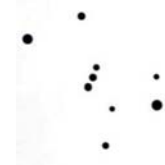




Determining the Light Pollution of the Arizona Skies

An ASTRO-Chile Project

TEACHER'S NOTES



General Objective:

To appreciate and understand the value the natural darkness of the night sky offers for humanity and astronomical observations.

Specific Objectives:

- ❑ To observe the night sky in order to identify the visible stars with the naked eye in a specific location.
- ❑ To compare the observation of the sky with stellar maps.
- ❑ To identify which stellar map best represents the observation.
- ❑ To record and report on the results of the observation.

Knowledge Recommended Prior to Doing the Activity:

- ❑ To be able to identify the cardinal directions.
- ❑ To understand that the 6 maps show a field of stars becoming more and more visible as you go from Star Maps #2 to 7. For example, Star Map #7 shows lots of stars as you would see with a clear sky and light only from stars. Star Map #2, on the other hand, shows a sky with light from other sources (e.g., street lights, stadium lights, business lights, the Moon). So the last star map would be what you would see with no light pollution. The maps get progressively better in terms of light pollution as you go from Star Map #2 to 7. Star Map #1 has next to no stars present (only 2, Rigel and Betelgeuse) and therefore is not displayed. The corresponding option on the observation form is "No stars visible".
- ❑ To understand the meaning of the fractions, $\frac{1}{4}$ and $\frac{1}{2}$, in terms of cloud coverage.
- ❑ OPTIONAL: to be able to identify the 8 major phases of the Moon and when the Moon at each phase rises and sets. One recommendation is to post a calendar with the phases of the Moon. Another recommendation is to give them a web site which lists the phases, dates and rise & set times (e.g., http://aa.usno.navy.mil/faq/docs/moon_phases.html) or gives basic info on the Moon and illustrates the phase pictorially for a particular day (e.g., <http://liftoff.msfc.nasa.gov/Academy/UNIVERSE/MOON.HTML>).
- ❑ To know the difference between artificial and natural light.
- ❑ OPTIONAL: to learn more about light pollution awareness, help preserve dark skies, and understand how these issues are related to economics, the environment, science, technology and society. The International Dark-Sky Association, a non-profit organization, was founded to help overcome the awareness problem and preserve dark skies, while at the same time maximizing the quality and efficiency of nighttime outdoor lighting. (Teachers should visit <http://www.darksky.org/> and, in particular, <http://www.darksky.org/aboutida/aboutida.html> and <http://www.darksky.org/education/educrres.html>.) A reference students will appreciate is the article entitled "Turn Down the Lights", by Eric Scigliano, published in *Discover* magazine, Vol. 24, No. 07, July 2003. It focuses on how "when we turn up the lights, nature goes a little haywire".
- ❑ To understand that the activity is not a contest of how many stars a student can see, but that it is dependent on the care and accuracy the student provides in doing the observation(s).
- ❑ To understand that observational data from the center of the largest cities, suburbs, smaller cities, as well as from excellent dark sky sites in the country are equally valuable, as is observational data from the same observer on different nights and from different sites.

Ancillary Material

- ❑ The Virtual Moon Atlas is software that allows you to view the lunar globe in real time, in 2D or 3D and to study lunar formations. It is available free on-line at http://www.astrosurf.com/avl/UK_index.html.
- ❑ More tools for figuring out times the Moon and Sun rise and set on days specified can be found at <http://aa.usno.navy.mil/data/> and <http://stardate.org/nightsky/moon/> (e.g., a monthly calendar).



Materials Needed for Each Student:

- ❑ Flashlight with a thick brown paper bag or a few layers of thin brown paper bags covering the light bulb and held together by a rubber band. (Or you can use red cellophane or a red balloon over the light bulb.)
- ❑ Pencil and eraser and a hard surface (e.g., clipboard) to write on outside
- ❑ Student Instructions and Observation Form
- ❑ General View of the Sky around Orion handout and Light Pollution Indicator handout

Evaluation

The evaluation could be based on the student's report on and discussion of the results. Have they provided clear, complete information about their observation? Do they have an appreciation of the factors (variables), which might affect the stars' limiting magnitude?

Closure

Students will observe that the limiting magnitude depends on the extent to which their eyes have adapted to the dark and on the brightness of the sky. This depends on the presence of natural light (the Moon) and artificial light (light pollution).

Until there is a capstone that a teacher can use to motivate students (such as submitting their observations to an on-line site), an analog counterpart could take place. Geographical plotting of the observational results could be made between schools and other locations in town. Also, there is the Southern Arizona Regional Science and Engineering Fair (<http://www.sarsef.com/>) where students could submit their projects as well as light pollution programs associated with the International Dark-Sky Association's student award (<http://www.darksky.org/education/edaward.html>).

As for geographical plots of the observational results, one recommendation is for teachers to universally use (for future inter-comparison of results across town) a readily accessible map available on-line at: <http://www.dot.co.pima.az.us/gis/maps/mapguide/mgmap.cfm?path=/gis/maps/mapguide/dotmap65.mwf>. Once at that site, click on the magnifying glass symbol with the plus. Then double-click on Tucson in the map 8 times, waiting between clicks for the new image to appear. Try as you are doing this, to zoom in on the area of Tucson where your students live. Notice the list of parameters in a frame on the left side of your window. Activate the one that says "Streets – All – With Names".

Again, for purposes of inter-comparison of results across town *and* possibly between Tucson and La Serena, Chile, we would like to adopt the same set of colors (e.g, magic markers) to use on the street maps to represent the 7 different Star Maps. The set of proposed colors are:

Star Map #	Color
7	Dark blue
6	blue
5	green
4	yellow
3	orange
2	red
1	white

An additional means of representing results could come in the form of a class bar graph of Star Maps # 1 -7 on the x-axis and the number of observations per Star Map on the y-axis.

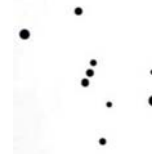
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STUDENT INSTRUCTIONS



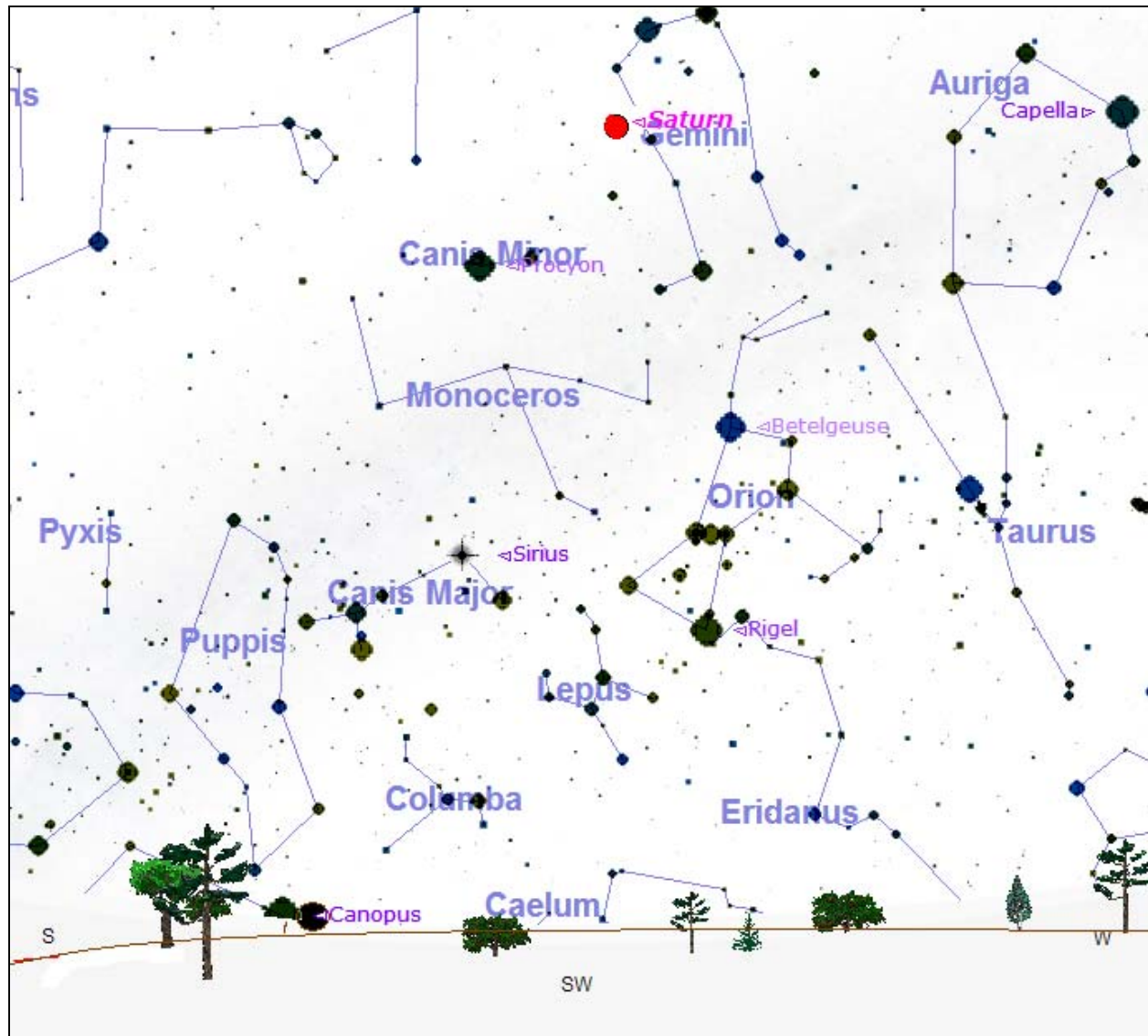
- 1) This activity is designed to be done during the first 9 days of April 2005 between the hours of 8pm and 9pm on a night without a Moon and without clouds covering the constellation of Orion.
- 2) Before you go outside, examine the “General View of the Sky around Orion” handout. Notice the biggest dot on the handout is the brightest object in that part of the sky. It is the planet Saturn. Orion is down and to the right of Saturn and looks like a stick figure shaped like an hourglass. At the narrow part of the hourglass are three bright stars in a row of similar brightness making up Orion’s belt.
- 3) Search for a place near your house where you can see many stars in the sky. If your house has lights on outside, turn them off.
- 4) To find the constellation of Orion on the handout, use a flashlight with a thick brown paper bag or a few layers of thin brown paper bags covering the light bulb and held together by a rubber band. Keep putting on layers of brown paper bags until there is a minimal amount of light. (Or you can use red cellophane or a red balloon over the light bulb.)
- 5) On your “Observation Form”, fill in the start time of observation.
- 6) You should be facing southwest, which is halfway between south and west. For reference points in direction, Speedway Boulevard runs east-west. If your home is in the Tucson city limits, not so much on its outskirts, then the Tucson mountains would be toward the west, the Rincon Mountains toward the east and the Catalina Mountains to the north (for the most part). The Santa Rita Mountains and Mexico are toward the south.
- 7) Turn the flashlight off and wait there outside for at least 10 minutes for your eyes to adapt to the darkness.
- 8) If clouds cover any part of the constellation of Orion, don’t do the measurement. Otherwise, continue.
- 9) When you are dark-adapted and still facing southwest, hold the “General View of the Sky around Orion” handout over your head, orienting it so that Orion’s knees (the two bright stars below Orion’s belt) point toward the southwest.
- 10) Using Star Maps #1-7 on the “Light Pollution Indicator” handout, identify which one of the star maps most likely looks like what you are seeing in the sky. Star map #7 shows all the stars your eyes would see with no light pollution. Star map #2 shows only the stars your eyes would see with a lot of light pollution. Star Map #1 is not displayed because it has next to no stars present. As you move from Star Map #1 to Star Map# 7, the light pollution level decreases.

In the form below, place an “X” next to the number of the star map that looks most like what you see in the sky. Also mark the appropriate square for the cloud coverage, should there be any, covering the constellation Orion. Back inside your home, fill in the rest of the information requested on your observation form, especially the end time of observation.
- 11) Return the observation form to your teacher the next day.

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General View of the Sky around Orion for April 2005



The celestial map is best used during the 1st 9 days of April 2005 from about 8pm –9pm. The view is looking directly southwest on April 5 at about 8pm. The horizon is shown in black at the bottom of the map. The biggest dot on the map is the brightest object in that part of the sky during April. It is the planet Saturn! Can you find Saturn on the map and in the night sky? Can you find the three stars of similar brightness in Orion's belt on the map and in the night sky?

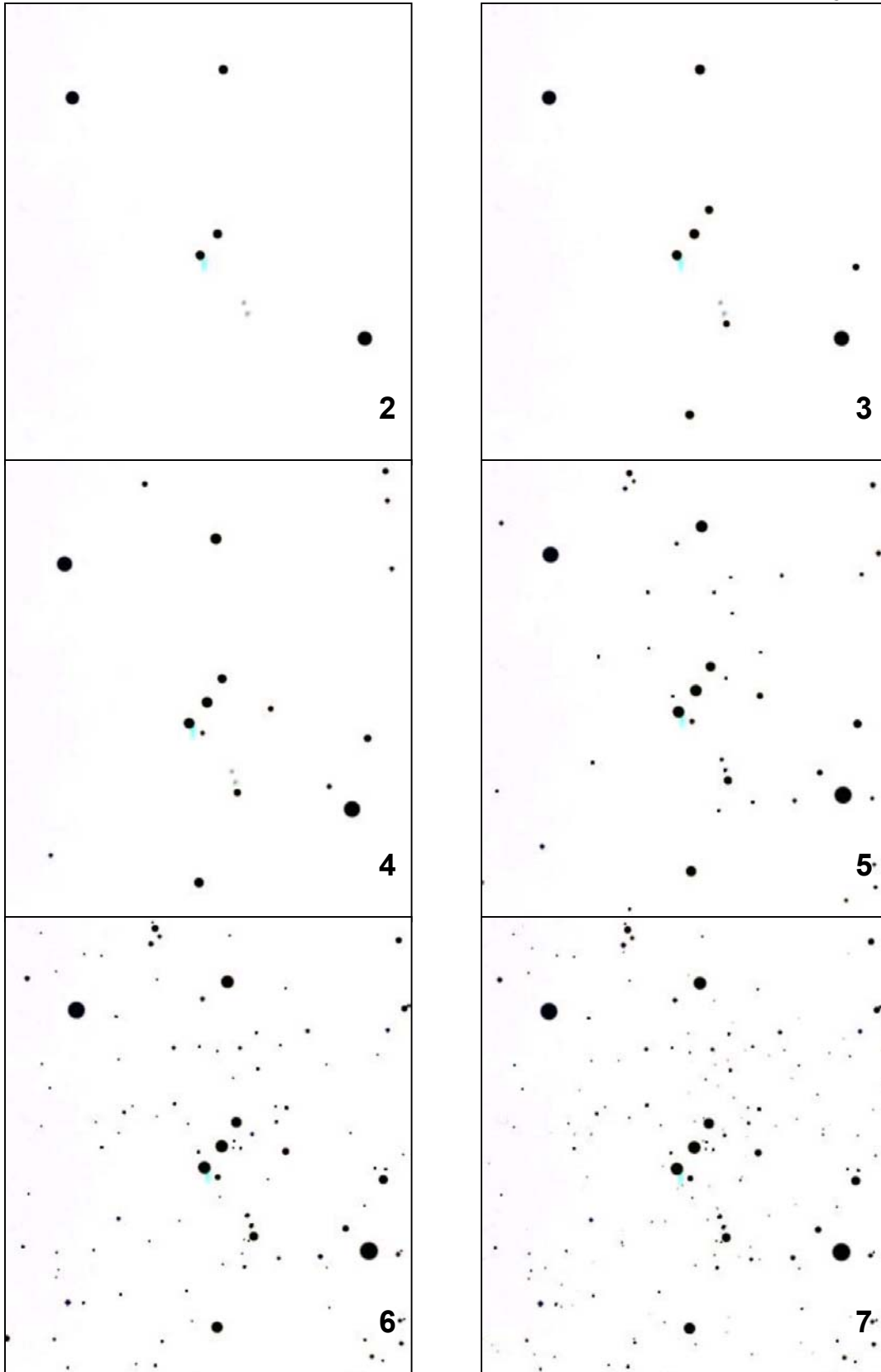


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Light Pollution Indicator

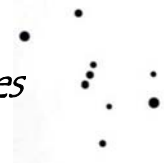
Star Map #1 has next to no stars present and therefore is not displayed.





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Observation Form	
Fill in indoors.	Name: _____ Date: _____
	Street Address of Observation: _____
	Nearest Cross-Streets: _____
	City of Observation: _____
	Age: _____ Grade: _____
	Teacher: _____
	School: _____
	School District: _____
	Fill in outside.
Cloud Coverage: <input type="checkbox"/> clear <input type="checkbox"/> 1/4 of sky <input type="checkbox"/> 1/2 of sky <input type="checkbox"/> more than 1/2 of sky	
Mark with an X the star map that best represents your observation: No stars visible Star Map 2 Star Map 3 Star Map 4 Star Map 5 Star Map 6 Star Map 7	
<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	
Fill in indoors. (Optional)	Comment on sky conditions (example: Light clouds to the north, some haze, but about normal for this location): _____ _____
	Comment on location (example: "The neighbor's front door light on the next house over" or "Only one street light within 200 yards & it is well shielded from my view"): _____ _____
	Other comments: _____ _____