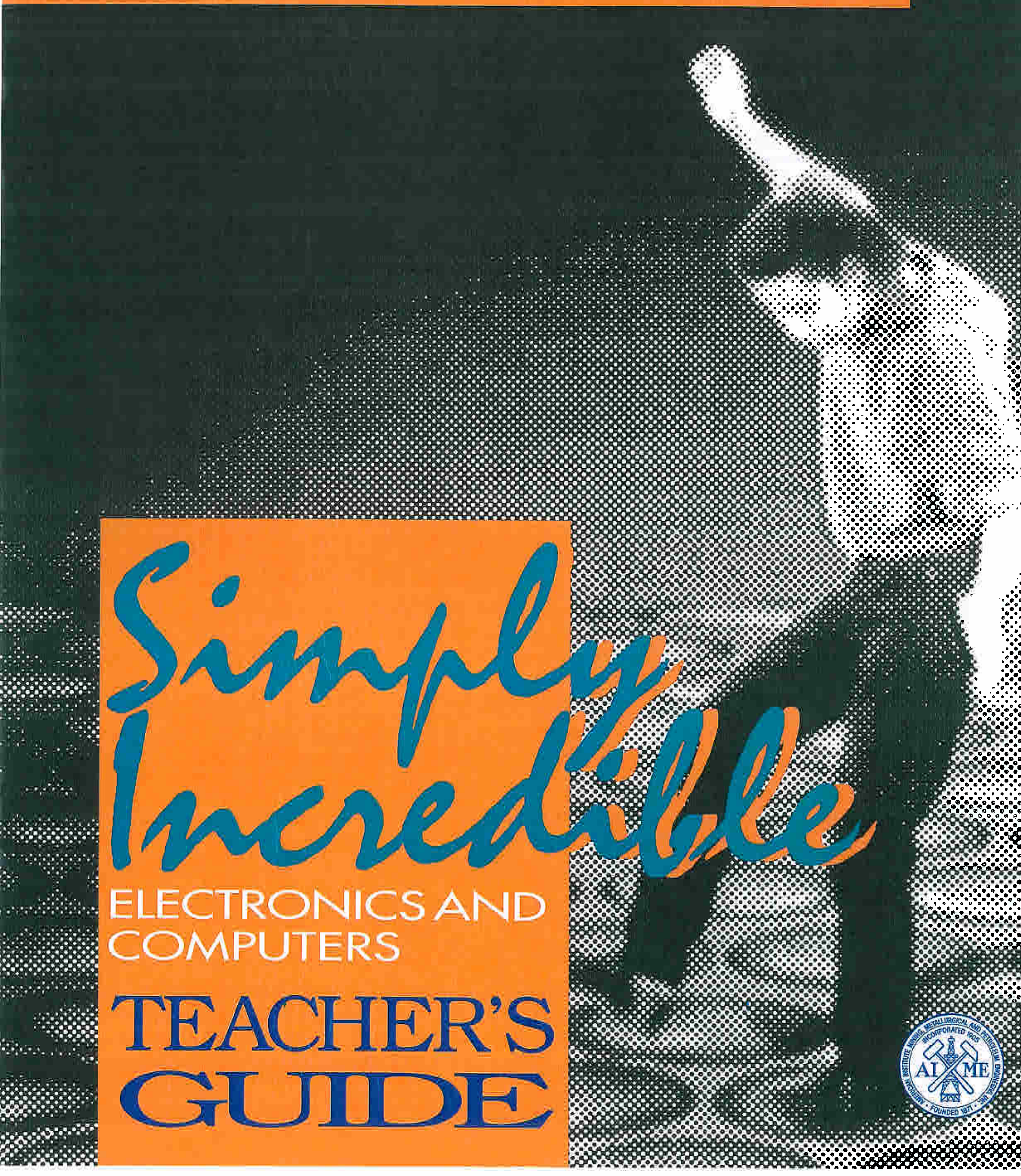
TRANSFORMATIONS
SCIENCE, TECHNOLOGY & SOCIETY



Simply Incredible

ELECTRONICS AND COMPUTERS

TEACHER'S GUIDE

AMERICAN INSTITUTE MINING, METALLURGICAL AND PETROLEUM ENGINEERS, INC.
INCORPORATED 1905
AIME
FOUNDED 1871

TRANSFORMATIONS: Science, Technology & Society

Program Goals

- ▲ to enhance and enrich science instruction in Middle School classrooms
- ▲ to explore ways that technology takes scientific knowledge and applies it to meeting society's needs and solving society's problems
- ▲ to foster among students a spirit of inquiry, encouraging and developing their problem-solving skills
- ▲ to help create citizens who are cricital thinkers, prepared to make informed decisions about complex social/technological issues that will confront them in decades to come

SIMPLY INCREDIBLE

Electronics and Computers

The subject of this unit is microelectronic technology, exploring transistors, integrated circuits, and the microchips that contain them. The video features a visit to Texas Instruments, the site of some of the original breakthrough work in the development of integrated circuits. Topics for this unit, presented and treated in the Guide, are

- ▲ Electrical Circuits
- ▲ Electronics and Computers

Curriculum Connections: General Science, Physical Science; Computer Science, Music (electronic music, synthesizers)

Summary of the Video

Dust on the negative ruins a band picture AJ and Simone develop. Meanwhile, Billy compares the vacuum tubes in his amplifier with the microchip Laurie is installing in the band's PC. The other band members arrive, and AJ ponders what computer "memory" is. An animated history of electronic components shows a progression from large and fast (vacuum tubes) through smaller and faster (transistors) to incredibly small and fast (integrated circuits). Laurie is hopeful that hooking up the band's synthesizers to the computer will add to their sound; AJ is dubious. However, a visit with Ray Simar, a computer architect at Texas Instruments, kindles his enthusiasm for microchips.

AJ sees how the design team uses a multiplier to design a microchip, how they have creatively responded to market needs, and how microchip "logic" is a matter of on-off switches. He also finds out– in an incredible-shrinking-AJ sequence–just how small a scale is involved in this work: So small, a piece of dust can destroy a circuit. Hence the need, in producing these chips, for a "clean room," like the one Ray and AJ visit.

A montage of the production of microchips leads to an example of these chips in action: The band finishes playing an instrumental number called "Simply Incredible." The computer enhancement then added makes the number less simple and more incredible.

Suggestion for Using Unit D: "Simply Incredible"

Page 3 — Introduction to the Teacher

Here you will find additional background information on the science and technology presented in "Simply Incredible"

Page 4 — Introduction to the Students

This section gives you material for introducing "Simply Incredible" to your students, including a statement of the purpose of the unit; suggestions for connecting the unit to students' experience; definitions of key concepts and terms; and directions for the Video Study Guide (see below).

Page 5 — Topic 1

Page 6-7 — Topic 2

These pages focus on the two topics in "Simply Incredible": Electrical Circuits, and Electronics and Computers. Each page furnishes options for introducing the topic to students and a wide array of ways for students to respond to the topic, including labs that are carried out through the Activity Masters.

Choose any of the topics as your focus, depending on where you are in the curriculum.

Video Study Guide

You can use the video guide (Activity Master 1) to focus students' attention on and check their comprehension of the video.

Video

Running time for the video is $18^1/_2$ minutes. You may want to preview the video and choose a Stop Point for conducting a discussion, carrying out an activity, or making a comprehension check. The video may also be show straight through.

Pages 8-13 — Activity Masters

The first blackline master is the Video Study Guide for "Simply Incredible". The other masters give students hands-on opportunities in the form or activities and labs.

Page 14 — Extension

This final section includes suggestions for science fair projects and research topics, ones that build on concepts explored in "Simply Incredible" Also listed are related resources for interested students to pursue, including book titles and organizations to contact.

Simply Incredible: An Introduction for the Teacher

"Simply Incredible" revolves around the mighty microchip—the integrated circuits and transistors it contains, what goes into its production, and its tremendous impact on our society.

Below is a more detailed explanation of concepts presented in the video and developed in this Guide.

What is the significance of the transistor?

A transistor is a small block of semiconducting material, such as silicon or germanium, that controls the flow of electrical current. The name is derived from the term **transfer resistor**. In 1947, one year after ENIAC, the first electronic computer, went into operation, three scientists at Bell Laboratories —John Bardeen, Walter Brattain, and William Shockley—developed the transistor. It has been called the single most important invention within the complex of inventions known as the computer.

ENIAC required 18,000 vacuum tubes and 140,000 watts of electricity to operate and filled a large room. A transistor is 1/1000 the size of and much more energy-efficient than a vacuum tube. The use of transistors led to the reduction in size not only of computers, but of televisions, radios, and other electronic devices.

What about integrated circuits?

IC's comprise many electronic components wired together on individual silicon microchips. The IC was developed simultaneously in 1959 by scientists at Texas Instruments and at Fairchild Camera and Instrument Co. The circuits began mass production in 1960. Every year since, the number of transistors the semiconductor industry can place on a single chip has doubled. The number of components a chip can hold keeps growing; a circuit holding one million components may already exist as you read this.

What makes silicon the best material for microchips?

Silicon, shiny like metal but brittle like glass, is an almost perfect insulator and it possesses an interesting characteristic, the presence of just a few impurities per ten billion parts of silicon can affect its conductivity. By controlling the impurity added, engineers can make silicon "transist"—that is, under certain conditions it will conduct electricity; under others it won't. An almost perfect insulator has the ability to become a switch. These switches can be arranged in a repetitive pattern on the surface of a disc (wafer) of very pure silicon. The switches are wired together, and the wafer diced up into many pieces, each containing the same pattern of switches. The surface patterns are integrated circuits; the pieces are microchips.

How is silicon transformed into microchips?

The first step involves growing a very pure single crystal of silicon. Polycrystalline silicon is melted, and a small "seed" of single crystalline silicon is dipped into the melt. Under computer control, the seed is then withdrawn from the melt, its surface covered with a "freeze" of molten silicon. An "icicle" of silicon is formed, which has an atomic arrangement identical to the seed. This icicle is divided into wafers, using a high-speed, diamond-impregnated wheel that actually pulverizes half of the carefully grown crystal in the process.

The wafer is polished to remove cutting marks, leaving a slice whose thickness is that of a playing card. A thin layer (about 1/200th that of a human hair) of silicon dioxide (SiO_2) is deposited on the wafer to protect and insulate its surface. The wafer is coated with photosensitive film and exposed to ultraviolet light through a mask to create "windows" of exposed film that hardens; film hidden by the mask is washed away. Acid etching removes exposed SiO_2 without attacking the hardened film or the very pure single crystalline silicon beneath. No longer needed to protect the silicon, the film is removed, and the wafer is doped with a specific impurity (phosphorus or boron). This silicon doping process alters the electrical characteristics of the exposed silicon, making it a switch. Then another thin layer of SiO_2 is deposited on the wafer, and again, tiny windows of silicon are exposed. These are doped with a different impurity to impart different electrical characteristics.

Finally, all switches are wired together, and an insulating layer is applied to the wafer's surface. The wafer is tested electrically and diced into microchips.

SIMPLY INCREDIBLE: An Introduction for Students

Introducing the Unit

Present the goals of "Simply Incredible" to students:

- ▲ to get an overview of the evolution of electronic components;
- ▲ to understand that the concept of on-off switches applies to all electrical circuits, including the integrated circuit;
- ▲ to see the relationship between microchip, transistors, and integrated circuits and to sense the scale involved;
- ▲ to realize the impact these components have on our society;
- ▲ to appreciate how rapidly the technology for these components has developed and is developing.

They should **not** feel, however, that they are responsible for memorizing the technological processes and tools described in the video.

Connecting the Unit to Students' Experiences

Point out that the field of electronics has advanced rapidly since1960, when integrated circuits first went into production. Explain that every year since then has seen changes and improvements. There have been enormous advances just since students were born—and the advances continue. By the time students are adults, the modern electronic devices of today will probably seem old-fashioned and primitive. Finding out just how "cutting-edge" this technology is may help students keep abreast of major developments.

Key Concepts and Terms

Students will be exploring and extending their understanding of the words listed below (in italics) by topic area. You might write these words on the board and briefly discuss them to determine which are familiar to your students.

Topic: Electrical Circuits

- ▲ **Electric current** is the flow of electrons along a path. The path is called an **electric circuit.**
- ▲ **Conductors** have a low **resistance** (electrons flow easily); materials with a high resistance are called**insulators**.
- ▲ The resistance of **semiconductors** can be made to vary; therefore, they are used to control the flow of electric current. Many semiconductors are made of treated silicon.
- ▲ The force moving electrons in an electric circuit is the **voltage**. If voltage is high, many electrons flow; if it is low, few electrons flow.
- ▲ A **switch** is used to control the electric current flow in a circuit. When the switch is open, the current is stopped.
- ▲ A **series circuit** has only one path for the current; if the circuit is broken at any point, the current in all parts is stopped.
- ▲ A **parallel circuit** has two or more separate branches for the electic current; if a switch in one branch is open, current still flows through the other branch(es).

Topic: Electronics and Computers

- ▲ **Electronic** devices translate electric current into useful energy (motion, light, heat) or information (sound, pictures).
- ▲ Before 1960, many electronic devices used components called **vacuum tubes,** comprising semiconductors and metal plates enclosed in glass tubes. Compared with modern electronic components, these tubes were unreliable, inefficient, complicated, and much larger.
- ▲ Introduced in 1947, **transistors** are small blocks of semiconducting material operating as on/off switches. A transistor is 1/1000 the size of and much more energy-efficient than a vacuum tube.
- ▲ **Integrated circuits** came out in 1960. The circuits are made up of transistors wired together on tiny microchips.
- ▲ A **microchip** is a piece of semiconducting material, typically silicon, perhaps 1/4 inch square, that may contain over 25 feet of wiring and hundreds of thousands of electronic components. One microchip can power a digital watch; a circuit board comprising many chips is needed to power a complex computer.

VIDEO STUDY GUIDE

To focus or direct students' viewing of the video, distribute Activity Master 1, the Video Study Guide. You might have your students work individually, or small groups could each be responsible for a particular section of the Study Guide. Allow time—stopping the video at various points or after the video is over—for students to discuss their responses.

SIMPLY INCREDIBLE: Electrical Circuits

Introducing the Topic: Options

▲ Materials needed: **remote control and TV used for video.** Have students tell how the remote operates. If necessary, aim the remote in various directions to show that there is an infrared beam that must connect with an eye on the TV/VCR.

▲ Materials needed: **electronic devices** (hand-held calculator, radio, hair dryer, tape recorder, musical greeting card). Include an older item, such as a transistor radio or crystal set. Or, include photographs of old console televisions or early computers. Students should examine the devices to compare the amount of room needed for electronic components.

▲ Materials needed per group: **cardboard toilet-paper tube, about 30 marbles.** To show them how electrons act in a wire and the effect of electrical force, have students flatten the tube to about the height of a marble and push marbles into the tube until they appear at the other end. When they push several more in one end, marbles will pop out of the other end almost instantly (like electrical force causing electricity to flow at the speed of light). Then have them choose an easily identifiable marble, push it in one end, and continue pushing marbles in until their marble appears, demonstrating how slowly individual electrons move (about .85 inch or 2.2 cm per minute).

STUDENT INVOLVEMENT: OPTIONS

Indicates an activity that would take less than a class period.

Indicates an activity that could take most of a class period.

Indicates an activity that would go beyond the class period.

Discuss the Video.

Video Guide notes can be used to help students answer straightforward questions. The answers to the Video Guide questions are provided below, since all apply to this topic.

1. vacuum tubes, microchips; Billy says his guitar/amp sounds sweeter than synthesizer/computer; 2. vacuum tubes, transistors, integrated circuits; smaller and faster; 3. defines function of chips but doesn't build them—like architect who designs and defines rooms but doesn't construct building; 4. no—it consists of switches that switch at high rates of speed; 5. human hair; piece of dust; something the size of piece of dust or human hair could destroy circuit, so environment must be as clean as possible; 6. being creative, working with a team, putting together technology that's going to shape the future; 7. and 8. answers will vary.

Demonstration: Resistance and Voltage Changes.

Materials needed: **garden hose and faucet**. Use the flow of water in a hose as an analog for the flow of electrons in a circuit. Connect the hose, and turn on the water. Have students note the flow; then, 10 ft. from the end, make a coil in the hose and tighten it slightly, decreasing the flow (effect of a low-value resistor in a circuit). Tighten the kink more (effect of a large-value resistor). Tighten the kink until the flow stops (the effect of an insulator). Use the water force to represent voltage, and repeat the experiment after cutting the flow in half

Demonstration: Creating a Microchip.

Convert the process described on Guide page 2 to a visual display, using an overhead projector and overlays. Begin with the polished disk. Overlay the silicon dioxide coating, followed by the coating of photosenstive film. Then overlay a mask with cutout "windows," and so on, through the silicon doping process. Repeat the sequence with different "windows." The last two overlays could show the switches wired up and a grid of "cutting lines" for individual chips.

Lab: Designing a Parallel Circuit (Activity Master 2).

Materials needed for each lab pair: **see master.** (NOTE: If necessary, partners could make their own switches using 2 tacks, a strip of aluminum foil and a block of wood per switch. The tacks are pushed partway in at either end of the block, with one anchoring the strip of aluminum. To close the switch, the foil is brought in contact with the other tack.) After students have used their circuit to send messages (they may use the computer code on Activity Master 3), have them discuss their responses to the question on the sheet.

Answer: Lights flashing=telegraphic pulses interpreted by electromagnetic field into clicks.

SIMPLY INCREDIBLE: Electronics and Computers

Introducing the Topic: Options

- ▲ Remind students that the first computer, ENIAC, was put into operation in 1946. Have students speculate about its size; then tell them it filled a room that was probably twice as big as their classroom. Point out that a microchip today, the size of the nail on their pinkie, is much more powerful than that room-sized computer.
- ▲ Initiate a discussion of computers, covering points such as these: Where are computers in use? (school, home, businesses, stores) How comfortable do students feel using a computer? When did they first use one? How did they feel then? Do they know people who are afraid to use computers? Why might they be fearful? How would students convince them to try computers?
- ▲ Materials needed: **singing greeting card or small calculator; microscope.** Display and operate the item. Carefully uncover the electronic components, and let students take turns viewing them under the microscope. (The greeting card uses a small speaker, a piezoelectric device.)

STUDENT INVOLVEMENT: OPTIONS

- Indicates an activity that would take less than a class period.
- Indicates an activity that could take most of a class period.
- Indicates an activity that would go beyond the class period.

Discuss the Video.

Video Guide notes can be used to help students answer straightforward questions. Since all the Video Guide questions apply to this topic, only their anwers are provided below:

1. vacuum tubes, microchips; Billy says his guitar/amp sounds sweeter than synthesizer/computer; 2. vacuum tubes, transistors, integrated circuits; smaller and faster; 3. defines function of chips but doesn't build them—like architect who designs and defines rooms but doesn't construct building; 4. no—it consists of switches that switch at high rates of speed; 5. human hair; piece of dust; something the size of piece of dust or human hair could destroy circuit, so environment must be as clean as possible; 6. being creative, working with a team, putting together technology that's going to shape the future; 7. and 8. answers will vary.

Class Brainstorming: A "Clean Room."

Remind students of a comparison from the video: a clean room used to produce chips is some 10,000 times cleaner than any hospital or surgical room. Tell students that a clean room must also be virtually vibration-free because of the exacting nature and microscopic scale of the work. Divide students into brainstorming groups that consider the issues involved in a room that must have these qualities. What kind of "dirt" needs to be taken into account? What could cause vibrations? As students come up with each factor to be handled, they should also come up with a possible way to handle it. Set aside time for students to compare the results of their brainstorming.

Activity: Counting, Computer-Style.

Remind students that the transistors in an IC of a digital computer serve as electrical switches; information is relayed in patterns of ON and OFF switches. Have students simulate how a computer counts by writing the following numbers on their fingernails:

"1" on index finger of right hand
"2" on thumb of right hand
"4" on thumb of left hand
"8" on index finger of left hand

Have students place their hands side by side, palms down, and form fists. Then ask them to extend only the marked fingers. A finger that is up shows that the swtich is in the ON position, so the value indicated is the number on the fingernail. A finger kept down shows that the switch is OFF, and the number value expressed is zero. Have students slowly count in unison from 0 to 15, using their finger computers (and their addition skills!) to express the numbers. You might also have students work in small groups, giving each other numbers to show or read.

Activity: Electronic Historians.

The video offers a quick overview of the development of electronic components. Investigative pairs or teams of students could pursue this subject in a general or specific way:

- ▲ They might flesh out the development of components and use their research to produce a time line ("From Edison to Integration")
- ▲ They might pick a particular electronic device (*e.g.*, TV, radio, computer) and trace its evolution. Their research might be presented in the form of a comic book.

▲ Activity: Amazing Ads.

Remind students that microchip engineers are constantly finding new applications for their miracle chips, such as:

- ▲ language boxes that provide instant translations, so you can talk with someone speaking an unfamiliar language;
- ▲ new limbs of amputees that look, feel, and respond like the real thing;
- ▲ an electric car map that draws your route on a dashboard monitor and tells you when to turn.

Have students write and design ads for these recent inventions. Or, have them brainstorm a product that **could** exist in the near future, such as a 3-D television, and design an ad for that product.

▲ Activity: Sending Messages in ASCII (Activity Master 3).

Explain that all information in a computer is represented by various series of switches which are either ON or OFF. An ON switch is closed, allowing the current to flow though a circuit. An OFF switch is open, causing a break in the circuit and stopping the current. You may want to go over the directions on the sheet with students before having them complete the coding activities described there. These include exchanging coded messages with partners.

Answer: example number is 50.

▲ Activity: Metric Meaning

Materials needed: **meter stick, metric rulers**. Display the stick, and distribute the rulers to pairs or teams of students. Encourage them to contribute the information as you create the following chart on the chalkboard:

1 meter = *100* centimeters

1 centimeter = *10* millimeters

1 millimeter = *1000* microns

Have students figure out how many microns there are in a centimeter (1000 x 10 = 10,000); how many microns there are in a meter (10,000 x 100 = 1,000,000).

Ask students to measure something small with their rulers—the head of a screw, the width of their fingernail, shoelace, or jewelry chain, etc. Have them write their measurements in centimeters, milimeters, and microns.

▲ Lab: One in a Million (Activity Master 4).

Materials needed per lab group: **See Master.** To set the stage, point out that the scale used in science is often quite small, such as the wire in an IC, which is less than a micron (one-millionth of a meter) long. Another example are substances on our planet so dangerous to us that their presence in our air or water is measured in parts per million or even parts per billion. This lab will help students get a sense of this kind of scale.

▲ Activity: Then and Now Chart.

Quickly remind students of the history of the development of electronic components (see Guide page 3). Have students work in brainstorming groups (in-class activity) or investigative teams (researching outside of class) to create a Then-and-Now chart of common electronic devices. Categories could be Early Models, Later Models, Modern Models; the items whose models are being compared might include lamps, telephones, watches, computers, hairdryers, televisions, radios, ovens (*i.e.*,conventional and microwave), light switches, clock radios, keyboard instruments, and electonic devices in cars. You may want to make clear to students that some "early" and "later" models may still be in production because there are still markets for them.

Students might illustrate their charts or turn them into a class display by finding or making pictures of the various models they have charted.

Homework: One-Millionth.

To make a micron (one-millionth of a meter) more meaningful to students, use a familiar context— the sun is about 93,000,000 miles away. Have students find a destination 93 miles away. Point out that when they get there, they will have driven one-millionth of the distance to the sun. For homework, have students figure out how long it would take, traveling 60 mph, to drive to the sun—in hours (1,550,000), in full days (64,583.33), in years (using 365.25, 176.82). Or, have students pick another vast distance and calculate the one-millionth part (*e.g.*, a light year: 9.5 trillion km = 950,000, or 5.878 million mi. = 587,800).

VIDEO STUDY GUIDE

This guide is designed to help you get the most out of the video for "Simply Incredible." Look over the questions below before you watch the video. Use the space under the questions to take notes. What does the video tell you in answer to each question?

1. What is Billy replacing in his amp? What is Laurie installing in the band's computer? How do they compare these two components?

2. Arrange these electronic components in the order of their development:

   Transistors Vacuum Tube Integrated Circuit

   What effect did new components have on the size of electronic devices? on the speed of operations?

3. How does Ray Simar, a computer architect, describe what he does? How does he compare his work to an architect working on building?

4. AJ compares the logic in a microchip to people's ability to think. Does Ray agree with the comparison? What does he say logic is?

name: ____________________ **class:** ________ **date:** __________

VIDEO STUDY GUIDE, continued

5. When AJ shrinks down enough to "stand" on an integrated circuit, what is the "log" he sees? What object is he afraid will crush him? How does this experience explain why microchips are produced in "clean rooms"?

6. What does Ray particularly enjoy about his work?

7. Compare the two versions of the instrumental "Simply Incredible"—before and after the computer "enhancement." Which do you prefer? Why?

8. What parts of the video did you like best? Why?

name: ______________________ **class:** ________ **date:** __________

DESIGNING A PARALLEL CIRCUIT

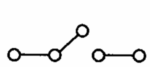
1. using the materials in the box, design a circuit that connects up all 8 light bulbs **but** lets each be turned on and off independently.
2. Draw a plan of your circuit in the empty box. In your plan, use the symbols electricians and electrical technicians use, shown below the box.
3. Build a circuit based on your plan.

MATERIALS NEEDED

- ▲ A strip of wood 1 foot x 2 feet
- ▲ Bell wire
- ▲ 1 Lantern battery
- ▲ 8 Knife-type switches
- ▲ Flashlight bulbs
- ▲ Matching flashlight sockets

4. Afterward, use your circuit to send coded messages to your lab partner. If you want, use ASCII, the binary code for computers that is shown on Activity Master 3.
5. How is your circuit like the first telegraph system? Be prepared to discuss this with your class.

SYMBOLS FOR DRAWING ELECTRICAL CIRCUITS

wire 	switch 	battery 	light bulb 

name: ____________________ **class:** ________ **date:** ________

SENDING MESSAGES IN ASCII

Computers only understand the numbers 0 (switch OFF) and 1 (switch ON), so all letters and instructions must be given a number code written in Base 2 (binary code). Each 0 or 1 in the code is a *bit*. Usually the code is a sequence of eight bits, called a *byte* (bite).

1. The byte below represents a number. What is it? (Think of each 1 as a checkmark showing that the number above it is part of the final total).

128	64	32	16	8	4	2	1

= ___ + ___ + ___ = _____

2. Write the numbers below (age, height) in Base 2 bytes. Exchange papers; figure out your partner's age and height.

	128	64	32	16	8	4	2	1
Your age (in months)								

	128	64	32	16	8	4	2	1
Your height (in inches)								

3. In ASCII (ask-key), **A**merican **S**tandard **C**ode to **I**nformation **I**nterchange, each letter of the alphabet is represented by a Base 2 byte. Fill in the missing codes in the chart below. Use the code to send your partner a message

A=65 ________	J=74 ________	S=83 ________
B=66 ________	K=75 ________	T=84 ________
C=67 ________	L=76 ________	U=85 ________
D=68 ________	M=77 ________	V=86 ________
E=69 ________	N=78 ________	W=87 ________
F=70 ________	O=79 ________	X=88 ________
G=71 ________	P=80 ________	Y=89 ________
H=72 ________	Q=81 ________	Z=90 ________
I=73 ________	R=82 ________	

name: ____________________ **class:** ________ **date:** ________

ONE IN A MILLION

Just how much is one part per million? You will be diluting food color until it is one part per million. You will do this by diluting it six times, each time at a ratio of one part food coloring to nine parts water.

PREPARATION

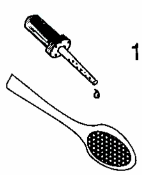
1. Practice releasing drops of water from the medicine dropper, one by one.
2. Label and line up two water-filled glasses– label one "water for rinsing" and the other "water for diluting."
3. Arrange the 6 spoons in a row. Think of them as tiny containers. You will be mixing drops of food coloring and water in the bowls of the spoons.

MATERIALS NEEDED

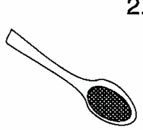
For each lab group

- ▲ 6 Plastic spoons
- ▲ 2 Clear plastic cups
- ▲ 6 Toothpicks
- ▲ 1 Medicine dropper
- ▲ 1 Bottle of food coloring
- ▲ Water and a place to throw away water

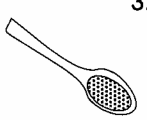
4. Look at the chart below. Fill in the missing numbers. You will be using the information from this chart as you carry out this lab.



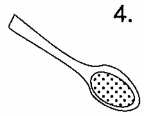
1. One drop food coloring from bottle into 9 drops water. Food coloring is 1/10, or one part in ten.



2. One drop from Spoon #1 into 9 drops water. Food coloring is 1/10 x 1/10, or ________



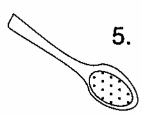
3. One drop from Spoon #2 into 9 drops water. Food coloring is 1/100 x 1/10, or ________



4. Food coloring represents:

1/1000 x 1/10 = ________

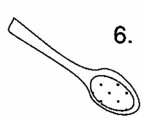
One part in ________



5. Food coloring represents:

1/10,000 x 1/10 = ________

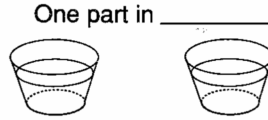
One part in ________



6. Food coloring represents:

1/100,000 x 1/10 = ________

One part in ________



Water for Rinsing Water for Diluting

name: ____________________ class: ________ date: ________

ONE IN A MILLION, continued

PREDICTIONS:

Before you begin the procedure, look over the chart to help you come up with predictions of your results. Circle your responses.

1. Between which two containers will you notice the biggest color difference?

   1 and 2   2 and 3   3 and 4   4 and 5   5 and 6

2. Which will be the last container in which you can still see a trace of color?

   2   3   4   5   6

PROCEDURE:

1. Place 9 drops of water in each of the 6 spoons.
2. Use the medicine dropper to take food coloring from the bottle, and release **one** drop into spoon #1. Stir carefully with a toothpick, and throw the toothpick away.
3. Rinse the medincine dropper in "water for rinsing." Throw away this water, and refill the cup.
4. Use the dropper to take some solution from spoon #1, and add one drop to spoon #2. Stir with a fresh toothpick.
5. Rinse the medicine dropper in "water for rinsing." Throw away this water, and refill the cup.
6. Repeat the procedure, adding one drop of the previous solution to all 6 spoons.
7. Place a piece of paper next to each container, labeling the amount of food coloring present. Use the information in the chart on the first sheet of Activity Master 4.

CONCLUSIONS:

Answer the questions below by circling your answer, based on your observations. Compare your results with your predictions. How accurate were you?

1. Between which two containers did you notice the biggest color difference?

   1 and 2   2 and 3   3 and 4   4 and 5   5 and 6

2. Which was the last container in which you could still see a trace of color?

   2   3   4   5   6

name: ______________________ **class:** ________ **date:** __________

SIMPLY INCREDIBLE: Extension

Interested students may wish to pursue ideas and concepts raised by this unit. You could direct them to the suggestions and resources listed on this page.

Possible Research Topics

- ▲ Interview a career auto mechanic to find out the changes—associated with electronics and computers— that have occurred in the manufacture of cars. Did the mechanic have to be retrained or go back to school?
- ▲ Explore the cause of computer viruses. Have your school computers been "attacked"? What is being done to protect computers and computer programs from viruses?
- ▲ Develop a computerized test using the binary code system.
- ▲ Survey the students in your school to see if they have a computer at home and, if so, what its major uses are.
- ▲ Visit several businesses in your community and find out how they use computers. What does it mean, at each site, to be "computer-literate"?
- ▲ Find out more about ENIAC, the first electronic computer. How was it developed? What problems had to be worked out? How quickly could it compute?

Suggested Science Fair Projects

- ▲ How do the chemical and physical properties of a substance affect its electroconductivity?
- ▲ Compare microprocessors—which is faster?
- ▲ Design and construct a database for forecasting weather.
- ▲ What is the ability of a variety of citrus fruits to conduct electricity?

Resource Center

Books to recommend:

Bits and Pieces: Understanding and Building Computing Devices by Irwin Math (Scribner's, 1984)

Computers: An Introduction by Roger Ford and Oliver Strimpel (Facts on File, 1985)

Computer Tech Talk by Ruth Radlauer *et al.* (Children's, 1984)

Electronics by Wayne J. Leblanc and Alden R. Carter (Watts, 1986)

Electronics Basics by Carl Laron (Prentice, 1984)

Grade Hopper: Navy Admiral and Computer Pioneer by Charlene Billings (Enslow, 1989)

The Inventors: Nobel Prizes in Chemistry, Physics, and Medicine by Nathan Aaseng (Lerner, 1988). Includes the invention of transistors.

Microchip: Small Wonder by Charlene Billings (Dodd, 1984)

More Wires and Watts: Understanding and Using Electricity by Irwin Math (Scribner's, 1988)

Radio: From Marconi to the Space Age by Alden R. Carter (Watts, 1987)

Supercomputers by Aldren R. Carter and Wayne J. Leblanc (Watts, 1985)

Organizations to contact:

Texas Instruments Inc.
135000 N. Central Expressway
Dallas, TX 75243

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