



## The National Optical Astronomy Observatory's Dark Skies and Energy Education Program



### Demonstrating Light Pollution and Shielding

**Grades:** 3<sup>rd</sup> – 12<sup>th</sup> grade

**Overview:** This interactive demonstration illustrates the effects of lighting on our view of the night sky and how shielding can reduce light pollution while at the same time making the lighting more effective. All of the materials are provided in the Dark Skies Education Kit or can easily be obtained. This demonstration is adapted from an activity on the Paper Plate Education website: <http://analyzer.depaul.edu/paperplate/lights.htm>.

**Purpose:** To demonstrate what constitutes ineffective lighting versus good lighting, by illustrating the effects ineffective lighting has on safety, energy consumption, cost, and our ability to see the stars.

**Objectives:** Using the demonstration materials, student will explore the “light footprint” of an unshielded light versus a shielded light, compare the effectiveness of one versus the other, discuss the ways ineffective lighting affects our lives and come up with a simple solution that keeps the lights on but directs shielded lights where needed, when needed and at a reduced wattage and cost, while allowing us to better see the stars.

**Time:** 15 minutes to do the demonstration. Discussion time can vary.

#### Materials and Tools:

- Two “mini-lights” (such as the Mini Maglite flashlight)
- Paper cube planetarium (cardboard cube with small hole on one side and pinhole “stars” on the opposite side)
- PVC cap or other items to act as shields
- City mat or white surface
- Optional - picture book with landscapes or city scenes, such as “There Once Was A Sky Full of Stars” by Bob Crelin
- Optional – figurines about 1.5 inches tall; matchbox cars

#### Preparation/Prerequisites:

This demonstration is best done when in a completely darkened room (e.g., no light). A room without windows is recommended. If a room with windows must be used, the windows can be covered with black trash bags (2 layers per window are very effective). The time required to cover the windows will depend on the number of windows.

Setting up the demonstration itself only takes 5 minutes. It is good to have either the demonstration set up in the middle of the classroom or to have the students stand around the table where the demonstration is set up.

The two mini-lights should have their reflectors taken off, exposing the bulb (which is very fragile). This “mode” allows one of the mini-lights to be a streetlight and the second the source of light for the paper cube planetarium.

4”x4” (or 10cm x 10cm) cardboard boxes for the paper cube planetarium can be bought at a local arts and crafts store. A push pin can be used to place tiny holes on the lid to represent constellations like Orion. And a scissor will be needed to make a hole just big enough for a mini-light (3/4 of an inch or 2cm) on the bottom of the box. Use black electrical tape to tape the entire box so that no light leaks out from crevices. Complete instructions for making the box are at the end of this activity.



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### Demostrating Light Pollution and Shielding

#### Background Information/Links:

All materials for this lesson and other Dark Skies Rangers activities are available at <http://www.globeatnight.org/dsr/>.

There are three main types of light pollution:

- Glare is too much background light. Can you see the stop sign or read the sign below it in this image?



- Light trespass is light that spills into an area where it is unwanted. Would you be able to sleep if your bedroom window faced this neighbor's light?





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## Demostrating Light Pollution and Shielding

- Sky glow is lots of light scattering off particles in the air, giving the appearance of a glowing sky. Do you see any stars in this image?



Image credit: <http://www.nightwise.org/examples.htm> (no longer in service)

More background on light pollution can be found on the GLOBE at Night website:  
[http://www.globeatnight.org/learn\\_light.html](http://www.globeatnight.org/learn_light.html)

Quality lighting should:

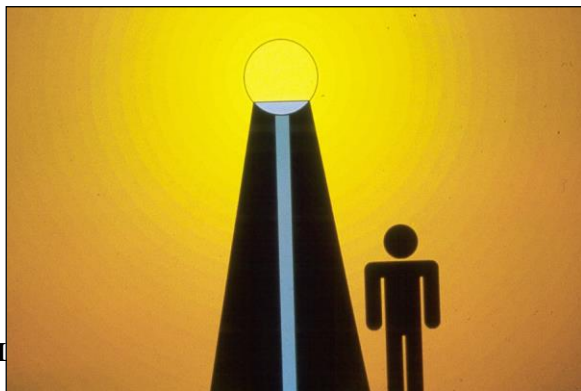
- Maximize the desired effects:
  - Good vision
  - Good night ambiance
- Minimize the adverse effects:
  - Energy waste
  - Glare
  - Light trespass
  - Sky glow

Keys to quality lighting:

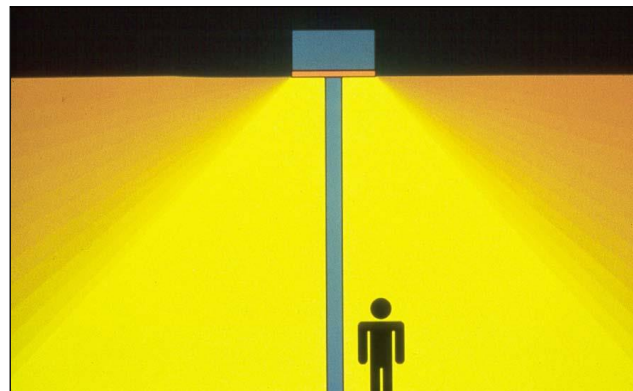
- Shine the light down.
- See the effect, not the source (e.g., no glare).
- Light only where and when needed.
- Don't over-light.
- Use energy efficient sources.

Shielding can maximize the desired effects of lighting by controlling the light output and minimizing the glare, light trespass, and light that travels straight up, as illustrated below.

Unshielded fixture



Shielded fixture





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*Activator:* Read/discuss with the class There Once Was a Sky Full of Stars (book by Bob Crelin).

*Formative Assessment:* Brainstorm facts about light pollution and various ways how it impacts us.

*Instructional Strategies:* See lesson plan sequence below.

*Summative Assessment:* Students survey home or neighborhood lighting for examples of good and bad lighting.

Doing the Light Shielding Activity:

- Make sure you are in a very dark room with a low ceiling. Set up the activity on a table with a city mat or white surface.
- If you'd like to include a landscape or city scene as part of the demo, prop open a book (like "There Once Was a Sky Full of Stars") to the page with the desired illustration (e.g., a street with light pollution).
- Unscrew the reflectors from both "mini-lights" and turn on one of them ("candle mode"). You can use the reflector ends as a base to stand the lights on the table.



- Place the bulb top of the "mini-light" barely into the big hole at the bottom of the white paper cube.
- With the room lights off, project the "stars" from the white paper cube onto the ceiling. Observe how many stars you can see and how bright they appear.
- Using the second "mini-light" as a "street light", place it on the city mat on the table (in front of the open book if you are using it) and turn on the "mini-light".



- What do you notice about the number of stars?
- Now place the PVC cap (or another shield) above the second "mini-light" to represent a shielded streetlight.
- What differences do you notice with and without the shield? How is your view of the stars affected? How does the lighting of the area directly under the lamp change?





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### Demostrating Light Pollution and Shielding

#### Questions:

Besides the questions throughout the lesson sequence, have the students discuss their observations and the benefits of shielded lighting. Note that shielded lighting improves our view of the stars (reduces sky glow), and is safer and more energy efficient, since it directs light down to the ground, where we want lighting rather than up into the sky. This improves the quality of life for people, animals, and plants; saves money and energy; and preserves our beautiful dark skies.

#### Integration:

Content reading skills (cause/effect, main idea/details, or vocabulary) may be reinforced using either online or offline reading materials to increase the effectiveness of this lesson.

#### Extensions:

You may want to encourage the students to take part in citizen science projects to measure light pollution (see resources below) and to write letters to the local newspaper, government, and businesses to encourage the installation of shielded lighting in their community.

#### Teacher Resources:

- A simple activity illustrating glare, light trespass, and sky glow shows how light pollution can be remedied by shielding outdoor lights – <http://www.youtube.com/watch?v=nb7eryzSBno>
- A video demonstration to understand light pollution and their effects on our environment– <http://www.youtube.com/watch?v=dd82jzstF1o>
- GLOBE at Night – <http://www.globeatnight.org/>
- International Dark Sky Association – <http://www.darksky.org/>
- Astronomical League – <http://www.astroleague.org>
- Astronomers Without Borders – <http://www.astronomerswithoutborders.org/>
- American Astronomical Society – <http://www.aas.org>
- Astronomical Society of the Pacific – <http://www.astrosociety.org>
- The Let There Be Night Program – <http://www.lettherebenight.org>
- Unihedron, the makers of the Sky Quality Meter – <http://www.unihedron.com>
- National Park Service Dark Sky Team – <http://www2.nature.nps.gov/air/lightscapes/>
- On Light Pollution: [http://en.wikipedia.org/wiki/Light\\_pollution](http://en.wikipedia.org/wiki/Light_pollution) and [http://www.globeatnight.org/learn\\_light.html](http://www.globeatnight.org/learn_light.html)
- On Light Pollution Interactive Game: [http://www.globeatnight.org/learn\\_orionsky.html](http://www.globeatnight.org/learn_orionsky.html)
- On Apparent Magnitude: [http://en.wikipedia.org/wiki/Apparent\\_magnitude](http://en.wikipedia.org/wiki/Apparent_magnitude)
- On Stellar Magnitude System: [http://www.skyandtelescope.com/howto/basics/Stellar\\_Magnitude\\_System.html](http://www.skyandtelescope.com/howto/basics/Stellar_Magnitude_System.html)
- On Limiting Magnitude: [http://en.wikipedia.org/wiki/Limiting\\_magnitude](http://en.wikipedia.org/wiki/Limiting_magnitude)
- On Sky Brightness: [http://en.wikipedia.org/wiki/Sky\\_brightness](http://en.wikipedia.org/wiki/Sky_brightness)
- On Skyglow: <http://en.wikipedia.org/wiki/Skyglow>



## **Demonstrating Light Pollution and Shielding**

### **Construction of the Planetarium Box**

- A 4"x4" (or 10cm x 10cm) cardboard box for the paper cube planetarium can be bought at a local arts and crafts store. On the top side, a pushpin can be used to place tiny holes on the lid to represent constellations like Orion. With a scissor, make a hole just big enough for a mini-light (3/4 of an inch or 2cm) on the bottom of the box.
- Construct the white 4-inch x 4-inch box into a cube by folding the flaps in. To do this, tuck in the flaps on the lid. The lid is the top side of the box that has punched out holes representing stars in constellations like Orion. On the bottom of the box (the other end of the box), tuck the flaps into the slots, making sure they lie flat.
- Using the electrical tape, seal all three sides on the top of the cube (the side with the star holes punched out). Seal as tightly as possible to avoid any light leaks at the edges of the cube. Avoid covering the stars on the lid with tape, if possible.
- Seal up the bottom of the box wherever there are seams in the folding. Make sure to put enough electrical tape not to allow any light to escape. Avoid covering the big hole on the bottom of the box with tape.
- Test the planetarium box. In a very dark room, take the reflector off of the mini-flashlight, place bulb just inside the hole on the bottom of the box. Turn on the flashlight. Make sure no excess light escapes other than through the punched out holes at the top of the box.
- You are done! Enjoy using the planetarium box in the "Demonstrating Light Pollution and Shielding" activity.

