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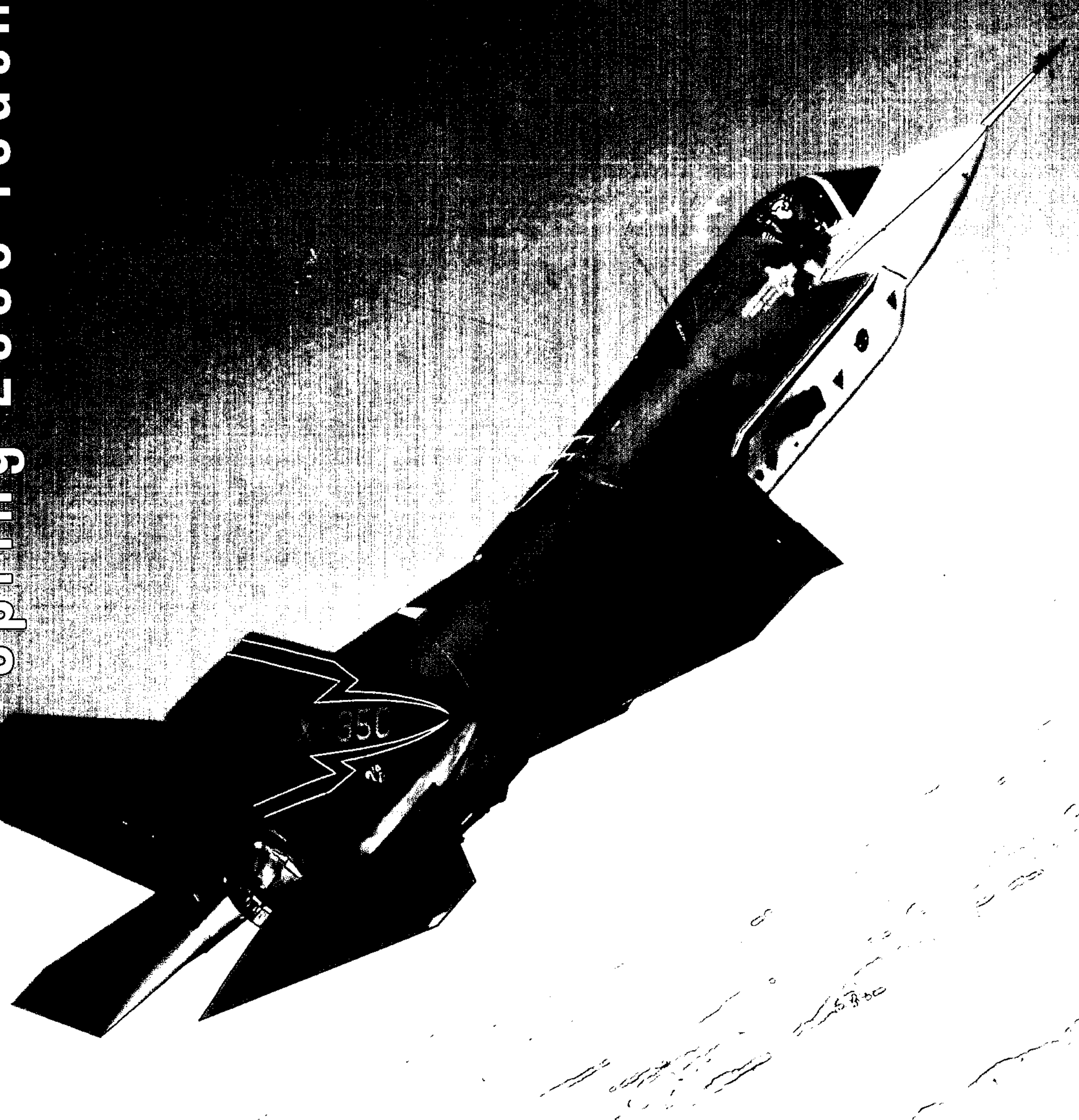
ABSTRACT

This teacher's guide contains supplemental activities to go along with the NOVA television program on PBS. Activities include: (1) "Last Flight of Bomber 31"; (2) "Ancient Creature of the Deep"; (3) "Battle of the X-Planes"; (4) "Mountain of Ice"; (5) "Lost Treasures of Tibet"; and (6) "Secrets of the Crocodile Caves". (KHR)

NOVA®

Spring 2003 Teacher's Guide

Major funding is provided by Sprint PARK FOUNDATION



Battle of the X-Planes

Airs February 4, 2003

www.pbs.org/nova

As a teacher, there is clearly nothing more important than connecting directly with your students. That's why Sprint is proud to support the newest generation of programs in the informative, award-winning NOVA series.

Entering its 30th year, NOVA offers a unique virtual window into the high-tech world in which we live and work. The series remains at the forefront of science, educating and inspiring with an in-depth look at the latest discoveries and innovations.

Since 1997, Sprint has connected thousands of teachers, parents, and students across the country through a variety of community relations programs. We are pleased to continue opening the lines of communication and exploration in the classroom and beyond through our sponsorship of the *NOVA Teacher's Guide.*

Sincerely,

Len Lauer
President
PCS Division, Sprint

Sprint

The Park Foundation is committed to education and quality television. We are pleased to be able to advance the work of NOVA, the preeminent television series in science education. As you know, through study of science, young people acquire skills, knowledge, and—most of all—an intellectual curiosity.

We wish to salute you, as teachers of science, for fostering that intellectual curiosity and passion for investigation among your students. Those skills will serve them well for a lifetime. It is our hope that this NOVA guide will assist you in your effort.

We are grateful for your commitment to teaching.

PARK FOUNDATION

Contents & Broadcast Schedule

NOVA Teacher's Guide SPRING 2003

Schedule Changes

Because of potential programming changes after April 1, 2003, NOVA programs listed here may not air on their currently scheduled date. **Please check your local listings after April 1 for final program information.**

Up-to-date schedule information can be obtained at: **www.pbs.org/nova/schedule.html** or by signing up for the Teachers electronic mailing list at: **www.pbs.org/nova/teachers/listsubscribe.html**

Because of schedule changes, some NOVA programs do not have lessons.

- * one-year off-air taping rights
- (R) repeat program
- + program title may change
- lesson within this guide
- lesson online at: www.pbs.org/nova/teachers/

Celebrating 100 Years of Flight

Dear Educators,

On a cold, windy day in 1903 a pair of self-taught bicycle mechanics managed to overcome every scientific, technical, and engineering problem that prevented humans from achieving controlled flight for more than 500 years. Orville and Wilbur Wright flew four historic flights that day. As part of its 30th year on television, NOVA celebrates the centennial of the first human-powered flight with five new programs.

In this spring's "Last Flight of Bomber 31," NOVA takes you back to World War II to follow the tale of a crew flying a Lockheed PV-1 Ventura as they set out on the final campaign of their lives. Later in the season, "Battle of the X-Planes" provides unprecedented access to the top-secret competition between Boeing and Lockheed to build the next-generation fighter aircraft. And in "Spies That Fly," see how the military wants to use "smart" robotic planes in modern warfare.

In the fall, NOVA provides a definitive retelling of the Wright brothers' tale, complete with breathtaking recreations of their epic flights, and brings you the story of Manfred von Richthofen (the Red Baron), a legendary fighter who achieved 80 victories during World War I, and is even today regarded as the ace of aces.

We hope these shows will inspire your students to investigate the amazing physics of flight that has changed our world.

Paula S. Apsell

Paula S. Apsell
Executive Producer

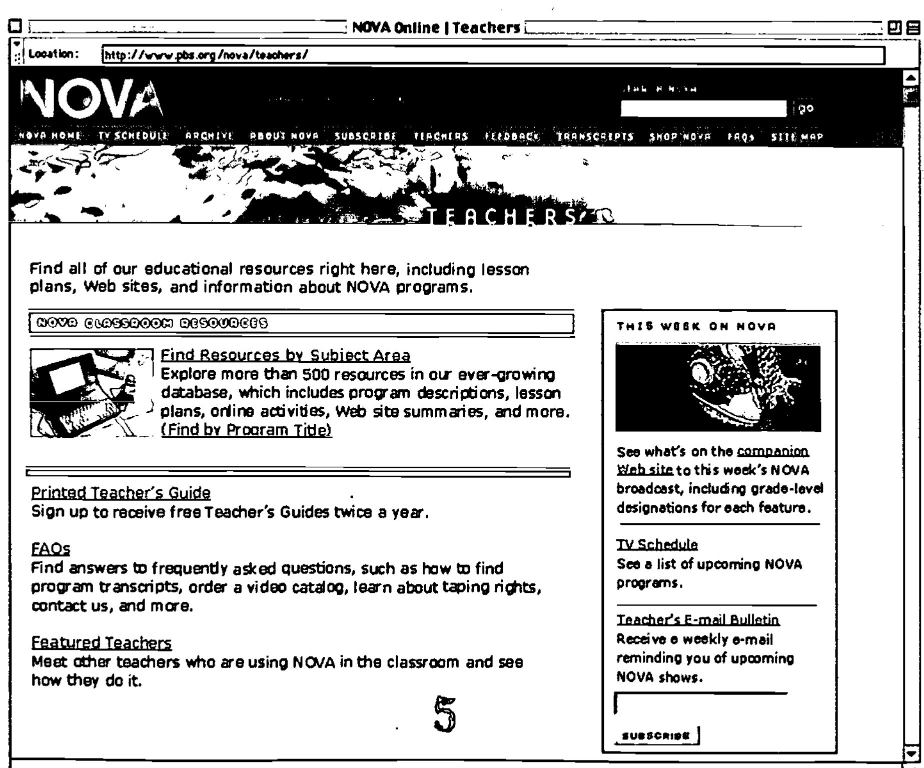
Visit NOVA's New Teachers Site www.pbs.org/nova/teachers/

We've redesigned our NOVA Teachers site to make it easier for you to find lesson plans, NOVA program information, online activities, and more.

Visit our Classroom Resources area to find more than 500 resources cataloged by subject area or program title.

Or visit each week to read a summary of features available on the companion Web site for the current week's NOVA program. TV schedule listings are also provided for the upcoming few months.

Each week we add new lesson plans and Web features to our ever-growing database. We hope you'll come back to visit often.



NOVA® Featured Teacher

Exploring Research Bias

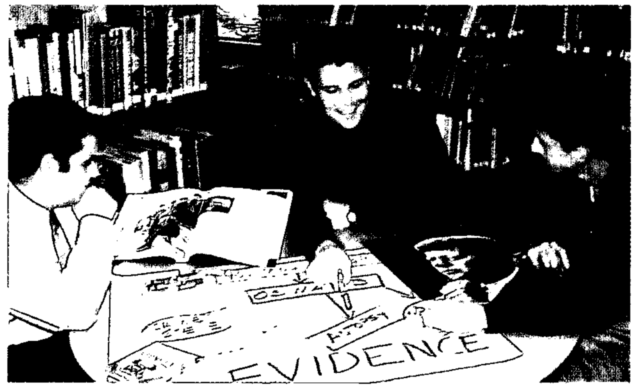
With some help from NOVA's "Neanderthals on Trial" program, history teacher Mike Accorsi uses the latest research on human evolution to help make a point about statistical bias and validity.

Eleventh grade students at Junípero Serra High School in San Mateo, California, are learning how to write a convincing and persuasive argument. In January of each year, Accorsi assigns each of his U.S. History classes a case to investigate, such as the assassination of John F. Kennedy, the effectiveness of the Vietnam War, or the conditions of coal miners in nineteenth-century Pennsylvania.

Each class is divided into two teams, which adopt opposing positions. Students then choose a subtopic for study. For example, when the class topic was the assassination of JFK, subtopics included the crime scene, ballistics evidence, autopsy, and single shooter vs. multiple shooter theory. Within each team, students work in pairs to research evidence that supports their team's point of view.

Leading into the final project, Accorsi introduces the idea that bias can influence research and data interpretation. To illustrate this, he shows a part of "Neanderthals on Trial," in which an anthropologist notes: "We delude ourselves into believing that the variations that we can measure, those bumps, those grooves, those little nodules coming out of a skull, that those actually give us information that answer the questions we're asking in the first place. And ... they may not." Accorsi then shows the film "12 Angry Men" to help students think about how making convincing arguments can influence how others view data.

As the spring semester unfolds, students work independently to gather evidence and conduct an expert interview. In May, team members debate for five consecutive days, spending each day on one subtopic. Students also turn in a research paper on the day they present. At the end of the week, each side writes a one-page conclusion that is given to school administrators who provide feedback about which argument they feel is the most persuasive.



From left, Shant Panossian, teacher Mike Accorsi, and Andrew Georgette review materials related to the John F. Kennedy assassination case.

Accorsi, who has been teaching for five years, says that often during the spring semester students change their minds as they do their research. In a concluding activity, Accorsi asks students if the viewpoint they presented also represents their own belief. He said that these two were often not the same.

For more information about Accorsi's project, you can e-mail him at:
MAccorsi@serrahs.com

Become a NOVA Featured Teacher

We'd like to hear from you! Tell us how you're using a NOVA program, the *NOVA Teacher's Guide*, or NOVA Online in your classroom. Your lesson idea will become a part of our Teachers' Ideas section online, and you will become eligible to become a NOVA Featured Teacher. If you are chosen, we'll send you and your students six free NOVA videos or two Classroom Field Trip kits of your choice.

Send your ideas to:
Erica Thrall
WGBH
125 Western Avenue
Boston, MA 02134
erica_thrall@wgbh.org

Or post them at:
www.pbs.org/nova/teachers/ideas/send.html

Program Contents

On March 25, 1944, seven Navy airmen took off from the Aleutian island of Attu in Bomber 31—and vanished. Fifty-five years later, the plane's wreckage was discovered in one of the most remote regions on Earth, Russia's Kamchatka Peninsula. NOVA chronicles the effort to solve the mystery of Bomber 31's last flight.

The program:

- shows the wreckage of Bomber 31 at the base of a volcano in the Russian Far East.
- notes how clues in the damaged plane indicate the pilot was forced to land after encountering enemy fire.
- introduces Attu, the westernmost Aleutian island, which was captured by the Japanese during World War II.
- explores possible reasons for the plane's crash.
- follows a forensic anthropologist as she looks for crewmembers' remains.
- documents the experience of one crewmember's son as he comes to terms with his father's death.
- shows how, through DNA analysis, the remains of some men may be identified.
- suggests that the harsh environment and prevalence of bears in the crash area may have played a role in the disappearance of crewmembers' remains.

Before Watching

1. Have students use a globe or world map to locate the following places featured in this program: Attu; the Kamchatka peninsula of Russia; and the Northern Kurile islands of Shumshu and Paramushir, which belonged to Japan during World War II but now belong to Russia. Ask students to predict the type of weather conditions that might be formed in this region, where the warm ocean currents off the coast of Japan mix with the cold Bering Sea.

2. Briefly review the history of World War II using a world map, highlighting the time period and major areas of conflict (see *Resources* on page 7 for information sources).

3. As students watch, ask them to list the evidence researchers discovered during their investigation and the conclusions drawn from this evidence.

Crash investigator Ralph Wetterhahn stands next to the wreckage of Bomber 31.

After Watching

1. Review students' notes in a class discussion. What expertise did each scientist bring to the investigation? Discuss the techniques scientists used to identify the wreckage and any remains. What method was expected to reveal the most about the identity of the small pieces of bone that were found?

7

Activity Setup

Objective

To identify which members of a family share the same mitochondrial DNA (mtDNA).

Materials for each team

- copy of *The Hunt for mtDNA* activity sheet on page 6
- colored pencil or pen

Procedure

1. Tell students that they will be working as forensic scientists to help solve a long-standing "missing persons" case.
2. Provide each team with a copy of *The Hunt for mtDNA* activity sheet. Explain to students what mtDNA is, how it differs from nuclear DNA, and how it is inherited (see *Activity Answer* on page 7 for more information).
3. Set up the challenge: An anthropologist has found a few human bones at a site in South Africa. Investigators think they might belong to a Nobel Prize-winning dung beetle biologist who disappeared in Africa. Since the bones have been exposed to severe weather for many years, the only DNA that may be salvageable is mtDNA. Investigators have compiled a pedigree chart that lists all the missing person's relatives. But investigators are having problems identifying his maternal relatives. Which of the people in the *Who's Related by mtDNA?* pedigree chart carry the great-great grandmother's mtDNA, and of those, which living relatives would be eligible to donate their mtDNA for comparison? (mtDNA can be retrieved from exhumed remains; however, this is a costly process and can be emotionally difficult for families. When possible, it is always best to retrieve mtDNA from a living relative. mtDNA cannot be retrieved from cremated remains.) The missing person is labeled with a question mark in the pedigree chart.
4. After students have completed the challenge, discuss their results. What do students conclude about the inheritance patterns of mtDNA? Why aren't the dung beetle biologist's children eligible for testing?
5. As an *extension*, have students research how mtDNA has been used in real-life forensic investigations.

Standards Connection

The activity on page 6 aligns with the following *National Science Education Standards*.

Grades 5–8

Science Standard C:
Life Science

Reproduction and heredity

- Reproduction is a characteristic of all living systems; because no individual organism lives forever, reproduction is essential to the continuation of every species. Some organisms reproduce asexually. Other organisms reproduce sexually.

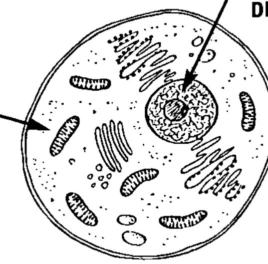
Grades 9–12

Science Standard C:
Life Science

The molecular basis of heredity

- In all organisms, the instructions for specifying the characteristics of the organism are carried in DNA, a large polymer formed from subunits of four kinds (A, G, C, and T). The chemical and structural properties of DNA explain how the genetic information that underlies heredity is both encoded in genes (as a string of molecular "letters") and replicated (by a templating mechanism). Each DNA molecule in a cell forms a single chromosome.

The Hunt for mtDNA



NOVA Activity **Last Flight of Bomber 31**

You are a forensic scientist recruited to help solve a long-standing "missing persons" case. Mitochondrial DNA, or mtDNA for short, is the key to your success.

Procedure

① Read the *Guidelines for mtDNA Inheritance*.

② Take careful notes as your teacher describes the important elements of the "Case of the Missing Dung Beetle Biologist." Identify which family members in the *Who's Related by mtDNA?* pedigree chart should be chosen to donate their mtDNA for comparison to the missing person's mtDNA (the missing person is noted by a question mark). All deceased individuals have been cremated and cannot be sampled for mtDNA.

③ Connect individuals who share mtDNA from the great-great grandmother by darkening the lines that link them to one another.

④ Of the individuals connected by dark lines, circle the living relatives who are eligible to be tested for mtDNA.

Questions

Write your answers on a separate sheet of paper.

① How many living relatives could provide mtDNA to test against the mtDNA of the discovered remains that are believed to belong to the missing person shown by a question mark in the pedigree chart?

② Describe the inheritance pattern of mtDNA.

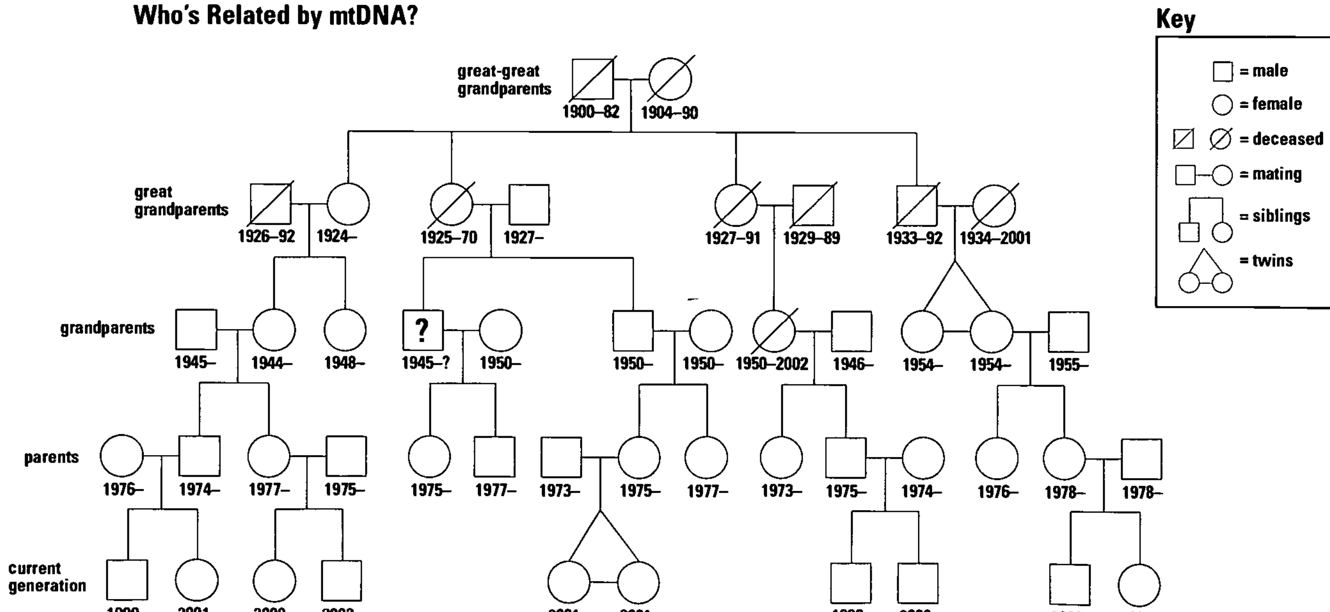
③ If two brothers died in a crash, could you use mtDNA to distinguish their remains from one another? Why or why not?

Guidelines for mtDNA Inheritance

Mitochondrial DNA (mtDNA) is found in each cell's mitochondria, structures that produce ATP, the cell's main energy source. Here are some guidelines about how mitochondrial DNA is inherited:

- mtDNA can only be inherited from a woman.
- A man can inherit mtDNA from a woman.
- A man cannot pass mtDNA on to any children.

Who's Related by mtDNA?



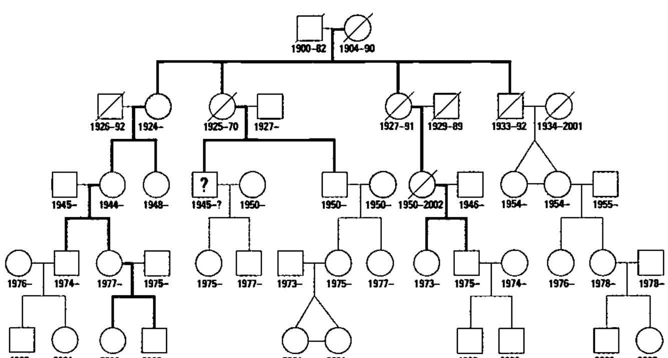
Activity Answer

Everyone carries two types of DNA: nuclear DNA, found in the nucleus of each body cell, and mitochondrial DNA (mtDNA), found in the mitochondria located in the cell's cytoplasm outside the nucleus. Nuclear DNA codes for most proteins made by the cell and is responsible for the inheritance of physical traits, such as hair color or whether a person has dimples, as well as inherited genetic disorders, such as sickle cell anemia or Tay-Sachs disease. mtDNA codes for its own proteins and for ribosomal and transfer RNAs.

During reproduction, the father's sperm cell—which contains both nuclear DNA and mtDNA—donates only its nuclear DNA to the zygote that results from the fusion of the sperm with an egg cell. (Some researchers argue that a fragment of the father's mtDNA is in fact passed on, though it represents much less than 1 percent of the total.) Therefore, all the DNA in a person's mitochondria comes from his or her mother. This means that each new generation has only the mtDNA of the mother, who has only the mtDNA of her mother, and so on. (Males have only the mtDNA of their mothers as well but do not pass it on.) As a result, mtDNA samples can be used to identify any maternally related individuals.

The people related to the missing person's maternal grandmother (who are the candidates for getting mtDNA to compare to that of the missing person), are connected with heavy lines in the pedigree chart below. The 10 living relatives eligible for testing are shaded.

Who's Related by mtDNA?



mtDNA could be used to confirm that two brothers with the same mother who died in a crash were related, but not used to distinguish their remains from one another in the way that nuclear DNA could. Because mtDNA molecules are present in thousands of copies per cell (compared to nuclear DNA, which is present in only two copies per cell), mtDNA is more likely to be found in small or degraded samples than is nuclear DNA. In addition, environmental factors, such as prolonged exposure to the elements, often destroy nuclear DNA.

Resources

Book

Garfield, Brian, and Terrence Cole.
The Thousand-Mile War: World War II in Alaska and the Aleutians.
Fairbanks: University of Alaska Press, 1995.
Uses U.S. and Japanese records, personal stories, letters, and diaries of participants to tell the story of the battles fought in Alaska and the Aleutians.

Article

Wetterman, Ralph.
"One Down in Kamchatka."
The Retired Officer Magazine, January 2001.
Online at: **www.troa.org/Magazine/January2001/feature_kamchatka.asp**
Tells the story of Bomber 31 and the efforts to recover and identify crewmembers' remains.

Web Sites

NOVA Online—Last Flight of Bomber 31
www.pbs.org/nova/bomber/
Provides program-related articles, interviews, interactive activities, and resources.

History of WWII in the Aleutians
www.nps.gov/aleu/WWII_in_the_Aleutians.htm
Provides a chronology and description of the Aleutian Campaign.

U.S. Army Central Identification Laboratory
www.cilhi.army.mil/
Shows how the lab searches for, recovers, and identifies missing personnel from World War II, the Korean War, the Cold War, and the Vietnam War.

Wars and Conflict: World War II
www.bbc.co.uk/history/war/wwtwo/index.shtml
Provides a summary of World War II from 1939 to 1945.

Program Contents

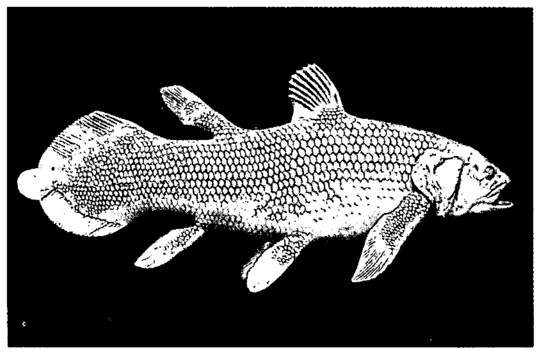
NOVA chronicles the discovery of a "living fossil," a fish called the coelacanth that has remained relatively unchanged since prehistoric times.

The program:

- recalls Darwin's prediction that some creatures would have not undergone any major adaptations due to selective pressures and would have remained relatively the same since prehistoric times.
- relates the 1938 discovery of the coelacanth off the coast of South Africa by Marjorie Courtenay-Latimer.
- tells the story of J.L.B. Smith, the scientist who identified Courtenay-Latimer's specimen as a coelacanth.
- notes that many anatomical features of coelacanths have changed little since the Devonian period 400 million years ago.
- examines the fossil record of the coelacanth.
- relates the discovery of coelacanths around the Comoros Islands and near Indonesia.
- compares the coelacanth to sharks and other types of fishes.
- discusses the significance of the coelacanth in the study of evolution.

Before Watching

1. Coelacanths have been found near South Africa, the Comoros Islands, and Indonesia. Ask students to locate these places on a map or globe and estimate the distances between them. Given the distances between sites, do students think all three coelacanth specimens are the same species? As students watch, have them take notes on characteristics of the coelacanth.



Adult coelacanths, which are dark blue in color, can grow to almost 6 feet (180 centimeters) and weigh up to 215 pounds (98 kilograms). This model illustrates the coelacanth's external anatomy.

After Watching

1. Review students' notes about coelacanths. What are some of the characteristics that the coelacanth has in common with most other fishes? What are some of its more unusual characteristics? What did students find most fascinating about the coelacanth?

2. France claimed the right to all coelacanths caught off the Comoros Islands, which were under French colonial rule at the time of the 1952 discovery. Ask students if they think it is fair for a nation to claim exclusive rights to new scientific finds. Discuss whether the same principles should govern finds in water and on land. Who should decide the principles that govern who has rights to scientific finds?

Activity Setup

Objective

To compare and classify a "living fossil," the coelacanth, in relation to a moray eel and a bull shark.

Materials for each group

- copy of the *Fish Anatomy* activity sheet on page 10
- access to Internet and print resources for research

Procedure

1. Review with students the meaning of the phrase "living fossil" *(an organism with a basic body design that has remained unchanged for millions of years).* Tell students that they will be comparing a living fossil, the coelacanth, with moray eels and bull sharks.
2. Organize students into groups and provide each group with a copy of the *Fish Anatomy* activity sheet.
3. Review with students the descriptions of fish anatomical structures on the activity sheet. Explain that these descriptions only represent a few of the different features of fishes.
4. Have students use additional resources to find more information about coelacanths, eels, and sharks. Ask students to research the skeletal types of each fish, its body covering, how the fish stays buoyant, and whether it bears live young. Then have them draw and label the body parts of each fish.
5. After students label all the fish body parts, review their answers (see *Activity Answer* on page 11).
6. Ask students if they think the coelacanth is more closely related to the eel or the shark, and have them explain their reasoning. List the reasons supporting each choice on the board. Then have a discussion to try to reach a consensus.
7. As an *extension*, have students research the characteristics of other living fossils, such as the horseshoe crab or the *Ginkgo biloba* tree. What makes these organisms distinctive? What might have enabled them to remain unchanged for so long?

Standards Connection

The activity on page 10 aligns with the following *National Science Education Standards.*

Grades 5–8

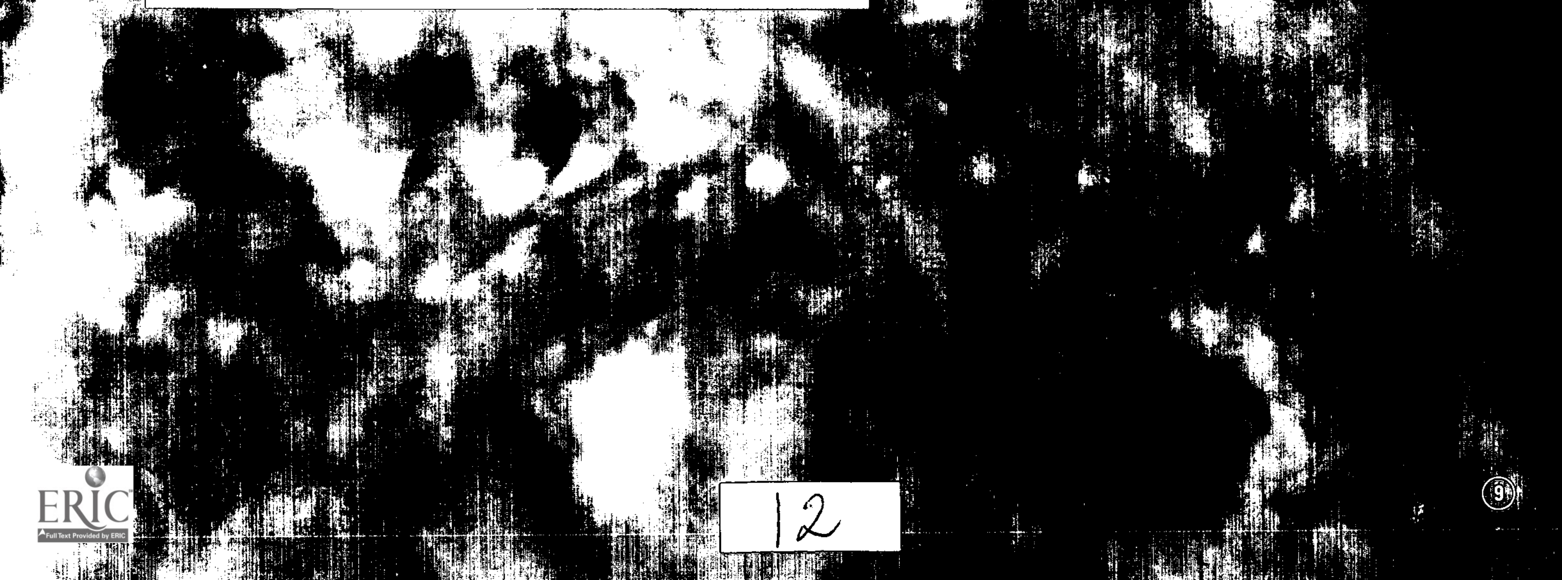
Science Standard C:
Life Science

Structure and function in living systems

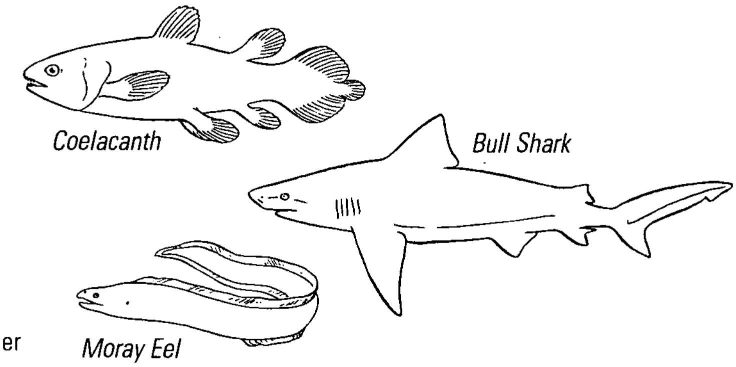
- Living systems at all levels of organization demonstrate the complementary nature of structure and function. Important levels of organization for structure and function include cells, organs, tissues, organ systems, whole organisms, and ecosystems.

Diversity and adaptations of organisms

- Millions of species of animals, plants, and microorganisms are alive today. Although different species might look dissimilar, the unity among organisms becomes apparent from an analysis of internal structures, the similarity of their chemical processes, and the evidence of common ancestry.



Fish Anatomy



NOVA Activity **Ancient Creature of the Deep**

Coelacanths are difficult to classify. They have many characteristics in common with sharks, and yet in certain characteristics they more closely resemble other types of fish. In this activity, you will decide which type of fish—moray eels or bull sharks—is more closely related to coelacanths.

Procedure

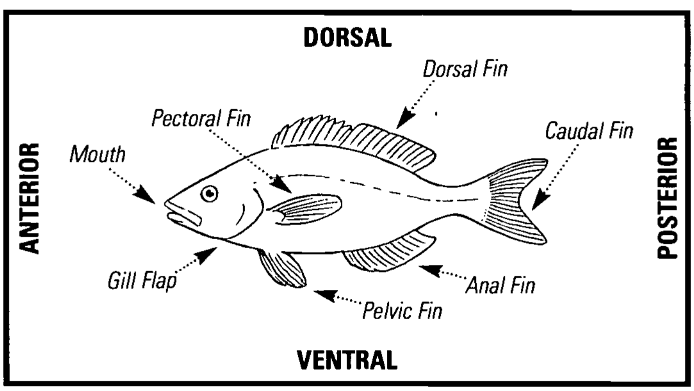
1. Begin by reading about fish anatomy in your *Basic Fish Facts* information below.
2. Use the Internet and print resources to learn more about these three types of fish. Compare:
   - their skeletal types
   - their body coverings
   - whether they bear live young
   - their buoyancy systems
   - whether they have gill slits or flaps
   - any other characteristics you learn about
3. On a separate sheet of paper, draw a coelacanth, bull shark, and moray eel and label the body parts of each.

Questions

Write your answers on a separate sheet of paper.

1. What characteristics do all fishes have in common?
2. What characteristics of a coelacanth cause it to be classified as a fish?
3. What features do the coelacanth and the bull shark have in common?
4. Which features of a coelacanth are similar to those of a moray eel?
5. Do you think a coelacanth is more closely related to a bull shark or a moray eel? Explain your reasoning.

Basic Fish Facts



Gills: Allow a fish to breathe. Some fishes have gills covered by flaps. When a fish opens its mouth, the flap closes, drawing water into the mouth. As the fish closes its mouth, the flap opens. Oxygen is extracted from the water as it passes over the gills. Other fishes have gill slits.

Tails: Fish tails also take many shapes. A crescent-shaped tail, like that of the swordfish, allows the fish to swim rapidly through the water. A forked tail, like that of the trout, can also allow fast swimming. A rounded tail, like that of the angelfish, enables quick bursts of speed to escape predators.

Fins: Help a fish move. The top fins are called dorsal fins. If there are two dorsal fins, the one nearest the head is called the first dorsal fin and the one behind it is the second dorsal fin. The belly or lower part of the fish is the ventral region. Within this section is the pectoral fin, which is located near the gills, and the pelvic fin, which may have a more specific name depending on its position in the ventral region. The bottom fin at the back of the fish is called the anal fin. The tail fin is called the caudal fin. Pectoral and pelvic fins come in pairs. Dorsal, anal, and caudal fins are single.

Mouths: Enable a fish to eat. Some mouths extend directly from the head of the fish; in others the lower jaw extends beyond the upper jaw. Some mouths are on the underside of a fish's head, while others are more snout-like and suck in food.

Bodies: The shape of a fish's body depends on the fish's habits. For example, the body may be streamlined for faster swimming, as in the barracuda. They may be flattened from side to side, as in the angelfish, allowing them to maneuver in narrow spaces. Fishes that are flattened from top to bottom, such as the stingray, live on the seafloor. Other fishes are snake-like, such as the eel, enabling them to move easily between rocks. Other fishes have their own unique shapes.

Activity Answer

A fish is an animal in the phylum Chordata and the subphylum Vertebrata. Most are covered in protective scales. Fish have fins, and most have swim bladders. The coelacanth has all these characteristics and is thus classified as a fish. The coelacanth is a unique fish because it has an extra lobe in its tail, paired lobe fins that move like our arms and legs, an incompletely developed vertebral column, and an intercranial joint that allows it to lift the front part of its head to feed.

The coelacanth and the eel are more closely related than the coelacanth and the shark. The coelacanth and the eel belong to the class Osteichthyes, the bony fishes. Bony fishes, as their name implies, have a bony skeleton. The shark is a cartilaginous fish (class Chondrichthyes). Cartilaginous fishes have a skeleton made of tough, flexible connective tissue. Most fish species are bony fishes. The class of bony fishes includes:

- Subclass Sarcopterygii (fleshy-finned fishes): includes the coelacanth and a few species of lungfish.
- Subclass Actinopterygii (ray-finned fishes): includes all other living bony fishes, such as salmon, trout, cod, eel, anchovies, and herring.

Here are some other comparisons:
Scales: Shark skin is covered by a layer of small tooth-like structures called dermal denticles. The denticles make the skin feel smooth when rubbed from head to tail and rough when rubbed the other way. Most bony fishes have large, overlapping scales. Eels have thick, non-scaly skin covered with more mucus than other fishes. Coelacanths have scales.

Buoyancy: Most bony fishes have gas-filled swim bladders that keep them afloat. The shark has an oily liver that serves the same purpose. The coelacanth has a fat-filled swim bladder.

Reproduction: Most sharks give birth to live young, but some deposit eggs to hatch outside the mother's body. Reproduction in bony fishes varies; most lay eggs that hatch later, but some give birth to live offspring. Coelacanths give birth to live offspring.

Resources

Books

Walker, Sally M.
Fossil Fish Found Alive: Discovering the Coelacanth.
Minneapolis: Carolrhoda Books, 2002.
Traces the scientific detective work that led to identification of this species, and describes findings about its physiology, habits, and habitat.

Weinberg, Samantha.
A Fish Caught in Time: The Search for the Coelacanth.
New York: HarperCollins, 2000.
Provides firsthand accounts from coelacanth researchers, including Marjorie Courtenay-Latimer.

Article

Jewett, Susan L.
"On the Trail of the Coelacanth, a Living Fossil."
The Washington Post, November 11, 1998, page H1. Online at: **www.washingtonpost.com/wp-srv/national/horizon/nov98/fishstory.htm**
Tells the story of the accidental spotting of a coelacanth by a biologist vacationing in Sulawesi, Indonesia, and his subsequent efforts to acquire a specimen for scientific study.

Web Sites

NOVA Online—Ancient Creature of the Deep
www.pbs.org/nova/fish/
Provides program-related articles, interviews, interactive activities, and resources.

Coelacanth: The Fish Out of Time
www.dinofish.com/
Includes sections on biology and behavior, conservation, recent news, and video clips.

Find a Fish: Coelacanth
www.austmus.gov.au/fishes/fishfacts/fish/coela.htm
Relates the discovery of the first living coelacanth off the Comoros Islands, the subsequent discovery of the species near Indonesia, and the ways in which coelacanths differ from other living fishes.

Battle of the X-Planes

Airs Tuesday, February 4, 2003 • www.pbs.org/nova/xplanes/

Program Contents

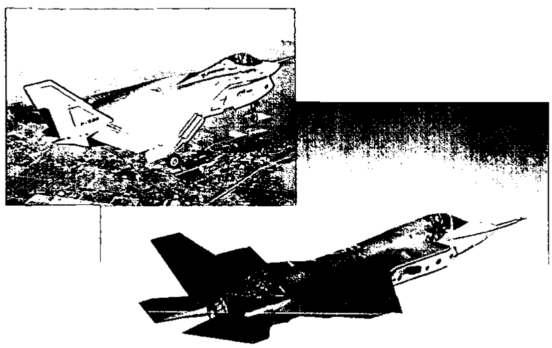
NOVA takes you behind the scenes of an intense five-year competition between Boeing and Lockheed Martin to see who will produce a single airplane design—the Joint Strike Fighter—to meet the needs of three U.S. armed forces: the Air Force, Navy, and Marine Corps.

The program:

- explains the requirements of the Joint Strike Fighter: a low-cost, adaptable design featuring stealth and vertical take-off and landing capabilities.
- presents the stakes of the competition: a $200 billion contract and the future of fighter aircraft design for the next few decades.
- focuses on the most demanding engineering challenge: building a practical vertical take-off and landing system.
- dramatizes the design and manufacturing process of the four demonstration airplanes.
- demonstrates how much of the design is worked out before assembly with the aid of computers and flight simulators.
- shows how two very different designs can meet the same criteria.
- reveals the rigorous flight testing procedure used for the demonstration airplanes.
- presents the government's evaluation process for choosing the winning design.

Before Watching

1. The prototype Joint Strike Fighter had to fit the design specifications of three different armed service branches: the Navy, the Air Force, and the Marines. Ask students how each branch uses airplanes. Why do students think the government decided to build one plane with multiple uses? What are some factors to consider when designing a military fighter plane? *(opponents' defenses, use, materials, production costs, and maintenance and repair).* As students watch, have half the class record the specifications that each branch of the armed services required and the other half record the special adaptations included in the two competing models.



Lockheed Martin's X-35 and Boeing's X-32 (inset) competed to be chosen as the final design model for the Joint Strike Fighter aircraft.

After Watching

1. Discuss with students the specifications required by each branch of the armed services for the Joint Strike Fighter. How effectively did the two design groups meet all the challenges of the contract specifications? Which design did students think was most likely to be chosen? Why? What elements did the chosen design possess that helped it come out on top?

Activity Setup

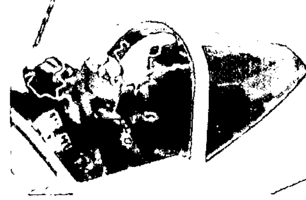
Objective
To design a backpack that meets multiple needs.

Materials for each group
- copy of the *Backpack Challenge* activity sheet on page 14
- copy of the *Designing Your Backpack* activity sheet on page 15
- copy of the *Materials Costs* activity sheet on page 16
- graph paper
- ruler

Materials for the class
- variety of student backpacks
- standard-sized textbooks
- pens and pencils
- other materials as specified by students

Procedure

1. Tell students they have been hired to be designers for a backpack company. Organize students into groups and distribute a copy of the *Backpack Challenge*, *Designing Your Backpack*, and *Materials Costs* activity sheets and materials to each group.
2. The backpack students design must include space for two textbooks, one notebook, and pens and pencils. Ask students to specify three additional objects they would like the design to accommodate. Provide a class set of those items for students to measure. Objects might include sneakers, three-ring binder, water bottle, jacket or sweatshirt, cell phones, and keys. Students might also decide to specify design elements, such as comfortable shoulder straps, water-resistant material, or a reflective strip.
3. Have students first look at existing backpack designs to understand some of the limitations and construction issues. Then have each group design a backpack to meet the needs outlined in the *Backpack Challenge* activity sheet, determine the amount of material necessary to create their design, and calculate the costs using the *Materials Costs* activity sheet.
4. Have students evaluate their initial designs and associated costs and redesign the backpack until they are satisfied with their results.
5. Upon completing their final design, have groups use any medium to create an advertisement highlighting special features of their backpack, including its dimensions, how the product meets design requirements, additional selling features, materials used, and cost. Note to students that the cost they calculate from the *Materials Costs* activity sheet is for materials only; actual production would also include labor, marketing, and distribution costs.
6. Conclude the lesson by comparing final designs and reviewing each group's process with the class. Ask students to discuss which design they think is the best overall and why.
7. As an *extension*, have students develop a marketing campaign for the chosen backpack.



Standards Connection

The activity on pages 14–16 aligns with the following *National Science Education Standards* and *Principles and Standards for School Mathematics*.

Grades 5–8

Science Standard E:
Science and Technology

Abilities of technological design
- Design a solution or product. Students should make and compare different proposals in the light of the criteria they have selected. They must consider constraints—such as cost, time, trade-offs, and materials needed—and communicate ideas with drawings and simple models.

Understandings about science and technology
- Perfectly designed solutions do not exist. All technological solutions have trade-offs, such as safety, cost, efficiency, and appearance.
- Technological designs have constraints.

Mathematics Standard:
Measurement

Grades 9–12

Science Standard E:
Science and Technology

Abilities of technological design
- Propose designs and choose between alternative solutions. Students should demonstrate thoughtful planning for a piece of technology or technique.

Understandings about science and technology
- Creativity, imagination, and a good knowledge base are all required in the work of science and engineering.

Mathematics Standard:
Measurement

Backpack Challenge

NOVA Activity **Battle of the X-Planes**

You are a designer for a backpack manufacturing company. Your company wants you to design an innovative backpack. They have asked your class to define three objects or elements that are essential to a backpack for students.

Your task is to work as a small group of designers to design a backpack that meets all the needs listed in *Backpack Design Requirements*. After you design your product, you will create an advertisement promoting its superior features. It must be convincing, because if your design is chosen for production, you all can look forward to big pay raises, or even promotions!

Backpack Design Requirements

Your backpack design must:

- incorporate the three objects or elements defined by the class.
- contain sufficient space for textbooks.
- feature a special place for pens and pencils.
- be as inexpensive as possible. (If they have time, teams should go to stores or online to see how much a typical backpack costs.)

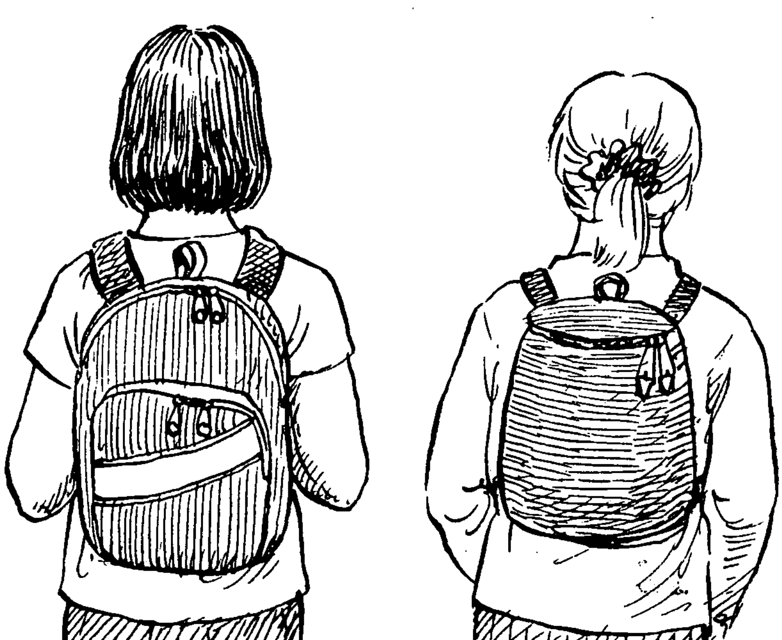
You should also consider whether to add design features that were not part of the original specifications that may enhance your backpack for your market audience. But remember your costs!

Three Objects or Elements Defined by Class

1.

2.

3.



Designing Your Backpack

NOVA Activity **Battle of the X-Planes**

Procedure

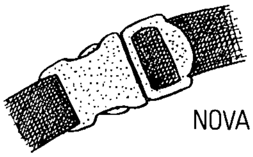
1. Before you begin your design, look at some existing backpacks. What special features do they have? How are they constructed?
2. For your backpack design, you need to know the dimensions of the items that must be placed in the backpack. Use your ruler to measure the sample items.
3. As you design your backpack, consider
   - What are the most important elements of the design?
   - What kinds of materials are you going to use and where?
   - Which parts of the backpack need to be closed off and how?
   - What will distinguish your backpack from its competitors?
4. After designing your backpack, determine how much of each material is necessary to create your design. Make sure to follow the *Materials Guidelines* listed on your *Materials Costs* activity sheet. Then use the costs listed on the *Materials Costs* activity sheet to calculate the cost of each material and the final cost of your backpack.
5. Evaluate your initial design and costs and redesign the backpack until you are satisfied with the results.
6. Use any medium to create an advertisement that illustrates the superior features of your final backpack. Make sure the advertisement includes
   - a drawing of the design
   - backpack dimensions
   - how the product meets design requirements
   - any additional selling features
   - materials used
   - cost
7. When you are done, you will have to present your design information to the design evaluators (your classmates), and they will choose one of the designs for the production model. Hopefully, it will be yours!

Questions

Write your answers on a separate sheet of paper.

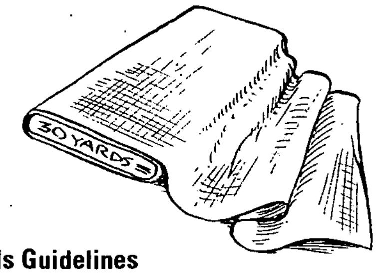
1. What was your design process? Did you create any designs that did not work? What did you learn from these designs?
2. Which features of your backpack are the most desirable? What is the least desirable part of your design?
3. What constraints prevented you from presenting a design that was better than your final design?
4. Which design feature was the most challenging to incorporate and why?
5. Is it possible to create a backpack that meets all needs without any compromises? Why or why not?

Materials Costs



NOVA Activity **Battle of the X-Planes**

When you have determined the amount of materials needed for your design, use this chart to determine the total materials cost for your backpack. Make sure your backpack meets all the *Materials Guidelines* listed at right.

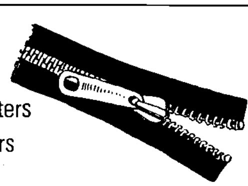


Materials Guidelines

- Thread must be used along every seam.
- Zippers must have a seam along both sides.
- Each edge must have one extra inch for a seam.
- Heavy-use areas, such as attaching shoulder straps to the main body of the backpack and sewing the bottom, require double seams.

Material	**Cost***	**Amount Needed**	**Total**
Water-resistant heavy-duty fabric	2 cents per square inch		
Heavy-duty fabric	1 cent per square inch		
Water-resistant light-duty fabric	0.5 cent per square inch		
Light-duty fabric	0.3 cent per square inch		
Expandable fabric (every square inch can equal up to two cubic inches in volume)	4 cents per square inch		
Padding	2 cents per cubic inch		
Heavy-duty zippers	10 cents for first inch; 5 cents for every additional inch		
Light-duty zippers	5 cents for first inch; 2 cents for every additional inch		
Heavy-duty Velcro patch	10 cents per square inch		
Light-duty Velcro patch	5 cents per square inch		
One inch wide nylon strap (to adjust length of shoulder straps)	5 cents per inch		
Plastic piece to tighten shoulder straps	10 cents each		
Reflective tape	15 cents per inch		
Buckle (for optional waist strap)	35 cents		
Heavy-duty thread	1 cents per sewn inch		
Light-duty thread	0.5 cent per sewn inch		
TOTAL COST PER BAG			

* metric equivalents:
1.00 inch = 2.54 centimeters
1.00 square inch = 6.45 square centimeters
1.00 cubic inch = 16.39 cubic centimeters



Activity Answer

As they complete the challenge, students will likely come to understand that there is no such thing as a perfect design. Trade-offs of one kind or another must be made in order to find an *optimal* design, one that provides the most desirable results possible given a set of restrictions. Designers are constrained by what actually can be manufactured. Other constraints include price, size, materials available, or environmental concerns. It is quite often the case that the technology is available to create a better, more advanced product, but the need to maintain an affordable price, or limit environmental impact, constrains the design.

There are many possible solutions to the backpack challenge. A successful design will meet all the requirements. Other design features, such as comfort or appearance, might place one backpack in better favor than another. For example, a backpack designed so that all the weight is on one side might be unwieldy and difficult to keep on your back. Additionally, a backpack that has a certain appealing "look" to it might sell better than another that doesn't look as nice but is designed more functionally.

Resources

Book

Sweetman, Bill.
Joint Strike Fighter: Boeing X-32 vs Lockheed Martin X-35.
Osceola, WI: Motorbooks International, 1999.
Covers the competitors' designs and performance features and includes photographs of production lines, test designs in flight, power plants, weaponry, cockpits, and markings.

Web Sites

NOVA Online—Battle of the X-Planes
www.pbs.org/nova/xplanes/
Provides program-related articles, interviews, interactive activities, and resources.

Joint Strike Fighter
www.jast.mil/
Serves as the official site of the Joint Strike Fighter, providing a complete background on the development of the Joint Strike Fighter program.

Military Analysis Network
www.fas.org/man/dod-101/sys/ac/jsf.htm
Gives details on which design eventually won the government contract and why.

Program Contents

NOVA follows a group of explorers and scientists as they scale Vinson Massif, Antarctica's highest peak, collecting snowfall data along the way to help determine Antarctic ice flow.

The program:

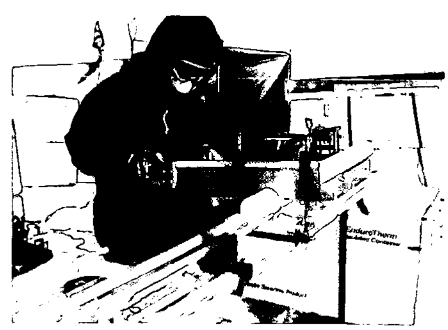
- interweaves historic footage of Robert Scott's and Roald Amundsen's race to the South Pole with modern-day footage of a climb up Vinson Massif.
- shows an international community of scientists and adventurers at a camp in Antarctica and the harsh conditions in which they work.
- depicts the method used to take snowfall samples and discusses how the samples are used to help understand continental ice flow.
- explains how Antarctica's mountains serve as a natural dam to block ice, an effect that helps make Antarctica the highest continent on Earth.
- describes how a history of snowfall is preserved in layers of ice.
- portrays the Antarctic ice sheet as being in a state of equilibrium, in which the amount of snowfall equals the amount of ice that breaks off and falls into the sea.
- discusses how Antarctic ice flow might affect global climate change and sea level rise.

Before Watching

1. Have students name the seven continents and locate them on a map *(Africa, Antarctica, Asia, Australia, Europe, North America, and South America)*. On Antarctica, have students locate the West Antarctic Ice Sheet where scientists are conducting research. What challenges do students think researchers face working in the Antarctic?

2. Ask students the difference between weather *(atmospheric conditions at a given place and time)* and climate *(average weather conditions for an area over an extended period of time)*. Why is it important to study climate? *(Looking at past climates can provide clues to climatic variability, which may help predict future changes. It can also contribute to understanding how humans influence Earth's climate system.)*

3. Ice cores, like tree rings, can reveal information about the past. As students watch, have them take notes on the substances scientists sample from ice cores and what they can infer from each substance.



U.S. International Trans-Antarctic Scientific Expedition member Susan Kaspari cuts an ice core at a field station on the West Antarctic Ice Sheet.

After Watching

1. Review with students the kinds of substances scientists sample from ice cores. What does each substance indicate? How do scientists use the substances in ice cores to make generalizations about climate?

Activity Setup

Objective
To graph and analyze chemical concentrations from ice core data.

Materials for each team
- copy of the *Secrets in the Ice* activity sheet on page 20
- copy of the *Ice Core Data* activity sheet on page 21
- 2 copies of the *Graphing Ice Core Data* activity sheet on page 22
- scissors
- ruler
- three different-colored pencils

Procedure

① Ice cores can reveal a lot about past climates. Tell students they will be analyzing chemical concentrations in ice core field data from the U.S. International Trans-Antarctic Scientific Expedition (ITASE) in this activity.

② Organize students into teams of two and provide each team with copies of the *Secrets in the Ice*, *Ice Core Data*, and *Graphing Ice Core Data* activity sheets and other materials.

③ After teams have prepared their graphs, have each team work together to graph all three ions (sodium, chloride, and sulfate ions) on their chart using the pencil colors you assign for each ion. Students may want to use a ruler to help them graph points.

④ Have students graph the data, making sure that each team starts with the top-most depth, 37.270 meters, and that all teams begin graphing at the same left-most point on their graphs. Tell students to round off each data point to the nearest whole number.

⑤ When the data have been graphed, refer students to the information about the ions on their *Ice Core Data* activity sheet. Have them use the information to label their graphs with estimated years or seasons. (Year demarcations are not evenly spaced because some years have more data points than others.)

⑥ After graphing is completed, discuss each team's interpretations of the data. Do all interpretations agree? Why or why not? What additional questions do students have about the data?

⑦ As an *extension*, have students repeat the activity, but this time only plotting every third data point, or every fifth point. Would students draw the same conclusions? How much confidence would they have in their results?

Standards Connection

The activity on pages 20–22 aligns with the following *National Science Education Standards* and *Principles and Standards for School Mathematics*.

Grades 5–8

Science Standard D:
Earth and Space Science

Structure of the Earth system
- The atmosphere is a mixture of nitrogen, oxygen, and trace gases that include water vapor. The atmosphere has different properties at different elevations.

Mathematics Standard:
Data Analysis and Probability

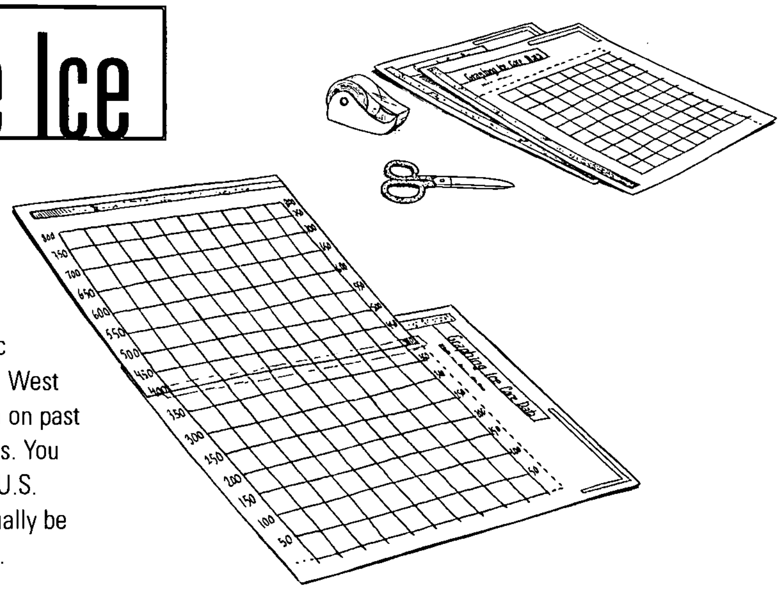
Grades 9–12

Science Standard D:
Earth and Space Science

Geochemical Cycles
- The Earth is a system containing essentially a fixed amount of each stable chemical atom or element. Each element can exist in several different chemical reservoirs. Each element on Earth moves among reservoirs in the solid Earth, oceans, atmosphere, and organisms as part of geochemical cycles.

Mathematics Standard:
Data Analysis and Probability

Secrets in the Ice



NOVA Activity **Mountain of Ice**

The U.S. International Trans-Antarctic Scientific Expedition (ITASE) to Antarctica drilled into the West Antarctic Ice Sheet to collect ice cores for data on past sulfate, sodium, and chloride ion concentrations. You will be analyzing some of the actual data that U.S. ITASE scientists obtained. The data will eventually be used to help understand global climate change.

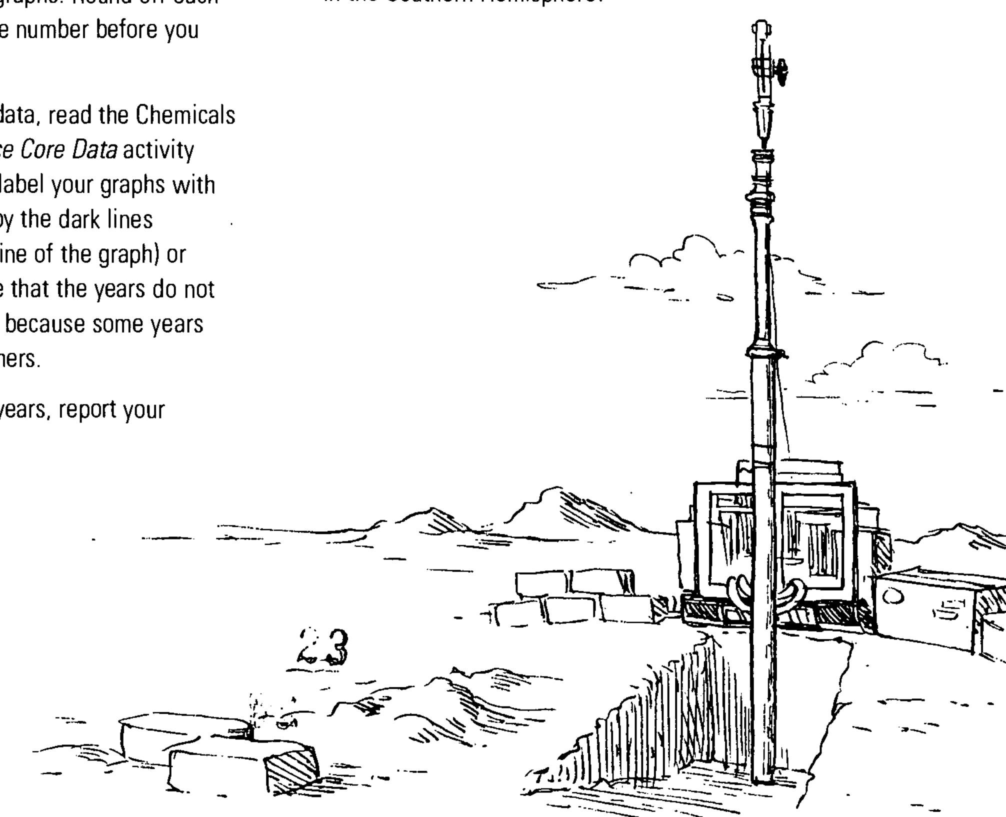
Procedure

1. Cut along the dotted lines of one of your blank graphs and line it up with the other one so that the bottom dark line of the graph you cut out and the top dark line of the other graph overlap. Tape the two graphs together.
2. Label the dark vertical lines on both sides of the graphs in 50-degree increments (50, 100, etc.) up to the top dark line, which will be 800.
3. Use the *Ice Core Data* and *Graphing Ice Core Data* activity sheets to graph the data for all three chemicals (sulfate ion—SO_4^{2-}, sodium ion—Na^+, and chloride ion—Cl^-) using the colored pencil assigned by your teacher for each chemical. Make sure you start with the top-most depth, 37.270 meters, and begin graphing at the left-most point on your graphs. Round off each data point to the nearest whole number before you graph it.
4. When you have graphed your data, read the Chemicals in the Ice information on the *Ice Core Data* activity sheet. Use this information to label your graphs with estimated years (represented by the dark lines extending beyond the bottom line of the graph) or seasons within the years. Note that the years do not fall at exactly spaced intervals because some years have more data points than others.
5. After estimating seasons and years, report your results to the class.

Questions

Write your answers on a separate sheet of paper.

1. What years do you think this data set spans? How did you determine these years?
2. What year does it appear that the volcanic sulfate from the unknown 1808–1809 volcano eruption arrived in Antarctica?
3. Look at your graph. What patterns, if any, do you see among the sodium, chloride, and sulfate ion concentrations?
4. Based on sulfate ion concentration peaks, when does spring seem to occur? Based on sodium and chloride ion concentration peaks, when does winter seem to occur? In what months do each of these seasons occur in the Southern Hemisphere?



Ice Core Data

NOVA Activity **Mountain of Ice**

Chemicals in the Ice

Sulfate (SO_4^{2-})

The sulfate ion has several sources in this Antarctic ice core. The most important of these are marine biological processes and volcanic activity.

- The sulfate ion produced by marine phytoplankton peaks in the spring. After the dark winter, the hours of daylight lengthen and the sea ice begins to melt and break up. This open ocean environment is ideal for marine phytoplankton growth. As the phytoplankton grow, they release sulfate-rich chemicals into the atmosphere, which in turn get transported by winds over the ice sheet.

- Another source of sulfate is volcanic eruptions. Volcanoes can spew millions of tons of sulfate into the atmosphere and concentrations can remain high for several years following a large volcanic eruption.

- The Tambora volcano in Sumbawa, Indonesia, erupted in 1815; acid from that event is believed to have settled in Antarctic ice about 1816–1817. Another unknown volcano erupted in late 1808 or early 1809.

Sodium (Na^+) and Chloride (Cl^-)

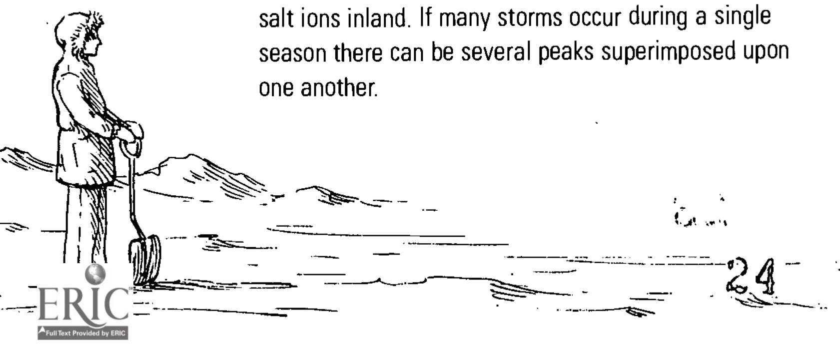
In this Antarctic ice core:

- Most of the sodium and chloride ion concentrations come from the ocean in the form of sea salt (NaCl).

- Sodium also has a terrestrial dust source but this only contributes a minute percentage in this core.

- Chlorine can be given off by volcanic eruptions in the form of hydrochloric acid (HCl).

- Sodium and chloride ion concentrations usually peak in the winter-spring season; during the winter–spring months the Antarctic wind strength increases and whips the ocean into foam and transports more sea salt ions inland. If many storms occur during a single season there can be several peaks superimposed upon one another.



Ice Core Data

U.S. ITASE–99–1

Latitude: 80.62 S Longitude: 122.63 W

Depth from top, in meters	Sodium (Na^+), in ppb*	Chloride (Cl^-), in ppb	Sulfate (SO_4^{2-}), in ppb
37.270	16.40	42.63	91.48
37.297	53.14	99.46	96.71
37.324	81.74	140.71	107.92
37.351	50.10	93.78	129.02
37.378	27.99	46.85	203.13
37.405	43.38	69.35	225.60
37.432	82.17	109.37	266.19
37.459	43.40	83.46	264.96
37.486	71.32	115.21	554.33
37.513	54.79	180.34	479.90
37.540	209.26	294.90	768.02
37.567	241.75	328.83	679.31
37.594	68.56	160.46	243.69
37.621	53.20	98.16	280.67
37.648	51.00	93.63	308.64
37.675	37.96	60.38	314.44
37.702	32.42	46.35	295.36
37.729	10.64	20.25	219.09
37.756	16.08	34.28	164.09
37.783	57.75	85.50	162.82
37.810	52.45	85.74	79.41
37.837	30.88	51.17	68.91
37.864	32.45	53.67	61.68
37.891	12.64	32.39	57.15
37.918	44.91	82.84	67.82
37.945	97.03	152.79	87.95
37.972	83.86	136.20	34.01
38.000	22.83	37.84	97.92
38.027	22.96	36.86	95.10
38.054	43.24	63.62	51.29
38.081	54.78	83.29	38.04
38.108	44.26	75.44	31.44
38.135	5.55	13.52	17.32
38.162	5.06	12.37	24.90
38.189	14.81	26.11	41.81
38.216	42.10	64.93	46.09
38.243	40.71	66.41	36.44
38.270	53.17	90.35	59.36
38.297	16.64	46.90	62.55
38.324	39.48	72.02	82.38
38.351	48.87	93.15	69.49
38.378	45.34	82.35	62.39
38.405	122.19	173.73	101.22
38.432	52.43	90.37	74.20
38.459	44.61	69.06	101.28
38.486	54.40	84.59	205.43
38.513	69.42	114.81	273.03
38.540	98.30	142.69	296.44
38.567	98.73	159.80	218.24
38.594	283.47	439.44	225.51
38.621	83.32	166.07	90.38
38.648	33.31	72.26	101.46

* parts per billion (micrograms per liter)

Graphing Ice Core Data

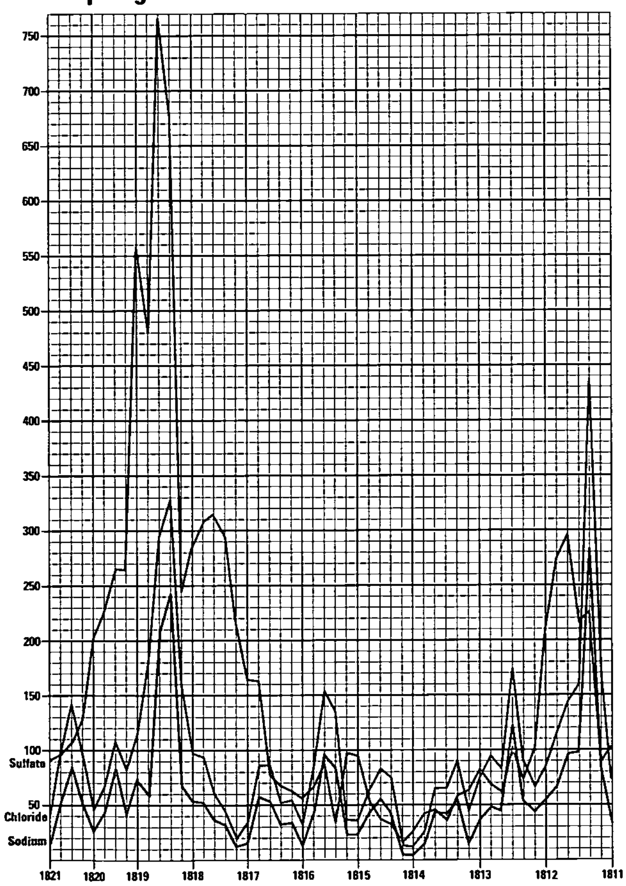
NOVA Activity **Mountain of Ice**

Activity Answer

The study of past climates is important to gain an understanding of the range of natural climatic variability prior to human influences. This knowledge can help to develop more accurate computer models to predict future climate changes. Most instrumental climate records, however, only go back about 150 years, so scientists look to nature to find additional information about past climates.

One way researchers do this is to recover and analyze ice cores, which represent accumulations of snowfall over time. Ice core researchers examine different chemical compositions in layers in the ice. Deeper ice core layers represent times farther in the past. A chemical composition that has not changed over time due to compression or other variables can indicate certain past atmospheric conditions. The concentrations of particular chemicals in ice cores over time can help scientists infer what past climates might have been like.

Graphing Ice Core Data*



*dates are plus or minus one year

Scientists were able to date this ice core with the help of some outside knowledge: They knew that the Tambora volcano erupted in 1815. Estimating that it took the volcanic sulfate about one to two years to reach Antarctica, scientists could then identify 1816–1817 from the first elevated (above normal) sulfate levels in the ice core. From that point, and using information about how certain chemical concentrations are connected to spring and fall, the dates for the rest of the core can be estimated. The volcanic sulfate from the unknown 1808–1809 eruption arrived in 1810–1811, as evidenced by the second set of elevated sulfate levels.

Sodium and chloride concentrations correspond closely because they come from the same source—seawater. Elevated chloride concentrations during the volcanic events are likely a result of hydrogen chloride released during a volcanic eruption. Slightly elevated chloride concentrations in the non-volcanic years (1812 to 1816 and again in 1820) may be due to higher atmospheric hydrogen chloride that is present during summer months.

Peaks for winter and spring can be seen each year with peaks in sulfate (spring/summer) and sodium chloride (winter/spring); sometimes the seasons appear concurrently in the ice core because there is not a high enough sampling resolution. Southern Hemisphere winter occurs from June to August; spring occurs from December to February. Core dating is not an exact science; the estimates given are plus or minus one year. The total range for this data set is 1811–1821.

Resources

Book

Mayewski, Paul, and Frank White.
The Ice Chronicles.
Hanover, NH: University Press of New England, 2002.
Discusses what scientists look for in ice cores and what the information may mean.

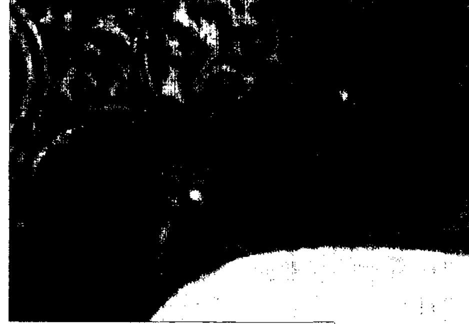
Web Sites

NOVA Online—Mountain of Ice
www.pbs.org/nova/vinson/
Provides program-related articles, interviews, interactive activities, and resources.

What Is Paleoclimatology?
www.ngdc.noaa.gov/paleo/primer.html
Defines paleoclimatology and provides links to information about climate studies.

Scientific Expedition
www.secretsoftheice.org/scientific/usitase.html
Explains the research efforts of the ITASE, a project that includes scientists from 15 countries.

Stories in the Ice
www.pbs.org/nova/warnings/stories/
Presents an ice core timeline showing the kinds of chemicals found in ice cores.



Program Contents

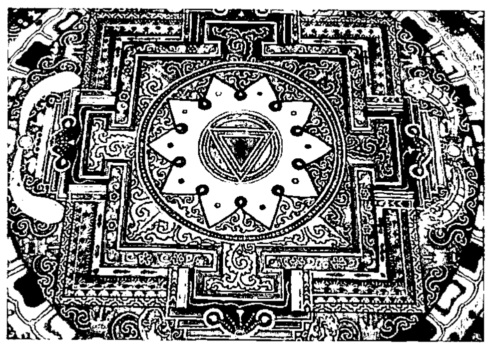
NOVA travels to the Mustang region in Nepal where a small group of Westerners are working with local townspeople to preserve murals on monastery walls.

The program:

- explores the village of Lo Manthang where the way of life has remained the same for the past 500 years.
- discusses Mustang's importance as a last stronghold of Tibetan culture, which was mostly destroyed when China invaded Tibet in the 1950s.
- focuses on the preservation of paintings on the walls of a monastery in Lo Manthang.
- explores the dynamics between Western preservationists and the citizens of Lo Manthang.
- examines the importance of Buddhism in Tibetan culture and the key role the monasteries play in town politics and education.
- documents techniques used by visiting specialists to preserve the monasteries and their paintings.
- shows the technology used by locals to repair the monasteries.
- compares the Renaissance periods that took place simultaneously, yet independently of one another, in Europe and Tibet.

Before Watching

1. Assign groups to research the basic tenets of Buddhism such as: Who was Buddha? What do Buddhists believe? How do Buddhists view nature? Where is Buddhism practiced today? By how many people? Have students record their findings. Conclusions may vary as Buddhism is extremely complex and many interpretations of Buddhism exist. Be sensitive to students who may practice Buddhism. As they watch, organize students into groups and have each group take notes about different areas of Buddhism revealed in their initial research.



Tibetan sand mandalas like this one can take weeks to construct.

After Watching

1. Have students combine what they learned in the program with their research and report their final notes about Buddhism. Did anything in the program change or add to what they learned in their earlier research? What, if any, further questions do they have?

2. An anthropologist is a scientist who studies human beings both in the past and in the present. Ask students to come up with reasons that anthropologists would be interested in the religion or religious art of a society. What might be learned from studying a society's religion?

Activity Setup

Objective

To create a mandala-style piece of art.

Materials for each student

- copy of the *Designing a Mandala* activity sheet on page 26
- paper
- colored pencils

Procedure

① Anthropologists and sociologists study cultural art and religion partly because they reflect other aspects of a society. One of the religious and artistic expressions important to Buddhists in Lo Manthang is the mandala. The circle represents the cosmos and is used as a guide to meditation. Tell students they will be creating their own mandala, and that, like a traditional mandala, it should have symbolic meaning of their own choosing.

② Provide a copy of the *Designing a Mandala* activity sheet to each student. Review with students the meaning of some of the components represented in the Chenrezig mandala shown on their activity sheets.

③ Have students create their mandalas. Tell them that symmetry is an essential quality of mandalas, with each mandala built on a series of concentric circles. Ask them to consider and choose angles and geometric shapes that will create symmetry in their mandalas.

④ After students have determined some shapes, have them create their symbol systems. As they do so, have students think about what is important to them, including people, places, objects, and beliefs. Have students create a chart describing what each symbol means, including colors and their meanings.

⑤ Once the mandalas are created, have students write short poems or essays explaining what their mandalas symbolize. Then organize the class into four groups. Have each group display its mandala pictures together in one area, putting a number on each picture. Then have members put letters on their descriptions of the mandalas and display the descriptions with the drawings (but not matched up).

⑥ Once all groups are done, assign groups to different stations. Have each group member first look at each mandala and try to interpret its meaning and then read the descriptions and match them up with the corresponding mandalas.

⑦ Conclude by discussing the different ideas that students' mandalas symbolize. How close were students' original interpretations of each others' mandalas to the actual descriptions?

⑧ As an *extension*, have students compare their mandalas to real ones. For photos of Tibetan mandalas, visit the Himalayan Art Web site at: **www.himalayanart.org/search/set.cfm?setID=91**

Standards Connection

The activity on page 26 aligns with the following *Principles and Standards for School Mathematics*.

Grades 6–8

Mathematics Standard:
Geometry

Grades 9–12

Mathematics Standard:
Geometry

Designing a Mandala

NOVA Activity **Lost Treasures of Tibet**

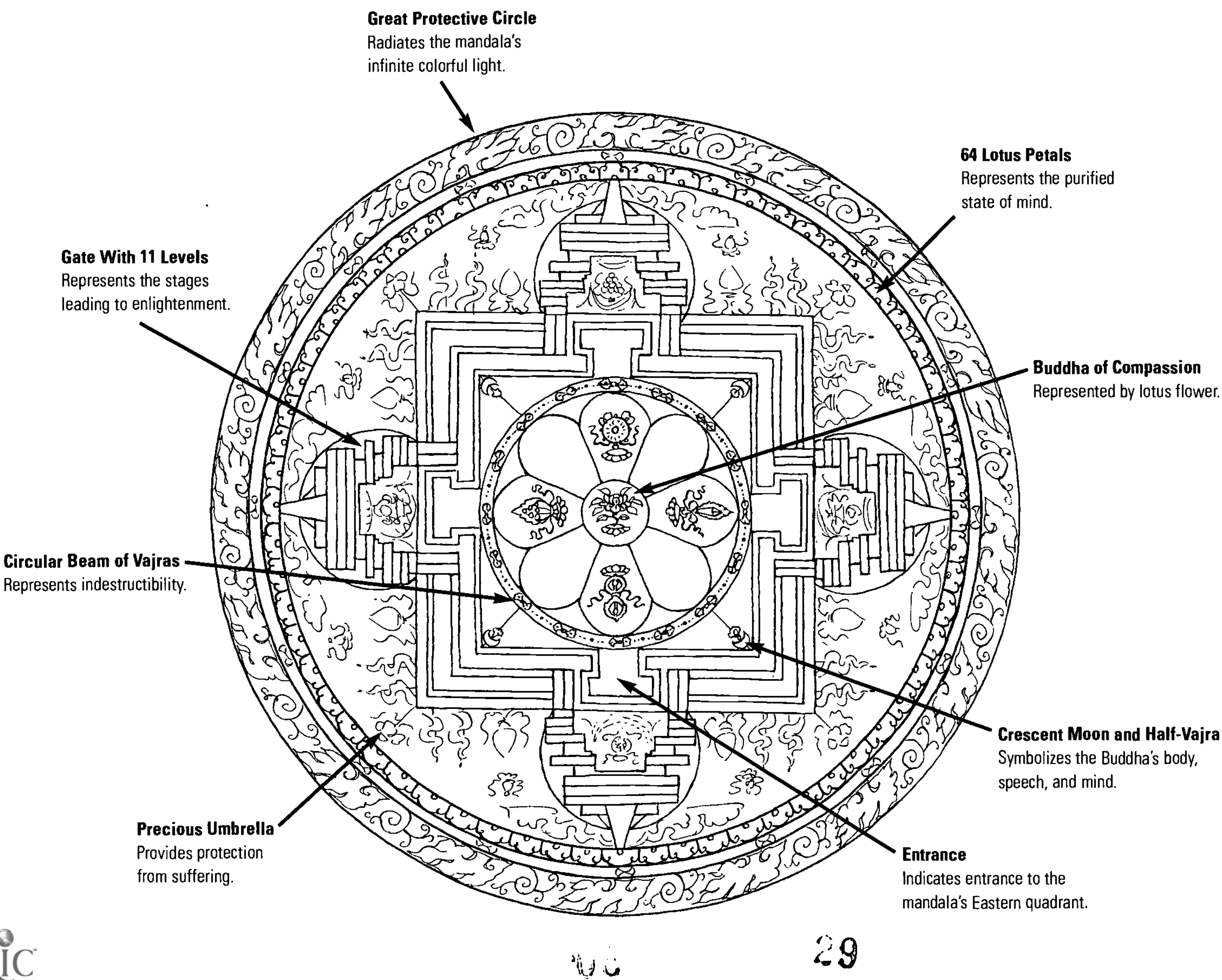
Mandala is the Sanskrit word for *circle* or *whole world.* It is a representation of the universe and everything in it. Mandalas often represent imaginary places contemplated during meditation and have strong geometric components. In religious art, the mandala is used to symbolize wholeness—the circle of eternity.

Chenrezig Mandala

This is a simplified version of a Tibetan Chenrezig mandala, which represents great compassion. This is only one of many kinds of mandalas.

Procedure

1. Design your own mandala. Use some of the geometric shapes you see in the mandala below or create other shapes for your mandala. Think about including various angles, triangles, squares, rectangles, or circles.
2. Create a chart of symbols and colors that have some special meaning to you and your life and include those symbols and colors in your mandala.
3. After you have created your mandala, write a short poem or essay explaining what your mandala symbolizes.



Activity Answer

Tibetan monks may spend weeks creating an intricate sand mandala, only to destroy it within seconds to symbolize the spirit of impermanence and non-attachment to the material world—that everything is in the process of passing away and returning. Sand mandalas are usually gathered in a jar, blessed, and poured into a river or stream where the water disperses the healing energies of the sand.

Each mandala is designed to invite people to greater awareness of various aspects of Buddhist teachings and desirable qualities, such as compassion, wisdom, or strength. Some of the colors used in a Chenrezig mandala, which represents compassion, include white, green, blue, yellow, and red. A mandala usually contains three levels: The outermost level represents the world in its divine form, the inner level depicts a map toward enlightenment, and a secret level represents the perfect balance between body and mind. Every aspect of a mandala has meaning, from the shapes and symbols chosen to the colors used.

Students' mandalas may show a great variety of forms, symbols, and colors—they should reflect some consciousness of the use of shapes and of symbols with meaning to the student artist. There is no right way to design or interpret a mandala.

Resources

Book

Jackson, David, and Janice Jackson.
Tibetan Thangka Painting: Methods and Materials.
Ithaca, NY: Snow Lion Publications, 1984.
Describes the sacred art of Tibetan scroll painting, from composition to application.

Articles

Day, Nicholas.
"The World in a Grain of Sand."
Washington Post, August 5, 1998, page C1.
Describes the process that Tibetan monks use to build and destroy a five-foot mandala made of millions of grains of crushed, vegetable-dyed marble sand.

Shacochis, Bob.
"Kingdoms in the Air."
Outside, October 2002, page 158.
Describes the Mustang region, including life in Lo Manthang.

Web Sites

NOVA Online—Lost Treasures of Tibet
www.pbs.org/nova/tibet/
Provides program-related articles, interviews, interactive activities, and resources.

The Mandala Project
mandalaproject.org/Index.html
Invites the submission of mandalas to an online gallery and discusses the importance of the mandala in different religious traditions.

A New Ceiling for the Roof of the World
www.asianart.com/ahf/index.html
Discusses the restoration of the 15th-century Thubchen Gompa monastery in Mustang.

The Mandala of Chenrezig
www.webster.edu/depts/artsci/religion/mandala/index.html
Presents Webster University's Mandala of Chenrezig and includes information about the Buddhist religion and a link to the World Wide Web Virtual Library for Buddhist studies Web sites.

Secrets of the Crocodile Caves

Airs Tuesday, April 15, 2003 ○ www.pbs.org/nova/croccaves/

Program Contents

NOVA profiles the lives of two of Madagascar's many species—the crowned lemur and the cave-dwelling crocodile.

The program:

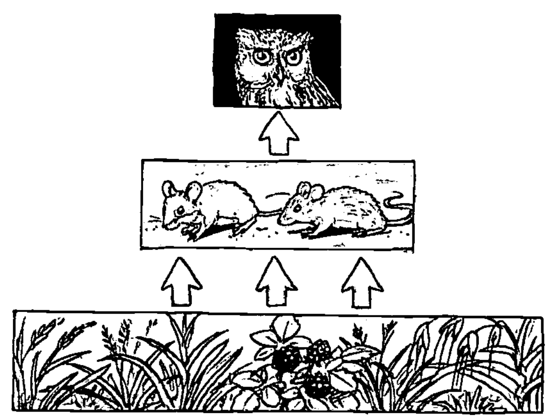
- explores Ankarana, a reserve in northern Madagascar, which is home to a region of stone forests and unique animals and plants.
- documents the crowned lemur's way of life, focusing on a troop of lemurs led by a one-eyed queen.
- hypothesizes that crowned lemurs are a matriarchal society because food is scarce, therefore increasing the importance of the preservation of females and young.
- explores the relationship between cave-dwelling crocodiles and a local tribe that believes they are sacred and protects them.
- features the fossa, a lemur-hunting carnivore that lives nowhere else on Earth.
- uses special filming techniques to capture the lepilemur, aye-aye, and other nocturnal animals.
- presents the lifestyle of the crocodiles, which retreat to caves to cool their ectothermic bodies.
- showcases how lemurs, crocodiles, and other animals and plants on Madagascar have developed adaptations suited to their own well-defined niches.

Before Watching

1. Ask students to find Madagascar on a world map. How might the fact that Madagascar is an island affect its biodiversity? What kinds of animals might live there?

2. Discuss with students the concept of an *energy pyramid.* Be sure to emphasize the direction of energy transfer in the pyramid from prey to predator (see illustration below.)

3. As students watch, have them take notes on predator and prey relationships on Madagascar. Organize the class into three groups to take notes on 1) land animals and plants, 2) animals that live in the water, and 3) animals that primarily live in the sky. Have students create a chart with columns labeled "animal name," "eats," and "eaten by." Students can use their notes to complete the *Home Sweet Home* activity on page 29.



Energy is transferred upward in a food pyramid.

After Watching

1. Ask students to describe the role (niche) played by the lemur in its community, or that played by the crocodile. How are these roles alike? How are they different? What might happen if the lemurs moved into the caves and the crocodiles moved into the forest?

Activity Setup

Objective

To learn about a small segment of the complex food web of a region in Madagascar.

Materials for each group

- copies of the *Home Sweet Home* activity sheet on page 30
- several sheets of unlined paper
- ruler

Procedure

1. Organize students into groups of three so that one member of each group has notes on the different categories outlined in the Before Watching activity #3 on page 28. Provide copies of the *Home Sweet Home* activity sheet and other materials to each group.
2. Discuss with students the concept of a *food web*. They are probably familiar with a simple food chain (e.g., grain is eaten by mice that are eaten by an owl). A food web is a more complex model of feeding relationships that includes many interconnected food chains.
3. After watching, have students in each group identify all the plants and animals on the activity sheet and draw arrows from each plant or animal to the animal that eats it. Then, using their program notes and activity sheet, have students draw a food web for the plants and animals of northern Madagascar. Note to students that these plants and animals are only a small part of the food web in this region of Madagascar. Ask students to draw arrows from an animal or plant to the animal that eats it to illustrate how energy flows through the food web.
4. Ask students to choose one food chain from their food web and use it to draw an energy pyramid. An energy pyramid shows how energy flows through the food chain.
5. To conclude, hold a class discussion about the balance of the food web. What might happen if one organism were taken out of the web? What if an organism, such as another species of lemur, were added?
6. As an *extension,* have students investigate what other plants and animals live on Madagascar and brainstorm how those plants and animals might fit into the food web students created.

Standards Connection

The activity on page 30 aligns with the following *National Science Education Standards*.

Grades 5–8

Science Standard C:
Life Science

Populations and ecosystems

- The number of organisms an ecosystem can support depends on the resources available and abiotic factors, such as quantity of light and water, range of temperatures, and soil composition. Given adequate biotic and abiotic resources and no disease or predators, populations (including humans) increase at rapid rates. Lack of resources and other factors, such as predation and climate, limit the growth of populations in specific niches in the ecosystem.

Grades 9–12

Science Standard C:
Life Science

Behavior of organisms

- Organisms have behavioral responses to internal changes and to external stimuli. Responses to external stimuli can result from interactions with the organism's own species and others, as well as environmental changes; these responses either can be innate or learned. The broad patterns of behavior exhibited by animals have evolved to ensure reproductive success. Animals often live in unpredictable environments, and so their behavior must be flexible enough to deal with uncertainty and change. Plants also respond to stimuli.

Home Sweet Home

NOVA Activity **Secrets of the Crocodile Caves**

Madagascar is home to a wide variety of organisms that occupy specific niches. Each species is connected to other species through a food web and depends on other species for survival. Learn about just a few of those relationships in this activity.

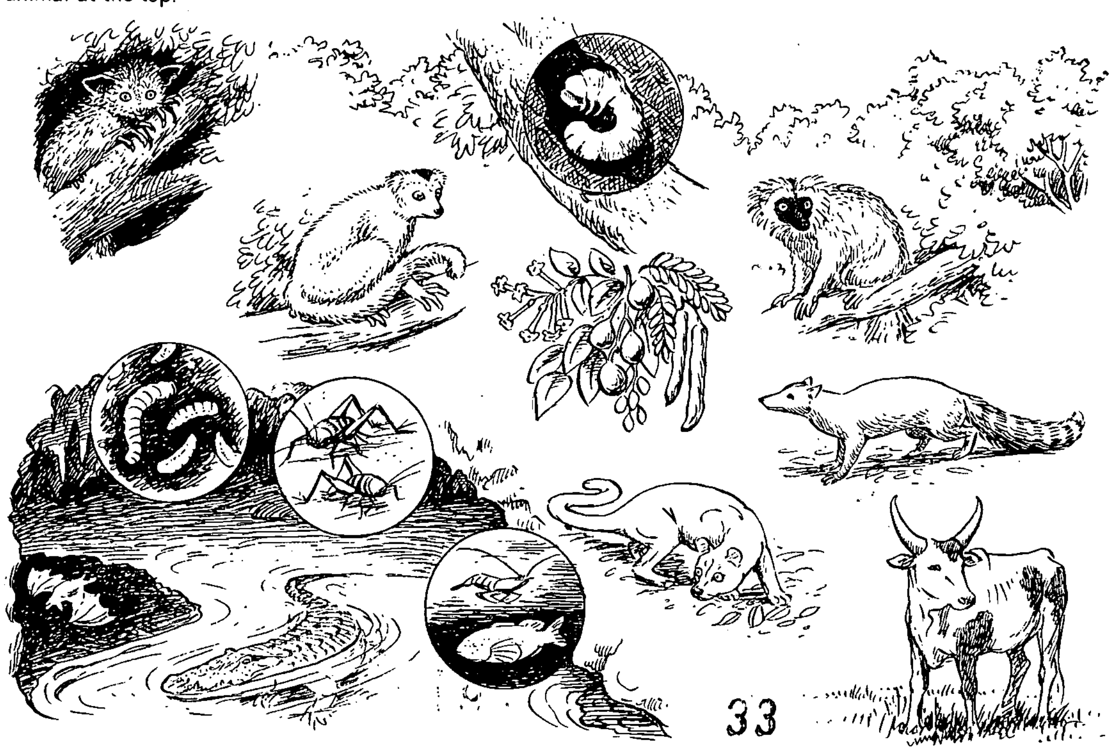
Procedure

1. Take careful notes of all the animals as you watch NOVA's "Secrets of the Crocodile Caves." Then label all the plants and animals in this illustration. Draw arrows from each plant or animal to the animal that eats it.
2. On a separate sheet of paper, draw a food web of all the plants and animals. Write the names of all the plants and animals and draw arrows from each plant or animal to the animal that eats it.
3. Choose a food chain from within your food web and draw an energy pyramid with the parts of that food chain. To create your energy pyramid, draw a triangle and divide it into a top, middle, and bottom. Show how energy flows through the food chain by writing the plant in the bottom segment, the animal that eats the plant in the middle, and the animal that eats that animal at the top.

Questions

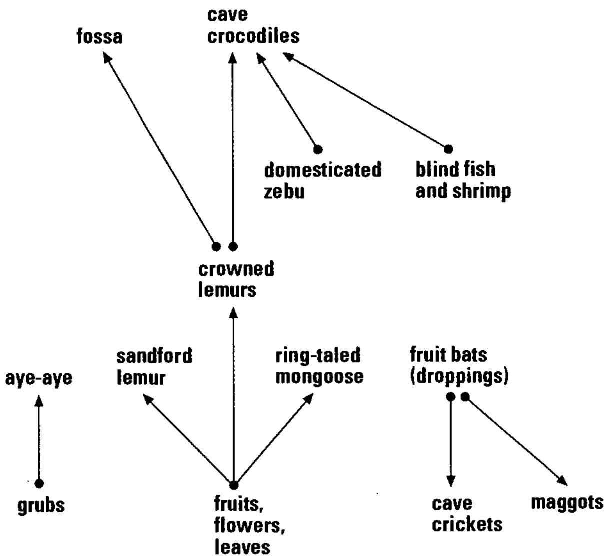
Write your answers on a separate sheet of paper.

1. Circle the crowned lemur on your food web. Identify what the crowned lemur eats in the rainy and dry seasons. List the crowned lemur's predators and competitors.
2. If the fig trees were struck by disease, how would the population of crowned lemurs be affected? How would the crowned lemurs' predators be affected? How would this affect the entire food web?
3. Circle the crocodile. What does the crocodile eat? The adult crocodile in the Ankarana region of Madagascar is free from predators because the Ankarana tribe holds the crocodile sacred. What other factors affect the population of crocodiles? What dangers threaten the eggs and the young crocodiles?



Activity Answer

As you review completed food webs with students, remind them that the animals and plants they used for their food web are just a small segment of the living organisms on Madagascar. The real food web is far more complex. This web is simply to show some of the interactions among plants and animals.



Some of the foods crowned lemurs eat are figs, flowers, and leaves. (They also eat tamarind pods, tree fruits, cicadas, screw plants, and other things not shown in this film.) Two of the crowned lemur's predators are crocodiles and fossas. The crowned lemur's competitors include Sandford lemurs and ring-tailed mongooses.

If the fig trees were struck by disease, the population of crowned lemurs might decrease. Predator populations might also decrease. Since figs are a staple for not just crowned lemurs, but also their competitors, the populations of many species dependent on figs would decrease. Their predators would grow hungry and possibly starve.

The animals that crocodiles eat that are shown on this program include crowned lemurs, domesticated zebu, and blind fish and shrimp. The population of crocodiles is affected by the availability of their prey.

Resources

Books

Garbut, Nick.
Mammals of Madagascar.
New Haven: Yale University Press, 1999.
Provides an overview of Madagascar's diverse group of 117 mammal species, more than 100 of which are endemic to the island.

Tyson, Peter.
The Eighth Continent: Life, Death, and Discovery in the Lost World of Madagascar.
New York: William Morrow, 2000.
Describes Madagascar through the eyes of four scientific experts—a herpetologist, a paleoecologist, an archeologist, and a primatologist—as they explore the world's fourth-largest island.

Web Sites

NOVA Online—Lemurs and Crocs
www.pbs.org/nova/croccaves/
Provides program-related articles, interviews, interactive activities, and resources.

Sights & Sounds—Madagascar Dry Forests
www.nationalgeographic.com/wildworld/madagascar/
Shows photos and video clips of some of Madagascar's rare animals, such as fossas and crowned lemurs.

NOVA Online—The Wilds of Madagascar
www.pbs.org/nova/madagascar/
Presents information about the Malagasy people, panoramic views of the Ankarana Reserve, facts about Madagascar's flora and fauna, a map of the island, an online activity about radio tracking, and more.

Madagascar: Biodiversity and Conservation
ridgwaydb.mobot.org/mobot/madagascar/
Highlights the biodiversity of Madagascar, including a section on the dry tropical forest.

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1 hr. WG36783 $19.95

Battle of the X-Planes
Two aviation giants, Lockheed and Boeing, compete to build the next generation fighter jet and win the largest government contract ever awarded – estimated at one trillion dollars. With unprecedented access from the Pentagon, *NOVA* has followed the trials and tribulations of this design war since its inception over four years ago. *Available March 2003.*
2 hrs. WG36743 $19.95

Dirty Bomb
This past summer, an American al-Qaeda sympathizer, Jose Padilla, was arrested on suspicion of planning a "dirty bomb" attack on the United States. But few know what a "dirty bomb" really is or what devastation it would cause. In this important and timely film, *NOVA* and *The New York Times* go beyond the alarming headlines to answer crucial questions: how easy is it to acquire materials and manufacture a "dirty bomb"? How does it differ from a conventional nuclear one, and how destructive would it be? And how can lives be saved if one should explode? *Available April 2003.*
1 hr. WG36793 $19.95

Killer Algae
This is the extraordinary story of how a supposedly harmless seaweed, used to decorate fish tanks and museum aquariums, has mutated into a monster, escaped into the Mediterranean, and is now choking indigenous sea-life across the world. This bizarre seaweed has become known as the "killer algae" and has taken over thousands of acres of seabed, and no one knows how to stop it. *AV market only. Available May 2003.*
1 hr. WG36733 $19.95

Last Flight of Bomber 31
NOVA follows an official US team searching for evidence from a lost World War II bomber which, for over 50 years, lay in fragments on the edge of a remote volcano in Kamchatka, Russia, its secrets hidden from the rest of the world. Nearby are the remains of several, but not all, of its crew. Who were these men and what was their role in the war? Is there any explanation for the crash? And, what became of the missing crewmembers? *Available February 2003.*
1 hr. WG36723 $19.95

Lost Treasures of Tibet
In April 2001, the final year of work resumed on a race against time: the complicated mission of restoring an ancient Tibetan Buddhist monastery of magnificent proportions. Housing extraordinary art unequaled in Asian monasteries, and damaged by weather and warped from age and infirmity, can science save the last surviving masterpieces? *Available March 2003.*
1 hr. WG36763 $19.95

Mountain of Ice
Mountaineers and scientists explore Antarctica and climb the continent's highest peak, the Vinson Massif. The film is told through the voice of Jon Krakauer, mountaineer and best-selling author of *Into Thin Air.* The present-day expedition is interwoven with a look back at the race between Scott and Amundsen to reach the South Pole in 1912. *Available March 2003.*
1 hr. WG36753 $19.95

Secrets of the Crocodile Caves
NOVA travels to a remote refuge in Madagascar to explore the different survival strategies of a lemur family in the forest and of the endangered crocodiles that skulk in the rivers and hide in the spectacular caves that are the visual centerpiece of the film. *AV market only. Available May 2003.*
1 hr. WG36803 $19.95

Spies that Fly
In the air war in Afghanistan, a 50-foot wingspan plane known as the *Predator* flew high over Taliban positions, enabling U.S. commanders to direct lethal fire with pinpoint accuracy. What's different about *Predator* is that it flies by remote control, with no pilot on board. *NOVA* looks at the next generation of pilotless planes, ones that will be capable of far more than aerial spying and in time may revolutionize the way we fight all future wars. *Available February 2003.*
1 hr. WG36713 $19.95

OTHER NOVA TITLES

Avalanche!
Without warning and within mere seconds, avalanches bury everything in their paths. Put yourself in the path of this terrifying force and see what risks scientists are taking to protect us.
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Climb from Base Camp all the way to the pinnacle of the earth at 29,028 feet. Wind, cold, extreme dehydration, and blinding solar glare add to the misery and peril. Narrated by Jodie Foster. By David Breashears.
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VHS: 1 hr. WG2506 $19.95

Hitler's Lost Sub
1941. German U-boats, Hitler's deadly submarines were sinking U.S. ships along the eastern seaboard. It was cataclysmic, but the Allies ultimately triumphed, sinking over 700 enemy subs. 50 years later, the secrets of the U-boats are revealed.
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Search for the Lost Cave People
Discover a lost civilization that inhabited caves high in the remote cliffs of southern Mexico nearly a millennium ago.
1 hr. WG2507 $19.95

Shackleton's Voyage of Endurance
Through rare footage, photos, interviews, and more, retrace Sir Ernest Shackleton's dramatic and courageous voyage on the *Endurance. AV market only.*
2 hrs. WG35583 $19.95

Sultan's Lost Treasure
A team of archaeologists dives down to the bottom of the South China Sea to retrieve a unique treasure—more than 12,000 intact pieces of Chinese porcelain. The priceless cargo poses countless riddles as the scientists seek to identify the ship, its destination, and the meaning of the symbols inscribed on the dishes. *AV market only.*
1 hr. WG2801 $19.95

Survivor MD
This ground-breaking special offers a behind-the-scenes look at what it really takes to become a doctor. For 14 years, *NOVA* cameras have followed the same group of aspiring doctors: from their first days at Harvard Medical School through grueling apprenticeships and now the rewarding years as real doctors.
3 hrs. WG2806 $29.95

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