarctica.
http://www.nsf.gov/od/opp/antarct/nsf9693/fls.htm

OPP's Director, Dr. Cornelius Sullivan, on "Why go to Antarctica to conduct scientific research?"
http://www.nsf.gov/od/opp/antarct/dec93/dec93-01.htm

Getting the Most from On-line

The on-line components of *Live From Antarctica 2 (LFA 2)* not only provide extensive information but also—perhaps more importantly—help the project come alive by connecting people together...

- **linking students and teachers directly with Antarctic experts**
- **allowing students to collaborate with other students**
- **encouraging teachers to interact with one another and with the *LFA 2* Team**

The *Passport to Knowledge* philosophy is ease of use and equity of access. We want teachers with a wide range of network skills and technologies—from simple e-mail up to full T-1 connectivity—to find success. *LFA 2* will work for those just getting started in cyberspace, even if their access is not from the classroom but at home or at the workplace of an involved parent. For schools with a little more technology and training, inexpensive cameras and free software can bring moving images and audio into classrooms, via CU-SeeMe, RealAudio and other similar technologies

How to start

All participants in *Live From Antarctica 2* should sign up for the *updates-lfa* mail-list. This service won't overwhelm your mailbox (we plan no more than two e-mail messages per week). *updates-lfa* will keep you informed about the latest opportunities and also bring you lively behind-the-scenes accounts *(Field Journals)* from the men and women exploring Antarctica. *Field Journals* can be used as reading exercises, discussion starters, or for information about careers.

To join the *updates-lfa* mail-list, send an e-mail message to:
listmanager@quest.arc.nasa.gov

In the body of the message, write only these words:
subscribe updates-lfa

You'll soon receive a reply showing you're subscribed, and full information about *Live From Antarctica 2.*

Other mail-lists available via e-mail include:

mail-list name	who posts	function	frequency	dates
updates-lfa	*PTK* Team	*LFA 2* info & Field Journals	1 or 2 per week	throughout project
discuss-lfa	educators	teachers share ideas	varies, perhaps 15-30/week	throughout
discuss-digest-lfa	educators	teachers share ideas	once daily, discuss daily messages	throughout
debate-lfa	student teams	students debate contributions of Antarctica	varies	2/6/97–3/31/97
answers-lfa	*PTK* Team	stream of question/answer pairs	varies	1/13/97–3/31/97

To join any of these groups, send an e-mail message to:
listmanager@quest.arc.nasa.gov

In the message body, write only these words: subscribe <listname>
For example: subscribe discuss-lfa

To participate via the World Wide Web ("the Web", or WWW)
http://quest.arc.nasa.gov/antarctica 2

Getting On-line for the First Time

If you want to get on-line, but aren't, follow these suggestions:

1) Watch out for Net Day in your state or city... and make sure you're included!
2) Ask your colleagues. It's easy to forget those closest at hand! It's likely there are teachers, administrators, or resource personnel who know what's available locally.
3) Don't forget your students. Today's youth is often leading the charge in this exciting arena.
4) Don't forget your students' parents, there's probably a relative with an Internet connection.
5) Check with a local University. Most have some type of connectivity available, and some provide it to fellow educators.
6) Call your School Administrators, School District, County Office, and/or State Board of Education. Inquire about special deals on hardware, phone rates or Internet subscriptions.

Temporary Acess

If you can get on-line only temporarily, visit "Getting U.S. Teachers On-line", a Web document found at:

http://quest.arc.nasa.gov/on-line/table.html

As noted above, teachers using all three components of PTK projects report they and their students get more from the experience. We really encourage you to go on-line, participate, and—as one of our most eloquent PTK Advocates puts it—"Don't just surf the 'Net, make waves!"

Live From Antarctica 2

LFA 2's Web Site provides three complementary kinds of on-line materials and experiences, some designed for teachers, and some for students:

- **Informational**
- **Interactive**
- **Collaborative and Sharing**

Informational opportunities include:

• An archive of *Biographies* and *Field Journals*. Get to know the men and women of the USAP through their personal stories—what they were like as kids, their diverse career paths, day-to-day activities, their dreams and frustrations, and why they thrive on the danger and hard work of exploring Antarctica!

• Backgrounders—packed with information about ice. Also, lots of pictures and pointers to other great Antarctic sites.

Interactive Resources

• *Researcher Q&A* (Question and Answer). Antarctic experts will be available to answer student questions via e-mail. The resource will be supported from January 13, 1997 through March 31, 1997. All questions will be answered, and all Q&A pairs will be archived and searchable using simple key-words.

• Live interactions with Antarctic experts. Using technologies such as WebChat and CU-SeeMe, researchers will connect with your students in real-time. Live events will be scheduled about once per week between the programs.

• A discussion group connecting teachers to one another and to the *LFA 2* Team is available via e-mail and on the Web.

• *Challenge Questions.* Once per week, a new brain-teaser will provide your students with a challenge to solve. Submit your answers for a chance at fun prizes.

Collaborative and Sharing

During the first *Live From Antarctica* Module, classes across North America, from Alaska to Florida, shared data on hours of daylight, as winter turned to spring and summer. This online activity—like Topsy—"just grew", but proved very popular. For *LFA 2*, we suggest that classes consider a similar activity, perhaps keyed to the experiments with plants and UV-B (Activity 3.2) Teachers, let us know—on-line, via *discuss-lfa*—if this seems interesting to your students. And comparative plant growth data from Activity 3.2 should also prove instructive, so that students can see if there's a clear and direct effect of geography and climate on their seedlings. Or go on-line and suggest something related to the content of the project that might work even better! Watch *updates-lfa* for news about this exciting opportunity.

As a Closing Activity, this Guide suggests a formal debate on the societal value of Palmer Station and research in Antarctica: consider sharing your students' comments and conclusions on-line. *debate-lfa* will provide an on-line forum for their voices to be heard across the nation, not just within the walls of your own classroom.

On the Web, *LFA 2's Student Gallery* also provides an on-line venue for student work of all kinds, whether journal entries, photos documenting class projects, art work, databases, HyperCard stacks, even student-generated html pages. You'll find directions about how to submit on-line.

Lastly, many of the *LFA 2* World Wide Web materials are also available to "e-mail only" users through a special service. For more details, send a message to

email-lfa@quest.arc.nasa.gov

And if you want to sample the on-line materials, but have no easy on-line access, there's even a way to do that! Call 1-800-626-LIVE (800-626-5483) and follow the menu options to "Please Copy This Disk", which provides low-cost Mac or Windows/DOS diskettes containing the words and pictures of the Web site.

Glossary

Antarctic Convergence: area in the southern ocean where warmer northern waters meet cold Antarctic waters.

Aurora australis: moving streams or curtains of light, caused by the interaction of charged particles from the sun with the outer fringes of the earth's atmosphere occurring in the southern ("austral") hemisphere (comparable to the Aurora Borealis in the northern hemisphere.)

Austral summer: period from August through February in Antarctica when the sun shines for 24 hours every day.

Baleen: long, narrow horny plates that hang from the inner upper jaws of some whales and act as filters or sieves to collect food.

Biotic: factors of the environment due to living things eg. predation, food supply, competition.

Brash Ice: accumulations of floating ice made up of fragments not more than 2m across.

Calving: word used to describe the breaking off of ice from ice shelves to form icebergs.

Centigrade (C): temperature scale in which the melting point of water is 0 degrees and the boiling point is 100 degrees. 100 degrees C is equal to 212 degrees Fahrenheit. To convert Fahrenheit to Centigrade: C degrees x9/5+32.

Cetacean: scientific name given to the sea mammal group that includes whales, dolphins and porpoises.

Chlorofluorocarbon (CFC): compound consisting of chlorine, fluorine, and carbon, very stable in the troposphere. Commonly used in refrigerants, solvents, and foam blowing agents.

Crevasse: cracks in ice formed when the ice moves over uneven rocks or when floating ice spreads.

Diatom: single-cell plant with siliceous shell, common in surface waters of polar regions in summer, important as the main photosynthesizers or "fixers" of solar energy.

Distribution: arrangement and interdependence of a group, such as krill.

Ecosystem: biological community of plants and animals and the physical environment around the community.

Fahrenheit: temperature scale in which the melting point of water is 32 degrees and the boiling point is 212 degrees. 32 degrees F is equal to 0 degrees Centigrade. To convert Fahrenheit degrees into Centigrade: F degrees-32x5/9.

Forbs: A non-grasslike herb.

Glacier: any natural accumulation of ice that moves. Glaciers are often described as rivers of ice.

Gondwanaland: former super-continent situated in the southern hemisphere, which contained the areas we now call Antarctica, South America, Africa, Australia, India and New Zealand. About 160 million years ago Gondwanaland began to break up and individual land masses moved to their current positions.

Grasses: family of plants with mostly rounded and hollow jointed stems, sheathing leaves, flowers borne on spikelets. The fruit is a seedlike grain.

Grazers: organisms which feed on growing plants (at the bottom of the food chain).

Greenhouse effect: the heating of the earth's atmosphere caused by the increased levels of carbon dioxide, water vapor and other gases, which prevents the escape of reflected solar energy.

Hypothermia: reduction in temperature of the body core to below 35° C. Occurs as a result of exposure to extreme cold.

Ice Edge: demarcation between the open sea and sea ice of any kind whether fast (fixed to the shore) or drifting.

Ice Floe: large piece of floating ice.

Ice Shelf: floating ice of considerable thickness showing 2-50 meters or more above sea level, attached to the coast.

Infrared imagery: pictures obtained by detecting the amount of infrared light (heat) an object emits.

International Geophysical Year (IGY): the International Council for Scientific Unions agreed to coordinate a research program with special emphasis on meteorology, oceanography and geomagnetism in Antarctica during 1957-58. IGY was so successful in Antarctica that the Scientific Committee on Antarctic Research (SCAR) was set up to continue its work.

Knot: a unit of speed equal to 1 nautical mile per hour. (multiply by 1.85 to convert to km/h).

Krill: small shrimp-like creatures that exist in huge numbers in the southern ocean and provide a vital link in Antarctic food chains between producers (plants) and herbivores.

Lead: any fracture or passageway through sea ice which is navigable by surface vessels.

Lichen: organisms made up of algae living in the threads of a fungus. The algal cells benefit from the protection and water-retaining properties of the fungus; the fungus benefits from being able to share the food made by the photosynthesizing algal cells.

Melt Pool: small frozen body of fresh water in a glacier or snow surface.

Nanometer: distance of one billionth of a meter.

Nunataks: places where mountain peaks appear through the ice.

Ozone: chemically active gas that is made up of three atoms of oxygen. Nearly 90% of the Earth's ozone is in the stratosphere and is referred to as the ozone layer.

Ozone layer: approximately 15-40 kilometers (10-25 miles) above the Earth's surface, in the stratosphere. Depletion of this layer will lead to higher UV-B levels, which can cause increased skin cancers, cataracts and potential damage to some marine organisms, plants, and plastics.

Pack Ice: broken pieces of floating ice which forms when storms or warmer weather melt the sea ice.

Pelagic fish: fish that live in the upper levels of the water column nearer the water surface.

Phytoplankton: microscope plant life (unicellular algae) that lives in the sea. Phytoplankton provide the majority of plant life upon which the Antarctic food chain depends.

Polynyas: areas of open water in pack ice.

Rookery: a colony of penguins (or seals).

Salinity: amount of salt in water.

Sea Ice: ice formed from sea water frozen during the onset of winter, reaching its maximum in September, covering 20 million square kilometers, and a minimum in February of about 4 million square kilometers. In midwinter the ice can reach thicknesses of 3-4 meters.

Skidoo: tracked personnel carrier for one or two people used on snow or ice, and towing sleds.

Skua: hawk-like gulls that prey on rookeries and unprotected penguin chicks.

Stratosphere: layer of atmospheric air above the troposphere, extending from about 10km to 50km in altitude.

Troposphere: lowest part of the atmosphere, extending from the surface up to about 10 km in altitude, although this height varies with latitude. Almost all weather takes place in the troposphere.

UV (Ultraviolet radiation): portion of the electromagnetic spectrum below visible light. The sun produces UV, which is commonly split into three bands: UV-A, UV-B, and UV-C. UV-A is not absorbed by ozone and is not as harmful as UV-B. UV-B is mostly absorbed by ozone, although some reaches the Earth. UV-B causes damage to plants and animals. Damage depends upon the amount of atmospheric ozone that acts as a filter, the angle of sun in the sky, and cloud cover, which shields the surface from some UV radiation.UV-C is completely absorbed by ozone.

Vascular of or relating to a channel for the transporting of a fluid, such as the sap of a plant or the blood of an animal, throughout the body

Zooplankton: small animals which drift in the surface waters of the ocean.

ACTS and LFA 2

"Any sufficiently advanced technology is indistinguishable from magic." —Author and telecommunications visionary, ARTHUR C. CLARKE.

The three *LFA 2* broadcasts from Palmer Station would be impossible without ACTS, NASA's Advanced Communications Technology Satellite System. ACTS provides for the development and flight test of high-risk, advanced communications satellite technology. Using advanced antenna beams and on-board switching and processing systems, ACTS is pioneering new initiatives in communications satellite technology.

NASA Lewis Research Center is responsible for the development, management, and operation of ACTS. The Jet Propulsion Laboratory manages development and operations of the ACTS Mobile Terminal (AMT) element of the program and, jointly, with Lewis directs the Propagation element. Overall ACTS program management resides in NASA Headquarters, Office of Space Access and Technology.

ACTS provides communications satellite technology for:

• operating in the Ka-band (30/20 GHz) where there is 2.5 GHz of spectrum available (five times that available at lower frequency bands)

• very high-gain, multiple hopping beam antenna systems which permit smaller aperture Earth stations

• on-board baseband switching which permits interconnectivity between users at an individual circuit level

• a microwave switch matrix which enables gigabit per second communication between users.

Live TV signals will arrive at Palmer by microwave from cameras on the R/V *Polar Duke* and off-shore islands, and will be beamed up to ACTS via a 1.2 meter dish, along with voice channels for program coordination. ACTS is only 7 degrees above the horizon, as seen from Palmer. The signal bandwidth should be up to 1.5 Mbps (megabits per second), approximately 6 times greater than the signal used to connect students to the South Pole during *LFA 1* in 1995. The ACTS signal is downlinked at NASA JPL, in Pasadena, CA, and then passed via T-1 to the Television Center at Mississippi State University, where it is integrated into the final live programs, and sent to PBS for distribution over public television's Telstar 401.

The ACTS link is "full duplex", meaning scientists at the Palmer communications "hub" will be able to see students in America while students are interacting with the researchers, as if students were on an actual field trip.

LFA 2 thanks NASA and the ACTS teams at Lewis and JPL: these will be the most extreme weather conditions under which the satellite has even been tested!

For more information on ACTS:

http://haagar.jpl.nasa.gov/~pinck/amt.html

http://kronos.lerc.nasa.gov/acts/acts.html

Multimedia Resources

See also the extensive Bibliography for educators and general audiences in NSF's "Facts about the U.S. Antarctic Program", packaged with this Teacher's Guide.

Elementary Level

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For Middle Schools

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For Teachers

"Forecasting the Future: Exploring Evidence for Global Climate Change", developed with the Scripps Institution of Oceanography, Alexandria Virginia: NSTA, ©1996. (Call 1-800-722-NSTA for ordering information.) Includes teacher tested activities, 40 extension exercises, and timeline.