DOCUMENT RESUME

ED 446 992 SE 064 297

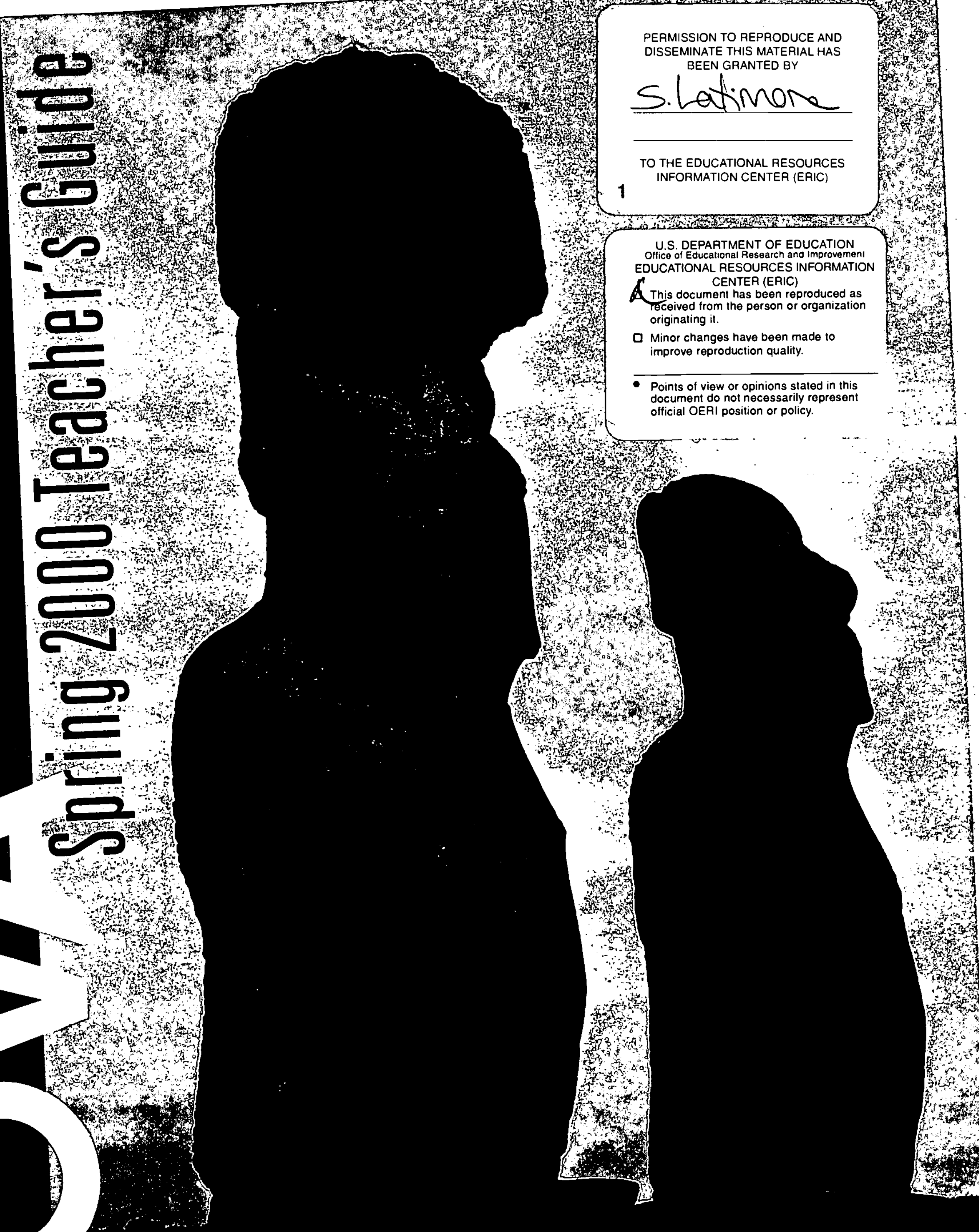
| | |
|---|---|
| AUTHOR | Colombo, Luann; Gregoire, Tanya; Ransick, Kristina; Sammons, Fran Lyons; Sammons, James |
| TITLE | NOVA Spring 2000 Teacher's Guide. |
| INSTITUTION | WGBH-TV, Boston, MA. |
| SPONS AGENCY | Northwestern Mutual Life Insurance Co., Milwaukee, WI. |
| PUB DATE | 2000-00-00 |
| NOTE | 46p.; Published semiannually. Also funded by CNET and the Park Foundation. |
| AVAILABLE FROM | NOVA Teacher's Guide, WGBH, 125 Western Avenue, Boston, MA 02134; e-mail: wgbh_materials_request@wgbh.org |
| PUB TYPE | Guides - Classroom - Teacher (052) |
| EDRS PRICE | MF01/PC02 Plus Postage. |
| DESCRIPTORS | Biological Sciences; Elementary Secondary Education; *Integrated Activities; *Mathematics Education; Relevance (Education); *Science Education; Social Studies |
| IDENTIFIERS | NOVA (Television Series) |


ABSTRACT

This teacher's guide complements six programs that aired on the Public Broadcasting System (PBS) in the spring of 2000. Programs include: (1) "Lost on Everest"; (2) "Lost Tribes of Israel"; (3) "Crocodiles"; (4) "Lost at Sea: The Search for Longitude"; (5) "Global Warming"; and (6) "Secrets of Lost Empires". It provides activity set-ups related to the programs and what to do before and after watching the programs. Activity sheets, answers for the activity sheets, and additional resources are also included. (ASK)

# NOVA

## Spring 2000 Teacher's Guide





# Secrets of Lost Empires

Easter Island moai:
one of five ancient mysteries page 26

At CNET, we support science education as a fundamental building block of a technology-driven future. For 25 years, NOVA has the opened the door on the world of science with unparalleled television programming that inspires learning and exploration. We applaud NOVA's effort to extend that spirit into the classroom where discovery begins.

CNET is pleased to bring you the Spring 2000 *NOVA Teacher's Guide*. The Guide is packed with information and activities to help you bring the wonders of science to your students. As masters of bringing science to life, NOVA and teachers make a great team.

As a proud sponsor of NOVA, CNET wishes all of you a successful school year.

CNET.com
The source for computers and technology.™

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.

The *NOVA Teacher's Guide* serves as an excellent supplement for your use. We are grateful to you for introducing students to the world of science.

PARK
FOUNDATION

# Contents & Broadcast Schedule



## Special Series:

**Secrets of Lost Empires**

Tune in during February to catch this special mini-series in which expert teams of engineers, archaeologists, and master builders attempt to recreate ancient structures, using the materials, tools, and techniques thought to have been available to their early counterparts.

**Medieval Siege**
Week of February 1

**Pharaoh's Obelisk**
Week of February 8

**Easter Island**
Week of February 15

**Roman Bath**
Week of February 22

**China Bridge**
Week of February 29

*Secrets of Lost Empires* programs will be broadcast at 8 p.m. EST before the regularly scheduled NOVA programs at 9 p.m. Activities for the *Secrets of Lost Empires* series start on page 26.

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

- * one-year off-air taping rights
- ** seven-day off-air taping rights
- (R) indicates a repeat program
- 📘 Lesson within this guide
- 🖥 Lesson online at: www.pbs.org/nova/teachers/teachersguide.html

4

# A Guide for The Millennium

Dear Educators,

It is with great pleasure and pride that we share with you the first *NOVA Teacher's Guide* of the millennium. For more than 20 years, this booklet has been our crucial link to educators across the country. You have not only given us valuable feedback to help shape its content and activities, but have also served as our inspiration with your ongoing enthusiasm in the teaching arena. Harkening to the same mission, NOVA welcomes the year 2000 with renewed dedication to making science interesting, exciting, and accessible to people of all ages and backgrounds. We are now "open 24 hours" through NOVA Online, and NOVA Large Format Films are featured in museums and science centers' IMAX® and IWERKS® theaters around the world. At the heart of it all lies what we believe in most—content. Behind every great program lies a great story. And with science as our wellspring for materials, we are assured that the riverbed of ideas will never run dry.

Our 27th season includes a brand new *Secrets of Lost Empires*, one of the most creative and educationally rich series NOVA has ever produced. Each program in this new, five-part series travels to an exotic locale and attempts to recreate ancient wonders of the world using traditional methods and materials.

We hope that *Secrets of Lost Empires* will enhance your curriculum. As always, we look forward to your feedback and working for and with you for many years to come.

Paula S. Apsell

Paula S. Apsell
NOVA Executive Producer

# NOVA Online's Teachers Site www.pbs.org/nova/teachers/

**Sign Up for Weekly Updates**
Would you like to know what's coming up on NOVA each week, both on television and the Web site? Join our mailing list and find out. Each week we'll send you a reminder of the date and title of the following week's broadcast, and what you'll find online to help you integrate the Web into your curriculum. And we'll keep you abreast of any special programs or online adventures we're planning.

**Lesson Ideas**
Here you'll find ideas from your colleagues and lesson plans from this teacher's guide to help you integrate current and past NOVA programs and NOVA Online Web sites into your curriculum.

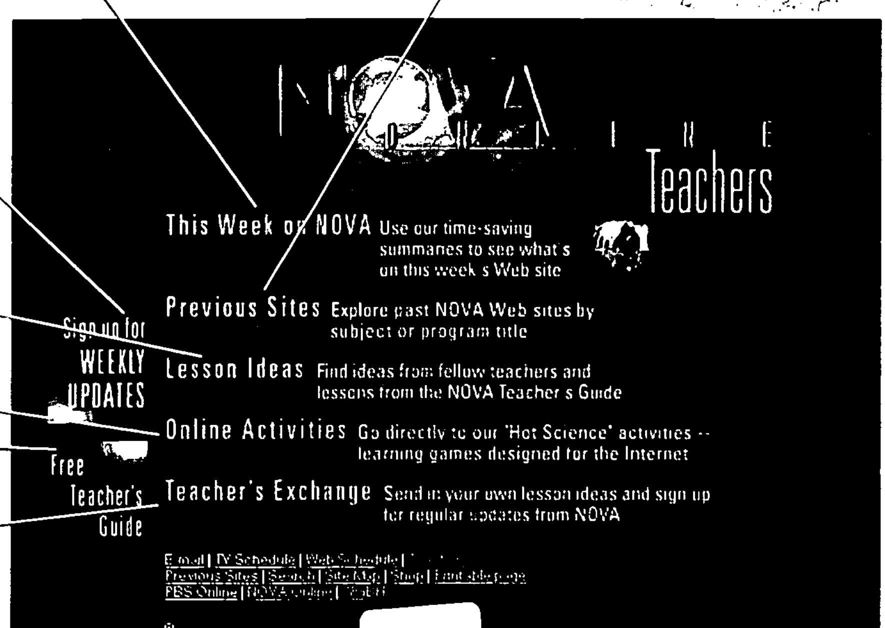
**Online Activities**
Click here to go to our activities designed especially for the Internet.

**Teacher's Guide**
Sign up to receive your free teacher's guide by mail twice a year.

**Teacher's Exchange**
Here you can swap ideas with other teachers about how to use NOVA in the classroom.

**This Week on NOVA**
This section features a listing of the science articles, multimedia presentations, and activities on the Web site that accompany the current NOVA program. Brief descriptions and grade-level designations are provided for everything on the site.

**Previous Sites**
This section provides access by program title or subject area to Web content for previous NOVA programs.



# NOVA Featured Teacher

## Bridges Form Foundation for Geometry Unit

Margaret Wells wanted her fourth grade students to describe and classify geometric shapes and be able to recognize and appreciate the geometry found in the real world. So she turned to the architecture and design of New Orleans and to NOVA and other PBS programs to build her own interdisciplinary unit on architecture.

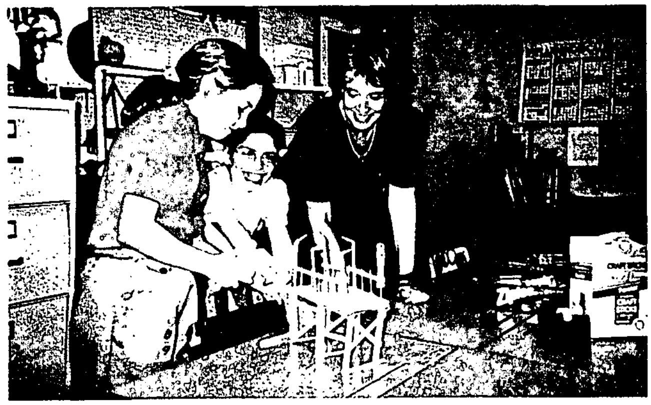
Wells, a gifted education teacher at Alice Harte Elementary School in Orleans Parish, Louisiana, teaches science and offers enrichment activities in mathematics and language arts. Already familiar with construction-related activities from PBS MATHLINE, Wells was inspired by the NOVA program "Super Bridge" to create a more comprehensive unit. "Super Bridge" tracks the work of engineers, construction crews, contractors, surveyors, and project managers as they build a bridge from ground up at Alton, Illinois.

First, students investigated and explored the attributes of geometric shapes using an activity from PBS MATHLINE (**www.pbs.org/teachersource/math/**). Wells, who has been teaching for 17 years, emphasizes hands-on, exploratory work with everyday objects and physical materials as a way to develop students' spatial sense and better prepare students to learn advanced mathematical topics.

Students then viewed "Super Bridge" and identified the different geometric shapes and bridge styles such as truss, beam, and arch found in the bridges profiled. Learning that the bridge in Alton was located on the Mississippi River—which flows through New Orleans—inspired students to look closely at the bridges, highway overpasses, and new construction in and around their own city.

Next, students built different models of towers and bridges. Using the *NOVA Teacher's Guide* Bridge Building lesson plan (available online at: **www.pbs.org/nova/teachersguide/bridge/**), students built towers that would support the most weight possible. To help students understand different types of bridges, Wells had students play the Build a Bridge game online (**www.pbs.org/nova/bridge/**).

Then Wells created a second building activity in which students, working alone or in teams of two and three, designed and built a bridge that could hold the most weight possible, be visually attractive, and be economically feasible.



**Fourth graders Melissa Tran (left) and Alexandra Gravalos use a glue gun to put finishing touches on their bridge while teacher Margaret Wells supervises.**

Using straws, spaghetti noodles, and craft sticks and glue guns, students applied their previous knowledge about geometric shapes and experience in prior building activities to their task. Wells used students' writing to assess the extent to which students understood the concepts.

Critical thinking and problem solving skills were emphasized as students worked to have their bridges support additional weight. If bridges weakened and failed, students then analyzed reasons for the failure.

Wells also used this unit as an opportunity to expose students to career opportunities—she invited an engineer to visit the class and discuss her work with students.

To see the Web page that contains Wells' bridge-building activity, visit: **www.gnofn.org/~msw03/BridgeContest.html**

## Become a NOVA Featured Teacher

We'd like to hear from you! Tell us how you're using a NOVA program or NOVA Online in your classroom.

Send your comments to:
**www.pbs.org/nova/teachers/teacherex.html**
and we'll post them in our Lesson Ideas section.
Or send your ideas to:

Karen Hartley
WGBH
125 Western Avenue
Boston, MA 02134

If we choose to feature your classroom in our *NOVA Teacher's Guide*, we'll send you and your students six free NOVA videos or two Classroom Field Trip kits of your choice.

## Program Contents

NOVA follows an expedition trying to determine whether British climbers George Leigh Mallory and Andrew Irvine ever reached the top of Mt. Everest during their 1924 summit attempt.

The program:

- reviews what climbing was like in 1924, when mountaineers climbed without the assistance of today's maps, high-tech clothing and equipment, or fixed guide trails.
- tracks a team of climbers who search for Irvine's body, last thought to be seen in 1975 by a Chinese climber.
- captures the moment the team finds a body, later identified as Mallory.
- presents items found on Mallory's body, including an altimeter, knife, pencil, snow goggles, and notes from others.
- chronicles climbers' attempts to recreate Mallory and Irvine's ascent using only the equipment available at the time.
- records the climbers who, at 1,000 feet below the summit, consider what Mallory and Irvine's decisions may have been at that same point where they were last seen alive.
- concludes with team members giving their opinions about whether they believe Mallory and Irvine ever reached the summit.

## Before Watching

**1.** As they watch, have students keep track of what equipment both early and modern climbers used during their ascent of Mt. Everest and what they wore or did to try to keep warm.

**Climbers recovered scraps of clothing (left) and items such as snow goggles, a knife, and an altimeter (below) from George Mallory's body.**

## After Watching

**1.** Discuss what students noted about the equipment early mountaineers relied on. How does this compare to the equipment mountain climbers use today? How did the early climbers keep warm? How does that compare to modern climbers' clothing? How did each help maintain body heat?

**2.** There are many times when unexpected events such as accidents, power outages, or a missed trail on a hike happen that require a person to preserve body heat. Ask students to choose one of these situations and describe clothing they might wear or carry along in the case of such an emergency. Have students brainstorm how they might survive different emergencies if they had not planned ahead for them.

## Activity Setup

**Objective**

To determine how effectively common clothing fabrics insulate against cold.

**Materials for each team**

- copies of the *Keeping Warm* activity sheet on page 6
- small round balloons
- bowl of room-temperature water
- measuring spoons
- laboratory-style thermometers
- rubber band
- tongue depressors
- fine-tip markers
- scraps of fabric assigned to that team
- staplers and tape

**Materials for teacher**

- half-gallon milk cartons
- cardboard box large enough to transport all milk cartons
- towel
- scissors or sharp knife
- freezer access

**Procedure**

Read the activity sheet to familiarize yourself with how students will make their climbers.

Prepare enough milk carton holders so each will hold no more than six climbers. Cut off the tops and cut large windows in the lower half of each carton.

For this experiment to be successful, there needs to be a range of results among the different fabrics. Run this experiment ahead of time in your freezer and check frequently to determine the time period that gives you the broadest spread of temperatures. Use this time frame when doing the experiment with your students.

Choose a variety of different fabrics, such as wool, cotton, corduroy, polar fleece, and denim for students to test. Because it takes about 30 minutes to prepare the climbers, consider setting up the experiment one day and running it the next.

Discuss with students how to best run the experiment to compare the insulating ability of different kinds of fabrics, both wet and dry. Assign students to teams and give each team a fabric and condition (wet/dry) to be tested. Discuss the variables involved in the experiment and how to best control them.

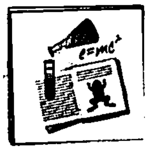
Have students make their climbers and record starting "core" temperatures on their thermometers. Place the climbers in the freezer and note the time. Remove them at the time you determined in your pretrial.

Prepare a class table of all data, directing students to group data for samples of the same fabric. Focus their discussion on traditional versus modern fabrics. How might the fabrics have been similar? How might they have been different?

## Standards Connection

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

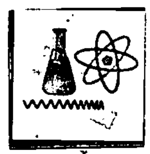
### Grades 5-8



**Standard A:**
Science as Inquiry

**Abilities necessary to do scientific inquiry**

- Design and conduct scientific investigations.
- Use appropriate tools and techniques to gather, analyze, and interpret data.
- Think critically and logically to make the relationships between evidence and explanations.



**Standard B:**
Physical Science

**Transfer of energy**

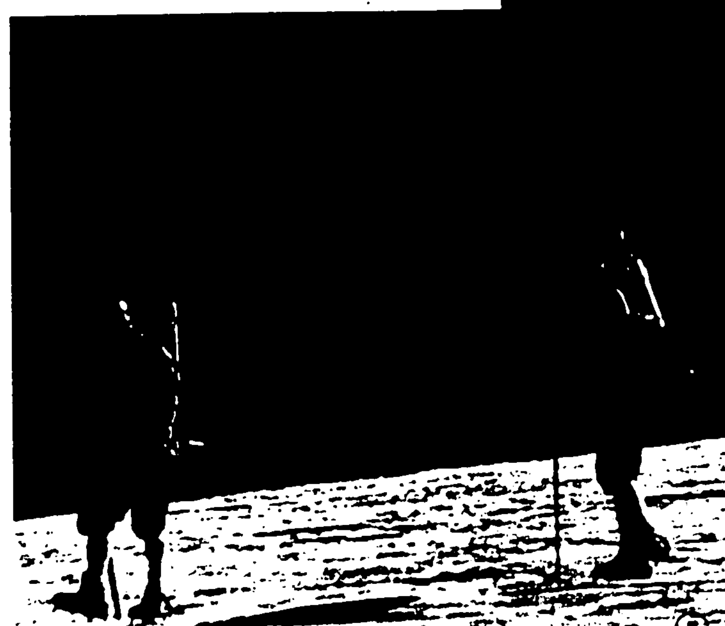
- Heat moves in predictable ways, flowing from warmer objects to cooler ones, until both reach the same temperature.

### Grades 9-12

**Standard A:**
Science as Inquiry

**Abilities necessary to do scientific inquiry**

- Design and conduct scientific investigations.
- Use technology and mathematics to improve investigations and communications.



# Keeping Warm

NOVA Activity | **Lost on Everest**

Survival in cold weather depends on the ability to preserve body heat. Here's a chance to test different fabrics and your assumptions about which ones insulate best, and therefore, best keep you warm. You and your classmates will build models of mountain climbers and dress them in different fabrics to protect them in freezing temperatures.

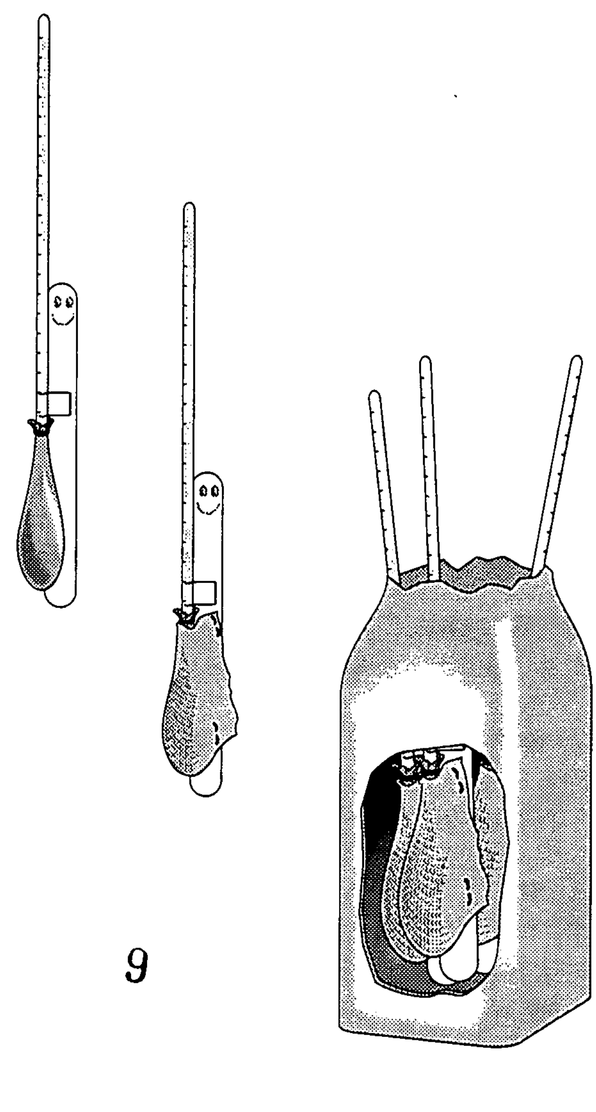
**Procedure**

1. Use a measuring spoon to pour 1 teaspoon (about 5 milliliters) of room temperature water into a balloon to represent the body's "core heat."
2. Slide a laboratory thermometer into the balloon so that the bulb nearly reaches the bottom of the balloon; the water should cover the bulb. Carefully seal the balloon to the thermometer with a rubber band.
3. Tape a tongue depressor to the thermometer so that the end of the depressor sticks about 3/4-inch (2 centimeters) below the balloon bottom. Draw a face on the depressor to give your explorer some personality, and write a name on the bottom.
4. Snugly wrap a single layer of test fabric around your explorer, stapling it on the back side of the depressor. If your climber will be wearing a wet fabric up the mountain, moisten the fabric with water. Record the starting core temperature.
5. After farewell wishes, place your dressed explorer in one of the milk carton holders provided by your Sherpa/Sherpanni (teacher), who will take them up the mountain (into the freezer).
6. While the climbers are enduring freezing temperatures, discuss which fabrics you believe will preserve heat best and why. Make a class chart that includes:
   - climber name
   - fabric type
   - fabric condition (dry, wet)
   - starting temperature
   - temperature when returned
   - temperature change
   - insulating quality (poor, fair, good, excellent)
7. When your climbers return from the freezer, quickly record their temperature and subtract it from the starting temperature. Put the temperature difference in the temperature change column of the chart. As a class, determine the insulating quality of the different fabrics.

**Questions**

*Write your answers on a separate sheet of paper.*

1. What did you notice about your results?
2. Which fabric types were the best and which were the poorest at preserving heat? Why do you think so?
3. What did you learn about dry versus wet fabrics in cold, windless conditions?



## Activity Answer

This activity explores the insulating ability of different materials. It does not take into account body heat, however, which helps real climbers stay warm. How much body heat a person generates depends on many factors, including the amount of body fat and the number of calories a climber has consumed. How much oxygen climbers receive is also a factor in their ability to keep warm (at high altitudes, where the air is thinner, climbers often become oxygen-deprived and rely on bottled oxygen for support).

There are many factors that can cause the end temperatures to be different for samples of the same fabric. These include different temperatures within the freezer, different volumes of water in the balloons, and tightness of the fabric around the explorer. This is a good place to discuss tight control of variables.

Flat, polished fabrics tend to trap less air than puffy fabrics with ample loft. Wool and spun polypropylene will perform well, while silk will do poorly if worn alone. Cotton, like that in blue jeans, should be avoided as it absorbs and retains water and can be difficult to dry. Most wet fabrics let heat escape quickly.

In cold conditions, it is best to layer clothes with several different types of fabrics. According to Princeton University's Outdoor Action Web site, the purpose of layering is to be able to mix and match the layers of clothes to match the weather conditions and your activity level. The idea is to maintain a comfortable body temperature without excess sweating, which increases heat loss.

Hydrophobic synthetic fabrics, such as polypropylene, move moisture away from your body to help keep you dry, according to the Princeton University site. Even if you get wet, wool or synthetic pile/fleece fabrics will keep you warm because they don't absorb water. In addition, windshells made of nylon or nylon/cotton blends reduce convective heat loss.

The comparison of traditional fabrics versus modern fabrics is important. Wool and fur trap air, thus maintaining a bubble of warm air around the body and minimizing heat loss. Some modern fabrics are lightweight, waterproof, and windproof, but they need a puffy inside layer to trap the air around the body.

You may want to mention to students that temperature is only one of the factors with which climbers must contend. They also must deal with wind, fog, and sun, all of which can influence temperature.

**The following is a set of sample data results for one trial run of the activity.**

| Fabric | Minutes | | | | | | |
|---|---|---|---|---|---|---|---|
| | 2* | 4* | 6 | 8 | 10 | 12 | 14 |
| dry denim | -3.0 | +0.5 | -11.0 | -14.0 | -16.0 | -19.5 | -22.5 |
| wet denim | -4.0 | 0 | -12.5 | -15.0 | -16.5 | -19.5 | -22.5 |
| polar fleece | -3.9 | +3.5 | -8.5 | -9.5 | -11.5 | -15.0 | -17.0 |
| melton wool | -3.5 | +3.0 | -8.5 | -11.0 | -13.5 | -16.5 | -18.5 |
| faux fur | -3.8 | -6.8 | -7.8 | -9.8 | -11.8 | -14.8 | -17.3 |

* Temperatures may be initially unstable because of a differentiation of warm and d air pockets within climbers' clothes; this should normalize after a few iutes in the freezer.

# Resources

**Books**

Gardner, Robert, and Eric Kramer.
**Science Projects About Temperature and Heat.**
Springfield, New Jersey: Enslow Publishing, Inc., 1994.
*Describes several activities for investigating the insulating properties of different materials.*

Holzel, Tom, and Audrey Salkeld.
**First on Everest: The Mystery of Mallory and Irvine.**
New York: Henry Holt and Company, 1986.
*Explores the Everest expeditions of the 1920s and describes in detail the 1924 expedition where Mallory and Irvine disappeared.*

**Article**

Wren, Christopher.
**"A Body on Mt. Everest: A Mystery Half-Solved."**
New York Times, 5 May 1999.
*Describes the discovery of Mallory's body by American climbers 75 years after Mallory and Irvine disappeared climbing Mt. Everest.*

**Web Sites**

NOVA Online—Lost on Everest
**www.pbs.org/nova/everest/**
*Delves deeper into the program's content and themes with features such as background information on Mallory and Irvine, photographs of the evidence collected during the expedition, program transcripts, and timelines of attempts to climb Mt. Everest. Launch date: Currently available.*

Mallory and Irvine Research Expedition
**everest.mountainzone.com/99/north/**
*Details the Spring 1999 expedition to determine the fate of Mallory and Irvine. Includes interviews with members of the expedition team and a daily journal entry. Click on dispatches to see the archive of all journal entries.*

Princeton University's Outdoor Action Guide to Hypothermia and Cold Weather Injuries
**www.princeton.edu/~oa/safety/hypocold.html**
*Learn how humans lose body heat to the environment and react to cold weather.*

## Program Contents

NOVA follows anthropologist Tudor Parfitt as he investigates the historical and genetic roots of the Lemba of Soweto in southern Africa who claim to be one of the Lost Tribes of Abraham.

The program:

- explores the Lemba's claim to be Jewish based on their oral history, religious observances, and social customs.
- relates Jewish religious traditions, including passing the priesthood from father to son.
- explains how the Y chromosome carries a genetic marker through generations of males and thus can be used to establish relationships between ancient and modern people.
- postulates that if the Lemba males have the same unique genetic marker as the priests called Cohanim then their claim of Jewish ancestry is more probable.
- traces Parfitt's journey to find the original Sena, the town from which the Lemba claim to have originated.
- follows Parfitt as he collects tissue samples from the Lemba males.
- concludes that the Lemba Y chromosomes show a number of genetic links with Middle Eastern peoples, and that one Lemba clan in particular possesses the Cohanim gene.

**Lemba tribe leader Professor Mathiva (below) says his tribe is descended from Abraham. Female and male chromosomes (right) are shown under magnification. (The male Y chromosome is the smaller of the two.)**

## Before Watching

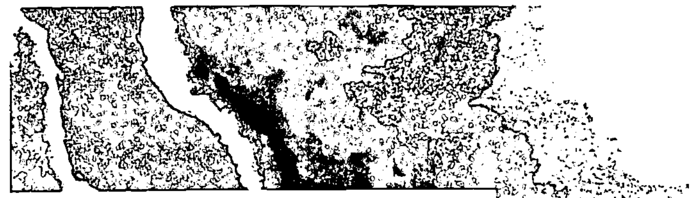
**1.** Discuss and record characteristics of a traditional Jewish belief system. Some of these include circumcision, opposition to marriage outside of the faith, kosher food system, and observance of holidays. As they watch, have students note the characteristics of Lemba tribe traditions.

**2.** Have students brainstorm and list the challenges European scientists might encounter as they cross Africa to collect tissue samples for DNA research.

## After Watching

**1.** Return to lists students made of traditional Jewish customs and compare and contrast those with characteristics of Lemba tribe traditions. How many characteristics of the Lemba tribe match? How much confidence do students have in the Lemba tribe's claim? What impact do the genetic tests have on their conclusions?

**2.** The anthropologist in this program uses DNA to try to establish relationships between groups of people. Discuss other ways DNA is used to determine relatedness or identity.



## Activity Setup

**Objective**

To understand the issues involved with using DNA evidence in a courtroom trial.

**Materials for each group**

- copies of the *Did the Dog Do It?* activity sheet on page 10
- additional reference sources

**Procedure**

Organize students into two juries of approximately 12 students each. Distribute copies of the *Did the Dog Do It?* activity sheet to each student.

Tell students they will be trying a case involving a man bitten by a dog. A pit bull named Buddy is accused of biting a 38-year-old man named Taylor. The pit bull's owner, Sam, says his dog didn't do it. Taylor claims that DNA taken from saliva on a towel he used to clean the bite matches Buddy's DNA.

Have students read the evidence that has come out during the trial and discuss what they can infer from this evidence.

Tell students to brainstorm other questions they would like to have answered about how DNA fingerprinting works. Instruct students to use additional resources to research their answers.

Have students consider what other questions are important in deciding this case, such as how the evidence was collected and processed.

Based on what students learn from their research and the other issues they have considered, have them vote and decide whether they think the accused canine is innocent or guilty.

Have each jury report its verdict and explain how it reached its decisions, including what resources it used to come to its conclusions. If either jury is hung, discuss why and whether additional information would have helped them reach a verdict.

Discuss with students the differences in how the DNA is used in the program and how it is used in this activity. *(The DNA evidence used in the program looks at a set of unique changes on the Y chromosome over time; however, those changes* may not *be present in Jewish males who* are *descendants of the Cohanim, or* may *be present in Jewish males who* are not *descendants of the Cohanim. The DNA markers in this activity are used to determine the probability of a match to a specific individual dog, as well to exclude dogs who do not have the match.)*

## Standards Connection

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

### Grades 5-8

**Science Standard F:** Science in Personal and Social Perspectives

**Science and technology in society**

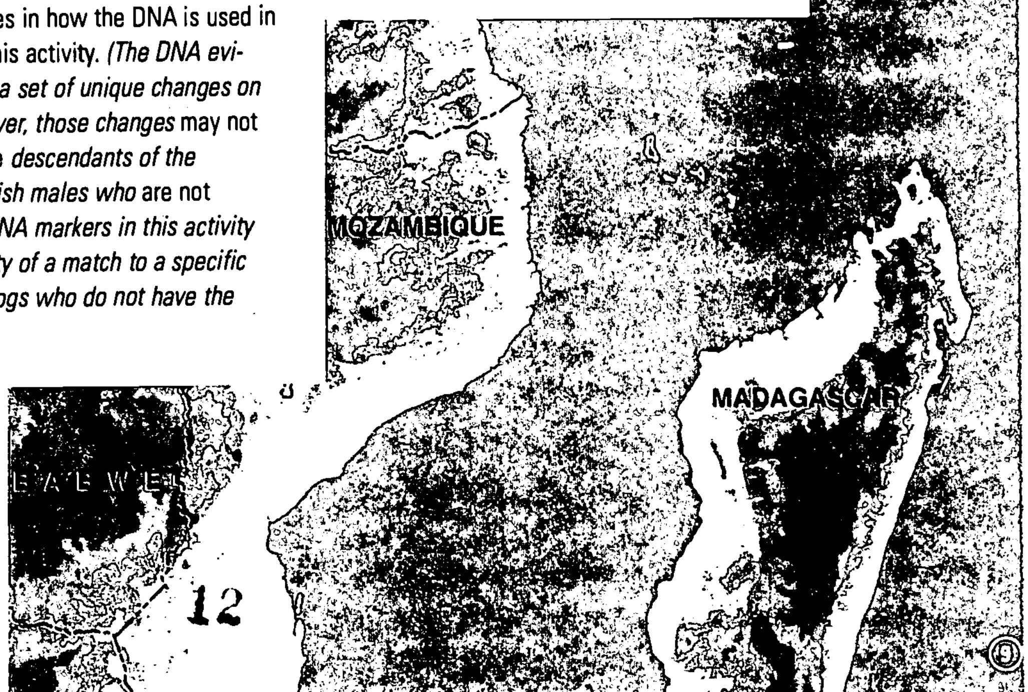
- Science influences society through its knowledge and world view. Scientific knowledge and the procedures used by scientists influence the way many individuals in society think about themselves, others, and the environment. The effect of science on society is neither entirely beneficial nor entirely detrimental.

### Grades 9-12

**Science Standard F:** Science in Personal and Social Perspectives

**Science and technology in local, national, and global challenges**

- Understanding basic concepts and principles of science and technology should precede active debate about the economics, policies, politics, and ethics of various science- and technology-related challenges. However, understanding science alone will not resolve local, national, or global challenges.



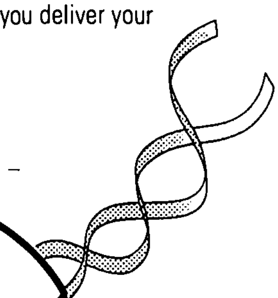
# Did the Dog Do It?

NOVA Activity | **Lost Tribes of Israel**

You have been appointed to a jury to determine the guilt of a dog accused of biting a man. The case rests on DNA evidence. It is your responsibility to decide whether the evidence is enough to find the dog guilty.

**Procedure**

1. Read the evidence you have been given and discuss it as a jury.
2. Consider what other questions you would like to have answered about how DNA fingerprinting works. For example, you might ask:
   - Where in a crime scene might DNA be found?
   - How is a DNA fingerprint made?
   - What probability of DNA match would be considered statistically significant? Is 1 in 10 good enough? 1 in 10,000? 1 in 1 million? 1 in 1 billion?
   - What are some of the problems with DNA fingerprinting?
3. Use additional resources to research answers to your questions.
4. Think about what other questions are important in deciding this case, such as how the evidence was collected and processed and how important the DNA evidence is compared to other evidence in the trial.
5. Based on what you learned from your research and the other issues you have considered, decide as a jury whether you think the accused dog is innocent or guilty. Cite your reasons for your decision when you deliver your verdict.



## The Case of the Dog Bite

**The Prosecution**

Taylor, a 38-year-old man, claims he was bitten by a pit bull named Buddy. He says that Buddy, who lives in Taylor's neighborhood, was loose in the neighborhood and attacked him without any provocation. After being bitten, Taylor claims he cleaned the wound with a towel and then rushed to the hospital. The bite required 10 stitches. Taylor had a local diagnostics laboratory extract DNA from the dog's saliva that was on the towel. DNA fingerprinting showed that five unique markers from the saliva matched markers from Buddy's blood. The odds that the saliva came from a dog other than Buddy are 1 in 350 million. There were no witnesses to the bite.


**The Defense**

Sam owns the pit bull named Buddy. He says that he always keeps Buddy locked up in the backyard and on a chain. He says he wasn't home the day that Taylor was bitten, but that when he got home that night, Buddy was tied up as usual. No one can verify whether Buddy was in the yard that day. Sam says there are three other pit bulls in the neighborhood and that one of them was the one who bit Taylor. Sam agreed to have Buddy's DNA tested.

## Activity Answer

DNA evidence cannot conclusively prove that a person, or in this case, a dog, committed a crime. What it can do is show the probability of someone having the same DNA match. The probability given for a DNA match states the probability of finding a particular profile by chance in a population. For example, if the probability of 1 in 10,000 were given for a match to the dog's DNA, then in a city of 5,000,000 dogs, there would be 500 dogs that could match this profile purely by chance. Jurors would then need to decide whether the dog is innocent given this probability.

DNA evidence can also rule out people from being considered as suspects when no match exists.

Every organism's DNA is composed of strings of four different nucleotides: G(uanine), C(ytosine), A(denine), and T(hymine). These strings of nucleotides are connected to one another by nucleotide pairing (G–C and A–T) to form the two-stranded DNA molecule that makes up the chromosome. For the most part, the order—or sequence—of these base pairs is very similar from one individual to another. However, there are regions of DNA that are highly variable in length and/or sequence and therefore are different from individual to individual (except in identical twins whose DNA is identical). These variable regions of DNA are typically used in DNA fingerprinting.

A DNA fingerprint is made by taking a sample of DNA—which can be taken from nuclear or mitochondrial DNA found in almost every living cell—making copies of the extracted DNA, and isolating certain known base pair sequences. Since the fragment lengths starting with these known sequences differ in every person, they can be used to help determine identity. A DNA fingerprint looks at only a small number of base pair sequences contained in a person's total DNA. Nevertheless, the differences between the DNA in different people is such that even these small number of sequences can eliminate a large majority of other people as a suspect.

**Other issues students might consider:**
How was the DNA collected and processed? Could the evidence have been contaminated with DNA from another source? How much DNA was available for testing? How many different DNA segments were analyzed? Are any other neighborhood pit bulls from the same litter as Buddy? Were the lab procedures conducted accurately? What were the credentials of the expert who presented the DNA evidence? Was the expert paid, and if so, how much?

## Resources

**Book**
Parfitt, Tudor.
**Journey to the Vanished City.**
London: Hodder and Stoughton, 1992.
*Delves deeper into the journey described in the program and includes features such as a map of the route.*

**Articles**
Jaroff, Leon.
**"Order in the Lab! As the judge sets a date for the Simpson trial, lawyers wrangle over the DNA tests that could seal O.J.'s fate."**
Time, 8 August 1994, 46.
*Reviews different types of DNA processing techniques.*

Travis, John.
**"The Priest's Chromosomes."**
Science News, 3 October 1998, 218–219.
*Details the DNA analysis supporting the passing of a genetic marker on the Y chromosome of Jewish priests from father to son.*

**Web Sites**
NOVA Online—Lost Tribes of Israel
**www.pbs.org/nova/israel/**
*Delves deeper into the program's content and themes, with features such as articles, timelines, interviews, resource links, and more. Includes an online activity on how to create a DNA fingerprint. Launch date: Friday, February 18.*

Basics of DNA Fingerprinting
**www.biology.washington.edu/fingerprint/dnaintro.html**
*Explores what DNA fingerprinting is, how it is done, its applications, and some of the problems with using it.*

Blackett Family DNA Activity
**www.biology.arizona.edu/human_bio/activities/blackett/introduction.html**
*Details the concepts and techniques behind DNA profiling, interpreting DNA autoradiograms, and evaluating DNA profiles to determine familial relationships.*

DNA Testing
**www.fbi.gov/kids/crimedet/dna/dna.htm**
*This FBI site explains DNA sequencing, relates DNA law enforcement stories, and provides a glossary of DNA-related terms.*

# Crocodiles!

Airs the week of February 29 • www.pbs.org/nova/crocs/

## Program Contents

NOVA explores the physical adaptations and behaviors that have made the crocodile a successful freshwater predator since the time of the dinosaurs.

The program:

- follows researchers who travel around the world to observe different species of crocodiles in their natural environments.
- outlines the specialized aspects of the crocodile's physiology that enable it to thrive in a range of freshwater and saltwater habitats.
- describes the crocodile's complex social behaviors relating to courtship, mating, feeding, and caring for its young.
- gives examples of crocodiles using a sophisticated system of sounds and movements to communicate with mates, parents, and siblings.
- follows the activities of a group of crocodiles and other animals in their community during a long dry season.
- uses infrared camera techniques to film rare footage of nighttime feeding and other behaviors.
- shows how the crocodile's skill as a hunter and flexible diet helps it to survive in difficult conditions

## Before Watching

**1.** To encourage students to think about their current knowledge of crocodiles, have them work in small groups to prepare Crocodile Profiles. The profiles should list students' ideas about crocodile classification, habitat, size, appearance, diet, birth, and communication method.

**Researchers have learned many new facts about the social behavior of crocodiles, including how they care for their young.**

## After Watching

**1.** Have students revisit their Crocodile Profiles. Which details were consistent with the information presented in the program? Which were different? Which of the differences was most surprising, and why? As a class, discuss possible reasons for naive conceptions. What sources had informed students' previous images of crocodiles? How has their attitude toward these animals changed?

**2.** The program suggests that the crocodile's finely-tuned adaptations enabled it to survive the circumstances that caused the dinosaurs to become extinct. Have students identify examples from the program of crocodiles overcoming challenges in their environment. In which cases do the crocodiles rely on physical adaptations? In which cases is their success related to behavioral adaptations?

## Activity Setup

### Objective

To help students understand the need to evaluate the accuracy and reliability of information by comparing facts collected from a variety of sources.

### Materials for each group

- copies of the *Whom to Believe?* activity sheet on page 14
- additional reference sources, including books, newspaper and popular magazine articles, science journals, and, if possible, access to a scientist and to the Internet

### Procedure

Start by asking students if they have heard the phrase "Information Age." Why do they think that this label is used to refer to the present time in our society? Have the class brainstorm a list of forms of media and other information providers.

Divide the class into two groups and hand out the *Whom to Believe?* activity sheet. Assign one group the topic of anatomy and physiology. These students should particularly watch for and record information about the crocodiles' distinct internal and external body features and how they have adapted to varying environments. Assign the second group the topic of social behaviors. These students should record information about the crocodiles' courtship and mating rituals, hunting practices, and methods of communication.

After viewing the program, have students from each group share what they learned about crocodilian anatomy and physiology and social behaviors. Clarify any points where opinions might differ.

Regroup students into teams with the same or similar facts and have them research their facts using several sources, including reference books, newspapers and magazines, science journals, and, if possible, scientists and the Internet.

Once team members have completed their research, have them review what they learned, choose the source or sources they most believe, and provide reasons for their choices.

Lead a class discussion about what each team found and the choices teams made. Are there any trends regarding which sources students most believed? Was certain information more likely to be the same across all sources? Why? If some sources had conflicting facts, or didn't have any information about what was revealed in the NOVA program, why might that be? What conclusions can students draw from what they learned? Conclude with a discussion about what makes a source reliable.

As an *extension*, have students develop a class list of information literacy guidelines. You may wish to invite the school librarian and/or media specialist to share some suggestions with the class.

## Standards Connection

**The activity found on page 14 aligns with the following *National Science Education Standards*.**

### Grades 5-8

**Science Standard G:** History and Nature of Science

**Nature of science**

- In areas where active research is being pursued and in which there is not a great deal of experimental or observational evidence and understanding, it is normal for scientists to differ with one another about the interpretation of the evidence or theory being considered. Different scientists may publish conflicting experimental results or might draw different conclusions from the same data.

### Grades 9-12

**Science Standard G:** History and Nature of Science

**Nature of scientific knowledge**

- Scientific explanations must meet certain criteria. First and foremost, they must be consistent with experimental and observational evidence about nature, and must make accurate predictions, when appropriate, about systems being studied. They should also be logical, respect the rules of evidence, be open to criticism, report methods and procedures, and make knowledge public. Explanations on how the natural world changes based on myths, personal beliefs, religious values, mystical inspiration, superstition, or authority may be personally useful and socially relevant, but they are not scientific.

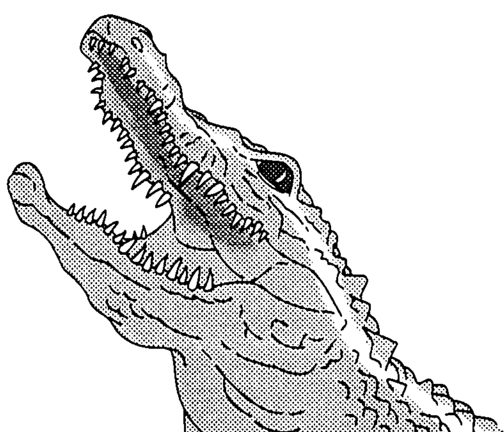
# Whom to Believe?

NOVA Activity | **Crocodiles!**

This NOVA program includes many facts about how crocodiles live. But this program is just one of many sources from which you can obtain information about these complex creatures. Which sources should you rely on? In this activity, you will collect information from several different sources and then evaluate your findings.

**Procedure**

1. First make a chart like the one below on a separate sheet of paper. Next, fill in your group's assigned topic—either the anatomy and physiology of crocodiles or their social behaviors.
2. As you watch, take notes in the column labeled "NOVA program" about facts that relate to your topic.
3. Research other sources to see whether they contain information that agrees or differs from the facts you collected from the NOVA program.



**Questions**

1. Once you have completed your research, consider all of your facts, and choose which source or sources you most believe for each fact. List this source in the last column of your table and give your reasons for why you feel this source is most believable. In evaluating the sources, you may want to consider the following:
   - How objective is the source given the topic you are considering?
   - How credible is the source?
   - When were the facts reported?
   - Where did the fact originate? (For example: Quote from scientist, text of article or narration in program, or paper authored by a scientist.)
2. Based on your selections in the last column, what conclusions can you draw about the reliability of different sources?
3. Choose one of the following roles and explain why the reliability of sources might be important to you in your work. What sources might you depend on?
   - a fifth-grade teacher preparing a lesson on crocodiles for your class
   - a politician reading a proposed law that could impact crocodile habitats
   - a news reporter writing a story about crocodiles in a local swamp
   - a reptile specialist building a new crocodile exhibit at a zoo

| | **Source 1:** NOVA program | **Source 2:** Reference books | **Source 3:** Newspaper and magazine articles | **Source 4:** Scientist or science journal article | **Source 5:** Internet | Which source(s) do you most believe and why? |
|---|---|---|---|---|---|---|
| **Fact 1** | **Example:** crocodiles can live in salt water | | | | | |
| **Fact 2** | | | | | | |
| **Fact 3** | | | | | | |
| **Fact 4** | | | | | | |
| **Fact 5** | | | | | | |

## Activity Answer

Students reporting about the anatomy and physiology of crocodiles may list:

- sharp teeth for gripping prey
- eyes that can see above and below the water's surface
- keen sense of smell
- control of buoyancy
- acidic digestive system that can digest bones, skin, and horns
- ability to remain underwater for long periods of time
- flexible diet

Students recording social behaviors may list:

- complex communication system, including courting calls and behaviors, territorial signals, contact calls, and distress calls
- courting and mating behaviors
- caring for eggs and young
- hunting in teams to kill large prey

What students discover from their research will vary. They may discover that numbers differ—such as how ancient crocodiles are, or how many exist in certain populations—or they may find that some sources give ranges of numbers instead of one definitive number. They are likely to find that facts regarding anatomy and physiology are more easily verified than facts involving numbers. Because some of the observations in the NOVA program were new, particularly regarding social behaviors, students may not find many corroborating sources.

In general, students may state that scientific sources such as journals and well-known reference materials such as encyclopedias are most reliable. Students may feel that educational materials and established Internet sites are also reliable. Sources such as popular magazines and personal Internet sites may be less reliable. Discuss criteria such as reviews and primary source information that lend credibility to sources.

Students will probably state that the reliability of sources is important to ensure that information is correct. Each of the job roles in Question 3 is passing the information along to others or making important decisions based on the information. Ask students to consider the consequences that misleading or incorrect information might have in each situation.

# Resources

### Books

Ross, Charles A., Garnett, S., and Pyrzakowski, T.
**Crocodiles and Alligators.**
New York: Facts on File, Inc., 1989.
*An encyclopedic and illustrated reference book with in-depth articles by leading crocodile researchers.*

Alderton, David, and Tanner, Bruce.
**Crocodiles and Alligators of the World.**
New York: Facts on File, Inc., 1991.
*Contains hundreds of photographs and facts about crocodilian species around the world.*

### Article

Throbjarnarson, John.
**"The Hunt for Black Caiman."**
International Wildlife, July/August 1999.
*Chronicles a research trip to the Brazilian Amazon that looks for ways to combine conservation of a crocodilian population with economic opportunity for the local people.*

### Web Sites

NOVA Online—Crocodiles!
**www.pbs.org/nova/crocs/**
*Includes interviews with crocodile researchers, facts on the 23 species of crocodilians, information on the challenges of working with crocodiles in the wild, and more. Launch date: Currently available.*

Crocodilians Natural History and Conservation
**www.crocodilian.com**
*Documents facts about crocodile species, houses photographs and sound bites, and provides links to other crocodile resources on the Web. Maintained by a crocodile scientist.*

American Alligator
**gnv.ifas.ufl.edu/www/agator/htm/aligator.htm**
*Provides information on American alligator populations, habitats, reproduction, behavior, interactions with humans, and safety tips.*

# Lost at Sea: The Search for Longitude

Airs the week of March 21 • www.pbs.org/nova/longitude/

## Program Contents

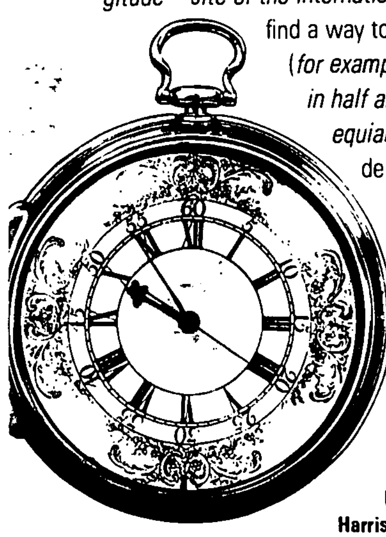
NOVA chronicles the seventeenth-century journey to determine longitude.

The program:

- In 1714, following a maritime disaster, British Parliament offers £20,000 for the first reliable method of determining longitude on a ship at sea.
- It is known that longitude can be found by comparing a ship's local time to the time at the port of origin.The challenge is finding a clock—a chronometer—that can keep time at sea, where temperature changes, humidity, gravity and a ship's movement affect accuracy.
- Early attempts are based on the assumption that astronomy can solve the problem.
- Self-taught clockmaker John Harrison believes the answer lies in large mechanical clocks. Through careful observation and experimentation, he invents many adaptations to improve clock accuracy. After decades of work, he realizes pocket watches are a better choice and redirects his efforts to pursue this smaller technology.
- In 1764, Harrison's watch proves accurate in helping determine the longitude on a six-week voyage to Barbados.

## Before Watching

**1.** Review latitude and longitude with students. Have students select a few locations on a map or globe and identify them by latitude and longitude. Give groups of students a marker and an orange or grapefruit, representing the Earth. Ask them to draw and label lines of latitude and longitude on the fruit and locate where East meets West (*at 180° longitude—site of the international date line*). Have students find a way to make the lines equiangular (*for example, they might cut the orange in half and use a protractor to mark equiangular segments*). Have students approximate where their city is on the fruit model of the Earth and then confirm latitude and longitude using a map.



**Completed in 1760 by John Harrison, this watch won the Longitude Prize, offered to whomever discovered a method of accurately fixing longitude anywhere on Earth. Harrison also produced the exquisite decoration found on the watch face.**

## After Watching

**1.** It was commonly believed in the 1700s that the secret to finding your longitude at sea was knowing the time in two places: Your ship's port of origin and its current location. Ask students to explain how knowing the time in two places can help determine longitude.

**Objective**

To research and chart the shortest course to circumnavigate the globe.

**Materials for each group**

- copies of the *Voyage Around the World* activity sheet on page 18
- world map, globe or atlas, with a scale
- small tacks, pins or self-stick notes (for marking locations)
- a 12-inch piece of string (for measuring distances)

**Procedure**

Organize students into groups and distribute activity sheets and materials to each group. Explain that the challenge is to research and chart a course that takes them to each Checkpoint Destination on their way around the world once. Have students review the Nautical Rules and Checkpoint Destinations before beginning. (You may delete or change Checkpoint Destinations to best suit your students' abilities.)

Have students research locations that match the Checkpoint descriptions, plot these locations on a map, record the latitude and longitude for each, and plan their course from one location to the next. Then have them estimate the distance between locations, using the string and a map scale.

When teams have completed their routes, have them exchange maps and recording charts to compare Checkpoint locations and estimated distances. Then, as a class, come up with the shortest route possible.

As an *extension,* you can have students convert the estimated distances from statute miles to nautical miles.

**The activity found on page 18 aligns with the following *National Science Education Standards.***

## Grades 5-8

**Science Standard G:**
History and Nature of Science

**Science as a human endeavor**

- Science requires different abilities, depending on such factors as the field of study and type of inquiry. Science is very much a human endeavor, and the work of science relies on basic human qualities, such as reasoning, insight, energy, skill and creativity—as well as on scientific habits of mind, such as intellectual honesty, tolerance of ambiguity, skepticism and openness to new ideas.

**Mathematics Standard 7:**
Computation and Estimation

**Mathematics Standard 13:**
Measurement

## Grades 9-12

**Science Standard G:**
History and Nature of Science

**Science as a human endeavor**

- Individuals and teams have contributed and will continue to contribute to the scientific enterprise. Doing science or engineering can be as simple as an individual conducting field studies or as complex as hundreds of people working on a major scientific question or technological problem.

# Voyage Around the World

NOVA Activity | **Lost at Sea: The Search for Longitude**

You are about to embark on a voyage around the world. Your mission is to chart a course that will take you to each Checkpoint Destination on your way around the globe once. Bon voyage!

**Procedure**

① Read the Nautical Rules.

② Review the Checkpoint Destination descriptions. Research and find locations that match each Checkpoint, which you must visit in order. Your goal is to visit every Checkpoint and circumnavigate the globe.

③ On a world map, globe or atlas mark the locations you've chosen for each Checkpoint. Record the location and its latitude and longitude for each Checkpoint.

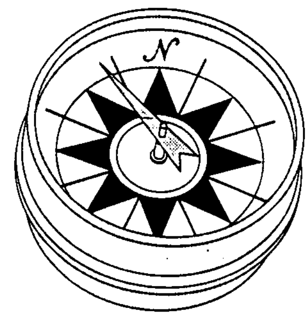
④ Plan a course from one Checkpoint to the next and estimate the distance between each location, using the string and map scale. Then calculate the total distance for the entire voyage.

⑤ Trade recording charts with another team and check that team's course and distance measurements.

⑥ Once you have checked another team's course, work as a class to chart the shortest course around the world.

**Nautical Rules**

- Begin and end your trip in Greenwich, England.
- Circumnavigate the globe once.
- Visit every Checkpoint Destination. (Each Checkpoint must be a different location.)
- Visit the Checkpoints in order.




| Checkpoint Destination | Location | Latitude and Longitude | Estimated Distance from Previous Checkpoint |
|---|---|---|---|
| 1 Start in Greenwich, England. | Greenwich, England | 51°29′ N, 0°00′ W | 0 miles |
| 2 Dodge an iceberg. | | | |
| 3 Dock next to a cruise ship. | | | |
| 4 Stop at a Spanish-speaking port. | | | |
| 5 Stop at an English-speaking port. | | | |
| 6 View a high mountain from a port. | | | |
| 7 Visit a major oil-supplying port. | | | |
| 8 Photograph a kangaroo. | | | |
| 9 Sight a penguin. | | | |
| 10 Collect exotic spices. | | | |
| 11 Have lunch in a country where rice is a dietary mainstay. | | | |
| 12 Visit a country that has changed its name within the past 50 years. | | | |
| 13 End in Greenwich, England. | | | |

## Activity Answer

Because the Checkpoint Destinations are open-ended, the locations and courses students choose will vary (see sample course below). When students present their locations, courses and estimated distances, they should be able to explain why each location matches the Checkpoint description, how they chose the course, and the method they used for estimating distances. Most maps students will be using show statute miles, the unit of measurement for distances on land. Distances at sea are measured in nautical miles. A nautical mile is found by dividing the Earth into 360 degrees, and then dividing each degree into 60 minutes. One nautical mile equals one minute, or 1/21,600 of the Earth's circumference. Students can convert statute miles to nautical miles by dividing the number of statute miles by 1.1508.

| | Checkpoint Destination | Location | Latitude and Longitude | Estimated Distance from Previous Checkpoint |
|---|---|---|---|---|
| 1 | Start in Greenwich, England. | Greenwich, England | 51°29' N, 0°00' W | 0 miles |
| 2 | Dodge an iceberg. | Reykjavik, Iceland | 64°09' N, 21°58' W | 1,230 miles |
| 3 | Dock next to a cruise ship. | St. Thomas, U.S. Virgin Islands | 18°20' N, 64°55' W | 4,010 miles |
| 4 | Stop at a Spanish-speaking port. | Panama Canal | 9°10' N, 79°37' W | 1,540 miles |
| 5 | Stop at an English-speaking port. | Los Angeles, California | 34°00' N, 118°15' W | 3,700 miles |
| 6 | View a high mountain from a port. | (Mt. Rainier) Seattle, Washington | 47°35' N, 122°20' W | 1,540 miles |
| 7 | Visit a major oil-supplying port. | Valdez, Alaska | 61°07' N, 146°17' W | 1,230 miles |
| 8 | Photograph a kangaroo. | Sydney, Australia | 33°55' S, 151°10' E | 9,560 miles |
| 9 | Sight a penguin. | Balleny Islands, Antarctica | 66°30' S, 163°00' E | 2,470 miles |
| 10 | Collect exotic spices. | Jakarta, Indonesia | 6°09' S, 106°49' E | 4,320 miles |
| 11 | Have lunch in a country where rice is a dietary mainstay. | Singapore | 1°17' N, 103°51' E | 620 miles |
| 12 | Visit a country that has changed its name within the past 50 years. | Sri Lanka (Ceylon) | 7°30' N, 81°50' E | 1,540 miles |
| 13 | End in Greenwich, England. | Greenwich, England | 51°29' N, 0°00' W | 8,020 miles |
| | | | | **39,780 (statute miles)** |
| | | | | **34,567 (nautical miles)** |

## Resources

### Books

Hobden, Heather, and Mervyn Hobden.
**John Harrison and the Problem of Longitude.**
Lincoln, England: Cosmic Elk, 1989.
*Includes a history of John Harrison and his invention of the maritime chronometer, which solved the problem of finding longitude at sea.*

Sobel, Dava.
**Longitude: The True Story of a Lone Genius Who Solved the Greatest Scientific Problem of His Time.**
New York: Walker, 1995.
*Takes the reader back to the maritime world of 1714, when finding the solution to the problem of determining longitude at sea was of the highest scientific, political and economic priority.*

### Web Site

NOVA Online—Lost at Sea: The Search for Longitude
**www.pbs.org/nova/longitude/**
*Includes an interactive game that provides a way to understand why knowing the time at your home port allows you to fix your longitude at sea. Also features how the Global Positioning System works, a timeline of ancient navigation, and contributions from leading experts on what they believe are some of the greatest scientific challenges of our day. Launch date: Currently available.*

## Program Contents

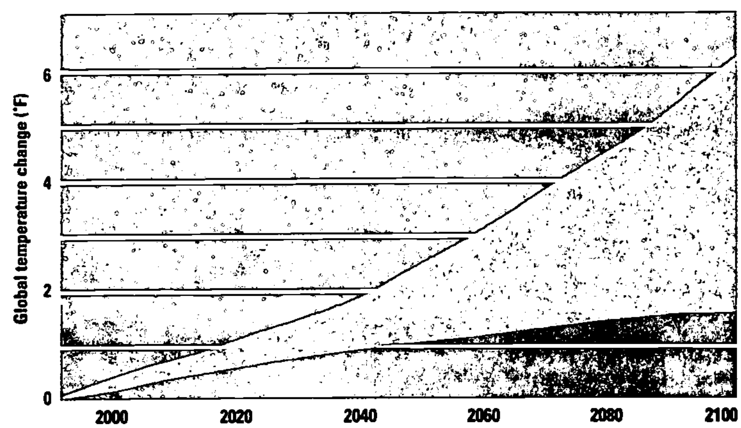
NOVA investigates the complex scientific, ethical, and political issues surrounding possible human-induced global warming caused by the burning of fossil fuels.

The program:

- explains the natural greenhouse effect of Earth's atmosphere and its role in creating a habitable environment.
- describes the link between burning fossil fuels and an increase in atmospheric carbon dioxide, the most important greenhouse gas.
- examines the variety of methods by which scientists are attempting to reconstruct Earth's climate history and predict its future.
- compares existing and potential human-induced change with known natural causes of climate change.
- presents a wide range of outcomes from increasing atmospheric carbon dioxide.
- quantifies the relationship between current and projected energy use and carbon emissions.
- describes the growing global problem of fossil fuel use as developing nations become industrialized.
- relates the difficulties surrounding recent international efforts to mitigate carbon dioxide emissions.
- outlines the economic and political challenges associated with non-fossil energy sources and other possible solutions, such as carbon sequestration and improvements in energy.

## Before Watching

1. Everyone knows temperatures in the same locations vary from day to day and from season to season. However, the really important changes are not the daily weather variations in one place, but rather long-term climatic changes averaged over the entire globe. To detect climate change, you must do much more than observe the local daily weather. As students watch, have them list ways scientists try to sort through appropriate data to find climate trends.




**The Intergovernmental Panel on Climate Change projects further increases in globally averaged surface temperatures of about 2°F to 6°F by the year 2100 as compared with 1990. The projection is based on estimates of future concentrations of greenhouse gases and sulfate particles in the atmosphere.**

## After Watching

1. Ask students to discuss the trade-offs, economic and social, of trying to reduce carbon dioxide emissions when the extent of the threat is unknown, or when the threat may be in the distant future rather than imminent. What are the risks of doing nothing?

2. Have students list specific changes they are willing to make to reduce their consumption of energy.

3. Have students identify other problems society faces that involve trade-offs for the sake of the greater good of the entire population.

# Activity Setup

**Objective**

To use a statistical analysis technique, the moving average, to search for meaningful trends in regional raw temperature data.

**Materials for each group**

- copies of the *Temperature Trends* activity sheets on pages 22–24
- pencil
- yellow, blue, green, and red pencils, markers, or crayons
- scissors
- tape
- calculator

**Procedure**

**Part 1**

Divide the class into 10 groups, one for each year of data.

Distribute both Part 1 activity sheets with the other materials. Ask student to discuss the raw data before graphing.

Record their observations on the board.

Have each group graph its year of data, using the data and chart provided on the Part 1 activity sheets. After they have graphed their data year, direct students to cut out their graphs and lightly tape them together temporarily, spanning 1989 to 1998.

Display the taped-together graphs on the wall or floor. Have students observe any trends. Add these observations to the initial observations on the board.

**Part 2**

Students will now plot a 12-month moving average. Distribute the Part 2 activity sheet. You may need to help students with the instructions in this part.

Demonstrate the algorithm until students are able to calculate the moving averages on their own. Students will realize they can plot only their first seven averages, June to December, on their own graph. They must plot the next five averages on the next year's group's graph, January to May. The previous year's group will fill in averages for January to May on their graph.

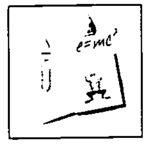
The group working on the final year has only enough data to produce one moving average, June.

Once students have finished their moving averages, discuss the results with them. What do they see in the data now? How does that differ from what they inferred from the previous plotting technique? What does each plotting technique tell them? What is the value of the moving average?

# Standards Connection

**The activity found on pages 22-24 aligns with the following *National Science Education Standards.***

## Grades 5-8



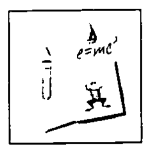

**Science Standard A:**
Science as Inquiry

**Abilities necessary to do scientific inquiry**

- Use appropriate tools and techniques to gather, analyze, and interpret data.
- Use mathematics in all aspects of scientific inquiry.

**Mathematics Standard 10:**
Statistics

## Grades 9-12

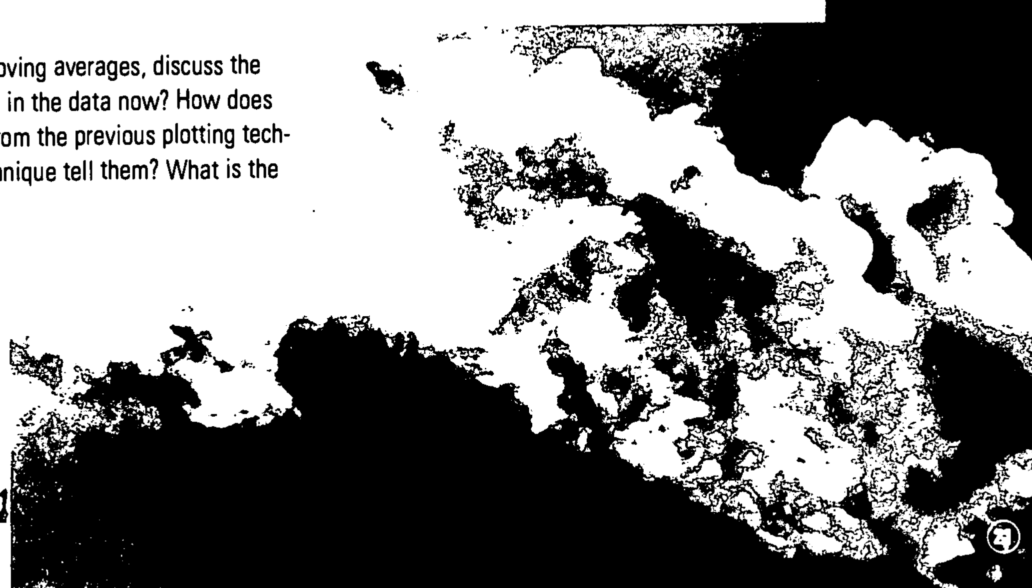



**Science Standard A:**
Science as Inquiry

**Abilities necessary to do scientific inquiry**

- Use technology and mathematics to improve investigations and communications.
- Formulate and revise scientific explanations and models using logic and evidence.

**Mathematics Standard 10:**
Statistics



Part 1

# Temperature Trends

NOVA Activity | **Global Warming**

Not much ice skating last year? Really hot this summer? Everyone's talking about the weather, yet not everyone seems to agree that real climate change is under way. How can something as simple as daily temperatures be so hard to interpret? Try your hand at analyzing some temperature readings and see if you can spot any trends.

**Procedure**

(1) Look at the Monthly Average Temperatures for Boston, Massachusetts, during the last 10 years (see below). Can you spot any long-term temperature changes by scanning the rows?

(2) These data will make more sense as a graph. When your teacher tells you which year your group will graph, highlight it in yellow. Using the Temperature Graph, do the following:

a From the information given in the table, plot your 12 monthly average temperatures starting with January on the left edge of your graph. Move right three lines to plot the next month, February.

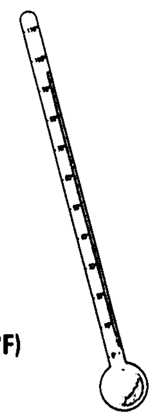
b When you have plotted all 12 months, connect the dots in pencil, and check your work.

c Lay your graph beside the graphs for the years before and after yours. Make sure the Boston 10-year average line on each graph matches up.

d Darken your pencil line with a blue marker.

e When the whole class is finished, temporarily tape all the graphs together to create a visual 10-year record.

(3) What, if any, trends do you see regarding long-term change? As a scientist, what would be your next step?



**Monthly Average Temperatures (°F)**
Boston, Massachusetts*

| | JAN | FEB | MAR | APR | MAY | JUNE | JULY | AUG | SEPT | OCT | NOV | DEC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1989 | 34.5 | 30.5 | 37.3 | 45.9 | 59.4 | 67.8 | 72.8 | 71.6 | 64.7 | 55.3 | 42.8 | 21.7 |
| 1990 | 36.4 | 34.1 | 40.1 | 47.6 | 54.9 | 66.6 | 73.1 | 73.3 | 64.6 | 58.3 | 48.5 | 40.7 |
| 1991 | 29.4 | 36.1 | 41.6 | 51.3 | 63.3 | 70.0 | 74.6 | 73.8 | 63.7 | 56.4 | 45.2 | 36.0 |
| 1992 | 31.0 | 32.4 | 35.4 | 46.4 | 55.6 | 67.8 | 69.5 | 70.4 | 63.9 | 52.5 | 42.9 | 34.8 |
| 1993 | 32.4 | 27.1 | 36.4 | 48.3 | 60.3 | 69.5 | 74.7 | 73.6 | 64.8 | 52.3 | 45.6 | 34.2 |
| 1994 | 22.2 | 26.9 | 38.2 | 51.4 | 58.4 | 71.9 | 77.5 | 72.4 | 64.2 | 55.5 | 49.0 | 38.5 |
| 1995 | 34.6 | 28.5 | 38.8 | 46.1 | 57.2 | 68.6 | 75.9 | 72.8 | 63.1 | 58.4 | 41.9 | 31.7 |
| 1996 | 30.1 | 30.9 | 36.5 | 47.9 | 57.4 | 68.1 | 71.9 | 70.9 | 64.2 | 53.2 | 40.3 | 39.3 |
| 1997 | 29.2 | 36.0 | 36.7 | 46.3 | 56.1 | 68.2 | 73.7 | 71.2 | 64.2 | 52.8 | 41.7 | 35.2 |
| 1998 | 33.9 | 35.3 | 41.5 | 49.4 | 60.3 | 64.7 | 74.4 | 72.5 | 66.3 | 54.5 | 44.6 | 39.1 |

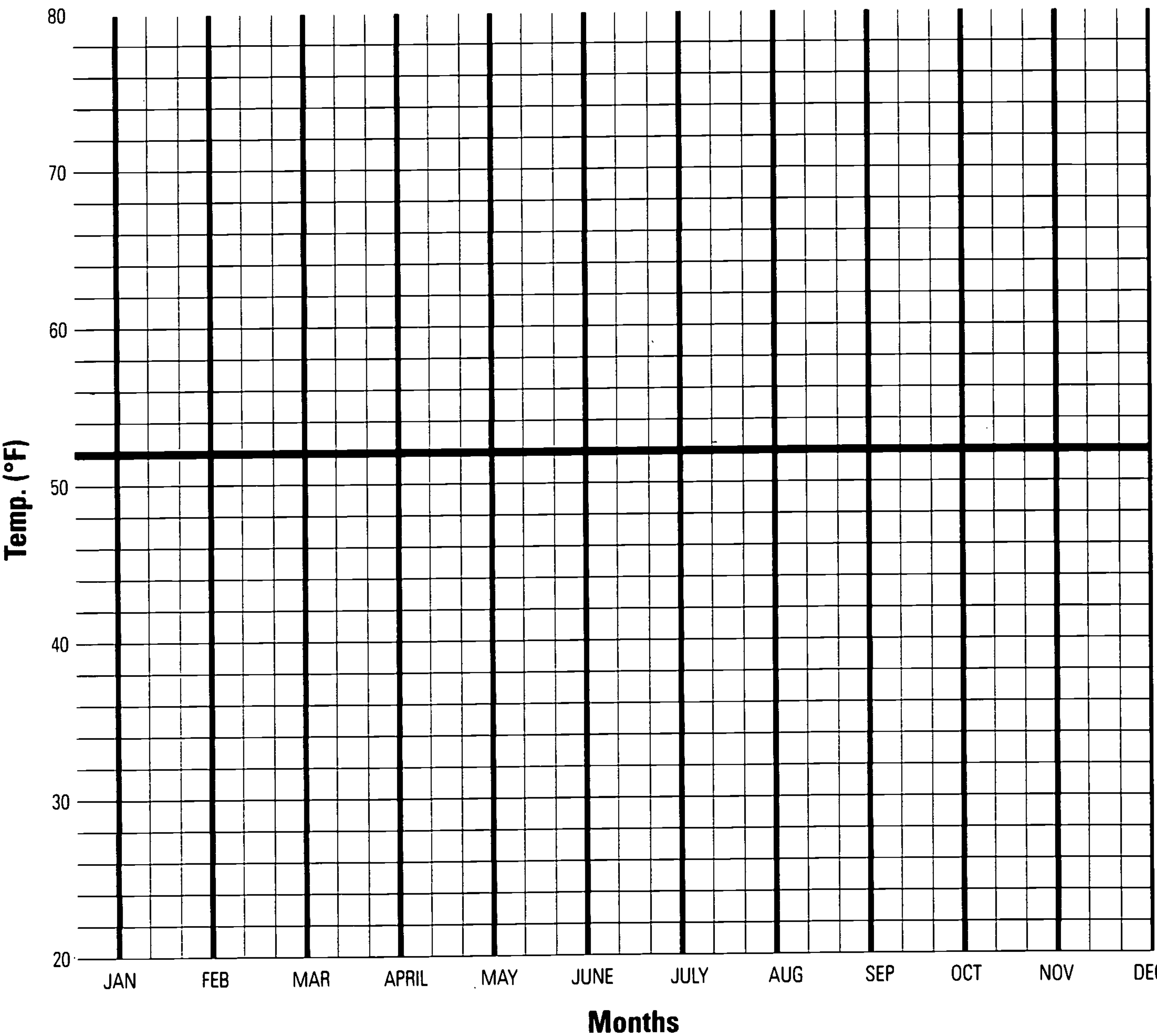
* Source: NOAA National Data Center

Part 1

# Temperature Trends

NOVA Activity | **Global Warming**

**Temperature Graph**



Part 2

# Temperature Trends

NOVA Activity | **Global Warming**

**Procedure**

In Part 1, you graphed your temperature data. If you want to see beyond the regular summer through winter temperature cycle, you must filter the data with a 12-Month Moving Average. A moving average allows you to do a continuous average of your data.

(1) Retrieve your Temperature Graph. The next step is prone to errors so work carefully and check each other's work.

a Add all 12 temperatures of your year and circle the SUM. Divide that sum by 12 to find the first average.

b Plot this average by putting a green dot on the June line.

c To move the average ahead one month, subtract your January temperature from your circled sum of all 12 months, and add the January temperature from the next year.

d Divide your new sum by 12. This is your second average. You now have a new 12-month average. Plot this with a green dot on the July line.

e Now find your third moving average. Subtract your February temperature from your second average sum and add your February temperature from the next year. Divide your new sum by 12. This is your third average. Plot it with a green dot on the August line. See Moving Average Algorithm below for a model.

(2) In the same manner, complete all 12 moving averages. You will find that you can plot only seven moving averages on your graph (June to December). Find the group with next year's data to plot your last five averages. Another group will plot the five moving averages (January to May) on your chart (except for group with the first year, 1989).

(3) Connect your 12-month moving average points with a red line. Make a smoothly flowing line from point to point. The 12-month moving average line now shows the longer term changes in Boston temperatures without the confusing seasonal changes.

(4) Tape the graphs together. What do you see?

**Questions**

*Write your answers on a separate sheet of paper.*

(1) Were your original ideas about the temperature trends supported by the 12-month moving average?

(2) Are long-term changes evident in the 12-month moving average trend?

(3) What might you do to extend your view of long-term temperature change?

(4) How does this help explain why there is so much controversy about long-term climate change?

(5) The moving average is an example of a statistical analysis technique and can be used to filter any data containing known regular cycles. Where else might you use a moving

**Moving Average Algorithm**

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| First Year Of Data | (1989) Jan 34.5 | +Feb 30.5 | +Mar 37.3 | +Apr 45.9 | +May 59.4 | +Jun 67.8 | +July 72.8 | +Aug 71.6 | +Sep 64.7 | +Oct 55.3 | +Nov 42.8 | +Dec = 21.7 | 604.3 1st average sum | ÷ 12 = | 50.4 1st average |
| 1st avg. sum 604.3 | (1989) -J 34.5 | (1990) +J = 36.4 | 606.2 2nd avg. sum | ÷ 12 = | 50.5 2nd avg. | | | | | | | | | | |
| 2nd avg. sum | (1989) -F | (1990) +F = | 3rd avg. sum | ÷ 12 = | 3rd avg. | | | | | | | | | | |

## Activity Answer

The graph students create will show temperatures above and below the average temperature line of the chosen data set. The moving average sums for each month are presented below. Plotting for the January sums begins in June. (Note: Strictly speaking, plotting for a moving average would begin at the exact center point of the data set; however, because 12 months is an even number and a 12-month average can't have a "center month," June was chosen as the starting point for plotting the averages.)

12-Month Moving Average for Boston, Jan. 1989 to Dec. 1998*

| | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 |
|---|---|---|---|---|---|---|---|---|---|---|
| Jan. | | 50.7 | 54.3 | 51.1 | 51.1 | 51.4 | 52.4 | 50.9 | 51.2 | 52.1 |
| Feb. | | 50.9 | 54.4 | 50.8 | 51.4 | 51.3 | 52.5 | 50.7 | 51.2 | 52.2 |
| Mar. | | 50.9 | 54.3 | 50.8 | 51.4 | 51.3 | 52.4 | 50.8 | 51.2 | 52.3 |
| Apr. | | 51.1 | 54.1 | 50.5 | 51.4 | 51.5 | 52.6 | 50.4 | 51.2 | 52.5 |
| May | | 51.6 | 53.8 | 50.3 | 51.7 | 51.8 | 52.0 | 50.3 | 51.3 | 52.7 |
| June | 50.4 | 53.2 | 53.5 | 50.2 | 51.6 | 52.2 | 51.5 | 50.9 | 50.9 | 53.0 |
| July | 50.5 | 52.6 | 53.6 | 50.3 | 50.8 | 53.2 | 51.1 | 50.8 | 51.3 | |
| Aug. | 50.8 | 52.8 | 53.3 | 49.9 | 50.7 | 53.3 | 51.3 | 51.2 | 51.3 | |
| Sept. | 51.1 | 52.9 | 52.8 | 50.0 | 50.9 | 53.4 | 51.1 | 51.3 | 51.7 | |
| Oct. | 51.2 | 53.2 | 52.4 | 50.1 | 51.1 | 53.0 | 51.3 | 51.1 | 51.9 | |
| Nov. | 50.8 | 53.9 | 51.7 | 50.5 | 51.0 | 52.9 | 51.3 | 51.0 | 52.3 | |
| Dec. | 50.7 | 54.2 | 51.5 | 50.7 | 51.2 | 52.6 | 51.2 | 51.0 | 52.0 | |

*The averages shown in this table were calculated using the common technique of rounding the number 5 by increasing the next higher place value by 1.

The visual result of plotting the monthly average temperature with the 12-month moving average temperature line is impressive. The Boston data set provides some tantalizing hints in the monthly plot that some cyclical temperature changes may be occurring, but they turn out to be inconclusive in the moving average trend. A moving average is a sliding average of whatever is being studied. In this activity, the continuous average of a cluster of data (a 10-year span of temperature records) yields more meaningful information about temperature trends than a single data set (a one-year span of monthly temperature records) provides. A single data set is more likely to contain fluctuations that do not appear in a larger trend analysis.

Most students will conclude that there isn't much of significance when looking at results in the moving average trend. Some may argue for a three- to four-year cycle of small change. The data on this graph alone, however, are not compelling as it only shows 10 years of information. Students may suggest that by looking farther back and creating a moving average for the past 100 years they can verify this trend. However, that opens the question about the past being a reliable predictor of the future.

Other uses include analysis of the economy, unemployment, rainfall, pollen, stream flow, sea water temperatures, traffic volume, and dress hemlines.

# Resources

### Books

Tesar, Jenny.
**Global Warming.**
New York: Facts on File, 1991.
*Describes the greenhouse effect, how human activities have impacted global carbon dioxide and ozone levels, and steps that can be taken to slow the rate of global warming and ozone destruction.*

Johnson, Rebecca L.
**The Greenhouse Effect: Life on a Warmer Planet.**
Minneapolis, Minnesota: Lerner Publications Company, 1990.
*Describes the science of how Earth's atmosphere works, identifies gases contributing to global warming and how human activities are causing global climate to change, and offers suggestions on how to help slow the rate of global warming.*

Bender, David, and Bruno Leone, ed.
**Global Warming: Opposing Viewpoints.**
San Diego, California: Greenhaven Press, Inc., 1997.
*Offers opposing viewpoints about many global warming issues including the causes of global warming, the seriousness of the threat, and possible effects of a changing climate.*

### Web Sites

NOVA Online—Global Warming
**www.pbs.org/nova/warm/**
*Delves deeper into the program's content and themes, with features such as articles, timelines, interviews, interactive activities, resource links, and more. Launch date: Friday, April 14.*

U.S. Global Change Research Information Office
**www.gcrio.org/index.html**
*Features general information, resources, and links to other organizations dealing with global change. Also includes an e-mail service, Ask Dr. Global Change, where you can send questions about global environmental change.*

# Secrets of Lost Empires

Airs the month of February • www.pbs.org/nova/lostempires/

## Program Contents

**Uncover the Latest Secrets from NOVA**

Magnificent structures—symbols of faith, power, commerce, or comfort—are the intriguing legacies of the civilizations featured in this five-part miniseries, *Secrets of Lost Empires.* Without modern technology, these ancient builders achieved construction feats that still impress today.

NOVA travels to the sites of these once-mighty empires to answer the question, "How did they do that?" Expert teams of engineers, archaeologists, and master builders attempt to recreate the structures, using the materials, tools, and techniques thought to have been available to their ancient counterparts. The researchers draw on tantalizing clues found in ruins, paintings, and documents to guide them. But in this real-world laboratory, things don't always go as planned. The teams demonstrate science inquiry in action, refining their hypotheses through trial and error. In the process, they gain a deeper understanding of the ancient builders and their worlds.

**Experts tackle challenge of recreating China's "rainbow bridge."**

## Medieval Siege

### Airs the week of February 1

England's Edward I is said to have used a fearsome machine, called "Warwolf," to batter his enemies' castle walls into rubble. Historians think Warwolf was a wooden trebuchet, a missile-throwing siege weapon that dominated seige warfare until cannons were invented. In the Scottish countryside, teams build two trebuchet designs side by side, using medieval building techniques. Will either, or both, be capable of destroying a model castle wall at a distance of 200 yards (182 meters)?

## Pharaoh's Obelisk

### Airs the week of February 8

How did ancient Egyptians transport and erect towering granite obelisks that weighed as much as 400 tons (360 metric tonnes)? NOVA's experts scour wall paintings, ancient ruins, and texts for clues about the Egyptians' methods. The first challenge is to load a model obelisk onto a barge for a trip down the Nile. Then, two teams with different strategies for erecting obelisks try their methods in a desert showdown.

## Easter Island

### Airs the week of February 15

Visitors to the island of Rapa Nui, the modern name for Easter Island, have long been fascinated by the giant statues, called moai, that stand on platforms along its rugged coastline. How did ancient islanders carve and move these enormous volcanic stones? To test their hypotheses, NOVA's team casts a 10-ton (9 metric tonnes) concrete model of a moai. Visiting researchers and islanders join together to pull the moai hundreds of meters, then attempt to raise it onto a platform.

## Roman Bath

### Airs the week of February 22

Many of the Roman Empire's best-known engineering feats were first used in their bathhouses: vaulted roofs, watertight concrete, and elaborate plumbing and heating systems. In the hills of Turkey, a team of engineers, historians, archaeologists, and local craftspeople build a working Roman bath. The challenges they face—from cracking tiles and leaky tubs to heavy rains—require cooperative problem-solving along the way.

## China Bridge

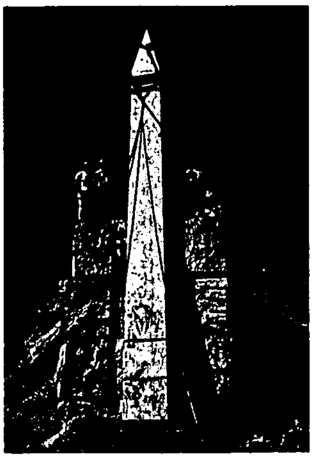
### Airs the week of February 29

Among the many inventions of China's Song dynasty during the eleventh and twelfth centuries was the "rainbow bridge." The high arch of the bridge solved the problem of spanning a fast-moving river without impeding boat traffic. But how were wooden beams interwoven to form the curve depicted in a scroll from the period? NOVA travels to the heart of the Song dynasty to build a replica rainbow bridge across a busy canal.

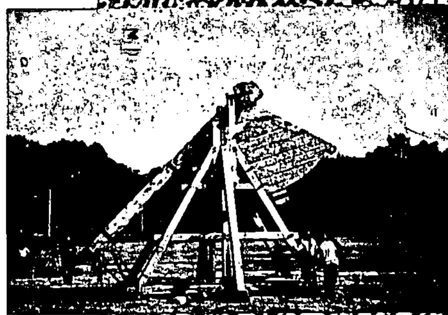
## Find Secrets Online

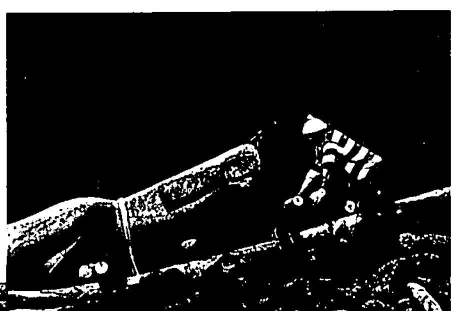
**www.pbs.org/nova/lostempires/**
Delves deeper into the program's content and themes, with features such as articles, timelines, interviews, interactive activities, resource links, and more.
Launch date: Friday, January 28

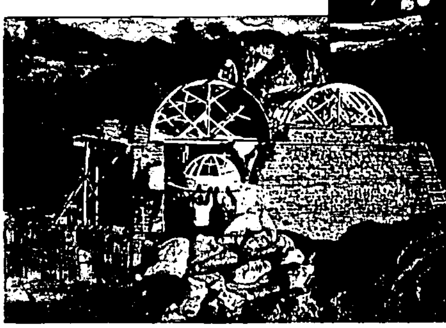
Also, check out these currently available related sites:
Secrets of Easter Island
**www.pbs.org/nova/easter/**
Mysteries of the Nile
**www.pbs.org/nova/egypt/**



**Expert teams attempt to recreate ancient structures (clockwise, from above): a trebuchet, moai, Roman bath, and obelisk.**







## Before Watching and After Watching

**1.** The engineers and other experts featured in each program make many inferences about ancient building techniques. They base their inferences on a variety of sources, including oral histories, paintings, texts, artifacts, and ruins. As students watch, have them keep a list of each inference made and the source of information behind it. After viewing, ask students which sources appeared to be most useful, and which were vague or misleading. Do students find each source as compelling or convincing as researchers did?

**2.** The experts use different types of models to plan their construction strategies. Have students keep track of each model as they watch. Discuss with students the advantages and limitations of using models and list any models they have used. How were models important in planning the projects in these programs? Then ask students to describe instances where the real projects encountered problems that didn't occur with the models. What were the reasons for the differences? What can they conclude about the limitations of models?

**3.** Each program's story is driven by the question, "How did they do that?" The engineers and archaeologists have developed hypotheses to answer that question. Then they design experiments to test their hypotheses. Have students consider how an ancient civilization might have solved a problem, such as how to move a heavy object, and how our civilization might do it today. What might be the similarities and differences in how the problem is solved?

**4.** The ancient building methods shown in the programs depend on the use of simple machines, including levers, ramps, pulleys, and wheels. Have students identify which simple machines are involved in the projects. How does each machine give the builders a mechanical advantage? What did the machines enable people to do that they could not otherwise have done?

## Activity Setup

# Fling It!

Medieval Siege

**Objective**

To design a working model of a trebuchet and demonstrate the power of a Class 1 lever.

**Materials for each student**

- copies of the *Fling It!* activity sheet on page 30
- plastic soda straws
- large and small paper clips
- short lengths of sturdy wire
- tape
- yarn or string
- pennies, bolts, or other small, heavy objects for counterweights
- ring or washer
- grapes
- tongue depressor
- small strips of cloth (such as cotton or muslin)

**Procedure**

1. Make sure students understand how a Class 1 lever works. (See *Activity Answer* on page 32.)
2. Discuss the guidelines for trebuchet design. They are minimal to allow for maximum student creativity.
3. As a class, have students decide on a protocol for running the experiment, such as any constraints on how the materials will be used or how the data will be collected. Also have students decide how to determine each trebuchet's effectiveness, i.e., will it be based on which machine throws a grape farthest, which throws the farthest with the least amount of effort, or some other criteria?
4. Set a reasonable deadline for the models to be built depending on whether the students can work at home or only during class time.
5. Supervise the launchings on the day students demonstrate their models, making sure that students wear safety goggles during the procedure. (Note that eye injury or other accidents could occur if safety rules aren't followed.)

**Standards Connection**

National Science Education Standards
Grades 5–8/9–12
Standard B: Physical Science—Motions and Forces

## Mix and Match

These activities can be used with more than one program. Choose the activity that best fits the program you are using.

# Lever Lift

## Activity Setup

Pharaoh's Obelisk
Easter Island

**Objective**

To discover how levers work by raising a brick with shish kebab skewers.

**Materials for each group**

- copies of the *Lever Lift* activity sheet on page 30
- brick
- 2 bamboo shish kebab skewers
- small pebbles about the size of a quarter or half dollar (thin or flat stones work best)
- coffee can to hold small pebbles
- newspapers
- paper and drawing paper
- pencil and crayons

**Procedure**

1. Review classes of levers with students. (See *Activity Answer* on page 32.) Remind students of the levers they saw in the videos. Set up work area on newspapers. Go over the rules for erecting the brick. Require the scribe to use words and drawings to describe the team's work.
2. Stop the activity after a given amount of time. Measure the brick's height off the ground for each team. Discuss the processes used and difficulties faced.
3. Discuss with students what classes of levers they used and how they used them.
4. Have students present their work, explaining what did and did not work. Presentations might include drawings of the lever lift from different angles.

**Standards Connection**

National Science Education Standards
Grades 5–8/9–12
Standard B: Physical Science—Motions and Forces

# Weighing In

## Activity Setup

Pharaoh's Obelisk
Easter Island

**Objective**

To compare the weights of Egyptian obelisks and Rapa Nui moai to other objects.

**Materials for each group**

- copies of the *Weighing In* activity sheet on page 31
- calculator
- drawing paper
- markers or crayons

**Procedure**

1 Direct students to determine how many objects of a given weight would be equivalent to the weights mentioned in the videos. For example, an average bike weighs 35 pounds (15.88 kilograms). *(Answer: 10 tons = 20,000 pounds ÷ 35 pounds = 571 bikes.)*

2 Make a bulletin board of drawings showing comparison. Have students show their calculations and ratios.

**Standards Connection**

Curriculum and Evaluation Standards for Mathematics
Grades 5–8
Mathematics Standard 5: Number and Number Relationships

# Tasty Arch

## Activity Setup

China Bridge
Roman Bath

**Objective**

To discover that you can build an arch that supports itself with no mortar.

**Materials for each team**

- copies of the *Tasty Arch* activity sheet on page 31
- 10 sugar wafers (the flat kind with two cookie layers; use fresh cookies; soft, stale cookies are difficult to sand)
- piece of 50 grit coarse sandpaper
- plastic knife

**Procedure**

1 Have students follow directions on the student activity sheet.

2 Provide students with this additional information:

- Try to keep the sanded edge of the cookie flat, not rounded.
- Do NOT sand both sides of the cookie; too much sanding weakens the blocks.
- Replace any badly broken cookie blocks with new ones.
- When constructing the arch remember: Too many cookies make a circle and too few will not complete the arch.

**Standards Connection**

National Science Education Standards
Grades 5–8/9–12
Standard B: Physical Science—Motions and Forces

# Fling It!

NOVA Activity | **Secrets of Lost Empires**

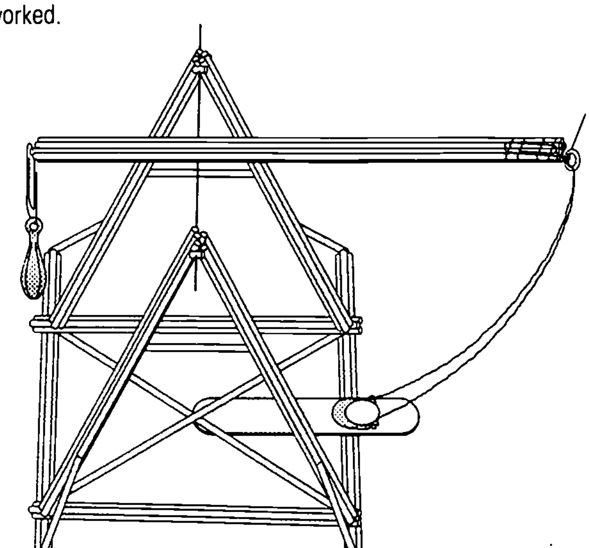
King Edward has asked you to design and build a mighty siege machine—called a trebuchet—that will fling a grape across a far distance. You have been provided with some materials to build your trebuchet: You must use plastic soda straws for all long construction pieces and a straightened paper clip for the axle. Your missile will be a grape. Study the diagram below before designing your grape-throwing trebuchet.

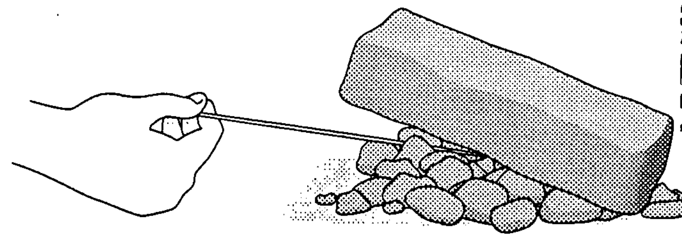
You will need to construct the following parts of a working trebuchet:

- two triangular pieces for the sides of the frame; these will need to be supported or braced to stay upright
- a long, strong throwing arm pierced by the axle; the short end of the throwing arm should have a small, heavy counterweight that will allow the throwing arm to swing freely without touching the sides of the frame or the ground
- a sling that will hold the grape during the upswing and release it at the top of the arc

To connect the straws together, pinch the end of one straw and slide it into the end of another straw. Wrap a band of tape around the joint to secure the connection.

Consider these and other methods as you design and build your trebuchet. As you work, keep a journal describing your design successes and failures. Include detailed, labeled drawings and descriptions in your journal. Tell what you discovered as you worked.





# Lever Lift

A Great Ruler has selected your team to erect a brick obelisk. How will your team raise it? Because a brick is tiny compared to a real obelisk, you must work under the following conditions to begin to experience the difficulties the ancients faced:

- You may not touch the brick with your hands.
- You are limited to 2 bamboo shish kebab skewers for your levers.
- You must use the small pebbles for support stones.
- A team member or members must act as scribe to draw and record what class of levers you used, what difficulties you had, and how you overcame them.

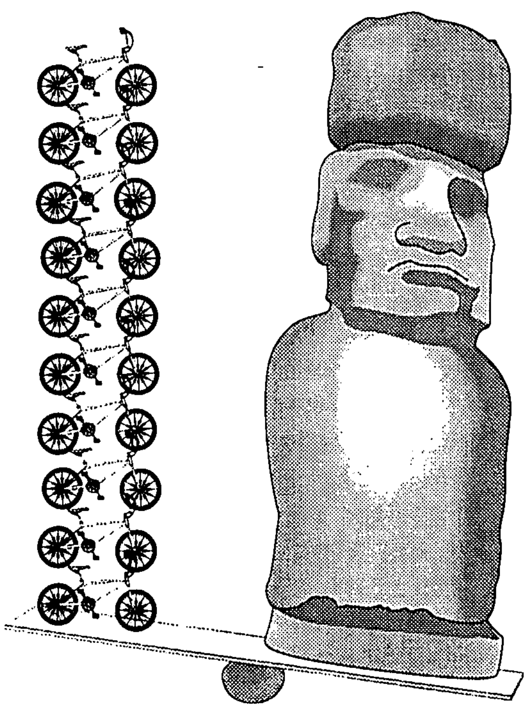
Use the materials you are given to raise the brick as far as you can. Your teacher will measure to determine which team raised its brick the highest.

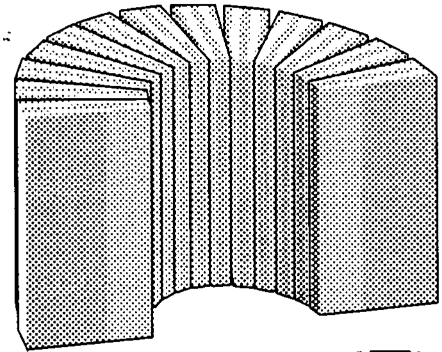
# Weighing In

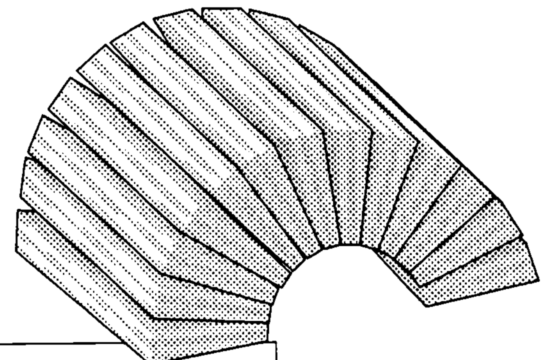
NOVA Activity | **Secrets of Lost Empires**

Can you appreciate the weight of an Egyptian obelisk or Rapa Nui moai? Try and make a few comparisons. If one of the moai weighed 10 tons, how many bikes would weigh the same amount? Choose your own object to compare to the models used in the programs and the real things. Record your calculations and ratios.

- 10-ton (9 metric tonnes) model moai
- 65-ton (58.5 metric tonnes) Rapa Nui moai
- 25-ton (23 metric tonnes) model obelisk
- 500-ton (450 metric tonnes) Egyptian obelisk
- 1,110-ton (999 metric tonnes) unfinished obelisk







# Tasty Arch

Chinese leaders have chosen you to build an arch bridge. First, you must get ready for this great feat. Before building the arch, you must prepare the stone blocks. Cut the cookies crosswise with a plastic knife. If you look closely at an arch, you'll see that the blocks are not rectangular, but trapezoidal solids. The face of the block on the inside curve of the arch is narrower than the face on the outside.

To create this stone-block shape on your cookie pieces, do the following:

- Lay a cookie flat on the sandpaper.
- Place your 3 middle fingertips on the long edge of a cookie.
- Holding a thumb on one short edge and your pinky finger on the other, gently and smoothly swipe the cookie back and forth two times. The combination of pressing off center and sanding four times will bevel your cookie blocks the correct amount for a small arch.

Now assemble your arch on its side. Line up the inside edges of the blocks as evenly as possible; don't worry about the outside edges. Lightly grasp all of the blocks and tip the arch into a standing position placing it on your sandpaper. Before you let go, have your teammate carefully fix any blocks that may have moved out of place. It may take a few tries before you succeed, but when you do, you'll have a genuine Roman arch supported only by its own weight.

## Activity Answer

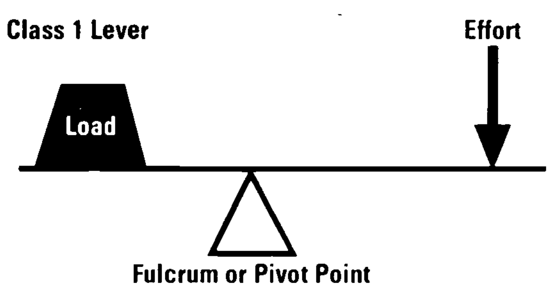
**About Levers**

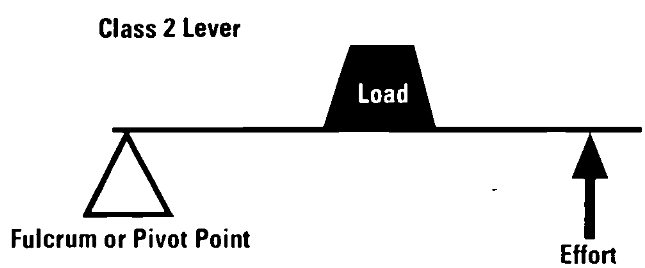
Students will use levers in two of these four activities. They will use a Class 1 lever to raise the brick and a Class 2 lever to turn or move it. They will also use a Class 1 lever in designing their trebuchets.

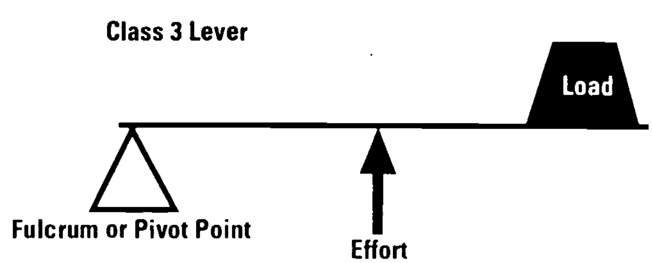
If students are unfamiliar with classes of levers, run a mini-lesson with the following information:

When describing levers you need these four terms: lever, fulcrum, effort, and load. The lever itself is long and stiff. The fulcrum is the resisting point where the lever turns or pivots. Effort is the force you apply and load is what you move. When you apply effort, the lever pivots around the fulcrum moving the load.

The job the lever must do determines how the load, effort, and fulcrum are arranged. This arrangement determines the class of lever. Look at the following illustrations:




Once students understand the three different classes of levers, they will recognize them all around. Here's a quick method to classify levers.

a Find the fulcrum. If it's in the middle, it's a Class 1. On the end, it's a Class 2 or 3.

b To determine whether it's 2 or 3, find the load. If it's in the middle, it's a Class 2. On the end, it's a Class 3.

Ask students to identify the class of lever for the following:

- a claw hammer pulling a nail (Answer: Class 1. A hammer pivots on the middle of its head.)
- a wheel barrow (Answer: Class 2. The wheel is the fulcrum and the barrow is the load.)
- an oar rowing a boat (Answer: Class 1. The oarlock is the fulcrum.)
- a paddle paddling a canoe (Answer: Class 3. The top hand is the fulcrum and the blade is the load.)
- a bottle opener (Answer: Class 2. The fulcrum is on the end and the load is in the middle.)

## Activity Answer

### Fling It!

A trebuchet is a Class 1 lever. The counterweight provides the effort. The load is the lighter boulder or missile. Between them on the machine carriage is an axle that serves as the fulcrum.

Student designs will vary. They will discover how to best connect straws together and how to brace the frame. They will experiment with varying the position of the axle along the throwing arm, the design of the sling, and methods of attaching the sling and counterweight to the throwing arm.

### Lever Lift

History records that Archimedes, an ancient mathematician and physicist, said, "Give me a lever long enough and a place to stand, and I will move the earth." His exaggeration proclaims the power of the simple lever. With levers, ancient Egyptians raised huge obelisks and the people of Rapa Nui raised massive moai. Because of their utility, levers became part of many other machines from trebuchets to modern devices.

This activity will help students understand the difficulties ancients faced in raising the obelisk or moai, including the instability of the rock pile and the problem of creating adequate fulcrums as the brick rises higher. For a follow-up exercise, students may want to raise a brick to the vertical. But as the ancients discovered, students will find that this will take many more stones and much more time.

### Weighing In

Students may choose to find their own weight comparisons. To get them started, you may want to give them the following weights of some common objects: sport utility vehicle = 4,500 pounds (2,025 kilograms); blue whale = 150 tons (135 metric tonnes); bowling ball = 16 pounds (7.2 kilograms); refrigerator = 200 pounds (90 kilograms).

### Tasty Arch

In an arch, the top stones distribute their weight to the blocks on either side and will not fall unless they can push the stones beneath them sideways. Stable arches, therefore, require that side stones be firmly set in place. The riverbanks of Chinese rainbow bridges provided this sideways support. The multiple arches in Roman aqueducts and the double arches of the Roman baths had similar support.

Arches are unstable during construction until the two sides meet in the middle. To experience the instability, have students stand back to back with a classmate with their shoulders touching. Have them slowly step away from each other, but keep their shoulders in contact. The two students maintain stability because the weight of their bodies is distributed down and sideways through each other's legs. If either were to move away suddenly, both would crash to the floor.

Raising the arch requires some dexterity. Remind students to apply inward pressure on the cookies to keep them in line. Tell them that early engineers built scaffolding to hold the stones in place until the arch achieved its own stability.

# NOVA Video Catalog

# Save 25%* on orders of 10 videos or more!

*not including shipping & handling

**This is not a complete listing of NOVA videos. Please call 1-800-949-8670 ext. 0100 for a catalog.**

**These videos have been categorized by their primary content strand; many programs are interdisciplinary. You may want to scan several categories for videos of interest.**

WGBH BOSTON VIDEO

### Special! For Educators Only!

Receive a special set of *NOVA* videos featured in this Spring 2000 Teacher's Guide for only **$99.95**, plus shipping and handling. Set includes: *Lost on Everest, Lost Tribes of Israel, Lost at Sea: The Search for Longitude,* and *Secrets of Lost Empires II Boxed Set.* 8 hrs. on 8 cassettes. **WG907**

## Earth & Space Science

### Buried in Ash

Learn what life was like ten million years ago when an enormous volcanic eruption buried much of what is now Nebraska in up to ten feet of ash. 1 hr. **WG2117* $19.95**

### Chasing El Niño!

Lethal ice storms, droughts, floods and devastation—what in the world is going on here? *NOVA* explores the myths, reveals the devastation, explains the fascinating facts and provides a new climate for understanding the ultimate weather machine. 1 hr. **WG2512 $19.95**

### Cracking the Ice Age

Take a trek to Tibet with a renegade band of researchers bent on proving that the Himalayas could be the cause of one of the planet's most dramatic climatic changes—the Ice Age. *Educational use only.* 1 hr. **WG2320* $19.95**

### Deadly Shadow of Vesuvius


Scientists believe it's only a matter of time before Italy's Vesuvius erupts... again. Find out how science can help predict when Vesuvius will change from dormant to destructive and see the astonishing power of nature—including footage from recent eruptions in other parts of the world. 1 hr. **WG2515 $19.95**

### Dinosaurs of the Gobi

Relive the exploits of 1920s explorer Roy Chapman Andrews—said to be the real-life model for Indiana Jones. *Educational use only.* 1 hr. **WGW2102* $19.95**

### The Doomsday Asteroid

Join the hunt to scan the skies and earth for evidence that giant rocks from outer space have struck before and will strike again. *Educational use only.* 1 hr. **WGD2212* $19.95**

### Earthquake

Predicting earthquakes is risky business, but *Earthquake* shows how today's advanced technology helps geologists interpret nature's rumblings. 1 hr. **WG1715* $19.95**

### Eclipse of the Century

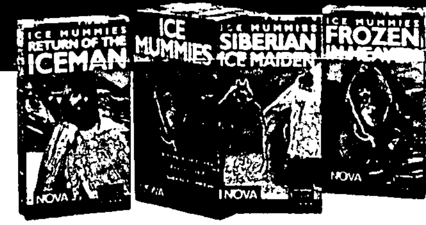
The race to view and study celestial splendor. 1 hr. **WG1910 $19.95**

### Flood!

Relive one of the greatest flood disasters—the Mississippi River in the summer of 1993—and explore the problem of taming the mightiest river. 1 hr. **WG2307 $19.95**

### Hunt for Alien Worlds

All eyes are on the heavens in search of planets around other stars, probably the best hope for showing that we may not be alone in the universe. *NOVA* covers an effort that is turning up more and more new worlds. *Educational use only.* 1 hr. **WG2407* $19.95**




### Ice Mummies Boxed Set

You're there as the ice mummies are unearthed, as clothing and artifacts are studied, and as mysteries of the Stone Age are explained. Includes *Frozen in Heaven, Siberian Ice Maiden* and *Return of the Iceman.* 3 hrs. on 3 cassettes **WG2525 $49.95**

### Iceman

*NOVA* covers the international efforts to unlock the secrets behind the mummified body of a man who lived over 5,000 years ago. *Educational use only.* 1 hr. **WG1916* $19.95**

### In Search of Human Origins Boxed Set

The award-winning exploration of the beginnings and expansion of the human race. Includes *The Story of Lucy, Surviving in Africa* and *The Creative Revolution.* 3 hrs. on 3 cassettes **WGW2111 $49.95**

### Lost at Sea: The Search for Longitude

Richard Dreyfuss narrates this riveting story of an ingenious country carpenter who discovered that the secret to navigation lay not just in the stars but in the mastering of time. Climb aboard an authentic tall ship and go back in time to see the quest for longitude unfold. 1 hr. **WG2511 $19.95**

### Lost City of Arabia

The secrets of Ubar—the ancient city from the *Arabian Nights* which vanished in the shifting desert sands—are revealed as archaeology and space-age intelligence team up. *Educational use only.* 1 hr. **WG2312* $19.95**

### Mammoths of the Ice Age

Piece together a picture of the life our ancestors shared with the woolly mammoth 10,000 years ago. *Educational use only.* 1 hr. **WG2201* $19.95**

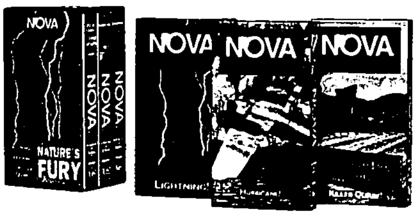
### Mysterious Mummies of China

Perfectly preserved 3,000-year-old mummies have been unearthed in a remote Chinese desert shedding new light on the contact between the East and West in the ancient world. But these don't appear to be the ancestors of the modern-day Chinese people—they have long, blonde hair and blue eyes. 1 hr. **WG2502 $19.95**

CC NOVA videos are closed-captioned for the hearing impaired
- * no retail packaging
- † public performance rights are not included

## Natural Disasters Boxed Set

Natural disasters strike with little or no warning—making them uniquely frightening and fascinating. Includes *The Day the Earth Shook, Tornado!*, and *In the Path of a Killer Volcano.* 3 hrs. on 3 cassettes **WG165 $49.95**




## Nature's Fury Boxed Set

Witness the awesome power of nature. Includes *Hurricane!, Lightning!* and *Killer Quake!*. 3 hrs. on 3 cassettes **WG027 $49.95**

## Secrets of Lost Empires Boxed Set

Uncover the secrets of ancient civilizations as *NOVA* journeys to five archaeological sites where teams of experts use traditional techniques to test their hypotheses. Includes *Colosseum, Inca, Obelisk, Stonehenge* and *Pyramid.* 5 hrs. on 5 cassettes **WG182 $69.95**


## NEW! Secrets of Lost Empires II Boxed Set

Filled with powerful recreations and revealing insights, this ambitious *NOVA* series examines five ancient civilizations and their unique impact on the past... and on the future. 5 hrs. on 5 cassettes **WG898 $69.95** *Available February 2000.*

- **Medieval Siege**

How did castle-bound warriors defend against the fearsome, mechanized catapult known as the trebuchet? Through fascinating re-creations, *NOVA* reveals battle strategies of the Middle Ages. 1 hr. **WG899 $19.95**

- **Pharoah's Obelisk**

In re-creating Egypt's massive memorials, discover how—and why—ancient Egyptians erected such giant granite monoliths as the notorious "Cleopatra's Needle" with minimal materials and maximum manpower. 1 hr. **WG900 $19.95**

- **Easter Island**

Discover how the transport and placement of Easter Island's massive and mysterious statues present a riddle enigmatic enough to stump even today's high-powered computer technology. 1 hr. **WG901 $19.95**

- **Roman Bath**

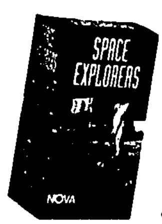
Steam open a secret history as *NOVA* recreates a working Roman bath and reveals how this engineering feat became both a social and cultural watershed for ancient Romans. 1 hr. **WG902 $19.95**

- **China Bridge**

Explore the wondrous ancient design of China's Rainbow Bridge, a graceful arching span whose ingenious construction baffles engineers and reveals China's little-known bridge heritage. 1 hr. **WG903 $19.95**

## NEW! Space Explorers Boxed Set

Step on the moon. Float in space. Explore the final frontier. *NOVA* assembles three of its most acclaimed space adventures to create this special four-hour set. Includes *To the Moon, Terror in Space* and *Rescue Mission in Space.* 4 hrs. on 3 cassettes. **WG667 $49.95**




## NEW! Stationed in the Stars

Go inside the planning, assembly and excitement of history's most ambitious and expensive engineering venture—a hugely ambitious "orbiting city" set for completion in 2004. 1 hr. **WG2708 $19.95** *Available May 2000.*

## Treasures of the Sunken City

It's an undersea adventure in Cleopatra's erstwhile capital: Alexandria, Egypt, where marine archaeologists are frantically salvaging mysterious stone ruins from the harbor floor. 1 hr. **WG2417 $19.95**

## Venus Unveiled

Travel with the spacecraft Magellan as it flies by Venus to reveal the planet's true face, one of the most bizarre places in the solar system. *Educational use only.* 1 hr. **WGV2210* $19.95**

## Volcanoes of the Deep

The pitch-black, near-freezing water nearly 8,000 feet below the ocean surface is the last place you'd suspect life to flourish. But here sea life thrives on mammoth superheated volcanic chimneys. Is the key to life's origins locked inside their fiery cores? 1 hr. **WG2609 $19.95**

## NEW! Voyage of Doom

The recent discovery of *Belle*, part of the fleet of fanatical French explorer Robert La Salle, has been called the most important shipwreck find in North America. Lying mud-covered and remarkably preserved on the bottom of a Texas bay, *Belle's* final resting place was unfortunate for La Salle, but incredible for historians and archaeologists. Join the unprecedented excavation effort as *NOVA* reveals *Belle's* vivid history, incredible artifacts and mysterious details. 1 hr. **WG2616 $19.95**

## Warnings from the Ice

Huge ice sheets in Antarctica may be in the process of collapse, triggering a catastrophic rise in sea level that will inundate the most populous regions of the world. Join *NOVA* as they gather data that will reveal new insight into the nature of global climate change. 1 hr. **WG2508 $19.95**

# General Science

## Anastasia Dead or Alive?

Investigate the massacre of Tsar Nicholas and his family, and evaluate whether modern science has resolved the mystery surrounding Princess Anastasia. 1 hr. **WGA2209 $19.95**

## B-29 Frozen in Time

Join a grueling expedition to recover this rare plane from the North Pole after 50 years—a trip which tests team members in ways they never imagined. 1 hr. **WG2303 $19.95**

## The Beast of Loch Ness

Is the Loch Ness Monster a hoax? Join *NOVA* for an all-out investigation of the mystery as scientists scour the loch with sonar and the most famous photo of Nessie is put to the test. 1 hr. **WG2601 $19.95**

## Codebreakers

*NOVA* delves into the history of secret communications and the people who decipher them. *Educational use only.* 1 hr. **WGW2101* $19.95**

## NEW! Decoding Nazi Secrets

Historic, fascinating and filled with stunning revelations, *NOVA* presents the first fully detailed account of the greatest codebreaking coup of all time. In this two-hour special, hear American and British codebreakers reveal long-held secrets for the first time. 2 hrs. **WG2615 $19.95**


* no retail packaging

## NEW! The Diamond Deception

What takes nature billions of years, man is doing now in a few days—creating flawless diamonds. *Educational use only.* 1 hr. **WG2703 $19.95** *Available February 2000.*

## Dr. Spock The Baby Doc

Meet one of this century's most influential Americans and understand his profound impact on changing ideas about child care. *Educational use only.* 1 hr. **WG2308* $19.95**

## ESCAPE! Because Accidents Happen Boxed Set

In the air, at sea, on the road, or in your home, you must be prepared to escape! *NOVA* goes behind the sensational headlines to examine the fascinating science of "survival engineering." Includes *Fire, Car Crash, Plane Crash* and *Abandon Ship.* 4 hrs. on 4 cassettes **WG260 $49.95**

## Everest: The Death Zone

Climb all the way from Base Camp to the very pinnacle of the earth at 29,028 feet. Wind,


cold, extreme dehydration and blinding solar radiation add to the misery. You'll witness first-hand why rational people can make astonishingly poor, and sometimes fatal decisions, on the world's highest peak. Narrated by Jodie Foster. By David Breashears, the Emmy® award-winning producer of the IMAX film. 1 hr. **WG2506 $19.95** DVD 1 hr. **WG800 $19.95**

## NEW! Everest: The Mystery of Mallory and Irvine

Did George Mallory and Andrew Irvine reach the top of Mt. Everest in 1924, nearly 30 years before Sir Edmund Hillary and Tenzing Norgay? This award-winning film, produced by renowned climbers and filmmakers David Breashears and Andrew Harvard, takes a fascinating look at Mallory's courageous attempt and the enduring mystery surrounding his disappearance. 1 hr. **WG830 $19.95**

## NEW! Fall of the Leaning Tower

Tilting at an amazingly dangerous angle, the Leaning Tower's problem is obvious—its solution isn't. See how science is attempting to save a medieval masterpiece with a high-risk rescue plan that may add centuries to the life of this architectural treasure. Discover centuries of eye-opening historical facts and curious restoration efforts as *NOVA* brings you inside a riveting battle to right history's wrongs. 1 hr. **WG2611 $19.95**

## In Search of the First Language

*NOVA* explores the common threads that link the more than 5,000 languages of Earth. *Educational use only.* 1 hr. **WG2120* $19.95**

## NEW! The Killer's Trail

Did Dr. Sam Sheppard kill his wife? With the help of advanced technology, *NOVA* re-examines the 1954 murder of Marilyn Sheppard and the subsequent trials of her husband. With a detailed reconstruction of the Sheppard house, access to little-known evidence plus insights from noted experts, America's most intriguing unsolved murder reveals fascinating new clues... and surprising new suspects. 1 hr. **WG2613 $19.95**

## NEW! Lost on Everest


The discovery of mountain-climbing pioneer George Mallory's body on Mt. Everest in May 1999 reveals new clues to his final hours and mountaineering's most haunting mystery. 1 hr. **WG2702 $19.95** *Available February 2000.*

## NEW! Lost Tribes of Israel

Nearly 3,000 years after their banishment, *NOVA* dispels both myth and fantasy in a dramatic genealogical quest that uses DNA evidence in the search of alleged descendents of Israel's Lost Tribes. 1 hr. **WG2706 $19.95** *Available March 2000.*

## A Man, A Plan, A Canal, Panama

Explore the mind-boggling construction of the Panama Canal through historic film footage, rare archival photographs and insightful narra-


tion from author David McCullough. Get an unprecedented look at the people behind the Canal's deadly 30-year construction and witness its amazing present-day operation. 1 hr. **WG1415 $19.95**

## NEW! Mystery of the First Americans

*NOVA* uncovers the astonishing history and explains the current Native American controversy over Kennewick Man—a 10,000-year-old Caucasoid discovered near Washington's Columbia River in 1996. 1 hr. **WG2705 $19.95** *Available March 2000.*

## Nomads of the Rainforest

Visit the unique tribe of the Waironi Indians in eastern Ecuador. 1 hr. **WG1112 $19.95**

## The Perfect Pearl

*NOVA* takes a deep look inside the pearl's precious world and reveals how these wonders of nature are fast becoming wonders of science. 1 hr. **WG2507N $19.95**

## The Science of Crime Boxed Set

Serial criminals wield a particular brand of terror. Fortunately for us, scientific sleuths are on their trail. Includes *The Bombing of America, Mind of a Serial Killer* and *Hunt for the Serial Arsonist.* 3 hrs. on 3 cassettes **WG164 $49.95**

## Search for the Lost Cave People

Discover a lost civilization that inhabited caves high on the isolated cliffs of Southern Mexico nearly 1,000 years ago. The tantalizing clues, including graphic evidence of ritual child sacrifice and a sophisticated writing system, shed new light on this mysterious people, the Zoqui. 1 hr. **WG2507 $19.95**

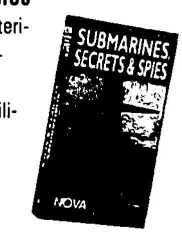
## Secrets of Making Money

Learn the secrets of counterfeiting—made easier by today's technology—and find out what the Feds are doing to fight back. 1 hr. **WG2314* $19.95**

## The Shape of Things

Marvel at the endlessly inventive patterns of natural things through photomicroscopy, computer animation and time-lapse photography. 1 hr. **WG1206* $19.95**

## Submarines, Secrets and Spies




*NOVA* lifts the veil on deadly, mysterious submarine accidents and high-risk spy missions through candid interviews with Soviet and U.S. military personnel, shocking underwater footage and recently declassified film and documents. 1 hr. **WG2602 $19.95**

## Three Men and a Balloon

For a few diehard daredevils, it's "the last great challenge in aviation"–to fly a balloon non-stop around the world. Follow one of the foremost teams in a hair-raising race against time, technology, and hot competition. 1 hr. **WG2313 $19.95**

## Titanic's Lost Sister


Search for the wreck of the *Britannic* and explore the clues as to how it sank. Four years after the *Titanic* went down, the *Britannic* sank in just one hour, despite an overhaul to meet post-*Titanic* standards. 1 hr. **WG2402 $19.95**

## The Tribe That Time Forgot

*NOVA* travels deep into the Amazon wilderness to search for a mysterious tribe that dismembered and partially ate three prospectors in 1976. *Educational use only.* 1 hr. **WG2115* $19.95**

## UFOs: Are We Alone?

Using rare UFO footage, *NOVA* investigates the claims of sightings. 1 hr. **WGW262 $19.95**

## Vikings in America

500 years before Columbus, the Vikings reached North America. Archaeologists are now revealing an extraordinary story of tragedy and triumph behind the myth. *Educational use only.* 1 hr. **WG2202* $19.95**

## War Machines of Tomorrow

Take a look back at the war technology employed in the Gulf War, "Desert Storm," and preview the military machines of the future.
1 hr. **WG2305 $19.95**

## Warriors of the Amazon

See a rare glimpse of life today for the Yanomami, who live in a remote and inhospitable part of the Amazon rain forest. 1 hr.
**WG2309 $19.95**

# Life Science


## Animal Hospital

Go behind the scenes for this offbeat, sometimes humorous, sometimes sad portrait of pets, their owners and their vets and the drama that unfolds everyday in homes, zoos and veterinary hospitals. 1 hr. **WG2504 $19.95**

## The Brain Eater

Scientists race to determine whether a variant of the 'mad cow disease' spells a deadly epidemic for humans. *Educational use only.*
1 hr. **WG2505* $19.95**

## Brain Transplant

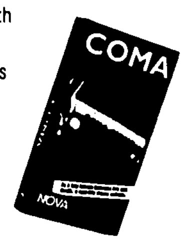
*NOVA* follows a medical detective story, leading from an inexplicable paralysis among drug abusers to the prospect of curing brain diseases with fetal implants. *Educational use only.* 1 hr. **WG1918* $19.95**

## Can Buildings Make You Sick?

Join *NOVA*'s quest to uncover baffling cases of bad air found in offices, schools, homes and even hospitals! *Educational use only.*
1 hr. **WG2217* $19.95**

## Coma

In a gripping real-life drama, *NOVA* follows famous neurosurgeon Jam Ghajar as he struggles to save a young boy with massive head trauma, using simple but crucial techniques that are dangerously absent from most hospitals across the country. 1 hr. **WG2411 $19.95**




## Cut to the Heart

Can a radical form of surgery from the jungles of Brazil save desperately ill heart-disease patients? Watch this cutting-edge procedure in action—and listen to the stories of those whose lives it has renewed. 1 hr. **WG2409 $19.95**

## Ebola: The Plague Fighters

The Ebola virus and its devastating impact is profiled as *NOVA* travels behind the quarantine line to observe the scientists battling to contain this most deadly of viruses. 1 hr.
**WG2304 $19.95**

## NEW! Electric Heart

Brilliant surgeons Michael DeBakey, Robert Jarvik and Denton Cooley compete to develop the first successful electric heart for human transplant. *Educational use only.* 1 hr.
**WG2617* $19.95**

## Haunted Cry of a Long Gone Bird

Explore the legacy of the great auk, a magnificent flightless bird that was hunted to extinction over a century ago. *Educational use only.*
1 hr. **WG2113* $19.95**

## NEW! Island of the Spirits

Mystical, magical and marvelous, Japan's northernmost island, Hokkaido, is filled with steaming lakes, fairy tale forests and wildlife as varied and unique as its terrain. Dazzling photography captures a year in the life of its rare inhabitants. *Educational use only.* 1 hr.
**WG2614 $19.95**

## Kingdom of the Seahorse

Witness a remarkable fish whose male becomes pregnant and gives birth. Tour the magical and complex world of the seahorse—from an underwater enclave in Australia to a village in the Philippines dependent on the seahorse for survival. 1 hr. **WG2410 $19.95**

## Life's First Feelings

A look at babies' emotional responses, clues about developing personality traits and how parents help with socialization. 1 hr.
**WG9304* $19.95**

## Little Creatures Who Run the World

Peer close-up into the worlds of the most amazing ants and understand why some believe ants are the most successful life form on earth. 1 hr. **WG2203 $19.95**

## MD: The Making of a Doctor

In this two-hour special, *NOVA* follows seven aspiring doctors as they undergo the exhilarating and rigorous years of medical training.
2 hrs. **WG2207 $19.95**

## The Miracle of Life

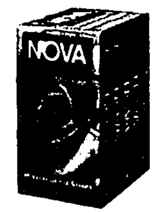
This Emmy® award-winning classic brings you along on an incredible microphotographic voyage through the human body as a new life begins, including the moment of conception.
1 hr. **WG001 $19.95**
DVD 1 hr. **WG799 $19.95**


## Mystery of the Animal Pathfinders

Travel to bird feeding grounds in Brazil, bat caves in Mexico and eel habitats in Maine to understand the mystery of animal migration.
1 hr. **WGW710* $19.95**

## Mystery of the Senses Boxed Set

Enjoy a celebration of the senses—a vivid blend of science and imagery. Includes *Hearing, Smell, Taste, Touch* and *Vision.*
5 hrs. on 5 cassettes **WG2214† $69.95**




## Night Creatures of the Kalahari

When the sun sets over southern Africa, the grasslands' strangest and most secretive residents sneak out from their lairs. Witness bush babies, meerkats, striped polecats, brown hyenas, flying termites, and more rarely seen exotic creatures. 1 hr. **WG2501 $19.95**

## The Private Lives of Dolphins

Discover the deep-sea drama of life for the ocean's most charming and sophisticated mammals. 1 hr. **WG1917* $19.95**

## Rescuing Baby Whales

Join the dramatic rescue of young, stranded pilot whales, and learn what is behind this puzzling phenomenon. 1 hr. **WG1908* $19.95**

## Shark Attack!

Are sharks developing a taste for human flesh? Join *NOVA* scientists as they discover some surprising truths about the way sharks kill. 1 hr.
**WG2316 $19.95**

## Siamese Twins

Witness the intricate plans and delicate operations that give independence to two young girls who were born joined at the pelvis. 1 hr.
**WG2204* $19.95**

## Stranger in the Mirror

*NOVA* explores the nature of human perception through the puzzling condition called visual agnosia—the inability to recognize faces and familiar objects. *Educational use only.* 1 hr.
**WGW709* $19.95**

## Surviving AIDS

Journey with *NOVA* to meet the scientists, physicians, and courageous patients whose cutting-edge experimentation and heroic acts will help achieve the ultimate goal: transforming every AIDS patient into a long-term survivor.
1 hr. **WG2603 $19.95**

* no retail packaging
† public performance rights are not included

## NEW! Tales from the Hive
Using specially developed camera lenses, *NOVA* brings you the most intimate—and most spectacular—portrayal of a working bee colony ever filmed. *Educational use only.* 1 hr. **WG2701 $19.95** *Available February 2000.*

## Treasures of the Great Barrier Reef
Visit Australia's greatest natural wonder, and view the undersea world's brilliant colors and extraordinary inhabitants. 1 hr. **WG2215 $19.95**

## The Universe Within
Travel on an extraordinary visual tour inside the human body, with microphotography and computer animation achieved by the creators of *The Miracle of Life. Educational use only.* 90 min. **WG2206A* $19.95** 1 hr. **WG2206 $19.95**

## Wild Europe Boxed Set
Part travel adventure, part nature expedition, *Wild Europe* presents an untamed, unexpected experience that reveals a Europe few have ever seen. This stunningly filmed special unveils hundreds of European species in their natural habitats. Includes *Wild Seas, Wild Mountains, Wild Arctic, Wild Origins* and *Wild Cities.* 6 hrs. on 6 cassettes **WG653 $69.95**


## The Wonder of Life Boxed Set
Hidden from the human eye, the wonder of life unfolds in, on and around us with startling beauty and unexpected drama. Includes *The Odyssey of Life Set (The Ultimate Journey, The Unknown World, The Photographer's Secrets)* and *The Miracle of Life.* 4 hrs. on 4 cassettes **WG177 $59.95**

# Physical Science

## The Best Mind Since Einstein
A profile of the late Richard Feynman—atomic bomb pioneer, Nobel prize-winning physicist, acclaimed teacher and all-around eccentric. *Educational use only.* 1 hr. **WGW708* $19.95**

## Daredevils of the Sky
Strap in for a ride with America's greatest stunt pilots. Stunning in-air photography puts you in the pilot's seat with the US Aerobatic Team. 1 hr. **WGW2103 $19.95**

## Einstein Revealed
Journey into the life and thoughts of a genius—through interviews with "Einstein" (Andrew Sachs of *Fawlty Towers*), insight from experts, and some whimsical computer animation. 2 hrs. **WG2311* $19.95**

## Fast Cars
Follow a racecar driver and engineers as they design a faster car. 1 hr. **WG2208 $19.95**

## Faster Than Sound
The race to build an aircraft that could crack the sound barrier was fraught with danger, ambition, and intrigue. *NOVA* tells the real story of those who risked all to make aviation history—including Chuck Yeager, the first pilot to fly faster than sound. 1 hr. **WG2412 $19.95**

## Race to Catch a Buckyball
Learn about the chance discovery of an entirely new form of carbon—soccer-ball-shaped miraculous molecules called Buckyballs. *Educational use only.* 1 hr. **WG2216* $19.95**

## Roller Coaster!
The thrill of the world's greatest rides and the science that creates them. *Educational use only.* 1 hr. **WGW706* $19.95**

## Super Bridge
Take a look at "the bridge of the future" and play sidewalk supervisor on one of the world's most remarkable and risky bridge projects—the building of the elegant, cable-stayed Clark Bridge spanning the Mississippi at Alton, Illinois. 2 hrs. **WG2416 $19.95**


## Supersonic Spies
This true tale of Cold War espionage reveals what really happened at the 1973 Paris air show, a supersonic competition between Soviet and French planes, when the Konkordski went down in a fatal, fiery explosion, never fully explained by either the French or Soviets. 1 hr. **WG2503 $19.95**

## This Old Pyramid
Join an Egyptologist as he reveals secrets of the pyramids and advises a stonemason from *This Old House* on how to build a new pyramid. 90 min. **WGW278 $19.95**

## NEW! Time Travel
Join scientists Kip Thorne, Stephen Hawking and others to see a theoretical time machine that may someday make time travel a reality. *Educational use only.* 1 hr. **WG2612* $19.95**

## Top Gun Over Moscow
For half a century we feared them. Now, for the first time, meet the rugged pilots of the Russian Air Force—and take a close-up look at the heart-stopping maneuvers that still fill Western flyers with awe. 1 hr. **WG2315 $19.95**

# Mathematics

## NEW! Trillion Dollar Bet
*NOVA* follows the riches-to-rags story of two Nobel Prize-winning economists whose mathematical formula to accurately predict financial markets brought them both notoriety and disgrace. *Educational use only.* 1 hr. **WG2704 $19.95** *Available March 2000.*

## The Proof
Princeton math whiz Andrew Wiles spent eight secluded years perfecting the proof of Fermat's Last Theorem, a famous enigma that had stumped experts for 300 years. Follow a fascinating tale of obsession, secrecy, brilliance—and one man's inspiring single-minded quest. *Educational use only.* 1 hr. **WG2414* $19.95**

# NOVA Field Trips

## Amazing Animals
From bugs to bats and more. Includes *All-American Bear, Little Creatures Who Run the World* and *Mystery of the Animal Pathfinders.* Teacher's guide included. 3 hrs. on 3 cassettes. **WG089 $49.95**

## Creatures of the Sea
Dive deep for an underwater visit with the ocean's most fascinating creatures. Includes *Shark Attack!, Private Lives of Dolphins* and *Treasures of the Great Barrier Reef.* Teacher's guide included. 3 hrs. on 3 cassettes. **WG091 $49.95**

## Dinosaurs
Explore the world of dinosaurs. Includes *Buried in Ash, Dinosaurs of the Gobi,* and *Mammoths of the Ice Age.* Teacher's guide included. *Educational use only.* 3 hrs. on 3 cassettes. **WG094 $49.95**

## The Discoverers
Take a close look at the century's great scientists and learn how they made their breakthrough discoveries. Includes *Einstein Revealed* (2 hrs.) and *Race to Catch a Buckyball.* Teacher's guide included. *Educational use only.* 3 hrs. on 2 cassettes. **WG106 $49.95**

## Discovering Ancient Cultures
Investigate new clues for ancient cultures. Includes *This Old Pyramid* (90 min.), *Vikings in America,* and *Warriors of the Amazon.* Teacher's guide included. *Educational use only.* 3.5 hrs. on 3 cassettes. **WG092 $49.95**

## The Doctors
Watch doctors operate behind the scenes. Grades 7 and up. Includes *MD: The Making of a Doctor* (2 hrs.) and *Ebola: The Plague Fighters.* Teacher's guide included. 3 hrs. on 2 cassettes. **WG104 $49.95**

## The Earth

A close-up look at some of Earth's most spectacular phenomena. Includes *In the Path of a Killer Volcano, The Day the Earth Shook* and *Flood!*. Teacher's guide included. 3 hrs. on 3 cassettes. **WG110 $49.95**

## Exploring Space

View the universe from new perspectives. Includes *Countdown to the Invisible Universe, Death of a Star* and *Rescue Mission in Space*. Teacher's guide included. 3 hrs. on 3 cassettes. **WG107 $49.95**

## Fast Physics

Understand the thrill and power of motion. Includes *Roller Coaster!, Fast Cars* and *Daredevils of the Sky*. Teacher's guide included. *Educational use only.* 3 hrs. on 3 cassettes. **WG086 $49.95**

## Flight

Feel the exuberance and the thrill of flight. Includes *Top Gun Over Moscow, Three Men and a Balloon* and *Aircraft Carrier!*. Teacher's guide included. 3 hrs. on 3 cassettes. **WG111 $49.95**

## The Human Body

The intricate wonders of the human body are revealed in extraordinary visual detail. Includes *The Miracle of Life, The Universe Within* and *The Ultimate Journey*. Teacher's guide included. 3 hrs. on 3 cassettes. **WG085 $49.95**

## In Search of Human Origins

The development of the human race. Includes *The Story of Lucy, Surviving in Africa* and *The Creative Revolution*. Teacher's guide included. 3 hrs. on 3 cassettes. **WG109 $49.95**

## The Mysteries of the Mind

Explore the intriguing phenomena of perception, psychological development, and reports of alien abductions. Includes *Kidnapped by UFOs, Secret of the Wild Child*, and *Stranger in the Mirror*. Teacher's guide included. *Educational use only.* 3 hrs. on 3 cassettes. **WG105 $49.95**

## The Planets, The Stars and More

Visit extraordinary places in the universe. Includes *Venus Unveiled, Eclipse of the Century* and *Doomsday Asteroid*. Teacher's guide included. *Educational use only.* 3 hrs. on 3 cassettes. **WG087 $49.95**

## Scientific Detectives

Search for answers to intriguing mysteries. Includes *Codebreakers, Hunt for the Serial Arsonist* and *In Search of the First Language*. Teacher's guide included. *Educational use only.* 3 hrs. on 3 cassettes. **WG090 $49.95**

## Secrets of Lost Empires

Travel to five archaeological sites with *NOVA* and their teams of experts. The mission? To replicate ancient engineering feats—using traditional tools. Includes *Stonehenge, Inca, Obelisk, Colosseum* and *Pyramid*. Teacher's guide included. 5 hrs. on 5 cassettes. **WG304 $69.95**

## Wild Weather

Join "stormchasers" on a journey into danger to learn how to tame nature's fury. Includes *Lightning!, Tornado!* and *Hurricane!*. Teacher's guide included. 3 hrs. on 3 cassettes. **WG088 $49.95**

# Instructional Videos

## Fast Cars Modules Set

Understand cars to understand physics. *Invisible Forces of Winds* puts students at the controls of an Indy 500 race car to demonstrate aerodynamics. *To Survive at High Velocity* demonstrates how vectors show how "corners make the driver and the car." *Test Day* lets you understand the complexity of race cars by testing every variable on the track. In *A Racing Engine for the Indy 500*, two companies battle to harness energy to create power. Teacher's guide included. *Educational use only.* 1 hr. on 4 cassettes. **WG2208A $49.95**

## Science First Hand Set

Observe teachers and students at work. *Structures* – Designing houses, bridges and towers to explore force, tension and compression. *Tops and Yo-Yos* – Understanding rotational motion by designing and building tops and yo-yos. *Waterwheels* – Simple machines that demonstrate efficiency, speed and testing variables. Teacher's guide included. *Educational use only.* 105 min. on 3 cassettes. **WG005 $39.95**

## NEW! Science K-6: Investigating Classrooms

Step inside three elementary classrooms to see what teachers from around the country are doing to incorporate in-depth investigations into their science lessons. This library of nine videos and a 110-page Facilitator's Guide are an invaluable resource in learning and refining the fine craft of teaching by observing and discussing real classrooms. The teachers offer themselves and their students as case studies in an effort to raise questions and inspire discussions about what it takes to prepare scientifically literate students. 7 hrs. on 9 cassettes. **WG545 $199.95**

# Ordering Information

**Phone**

Call 1-800-949-8670, and mention keycode "0100." (8 AM to 3 AM, EST, 7 days a week). Please have your American Express, VISA, MasterCard or Discover card ready.

**Fax**

Fax your order with credit card payment or purchase order to: Dept: 0100, 1-802-864-9846

**Mail**

Mail your order with credit card payment or purchase order to: NOVA Videos/Dept. 0100, South Burlington, VT 05407-2284

**Shipping**

Videos will arrive within two weeks from date of order if items are in stock. Back-ordered items take 4-6 weeks. Shipping and handling charges for videos sent to the same address are as follows: $3.95 for the first video, $1.00 for each additional video; $6.95 for the first Field Trip, $2.00 for each additional Field Trip. Rush and overnight delivery can be arranged at an additional charge. Sales tax applies on NY, CA, MA (5%) and VT (5%) orders.

Your purchase helps support public television.

**Visit us at www.wgbh.org**

WGBH BOSTON VIDEO

• no retail packaging

# Guides

To be placed on our mailing list to receive a free subscription to the semiannual *NOVA Teacher's Guide*, send us a note with your name, address, and the grades and subjects you teach to:

NOVA Teacher's Guide
WGBH
125 Western Avenue
Boston, MA 02134
E-mail: WGBH_Materials_Request@wgbh.org

# Transcripts

Full transcripts of NOVA programs airing after January 7, 1997, are available on NOVA's Web site at:
**www.pbs.org/nova/transcripts**

Transcripts of shows airing before that date are available for purchase by calling (800) ALL-NEWS.

# Taping Rights

NOVA programs that air or have aired after January 1996 may be used for one year from their broadcast date. Programs airing prior to that date may be used for seven days from when they are broadcast.

# Credits


The *NOVA Teacher's Guide* is produced by the Educational Print and Outreach department of the WGBH Educational Foundation.

*Director of Educational Outreach*
Beth Kirsch

*Associate Director of Educational Print and Outreach*
Karen Barss

*Manager of Educational Print*
Sonja Latimore

*Project Director*
Karen Hartley

*Associate Editor*
Beth Winickoff

*Production Coordinator*
Gay Mohrbacher

*Writers*
Luann Colombo, Tanya Gregoire, Kristina Ransick, Fran Lyons Sammons, James Sammons

*Curriculum Consultants*
**Candace Dunlap**, Science Department, Malden Public Schools, Malden, MA
**Reen Gibb**, Science Department, Brookline Public Schools, Brookline, MA
**Hollington Lee**, Science Department, West Springfield High School, West Springfield, MA
**Maxine Rosenberg**, Science Department, Newton Public Schools, Newton, MA

*Designer*
Elles Gianocostas

*Photo Researchers*
Lisa Abitbol, Debby Paddock

*Print Production*
Lenore Lanier

*Illustrator*
Steve Stankiewicz, Rose Zgodzinski

The NOVA television series is produced by WGBH Boston, which is solely responsible for its content, and distributed by the Public Broadcasting Service.

Major funding for NOVA is provided by




CC
Closed captioned for viewers who are deaf or hearing impaired.


Cover Photography
Leisl Clark

**Inside Photography**
Cover: Liesl Clark/©WGBH; page 2: Monika Andersson/©WGBH; page 3: Linda Grusenmeyer; page 4: (top) Liesl Clark/©WGBH (bottom) ©Thom Pollard; pages 4–7: (background) Liesl Clark/©WGBH; page 8: (top) ©Biophoto Associates/ Photo Researchers, Inc. (bottom) Courtesy Cicada Films, Ltd; page 12: ©Sunset (Brake)/Peter Arnold, Inc; pages 12–15: (background) ©Zigmund Leszczynski/ Animals Animals; page 16: Courtesy of the National Maritime Museum, London; pages 16-19: (background) Giraudon/Art Resource, NY; page 20: (graph) Courtesy U.S. Global Change Research Information Office; pages 20–25: (background) ©Bruce Forster/Tony Stone Images, Inc; page 26: Jackie Mow/©WGBH; page 27: (top to bottom) Terri Manoogian/©WGBH; Peter Tyson/©WGBH; Liesl Clark/©WGBH; Deborah Fryer/©WGBH; pages 26-33 (background) ©Kevin Schafer/Tony Stone Images, Inc.


# Feedback

We'd like to know what you think about NOVA, this *Teacher's Guide*, and our online activities. Please write to:

Karen Hartley
WGBH
125 Western Avenue
Boston, MA 02134
E-mail: Karen_Hartley@wgbh.org

The future of a country lies in its young people, and the future of those young people lies in their teachers. As an educator, you know that shaping a future means working hard in the present.

I understand how much support you need in this effort, because helping shape futures is our business at Northwestern Mutual Life. We help people put together personal and financial plans that will make a positive difference throughout their lives.

So it's with an eye toward the future that we offer you the new spring issue of the *NOVA Teacher's Guide.* I think this season's shows are full of interesting material for study and the guide will turn them into a powerful teaching aid in your classroom. As proud sponsors of this award-winning educational series, everyone here at Northwestern Mutual Life would like to thank you for your integrity and dedication to shaping the future.

James D. Ericson

James D. Ericson
President and Chief Executive Officer

Northwestern Mutual Life®
The Quiet Company®

## Sign Up for Your Free Teacher's Guide

**To receive this semiannual guide for free, send your name, address, and subjects and grades you teach to:**

**NOVA Teacher's Guide**
**WGBH**
**125 Western Avenue**
**Boston, MA 02134**

**E-mail: WGBH_Materials_Request@wgbh.org**

BH Educational Foundation
/A Teacher's Guide
125 Western Avenue
Boston, MA 02134

WGBH

ADDRESS CORRECTION REQUESTED

Nonprofit Organization
U.S. Postage
Paid
Boston, MA
Permit No. 51738

**Video Orders:**
see page 39 for address.

SEE IT ON PBS

Major funding is provided by

c|net CNET.com

PARK FOUNDATION

Northwestern Mutual Life
The Quiet Company

46

SE064297

ERIC

**U.S. Department of Education**
*Office of Educational Research and Improvement (OERI)*
*National Library of Education (NLE)*
*Educational Resources Information Center (ERIC)*

# REPRODUCTION RELEASE

(Specific Document)

## I. DOCUMENT IDENTIFICATION:

Title: NOVA, SPRING 2000 TEACHER'S GUIDE

Author(s): WGBH

Corporate Source: Same

Publication Date: 2000

## II. REPRODUCTION RELEASE:

In order to disseminate as widely as possible timely and significant materials of interest to the educational community, documents announced in the monthly abstract journal of the ERIC system, *Resources in Education* (RIE), are usually made available to users in microfiche, reproduced paper copy, and electronic media, and sold through the ERIC Document Reproduction Service (EDRS). Credit is given to the source of each document, and, if reproduction release is granted, one of the following notices is affixed to the document.

If permission is granted to reproduce and disseminate the identified document, please CHECK ONE of the following three options and sign at the bottom of the page.

| The sample sticker shown below will be affixed to all Level 1 documents | The sample sticker shown below will be affixed to all Level 2A documents | The sample sticker shown below will be affixed to all Level 2B documents |
|---|---|---|
| PERMISSION TO REPRODUCE AND DISSEMINATE THIS MATERIAL HAS BEEN GRANTED BY ______ Sample ______ TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC) | PERMISSION TO REPRODUCE AND DISSEMINATE THIS MATERIAL IN MICROFICHE, AND IN ELECTRONIC MEDIA FOR ERIC COLLECTION SUBSCRIBERS ONLY, HAS BEEN GRANTED BY ______ Sample ______ TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC) | PERMISSION TO REPRODUCE AND DISSEMINATE THIS MATERIAL IN MICROFICHE ONLY HAS BEEN GRANTED BY ______ Sample ______ TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC) |
| 1 | 2A | 2B |
| Level 1 | Level 2A | Level 2B |
| [✓] | [ ] | [ ] |
| Check here for Level 1 release, permitting reproduction and dissemination in microfiche or other ERIC archival media (e.g., electronic) *and* paper copy. | Check here for Level 2A release, permitting reproduction and dissemination in microfiche and in electronic media for ERIC archival collection subscribers only | Check here for Level 2B release, permitting reproduction and dissemination in microfiche only |

Documents will be processed as indicated provided reproduction quality permits.
If permission to reproduce is granted, but no box is checked, documents will be processed at Level 1.

*I hereby grant to the Educational Resources Information Center (ERIC) nonexclusive permission to reproduce and disseminate this document as indicated above. Reproduction from the ERIC microfiche or electronic media by persons other than ERIC employees and its system contractors requires permission from the copyright holder. Exception is made for non-profit reproduction by libraries and other service agencies to satisfy information needs of educators in response to discrete inquiries.*

**Sign here,→ please**

| Signature: Sonja Latimore | Printed Name/Position/Title: Sonja Latimore - Print Mgr. | |
|---|---|---|
| Organization/Address: WGBH Boston | Telephone: 617-300-4379 | FAX: 617-300-1040 |
| | E-Mail Address: Sonja_latimore@wgbh.org | Date: 5-9-2000 |

(over)

## III. DOCUMENT AVAILABILITY INFORMATION (FROM NON-ERIC SOURCE):

If permission to reproduce is not granted to ERIC, *or*, if you wish ERIC to cite the availability of the document from another source, please provide the following information regarding the availability of the document. (ERIC will not announce a document unless it is publicly available, and a dependable source can be specified. Contributors should also be aware that ERIC selection criteria are significantly more stringent for documents that cannot be made available through EDRS.)

| |
|---|
| Publisher/Distributor: |
| Address: |
| Price: |

## IV. REFERRAL OF ERIC TO COPYRIGHT/REPRODUCTION RIGHTS HOLDER:

If the right to grant this reproduction release is held by someone other than the addressee, please provide the appropriate name and address:

| |
|---|
| Name: |
| Address: |

## V. WHERE TO SEND THIS FORM:

| |
|---|
| Send this form to the following ERIC Clearinghouse: |

However, if solicited by the ERIC Facility, or if making an unsolicited contribution to ERIC, return this form (and the document being contributed) to:

**~~ERIC Processing and Reference Facility~~**
**1100 West ~~Street, 2nd~~ Floor**
**~~Laurel, Maryland 20707-3598~~**

**Telephone: 301-497-4080**
**Toll Free: 800-799-3742**
**FAX: 301-953-0263**
**e-mail: ericfac@inet.ed.gov**
**WWW: http://ericfac.piccard.csc.com**

ERIC/REC
2805 E. Tenth Street
Smith Research Center, 150
Indiana University
Bloomington, IN 47408