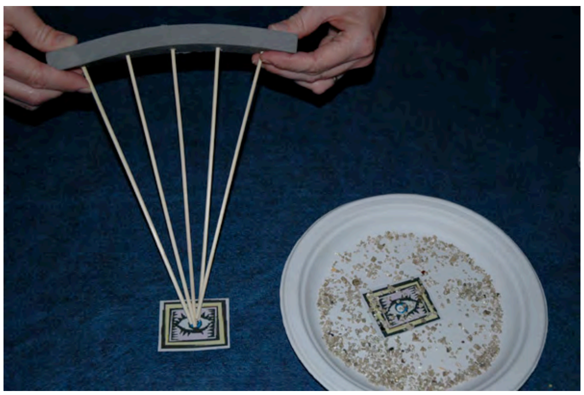
Night Sky Network
Astronomy Clubs bringing the wonders of the universe to the public

What Power Is Your Telescope?

How is the power of telescopes determined?

About the Activity

Using a few simple props, show the basics of how telescopes collect light with these activities. Address the concept of aperture and light-gathering capabilities.



Topics Covered

- What power is your telescope?
- How does a telescope work?
- How is your telescope different from Hubble, Chandra, or Keck?

Participants

Adults, teens, families with children 5 years and up. If a school/youth group, 7 years and older. From one person to twenty participants

Materials Needed

- 8” paper plate
- Small white-light flashlight
- Scissors
- Concave mirror (see page 2)
- Shaker-top container of vermiculite (from nursery or garden supply) or coarse pepper
- Adhesive tape
- Skewers (5 per model)
- Foam strip (see Assembly Instructions)
- Sidewalk chalk
- String
- Tape measure
- Eye images (page 11)
- Telescope labels, printed on Avery Labels 8160 or cut apart and secured with clear tape.

Location and Timing

- Introduction: Light spreads out with distance: 2 minutes
- How do telescopes work: 3 - 10 minutes
- Aperture: How big are telescopes NASA uses?: 10 - 15 minutes

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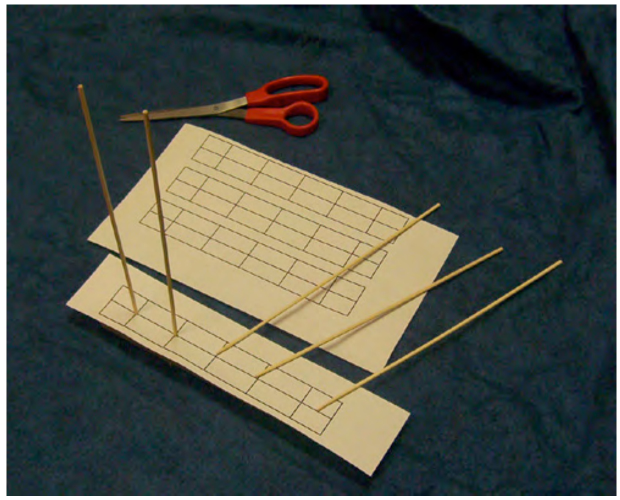
Assembly Instructions

1. To make the foam and sticks:

a) You need the Template sheet, skewer sticks, and foam strips: You can use any fairly dense soft foam (like the material some computers come packed in) or you can order the material at: http://www.oneoceankayaks.com/ – the material is "Minicel Foam". Order the 5/8" thickness. A 20"x24" sheet will make about 48 strips that are 1-1/4" x 8". You can use a utility knife to cut the foam.



b) With scissors you supply, trim about 1/4 inch off the sharp end of each skewer stick.

c) Place one foam strip template on one of the foam strips and insert the skewer sticks into foam strip at the marks – try to make them as vertical and parallel as possible.

d) Remove the template.

2. Telescope Labels:

Affix the telescope labels to the string at the appropriate distances. You'll need a tape measure to measure out the distances on the string. Here's how:

- Tie a loop in one end of the string. This is the center of the telescope apertures.
- Each label is marked with both the aperture and radius for each particular telescope. The radius is the distance you should place the label from the loop. For instance, the Chandra X-Ray telescope has an aperture of 4 feet, so mark the string at half of that or 24 inches and place the label there.

3. Concave Mirror:

Available in 3 sizes from science supply companies like http://www.schoolmasters.com(Search for "Concave mirror")

Detailed Activity Descriptions

If doing these activities as a prelude to an observing session, you might want to introduce your presentation like this:

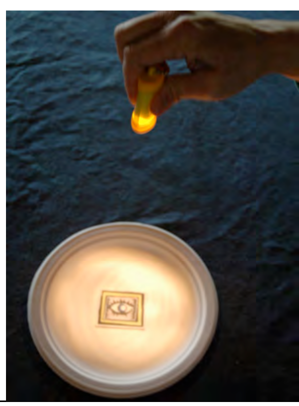
Introduction: Light Spreads Out With Distance

<table>
<tr><td>Leader’s Role</td><td>Participants’ Roles (Anticipated)</td></tr>
<tr><td colspan="2">Key message for your visitors to take home:
Although other telescope characteristics, like magnification, are sometimes referred to as the telescope’s “power”, the most important power of a telescope is its ability to collect a lot of light, determined by the aperture (i.e., the diameter of the telescope’s large lens or mirror).</td></tr>
<tr><td>To Say:

By the time light from the universe reaches Earth, the light is very dim. The farther the light-emitting object is away from us, the dimmer its light appears to us here on Earth. Why?

Light radiates. It spreads out as it leaves its source. Let’s see what that means.

To Do:
Tape or place image of eye onto paper plate or to a wall. Hold a small flashlight very near the eye.

Start very close to the eye then move the light away and watch how the light spreads out and dims.

How much light is coming in here (indicating the pupil of the eye).

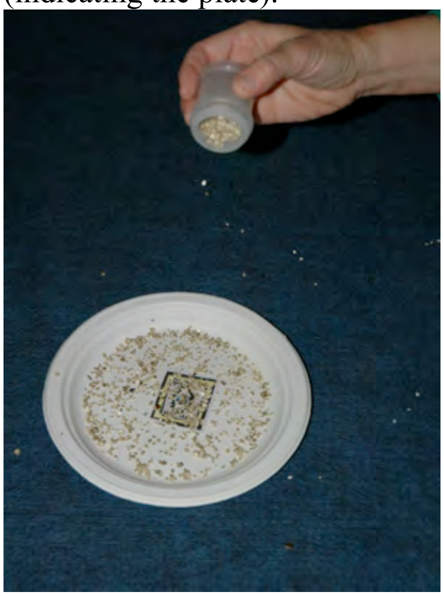
(Refer to a circular plate representing a telescope mirror). “How much light is this one collecting?”</td><td>Answers

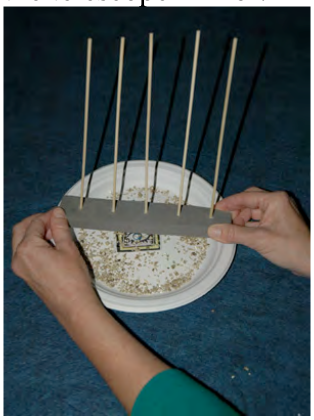
Just that little amount.

A lot more.</td></tr>
</table>

Leader's Role	**Participants' Roles (Anticipated)**
To Say: If I was to take this light to {that mountain top, over to that city, on top of that building} would you still be able to see it? Right, less of its light is reaching us, because it is spreading out – a bit like water spraying out of your showerhead – the farther from the showerhead, the more the water is spread out. There is only so much light coming from an object each second. Little packets of light called photons. The farther you are away, the more the light is spread out. A galaxy outside of the Milky Way is tremendously far away and its light is spread out all over the universe, so only a little of its light, or photons, hits the surface of the Earth. But the light is spread out all over the side of the Earth facing that galaxy. The more of its photons we can collect, the more likely we are to see it. Telescopes have big mirrors to collect light.	Probably not.

HOW DO TELESCOPES WORK?

Leader’s Role	**Participants’ Roles (Anticipated)**
Key message for your visitors to take home: Telescopes collect more light and concentrate the light so it will fit into our eye, allowing our brain to detect the object.	
<u>*To Say:*</u> This plate represents the size of a mirror in a telescope. Our eye needs at least 500 photons, or packets of light, coming into it every second for our brains to sense that something is there. We’ll use these grains represent photons of light from a distant galaxy. We’ll sprinkle these photons for one second on this area (indicating the plate).  <u>*To Do:*</u> You or a participant sprinkles vermiculite (“photons”) on plate with eye. <u>*To Say:*</u> Will our eye ever detect the light? How many photons are getting into our eye? Is that enough light for our brains to detect it? Is there enough light hitting the telescope mirror (indicating the plate)?	Just a few No. We need 500 photons. Yes!

Leader's Role	**Participants' Roles**
To Do: Hold foam strip on surface of plate - Foam strip represents a section of the telescope mirror.  *To Say:* But how can we get all the light hitting the telescope mirror into our eye? Let's remove a strip of the telescope mirror. The sticks show the light from that galaxy reflecting off the telescope mirror.	Don't know!
To Do: Bend foam strip.  *To Say:* A telescope mirror is curved. So when the light comes in, the mirror reflects the light back to a point, like this. Now can we fit all this light into our eye? In essence, this is what telescopes do: concentrate the light to what is called a focal point (or focal plane) and, using a second mirror, redirect that light through the eyepiece and into our eye. That's how we are able to see dim objects, like distant galaxies, using a telescope.	Yes!
To extend this activity and show how mirrors reflect light, you might want to use the activity It's All Done With Mirrors, found on the Night Sky Network Resource Lookup Page: http://nightsky.jpl.nasa.gov/download-search.cfm	

Aperture- How Big are the Telescopes NASA Uses?

<table>
<tr><td>Leader’s Role</td><td>Participants’ Roles</td></tr>
<tr><td colspan="2">Key message for your visitors to take home:

The power of a telescope is primarily aperture, not magnification or length. Its power is mostly determined by its ability to collect a lot of light.</td></tr>
<tr><td><u>To Do:</u>
Get four or five participants to stretch out the aperture string to draw the diameters of various kinds of telescopes.
You will need a large area, depending on how many of the mirrors you will be drawing. Note the diameters.
Options for surfaces to construct mirror diameters:
A grass field and use people, or lengths of rope to mark the sizes.
A playground or parking lot and use chalk to mark the sizes
A long hallway or sidewalk and use chalk or markers to mark either side of the telescope mirror.
ALTERNATE WAY TO DEMONSTRATE APERTURE SIZES:
Cut out circles from a plastic drop cloth (you can purchase this from a painter’s supply store) or a large plastic tablecloth (from a party supply store).
Lay the circles on the ground, putting the largest one down first.
If it is windy, you’ll need to use masking tape or rocks to hold down the circles.
This is a quick, reusable way to show the apertures.</td><td></td></tr>
</table>

Leader’s Role	**Participants’ Roles**
To Say: How big are telescope openings? How big are their light-collecting areas? Here we have a string that has various markers marking the size of various telescopes. Who wants to be at the center of these telescope openings? And who wants to hold the other end? Now we need one person at each marker to mark the telescope size. Let’s draw circles to represent the sizes of the light-collecting areas. *To Do:* Direct the person at the end of the string to stretch the string straight. Have each person at a telescope label mark the ground with their chalk. Direct the person at the end of the string to move a few feet, then have the telescope label people make another mark. Continue until the circles are complete.	

To Say: Let’s walk across (or around) each telescope. Compared to this telescope (indicate an amateur scope), can this one (indicate one of the circles) collect more or less light?	Walk and consider; give answers

Leader's Role	**Participants' Roles (Anticipated)**
To extend the activity: Compare how many more grains of vermiculite (or pepper) – representing photons – the larger telescopes can collect.	
Presentation Tip: Only do this outside on a surface that won't be damaged or cause people to slip on the pepper or vermiculite. Unless you have the means to clean up the grains, it must be where it won't matter that the grains are left on the surface, like a parking lot or a grass field.	
To Do: Get four or five participants to spread vermiculite (or pepper) at the same concentration as the grains on the eye and plate, counting how many teaspoons they can spread over each scope. *To Say:* **If we used one teaspoon to cover the 8" telescope mirror, how many teaspoons do you think it will take to cover this telescope opening (point to one of the circles)?** Let's try!	Guesses.
Presentation Tips: If doing this for a classroom, you can also just have the kids calculate how much more surface area each telescope has – using the formula pi times radius squared. Take the radius as shown on each label on the string – make sure they are all in the same units! Square the radius of the telescope aperture and multiply by pi (□ or 3.14). For example, if your telescope had an aperture of 10", its radius is 5". $5^2 * 3.14 = 25 * 3.14 = 78.5$ square inches. The Hubble is 8 feet or 96" in diameter. Its radius is 48" $48^2 * 3.14 =$ 7,235 square inches. Almost 100 times more light-collecting area than the 10" telescope. This would be about 2 cups of vermiculite (or sand).	

Background Information

1. See the following websites for information on the telescopes on the labels on the string for “How big are telescopes NASA uses?”

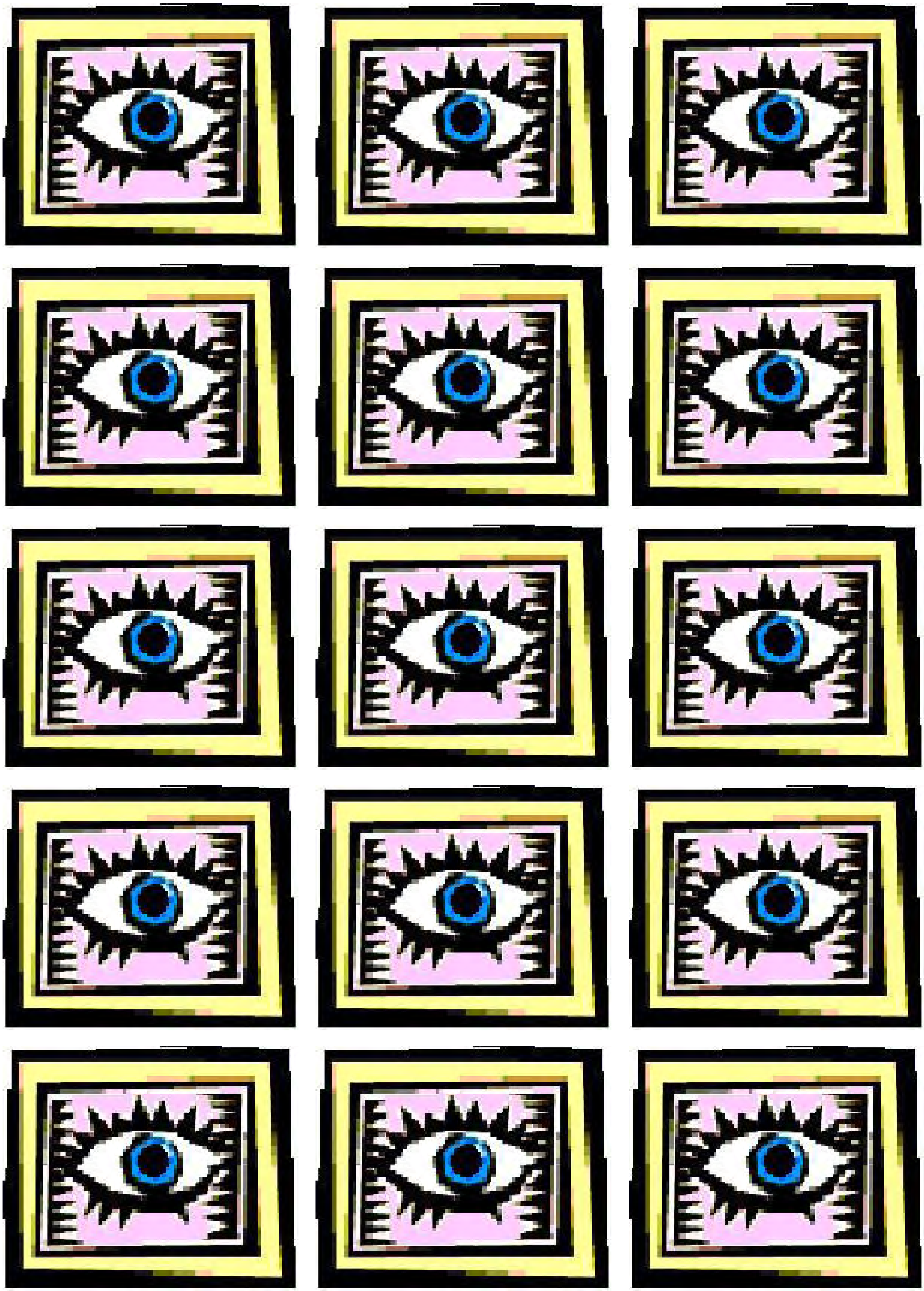
- Spitzer (IR): http://www.spitzer.caltech.edu/spitzer/index.shtml
- Chandra (X-ray): http://chandra.harvard.edu/
- Hubble (Optical): http://www.stsci.edu/hst/
- Keck (Optical/IR): http://www2.keck.hawaii.edu/geninfo/about.php
- GALEX (UV): http://www.galex.caltech.edu/
- Arecibo: http://www.naic.edu/

2. The “Power” of a Telescope

People speak of three types of “power” that a telescope has:

- magnifying power,
- resolving power,
- and light-gathering power.

The public most commonly hears about magnifying power (e.g., in telescope advertisements that proclaim, “500x power!”). This set of activities helps your visitors understand that although other telescope characteristics, like magnification, are sometimes referred to as the telescope’s “power”, the much more important power of a telescope is its ability to collect a lot of light, which is determined by the aperture (i.e., the diameter of the telescope’s large lens or mirror).



Backyard Scope

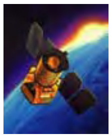
Optical
Ground
Aperture:

Backyard Scope

Optical
Ground
Aperture:

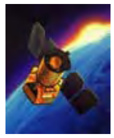
Backyard Scope

Optical
Ground
Aperture:



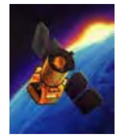
GALEX

Ultraviolet Space
Telescope
Aperture:
50 cm (20 in)
(10” radius)



GALEX

Ultraviolet Space
Telescope
Aperture:
50 cm (20 in)
(10” radius)



GALEX

Ultraviolet Space
Telescope
Aperture:
50 cm (20 in)
(10” radius)

Spitzer

Infrared Space
Telescope
Aperture:
85 cm (2.8 ft)
(17” radius)

Spitzer

Infrared Space
Telescope
Aperture:
85 cm (2.8 ft)
(17” radius)

Spitzer

Infrared Space
Telescope
Aperture:
85 cm (2.8 ft)
(17” radius)

Chandra

X-Ray Space
Telescope
Aperture:
1.2 m (4 ft)
(24” radius)

Chandra

X-Ray Space
Telescope
Aperture:
1.2 m (4 ft)
(24” radius)

Chandra

X-Ray Space
Telescope
Aperture:
1.2 m (4 ft)
(24” radius)

Hubble

Optical Space
Telescope
Aperture:
2.5 m (8 ft)
(4 ft radius)

Hubble

Optical Space
Telescope
Aperture:
2.5 m (8 ft)
(4 ft radius)

Hubble

Optical Space
Telescope
Aperture:
2.5 m (8 ft)
(4 ft radius)

Keck

Optical / IR
Ground
Aperture:
10 m (33 ft)
(16 ft radius)

Keck

Optical / IR
Ground
Aperture:
10 m (33 ft)
(16 ft radius)

Keck

Optical / IR
Ground
Aperture:
10 m (33 ft)
(16 ft radius)

Arecibo

Radio Ground
Telescope
Aperture:
305 m (1000 ft)
(500 ft radius)

Arecibo

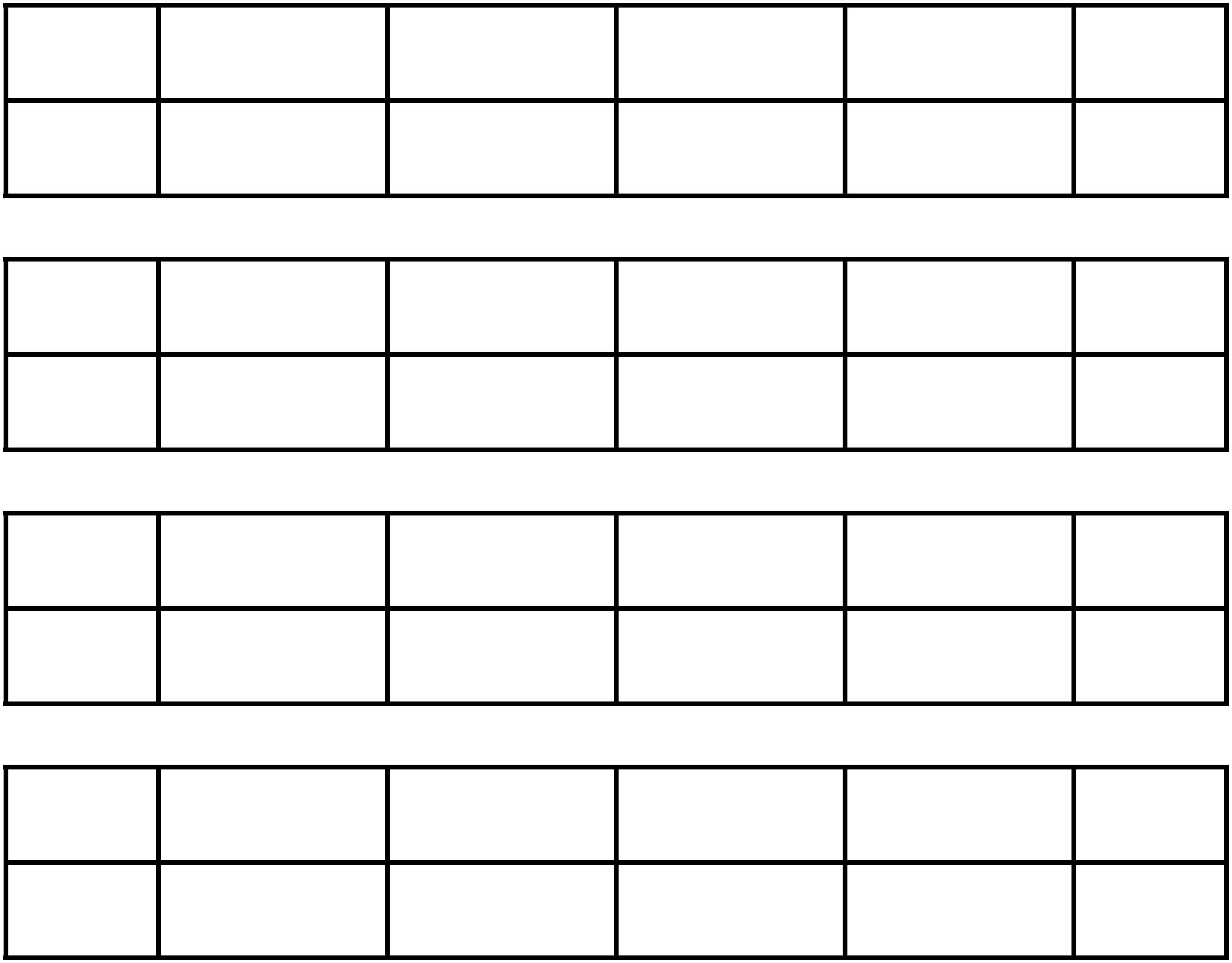
Radio Ground
Telescope
Aperture:
305 m (1000 ft)
(500 ft radius)

Arecibo

Radio Ground
Telescope
Aperture:
305 m (1000 ft)
(500 ft radius)

These print on Avery Labels 8160

1” x 2-5/8”



FOAM STRIP TEMPLATES