Live from McDonald Observatory: Telescopes & Careers at McDonald Observatory Videoconference
Teacher Edition for grades 9-12

Introduction
The videoconference will introduce students to McDonald Observatory, research telescopes, and the fascinating careers the people have that work and live there. The student sheets are designed to help the student discuss important concepts. Students should be directed to not fill in their sheets until prompted.

Visiting Otto Struve Telescope
Students will receive a behind-the-scenes tour of the 2.1m Otto Struve Telescope. The videoconference facilitator will point out and describe the parts of the telescope and how they work. Note that the Otto Struve Telescope uses several different mirrors to send the focused light to different physical locations where different instruments may be used. Telescopes are housed in buildings, usually domes, which open to the sky to allow the light from astronomical objects into the telescope. The building protects the telescope from weather damage.

Why is the telescope called “the Otto Struve”? Dr. Otto Struve was the first director of the Observatory; he helped direct the site selected for the telescope and the construction. To show appreciation for his important work, the telescope was named after him.

Why is the Observatory in the remote mountains of west Texas? The farther the telescope can be from towns and cities, the better. By putting the Observatory in west Texas, astronomers are trying to avoid light pollution that obscures stars and other astronomical objects. The reason the telescopes are on mountaintops is because there is less air on top of the mountain. Have you ever looked at the stars and noticed them twinkling? It may look pretty, but when using a telescope and studying objects in the sky, the twinkling makes it very hard to focus the telescope correctly. Air is one of the greatest nuisances to astronomers because of this reason. Ground-based telescopes are put on mountaintops to allow as little air as possible between the telescope and space.

Using the word list below, fill in the labels on the following photograph.

Answers:

<table>
<thead>
<tr>
<th>Primary mirror</th>
<th>Secondary mirror</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instrument/Camera</td>
<td>Polar axis</td>
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References and Extensions:
For a history of telescopes, visit the NASA website at: http://amazing-space.stsci.edu/resources/explorations/groundup/
The 2.1m Otto Struve Telescope: http://mcdonaldobservatory.org/research/telescopes/telescope.php?t_id=17
“StarDate”, a large source of teacher resources and astronomy news: http://telescopes.stardate.org/

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Visit the 10m x 11m Hobby-Eberly Telescope

Students will receive a behind-the-scenes tour of the Hobby-Eberly Telescope (HET), one of the largest and unique telescopes in the world. The videoconference facilitator will point out and describe the parts of the telescope and how they work. The HET is located at the summit of Mt. Fowlkes, next to Mt. Locke. You might point out to your students that in aerial photograph the 2.1m Otto Struve telescope (right) and 2.7m Harlan J. Smith telescope dome (left) are visible in the distance. Even though the HET collects light just like the other telescopes at McDonald Observatory, the HET doesn’t look like and doesn’t act like a normal telescope.

Telescopes, by themselves, are not scientific achievements. Instead, they are achievements of engineering! Most research telescopes are built to rotate on an axis that is aligned with the axis of Earth. This is so astronomers can collect light from an astronomical object while the Earth is rotating. Earth rotates eastward, thereby causing stars to appear to move westward. In most cases, telescopes themselves slowly rotate west to follow the apparent motion of the sky. Not so at the HET. Instead, the HET primary mirror array stays stationary while it reflects light to instruments. A large tracker at the top of the telescope slowly moves the instrument as Earth turns. From an engineering perspective, it costs far less money to design and build a mechanism to move an 8-ton instrument than it does to move an 80-ton telescope.

During the behind the scenes tour, your students will see that it takes much more that astronomers to maintain a telescope like the HET. On the tour we will meet Emily Schroeder, a mechanical engineer. Like many people who work here, she loves her career and enjoys sharing her work with others.

Is Emily Schroeder an astronomer? Answer: No. She is a mechanical engineer. The point is that most people who work at the Observatory are not astronomers.

Briefly explain her job at the HET? Answer: Students should describe one of her duties at the HET.

Extended science details: Efforts have begun to modify the telescope for the upcoming Dark Energy Experiment called HETDEX, which will allow us to explore why the universe is growing ever larger at a faster and faster rate. A new tracker, the massive framework on the top of the HET, will increase the telescope’s field of view. The addition of state of the art instruments, mounted to the sides of the main framework, will give the HET the ability to map the expansion rate of the early universe, looking back in time billions of years, to measure how clusters of galaxies moved in relation to one another as the universe evolved.

References and Extensions:
More about the HETDEX project: http://hetdex.org/

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Explore LIGHT and how it REFLECTS
The purpose of this page is to re-enforce that telescopes gather light with curved mirrors. The mirrors are curved so that we can direct that light to scientific instruments used to investigate astronomical objects.

First, the videoconference facilitator will give your students time to think critically about how light behaves with a flat mirror and make their prediction for where a reflected light ray will go. Next, the videoconference facilitator will demonstrate the Law of Reflection using a protractor and laser. Students will be able to see a bright laser beam tracing out incident and reflected rays. It’s best for you to have your classroom lights off for this demo. Lastly, the videoconference facilitator will explain that a curved mirror reflects light in just the same way as a flat mirror does.

A misconception your students might have is that light always travels in straight lines. The facilitator will briefly demonstrate that by passing from one substance to another, light can bend. This is known as “refraction”. “Refracting telescopes” use lenses to refract, or bend all the light from an astronomical object to a focus. But the research telescopes at McDonald Observatory are not “refracting telescopes” because there are no lenses to bend light. They are “reflecting telescopes” because they use a large, curved mirror to reflect light to a focus. Reflecting and refracting telescopes both collect light.

Be sure that your students have a working definition for “reflect”. You might tell them that when a mirror is “reflecting” light, we don’t mean the mirror is bending, or bouncing the light. Instead, we mean that the light is being redirected and now can be seen as coming from a different direction than before.

Draw the reflecting rays for each showing in what direction the starlight will reflect?. Answer: Students should measure the incident light ray angle, and then measure an equal reflecting light ray angle. In the first diagram, a normal line (dashed) has been drawn in several places along the mirror. They are drawn in to remind the student that the scientific way to measure the incident and reflected angles is to measure with a protractor the angle the incident and reflected light rays make with the line that is normal to the mirror. The facilitator will demonstrate the LOR and make the connection to curved mirrors in the telescopes that your students visited today.

Do you think the Law of Reflection applies to curved mirrors, used in telescopes like those at McDonald Observatory? Answer: The Law of Reflection applies to curved mirrors allowing astronomers to direct the light into scientific instruments. For the curved mirror, the normal to the surface is pointing in different directions along the curve. The facilitator will not provide time for students to work on the last diagram, but some may want to after the videoconference has ended. We want students to see that curved mirrors can direct light to instruments.

References and Extensions:
Many different simple optics experiments: http://howtosome.org (password is free)
For hands-on activities involving the Law of Reflection (how mirrors work):
Mirror, Mirror: http://stardate.org/teachers/plans/plan.php?lp_id=1

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