## Teacher Information

### Background Information

An image is a picture created by a camera on photographic film (called a photograph) or by a remote sensing detector, and displayed on a screen or on paper. A camera takes light energy and records it chemically on the film. The film is then processed, and the image transferred to paper where we can look at it. This is called a photographic image. Most films have chemicals that are sensitive to visible light energy. This means it will record the same images a human eye can see. Camera film can also be chemically sensitive to the "invisible" infrared energy, recording on the film images that the human eye cannot see.

Scientists have created very complex detectors that can sense many different wavelengths in the electromagnetic spectrum. These sensitive instruments record the reflected energy as numbers or digits. Digital images are recorded and transferred as pixels. The more pixels that are used, the better or clearer the image. This is often referred to as resolution. This digital information is often recorded on magnetic tape, like in a tape recorder or videocassette, or radioed back to Earth. Computers then put these numbers together and make pictures.

In an analog television, each line is a continuous signal that is shot onto the screen by an electron gun. When an electron hits the phosphorus that coats the screen, it will emit light. The gun shoots electrons through three sets – red, green, and blue. There are magnets on each side of the tube, which move the electrons across the screen. There are also magnets on the top and bottom of the screen, which can move the electrons up or down rows.

High-Definition Television (HDTV) is more lines of resolution both horizontally and vertically plus digital audio. The basic concept behind HDTV is actually not to increase the definition per unit area, but rather to increase the percentage of the visual field contained by the image. It takes more lines of resolution to achieve this wider field of vision, and this wider field engages the viewer significantly more than the old standard does.

Portable ultrasound machines that can send images to doctors also use a similar concept. These machines have been tested on the International Space Station. While in space, the images from the ultrasound were transmitted to doctors on the ground. This will be useful on long-distance missions when astronauts are more likely to develop illnesses that need medical attention.

In this lesson, students will learn how digital images can be transmitted from place to place.

### Key Concepts and Student Information

- Pixel – one unit of resolution

**Teacher Information (Continued)**

**Materials**
NASAexplores 5-8 article, “A Closer Look at Ultrasound” (1 copy per student)
NASAexplores 5-8 article, “HDTV: Coming Soon to a Television Near You” (1 per student)
Student Sheets (1 copy per student)
Color Markers or Pencils

**Procedure**
1. Read the NASAexplores articles. Discuss and answer any questions the students may have.
2. Discuss how digital images are recorded and transferred as pixels.
3. Divide students into pairs.
4. Distribute Student Sheets and materials. Go over instructions and answer any questions.
5. Allow time for students to complete activity.

**Enrichment Activities**
- Have students create color drawings, and repeat the activity. Remind students that each color used will have to be assigned with a number code.
- Have students make a picture and write the code out on paper. This code could then be shared with the class, and students could use it to make images.

## Sending Images

**A Closer Look at Ultrasound**
NASAexplores article, September 22, 2004
http://www.nasaexplores.com/show2_articlea.php?id=04-062

What is an ultrasound? Some people think of the pictures of babies before they're born. These give a sneak preview of the babies. But, ultrasound isn't just for viewing babies. Ultrasound uses sound waves to gain information about other medical conditions, too, from gallbladder disease to kidney stones. Ultrasound waves create images that show objects inside the body—things people never used to be able to see without surgery.

NASA crew members are more likely to develop serious medical conditions on long missions. X-ray and computerized tomography (CT) scans used by doctors on Earth are not available on the International Space Station (ISS). The machines are too heavy and use too much power. A state-of-the-art ultrasound machine is being tested on the ISS to examine medical conditions of crew members. Astronauts learn the procedures to provide accurate diagnostics. They then send ultrasound images by Internet or wireless transmission to the experts back on Earth. These experts let them know what to do next.

NASA worked closely with the surgeons at Henry Ford Hospital in Detroit to develop the special ultrasound techniques and equipment. Portable machines, weighing 76 kilograms (168 pounds), transmit images by satellite for radiologists to read them. The technology was tried for the first time on ISS Expedition Five, but it was in the works long before that.

"There was lots of practice ahead of time to develop the procedures, refine how they'd work in microgravity, and test how the images would transmit through satellite links, " says Dr. Jeff Jones, lead flight surgeon for the project. Tests were done on the KC-135 microgravity airplane and on Devon Island in the Canadian arctic. "In space, Peggy Whitson, science officer on ISS, went through the entire process. Experts on the ground, including project leader Dr. Ashot Sargasyan, provided the remote guidance. Since then, we've done additional work on each ISS mission."

## A Closer Look at Ultrasound (Continued)

There is a slight time delay in sending video images to the ground, but even so, images of the heart, carotid artery, kidney, and bladder are delivered clearly. "The remote application of these methods has very positive implications for long-duration spaceflight, as well as potential use here on Earth," said astronaut Whitson.

Here on Earth, there are many places that don't have access to diagnostic imaging services, says Jones. Rural communities and ships at sea can benefit from portable ultrasound tools to transmit information to medical workers who can provide the link to better care. Satellite phone services may soon allow the techniques to be expanded for use on ambulances or at accident sites.

This technology is already being tested in another arena: the sports arena. The Detroit Red Wings hockey team has used remote guidance to help team trainers treat players. The remote expert helps the trainers perform an ultrasound test on a shoulder, ankle, knee, hand, or foot. The images are transmitted to the hospital and can be used to confirm injuries to these areas.

## Sending Images

**HDTV: Coming Soon to a Television Near You**
NASAexplores article, October 10, 2001
http://www.nasaexplores.com/show2_articlea.php?id=01-088

The days of fuzzy images transmitted from space soon will be history. Instead you'll see crystal-clear images that make you want to reach out and touch your screen to be sure you're not really in the Space Station with those astronauts. High Definition Television (HDTV) will make this possible.

Part of NASA's mission is to share information about space with the public. Whether it's documenting an experiment, broadcasting an interview, showing views of Earth, or producing an educational video, the images coming from space to Earth will now be brighter and sharper and more informative than ever before, says Rodney Grubbs, chairman of NASA HDTV Working Group at Marshall Space Flight Center in Huntsville, Alabama. This is good, because the better people can see what's going on, the more interested they'll be in watching and learning.

HDTV has flown periodically in space since 1998. During these short flights, the camera's imaging device suffered damage from space radiation. The current camera will remain in orbit much longer than any of the previous flights, giving researchers more information about the performance of HDTV in space.

The camera uses a Charged Coupled Device (CCD) image sensor, which is a silicon chip made up of light-sensitive cells. The CCD produces a charge of electricity for each pixel based on the intensity of light, which is then recorded onto magnetic tape. The CCD-imaging chip degrades in space because radiation exposure causes the pixels to go bad, leaving blank spots on the screen. The cameras sent into space correct for lost pixels, but there's a limit to how much damage can be corrected without image loss. Too much damage correction results in a picture that isn't as sharp and clear as it should be.

HDTV has flown from time to time on the Space Shuttle from 1998 through 2000 with missions STS-95, -93, and -99, as well as the most recent flight. The HDTV camera flown on STS-105 and left on the International Space Station has 1,080 vertical lines of resolution. Plans are underway to fly an HDTV camera next year with 720 vertical lines of resolution that may not be as susceptible to radiation damage.

**HDTV: Coming Soon to a Television Near You (Continued)**

What is HDTV? High Definition Television is the next level of TV sophistication. Most televisions on Earth use analog TV.

With analog TV, a process called interlaced scanning divides each frame of a television signal into fields that are designated odd and even. Every other one is scanned every 1/60th of a second and sent through the airwaves. One frame of analog television is actually two fields of

lined images; these frames are refreshed so rapidly (every 1/60th of a second) that they appear to be one solid image.

Fifty years ago, that was amazing technology. In 2001, there's a better way. Progressive scan refreshes the entire screen at once, rather than dividing the images. Computers use progressive scanning. When complete frames are transmitted, there is a clearer, sharper picture.

Digital imaging uses codes, rather than scan lines to display the images onto a television screen. Every color has a code, made of zeros and ones, and those codes are transmitted, translated, and put onto the screen. As a result, the precise color and contrast are present every time, rather than the scrambling that takes place with analog transmission.

As a comparison, when painters create a blended color, if they tell someone to mix yellow and blue to make green, the quantities of each color are left to chance. The resulting green could vary greatly in intensity and hue. If the painters provide more specific data—three drops of pure yellow and two drops of cyan blue—the results will be uniform, specific, and the same every time. HDTV does that to television broadcasts. It gives a specific recipe for every image, rather than merely copying and transmitting them in a sliced-up format.

If you receive digital satellite or digital cable television at home, you're receiving standard definition TV (SDTV) that has 480 vertical lines of resolution. The box on your television set is a digital-to-analog converter, to help your analog TV see the digitally produced images. High Definition TV has at least 720 lines of resolution, which results in an image up to five times as clear.

Why go to all this trouble to provide great viewing of Space Station and other in-space activities? "Better cameras can better demonstrate what's happening," says Grubb. "When people can see activities clearly, there's more interest. Additionally, clear pictures help ground crew see important details of crew activity or launch vehicle performance. If something goes wrong, they can more easily see what it is, and what to do about it."

**HDTV: Coming Soon to a Television Near You (Continued)**

The only down side to the HDTV NASA has produced, Grubbs says, is that most people do not have HDTV sets in their houses to watch the programming. If the high-quality images are sent out to homes that have analog televisions, the quality isn't as wonderful as it might be. "It's still better than it was because it started out with higher quality," says Grubb. "When home televisions are high definition, that's when everyone can truly see and appreciate the quality of these new cameras."

HDTV is exciting and new, and it enhances the images of space that we can view. That's only the beginning, Grubb says. "Today, television is a one-way communication," he says. "The broadcaster sends, and you receive that transmission. In the near future, TV will be much more interactive. With digital transmission, data can be inserted, and viewers will be able to click for more information. It'll be much like surfing the Internet. There will be chats, you can call for a pizza, or download specific material, except that it will be on your enhanced TV rather than your PC."

# Sending Images

**Student Sheet**

**Objective**
To investigate how digital images are created, sent and received.

**Materials**
A partner
Pencil
Colored Pencils or Markers
Graph Paper (included with worksheets)

**Procedure**
1. Read the "Do You Hear What I'm Saying?" article from NASAexplores.
2. Read the directions for each role on the top of the graph paper sheet. You get to do both roles, so each partner needs to draw a design they are going to send to the receiver. Do this now by marking an X in boxes to create a design. Make sure that your partner does not see your design.
3. Decide who is going to be the first "sender of the image" and who is going to be the first "receiver of the image"
4. The sender should read the image to the receiver using the following code (0 for empty box and 1 for a box with an X)
5. The sender, using the code, starts with the top left square (A1) and proceeds across the row, one row at a time.
6. The receiver, upon hearing the code, transfers the information to each square on the graph.
7. When the sender is done reading the code, compare the two images to check how accurate the transfer was.
8. Switch roles and try again.
9. Answer the questions on the *Student Worksheet.*

**Challenge activity:**

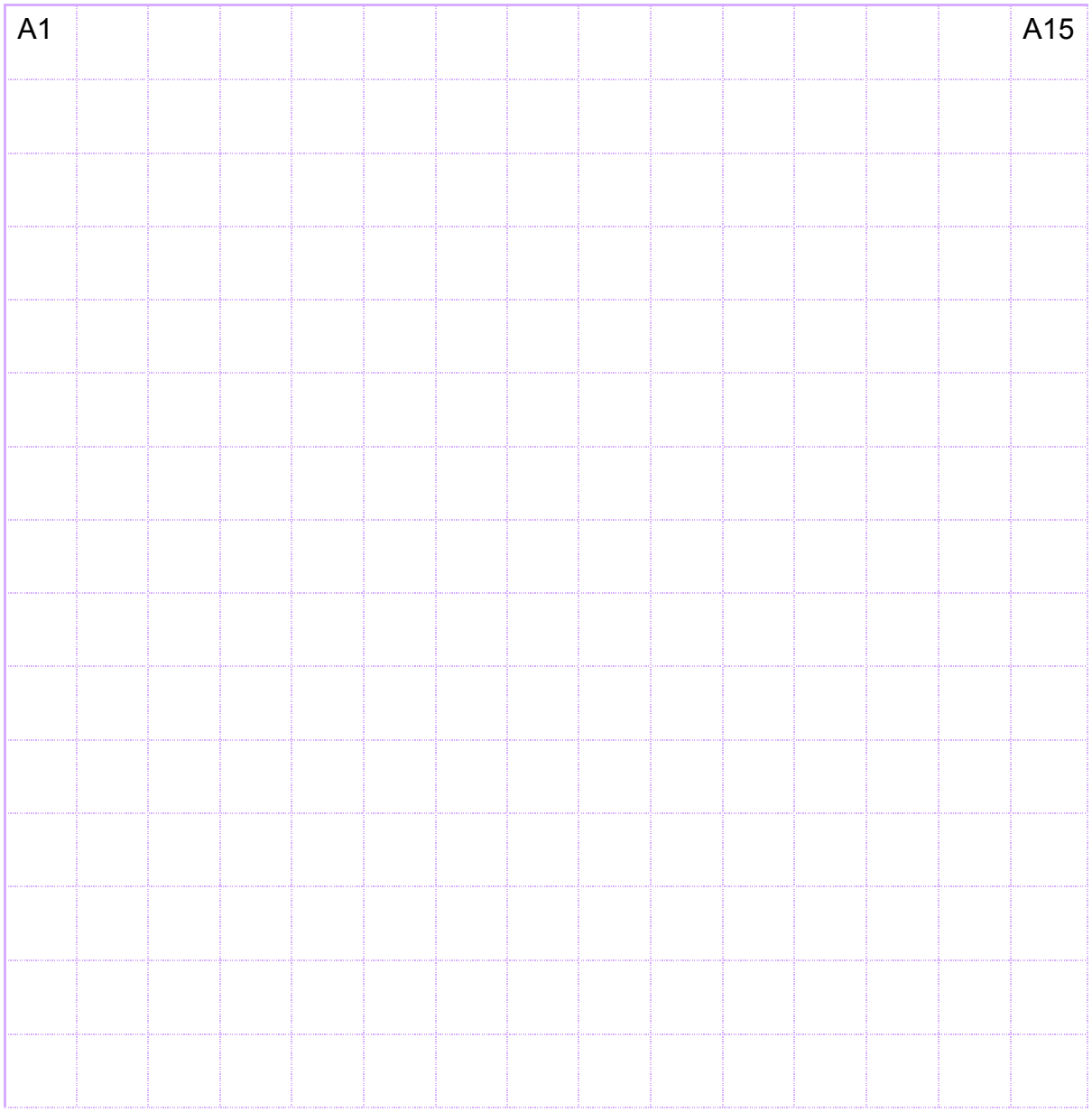
1. Try using different colors to create your image.
2. The sender should create an image using different colors and then create a code for those colors (0 for empty square, 1 for red square, 2 for green square, 3 for blue square, …)
3. The receiver should then, using the new code, transfer the image.

**Student Sheet – Graph Paper**

Sender: Color in boxes in the square to create a sample picture. Do not allow the receiver to see your design.

- Say zero for an empty box
- Say one for a colored in box
- At the end of the first row, say “end row one” and repeat this for every row

Receiver: When the sender reads you the code, fill in the appropriate boxes to create the design.



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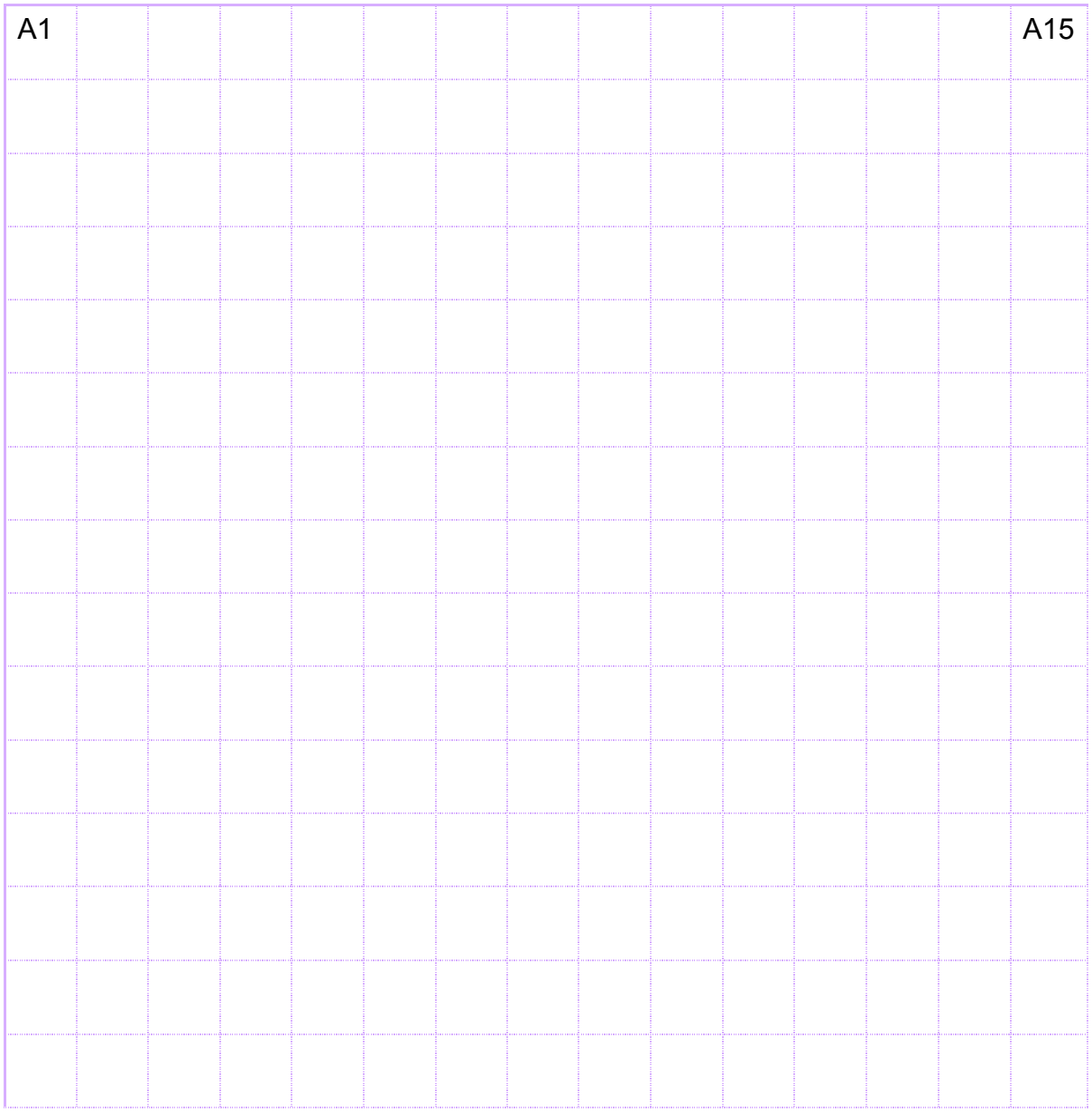

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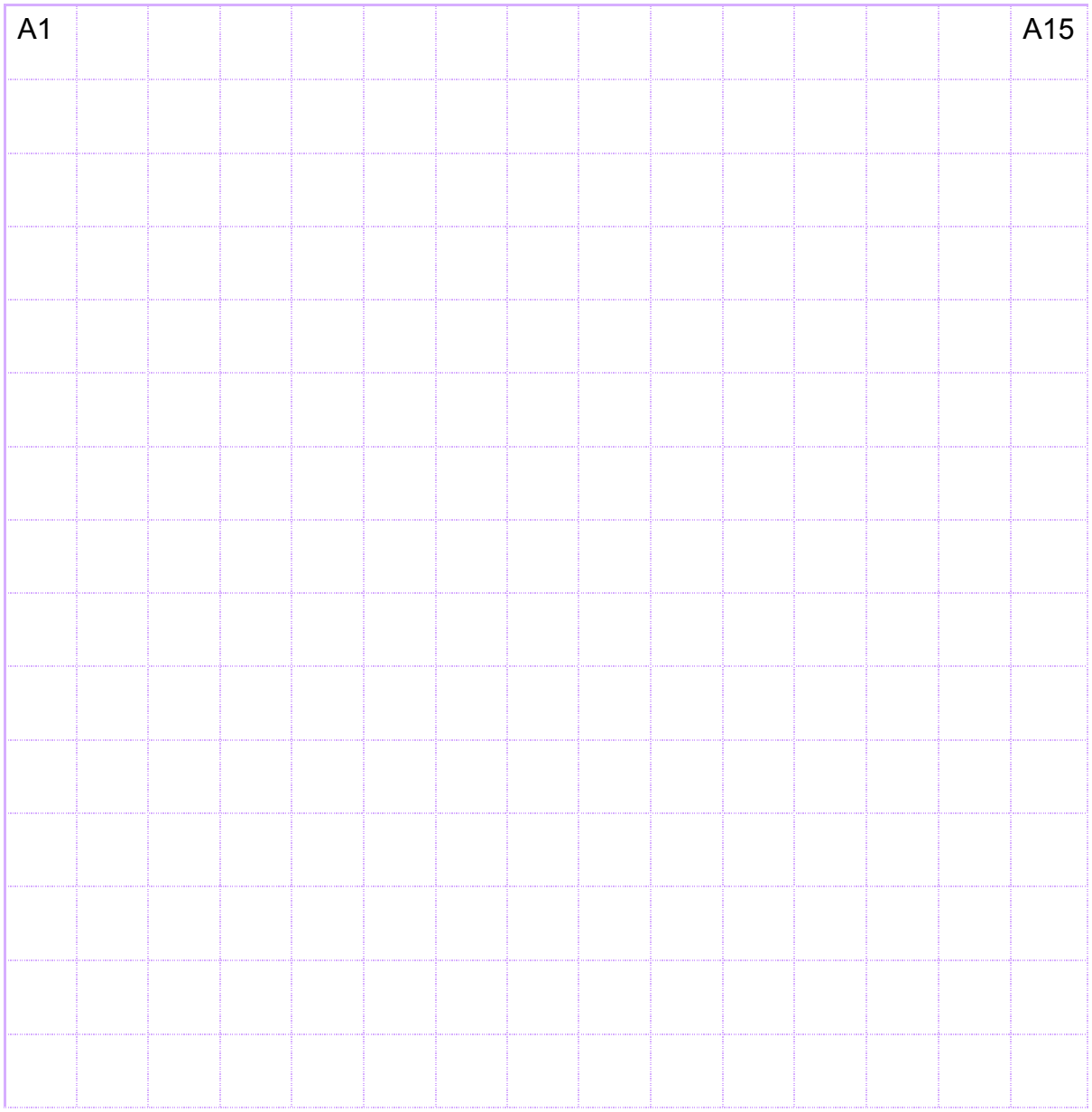

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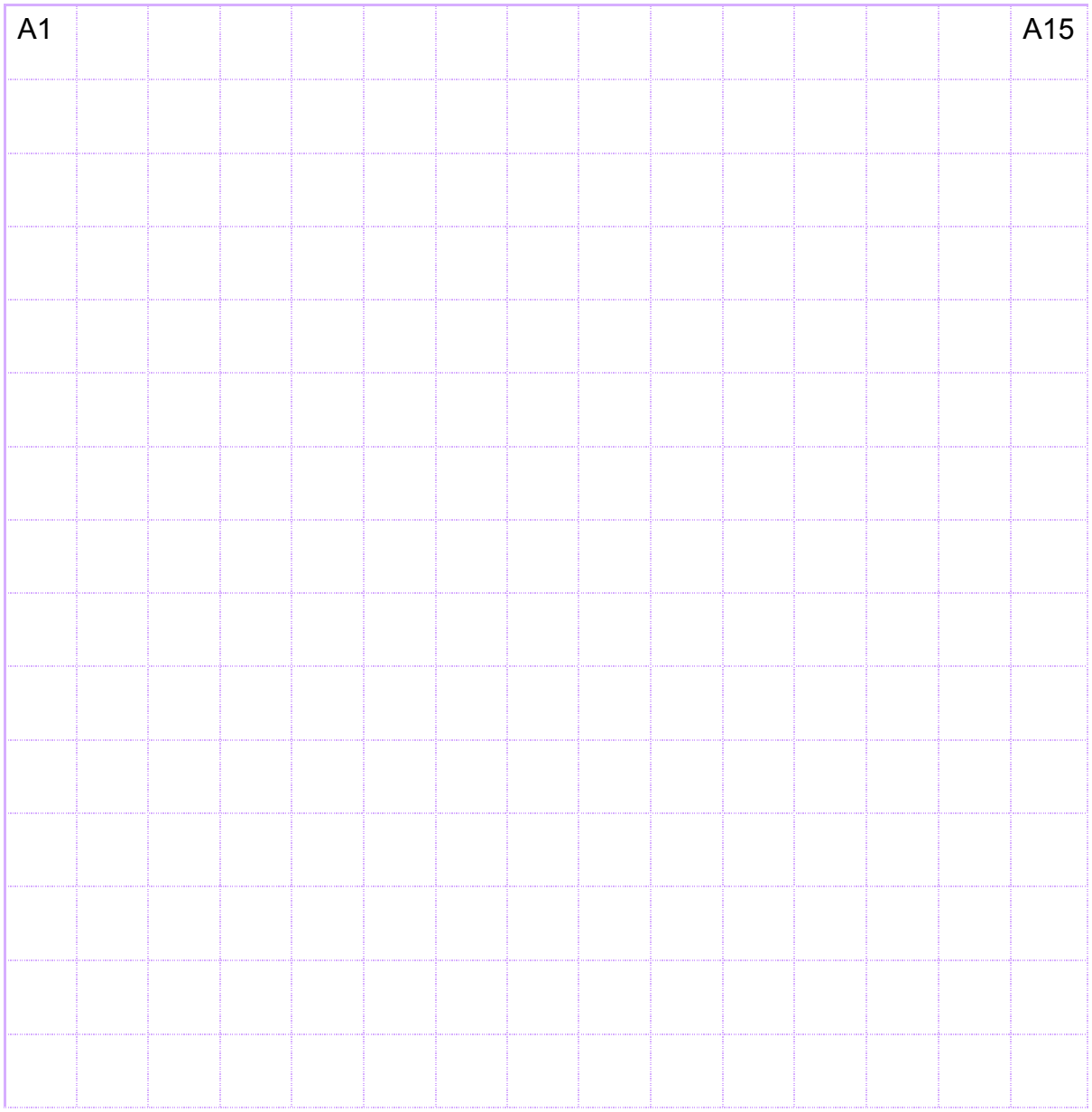

**Student Worksheet**

**Directions:** Answer the following questions from the information that was read and from the activity that was performed.

1. Describe how a digital image is formed based on what was learned from your experiment and from the information that you read.

2. How is your activity similar to the way your television works?

3. What was the most difficult part of the experiment?

4. Can you think of a better way to transmit and receive information?