Making pretty pictures

How Astronomers make images

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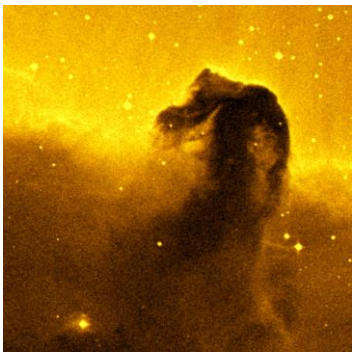
ver4.0



Horse Head Nebula
Sidney High School student
Dec 2004

Teaching Notes
A note From the Authors

The goals of this activity are to have students learn the basics of image processing, and to develop an understanding of how astronomers use raw image data to process images, and to make pretty pictures.
Techniques were learned at TLRBSE 2004 from Dr. Travis A. Rector.
See his site at.

Prerequisites

To get the most out of this activity, students should have knowledge of
a. internet searches,
b. file extension knowledge, and
c. some knowledge of Adobe Photoshop Elements 4.0.

The 0.9-meter telescope
at Kitt Peak National
Observatory in Arizona
Image by DW McDonald

Description of Data Sources

The first images used in this lesson will be from the Digitized Sky Survey at http://archive.stsci.edu/cgi-bin/dss_form. The images will be in gif format to ease the learning curve of image processing.
The Digitized Sky Survey is a set of images from the Palomar & UK Schmidt telescopes. The photographic plates were digitized to allow easy access to astronomers. This survey was produced at the Space Telescope Science Institute. The images are in the public domain but STScI requests acknowledgement when images are used.

The 9-meter telescope at Kitt Peak
National Observatory in Arizona
Image by DWMcDonald

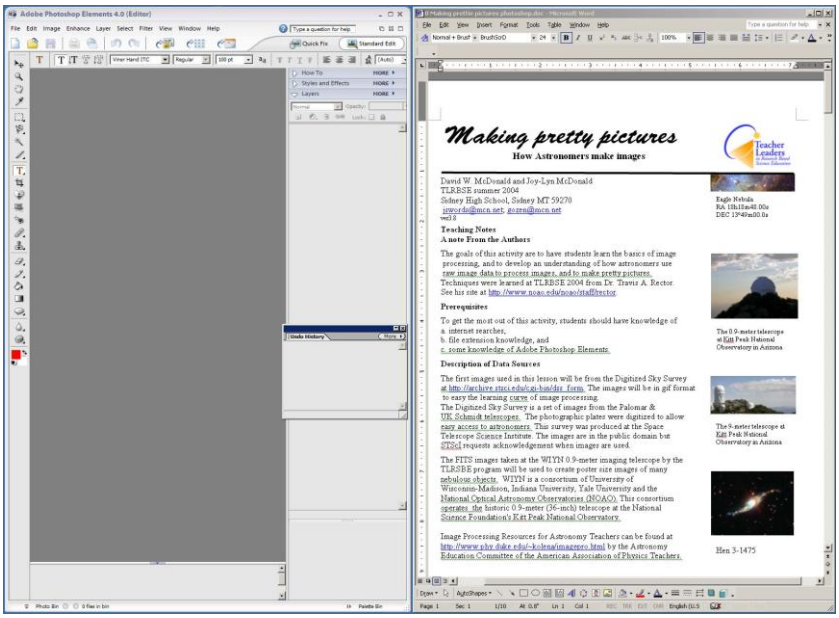
The FITS images taken at the WIYN 0.9-meter imaging telescope by the TLRSBE program can be used to create poster size images of many nebulous objects. WIYN is a consortium of University of Wisconsin-Madison, Indiana University, Yale University and the National Optical Astronomy Observatories (NOAO). This consortium operates the historic 0.9-meter (36-inch) telescope at the National Science Foundation's Kitt Peak National Observatory.

LDN 880 by J.Schaefers
using STScI images

Image Processing Resources for Astronomy Teachers can be found at http://www.phy.duke.edu/~kolena/imagepro.html by the Astronomy Education Committee of the American Association of Physics Teachers.

About the Software to be used

1. Image processing - This project is designed for Adobe Photoshop Elements 4.0 Windows. Elements is an image processing program that allows you to enhance and edit images. You can easily make a stack/layer of images and modify each layer and manipulate the pixels making up the image. There are other image processing programs that work just as well.



2. Multitasking – In this workshop you will be asked to do many tasks on the computer and using multitasking best does this. At this time please **start up a new MS Word** document and place a title of Imaging Workshop. Now do a **save as** and place it in your file folder with a file name of Imaging (AAPT use c://nova & pictures/pretty picture/student work). This will be a place to type in any notes that you want to keep, copy and paste images and web sites into and, as a quick reference sheet. Now start up **Photoshop Elements 4.0** and click on the **Edit & Enhance Photos icon** in the wide tool bar area. Finally use the middle minimize button (upper right hand side of Windows tool bar) on each program (2 Word and 1 Photoshop) and arrange so that Photoshop takes up the left half of the screen and the two Word doc are stacked on the right half of the screen.

Computer Imaging

1. Digital images – **A Real Zero of an Activity**

In this Imaging activity you will work with your partner and explore how digital images are transmitted and viewed. Sitting at different tables (different sides of room) first take a minute or two to determine how you will transmit orally the following set of numbers. One person will read/transmit (and has the numbers) the information while the other person must record/decode the information (does not have the numbers).

start
0 0 1 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 1 1 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 1 1 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0
1 1 1 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0
1 1 1 0 0 0 0 0 0 1 0 0 0 0
0 0 0 0 0 0 0 0 0 0 1 0 0 0
0 0 1 0 0 1 0 0 0 0 0 1 0 0
0 0 0 0 0 1 1 1 1 1 1 1 0 0
0 0 0 1 0 0 0 0 1 1 1 1 1 1
0 0 0 0 0 1 1 1 1 1 1 1 0 0
0 0 1 0 0 1 0 0 0 0 0 1 0 0
0 0 0 0 0 0 0 0 0 0 1 0 0 0
0 0 1 0 0 0 0 0 0 1 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 1 1 1 0 0 0 0 0 0 0 0 0 0
0 1 1 1 0 0 0 0 0 0 0 0 0 0
0 1 1 1 0 0 0 0 0 0 0 0 0 0
stop

The recorder will mark the information on graph paper. The recorder will leave blank all zeros and fill in all ones.

When finished both will look at the image produced and then will analyze the image.

Record your analysis in your word doc. (Again science is a descriptive science so you must have a complete statement of what the image is with your interpretation of what it represents – think astronomy and think near-by astronomy)

2. Image Formats

We will be using five different raster image formats. Each has its use and there are many different ways to store the information about an image on a computer.

The first type is called a **GIF or Graphic Interchange Format**. This is one of the very first types of image format and was brought to the internet by CompuServe in 1987. The algorithm patent belonging to Unisys saves the images at 8 bits-per-pixel (this gives a 256 color levels). This format was widely used as many computer platforms could read GIF's. Being replaced with PNG (ping) with no patent restrictions.

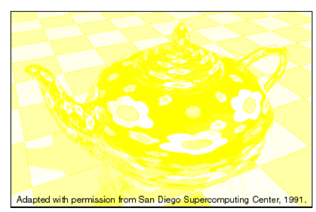
The second type is **JPEG**, an algorithm that compresses the image, and was developed by the **Joint Photographic Experts Group**. The ability to compress an image file size allows them to be stored on a hard drive using less bytes than the displayed images. This format works well for internet uses. Because of the compression a lot of information is stripped from the image. This is not the best format for images needing to convey detailed information for research or to print large images.

Third is the **PSD**, photoshop file extension, which is the native format used by Adobe Photoshop. This format allows multiple image layers and saves data in true color format, and has only a small compression so less is "lost" in saving the image. These images can be very large and so you need lots of memory on your hard drive.

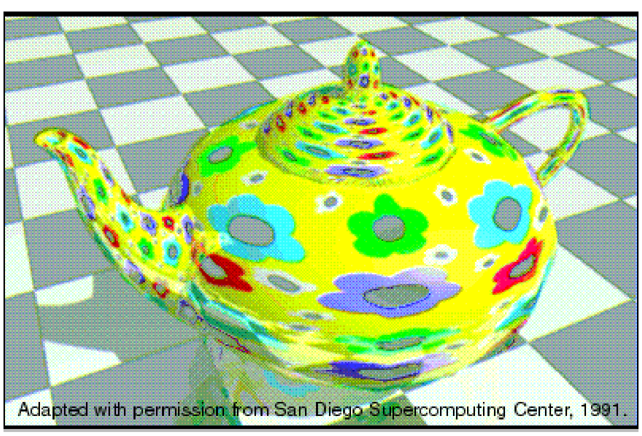
Fourth is **TIFF** a cross platform and lossless compressed format. The TIFF like the PSD format can store multiple images (layers) in one file.

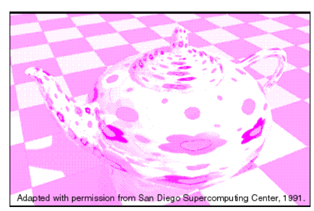
The last format call **FITS or Flexible Image Transport System.** It is often used for astronomical data or other data that need keyword value statements as headers describing the data.
"FITS (Flexible Image Transport System) is a data format designed to provide a means for convenient exchange of astronomical data between installations whose standard internal formats and hardware differ. A FITS data file is composed of a sequence of Header Data Units (HDUs). The header consists of keyword-value statements, which describe the organization of the data in the HDU and the format of the contents. It may provide additional information, for example, about instrument status or the history of the data. The data follow, structured as the header specifies. The data section of the HDU may contain a digital image, but, except for the first HDU, *it doesn't have to*. The "Image" in FITS comes from the original use of the format to transport digital images, but it's not just for images any more."

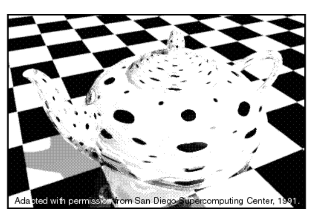
Info on software http://fits.gsfc.nasa.gov/software.html
and http://fits.gsfc.nasa.gov/fits_intro.html
FITS images http://archive.stsci.edu/fits/fits_standard/

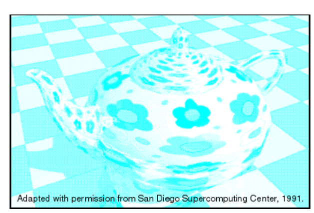


Color addition as seen with the tea pot images and in color newspaper images









Pretty Pictures from STScI Digitized Sky Survey image

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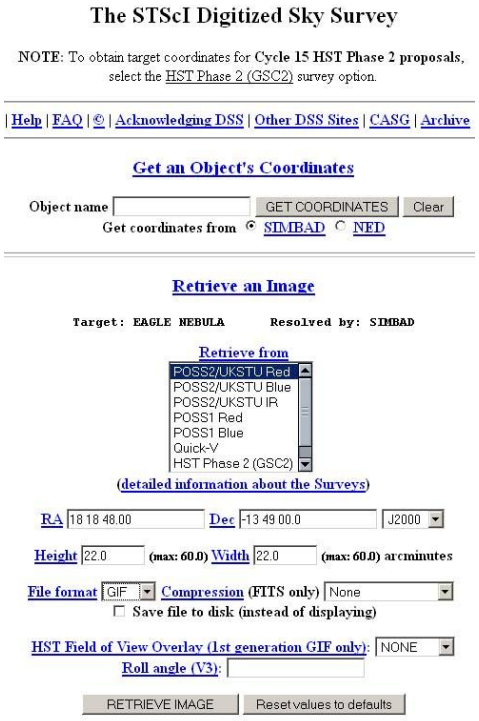
1. Search for an object that you would like to make into a color picture.
Use Google for astronomy images or try the following
www.noao.edu/image_gallery
http://antwrp.gsfc.nasa.gov/apod/archivepix.html
Record the name, type of object & you might need RA & DEC

Some sites to check: Think Messier Objects
http://www.seds.org/messier/xtra/supp/m_APOD.html
http://antwrp.gsfc.nasa.gov/apod/archivepix.html
http://www.nasa.gov/multimedia/imagegallery/

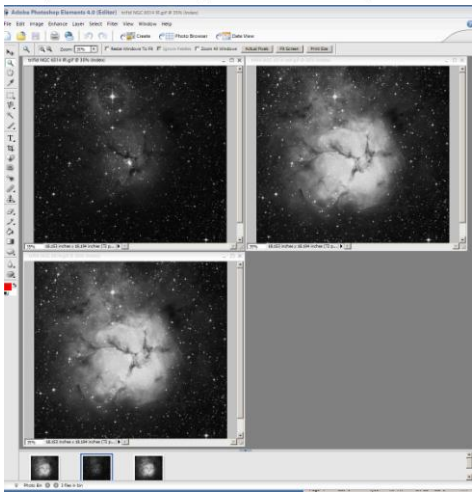
2. Use "The STScI Digitized Sky Survey" to get the images used to make pretty pictures.
   a. http://archive.stsci.edu/cgi-bin/dss_form
   b. Type in Object name and click button GET COORDINATES
   c. Pick color of image (as POSS2/UKSTU Red – you need at least 3).
   d. Pick Height & Width – for Kitt Peak's 0.9 m telescope use **22 arcminutes** (you pick size)
   e. Pick File Format as **GIF**
   f. Click button, **Retrieve image,** and save the image with the color in the name (ie Red Eagle nebula.gif)



OR steps 1 & 2 … Files are found in
c://nova & pictures/…./STScI Digitized Sky Survey Images & others

3. Start up Photoshop {click on **Edit & Enhance Photos**}
To open up the three images –
File/open/→use ctrl to select all 3 or 4 images←
then click on the **open button**

4. **Window/images/tile** to set all images side by side. And you need to arrange them in decreasing wavelength (IR in upper left hand corner – or longest wavelength – and work clockwise to shorter wavelengths- bluer) as in figure to the right. To move images click on the image title bar – hold click – and drag to where you want it to be.



An example of the arrangement would be if you took four infrared images from the Spitzer camera. You could make a 4-color composite image of infrared light, using wavelengths of 8.0 microns (red as main image in the upper left hand corner), 5.8 microns (as an orange color), 4.5 microns (as a green color), and 3.6 microns (as a blue color). ***A list of filters, wavelengths and uses is located at the end of this document in appendix A.*** note: IR and red wavelengths normal shows dust and blue shows stars.

*If all three images do not have the same size listed on the light-blue/grey title bar at the bottom of each image you need to fix them before you go on to the next step. To do this click on the zoom tool and then either click on your image or alt-click on your image. Or use **Image/Resize/Image Size** and under document size make changes so that all three images have the same width and height (same as smallest).*

5. Click **Image/mode/RGB color** on all images. (Layers tab should say *background* and not *Index*)

NOTE: you may need to drag down your layers tab or window/layers so that you can view the layer names as you are working.
Also you need to click **Image/mode/8 bits/channel** to change from 16 bit to 8 bit

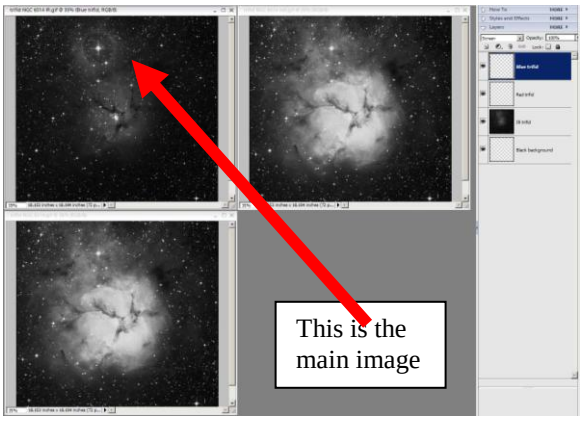
6. The upper left image will be called the **main image** and layers will be *added to this image*.
To accomplish adding layers in this upper left image make a new layer. Click **Layer/New/Layer**
and in the dialog box name this layer ***Black background***. Click **ok.** If needed make a click by **Window/layers** to turn on so that you can see the different layers in a dialog box on the right side of
Photoshop's window.

Add image showing black background change.

7. Now the upper left image (main image) will have two layers listed under the layers tab where the layer – *Black background* - is blued. In the layers tab click on the bottom layer – *Background* - to make it active (blued). Then click **Layer/New/layer from background** and in the New Layer's dialog box, name it to match the color of the main image (color found in the images title bar) and change the mode to **screen**. Then click **ok**. The lock icon should now have disappeared.

8. Now you need to change the layer order to make the *Black background* layer the bottom layer.
So in the layers tab click on the *Black background* layer to make it active (blued) and then click and hold the click and then drag the layer, onto of the top of the lower layer and let go of the click.

9. Now you need to copy the other two color/wavelength images onto layers in this **main image**. Click on the top layer in the layers tab in the **main image** to make it active. Then **Layer/New /layer** and name the new layer with the color of the next color/wavelength image in decreasing wavelength, also change the mode to **screen**. Click **ok**. Continue making layers so that you have one for each of your other images. So each color/wavelength image layer should be made but currently holding no information.



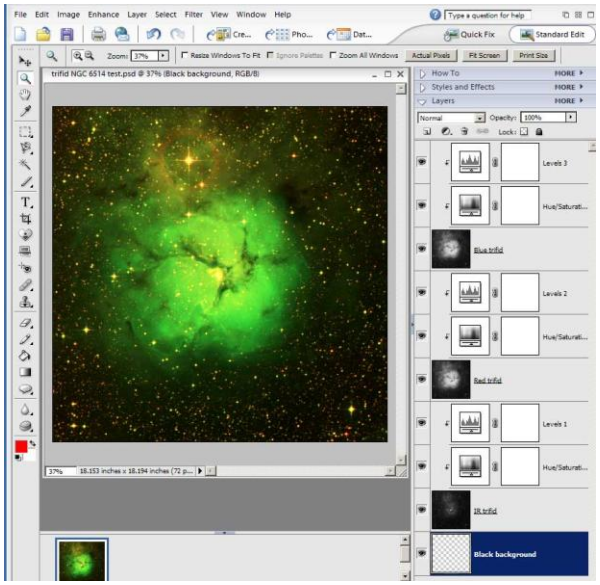
10. Click on the next image, the next smaller wavelength color, and make that image the active image (File name title will turn black) by click on the image.
Use **Select/All** on this image and then **Edit/copy**. Note which name/color image you picked (see the title bar for file name). Now click on the, **–. minimize** button on this image. If you started with three images you now have two images open and both are still large.

11. Now click on the main image (longest wavelength) and then click on the correct layer (matching the color image you just copied) and make it active (blued). Then **Edit/paste**. You should see the image show up in the layers tab.

12. Repeat steps 10 and 11 until the other color/wavelength images have been copied to layers in the main image.
If the images are blurry (the images are not well aligned) then you will need to use the move tool (top of left hand tool bar). You will need to turn on and off different eyes until you can see which image to move.
With the layer to be moved active, click on the move tool and place the cursor over the image. Now use the four arrows to slowly move the image to align.

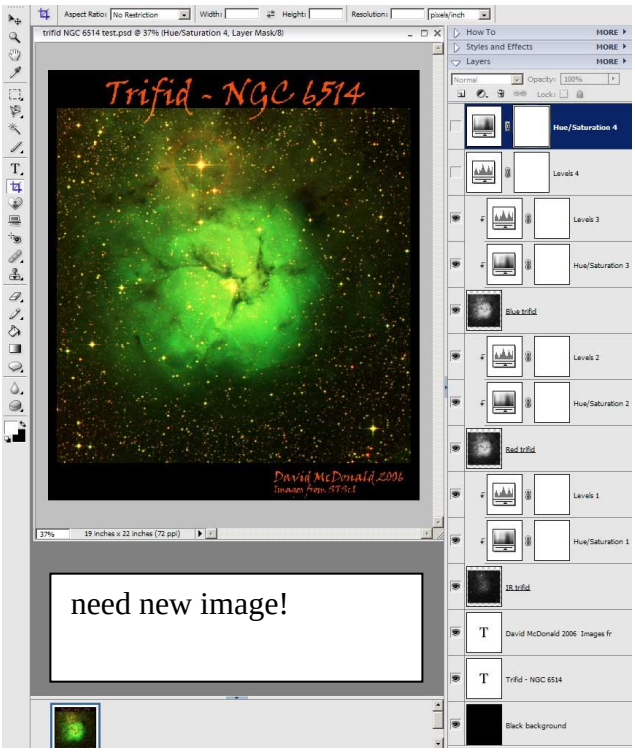
13. You now have all wavelengths' images on the main image as layers so now you need to save your work. So now **file/save as,** to save this new image in the form ✡**ver1.psd, -- where** ✡ is your file name for your main image (ie eagle nubula ver1.psd)**.**

14. You can now exit (close) all other images that you had minimized leaving the main image open with the several layers.



15. Turn off (click on eye) all layers but the one you are working on. Pick the bottom layer of the three color/wavelength layers to work on first. Make sure this colored layer is active (blued). Then click **Layers/new adjustment layer/levels**. In the dialog box click the **Group With Previous Layer** and then click **ok**. Only the color layers are supposed to be screened, NOT the adjustment layers. The next dialog box is the levels histogram box. In the histogram, move the left triangle to the right towards (or just into) the black area. You should get a nice crisp black image with sharp stars. Then move the right most triangle to the left, close to the black area. Leave the middle triangle alone. Remember that art has no definite answers. You should get a lightly salt and pepper background. Click **ok** when finished. The adjustment layers make changes to the layer it is grouped with, without changing permanently the pixels in the main layers. Again make sure the colored layer is active (blued).

16. Then click **Layer/New Adjustment layer/Hue & Saturation**
In the dialog box click the **Group With Previous Layer** and then click **ok**.
Next - click in to the **Colorize** check box
then **Set Saturation to 100, Set Lightness to -50** then **Pick Hue. Remember this is art.**



Turn this layer off (click on eye), and make active (blued) and turn on (eye) the next color/wavelength layer to work on. Do steps #15 and 16 for each color/wavelength layer.

17. Now adjustment layers can be added that will affect the complete image. Sometimes they will work well and sometimes not. So add these new layers and make a decision to keep them or to delete these new layers. Turn on (click on eye) all layers. Pick the top layer of the three color/wavelength layers and make sure this colored layer is active (blued). Then click **Layers/new adjustment layer/levels**. In the dialog box **do not** click the Group With Previous Layer and then click **ok**. Only the color layers are supposed to be screened, NOT the adjustment layers. The next dialog box is the levels histogram box. In the histogram move the left triangle to the right towards (or just into) the black area, then move the right most triangle left close to the black area. Leave the middle triangle alone. Remember that art has no definite answers. Click **ok** when finished. This adjustment layer will make changes to all the layers below, without changing permanently the pixels in the main layers.

18. Then click **Layer/New Adjustment layer/Hue & Saturation**

In the dialog box **do not** click the Group With Previous Layer and then click **ok**.

Next – **Do not** click into the Colorize check box as before but

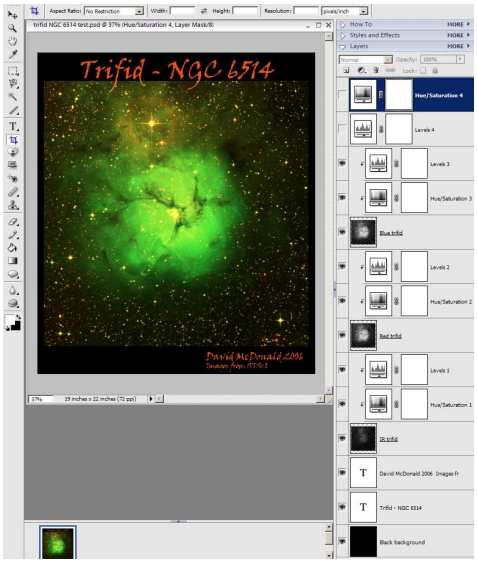
then **Set Saturation and Lightness, then Pick Hue. Remember this is art.**

A sample list of layers is located at the end of this document in appendix A.

19. Go back and adjust each adjustment layer to improve your image. Again -- **SAVE YOUR IMAGE (✡ver2.psd)!** That way you can always go back and make changes as needed.

20. You now might want to artistically crop your image and resave – make new name by adding ver3 at the end of the name.

21. Now you need to make a Title and Information area on your image. The image canvas size must be made larger in height and maybe in width. To resize the image, use **Image/Resize/canvas size**. In the Canvas Size dialog box you need to add about 20% more length to the height and maybe some to the width. It looks good to have the title of the object large at the top of the image and your name with reference to where images were found at the bottom. So have the Anchor stay in the middle. You may have to use the zoom tool, on the tool bar at the left side, to see the extra area.



22. With the *Black background* layer active (blued) click on the **paint bucket tool** located tool bar on the left side. Look at the two color palettes at the bottom of the tool bar. If the foreground color is black proceed to painting the *Black background* layer. If the foreground palette (top palette) is not black then double click on the palette and then move cursor over the select foreground color palette and click on black (might be lower left hand corner). Pick the blackest black or you can type in **010101** or about in the box. Move curser over the image and click. You should see the *Black background* layer turn all black.

23. Information for the header should include the name of the object, reference to where your images came from and your name. To type in the title, in the header, make sure that the bottom black background layer is active (blued) and then click on the text tool (**T**). Then pick the font, font size and color in the top tool bar area. Then move the cursor to your image and click and **drag diagonal across** the area where you would like the title to be located. When you let up on the click you may need to change font size, font style and color using the tool bar and then you can start typing. When finished with the title move the cursor off the text box and **left click** to complete the text box.

The information for the footer should include your name, date, and a reference for the images.
To type in the footer again click on the text tool and drag diagonal across the area for the information. When finished with the footer move the cursor off the text box and **left click** to complete the text box.

24. Save your image with a version 2 notation (as ✡ **ver3.psd**).

25. Click on all eyes to turn on. You can now print this image as a psd file but before you can easily transport and print your image you might need to click **Layer/Flatten Image** then **File/Save as** and change format to JPEG, change file name, then for JPEG options pick something of about quality of 5 (look at file size to decide quality). If your print does not match your computer screen see Appendix B.

The STScI images are about 1 Mb (or about 3 Mb for the pretty picture) to get good quality poster size images you need better starting images. The FITS images taken at the WIYN 0.9-meter imaging telescope by the

TLRSBE program are about 16 Mb (or about 48 Mb for the pretty picture) and will give the quality and pixel depths to print large posters.

Pretty Pictures from FITS image

1. Start up Image J. And open, one at a time, each FITS image and then save as a TIFF image, and then close the image before opening the next image. Close Image J.

2. Start up Photoshop
   Open up the three or more TIFF images

3. Make each Image active (the title bar - blue) then click **Image/Mode/8Bits/channel**
   for method – **Equalize Histogram**

4. Now **follow directions from above steps 5 - 25**

5. Sit back and enjoy.

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Notes and Information:

Rector, Travis A. Image-Processing Techniques for the Creation of Presentation-Quality Astronomical Images

http://www.msb-astroart.com/
three tutorials

http://www.eso.org/outreach/press-rel/pr-2006/phot-14-06.html

http://www.astropix.com/HTML/J_DIGIT/OUTPUT.HTM

Lodriguss, Jerry Catching the Light at http://www.astropix.com/HTML/J_DIGIT/TOC_DIG.HTM

Appendix A

Red filters are good for dust and blue filters are good for stars.

Filters and Wavelengths

I 700 to 300000 nm

SII --- 673.1 nm

red about 650 nm

Ha ---- 656.2 nm –
glowing hot dust

NII ---- 6548.3

OIII ------ 500.7 nm

blue ---- about 475 nm –
hot stars

v about 400 nm

u about 300 nm

Order of Layers

Hue/Saturation – affecting over-all image
Levels – affecting over-all image

Hue/Saturation -
Levels -
Main layer – Red

Hue/Saturation -
Levels -
Main layer – Green

Hue/Saturation -
Levels -
Main layer – Blue

Footer layer

Appendix B

From: digital_astro@yahoogroups.com [mailto:digital_astro@yahoogroups.com]
Re: matching my printer color to monitor color? Sat Dec 16, 2006 8:01 am (PST)
Posted by: "Sean Curry" sxcurry@drakevisual.com

Roger,

You're about to enter the interesting world of color management in Photoshop. There are entire books written on this topic, but at a minimum you should:
1) Calibrate your monitor using the Adobe Gamma utility, which should have installed with Photoshop.
2) Let Photoshop manage colors for printing, and make sure your printer does no color management, This is usually a setting in the printer driver.
3) Use Print with Preview in Photoshop, make sure More Options is clicked, then choose "Let Photoshop Determine Colors" under Color Handling. Then, under Printer Profile, choose a profile for the Printer/Paper combination that you're using. Depending on the printer, and assuming that the profiles got installed when you set up your printer, you should have one or many profiles to choose from. This is the critical step, because Photoshop needs to handle color management specifically for the printer and paper you're using.

Finally, under View/Proof Setup, choose the Printer/Paper profile. Then you can toggle View/Proof Colors on to see how the image will look when printed- Photoshop simulates the color performance of your printer on the screen. If everything is set correctly, you can now work with your color adjustments in confidence.

This approach should give pretty good results. You can go further, by buying hardware, monitor calibration device to get your monitor precisely calibrated, and by sending out test print patterns from your printer to companies that scan them and return a very accurate printer profile.

A good reference is the book "Real World Color Management" by Fraser, Murphy, and Bunting,

Hope this helps, Sean

Appendix C

Science Content Standards: 9-12 Chapter 6 National Science Education Standards

Science as Inquiry
CONTENT STANDARD A: As a result of activities in grades 9-12, all students should develop
- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

"The use of computers for the collection, analysis, and display of data is also a part of this standard." "Scientists rely on technology to enhance the gathering and manipulation of data."

Physical Science
CONTENT STANDARD B: As a result of their activities in grades 9-12, all students should develop an understanding of
- Interactions of energy and matter

"Electromagnetic waves result when a charged object is accelerated or decelerated. Electromagnetic waves include radio waves (the longest wavelength), microwaves, infrared radiation (radiant heat), visible light, ultraviolet radiation, x-rays, and gamma rays. The energy of electromagnetic waves is carried in packets whose magnitude is inversely proportional to the wavelength."
"Each kind of atom or molecule can gain or lose energy only in particular discrete amounts and thus can absorb and emit light only at wavelengths corresponding to these amounts. These wavelengths can be used to identify the substance."

Earth and Space Science

CONTENT STANDARD D: As a result of their activities in grades 9-12, all students should develop an understanding of

- Origin and evolution of the universe

"It is thus possible to understand the structure and evolution of the universe through laboratory experiments and current observations of events and phenomena in the universe.

"The age of the universe and its evolution into galaxies, stars, and planets--and eventually life on earth--fascinates and challenges students."

" Because direct experimentation is usually not possible for many concepts associated with earth and space science, it is important to maintain the spirit of inquiry by focusing the teaching on questions that can be answered by using observational data, the knowledge base of science, and processes of reasoning."

"Billions of galaxies, each of which is a gravitationally bound cluster of billions of stars, now form most of the visible mass in the universe."

Science and Technology

CONTENT STANDARD E: As a result of activities in grades 9-12, all students should develop

- Abilities of technological design
- Understandings about science and technology

"New technologies often extend the current levels of scientific understanding and introduce new areas of research."

"Creativity, imagination, and a good knowledge base are all required in the work of science and engineering."

"Technological knowledge is often not made public"