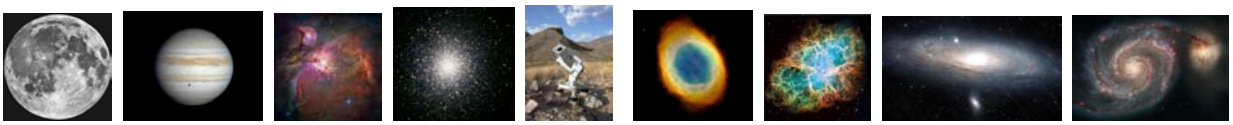

“Kids Capture Their Universe”

This apprenticeship was developed by MIT Kavli Institute (MKI) and the Smithsonian Astrophysical Observatory (SAO) during 2006 and 2007, in partnership with Citizen Schools, Boston. Final pilot testing was completed in Boston during spring 2008.

What do we want to teach?

We want to teach apprentices the art and science of astrophotography. They will learn how to interpret both images and written information about several objects in the universe. They’ll learn to communicate their understanding about some of those objects using pictures, models, and poems as well as the process of how they “personalized” their image using image manipulation tools similar to those used by professional astronomers.

New Basic Skills: Teamwork (Students are able to contribute to group work while sharing the “spotlight”) and Leadership (Students are able to speak more confidently in front of an audience), with Advanced Literacy (Students are able to correctly apply terms and vocabulary associated with the Apprenticeship)

Student blurb: Title: Kids Capture Their Universe!

Have you ever wondered what's going on out there in the universe? Would you like to discover exciting things about planets, stars, galaxies and black holes?

In this apprenticeship, you will become an astronomer-photographer and capture digital pictures of objects in outer space using real robotic telescopes that you control over the Internet. Then you'll use computer software and your artistic creativity to present your favorite views of the universe by building an astronomy photo exhibit with your fellow apprentices.

Description of the WOW! A Live Astrophotography Exhibition

Students will develop a portfolio of astronomical images that they have taken and processed with the MicroObservatory online telescopes and image processing software. The group will vote on their favorites from each portfolio, after which each apprentice will choose a small number he or she would like to be part of the final exhibition. The group will then organize the images into several categories, and small groups will take responsibility for developing a poem and/or model to go along with each category.

An exhibition with several areas will be set up in a temporary space and time (community/school-wide WOW event) as well as a more permanent location, possibly in the apprentices’ school. Each area will include several photos with descriptive and explanatory captions, the accompanying model and/or poem. During the school/community WOW, apprentices should have access to a computer to show visitors how to process images themselves.

Table of Contents

Introductory Materials (review these before beginning the apprenticeship)

Weekly Lesson Plans (use these to plan your weekly sessions)

Worksheets and Templates (copy these for apprentices as necessary)

Appendices (for Citizen Teacher and facilitators' reference)

Overview of the Apprenticeship

Apprenticeship Fair: The Citizen Teachers introduce potential apprentices to the apprenticeship through interactive demonstrations of apprenticeship experiences (image processing and/or astro-creative activities) and/or showcases of apprenticeship topics (telescopes, astrophotography and/or exhibitions)

Weeks 1-5: The first half of the apprenticeship is spent learning the "tools of the trade" and developing teamwork and presentation skills. Each week consists of three key components, in addition to the opening and closing circles:

- Icebreaker/Team-Building Activity

Part of the opening circle, each week includes a non-astronomy activity that helps the group get to know each other better and foster a fun, supportive environment.

- Image Requests and Processing

In addition to learning how to use the MicroObservatory telescopes to request images of astronomical objects, apprentices gain familiarity with basic image processing techniques for astronomical images. Explorations consist of a guided activity (in which the facilitator models the use of one or more processing tools), a challenge (in which apprentices re-create a pre-processed image using those tools), and free processing (in which apprentices apply these tools to the images they have requested). Students also create descriptive captions to accompany each processed image and practice sharing and reflecting on these images with their fellow apprentices and facilitators.

- Astro-Creative

Students devote time each week to a hands-on project that draws upon and showcases their creative talents: kinesthetic modeling, poetry, and art/sculpture

- Week 5 is traditionally devoted to a field trip, during which apprentices can talk to experts, share and ask questions about their images, see real telescopes, and/or visit a professional museum exhibition.

The knowledge, skills, and products developed during Weeks 1-5 will be incorporated into the final exhibition and/or used as an example for creating the displays and presentations.

Weeks 6-10: The second half of the apprenticeship is spent assembling the final WOW exhibit displays and presentations, using the skills and products developed during the first half of the apprenticeship. Apprentices practice presenting and demonstrating their projects and skills.

WOW Event(s): The final exhibition, featuring exhibit displays, hands-on demonstrations, and live presentations, is presented to the community. Be sure to start planning this before the apprenticeship begins so you can communicate clear expectations to the apprentices!

Products needed for the WOW:

Each group of apprentices should create:

1. A portable exhibit display, mounted on poster board/foam core or other display structure that can be set up on a table or easel. Each display must contain:
    - Quality images of several objects, taken with MicroObservatory and processed by the student using the MicroObservatoryImage software
    - Apprentice-written captions for each image in the display
    - Individual and/or group-made poem and/or 3D model that adds to the understanding of the theme of that part of the exhibition
    - Title and descriptive summary of the display
2. A well-rehearsed oral presentation, featuring one or more elements of the exhibit display above and presenting information about astronomy and/or the apprenticeship to visitors in a creative way. Presentation topics could include:
    - Explanation/guided tour of the exhibition
    - Explanation/demonstration of image processing, focusing on one or more specific tools and/or images presented in the display
    - What happened during the apprenticeship
    - An explanation of how telescopes work and what they do, using images, sketches and/or a real telescope
    - Information about a class/category of objects, as demonstrated with their own images
    - A comparison of MicroObservatory images with professional astronomy images
    - Demonstration/explanation of a kinesthetic model
    - Interactive demonstration of physical model building or sculpture based on one or more images.
    - Interactive demonstration of poem making, based on one or more images.

All displays should be arranged into a creative exhibition with approximately 15’ x 15’ floor space. Presentations may be given as part of the exhibition or in an auditorium.

Physical supplies needed for the apprenticeship (quantities reflect 8-12 apprentices)

- 20 pens/pencils, 20 markers, 150 blank note cards, hanging file folders (one per student), sticky notes, ~100 colored dot stickers, name tags, 5 glue sticks, masking tape, Scotch tape & dispenser, dry erase markers/eraser, 3-4 scissors, stapler, small box of clay, 4-5 blindfolds, prizes (e.g. candy, trinkets), large chart paper (for wall) and craft supplies, as described in Week 4 (page 48)

Technical Requirements for Running the Apprenticeship

Minimum necessary requirements:

- Computer area/room with one (1) computer per apprentice (ideal) or one (1) computer per pair of apprentices (acceptable)

- Each computer (PC or Mac OK) must have:
  - Internet connection on ALL computers (ideal) or two separate workstations (acceptable) with access to http://www.MicroObservatory.org
  - Free MicroObservatory image processing software (http://mo-www.harvard.edu/MicroObservatoryImage/) downloaded, installed, and running.
  - Ability to save files to a location easily accessed by the CT and students.
  - Stability of computer such that software installation / saved files, etc. are not erased or moved from week to week.
  - Ability to transfer files between computers (local network or flash drive or disk drive with read/write access, etc.), so CT can collect/distribute image files.

- Access to the school computer specialist (direct or through Teacher Leader) to help (on minimal "as needed" basis) with the following:
  - Initial software installation / setup
  - Change computer display properties
  - Clarify procedures for use
  - Resolve technical problems

- Activities area: 10-12 people able to stand in an open circle
- Secure, accessible storage space for materials: several 2 foot square boxes / poster tubes

Additional requirements:
(Would make apprenticeship easier if located in apprenticeship computer room, but must be available to CT somehow)

- Access to color printer in apprenticeship computer room
- Access to black and white printer/copier

Useful Links

MicroObservatory Guest Observer Portal: http://www.microobservatory.org

Image processing software: http://mo-www.harvard.edu/MicroObservatoryImage/

Image directory: http://mo-www.harvard.edu/jsp/servlet/MO.ID.ImageDirectory

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Resource Management Guide

Retrieving Images from MicroObservatory

When an image is requested via the MicroObservatory Guest Observer Portal, the telescope will take the image that night and send an email to the user's email address (assuming it was entered correctly). The easiest way to access the image is to check the email account and **click on the link** provided in the email.

The email will come from MicroObservatorySupport@cfa.harvard.edu

(Users may wish to set up a filter in the mail program so that all emails from this address go to the same folder.)

Due to security constraints on public computers, however, students may not be able to check their email on the school computers. The best way to deal with this issue is for a facilitator to **pre-load the students' computers** each week with the images requested the previous week. We recommend having all image requests sent to the CT's or TL's email address or an independent email address (such as astronomycitizen@yahoo.com) that can be accessed outside of the apprenticeship sessions. If retrieving images via email is not possible, the images can be accessed via the web, at either of the two locations:

- The daily index of the Guest Observer Portal images:
  http://mo-www.harvard.edu/GA/ImageAnalysis/TodaysImagesMM:DD:YYYY
  (fill in the month, day, and year for the day AFTER the images were requested)

- Main MicroObservatory Image Directory:
  http://mo-www.harvard.edu/jsp/servlet/MO.ID.ImageDirectory
  (look for users "moguest" and "cquestions" on the correct date)

Be sure to retrieve and transfer the unprocessed FITS files, not the GIF thumbnails!

Note that links above include MORE images than those requested by the student. If this is the intended method of retrieval, it may be useful for the Citizen Teacher to make note of the images requested by students so that only those images get downloaded and transferred to the students' computers.

Transferring unprocessed FITS images to the campus computers

Do this before the session begins. It is the Citizen Teacher's responsibility to make sure students have the images they need for each session. Some options:

1. Load all requested images onto a flash drive or CD and transfer them to each computer. (Make sure the software runs properly before the apprenticeship begins)

2. Upload all requested images to a central server and download them to each machine. (Make sure there is a valid Internet connection on each machine.)

3. Some combination of the above (e.g. upload images to a server, download them to one computer and transfer them to others via flash drive.)

Unprocessed FITS images should be stored on identical folders on each computer, so that all apprentices can follow a single procedure for retrieving them. We suggest weekly request folders within a larger "Images" folder.

File Management (What to Do With Processed GIF Images)

Choose a system that works for you and be consistent. Once an image is processed, it should be filed into an accessible location:

1. A collective "Processed Images" folder (if students do not use a consistent computer each week)

2. A personal "Name's Processed Images" folder (if students use the same computer each week)

Apprentices will need to **specify the folder** when they click "Save As…" because the default is the same folder from which the original FITS image was retrieved.

Before the apprenticeship begins, **make sure that images (and the image processing software) will remain on the computers from week to week.** Double-check this during Weeks 1 & 2! If the machines are cleared each time the student logs out, you will need to reinstall both the software and the images each week, including the original FITS files and the students' processed GIF images.

To retrieve students' processed GIF images for storage or printing, there are two options:

1. Load them onto a flash drive or other portable media storage device

2. Upload them to a central server to download and print later

It is expected that **Citizen Teachers will be responsible for printing** the final color images for the apprentices' exhibits. Note that this may include typing up captions and printing them out along with each image.

YOUR GOAL is to find a system that works independently at your site. Citizen Teachers should work with their Teacher Leader and campus staff to make sure students can find and save their images appropriately.

Facilitating New Basic Skills

There are several ways in which to support the development of these skills, which are built into the KCU curriculum.

Working with vocabulary: Each week, there are 4-5 "focus vocabulary" words. These words and their definitions should be printed out, possibly laminated, and posted prominently in the room before the start of each session. (See Appendix B.) Additional vocabulary that come up in each lesson can be presented, but maintain specific effort on using the focus vocabulary. Other ideas include the following:

- Presenting vocabulary at start of lesson: Several approaches include a physical scavenger hunt to locate the printed definitions scattered around the room, assigned students read vocabulary out loud, or the CT/TL reads vocabulary out loud. The introduction of vocabulary should be very short, but then incorporated throughout the lesson.
- Caption writing: This is the most important way apprentices can learn vocabulary and content. Award points for correctly using vocabulary in written captions, with team or individual points across one day leading to recognition/ award.
- Vocabulary "jeopardy": Although a version of this is included explicitly in week 8, at any time students can be challenged to recall a vocabulary word based on its definition, or an image that shows or demonstrates it. (e.g. "What kind of object is in this image?" A planet! or "Which tool was used in processing this image?" Zoom!)
- At closing circle: Based on their experience that session, have students define or give an example of one of the vocabulary in their own words.

Supporting teamwork: In addition to the "Lighthouse game" in week 7 and the group selection of exhibit materials and exhibit groupings, other ideas include the following:

- Image processing: After week 1, students can be paired during "free processing time" and develop processing challenges for their partner (i.e. can you make your image look like mine?)
- Caption writing: Paired students can write captions for their partner's image, forcing them to interview their partner for information.
- Closing circle: Apprentices can give recognition to good work done by peers, including recognizing good image / caption combinations on the image wall (see next section)
- Image wall: Based on initial caption/image combinations on the wall, students can add more comments/ questions to each caption, leading to a richer discussion, and "group-created" captions.

Speaking confidently in front of an audience: In addition to the presentation demonstration and games in weeks 9 and 10, other ideas include the following:

- Caption writing: With any additional time, apprentices read captions aloud to partners or the group.
- Introducing vocabulary: Apprentices read vocabulary aloud to partners or the group.
- Closing circle: Read captions or give verbal recognition to the work of others.

Creating an Image Wall on Ongoing KCU Apprenticeship WOW Board

During pilot runs of this apprenticeship, pilot teachers (both CTs and TLs) expressed a need for weekly physical recognition of the students' work:

> **A physical or electronic display of students' color images, accompanied by information about them (process to create, contents, inspiration, etc.), contributed by the creator and/or peers**

There are many reasons for doing this:

- Actually seeing printed/publicly displayed images provides concrete sense of accomplishment and progress toward the final WOW exhibit
- Encourages teamwork and cooperation (a New Basic Skill)
    - Students can help write captions for other people's display-worthy images
    - Students can work together to create a caption that compares two views of the same object, or that relates an image to a poem
- Rewards students for good work (both image processing and caption writing)
    - Only images with good captions or interpretation get displayed
    - Facilitator can nominate images/captions to the board
    - Students can give "shout outs" to their peer
- Encourages/motivates students to create display-worthy images and captions
- Reduces the amount of work required during the final weeks of the program
    - Bulk of images are pre-chosen
    - Students need only to reorganize
    - Captions can be edited rather than re-created
    - Provides a model of what an exhibit display board should look like
- Provides a public display for group-created AstroCreative projects (i.e. poems, photos of sculptures) that may not make it into students' own exhibit displays

What form should this take?

Best option: Print out the best images and captions each week and add them to an exhibit display board that is updated weekly.

- *Pro: provides a physical place where students can watch the WOW exhibit develop*
- *Con: Requires weekly access to a color printer*

Backup option: Create a digital display of the electronic images that gets updated each week (e.g. Flickr or other online photo album program, PowerPoint or "Best Of" folder on the facilitator's "master computer")

- *Pro: Does not require weekly access to a color printer*
- *Con: Does not have a concrete connection to the physical WOW display*

If an electronic photo album is created, the facilitator can print out the chosen images when it is time to assemble the final exhibition. Either way, the resulting exhibit board that the group creates will become an introductory panel in the final WOW exhibition and model for the students what the boards should look like.

How should the board/album be organized?

Images and accompanying captions can be posted with no particular organization in mind, or the facilitator can provide some overarching guidance. We recommend:

- Divide the board into five sections, one for each week
- Divide the board into categories that relate to specific apprenticeship content
    - Processing tools/activities (changing contrast, astro-poetry, etc.)
    - Astronomical objects (Moon, planets, stars, nebulae, galaxies)
- Other, at the facilitators' and apprentices' discretion

Although black-and-white placeholder images can be used, most of the apprentices' excitement comes from seeing the full color versions of their images.

When should images and accompanying information be added?

Option 1: Students and facilitators nominate and select images for the board during the processing challenge reflection period. A facilitator prints those images and captions out while other activities are going on, and adds them to the board during closing circle.

Option 2: Students and facilitators nominate and select images for the board during the reflection time and/or closing circle. A facilitator prints them out during the week and adds them to the board at the following week's opening circle.

Option 3: A facilitator prints out all "display-worthy" images and captions during the week and students choose which ones to display during opening circle the following week.

It is up to the facilitators how and when this display will be created. The main goal is for apprentices to see throughout the apprenticeship how their work is becoming a part of a real exhibition.

Template for activity write-up appears on Page 12 of this curriculum. Be sure to add this activity to each week's lesson plan!

Weekly Lesson Plans

Apprenticeship Fair
- Strategies for Engaging Students

Week 1: Introduction to Telescopes and Images
- Look Through a Telescope/Kinesthetic Telescope
- Processing Challenge: The Prudential Tower

Week 2: The Moon, Planets, and Our Solar System
- Processing Challenge: The Moon (sharpen, zoom, crop)
- Astro-Creative Challenge: Astro-Poetry

Week 3: Stars and Nebulae in our Milky Way galaxy
- Processing Challenge: Orion Nebula, Hercules Star Cluster
- Astro-Creative Challenge: Kinesthetic Life Cycle of Stars

Week 4: Galaxies Outside the Milky Way
- Processing Challenge: Whirlpool Galaxy
- Astro-Creative Challenge: Astro-Sculpture

Week 5: Field Trip

Week 6: Prepare Exhibit Materials
- Image Processing and Selection
- Final Image Caption Writing

Week 7: Exhibit Component Construction
- Group Selection and Planning
- Creative Component Construction
- Final Resources Assembled

Week 8: Final Exhibit Construction
- Exhibit Displays Assembled
- Introduction to Visitor Conversations

Week 9: Prepare and Practice Presentations
- Prepare Presentations and Demonstrations
- Practice Presenting and Provide Feedback

Week 10: Final Preparation for WOW Event(s)

Week 11: Optional Reflection

Supplemental Activities: Making Images, Images from Telescopes, False Color Tables

Activity Name: Apprenticeship Fair	**Time: 5 minutes**
DO AN ACTIVITY Image Processing Demonstration • Open an image • Open "Adjust Image" tool • Hit "Auto" • Change the color table (let students choose which colors to try) Astropoetry Demonstration • Show a beautiful image of an astronomical object • Ask apprentices what words they would use to describe it. What does it remind them of? • Write the words on index cards or Post-Its • Shuffle them around to create a poem EXPLAIN THE APPRENTICESHIP • Show students the telescopes they will be using • Describe the apprenticeship and WOW, being sure to include examples of student creations • Ask for questions	***Objective*** To entice students to enroll in the astronomy apprenticeship You may wish to assure students that this apprenticeship is not for "science geeks only." It involves computers and creative arts projects.

The following template should be filled out by the CT/TL and included in each week's lesson plan for the first half of the apprenticeship.

Activity Name: Image Wall/WOW Board	**Time: 5 minutes**
Use this template to fill in your specific strategy for creating a model WOW board or electronic photo album. Exact procedure will depend on your specific resources and apprenticeship. See the "Guide to the Image Wall" on pages 8 and 9 of the curriculum for suggestions.	***Objective*** To create an ongoing display of students' accomplishments

Week 1 (With Telescope)

Lesson Objectives: ***What do we need to get done today?***
By the end of the lesson, the students will:

1. Get to know each other and the Citizen Teacher
2. Take at least one image of a Moon or planet with MicroObservatory telescope

Learning Objectives: ***What will the students learn today?***
By the end of the lesson, the students will have learned:

1. How a telescope works
2. How to take images with the MicroObservatory telescopes
3. How to open and save images with the image processing software

Agenda based on the lesson plan. Post in the room for the students to see.

1. Opening: Survey & Get To Know You Icebreaker	15 Minutes
2. Review Agenda and WOW format	5 Minutes
3. Activity: Looking Through a Telescope	15 Minutes
4. BREAK	5 Minutes
5. Take Images: Moon, Planets	10 Minutes
6. Activity: Introduction to Image Information	10 Minutes
7. Processing Challenge: Prudential Tower	20 Minutes
8. Closing Circle	10 Minutes

Preparation and Space Set up:
Post daily agenda, 10-week apprenticeship outline, and focus vocabulary for apprentices
Make sure software is installed and running on the computers
Load challenge images into appropriate folder on the computer
Create students' processed images folder on each machine
Set up telescope

Vocabulary *What terms or concepts will you introduce in this session? Post these for the students to see.*

Focus Vocabulary (to be posted): Telescope, image, pixel, brightness, image processing
Additional Vocabulary (to be aware of): Exposure time, aperture, mirror, shutter, detector

Materials and Equipment

*Physical resources: S*urvey, writing utensils, observing logs, empty portfolio folders, vocabulary

Electronic resources: Stock challenge image (TowerChallenge.FITS)

Computing resources: Image processing software, Internet browser, folders set up on computer

Week 1 Icebreaker: A Big Wind Blows	**Time:** 10 minutes
Procedure MODEL THE ACTIVITY (1 minute) • All apprentices stand in a circle with the CT in the center. Use chairs or desks to mark each apprentice's place in the circle. • The person in the middle says. "My name is [name] and I [something that is true about me]. (E.g. am wearing sneakers, have brown hair) • Everyone else for whom that fact is also true (e.g. everyone who is wearing sneakers or has brown hair) leaves their spot and tries to find a new spot. The person in the middle takes someone else's spot. • The person who is left without a spot is in the middle DO THE ACTIVITY • Repeat the process above, being sure to include facts that cannot be seen just by looking at people (e.g. "is an only child," "used to live in another state," "likes basketball") DISCUSS THE ACTIVITY • Astronomers make observations of objects in space, using telescopes and other tools. • Some properties of an object can be observed just by looking at them (shape, brightness, etc.). Others need more information to explain what they are like (what they are made of, how they move, etc.) • In this apprenticeship, we will be making observations of objects in space and learning more about them through activities and research.	***Objective*** To get to know each other To begin thinking about how to describe objects

Week 1 Activity: Looking Through a Telescope **Time:** 15 minutes

Procedure

PREPARE THE ACTIVITY

- Set up a telescope outside, if possible, or in a long hallway or classroom. Point the telescope at the Moon or an object on Earth that is far enough away that its details cannot be resolved.

DO THE ACTIVITY

- Hand out paper to each apprenticeship and instruct them to split it into three sections—two large sections next to each other at the top, and one smaller section at the bottom (see example, right)
- In one section, apprentices sketch the object as it appears to them standing next to the telescope
- In the second section, apprentices sketch the object as it appears to them looking through the telescope
- In the third section, apprentices write a caption explaining what they expected to see, what they saw, and how the two views compare

DISCUSSION

- What do telescopes do? (They show us more detail in objects that are far away)
- Apprentices can share their captions if desired

Objective

To look through a telescope

To compare naked eye views with telescopic views

Example of observation page:

<table>
<tr><td>Section 1 (view without telescope)</td><td>Section 2 (view with a telescope)</td></tr>
<tr><td colspan="2">Section 3 (caption explaining expectations and observations)</td></tr>
</table>

Materials Needed: Telescope, paper, pens/pencils

Week 1: Request images from MicroObservatory	**Time:** 10 minutes
• Week 1: CT models how to request an image using the Guest Observer Portal and record the request in the Observation Log HOW TO REQUEST AN IMAGE • Open Internet browser • Go to www.microobservatory.org • Choose an activity (see list below) • Choose an object • Choose an exposure time (faint objects require longer exposure times) • Enter an email address (astronomycitizen@yahoo.com can be used) • Record request in observing log • Confirm request	***Objective*** Take images of the Moon and planets for next time.

Hint: It will save you time if you write the URL on the board for apprentices to see (it is also written on their observing logs)

How do I use the generic email account?

Go to http://mail.yahoo.com/
Enter username: astronomycitizen
Enter password: cosmos

Note: The automated emails from the MicroObservatory server are sent around 1 p.m. the day AFTER images are requested. Because multiple apprenticeships may be sharing this account, be sure to download the correct set of images from the appropriate set of emails.

Where will apprentices find the various telescope targets they need?
Look within the following Guest Observer Portal activities to find the desired targets

- ***Moon (Telescope As Time Machine, Galileo)***
- ***Planets (Galileo, Telescope As Time Machine)***
- Stars & Star Clusters (Galileo, Telescope As Time Machine)
- Nebulae (Colorful Cosmos, Black Hole Hunt)
- Galaxies (Galaxies Galore, Black Hole Hunt)

Week 1 Activity: Introduction to image information	**Time:** 10 minutes
INTRODUCTION (Open and Explore the Image) Students do each action along with the facilitator 1. Open the image processing software 2. Click “File” > “Open image on local disk…” and choose the image from the appropriate folder (TowerChallenge.FITS) 3. Click “Window” > “Image Info” 4. Move cursor over the image and notice the changes in the Image Info window. Three possible answers. The third being the one to focus on: a. The picture in the view box changes b. The numbers next to “X” and “Y” change c. The number next to the word “Pixel” changes 5. Explain what is going on. Again, answer “c” is the one to focus on. a. The view box allows us to see a closer view of the object b. The numbers next to “X” and “Y” tell us where we are in the image c. The “Pixel Value” number tells how bright that part of the image appears, or how much light is coming from that part of the object 6. CHALLENGE: Where in the image is the pixel value the highest? What value does it have? Where is it lowest? 7. OPTIONAL EXPLORATION: How can students get a better view of the individual pixels? (Answer: zoom tool—the magnifying glass icon at the top of the image)	***Objective*** Learn how to open an image on the computer Use the mouse and “Image Info” window to get information about the image. (Optional) Use the zoom tool to see the pixels more closely

Week 1 Processing Challenge: Prudential Tower (Quick reference available on page C-2 of the curriculum)	**Time:** 20 minutes (including reflection)
MODEL THE ACTIVITY Apprentices do each step along with the facilitator to achieve the activity goal: **To increase the contrast between the windows on the left side of the building and the building itself.** 1. Re-open the image TowerChallenge.FITS or return it to its original view by double clicking on the magnifying glass icon to zoom all the way out 2. Make sure the "Image Info" window is open 3. Click "Process" > "Adjust Image…" 4. Point out the "Max" and "Min" fields in the "Adjust Image" window and explain that changing these numbers changes the appearance of the image. 5. Explain that you want to make the windows on the left side of the building appear white against a black background. 6. Click on the main image window, and note in the "Image Info" window the approximate pixel value of the area that you want to appear white—windows. 7. Enter that value (300) into the "Max" field (be sure to hit enter). 8. Click on the main image window, and note in the "Image Info" window the approximate pixel value of the area of the image that you want to appear black—the surrounding building. 9. Enter that value (275) into the "Min" field (be sure to hit Enter). 10. Click on "File" > "Save Image As…" > "GIF" and choose the folder to save it in (e.g. "Week 1") 11. Save the file with a descriptive file name (e.g. NameTowerDate.GIF)	***Objective*** Learn how to change the contrast of an image using the "Adjust Image" tool. (Optional) Learn how to use false color tables to change the appearance of an image Learn how to save images with descriptive file names. • Object name • Apprentice name • Descriptive feature such as date or color of processing • File extension (.GIF) must be added explicitly. **Additional Information:** At the end of this activity, students should reopen the program and the image to make they can find and access the image on their computer. If a file is not saved as a GIF with a .GIF extension, it will not open! **WOW Goal:** Practice articulating your personal connection to the images you create.

What's Going On?

- Any pixel with a value greater than or equal to the Maximum value will appear **white** in the image
- Any pixel with a value less than or equal to the Minimum value will appear **black** in the image
- Pixel with values in between the Minimum and Maximum will appear some shade of gray
- Changing the display does NOT change the actual information in the image, just how it appears to the person looking at it

CHALLENGE

Once students have successfully recreated Tower1.GIF they should move on to the Challenge. Students should try to figure out the steps on their own, but for this first challenge, facilitators should be prepared to prompt and guide students through the specific actions:

1. Show the processed image (Tower2.GIF) and identify the goal: **Make the name of the building appear white with a black background.**
2. Open the image to be processed
3. Set "Max" value to match approximate pixel value of the letters in the word "PRUDENTIAL" (~500)
4. Set "Min" value to match approximate pixel value of the building *around* the word "PRUDENTIAL" (~350)
5. Save image with a unique, descriptive name (don't forget .GIF at the end!)

REFLECTION (Caption-writing and/or discussion)

6. Which view(s) of the Tower do you like best? Why?

This reflection helps students prepare for their final exhibit by creating a label for a chosen image: Why did you choose to put this image in your exhibit? What should visitors know about how it was made?

Once students have completed the challenge, they may change the color table of their image, and save a new version as a GIF with an appropriate descriptive name. See the Processing Challenge: Color Tables for an in-depth presentation of this tool and reflection activity.

NOTE: Some facilitators may wish simply to introduce the color tables as an add-on, rather than a separate activity.

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Week 1 (Without A Telescope)

Lesson Objectives: ***What do we need to get done today?***
By the end of the lesson, the students will:

1. Get to know each other and the Citizen Teacher
2. Take at least one image of a Moon or planet with MicroObservatory telescope

Learning Objectives: ***What will the students learn today?***
By the end of the lesson, the students will have learned:

1. How a telescope works
2. How to take images with the MicroObservatory telescopes
3. How to open and save images with the image processing software

Agenda based on the lesson plan. Post in the room for the students to see.

1. Opening: Survey & Get To Know You Icebreaker	15 Minutes
2. Review Agenda and WOW format	5 Minutes
3. Kinesthetic Telescope	15 Minutes
4. BREAK	5 Minutes
5. Take Images: Moon, Planets	10 Minutes
6. Activity: Introduction to Image Information	10 Minutes
7. Processing Challenge: Prudential Tower	20 Minutes
8. Closing Circle	10 Minutes

Preparation and Space Set up:
Post daily agenda, 10-week apprenticeship outline, and focus vocabulary for apprentices
Make sure software is installed and running on the computers
Load challenge images into appropriate folder on the computer
Create students' processed images folder on each machine
Prepare kinesthetic telescope cards and narration (Appendix E)

Vocabulary *What terms or concepts will you introduce in this session? Post these for the students to see.*

Focus Vocabulary (to be posted): Telescope, image, pixel, brightness, image processing
Additional Vocabulary (to be aware of): Exposure time, aperture, mirror, shutter, detector

Materials and Equipment

*Physical resources: S*urvey, writing utensils, observing logs, empty portfolio folders, vocabulary, kinesthetic telescope cards and narration (Appendix E)

Electronic resources: Stock challenge images (TowerChallenge.FITS)

Computing resources: Image processing software, Internet browser, folders set up on computer

Week 1 Icebreaker: A Big Wind Blows	**Time:** 10 minutes
Procedure MODEL THE ACTIVITY (1 minute) • All apprentices stand in a circle with the CT in the center. Use chairs or desks to mark each apprentice's place in the circle. • The person in the middle says. "My name is [name] and I [something that is true about me]. (E.g. am wearing sneakers, have brown hair) • Everyone else for whom that fact is also true (e.g. everyone who is wearing sneakers or has brown hair) leaves their spot and tries to find a new spot. The person in the middle takes someone else's spot. • The person who is left without a spot is in the middle DO THE ACTIVITY • Repeat the process above, being sure to include facts that cannot be seen just by looking at people (e.g. "is an only child," "used to live in another state," "likes basketball") DISCUSS THE ACTIVITY • Astronomers make observations of objects in space, using telescopes and other tools. • Some properties of an object can be observed just by looking at them (shape, brightness, etc.). Others need more information to explain what they are like (what they are made of, how they move, etc.) • In this apprenticeship, we will be making observations of objects in space and learning more about them through activities and research.	***Objective*** To get to know each other To begin thinking about how to describe objects

Week 1 Activity: Kinesthetic Telescope (More information/materials in Appendix E)	**Time:** 15 minutes
Procedure MODEL THE ACTIVITY (5 minutes) • CT reviews the vocabulary describing different parts of a telescope • Ask for volunteers to be each part of the telescope. Some parts (e.g. aperture) will need multiple people to create an appropriate formation • Set up the apprentices in the appropriate formation and designate the TL as a beam of light coming from an object in outer space. • Walk the TL through the telescope, narrating what happens to the light at each stage DO THE ACTIVITY (10 minutes) • Apprentices create their own model of the process, or recreate the process they just saw. Non-telescope apprentices can be beams of light, objects in space, or astronomers at the detector end of the telescopes. • Each part of the telescope must explain what he or she is doing. The light cannot move forward until it is given permission from the telescope o Light: travels from objects in space to the telescope o Aperture: lets the light into the telescope o Mirror: focuses the light toward the detector o Shutter: lets the light through to the detector o Detector: records the light to create an image	***Objective*** To learn/review how light travels through a telescope To learn/review what different parts of the telescope does To work together as a team to create a human telescope

Materials Needed: Narration of the process, telescope vocabulary words

Week 1: Request images from MicroObservatory	**Time:** 5 minutes
• Week 1: CT models how to request an image using the Guest Observer Portal and record the request in the Observation Log HOW TO REQUEST AN IMAGE • Open Internet browser • Go to www.microobservatory.org • Choose an activity (see list below) • Choose an object • Choose an exposure time (faint objects require longer exposure times) • Enter an email address (astronomycitizen@yahoo.com can be used) • Record request in observing log • Confirm request	***Objective*** Take images of the Moon and planets for next time.

Hint: It will save you time if you write the URL on the board for apprentices to see (it is also written on their observing logs)

How do I use the generic email account?

Go to http://mail.yahoo.com/
Enter username: astronomycitizen
Enter password: cosmos

Note: The automated emails from the MicroObservatory server are sent around 1 p.m. the day AFTER images are requested. Because multiple apprenticeships may be sharing this account, be sure to download the correct set of images from the appropriate set of emails.

Where will apprentices find the various telescope targets they need?
Look within the following Guest Observer Portal activities to find the desired targets

- ***Moon (Telescope As Time Machine, Galileo)***
- ***Planets (Galileo, Telescope As Time Machine)***
- Stars & Star Clusters (Galileo, Telescope As Time Machine)
- Nebulae (Colorful Cosmos, Black Hole Hunt)
- Galaxies (Galaxies Galore, Black Hole Hunt)

Week 1 Activity: Introduction to image information	**Time:** 10 minutes
INTRODUCTION (Open and Explore the Image) Students do each action along with the facilitator 1. Open the image processing software 2. Click “File” > “Open image on local disk…” and choose the image from the appropriate folder (TowerChallenge.FITS) 3. Click “Window” > “Image Info” 4. Move cursor over the image and notice the changes in the Image Info window. Three possible answers. The third being the one to focus on: a. The picture in the view box changes b. The numbers next to “X” and “Y” change c. The number next to the word “Pixel” changes 5. Explain what is going on. Again, answer “c” is the one to focus on a. The view box allows us to see a closer view of the object b. The numbers next to “X” and “Y” tell us where we are in the image c. The “Pixel Value” number tells how bright that part of the image appears, or how much light is coming from that part of the object 6. CHALLENGE: Where in the image is the pixel value the highest? What value does it have? Where is it lowest? 7. OPTIONAL EXPLORATION: How can students get a better view of the individual pixels? (Answer: zoom tool—the magnifying glass icon at the top of the image)	***Objective*** Learn how to open an image on the computer Use the mouse and “Image Info” window to get information about the image. (Optional) Use the zoom tool to see the pixels more closely

Week 1 Processing Challenge: Prudential Tower (Quick reference available on page C-2 of the curriculum)	**Time: 20 minutes (including reflection)**
MODEL THE ACTIVITY Apprentices do each step along with the facilitator to achieve the activity goal: **To increase the contrast between the windows on the left side of the building and the building itself.** 1. Re-open the image TowerChallenge.FITS or return it to its original view by double clicking on the magnifying glass icon to zoom all the way out 2. Make sure the "Image Info" window is open 3. Click "Process" > "Adjust Image…" 4. Point out the "Max" and "Min" fields in the "Adjust Image" window and explain that changing these numbers changes the appearance of the image. 5. Explain that you want to make the windows on the left side of the building appear white against a black background. 6. Click on the main image window, and note in the "Image Info" window the approximate pixel value of the area that you want to appear white—windows. 7. Enter that value (300) into the "Max" field (be sure to hit enter). 8. Click on the main image window, and note in the "Image Info" window the approximate pixel value of the area of the image that you want to appear black—the surrounding building. 9. Enter that value (275) into the "Min" field (be sure to hit Enter). 10. Click on "File" > "Save Image As…" > "GIF" and choose the folder to save it in (e.g. "Week 1") 11. Save the file with a descriptive file name (e.g. NameTowerDate.GIF)	***Objective*** Learn how to change the contrast of an image using the "Adjust Image" tool. (Optional) Learn how to use false color tables to change the appearance of an image Learn how to save images with descriptive file names. • Object name • Apprentice name • Descriptive feature such as date or color of processing • File extension (.GIF) must be added explicitly. **Additional Information:** At the end of this activity, students should reopen the program and the image to make they can find and access the image on their computer. If a file is not saved as a GIF with a .GIF extension, it will not open! **WOW Goal:** Practice articulating your personal connection to the images you create.

What's Going On?

- Any pixel with a value greater than or equal to the Maximum value will appear **white** in the image
- Any pixel with a value less than or equal to the Minimum value will appear **black** in the image
- Pixel with values in between the Minimum and Maximum will appear some shade of gray
- Changing the display does NOT change the actual information in the image, just how it appears to the person looking at it

CHALLENGE

Once students have successfully recreated Tower1.GIF they should move on to the Challenge. Students should try to figure out the steps on their own, but for this first challenge, facilitators should be prepared to prompt and guide students through the specific actions:

1. Show the processed image (Tower2.GIF) and identify the goal: **Make the name of the building appear white with a black background.**
2. Open the image to be processed
3. Set "Max" value to match approximate pixel value of the letters in the word "PRUDENTIAL" (~500)
4. Set "Min" value to match approximate pixel value of the building *around* the word "PRUDENTIAL" (~350)
5. Save image with a unique, descriptive name (don't forget .GIF at the end!)

REFLECTION (Caption-writing and/or discussion)

6. Which view(s) of the Tower do you like best? Why?

This reflection helps students prepare for their final exhibit by creating a label for a chosen image: Why did you choose to put this image in your exhibit? What should visitors know about how it was made?

Once students have completed the challenge, they may change the color table of their image, and save a new version as a GIF with an appropriate descriptive name. See the Processing Challenge: Color Tables for an in-depth presentation of this tool and reflection activity.

NOTE: Some facilitators may wish simply to introduce the color tables as an add-on, rather than a separate activity.

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Week 2 (Objects in Our Solar System)

Lesson Objectives: ***What do we need to get done today?***
By the end of the lesson, the students will:

1. Process and save at least one image of the Moon (with caption!)
2. Create an astronomy poem

Learning Objectives: ***What will the students learn today?***
By the end of the lesson, the students will have learned:

1. How to use the sharpen and zoom tools
2. How to make detailed observations
3. What sorts of words can help people understand astronomy images
4. Information about objects in our solar system

Agenda based on the lesson plan. Post in the room for the students to see.

1. Opening: What's Different? Icebreaker	10 Minutes
2. Review Agenda and Introduce Vocabulary	5 Minutes
3. Processing Challenge: Moon	25 Minutes
4. Take images: Nebulae, Stars	5 Minutes
5. BREAK	5 Minutes
6. Creative Challenge: Astro Poetry	25 Minutes
7. Closing Circle	15 Minutes

Preparation and Space Set up:
Post daily agenda, 10-week apprenticeship outline, and focus vocabulary for apprentices
Make sure software and processed images are still on computers
Retrieve apprentices' requested images from last week and load them onto the computers

Vocabulary *What terms or concepts will you introduce in this session? Post these for the students to see.*

Focus Vocabulary: Moon, Planet, Our Solar System, Zoom
Additional Vocabulary: Crater, Sharpen, Crop, False Color Table

Materials and Equipment

Physical resources: Observing logs, processing logs, index cards, markers, astronomical images

Electronic resources: Moon & planet images requested last week, Stock Moon challenge image (MoonChallenge.FITS)

Computing resources: Electronic folders, processing software, Internet browser on each computer

Week 2 Icebreaker: Noticing Detail – What's different? **Time:** 10 minutes	
Procedure MODEL THE ACTIVITY (2 minutes) • All apprentices line up facing the front of the classroom. CT/TL stands facing the apprentices. • Apprentices examine the CT/TL and observe as many things about his/her appearance as they can. • After 30 seconds, apprentices turn around to face the back of the classroom while the CT/TL changes a small but noticeable feature on his/her person (e.g. takes off name tag, rolls up shirt sleeve, changes hair style) • When given the "all clear" by the CT/TL, apprentices turn around and try to identify what has changed. DO THE ACTIVITY (6 minutes) • The person who correctly identifies the change becomes the next person to make a change. • Repeat until everyone has had a turn DISCUSS THE ACTIVITY (2 minutes) • Astronomers must notice details in images and make very careful observations to determine what objects are like and how they change. • In this apprenticeship, students will be examining images of their own and explaining to their audience what they observe.	***Objective*** To begin looking carefully at objects being observed

Week 2 Processing Challenge: The Moon (Quick reference available on page C-3 of the curriculum)	**Time: 25 minutes (including reflection)**
INTRODUCTION 1. Review how to open the software, images, and image windows (Image Info, Adjust Image) 2. Open image MoonChallenge.FITS 3. Explain the goal of the activity: **To get a better, more detailed view of a chosen crater on the surface of the Moon** MODEL ACTIVITY (students follow along) 1. Click “Process” > “Sharpen” 2. Click on the ‘zoom’ tool (magnifying glass) 3. Click on the crater to be observed (middle of image) 4. Adjust the contrast on the image in the by moving the triangles in the “Adjust Image” window 5. Demonstrate the use of color tables and re-adjust the contrast if necessary/desired. 6. Once the image looks how you want it, click on the ‘select area’ tool (dotted rectangle) 7. Select the area to be cropped by clicking on one corner of the desired area and dragging the mouse to the opposite corner and then releasing 8. Click “Process” > “Crop” 9. Save the new image as a GIF file with a descriptive name **Note:** Cropping should always be the LAST thing that you do before saving an image. The cropped image will open up in a new window and the zoom tool will not work the same way as it does in the original.	***Objective*** Review how to open and save an image. Learn how to zoom in on an image Learn how to crop an image Practice using the “Adjust Image” tool to change the contrast of an image in a new way Learn how to sharpen an image Apply color tables to change the appearance of an image **Additional Information** The Sharpen tool is rarely used for processing images other than the Moon. As such, it may be skipped. Because the color tables are so popular, students will likely have discovered them during the first week of processing challenges. If they have not, introduce them as an add-on this week. **WOW Goals:** Use teamwork to communicate information about an image to an audience. Practice writing captions.

STUDENT CHALLENGE The challenge is presented in gray scale so that students can focus on the contrast, zooming, and cropping tools. Color tables can be added later. 1. Show the processed image (Moon2.GIF) and identify the goal: **Create a sharp detailed view of craters at the bottom of the Moon** 2. Prompt and assist students in figuring out how to complete the challenge on their own/in pairs. 3. Sharpen the image 4. Zoom in on the chosen area 5. Adjust the contrast by moving the triangles/changing the "Min" and "Max" values in the "Adjust Image" window. 6. Select and crop the chosen area of the image 7. Save the cropped image as a GIF file	Steps 3-6 are listed for the facilitator's reference only—students must make a good faith effort to figure things out before facilitators reveal the "answers." NOTE: Students do not need to match the contrast settings exactly, but for reference, the "Min" and "Max" values in the presented image were set to match the pixel values of the background (~280) and bright spots on the surface (~550).
OPTIONAL CHALLENGE/FREE PROCESSING If desired, create another challenge image with a false color table. See "Color Tables" challenge for more info. 1. Experiment with the various tools (including color tables) using the telescope images requested last week. 2. Save all processed images as GIF files with unique, descriptive names, and record in the processing log how you made each image.	With limited time, it is tempting to skip the caption-writing part of the exercise, but this will be a key element of the final projects.
REFLECTION (Caption-writing/gallery interviews) 1. Look at another image that has been created. Interview the person who created it. How did they make it? What do they like about it? 2. Prepare a caption for your partner's image and share it with the group	The interview model is useful because it helps students articulate what they or other people did to create an image. During the final WOW, students will be responsible for presenting each other's images as well as their own.

Week 2: Request images from MicroObservatory	**Time: 5 minutes**
HOW TO REQUEST AN IMAGE • Open Internet browser • Go to www.microobservatory.org • Choose an activity (see list below) • Choose an object • Choose an exposure time (faint objects require longer exposure times) • Enter an email address (astronomycitizen@yahoo.com can be used) • Record request in observation log • Confirm request	***Objective*** Take images of stars and nebulae for next time. **Hint:** It will save you time if you write the URL on the board for apprentices to see (it is also written on their observing logs)

Telescope Targets (Guest Observer Portal Activity Locations)

- Moon (Telescope As Time Machine, Galileo)
- Planets (Galileo, Telescope As Time Machine)
- ***Stars & Star Clusters (Galileo, Telescope As Time Machine)***
- ***Nebulae (Colorful Cosmos, Black Hole Hunt)***
- Galaxies (Galaxies Galore, Black Hole Hunt)

Week 2 Creative Challenge: AstroPoetry	**Time:** 20 minutes
Procedure MODEL THE ACTIVITY (CT & TL) (5 minutes) • CT shows an astronomical image taken by a professional or amateur astronomer/astrophotographer. • Ask apprentices what they know about the image and what words they would use to describe it (e.g. bright, swirling) or what it reminds them of (e.g. marble, pancake, hula hoop). • TL records one word per index card. • CT & TL rearrange words to create a poem and read the poem aloud. DO THE ACTIVITY (Apprentices) (15 minutes) • Split into two teams—each team is given/chooses an astronomical image about which to create their poem • 5 minutes to brainstorm words (include nouns, verbs, and adjectives!) • 5 minutes to create poem (can add in connecting words if desired, or add pre/suffixes to existing words) • 5 minutes to share & reflect	***Objective*** To notice details in an astronomical image. To creatively express what is known objects in space.

Materials needed: Index cards, markers, astronomical images

Other notes:
- Groups can compete to make the most descriptive poem about the same object, or they can each work on a different object (chosen or assigned)
- Poems can include astronomical information if it is known
- Apprentices should practice good oral presentation skills when they present their poems—speaking slowly, loudly, and clearly, while showing their image with the poem.

Week 3 (Stars and Nebulae)

Lesson Objectives: ***What do we need to get done today?***
By the end of the lesson, the students will:

1. Process and save at least one image of a nebula (with caption!)
2. Work together to create kinesthetic models

Learning Objectives: ***What will the students learn today?***
By the end of the lesson, the students will have learned:

1. What stars and nebulae are
2. How the "Adjust Image…" tool changes the contrast of an image

Agenda based on the lesson plan. Post in the room for the students to see.

1. Opening: Human Machines Teambuilding	15 Minutes
2. Review Agenda and Introduce Vocabulary	5 Minutes
3. Processing Activity: Orion Nebula	10 Minutes
4. Processing Challenge: Star Cluster	10 Minutes
5. Take images: Galaxies	5 Minutes
6. BREAK	5 Minutes
7. Creative Challenge: Kinesthetic Astronomy	25 Minutes
8. Closing Circle	10 Minutes

Preparation and Space Set up:
Post daily agenda, 10-week apprenticeship outline, and focus vocabulary for apprentices
Retrieve apprentices' requested images from last week and load them onto the computers
Choose an open area (outside or indoors) for the kinesthetic astronomy activity

Vocabulary *What terms or concepts will you introduce in this session? Post these for the students to see.*

Focus Vocabulary: Star, Nebula, Contrast, Gravity
Additional Vocabulary: Our Milky Way Galaxy

Materials and Equipment

Physical resources: Portfolio folders, observing logs, processing logs, token astronomical images for illustrating stellar life cycle (Appendix A)

Electronic resources: Images of stars and nebulas, Stock challenge images (NebulaChallenge.FITS and StarClusterChallenge.FITS)

Computing resources: Image processing software, Internet browser, electronic image folders

Week 3 Icebreaker: Human Machines (Teambuilding) **Time:** 15 minutes

Procedure

MODEL THE ACTIVITY (5 minutes)

- CT and TL work together to kinesthetically create a machine, such as an old-fashioned grandfather clock (one person is the face; the other is the pendulum)
- Help the apprentices to create their first machine:
  - Computer: two students can make the outline of a screen with their arms; everyone else squats down to become buttons on the keyboard
  - Microwave: two students create the compartment, one student is a rotating plate inside, others are buttons, plugs, etc.

DO THE ACTIVITY (All together or in small groups)

- Challenge apprentices to create other machines, such as a telephone, toaster, television, carousel, blender, bicycle, etc. (be creative…choose your own!)
- Each apprentice becomes one part of the machine, NOT the humans operating it, unless necessary

DISCUSS THE ACTIVITY

- What was hard about this activity? (Listening to others, communicating your ideas, working together, people forgetting to do their action, etc.)
- Astronomers have to share ideas and work together to build telescopes and interpret their data.
- In this apprenticeship, we will need everyone's input to make our exhibit a success. If one person doesn't do their part, the process won't work!

Objective

To become comfortable working together toward a common goal.

To improve communication and cooperation among apprentices.

Week 3 Processing Activity: Orion Nebula **Time: 5-10 minutes**
(Quick reference available on page C-4 of the curriculum)

MODEL THE ACTIVITY

Students follow along on their own computers, through both examples

1. Open the image processing software and the image "NebulaChallenge.FITS"
2. Open the "Image Info" window, and the "Adjust Image" window
3. Point out the buttons at the bottom of the "Adjust Image" window ("Linear," "Log," "Auto") and explain that these are shortcuts that we can use to bring out interesting parts of an image.

EXAMPLE 1 (Nebula1.GIF)

1. Click the "Auto" button in the "Adjust Image" window and ask students to describe the resulting image
2. Ask if anyone remembers how to set the background of the image to black and, at their prompting, or as a reminder, guide them through setting the "Min" field to the approximate pixel value of the background (~289)
3. Point out the newly revealed features around the edges of the cloud (wisps of gas on the right, etc.)
4. Crop and save image as a GIF with a descriptive name

Objective

Learn how to use the "Auto" and "Log" functions of the "Adjust Image" tool

Remember how to change the contrast in an image, zoom, and crop

Additional Information

Because the "Auto" function is quick and straightforward (at least mechanically), two examples are given using the Orion Nebula image. Both examples will make minor adjustments to the appearance of the image to improve the view after using the "Auto" function.

The challenge itself will use a different image, but the same procedure.

EXAMPLE 2 (Nebula2.GIF)

1. Re-open image NebulaChallenge.FITS
2. Choose “Log” and click the “Auto” button in the “Adjust Image” window…what do students see?
3. Explain that you want a better view of what is going on at the center of the nebula
4. Zoom in on the center of the nebula
5. Ask students to look at the “Image Info” window and describe the range of pixel values in that area
6. Set “Max” field to the highest pixel value in the image (~4000, at the heart of the nebula)
7. Point out the newly revealed details of the cloud in the image (i.e. stars and texture)
8. Crop and save the image as a GIF with a descriptive name

What’s Going On?

- **Auto** looks at the range of pixel values in the image and sets the contrast range (Min/Max) to display high pixel values as bright areas of the image and low pixel values as dark areas
- **Linear** is the default scale: low pixel values appear darker and high values appear brighter, in roughly even intervals
- **Log** scale is an exponential scale. It displays a wide range of brightness for high pixel values and allows you to see more details at both ends of the range
- Generally, log scale is the best way to view images of objects like galaxies and nebulae

Week 3 Processing Challenge: Star Cluster (Quick reference available on page C-5 of the curriculum)	**Time: 10-15 minutes**
CHALLENGE Students work independently or in pairs to figure out how to make StarClusterChallenge.FITS look like StarCluster1.GIF 1. Open StarClusterChallenge.FITS, show the processed image (StarCluster1.GIF) and identify the challenge: **Make visible as many stars as possible in the Hercules star cluster.** 2. Remind students about what they did to make the details of the image of the Orion Nebula visible and use this information as prompts to complete the following: 3. Click the "Auto" button in the "Adjust Image" window 4. Set the "Min" field to the approximate pixel value of the background (~295) 5. Click the "Log" in "Adjust Image" window 6. Set "Max" field to the highest pixel value in the image (~950, at the center of the cluster) 7. Crop and save the image as a GIF file with a descriptive name FREE PROCESSING AND REFLECTION Students should process images of other objects using the various processing tools on their own telescope images. Remember to save all processed images as GIF files with unique, descriptive names, and record in the processing log each image was made. At the end of the session, everyone should discuss, caption, and reflect on the processed images with partners or in the large group. Shout-outs welcome.	***Objective*** Practice using the image processing software to bring out detail in an image **Additional Information** Although false color tables are not an explicit part of this challenge, students are encouraged to experiment with color tables and/or the invert color tool in creating their final, saved images. **WOW Goals:** To make detailed observations about an image To practice sharing observations about an image

Week 3: Request images from MicroObservatory	**Time: 5 minutes**
HOW TO REQUEST AN IMAGE • Open Internet browser • Go to www.microobservatory.org • Choose an activity (see list below) • Choose an object • Choose an exposure time (faint objects require longer exposure times) • Enter an email address (astronomycitizen@yahoo.com can be used) • Record request in observation log • Confirm request	***Objective*** Take images of galaxies for next time. **Hint:** It will save you time if you write the URL on the board for apprentices to see (it is also written on their observing logs)

Telescope Targets (Guest Observer Portal Activity Locations)

- Moon (Telescope As Time Machine, Galileo)
- Planets (Galileo, Telescope As Time Machine)
- Stars & Star Clusters (Galileo, Telescope As Time Machine)
- Nebulae (Colorful Cosmos, Black Hole Hunt)
- ***Galaxies (Galaxies Galore, Black Hole Hunt)***

Week 3 Creative Challenge: Kinesthetic Astronomy (More information available in Appendix D)	**Time:** 25 minutes
Procedure • Review the day's vocabulary, explaining that stars, like nebulae, are made of gas and dust. They are born inside giant star-forming nebulae and when they die they leave behind other types of nebulae. Each student will represent a clump of gas in the star or nebula. • CT shows an astronomical image and explains the process that each object is going/has gone through. • TL helps students recreate that process kinesthetically. o Star Forming Nebula: Clumps of gas are pulled together by the force of gravity, forming stars o Star: Fusion in the core of a star creates an outward pressure that balances the force of gravity in the outer layers. o Planetary Nebula: The core of an ordinary star collapses and the outer layers drift outward into space. o Supernova (Remnant): The core of a very massive star collapses and the outer layers fall inward and bounce off the core and explode outward, releasing energy. See additional background information for a diagram of student motion in each stage.	***Objective*** To learn about different types of nebulae To create a kinesthetic model of astronomical phenomena

Materials Needed: Astronomical images and/or poster showing stellar life cycle objects (star-forming nebula, stars (main sequence & red giant), planetary nebula, supernova remnant)

Other notes:
- Rather than using this activity to teach about the overarching life cycle of stars, this approach focuses on interpreting what can be seen in images.
- See Appendix D for detailed background information and additional resources

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Week 4 (Galaxies)

Lesson Objectives: ***What do we need to get done today?***
By the end of the lesson, the students will:

1. Process and save at least one image of a galaxy (with caption!)
2. Create a three-dimensional astronomy sculpture

Learning Objectives: ***What will the students learn today?***
By the end of the lesson, the students will have learned:

1. What a galaxy is
2. How physical perspectives affect our view of objects in space
3. How to give clear instructions to a peer

Agenda based on the lesson plan. Post in the room for the students to see.

1. Opening: Blind Sculpture Challenge	15 Minutes
2. Review Agenda and Introduce Vocabulary	5 Minutes
3. Processing Challenge: Galaxies	25 Minutes
4. Take images: Miscellaneous	5 Minutes
5. BREAK	5 Minutes
6. Creative Challenge: Astro Sculpture	25 Minutes
7. Closing Circle	10 Minutes

Preparation and Space Set up:
Post daily agenda, 10-week apprenticeship outline, and focus vocabulary for apprentices
Retrieve apprentices' requested images from last week and load them onto the computers
Set up work space (and supplies) for 3D model construction

Vocabulary *What terms or concepts will you introduce in this session? Post these for the students to see.*

Focus Vocabulary: Galaxy, Universe, Noise, Gravity

Materials and Equipment

Physical resources: Portfolio folders, observing and processing logs, craft supplies (including clay for blind sculpture challenge), writing utensils

Electronic resources: Students' requested images of galaxies from last week, Stock challenge image (GalaxyChallenge.FITS)

Computing resources: Image processing software, Internet browser, electronic image folders

Week 4 Icebreaker: Blind Sculpture (Teambuilding) **Time:** 10 minutes

Procedure

MODEL THE ACTIVITY (2 minutes)

- CT creates a sculpture by piecing together multiple basic shapes out of a blob of clay.
- CT then describes the sculpture to the TL, who recreates it out of another blob of clay.

DO THE ACTIVITY (6 minutes)

- Apprentices sit back-to-back and each create a sculpture with at least two components
- Apprentices take turns describing their sculptures for their partners to recreate.
- (Optional) Apprentices can ask clarifying questions.

DISCUSS THE ACTIVITY (2 minutes)

- What could your partner have said that would have helped you create a better replica of their sculpture?
- Good science involves designing an experiment or project in a way that allows others to reproduce it. Astronomers have to be very clear about ideas and models so that everyone working on the project is on the same page.
- In this apprenticeship, everyone will have their own ideas for what they mean by the same term, and will need to clearly communicate what they want to happen. (For example, if someone says to "make a star," does that mean a five-pointed object or a round ball, like stars in space?"

Objective

To practice clear communication.

To practice listening and asking questions about what other people are saying.

Materials: Clay

Week 4 Processing Challenge: Whirlpool & Other Galaxies **Time: 25 minutes**
(Quick reference available on page C-5 of the curriculum)

MODEL THE ACTIVITY (5 minutes)

Because this is the final week of processing challenges, students will be encouraged to review their own knowledge in both the activity and the challenge.

1. Show students the processed image (Galaxy1.GIF) and identify the challenge: **To create a clear, detailed image of another galaxy outside of the Milky Way**
2. Open image GalaxyChallenge.FITS and encourage students to provide step-by-step guidance on how to best process the image (see steps below)
3. Open the "Image Info" and "Adjust Image" windows
4. Choose "Log" and click the "Auto" button in the "Adjust Image" window
5. Adjust the "Max" value by moving the upper triangle in the "Adjust Image" window
6. Once the image looks the way the facilitator and students want, announce that it is time for the final new image processing tool of the apprenticeship.
7. Click on "Process" > "Reduce Noise" to get rid of the background "fuzz" in the image and make the stars in our own Milky Way galaxy stand out clearly
8. Zoom in, crop, and save the image as a GIF with a unique, descriptive name.

What's Going On?

- The **Reduce Noise** tool essentially blurs the image, so that individual pixels in the image are blended with the surrounding pixels
- This actually changes the image data (pixel values) but is a useful tool for helping students distinguish between stars and "background fuzz"
- Note that all individual stars in these images are *inside* our own Milky Way Galaxy

Objective

Learn how to use the "Reduce Noise" tool

Apply all processing tools to the images taken during the apprenticeship

Additional Information

For an added challenge, change the color table and/or invert the image. Can students replicate the final view?

WOW Goals:

To make detailed observations about an image

To practice sharing observations about an image

CHALLENGE (10 minutes) Goal: **For apprentices to process one of their own images and teach someone else how to reproduce it.** 1. Now that students have learned how to use the basic tools of the image processing software, they are free to apply any or all of them to their own telescope images. 2. Students take approximately 2 minutes each to process one of their own images using the full suite of processing tools (adjust contrast, sharpen, reduce noise, zoom, crop, color tables, etc.) 3. In pairs, take turns examining and recreating the other person/team's image. 4. Remember to save every processed image as a GIF with a unique, descriptive name. 5. Together, the pairs should create captions for each image, using the processing log prompts FREE PROCESSING AND REFLECTION (10 minutes) 1. With any remaining time in the session, students continue to process their own telescope images 2. As an additional challenge, choose two galaxies that look very different and process them using the same steps and tools. 3. Be sure to leave time at the end of the session for shout outs and caption/image sharing	

Week 4: Request images from MicroObservatory	**Time: 5 minutes**
HOW TO REQUEST AN IMAGE • Open Internet browser • Go to www.microobservatory.org • Choose an activity (see list below) • Choose an object • Choose an exposure time (faint objects require longer exposure times) • Enter an email address (astronomycitizen@yahoo.com can be used) • Record request in observation log • Confirm request	***Objective*** Take images for next time (variety of astronomical objects). **Hint:** It will save you time if you write the URL on the board for apprentices to see (it is also written on their observing logs)

Telescope Targets (Guest Observer Portal Activity Locations)

- Moon (Telescope As Time Machine, Galileo)
- Planets (Galileo, Telescope As Time Machine)
- Stars & Star Clusters (Galileo, Telescope As Time Machine)
- Nebulae (Colorful Cosmos, Black Hole Hunt)
- Galaxies (Galaxies Galore, Black Hole Hunt)

Note: This is the last week that students will use the online telescopes to request images!

Week 4 Creative Challenge: AstroSculpture	**Time:** 25 Minutes
Procedure MODEL THE ACTIVITY (CT & TL) (5 minutes) • Show an image of the Moon • Hold up a paper plate and a balloon/clay ball—ask apprentices which one is a better representation of the object in the image and ask them to explain why. • Ask apprentices for ideas about how to make their chosen model look more like the actual object in space (draw on craters, make dents, sprinkle with dust, etc.) **OR:** Show a pre-made model of a galaxy (CD with cotton ball center, for example) and demonstrate how it can be viewed so that it looks like different MicroObservatory images (face-on, edge-on, close, far away). DO THE ACTIVITY (Apprentices) (20 minutes) • Split into small groups (2-3 students) • Each group chooses an image taken by a professional or amateur astronomer/astrophotographer and creates a three dimensional model of the object in the photo • CT & TL help the groups by asking leading questions: What do you think this object feels like? Is it all one piece? What is it made of? What is this object doing? How can you represent that process? • Each group shares their model (5 minutes)	***Objective*** To explore the relationship between three-dimensional objects and two-dimensional images. To creatively interpret the nature of astronomical objects.

Materials Needed: Astronomical images, craft supplies of different shapes (flat, round, pointy, etc.), textures (smooth, stretchy, gritty, soft, etc.), and appearances (shiny, translucent, dark, bright, etc.), craft tools (scissors, glue, tape, stapler, markers, etc.)

SUGGESTIONS FOR CRAFT SUPPLIES: Colored construction paper, box of clay, cotton balls, yarn, fabric, netting (tulle), fiber batting, fiber batting (quilt filler), glow string, bubble wrap, wax paper, aluminum foil, plastic wrap, balloons, pipe cleaners, craft sticks, small styrofoam or squishy balls (e.g. pom-poms) of various sizes, paper plates, toilet paper

Week 5

Lesson Objectives: ***What do we need to get done today?***
By the end of the lesson, the students will:

1. See a telescope?
2. See an exhibit?
3. Meet astronomers?

Learning Objectives: ***What will the students learn today?***
By the end of the lesson, the students will have learned:

1. How astronomers process images?
2. What makes an exhibit interesting and/or effective?

Agenda based on the lesson plan. Post in the room for the students to see.

1. Opening Circle	10 Minutes
2. Field Trip, Part I	20 Minutes
3. BREAK	5 Minutes
4. Field Trip, Part II	20 Minutes
5. Closing Circle	5 Minutes

Preparation and Space Set up:

Depends on field trip

Vocabulary *What terms or concepts will you introduce in this session? Post these for the students to see.*

Depends on field trip

Materials and Equipment

Physical resources: Depends on field trip…paper and writing utensils for taking notes?

Electronic resources: Depends on field trip…astronomical images?

Computing resources: Depends on field trip…image processing tools?

See next page for suggestions of possible field trip destinations

Field Trip Ideas for Week 5 (could be week 4 or 6 if desired; adjust schedule accordingly)

The purpose of the field trip is to give students an experience with /exposure to the authentic work of adults which is reflected in the work of the apprenticeship.

Obviously, we encourage you to share more directly what you do in your profession or vocation, which has some connection to what the apprentices do during "Kids Capture Their Universe"

Ideas (some tried previously) include the following:

- Visit to Harvard-Smithsonian Center for Astrophysics to see the MicroObservatory telescopes in person.
- Visit to lab/research center to interact with astronomers using similar image processing tools in their work
- Visit to museum to observe the work of a curator in organizing an exhibit and to get ideas for apprentices' own exhibition
    - The Museum of Science astronomy gallery outside the planetarium is free
    - Other local museums may not have astronomy displays, but can still be relevant to the apprenticeship—Museum of Fine Arts, MIT Museum
- Visit to a workshop/observatory for making telescopes / observing
- Visit to a planetarium (could include exhibits?)
- Visit to lab/research center where you work.
- Visit to any company / lab where image processing is used on a regular basis (medical imaging, x-ray technician, etc.)

Students are encouraged to choose at least one question and associated image they have processed to ask any experts they may encounter during the field trip.

Arrange for apprentices to meet you at the field trip location at a certain time. Be sure to leave "wiggle room" for traffic or transportation delays.

Week 6

Lesson Objectives: ***What do we need to get done today?***
By the end of the lesson, the students will:

1. Process the remaining images in their portfolios
2. Write the remaining captions for their images
3. Choose images for their exhibit displays

Learning Objectives: ***What will the students learn today?***
By the end of the lesson, the students will have learned:

1. A strategy for providing feedback to their peers
2. How to make choices using their own and other people's opinions
3. That all their processing challenges play a role in the final exhibit!

Agenda based on the lesson plan. Post in the room for the students to see.

1. Opening: Review Field Trip and write Thank You cards	5 Minutes
2. Review Agenda and Vocabulary	5 Minutes
3. Challenge: Final Processing & Caption Writing	25 Minutes
4. BREAK	5 Minutes
5. Activity: "Best in Show" peer feedback	20 Minutes
6. Activity: Develop exhibit image groups for WOW	15 Minutes
7. Closing Circle	15 Minutes

Preparation and Space Set up:
Post daily agenda, 10-week apprenticeship outline, and focus vocabulary for apprentices
Retrieve apprentices' requested images from Week 4 and load them onto the computers
If desired, fill out "Image Template" worksheet with existing images and accompanying captions
Print out document and place pages in respective students' portfolio folders

Vocabulary *What terms or concepts will you introduce in this session? Post these for the students to see.*

No new vocabulary, but words from past weeks should be posted
Focus Vocabulary: zoom, contrast, brightness, noise
Additional Vocabulary: crop, pixel, false color table

Materials and Equipment

Physical resources: Student folders (with all existing images, captions, and observing logs), blank processing logs, Post-Its, colored stickers for voting, writing utensils, WOW Voting template slips (if desired)

Electronic resources: Full supply of images requested by students, loaded onto computers

Computing resources: Image processing software

Week 6 Activity: Final processing and caption writing **Time:** 25 minutes	
Procedure • Apprentices take time to finish processing final 1 to 2 images. • Apprentices create captions for any images they want to be considered for the final exhibit display. • Students can add to captions, based on the answers to questions they had about each image that may have been answered during the field trip. • If time, students can use resources to find answers to questions they have raised about their images.	***Objective*** To finish all captions for processed images

Week 6 Activity: "Best in Show" peer feedback	**Time:** 20 minutes
Procedure PREPARATION (5 minutes) • Print out or have each apprentice display all images for consideration on their computer screen. • Print/write out captions for each image and display it near the image. VOTING (10 minutes) • Students take a few minutes to wander around the room and mentally identify their favorite image/caption combination created by their peers. • Each student/CT/TL gets 10 or so sticky dots • Students/CT/TL place sticky dots on the labels associated with their favorite images CHOOSING (10 minutes) • Students return to their image collection and choose their top 2-3 images for the WOW! (Sticky dots provide feedback about which images their peers liked best, but the ultimate decision is their own.) • Students assemble their chosen images and accompanying captions	***Objective*** To provide positive feedback on apprentices' images To choose final images for exhibit displays

Materials needed: Sticky dots, pens/pencils, Post-Its

Week 6 Activity: Develop image exhibit groups	**Time:** 15 minutes

Procedure
 	
• Students present each of their chosen images to the group, pointing out important vocabulary that their selections include
 	
• With input from apprentices, CT/TL presents possible groupings for final exhibit displays, based on the submitted images and range of vocabulary
 	
• Some ideas for groupings include the following:
  ○ type of object (solar system, nebulae, galaxies)
  ○ color
  ○ image processing tool used
 	
• If needed, students can vote on the final groupings.
 	
• Note: assigning students to a particular group happens in week 7, but if there is extra time, facilitators can get a head start on this by soliciting requests/preferences in week 6 (to be discussed between CT and TL during the interim)
	Objective
	
	To decide the group themes for the exhibits.

Week 7 (Creative Element Construction)

Lesson Objectives: ***What do we need to get done today?***
By the end of the lesson, the students will:

1. Complete at least one "creative element" for their exhibit displays, including a caption
2. Create an overall written introduction for their exhibit display

Learning Objectives: ***What will the students learn today?***
By the end of the lesson, the students will have learned:

1. Organizational skills for sharing work between team members
2. Time management skills for working within a deadline

Agenda based on the lesson plan. Post in the room for the students to see.

1. Review Agenda	5 Minutes
2. Choose exhibit groups	10 Minutes
3. Lighthouse Game (Teambuilding Activity)	10 Minutes
4. "Creative element" construction	50 Minutes (including break)
5. Clean up	5 Minutes
6. Closing: Lighthouse Awards	10 Minutes

Preparation and Space Set up:
Post daily agenda, 10-week apprenticeship outline, and focus vocabulary for apprentices
Insert processed images and captions chosen for display into the "Images Template" (if desired)
Print out remaining processed images and captions and place them in the appropriate portfolios

Vocabulary *What terms or concepts will you introduce in this session? Post these for the students to see.*

No new vocabulary, but words from past weeks should be posted (they will be helpful in writing captions and/or preparing for next week's vocabulary competition).
Focus Vocabulary: Moon, planet, star, nebula, galaxy,
Additional Vocabulary: Our Solar System, Milky Way, universe

Materials and Equipment

Physical resources: Blindfolds, candy, exhibit display boards. craft supplies, students' printed-out images and captions for exhibit displays, WOW Planning checklists, (optional) sample exhibit display created by CT/TL to show apprentices, WOW Voting slips if not already decided

Electronic resources: None, but apprentices' images should still be on the computers

Computing resources: None, unless text for exhibit display boards is to be typed/printed during the session or additional images need to be processed (software would be needed for this)

Week 7 Activity: Choose exhibit groups	**Time:** 10 minutes

Procedure
 	
• CT/TL sets out all color images and associated captions for each of the exhibits, as determined in week 6. In each area, one piece of paper is available
 	
• Apprentices vote on which exhibit "team" they'd like to work.
 	
• While CT and TL create the final exhibit groups, students visit every exhibit area and brainstorm ideas for possible "creative" projects that could go with each exhibit area.
 	
  ○ Examples include words for astropoems, sketches for sculptures, or some other idea (flipbook, game, etc.)
 	
  ○ Apprentices write ideas on a common piece of paper to be left in that area.
 	
• CT/TL announces final groups (which then stay together for the light house opening challenge).
	Objective
	
	To choose the apprentices who will work on each exhibit display
	
	To allow all students to have creative input on each exhibit section

Materials: All color images and captions, scrap paper

Week 7 Activity: Lighthouse Game (Teambuilding)	**Time:** 10 minutes
Procedure MODEL THE ACTIVITY • CT (or TL) is blindfolded by TL (or CT) • TL sets up a short obstacle course of furniture, etc. and positions CT at one end of it. TL puts a few pieces of candy in the CT's hand and moves to the opposite side of the obstacle course. • The CT is the "ship," the candy is the "cargo" and the TL is the "lighthouse," who must guide the ship through the course to deliver the cargo by giving very specific and clear instructions (turn a little bit to your left, take a small step forward, etc.) • When the CT makes it through the course without hitting any of the furniture, the TL gets the cargo as a reward for good guidance DO THE ACTIVITY • Apprentices take turn being ships and lighthouses within their project groups. (For groups of three or more, take turns giving instructions, or have two lighthouses guide the ship through different parts of the obstacle course.) • If the ship is guided through the course and manages to deliver its cargo without running into anything, the lighthouse gets to keep the cargo as a reward for good guidance. DISCUSS THE ACTIVITY • Astronomers work in teams and must trust each other • Each component of the exhibit will require multiple people's input to be successful and people will have to work on each other's ideas.	***Objective*** To develop trust among peer groups To practice giving clear, specific instructions and explanations

Materials: Blindfolds, small pieces of candy

Week 7 Activity: Creative element construction	**Time:** 50 minutes (including break)
Procedure • Based on brainstormed ideas contributed for each exhibit display group, apprentices decide on one or more possible "creative elements" that is inspired by one or more of the images/captions in their display. ○ Apprentices should focus on astropoems and/or astrosculptures, but can decide on other creative expressions like flip-books, games, songs, etc. • Apprentices select one or more ideas, and assign team members to construct /create them. • For each "creative element" constructed, apprentices must write a caption answering the following question: **How is this creative element related to the image(s) in your display?** • For each group's exhibit, students must write a "written introduction" about the overall exhibit, answering the following question: **What is this exhibit about?**	***Objective*** To complete a creative element to the exhibit, including a caption. To create a "written introduction" for each segment of the exhibit (one per apprentice group) **Note:** By the end of Week 7, all components of the exhibit displays should be completed! Students should be sure to point out important vocabulary in their captions

Materials: Construction materials, construction paper for astropoems, "creative element" captions and "written introduction"

Week 7 Activity: Lighthouse Awards (Teambuilding)	**Time:** 10 minutes
Procedure This is a closing circle activity • Apprentices give "shout outs" to someone else on their team, praising something that person did to guide/help them with their project • Both apprentices (the "shouter" and the person he/she recognizes) get a prize	***Objective*** To recognize team members for their contributions to the group project

Materials: Prizes (candy or paper/sticker stars)

Week 8

Lesson Objectives: ***What do we need to get done today?***
By the end of the lesson, the students will:

1. Complete building their exhibits
2. Identify important things to share about their exhibits, based on peer feedback.

Learning Objectives: ***What will the students learn today?***
By the end of the lesson, the students will have learned:

1. Organizational and time management skills for group work
2. What other people like/want to learn more about in their displays

Agenda based on the lesson plan. Post in the room for the students to see.

1. Opening: Review Agenda	5 Minutes
2. Vocabulary Review Challenge	15 Minutes
3. Construct exhibit	20 Minutes
4. BREAK (with clean up)	10 Minutes
5. Exhibit Gallery Interviews	30 Minutes
6. Closing: Share interesting points about exhibit	10 Minutes

Preparation and Space Set up:
Post daily agenda and 10-week apprenticeship overview
Lay out exhibit displays and unattached materials for each group

Vocabulary *What terms or concepts will you introduce in this session? Post these for the students to see.*

No new vocabulary

Materials and Equipment

Physical resources: All printed images and captions for the display, poems/models created the week before, glue, etc. for final construction of exhibit display

Electronic resources: Slide show of example “creative presentations” from past apprenticeships (or printed photos thereof if a projector/computer is not available)

Computing resources: None

Week 8 Activity: Vocabulary Competition **Time:** 15 minutes

Procedure

PREPARATION

- Write each vocabulary word on an index card, shuffle all cards, and put them in a box/hat/bag
    - Telescopes: telescope, aperture, mirror, shutter, detector, image
    - Image processing: sharpen, zoom, brightness, contrast, false color table, noise
    - Astronomy: Moon, planet, star, nebula, galaxy, universe, Solar System, Milky Way
- Category distinctions can be given as hints, if desired

DO THE ACTIVITY

- Split the apprentices into small groups, preferably those in which they will be working on their exhibit displays
- Individuals take turns drawing a word from the box/bag/hat and, after consultation with their team, trying to define it
- If they get it right (as judged by the CT), they get a point
- If they get it wrong the other teams get a chance to "steal" the point by supplying the correct definition
- Team with the most points gets a prize
- Vocabulary remains posted for the rest of the session (teams may not get through all the words—the facilitator may choose to end the game before all words are defined)

Objective

To review vocabulary from the apprenticeship

To encourage cooperation and conversation within teams

Week 8 Activity: Construct exhibit	**Time:** 20 minutes
Procedure MODEL THE ACTIVITY (CT/TL) • CT/TL arranges several pre-chosen images, captions and self-made creative element into a well-organized "example exhibit." • Model positive handling of conflicts about "what goes where", as well as good gluing techniques (i.e. not too much!), and prominent placement of title. • Additionally or alternatively, show physical examples or pictures of previous KCU WOW exhibits to spark student creativity. DO THE ACTIVITY • Apprentices construct their exhibit, following guidelines demonstrated by CT/TL. • Once all components are attached, apprentices may decorate the displays	***Objective*** To construct exhibit with good teamwork and cooperation.

Week 8 Activity: Exhibit Gallery Interviews	**Time:** 30 minutes
Procedure All exhibit displays should be fully assembled and displayed around the room before beginning this activity. MODEL THE ACTIVITY (5 minutes) • Using the example exhibit they've constructed, the CT and TL take on the roles of an exhibit designer and exhibit visitor. • Exhibit visitor asks questions, including some of the following: o How did you get these images? Where did they come from? o Which is your favorite image, and why? o How are these images the same and/or different? o Why did your group choose to make this particular creative element? o What is different/similar about the objects in these two images? o Tell me about how this image was created o What's the difference between this nebula here, and that galaxy, there? o What tools did you use to make these two images of the same object look different? o Show me an interesting detail about that image. • Exhibit designers use vocabulary correctly to answer questions, and also interviews the visitor, recording answers to the following questions: o What do you find most interesting about our display? o What do you want to know more about? **For a more interactive/lively exchange**: Apprentices are rewarded for using vocabulary correctly in both questions and answers. Each time a team uses a vocabulary word correctly, they get a point awarded by CT/TL. Team with most points at end gets a reward.	***Objective*** To experience what it is like for visitors to visit the exhibition. To provide constructive feedback on the information presented in the exhibit displays To come up with a creative way of teaching about the astronomy content in the exhibition

DO THE ACTIVITY (20 minutes) • Pair display groups, along with a CT or TL with each pair. • Begin at one group's display, spending 1-2 minutes silently examining/reading the information presented. • Exhibit visitors ask questions, with some help from CT/TL, if needed. • The designer group should interview the visiting group, recording answers to questions on the right • Repeat the above exchange at the other group's display, reversing roles. APPLY THE ACTIVITY (5 minutes) • Based on recorded answers and questions, exhibit design groups record 1 to 2 things they would like to emphasize in their oral presentation. These should be reflective of what the other group found most interesting. These ideas can be shared during closing circle.	

Materials Needed: Paper and writing utensils for taking notes

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Week 9

Lesson Objectives: ***What do we need to get done today?***
By the end of the lesson, the students will:

1. Practice giving oral presentations
2. Provide feedback to classmates on oral presentations

Learning Objectives: ***What will the students learn today?***
By the end of the lesson, the students will have learned:

1. How to give and receive positive and constructive feedback to and from peers
2. How to effectively engage audiences with astronomy content

Agenda based on the lesson plan. Post in the room for the students to see.

1. Opening: Review Agenda — 5 Minutes
2. Activity: What makes a good presentation? — 30 Minutes
3. Practice presentations & provide written feedback, including break — 45 Minutes
4. Closing circle — 10 minutes

Preparation and Space Set up:
Post daily agenda and 10-week apprenticeship overview
Make copies of Presentation Feedback form

Vocabulary *What terms or concepts will you introduce in this session? Post these for the students to see.*

No new vocabulary

Materials and Equipment

Physical resources: Completed exhibit displays, Presentation Planning worksheets, Peer Review feedback forms, writing utensils

Electronic resources:

Computing resources:

Week 9 Activity: What makes a good presentation? **Time:** 30 minutes

Procedure

MODEL THE ACTIVITY (15 minutes)

- Model a "bad" presentation
  - Hard to understand (orally)
  - Hard to understand (content-wise, incorrect use of vocabulary)
  - Bored/uninterested presenter
  - Not paying attention to the audience
  - One person dominates and the other does not contribute
  - Is not clear when the presentation has ended
- Ask apprentices what the presenter(s) could have done to improve the presentation
- Write the qualities of a good presentation on the board and hand out the "KCU exhibit Criteria for Excellence" review forms, which include the following: teamwork, good explanations (i.e. use of vocab), presentation style.
- CT/TL list possible roles for apprentices to take, and brainstorm more with apprentices' help (see list below)

DO THE ACTIVITY (15 minutes)

- Apprentices plan their own presentations, based on what they want to share about their exhibit, and the criteria and roles presented.
- Apprentices can be asked to explicitly select roles, if that works well for your group. (Choose several roles from the list below and create a "sign-up" sheet for each group.)

Objective

To identify the elements of a good presentation

To practice presenting

Suggestions for presentation roles are listed on the next page.

Suggestion for Apprentice Roles in the Presentation

- Welcome people to the exhibit
- Present the overall theme of this panel of the exhibit.
- Point out an image and present the caption to explain WHAT the object is (using vocabulary correctly).
- Point out an image and present the caption to explain HOW the image was processed (using vocabulary correctly.)
- Point out an image and then SHOW how that image was processed by taking a visitor through that process on a nearby computer until the image is exactly like what's on the exhibit. (THIS IS A HUGE WOW FACTOR FOR AUDIENCES!!)
- Help visitors to take their own image on the Guest Observer Portal (Note: computer with internet connection needed in the WOW space)
- Define an important vocabulary word (for example, if all exhibit pictures are galaxies, explain what a galaxy is)
- Define an important processing tool and explain what it does, using example images, if possible
- Show a processing tool on a nearby computer.
- Present the "creative element" (read poem or point out features of sculpture/model) and explain which images inspired its creation.
- Explain why two images of the SAME object look different.
- Tell about what happened during the apprenticeship over the past 10 weeks using parts of your exhibit as visual aids
- Describe the field trip and do a teachback about what you learned there.
- Tell about your most and least favorite part of the apprenticeship and WHY.
- Create a kinesthetic model as a group, with one or more narrators (e.g. telescope or lifecycle of a star)
- Explain what a telescope does, if there are exhibit images to support that explanation.
- Explain how astronomers use color when displaying images.
- Point out features of an image while a teammate talks about it.
- Explain why they organized the display the way they did.
- Thank visitors for coming to your exhibit.
- Anything else that your group wants to share about the exhibit or the apprenticeship!

Week 9 Activity: Practice presentations with written feedback	**Time:** 40 minutes
Procedure • Apprentices present to at least one other group, if not the whole class. • Class gives oral and/or written feedback on the presentation, based on the criteria for excellence: TEAMWORK o Good transitions between apprentices o Each apprentice has a role in the presentation o Apprentices give credit to the work done by others GOOD EXPLANATIONS o Includes astronomy vocabulary, used correctly o Includes image processing vocabulary, used correctly o Apprentices use descriptive words in place of “it”, “this”, “thing”, etc PRESENTATION STYLE o Apprentices point to features of visual aid (image, model, etc.) when talking about them o Apprentices make eye contact o Apprentices speak slowly, loudly and clearly Not paying attention to the audience • If time, students present again, incorporating that feedback.	***Objective*** To practice presenting

Materials needed: writing utensils and peer review feedback forms (Page 86)

Week 10 (Final Preparation for the WOW)

Lesson Objectives: ***What do we need to get done today?***
By the end of the lesson, the students will:

1. Practice presenting twice
2. Choose a peer representative to represent their apprenticeship at the WOW event.

Learning Objectives: ***What will the students learn today?***
By the end of the lesson, the students will have learned:

1. How to give effective presentations in front of an audience

Agenda based on the lesson plan. Post in the room for the students to see.

1. Opening: Survey	5 Minutes
2. Make final changes to exhibit displays, if necessary	15 Minutes
3. BREAK (can occur between rounds of Astronomy Idol)	5 Minutes
4. Icebreaker: Color-Passing Challenge	10 Minutes
5. Challenge: Astronomy Idol	45 Minutes
6. Closing: Prepare for WOW events	10 Minutes

Preparation and Space Set up:
Post daily agenda and 10-week apprenticeship overview
Make additional copies of Presentation Feedback forms if necessary
Choose space for Astronomy Idol (auditorium, cafeteria, etc.), set up working spaces for each exhibit display group, if necessary

Vocabulary *What terms or concepts will you introduce in this session? Post these for the students to see.*

N/A

Materials and Equipment

Physical resources: Exhibit displays, glue, markers, and (minimal) craft supplies, prize for Astronomy Idol, presentation feedback forms

Electronic resources: Images for processing demonstrations, if necessary

Computing resources: Image processing software, if necessary

Week 10 Activity: Color Passing (Skill building)	**Time:** 10 minutes
Procedure DEMONSTRATE THE PURPOSE OF THE ACTIVITY • Start by shouting the explanation loudly and incoherently; then, slow down and repeat what you said so apprentices can understand you • Explain If you do not speak clearly, no one will understand what you are saying • In large rooms, voices tend to echo, which makes it hard to understand what someone is saying • Speak slowly and loudly, but do not shout • Take breaks between thoughts of a sentence so the audience can have time to absorb and process the information you are giving MODEL AND DO THE ACTIVITY • Everyone stands around the edged of a large (echo-y) space, as far away as other people as possible • The CT models the activity by "passing" to the TL "My name is TEACHER and I pass BLUE to LEADER" • The TL models the activity by "catching" the color "BLUE!" • The TL passes a new color to someone else in the room • Continue passing and catching colors (or other silly words) around the room	***Objective*** To practice speaking slowly, loudly, and clearly

Week 10 Activity: Astronomy Idol	**Time:** 45 minutes
Procedure CT or TL acts as emcee for the competition ROUND 1 (15 minutes) • Each group presents their exhibit/demonstration to their peers. • Other groups evaluate the presentations, using the feedback form provided by the CT/TL • After each group has presented, the other groups provide oral feedback (one positive response, one suggestion for improvement) based on their written forms ROUND 2 (15 minutes) • Each group presents again, taking into account the feedback they have received • After all groups have presented, all individuals vote anonymously on which presentation was most effective and engaging. • CT/TL tally the votes (including their own) and gives a prize to the most deserving Astronomy Idol.	***Objective*** To practice presenting astronomy content to an audience To provide feedback on apprentices' presentations

Materials: Pens/pencils, feedback forms, clipboards/notebooks to write on, prize for winner of the competition

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Week 11 (Optional Reflection)

Lesson Objectives: ***What do we need to get done today?***
By the end of the lesson, the students will:

1. Reflect on the apprenticeship and the WOW events

Learning Objectives: ***What will the students learn today?***
By the end of the lesson, the students will have learned:

1. N/A

Agenda based on the lesson plan. Post in the room for the students to see.

1. Post-apprenticeship survey	10 Minutes
2. KCU Focus Group	15 Minutes
3. Some game of apprentices' choice	Remaining Minutes

Preparation and Space Set up:
Set up feedback questions as stations around the room
Set up circle of chairs for group discussion/focus group

Vocabulary *What terms or concepts will you introduce in this session? Post these for the students to see.*

N/A

Materials and Equipment

Physical resources: Method for recording apprentices' reflections

Electronic resources: N/A

Computing resources: N/A

Activity: KCU Focus Group	**Time:** 15 minutes
Procedure • After giving students the post-apprenticeship survey, have them sit in a circle to reflect on and discuss their experience during the apprenticeship. • It may be advantageous to have apprentices think quietly or jot down ideas about a question before discussing it with the whole group, to give them time to develop meaningful contributions. Alternatively, they could even discuss different questions in subdivided groups. • The goal here is to give students a chance to see how far they've come in 10 weeks, as well as give the CT some feedback, if they'd like to run the apprenticeship again. (And we hope you do!) Possible questions / reflections to bring up: • Have students remind each other what happened during each week of the apprenticeship, using the 10 week outline plan as a visual guide. • What was your most favorite thing about the apprenticeship? • What was your least favorite thing about the apprenticeship? • What was the funniest thing that happened? • What was the most important thing you got out of being an astronomy apprentice this semester? • If you were teaching the apprenticeship, what would you do differently? • What would you tell other kids about this apprenticeship, if you were advertising it? • What do you feel most proud of about your WOW exhibits? • What was the best part about participating in the WOW? • How do you think you are different now than on day one of the apprenticeship? • Is this what you thought "doing science" would be like? • How was the apprenticeship different from what you expected?	***Objective*** To reflect on their experience and give feedback to the CT/TL

Supplemental Activities

Supplemental Activity: Making Images With Mirrors	**Time:** 10 minutes
Procedure PREPARE THE ACTIVITY • Set up a bright light bulb or other source at one side of a room or hallway (this activity can be done outside if a plug is available). If no light bulb is available, this activity will sometimes work with a day-lit window in a darkened room • Test the activity before doing it with apprentices—if the conditions are not right, the activity will not serve any purpose except to frustrate the apprentices! • Use the template on page E-2 in the curriculum to cut out the aperture on the aperture/detector worksheet. Use a piece of scrap paper or cardboard as the shutter • Make enough of each page (aperture/detector & shutter) for each pair of apprentices. DO THE ACTIVITY • Give each pair of apprentices a concave mirror, such as cosmetic mirrors found in a traditional drug store, a shutter page, and an aperture/detector page. • Their challenge is to focus the light from the light source to create an image of the light source on the detector. DISCUSS THE ACTIVITY • Can they explain how they made their image? What does the shutter do? What is the path of the light?	***Objective*** To learn how light travels through a telescope and how astronomical images are made

Materials Needed: Pre-made aperture/detector pages, pre-labeled shutter pages, concave mirrors, bright light bulb or other detectable light source

Supplemental Activity/Discussion: Images from telescopes **Time: 10 minutes**

This activity is more of a discussion than a processing challenge, but it is done around a computer.

- Open MicroObservatoryImage from shortcut on desktop.

OBSERVATION (5 minutes)

- Open the image of the Prudential tower captured WITHOUT a telescope
- Explain that this is a digital image taken with an ordinary digital camera from the roof of the Harvard Observatory, where MicroObservatory telescopes are located.
- Ask apprentices how they would describe the tower just from looking at the non-telescope image
- Record (or have apprentices record) their observations
- Open the image of the Prudential tower captured WITH a telescope, explaining that it was taken from the same location, but with a telescope
- Ask apprentices how they would describe the tower just from looking at the telescope images
- Record (or have apprentices record) their observations.
- Optional: Students can create a caption to describe the two views/images.

DISCUSSION (5 minutes)

- Why use telescopes? What do telescopes do?
  - Make a far-away object appear closer
  - Show more detail in/on an object
  - Collect more light (objects appear brighter, but this is not shown by observing the images of the Prudential Center)

- Optional: Zoom in on the tower in the non-telescope image so that it shows the same field of view as the telescope image…do they look the same now?

Objective

Model how to open images using MicroObservatoryImage

Learn what a telescope does:
- Makes far-away objects appear closer
- Shows more detail about objects
- Collects (more) light (than can be collected without a telescope)

(Optional) Model the use of the Zoom tool.

Supplemental Processing Challenge: Color Tables **Time: 10 minutes**

Each computer station should be assigned a different color table, either by random assignment or by having students drawing the color table names out of a hat.

1. Write the name of the color table at the top of the page and create a 3x3 chart below it, labeling the rows and columns as in the examples to the left.
2. Open an already-processed image such as Tower2
3. The facilitator first models the activity using the Gray Scale color table
4. Apply the assigned/chosen color table to an already-processed image by choosing "Process" > "Color Table" > "Gray Scale" (or "Red" or "Spectrum," etc.)
5. Fill in the second line of the chart by observing which colors represent the highest, lowest, and in-between pixel values in the image.
6. Save the image as a GIF with a descriptive name
7. Re-open the image and apply the assigned color table, then choose "Process" > "Invert Color"
8. Fill in the third line of the chart for the new appearance
9. Save the new image as a GIF with a different name

REFLECTION

1. Open both images so they are visible on the screen
2. Walk around the room and look at all the images that have been created. After observing them all, each student stands next to his or her favorite view
3. Each person/group must come up with a reason why they chose that image as their favorite and share it with the group (beyond "I like the color")

Objective

Apply color tables to change the appearance of an image

Articulate your personal connection to an image

Color Table: Gray Scale

	High Pixel Values	Pixel Values In Between	Low Pixel Values
False Color	*White*	*Light gray Dark gray*	*Black*
Inverted	*Black*	*Dark gray Light gray*	*White*

Color Table: Blue

	High Pixel Values	Pixel Values In Between	Low Pixel Values
False Color	*Bright blue*	*Royal blue Navy blue*	*Black*
Inverted	*Black*	*Royal blue Navy blue*	*Bright blue*

Example Color Table: Fire

	High Pixel Values	Pixel Values In Between	Low Pixel Values
False Color	*White*	*Yellow Orange Red Purple Blue*	*Black*
Inverted	*Black*	*Blue Turquoise Green Yellow*	*White*

Other color tables:
Red, Green, Spectrum, Ice

Prompts: What is it about this color choice that you like? What features of the image stand out? Does it remind you of anything?

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Worksheets and Templates

Useful Tools for Running the Apprenticeship

Pre/Post Apprenticeship Survey
Assessment tool for Weeks 1 and Week 10 or 11

Observing Logs
For keeping track of telescope requests—can be recorded by individual apprentices, or a collectively across the whole group

Image Processing Log
For apprentices to keep track of the images they save and create good captions to accompany the saved images

Checklist for WOW
Apprentice-friendly requirements for the exhibit displays

Oral Presentation Planning
For figuring out which topics and images will be included in each group's oral presentation, and who will present each part

Presentation Feedback Form
Peer review criteria for practicing and improving presentations

Image Display Template
Model of how facilitator can consolidate final images and captions for the exhibit displays (color printer recommended)

Group Preference Forms
A strategy for taking apprentice preference into account when choosing who will work on which exhibit displays

Kids Capture Their Universe Apprenticeship Survey

Name: _____ **Date:** _____

Imagine this situation: You have just completed a project with a group of other Citizen Schools students. You are all about to get up in front of a group of 25 of your peers to describe what you've done as part of a "teach back."

1. Place an "X" somewhere along the scale to indicate how you would feel at that moment:

I do not feel comfortable.	____ ____ ____ ____ ____	I feel comfortable.

2. Place an "X" somewhere along the scale to indicate how you feel about these opposite statements.

I am happy that I am in this apprenticeship.	____ ____ ____ ____ ____	I am **NOT** happy that I am in this apprenticeship.
It is possible for everyone to make an important contribution to a group project in science.	____ ____ ____ ____ ____	It is **NOT** possible for everyone to make an important contribution to a group project in science.
Accepting feedback from my peers is important to me.	____ ____ ____ ____ ____	Accepting feedback from my peers is **NOT** important to me.

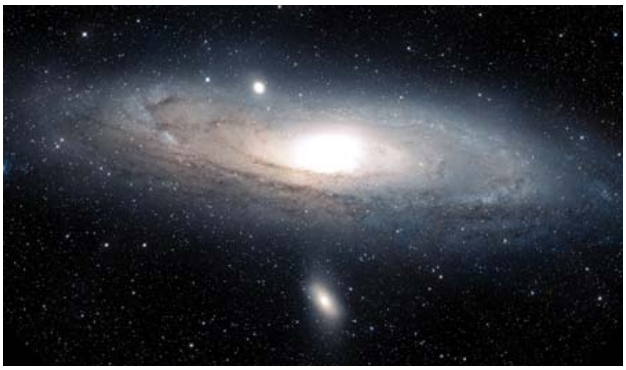
4. List words you'd use to describe or tell about this object:

_____

_____

_____

_____



CONTINUED ON NEXT PAGE!!!

5. Circle the single best answer for this question:

Our solar system contains:

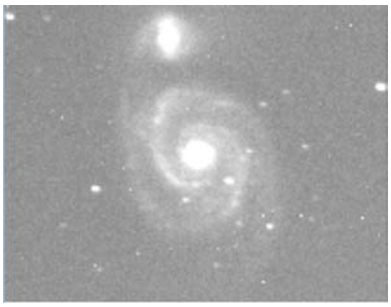
a. One average star
b. Several stars spread across space
c. One older, dimmer star, and one younger, brighter star
d. Three stars
e. No stars

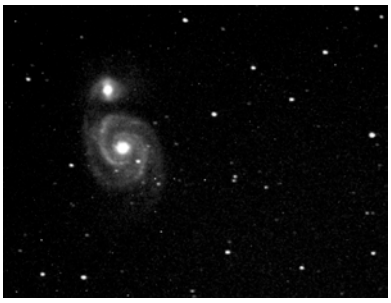
6. When you think about **doing science**, which of these words come to your mind? (Circle as many as you like.)

working alone	hard	important to me	easy
creative	understandable	group work	interesting
boring	fun	scary	

6. What do you wonder about astronomy, outer space and the universe? List your questions:

7. Describe what is different about these two images:





Observing Log Name: _____

Go to http://www.MicroObservatory.org to take images with the MicroObservatory online telescopes. Record your observations below. Keep this log in your folder.

Date of Observation	Object Name (e.g. Moon, M101 Galaxy)	Other Notes	√

√ Make a check mark next to an object when you have processed its image!

Group Observing Log (Alternative to Individual Logs)

Create a master version of this chart and display it publicly to fill out each week.

Object Type	Object Name (e.g. Moon, M101)	Taken By (Apprentice Names)	Date Requested	Mark when processed
In Our Solar System				
Stars and Clusters of Stars				
Nebulas				
Galaxies				

Image Processing Log

Fill this out whenever you process an image. If you have any questions about what is going on in your image, be sure to ask a Citizen Teacher!

My Name: _____

Object Name and Type: _____

Name of Saved Image: _____

Date Processed: _____

1. How were image processing tools used to make the image appear like this?

2. What do you want other people to know or notice about this object?

3. What words do you think of when you look at this image? Does the image remind you of anything else?

4. What question(s) do you have about this object or image?

Use your answers to create the final caption for this image. Don't forget the title!

WOW Exhibit Checklist

Your astrophotography exhibit is made up of several displays. Each display in your exhibit must have the following parts:

☐ Display Name/Title: _____

☐ Names of People Working on this Display

Write them here:

☐ Processed MicroObservatory images

☐ Captions for the MicroObservatory images

☐ Creative element for the display

__ Sculpture __ Poem __ Other

☐ Caption for the creative element

How does this element relate to the image(s) in your display?

(Write your caption on a separate page)

☐ Written introduction to the WHOLE Display

What is this display about?

(Write your explanation on a separate page)

Kids Capture the Universe: Oral Presentation Planning

GROUP/EXHIBIT NAME: _____

You will be presenting your exhibit during your WOW. Don't forget to:

- Welcome your visitors and introduce yourselves.
- Tell the story of your display—the theme, organization, and inspiration. Don't forget to include the important astronomy information!
- Tell the story of your creative element—what you made and why you made it. (You can use the information in your caption to help you.)
- Highlight some of the images in the display (not just your own!) and teach back about them in some creative way.
- Thank your visitors for coming and invite them to explore the display.

Who will do what for your oral presentation?

Role or Responsibility	Who Will Do This?

Astrophotography Exhibit Peer Review

Exhibit Name: _____

Presenters' Names: _____

Check the box you think indicates how well this group did with each guideline:

Criteria for Excellence	Did great!	Did okay	Needs improvement
Teamwork: • Each apprentice has a role in the presentation • Apprentices give credit to the work done by others • Good transitions between apprentices			
Good Explanations: • Includes astronomy vocabulary, used correctly • Includes image processing vocabulary, used correctly • Apprentices use descriptive words in place of "it", "this", "thing", etc.			
Presentation style: • Apprentices point to features of visual aid (image, model, etc.) when talking about them • Apprentices make eye contact • Apprentices speak slowly, loudly and clearly			

One thing I **liked** about this group's exhibit and presentation is…

One thing this group **could improve** about their exhibit and presentation is…

Template for Collating Images and Captions for the WOW!

Ideally, apprentices will write or type up their own captions. This is a template that apprentices or CTs can use to combine the digital GIF files from the apprentices' computers, and the caption information from the processing logs of chosen images. Example pages follow this template.

Delete the text and insert saved GIF image here

If a student has saved an un-zoomed image, but wants to display it in a zoomed format (e.g. a Moon crater), you must:

Crop the image around the zoomed area.
Enlarge the cropped image so it is roughly the same size as the other images in the exhibit. (Example images are both zoomed.)

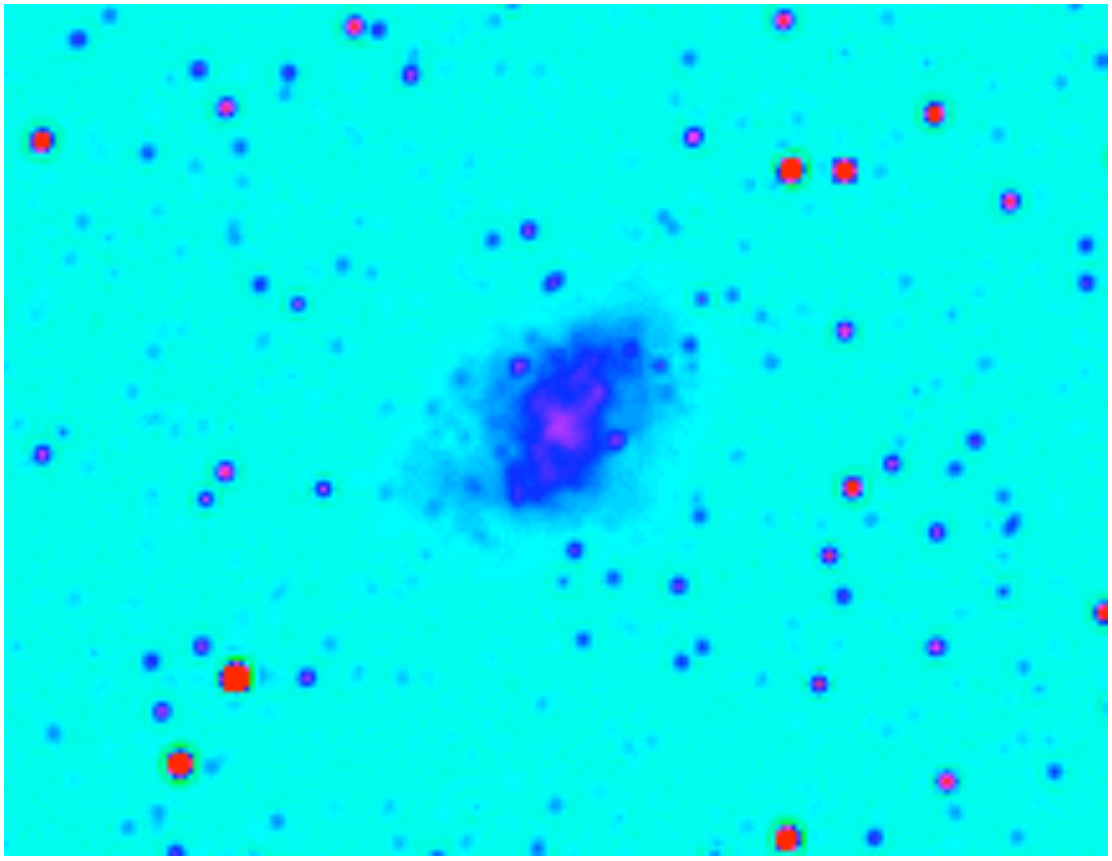
One image/caption pair per page is a good model. In the event that an apprentice wishes to pair two images (to show an image before and after processing, for example), the layout can, of course, be adjusted. This template is meant as a guide only!

Title of image goes here (if available)

Created by
Apprentice(s) name(s) here

Type caption here (from students' processing logs)

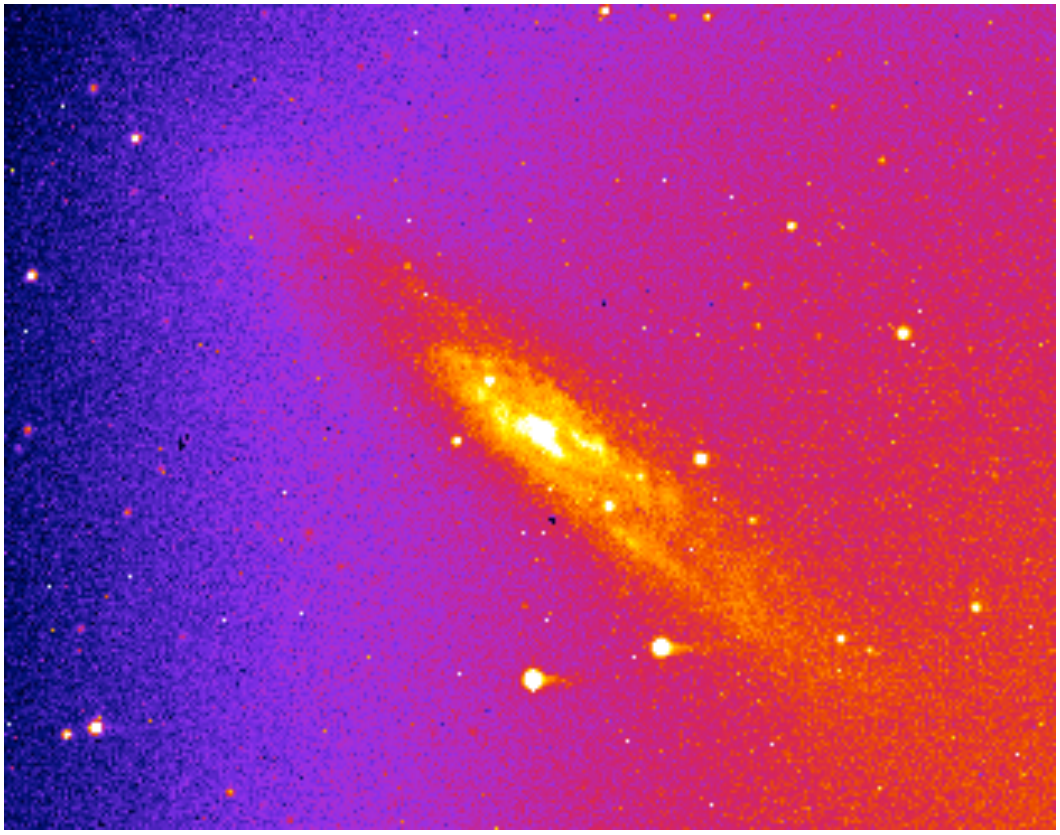
Print the images and captions on a color printer and distribute the appropriate pages to each group with a glue stick. They can cut or decorate the pages as they like to create their exhibit display. Copy this template into a separate document to remove header/footer.



Crab Nebula

By Ashley

This is a dying star.
It looks like a bird's wing.
To make my processed image:
Press "Auto" and change the
color table to Spectrum.



NGC 253 (Galaxy)

By Duncan

A galaxy is made out of billions of stars. This is the NGC 253 galaxy. It is bright enough to see from far away. It looks like a spinning top. Our galaxy might look exactly like this.

To make my processed image, I opened it, then I changed the brightness and the contrast, then zoomed in three times and changed the color.

Group Preference (Request) Forms

Use this template to help apprentices choose the groups they will be working in for the final exhibit displays. You can make copies of this form as-is and distribute the slips with a master "reference guide" to the exhibit display topics (e.g. 1 = Galaxies, 2 = Orion Nebula, etc. posted on a wall), or you can modify the document to include exhibit display names on the request slips.

Your Name: _____

Put a "1" next to the display you would be most excited to work on. Put a "2" next to your second choice and a "3" by your third choice.

___ Display 1 ___ Display 2 ___ Display 3

Your Name: _____

Put a "1" next to the display you would be most excited to work on. Put a "2" next to your second choice and a "3" by your third choice.

___ Display 1 ___ Display 2 ___ Display 3

Your Name: _____

Put a "1" next to the display you would be most excited to work on. Put a "2" next to your second choice and a "3" by your third choice.

___ Display 1 ___ Display 2 ___ Display 3

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KCU Curriculum Appendices

Additional Resources for Facilitators

Appendix A

Token Astronomical Images

Appendix B

Vocabulary Master List

Appendix C

Processing Challenges Key (Weeks 1-4)

Appendix D

Kinesthetic Life Cycles of Stars Summary (Week 3)

Appendix E

Materials for Hands-on Telescope Activities
Kinesthetic Telescope (Week 1) & Making Images With Mirrors (Supplemental Activity)

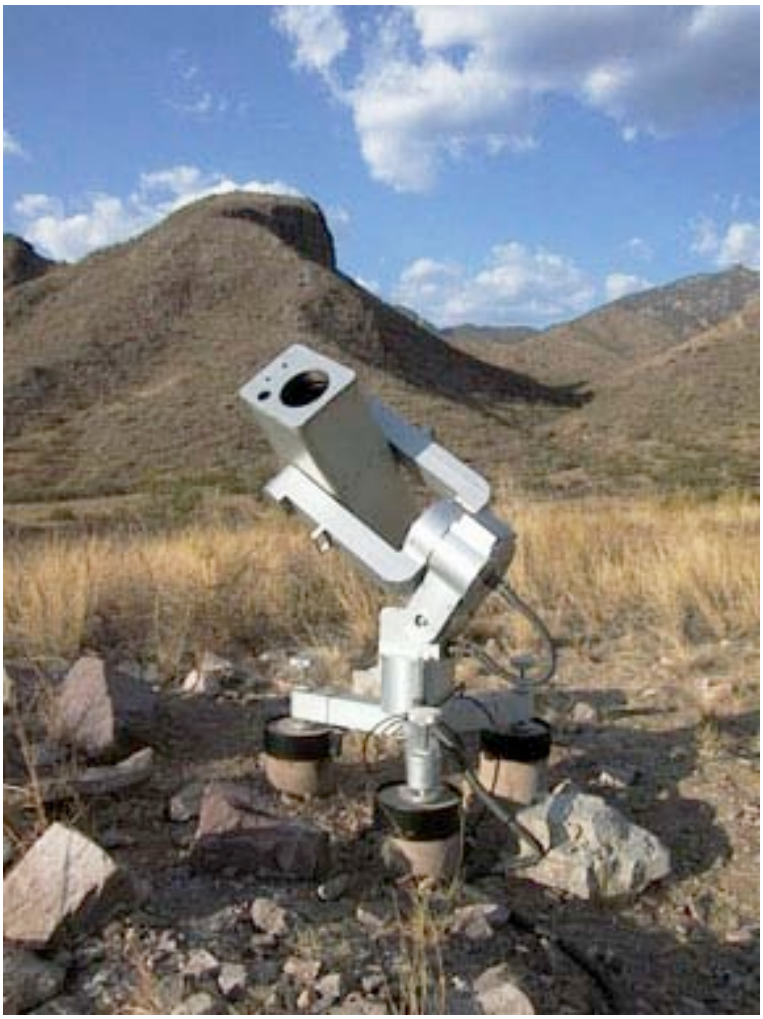
Appendix F

Illustrated Processing Tools Guide

Appendix A Token Astronomical Images

Apprentices are often inspired by beautiful, full-color images of astronomical objects captured by professional and amateur astronomers. We have chosen a selection of such images for Citizen Teachers to use in this apprenticeship. Each image accompanied by a kid-friendly "biography" designed to inspire further conversation.

MicroObservatory Telescope



I am a teenager, but I am only three feet tall. I enjoy exploring the universe, but I prefer to stay here on Earth. I am an excellent photographer and am responsible for many of the images you will see during this apprenticeship. I enjoy email and making new friends on the Internet.

Moon

Hello neighbor! You can sometimes see me during both day and night, but I am sometimes scared that you won't recognize me. I change a little bit each day. I am made of dusty rock and am about one quarter the size of the Earth. If you stood on my surface, you would weigh one sixth of what you weigh on Earth, because I am smaller and have less mass than Earth. During the first few billion years of my existence, interplanetary invaders from beyond Mars left their mark on my surface. Where do you suppose they are?

HINT: Look on my surface for pits, dents, and streaks.

Image Credit: Lick Observatory

The Planet Jupiter (and its moon Io)

I am named after the king of the Roman gods. If you look at me carefully with a telescope, you might be able to see some of the rocky objects that orbit around me. You could fit 1,000 Earths inside me—if I had been just a little bit bigger, I could have been a star. If you could visit me, you would weigh 2.5 times what you weigh on Earth, but it would be hard to stand on my surface because, like a star, I am made of gas. Because I am spinning, the gas at my surface forms bands of clouds that change over time, just like the weather on Earth. Unlike a star, I do not shine with my own light. Even so, I am still one of the brightest objects in the night sky. Why do you suppose that is?

HINT: I do orbit the same star as you Earthlings.

Image Credit: NASA/JPL/Caltech

Star-Forming Nebula

I am a giant cloud of dusty gas where new stars are being born. You can find me in the constellation Orion in the winter sky, but traveling towards me on a beam of light would take more than 1,500 years. Once you reached me, it would take another 30 years to travel all the way across me, even at the speed of light! Seeing through the clouds of gas and dust can be difficult, but luckily, I am filled with bright, newborn stars to light the way. Where do you suppose they are?

HINT: Look closely at my image to find where the gas is glowing brightest.

Image Credit: NASA, ESA, M. Robberto (STScI) and The Hubble Space Telescope Orion Treasury Project Team

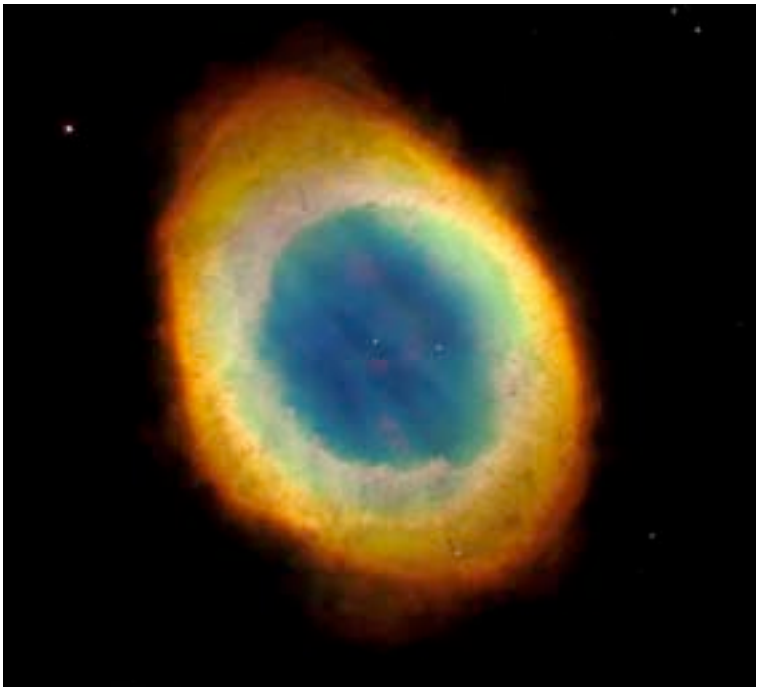
Star Cluster

You can find me in the constellation Hercules, but if you could hitch a ride on a beam of light, it would take you more than 1,000 years to travel from me to the Earth. I am made of hundreds of glowing balls of gas, all formed at the same time. Some have already stopped glowing and died, but most are still shining brightly. All of them are clustered together in a huge ball-shaped clump. What do you suppose holds them all together?

Hint: It is the most far-reaching force in the universe.

Image credit: Tom Bash and John Fox/Adam Block/NOAO/AURA/NSF

The Ring Nebula (A Dying Star)



My picture is like looking into the future of the Sun—a preview of what will happen in 5 billion years. You can find me in the constellation Lyra. When I first came to be, I was an ordinary star, burning fuel in my core and shining brightly to balance the unavoidable collapse that would eventually end my life. In my final moments I released a huge puff of gas, leaving nothing behind but a smooth bubble of gas and small dying core. Where do you suppose that is?

HINT: Look closely at my image to find my small dying core.

Image credit: The Hubble Heritage Team (AURA/STScI/NASA)

Exploded Star Nebula (Supernova Remnant)

You can call me The Crab. I am all that remains of a massive, violent explosion known as a supernova. That explosion was seen on Earth in the year 1054 and when it happened, I was visible to the naked eye for three days and three nights. Before the explosion, I was a giant star that shone very hot and very bright. Now I am the tiny spinning core of that star, surrounded by a rough, irregular cloud that used to be my outer layers. Where do you suppose that is?

HINT: Look for bright, colorful streaks of gas and a pale, glowing haze.

Image credit: NASA, ESA, J. Hester and A. Loll (ASU)

The Andromeda Galaxy

People call me the Twin of the Milky Way. You can find me far beyond the constellation Andromeda. Objects like me are the building blocks of the universe. A giant pinwheel of gas and dust, I shine brightly with the light of 200 billion stars. My starlight takes more than 2 million years to reach your telescopes, yet I am one of the nearest neighbors to the pinwheel of stars where you live, the Milky Way. I am the same kind of structure as the Milky Way and another character in your apprenticeship, but pictures of us look very different. When you take a picture of me, it is hard to see my outermost edges. Why do you suppose that is?

HINT: Where are most of my stars located?

Image credit: P. Challis/Caltech/Palomar Observatory

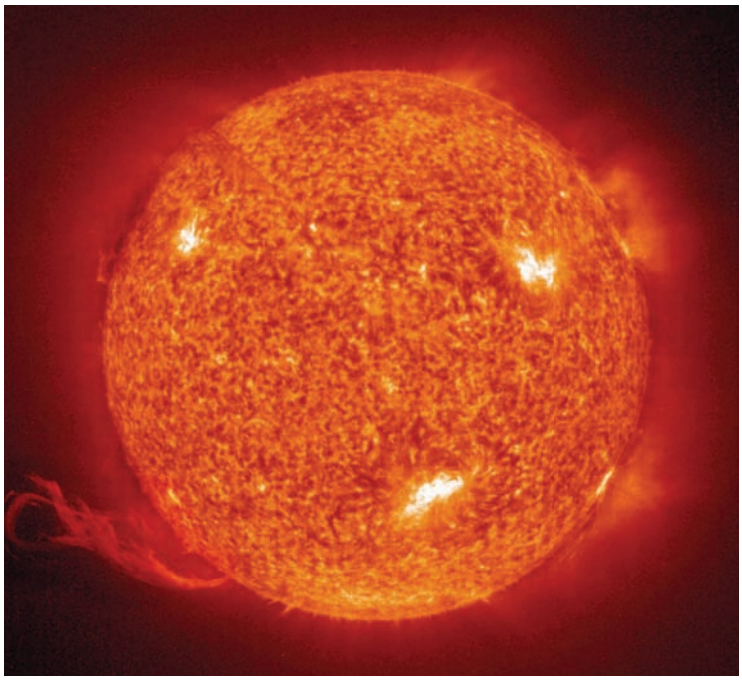
Face-On Spiral Galaxy

You can call me The Whirlpool. I am like an island in the sea of space, a bright center surrounded by swirling streams of gas and dust and the light of billions of stars. If you could fly out of and over your own Milky Way, it would look like me. I am one of billions in the universe, yet your view of me is quite remarkable. This “face-on” view even allows you to see the evidence of my interaction with a nearby companion: new stars being born. Where do you suppose they are?

HINT: When new stars begin to shine, they create a rosy glow in the gas around them.

Image credit: NASA, ESA, S. Beckwith (STScI) and The Hubble Heritage Team (STScI/AURA)

Our Star, The Sun



You can call me Goldilocks because, compared to all the other stars around me, I'm not too hot, not too cold, not too big, and not too small. My life is halfway through, but I'm still going strong. It's a good thing too, because I've got a lot of life to support. My insides are a very busy place: The tremendous pressure of my great round weight produces extreme heat and (atomic) energy deep within my core, which causes my face to turn hot and shine really bright. I live at the center of a solar system, and it takes my light 8 minutes to travel to Earth. I am not the brightest star to ever exist, but I am definitely the brightest star you'll ever see. Why do you suppose that is?

HINT: Think about the brightness of a flashlight held right next to your eye compared to a light bulb 2 miles away.

Image credit: SOHO/ESA/NASA

The Hubble Space Telescope

I'm the size of a school bus and I orbit the Earth. When I am above you, I am closer than Washington, D.C. My favorite hobbies are photography and flying in circles. Although I do not wander around the universe, I do enjoy sightseeing. I had sight problems when I was born, back in the early 1990s, but now I wear something similar to your contact lenses and I can see perfectly! I am responsible for many of the images you will see during this apprenticeship.

Image credit: STScI/NASA

Appendix B Vocabulary Master List

Choose from the following words and definitions to determine which concepts you wish to highlight each week. A = Astronomy Vocabulary, P = Processing Vocabulary

Week 1		
telescope	A	An instrument that makes a far away object look nearer by collecting and focusing light. Allows us to see more details than we can with our eyes only.
aperture	A	The opening in a telescope through which light enters
mirror	A	The part of a telescope that reflects and focuses light
shutter	A	The part of a telescope that opens and closes to let light through to the detector.
exposure time	A	The amount of time the shutter stays open
detector	A	The part of a telescope that collects the focused light, and records it as an electronic image.
image	A	A picture
image processing	P	Changing how we display an electronic image on a computer screen
pixel	P	Short for "picture element". The smallest square portion of an electronic image, where light was collected by each part of the detector.
brightness	P	The amount of light that was collected by the telescope from part of an object. Measured as "pixel value" from an image using MicroObservatory Image software.

Week 2		
moon	A	A chunk of material (usually rock), that travels in a circle around a planet.
planet	A	A chunk of material (can be rock or gas) that travels in a circle around a star.
Our Solar System	A	Made of our one star, the Sun, and all the planets and their moons, which move in a circle around the sun.
zoom	P	A tool that makes each pixel larger when we view an image, so it appears that the whole image is larger.
crop	P	A tool that takes away the parts of an image around a chosen area.
false color table	P	A tool that represents the brightness of pixels in an image with different colors.
sharpen	P	A tool that makes clearer the edges between nearby regions of high and low brightness.

Week 3		
nebula	A	A giant cloud of gas and dust.
star	A	A massive ball of gas that shines brightly because of the huge amount of energy that is produced inside it.
gravity	A	A force which pulls all things together.
contrast	P	The range of brightness (pixel value) that we choose to display in an image. (We don't HAVE to display the WHOLE range of brightness in an image.)

Week 4		
galaxy	A	A collection of many billions of stars, gas and dust (including nebulae), all held together by the force of gravity.
Milky Way	A	Earth and our solar system are part of one galaxy called the Milky Way. All the stars visible in the night sky are part of our galaxy.
universe	A	Our universe is made of billions of galaxies. All the galaxies you could see with any telescope are part of our universe.
noise	P	Extra brightness in an image that did not come from light from an object; usually from electronics in the detector, like the fuzz on TV when a channel is empty.

Summary of Apprenticeship Vocabulary

Image Processing Terms
- electronic image
- image processing
- FITS file
- pixel
- brightness
- contrast
- false color
- zoom
- crop
- sharpen
- noise

Astronomy Terms
- moon
- crater
- planet
- Our Solar System
- nebula
- star
- gravity
- galaxy
- Milky Way
- universe

Telescope Terms:
- telescope
- aperture
- mirror
- shutter
- detector
- exposure
- image

Note: Image processing vocabulary introduced in Week 1 will be reviewed and practiced throughout the processing challenges in the following weeks. In particular, all processing challenges make particular use of the tools associated with "brightness" and "contrast."

Appendix C Processing Challenges Key (Overview and "Cheat Sheet")

Goals
- To learn how to use image processing tools to change the appearance of an image
- To reflect on the types of objects that can be observed with telescopes
- To express creativity in sharing a personal view of objects in the universe

Procedure
- Phase 1: Model the use of a new tool (ObjectChallenge.FITS → Object1.GIF)
- Phase 2: Challenge students to recreate an image using that tool (Object2.GIF)
- Phase 3: Students create their own images of similar objects (their own images)
- Reflection: caption-writing, pair shares, interviews, and/or shout outs

Processing Tools

All challenges center around the "Adjust Image" tool, which changes the contrast of an image. Other processing tools are listed below (with the week they should be introduced).

- Open Image (Week 1)
- Save Image (Week 1)
- Color Tables (Week 1 or 2)
- Sharpen (Week 2)
- Zoom (Week 2)
- Crop (Week 2)
- Auto and Log function (Week 3)
- Reduce Noise (Week 4)

Optional Tools
- Invert Color (see "Color Tables")
- Text tool (not included in curriculum)
- Draw tool (not included in curriculum)
- Measure (not included in curriculum)
- Shift, Stack, Math, etc. (not appropriate for most middle school students at this level of instruction)

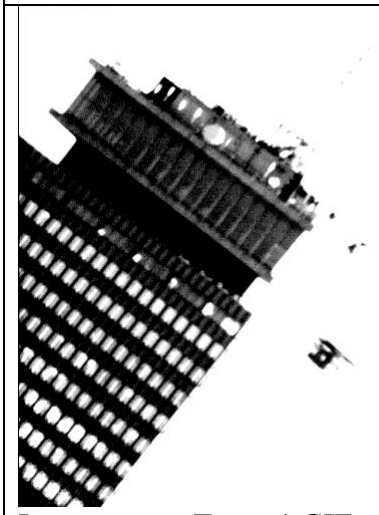
Guide to Processing Challenges

Astronomical Objects (Primary Telescope Activity Locations)
- Moon (Telescope As Time Machine, Galileo)
- Planets (Galileo, Telescope As Time Machine)
- Stars & Star Clusters (Galileo, Telescope As Time Machine)
- Nebulae (Colorful Cosmos, Black Hole Hunt)
- Galaxies (Galaxies Galore, Black Hole Hunt)

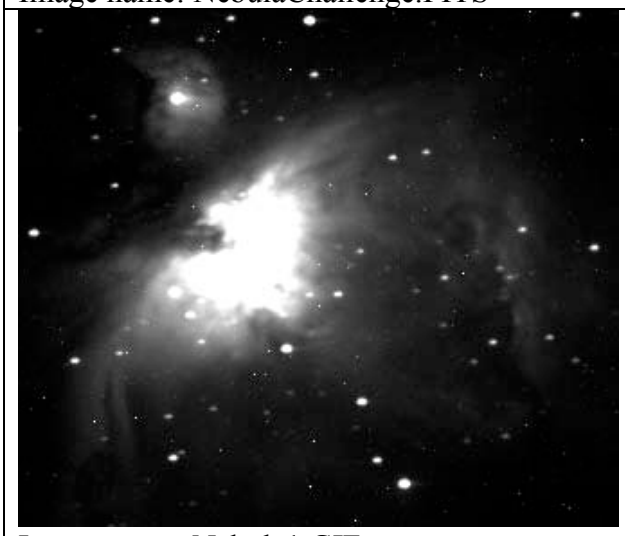
Things to notice (and point out to students!) about processed images
- Specific details about the object (e.g. shape, structure, brightness, texture)
- How processing an image changes the appearance/reveals new features
- Spatial relationships (e.g. viewing angle, other objects in the background/foreground)
- *These are the types of things that students should include in their captions!*

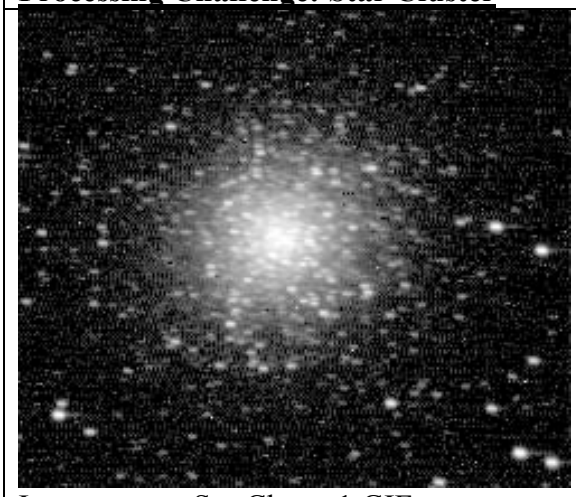
The images and instructions on the following pages provide a "cheat sheet" for facilitators on how each challenge or example image was created. Students should process the example image along with the facilitator. Challenge images should be processed by the facilitator and shown to the students to recreate, with the necessary prompts. It may be necessary to create new challenge images depending on the level of the students' image processing skills.

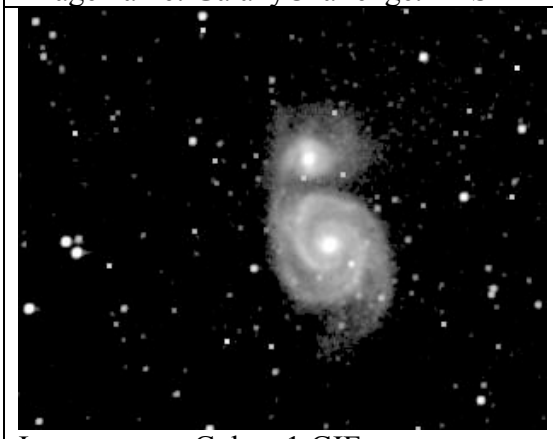
ALWAYS LEAVE TIME FOR CAPTION-WRITING AND REFLECTION!

Processing Activity & Challenge: Prudential Tower	**How to Complete This Activity/Challenge**
 Image name: TowerChallenge.FITS	File > Open image Window > Image Info Process > Adjust Image… (Contrast) File > Save As… > GIF Zoom (if necessary) Process > Color tables (if time) Process > Invert Color (if time) All activities begin by opening the image, the "Image Info" window, and the "Adjust Image" processing window. All activities end with students saving the image as a GIF with a unique, descriptive name.
 Image name: Tower1.GIF	GOAL: To increase the contrast between the windows on the left side of the building and the building itself. (as seen inTower1.GIF) 1. Click on image window and observe the pixel value of the building's windows (left side) in the "Image Info" window 2. Enter approximate pixel value of building windows into "Max" field of "Adjust Image" window (~300) 3. Determine approximate pixel value of the building surrounding the windows and enter value into "Min" field of "Adjust Image" window (~275) 4. Save image as GIF
 Image name: Tower2.GIF	STUDENT CHALLENGE: Make the name of the building appear white with a black background. (as seen in Tower2.GIF) 1. Set "Max" value to match approximate pixel value of the letters in the word "PRUDENTIAL" (~500) 2. Set "Min" value to match approximate pixel value of the building *around* the word "PRUDENTIAL" (~350) 3. Apply a new color table and/or Invert Color if desired 4. Save image with a unique, descriptive name (don't forget .GIF at the end!)

Processing Activity & Challenge: Moon	**How to Complete This Activity/Challenge**
 Image name: MoonChallenge.FITS	Tools to review: File > Open Image Process > Adjust Image File > Save Image As… > GIF Tools to learn: Zoom (magnifying glass icon in image window) Select area (dotted rectangle icon in image window) Process > Crop Sharpen, Color Tables, and/or Invert Color may be used
 Image name: Moon1.GIF (Sharpen tool has been applied to image)	GOAL: To get a better, more detailed view of a chosen crater on the surface of the Moon (as seen in Moon1.GIF) 1. Open image MoonChallenge.FITS 2. Click "Process" > "Sharpen" 3. Click on the 'zoom' tool (magnifying glass) 4. Click on the crater to be observed (middle of image) 5. Adjust the contrast on the image in the by moving the triangles in the "Adjust Image" window 6. Change the color table and/or Invert Color if desired (image to the left is in Gray Scale) 7. Click on the 'select area' tool (dotted rectangle) 8. Select the area to be cropped 9. Click "Process" > "Crop" 10. Save the new image as a GIF with a descriptive name
 Image name: Moon2.GIF (Sharpen tool has been applied to image)	STUDENT CHALLENGE: Create a sharp, detailed view of the craters at the bottom of the Moon (as seen in Moon2.GIF) 1. Open image MoonChallenge.FITS 2. (Optional) Sharpen the image 3. Zoom in on the chosen area 4. Adjust the contrast of the image by moving the triangles in the "Adjust Image" window and/or setting the "Min" and "Max" values to match the pixel values of the background (~280) and bright spots on the surface (~550) 5. (Optional) Change the color table and/or Invert Color if desired 6. Select and crop the chosen area of the image 7. Save the cropped image as a GIF file

Processing Activities: Orion Nebula	**How to Complete These Activities**
 Image name: NebulaChallenge.FITS	Tools to learn: "Auto" and "Log" functions of the "Adjust Image" tool Tools to review: Process > Adjust Image Zoom/select area tools Process > Crop This week is slightly different from previous weeks. There are two guided explorations on the same image (Nebula), and the challenge is done on a different image (StarCluster).
 Image name: Nebula1.GIF	GOAL: To see more detail in the star-forming nebula (Nebula1.GIF) 1. Open image NebulaChallenge.FITS 2. Open the "Image Info" and "Adjust Image" windows 3. Click the "Auto" button in the "Adjust Image" window 4. Set the "Min" field to the approximate pixel value of the background (~289) 5. Crop and save image as a GIF with a descriptive name
 Image name: Nebula2.GIF	GOAL: To see the full extent of the cloud and as many details as possible in the center of the nebula where stars are forming (Nebula2.GIF) 1. Open image NebulaChallenge.FITS 2. Open the "Image Info" and "Adjust Image" windows 3. Choose "Log" and click the "Auto" button in the "Adjust Image" window 4. Zoom in on the center to see more detail 5. Set "Max" field to the highest pixel value in the image (~4000, at the heart of the nebula) 6. Crop and save the image as a GIF with a descriptive name

Processing Challenge: Star Cluster	**How to Complete This Challenge**
 Image name: StarCluster1.GIF	STUDENT CHALLENGE: To make visible as many stars as possible in the Hercules star cluster (as seen in StarCluster1.GIF) 1. Open StarClusterChallenge.FITS and the "Image Info" and "Adjust Image" windows 2. Click the "Auto" button in the "Adjust Image" window 3. Set the "Min" field to the approximate pixel value of the background (~295) 4. Click the "Log" in "Adjust Image" window 5. Set "Max" field to the highest pixel value in the image (~950, at the center of the cluster) 6. Apply color tables/invert color if desired 7. Crop and save the image as a GIF with a descriptive name

Processing Activity: Whirlpool Galaxy	**How to Complete This Activity**
 Image name: GalaxyChallenge.FITS	Tools to learn: Reduce Noise Tools to review: All others NOTE: This week's challenge image will be created by the apprentices themselves. Students should spend any remaining processing time applying their knowledge of processing tools to ALL the images they have been taking throughout the apprenticeship.
 Image name: Galaxy1.GIF	GOAL: To create a clear, detailed image of another galaxy outside of the Milky Way (as seen in Galaxy1.GIF) 1. Open image GalaxyChallenge.FITS 2. Open the "Image Info" and "Adjust Image" windows 3. Choose "Log" and click the "Auto" button in the "Adjust Image" window 4. Adjust the "Max" value by moving the upper triangle in the "Adjust Image" window 5. Click on "Process" > "Reduce Noise" 6. Zoom in, crop, and save the image as a GIF with a unique, descriptive name

Kids Capture Their Universe: An Astronomy Apprenticeship

Appendix D Kinesthetic Life Cycle of Stars (detailed information)

Adapted from "Kinesthetic Life Cycle of Stars" by Erika Reinfeld (CfA) & Mark Hartman (MKI), *Astronomy Education Review*, Fall 2008

Five stages of stellar evolution are described and diagrammed below. In each stage, facilitators should provide a brief narration of the science and physical actions that are about to occur, before "starting the clock." It may be instructive to show a poster illustrating the stages of stellar evolution, or to preview an image that the students will recreate at each stage. Once the action begins, students move into the appropriate formation. Facilitators may need to provide more detailed instruction or hands-on guidance to individual students. Once students have completed the action of a stage, they should stop moving while facilitators summarize the process and begin the next segment of narration.

The "description" column in the table below does not represent verbatim narration, but rather a summary of basic principles involved in each stage. In particular, facilitators should emphasize the interplay between the inward force of gravity pulling the star together and the outward force resulting from fusion in the core.

Stage	Description	Action
Star-Forming Nebula [Gravity rules.]	A cloud of gas and dust forms many stars. A single star is created when clumps of this material (mostly hydrogen gas) are pulled together by the force of gravity.	Students, scattered randomly throughout the room, point in the direction where "the most other clumps" are, and slowly make their way to that point.
Birth of the Star (Protostar) [Gravity rules. Fusion begins.]	As a region of the cloud collapses, gravity pulls the clumps of gas together. The gas in the center becomes hot enough and dense enough to begin fusion. Hydrogen atoms inside the clumps smash into each other, combining to create helium and releasing light and heat. The star begins to shine.	Students clump together, forming a large ball. Those on the outside ("envelope") continue to move toward the center. When students on the inside ("core") start bumping into each other, they face outward.
Life of the Star (Main Sequence) [Gravity and fusion in balance.]	Fusion in the core generates an outward force to balance the inward gravitational force from the outer layers.	Core students and envelope students gently push against each other, palm-to-palm, elbows bent, balancing. There should be one or two envelope students per core student.

Continued on next page...

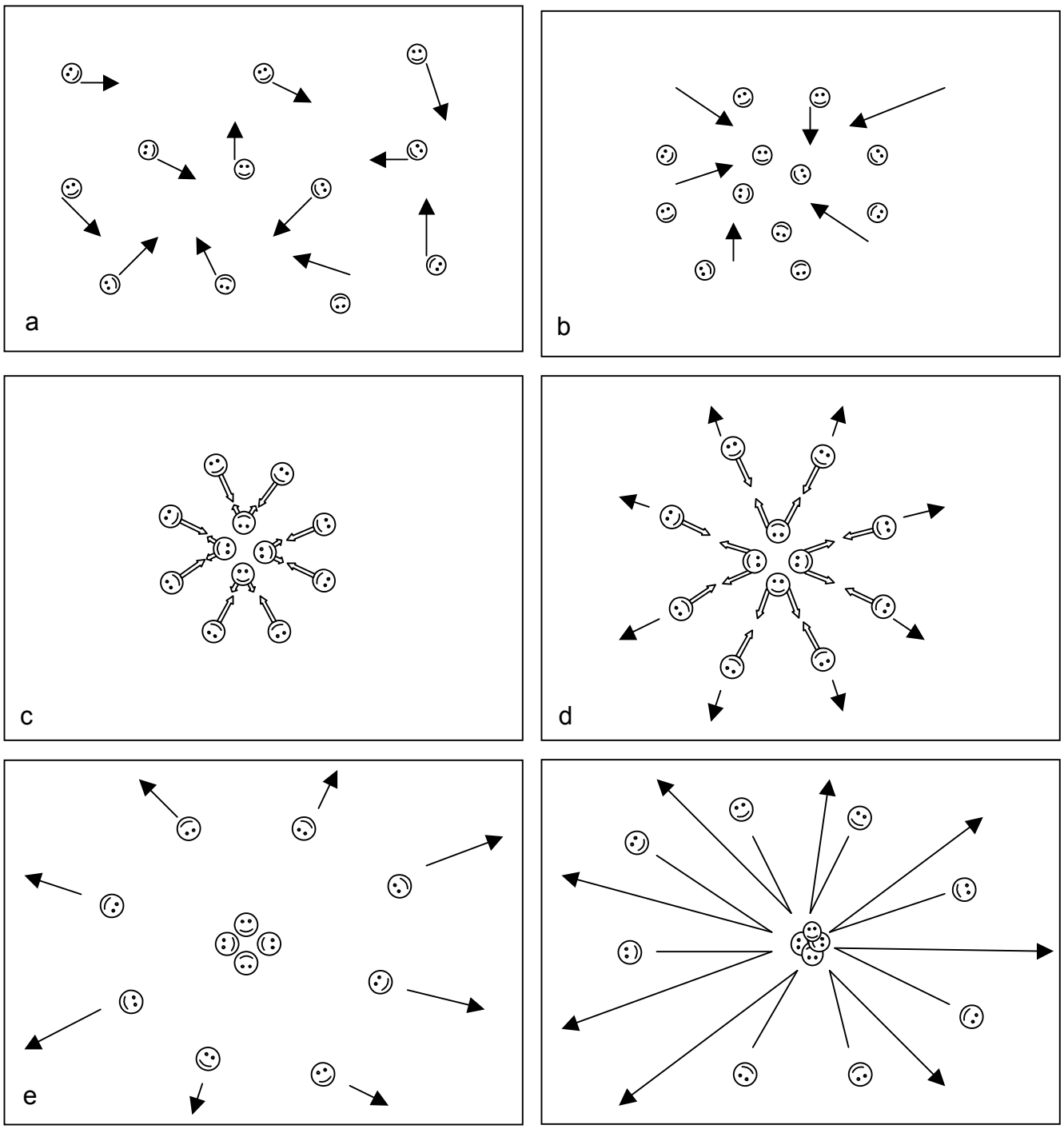
Red Giant [Fusion overtakes gravity.]	As the core nears the end of its fuel supply, the outer layers continue to push inward, increasing the temperature in the core. This produces a new series of fusion reactions that produce enough outward force to overpower the inward gravitational force and expand the star.	Core students fully extend their arms, pushing the envelope students backwards, expanding the star.
Death of a Low-Mass Star (Planetary Nebula with White Dwarf) [Fusion ends; gravity wins.]	As the core runs out of fuel for fusion, it emits one last push outward, ejecting the star's outer layers, which drift away into space. The core then contracts under its own gravity, forming a white dwarf.	Core students push the envelope outward then move together into a tight blob at the center. The envelope students, in a ring-like shape, drift away from the core.
Death of a High-Mass Star (Supernova, with Neutron Star or Black Hole) [Fusion ends; gravity wins.]	The massive core continues to fuse elements and expands the star so it is even larger. Once the core runs out of fuel, it collapses to form a neutron star. The outer layers then collapse as well. As material falls toward the star's center, it bounces off the core and explodes outward through the star. This explosion is called a supernova. In the most massive stars, the collapsed core will become a black hole.	Core students extend their arms, expanding the star. Then, they stop pushing and scrunch together at the star's center. Envelope students rush inward, and bounce off the packed-together students in the core, exploding outward dramatically, revealing the collapsed core.

To transition between the deaths of low- and high-mass stars, facilitators must rewind the clock, to the original star-forming nebula or to the main sequence stage. Recreating all stages of the activity up to the red giant phase, from students' memory, is most effective because it highlights the parallel paths of the two stars and allows students to review and teach back what they have learned.

Additional information and posters about this topic can be found at
http://imagine.gsfc.nasa.gov/docs/teachers/lifecycles/stars.html

Photographs of students in action can be found at
http://www.flickr.com/photos/24452156@N07/sets/72157605963324609/

Illustration of student motion appears on the next page.



a. Star-Forming Nebula (random motion)
b. Protostar (clumping, motion toward the center, core and envelope start to differentiate)
c. Main Sequence (core and envelope pushing in balance)
d. Red giant (core pushing harder, motion outward)
e. Planetary Nebula (core compacted, all other motion outward)
f. Supernova (core compacted, motion inward then outward)

Kinesthetic Telescope: Narration (Week 1, No Telescope)

1. **Light** travels from an object in space to the telescope
2. The **aperture** lets the light into the telescope
3. The **mirror** focuses the light toward the detector
4. The **shutter** lets the light through to the detector
5. The **detector** records the light to create an **image**

Kinesthetic Telescope: Cards (Cut apart and distribute to students)

Narrator	**Aperture** The opening of the telescope that lets light in	**Aperture** The opening of the telescope that lets light in
Mirror The piece of the telescope that reflects and focuses the light	**Shutter** The piece of the telescope that opens and closes to let light through to the detector	**Detector** The piece of a telescope that collects the focused light, and records it as an electronic image
Light	**Light**	**Light**

Making Image With Mirrors Template (Supplemental Activity)

Detector

Focus reflected light onto detector

Aperture

Cut along dotted lines to create aperture (opening)

Cover aperture with shutter to block light from getting to the mirror

Kids Capture Their Universe: An Astronomy Apprenticeship

Appendix F Illustrated Processing Tools Guide

This illustrated guide provides additional information about the image processing tools used in the "Kids Capture the Universe" processing challenges. More information about the full suite of processing tools in this software program can be found in the official MicroObservatoryImage manual. This PDF file can be found, along with supporting technical information, at

http://mo-www.harvard.edu/MicroObservatoryImage/mObs_Manual.pdf

or in the program folder that was downloaded with the MicroObservatory Image software.

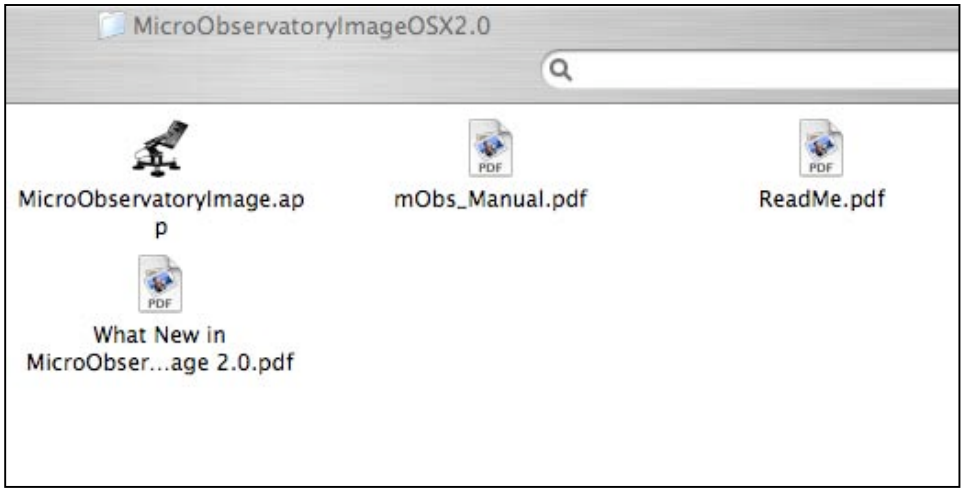
Kids Capture Their Universe: An Astronomy Apprenticeship

How to start MicroObservatoryImage

This is what the contents of the program folder for this application should look like once you have downloaded and extracted the MicroObservatoryImage software:

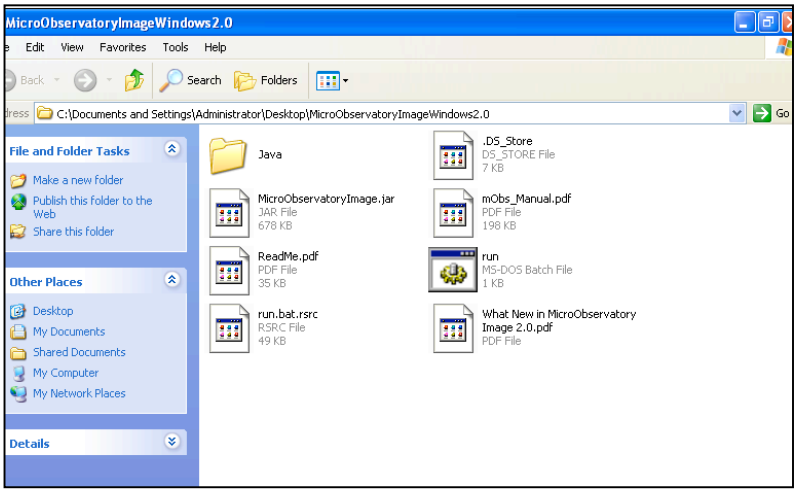
For Mac:

You can drag the MicroObservatory Image.app icon to your launch bar for convenience.



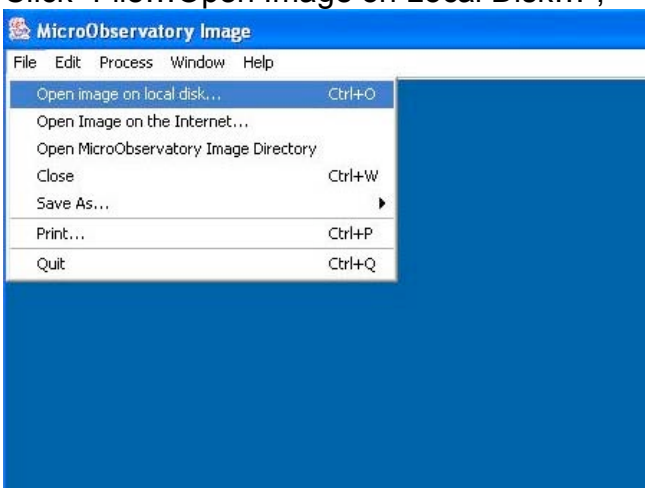
For PC:

Click "run.bat" to start MicroObservatory, but feel free to rename it something like "MicroObservatory Image Processing" and create an shortcut on the desktop, for convenience.

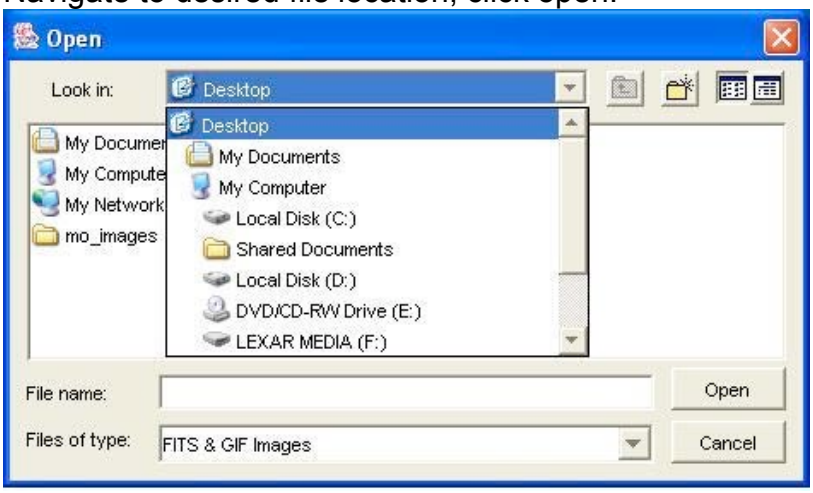


Open:

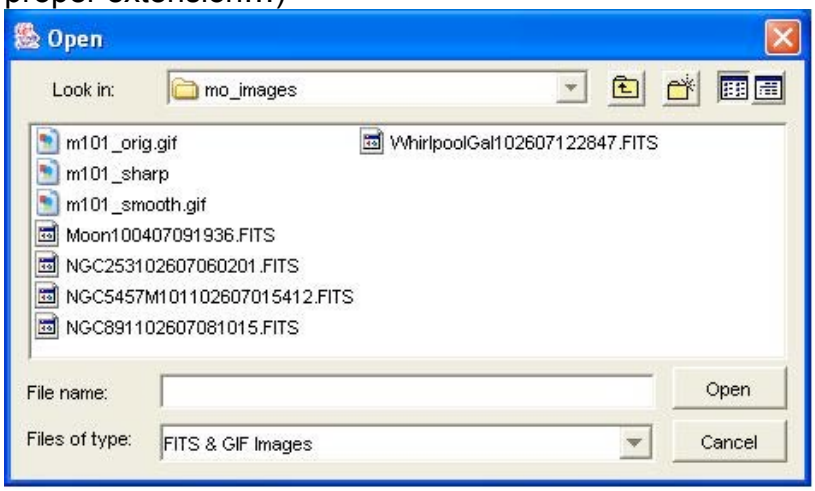
- Click "File…Open Image on Local Disk…",

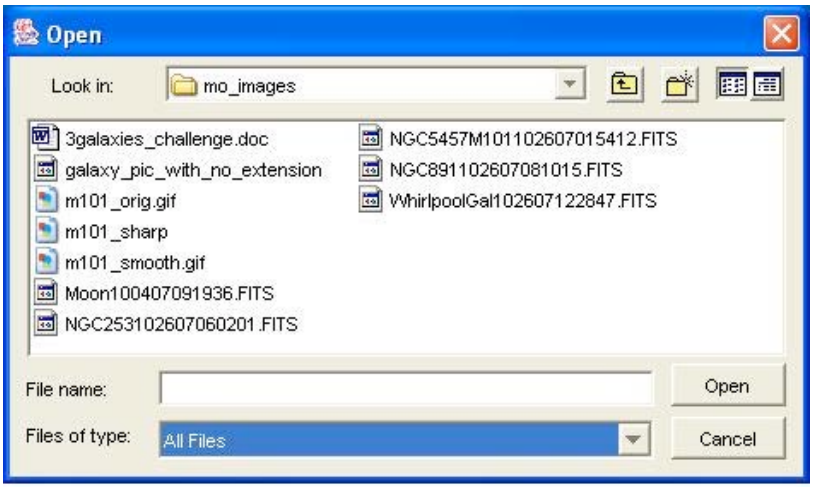


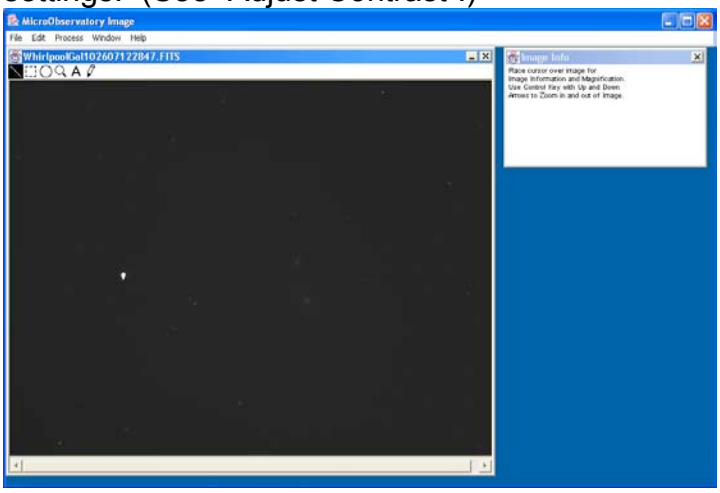
- Navigate to desired file location, click open.



- Default is to look ONLY for .fits and .gif extensions. You can change the bottom selector box to look for "All files" if you have FITS or GIF files without that extension, and MicroObservatory will still open them. (However, it's a better habit to save files with the proper extension…)

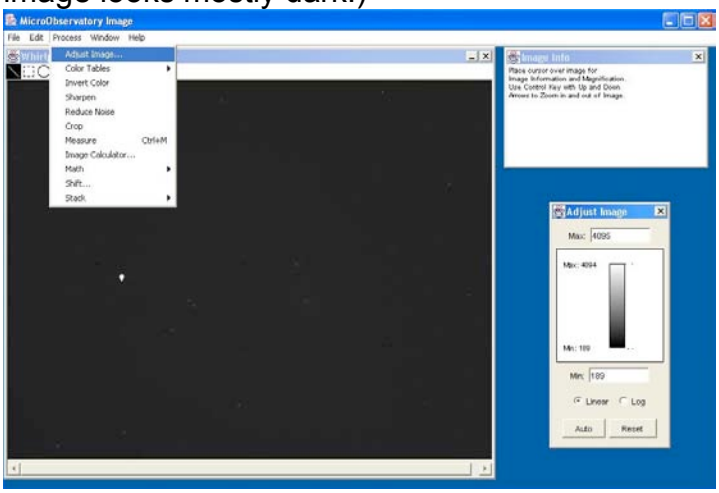


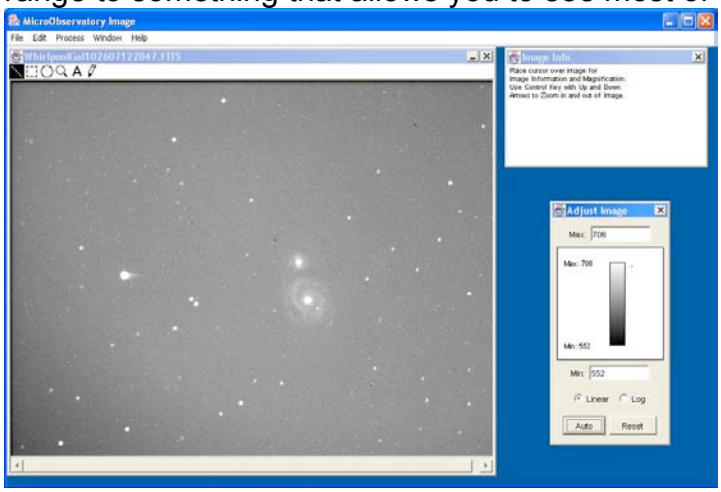
- If names do not have this extension, select “Files of type: All files” in the bottom selector box.
- 

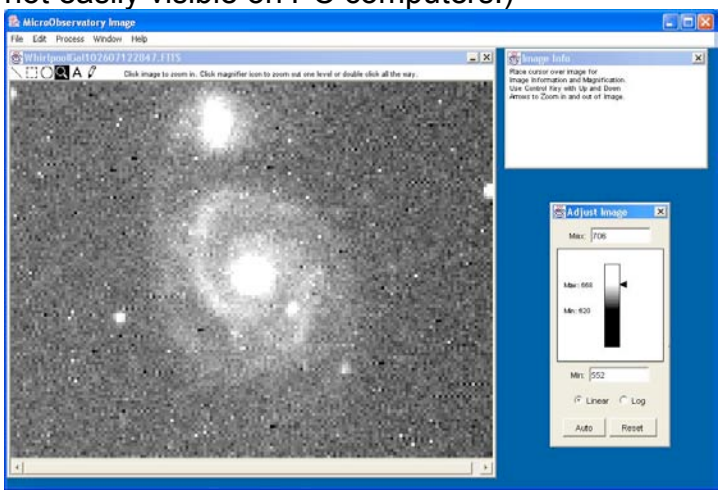
- A ‘Drag and Drop’ feature is available which allows you to drag an image, a file, or a URL address onto to an open MicroObservatory Image home window (the one with the blue background).
- Note: you will likely not see much detail in FITS images at the default contrast settings. (See “Adjust Contrast”.)
- 

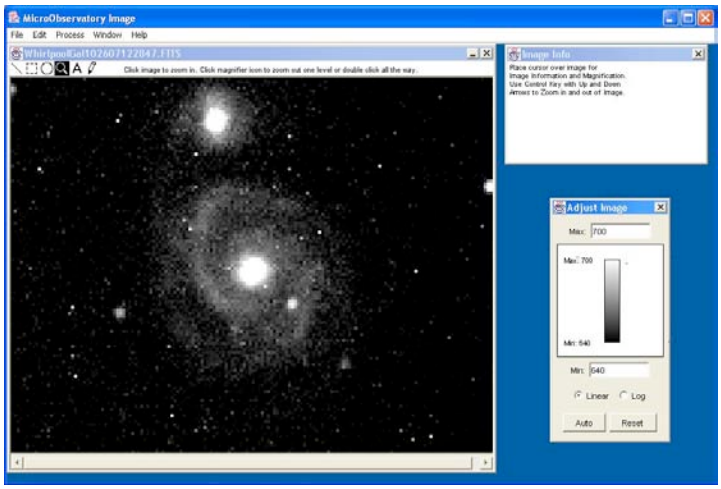
"Adjust Image" (changing contrast):

Rescales or remaps the brightness values of each picture element (pixel) of the image to a different scale of values

- Select "Process…Adjust Image…" from the menu bar.
- A new window pops up with the title 'Adjust Image'. At first the contrast (the range of brightness or "pixel value" we choose to display in an image) is set to show the WHOLE range of pixel values present in the image. (Which may mean that you're "wasting" viewing range on parts of the image that aren't important. In most cases, the image looks mostly dark.)
- 

- You can change the contrast in 3 ways: click auto, click and drag arrows, or enter new values for min/max
    - Auto: this process examines the range of pixel values and sets the contrast range to something that allows you to see most of the important details.
    - 

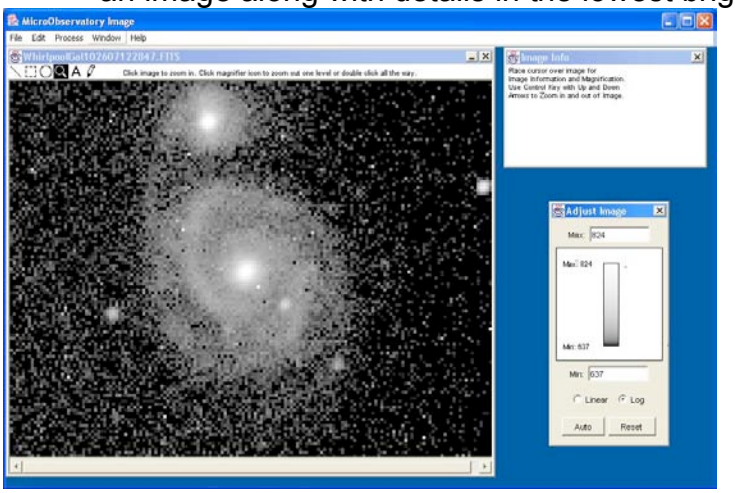
- Click and drag arrows to the right of the scale: You can shrink the range of pixel value to be displayed from the Min and max values. (These arrows are not easily visible on PC computers.)
- 

- Enter new integer value for min/max: This allows you to shrink or expand the range of pixel values to be displayed. You must hit "Enter/Return" after typing in a new value for it to take effect.
- 

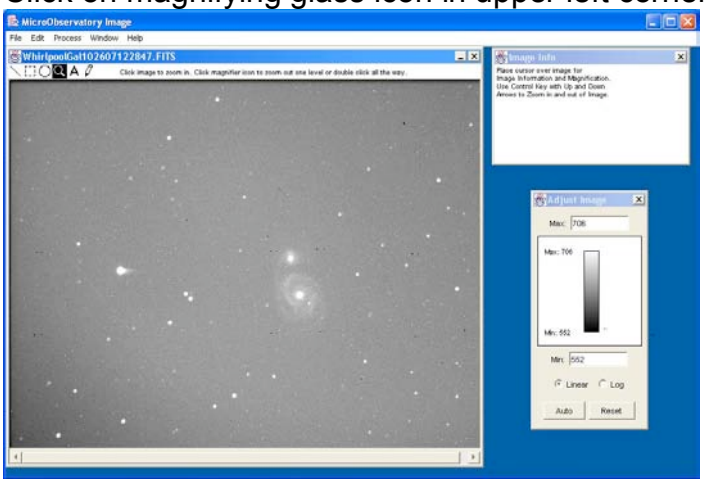
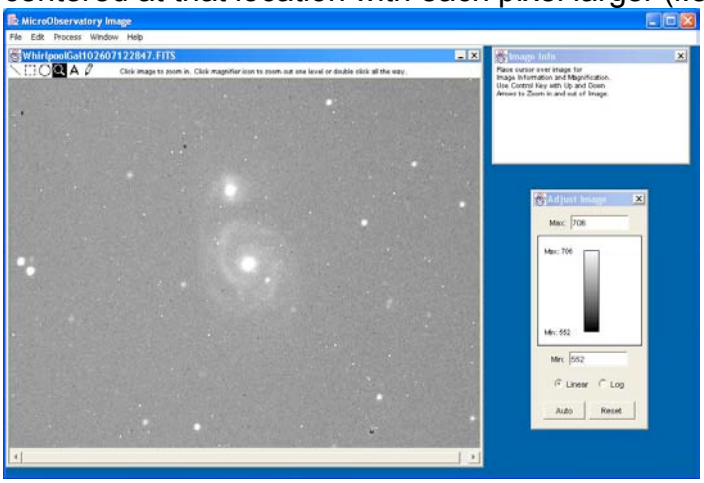
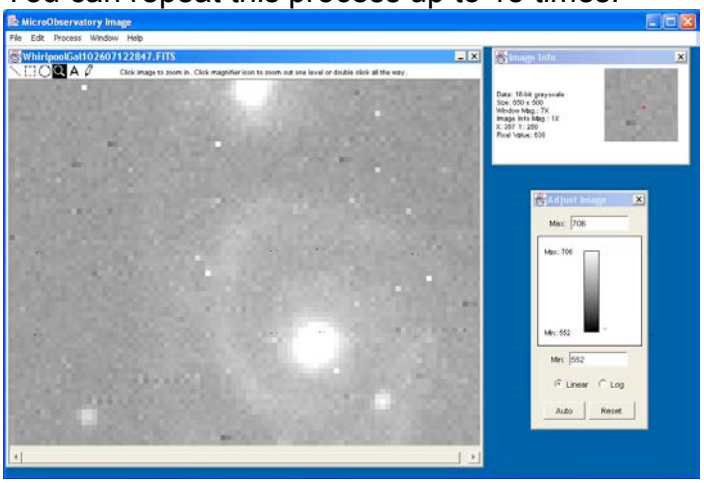
- Log vs. Linear scale: the "Log" scale helps us to see differences across a wide range of brightness.
  - Usually, very bright regions in an image change brightness a lot between pixels right next to each other. The logarithmic ("log") scale represents big differences of image brightness at the high end of the scale as smaller differences in displayed brightness. (Note in the image that a large difference in location along the bar at the top of the scale is not a big change in displayed brightness.)
  - Usually, less bright regions change brightness only a little between pixels right next to each other. The logarithmic ("log") scale represents small differences of image brightness at the low end of the scale as large differences in displayed

brightness. (Note in the example image that a small difference in location along the bar at the bottom of the scale is a big change in displayed brightness.)

- Thus, using the “log” scale, we can see details in the highest brightness parts of an image along with details in the lowest brightness parts of an image.



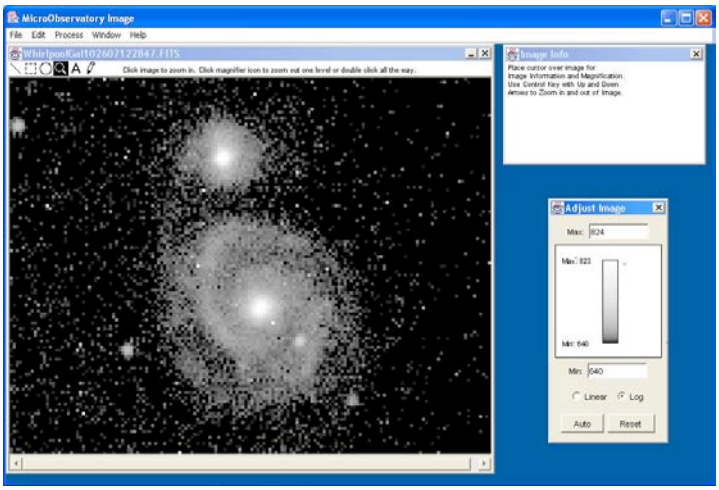
Zoom:

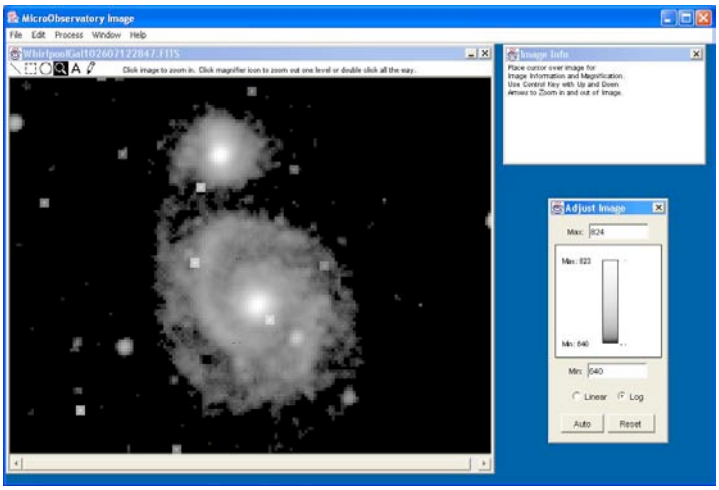
- Click on magnifying glass icon in upper left corner of image window.
- 
- Click the mouse in location where you would like to zoom in. The image is redisplayed centered at that location with each pixel larger (i.e. zoomed)
- 
- You can repeat this process up to 15 times.
- 
- To zoom out: click magnifier icon to zoom out one level, or double click the icon to zoom out to entire image.

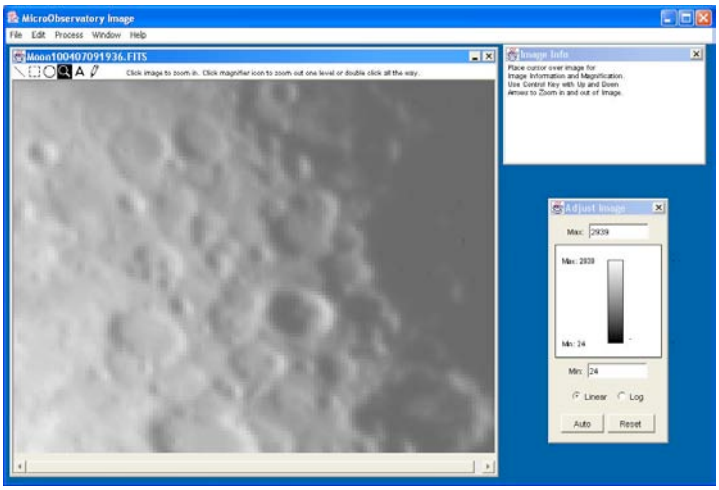
Reduce Noise:

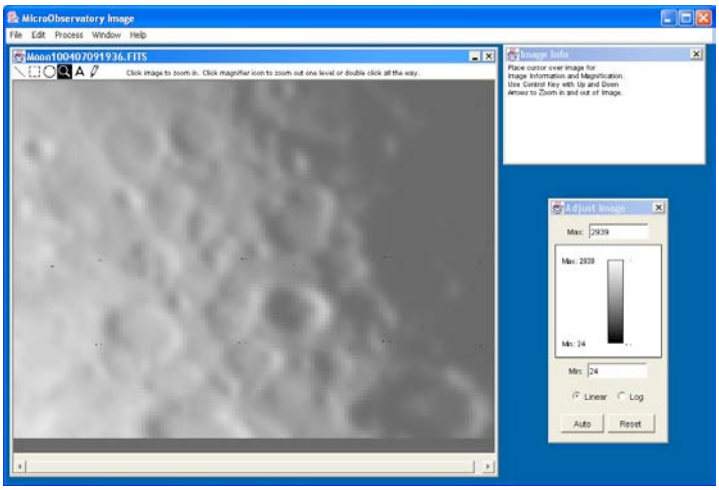
- Select "Process…Reduce Noise" from the menu bar.
- This tool averages a pixel's value with the surrounding pixels' values.
- The "reduce noise" tool actually **changes the image data** (i.e. changes the pixel values) unlike changing contrast, which does NOT change pixel values.
- This function reduces the noise viewed in an image but also reduces the detail or blurs the image.
- *How to "undo" reduce noise*: : Use "Edit…Undo" from the menu bar to reverse a "reduce noise" function. NOTE: You can only "Undo" the LAST action taken, so you cannot undo "reduce noise" if you've done another processing function after it. You must then open the image and start from scratch.
-

BEFORE ----------→ AFTER





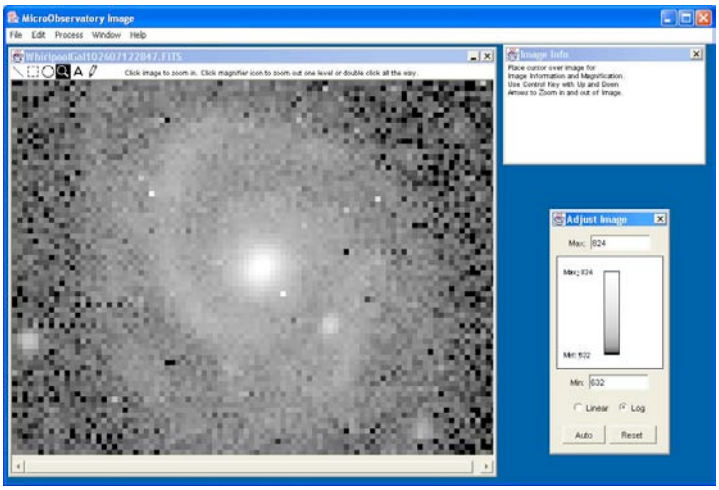


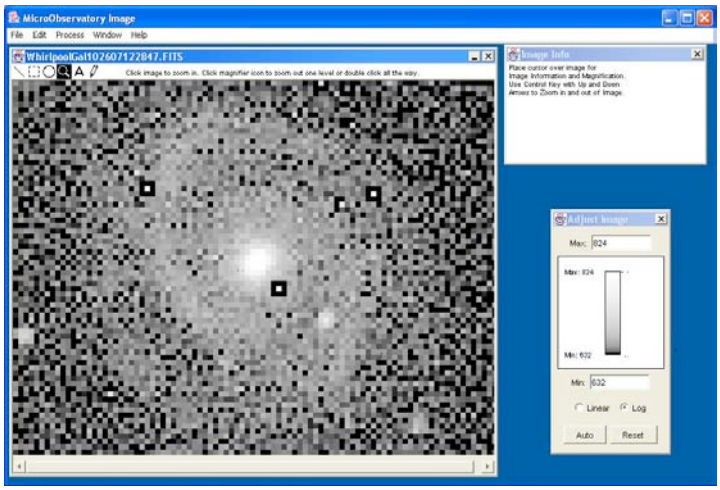


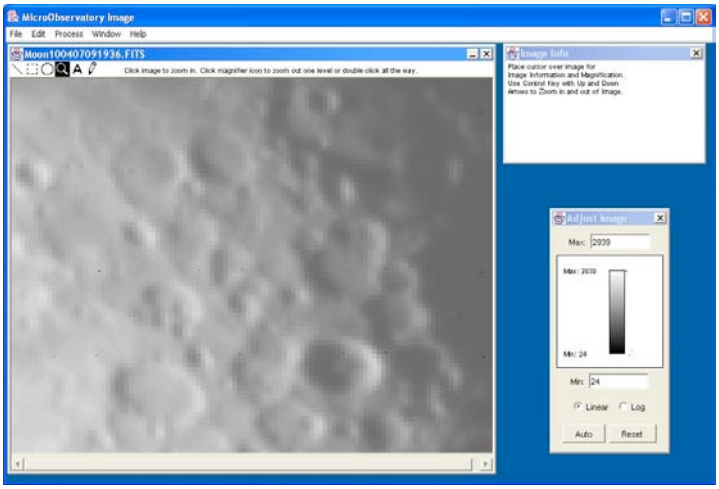
Sharpen:

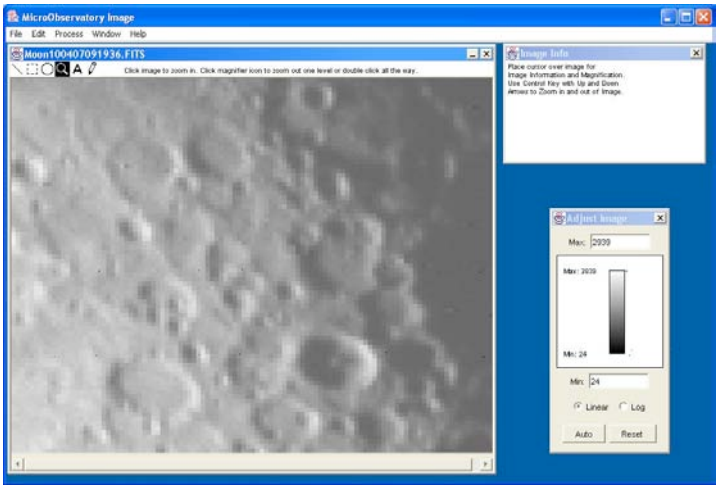
- Select "Process…Sharpen" from the menu bar.
- This tool emphasizes the edges between nearby regions of high and low brightness by changing the pixel values to increase the difference in brightness between a pixel and all the surrounding pixels.
- The sharpen tool actually **changes the image data** (i.e. changes the pixel values) unlike changing contrast, which does NOT change pixel values.
- This tool may show you more details, but also increases the noise in an image.
- *How to "undo" sharpen*: Use "Edit…Undo" from the menu bar to reverse a sharpen function. NOTE: You can only "Undo" the LAST action taken, so you cannot undo sharpen if you've done another processing function after it. You must then open the image and start from scratch.

BEFORE ----------→ AFTER





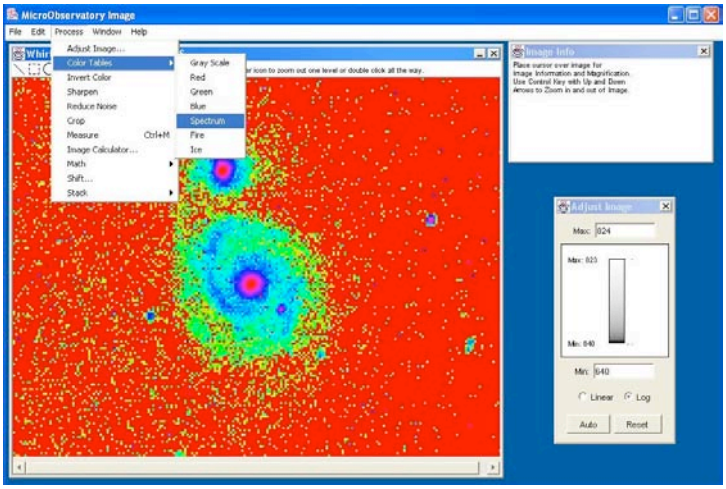




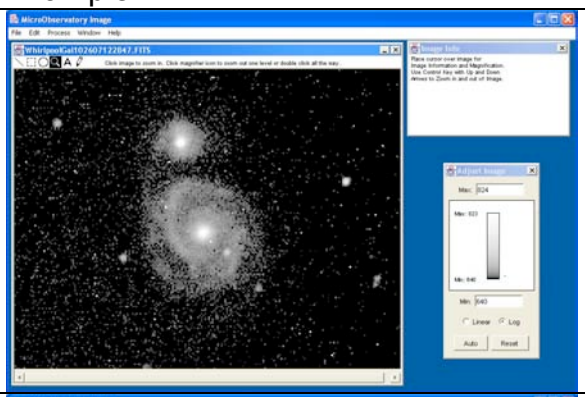
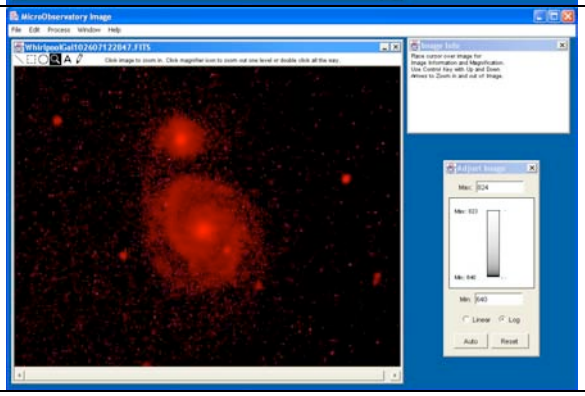
Color Tables:

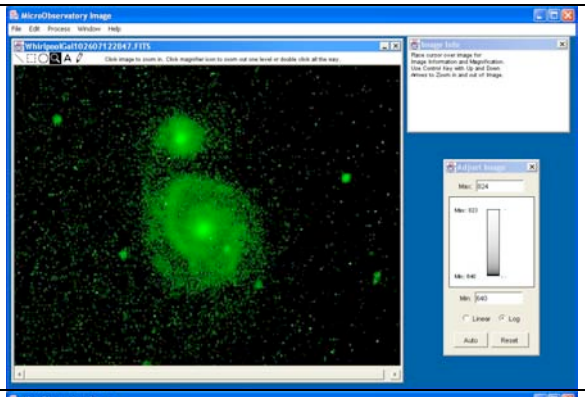
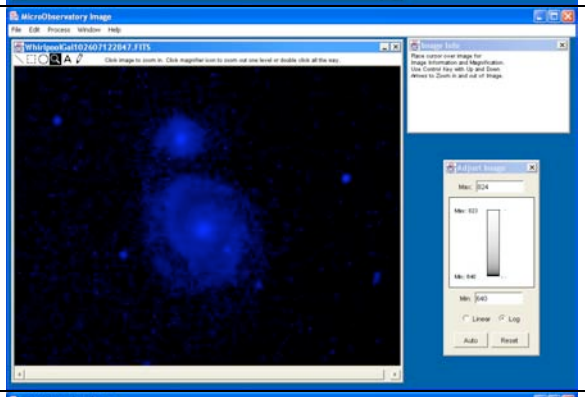
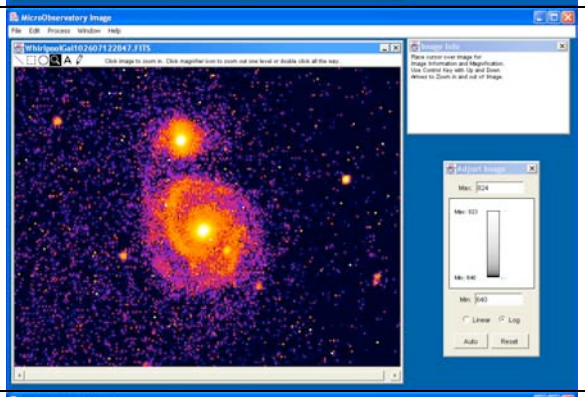
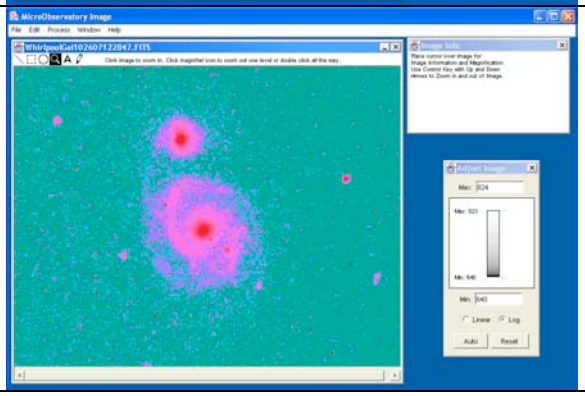
The image can be 'colorized', meaning that for each brightness level a specific color can be assigned to that value. The default 'color table' is a gray scale where the smallest value is black and the highest value is white, with intermediate values being darker shades of gray as pixel values increase.

- Select "Process…Color Tables…Name of color table" in the menu bar.



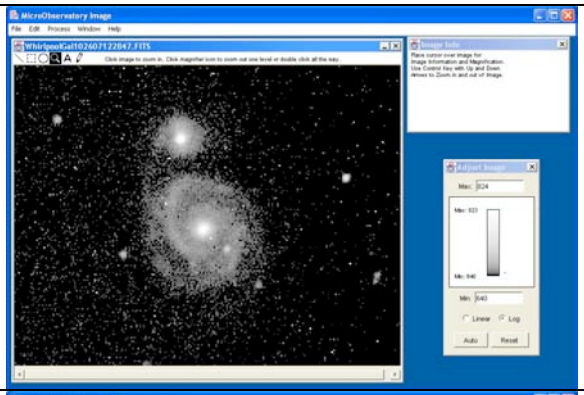
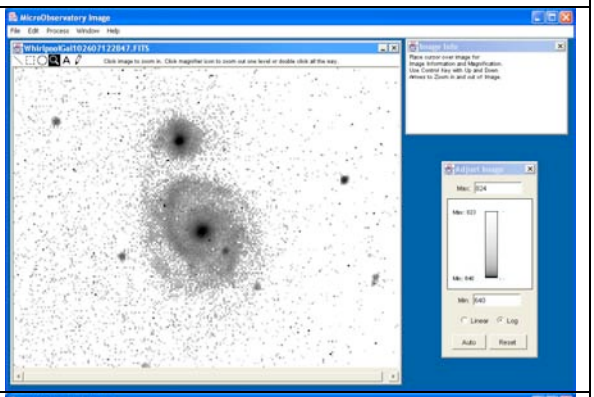
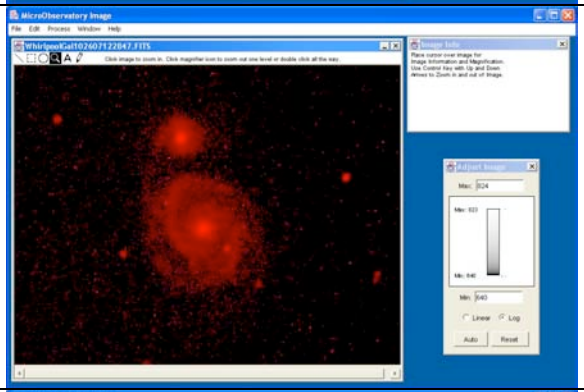
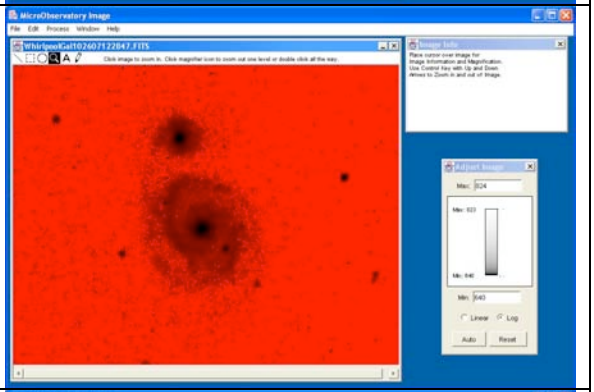
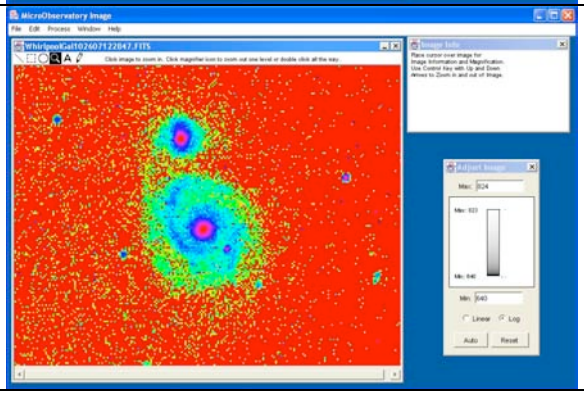
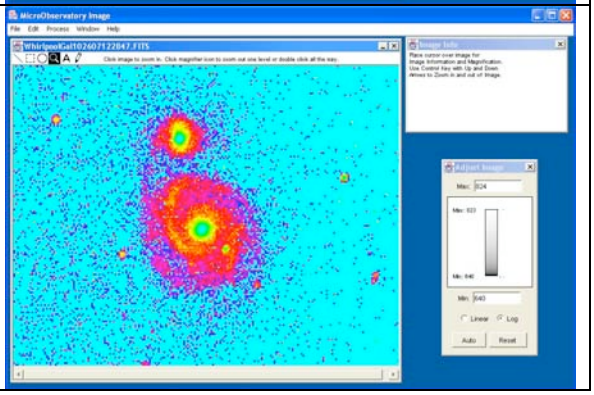
-
- This example is "Spectrum." Other examples/choices are below.

Color table	Example
Gray Scale	
Red	

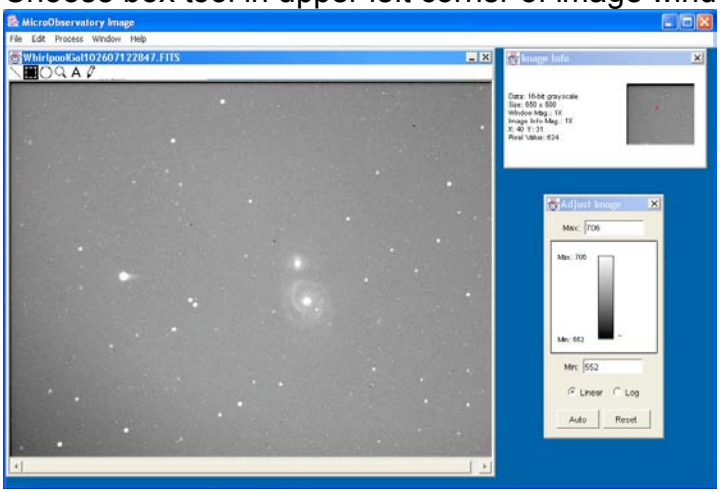
Green	
Blue	
Fire	
Ice	

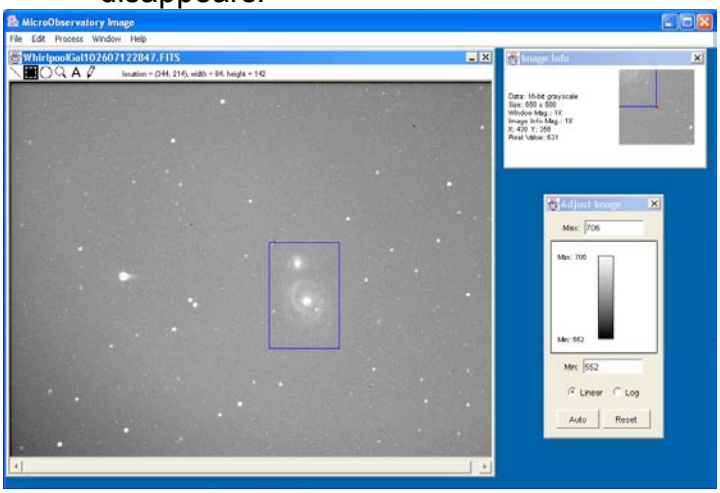
Invert color:

- Select “Process…Invert Color” in the menu bar.
- For greyscale, and the red, green and blue color tables, this tool swaps the way the highest and lowest brightness pixels are displayed.
- For the spectrum, fire and ice color tables, this tool simply creates a different color table (i.e. the highest and lowest pixel values are NOT simply swapped.)

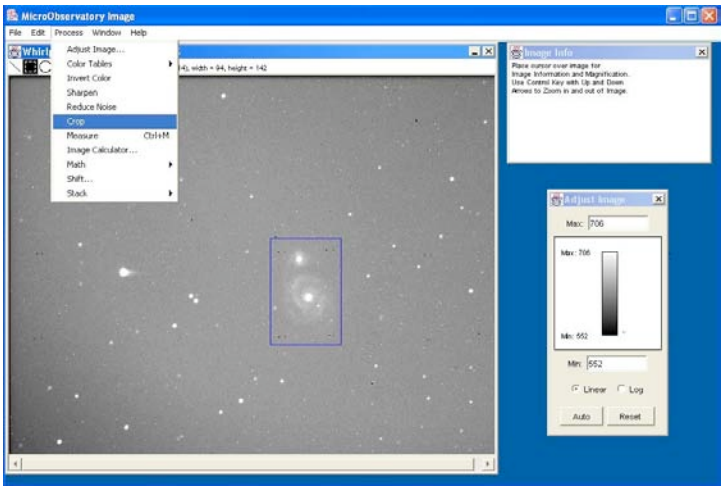
Color table	Original	Invert Color
Gray Scale		
Red		
Spectrum		

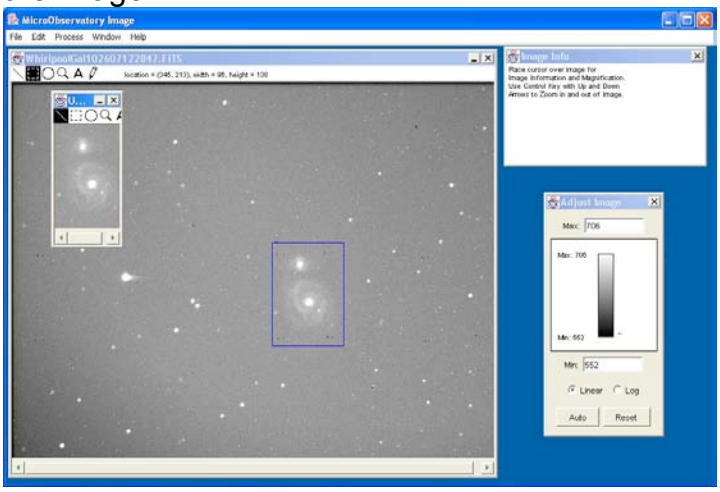
Crop:

- Choose box tool in upper left corner of image window.
- 

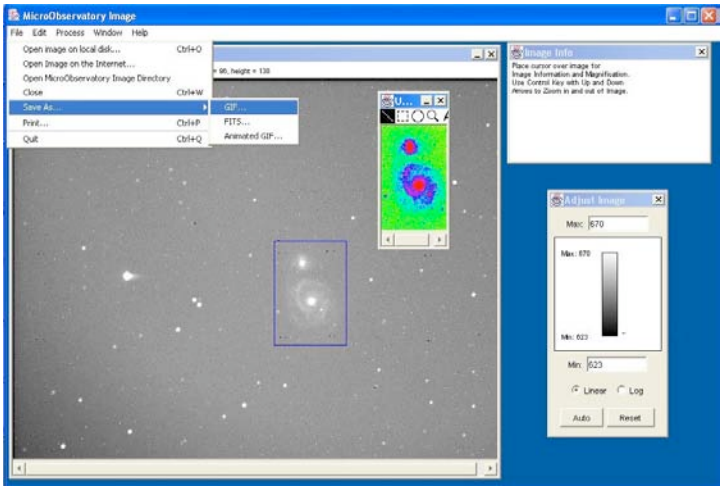
- In the image, click and drag out the rectangle over the area you want to crop.
    - The box can be moved around the image by cliking and holding the cursor inside the shape, dragging, and then releasing the mouse.
    - Boxes cannot be resized—simply click and drag another box; the first box disappears.
- 

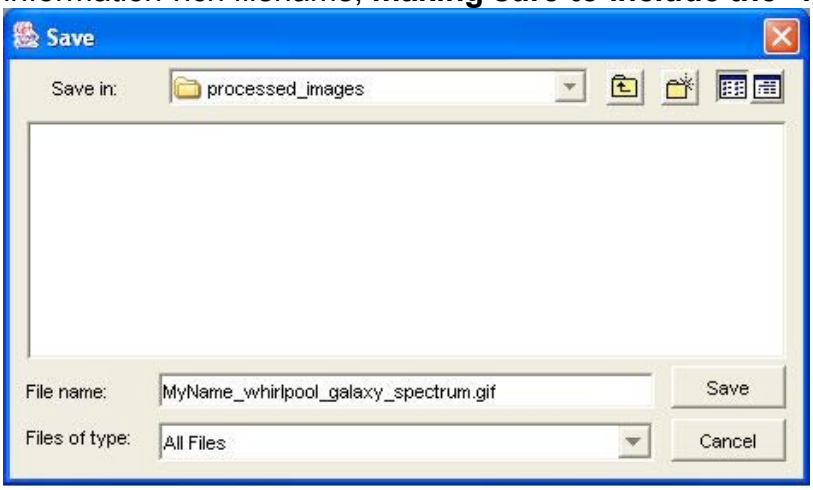
- Select “Process…Crop” from the menu bar.



- This process opens a new image window called “Untitled” with the cropped portion of the original image.
    - Note: Cropping while zoomed works, but the cropped portion will show up as original size. Crop should be the last thing a student does just before saving the image.
    - 

Save:

- Once your image is in the processed form you want (including changed contrast, applied color tables and cropping), you should save the image as a .GIF file to save your processing. (Saving as .FITS will save the original image with no processing.)
- Highlight the image window you wish to save.
- Select "File…Save As…GIF…" from the menu bar.
- 

- Navigate to the folder where you put processed images, and name the file with an information-rich filename, **making sure to include the ".gif" extension!**
- 

- IMPORTANT NOTE: There may be a character limit to the length of the file name, so the basic information to include is the apprentices name and the name of the object in the image. Encourage students to avoid spaces in the titles, favoring the underscore character instead.