2013

Astronomy at Learning Works

WITH DATA FROM THE FAULKES TELESCOPES

Learning Works Grade 9 Class

NASA's Spitzer Space Telescope
IPAC Communications and Education Team
California Institute of Technology

www.spitzer.caltech.edu
www.publicworksinc.org/lw

Chapter 1

The Project

The IPAC Communications and Education Team, based at the California Institute of Technology, has paired up with the Learning Works Charter School to bring astronomy to their Grade 9 students. Over 8 weeks, the students met with the scientists to learn about astronomy, telescopes, light and color.

The students read about nebulae, galaxies and supernova remnants, and wrote and presented proposals to select a final group of objects to observe.

These objects were observed with the robotic Faulkes Telescopes, to create the images found in Chapter 3 of this book.

Image Credit: NASA/JPL-Caltech

Section 1

About Learning Works

The mission of Learning Works Charter School, based in Pasadena, CA, is to provide a personalized, rigorous academic program and relevant life skills to traditionally underserved students in grades 7-12 who have withdrawn or are in danger of withdrawing from mainstream education without attaining a high school diploma. The youth we serve would inaccurately be called “at-risk.” They are, in fact, “in crisis” or have already demonstrated a behavior or condition that exceeds at-risk, such as becoming pregnant, dropping out of school or entering the juvenile delinquency system.

Learning Works is more than a school—it’s a movement. We have an approach to poor families that works, and a means to improve the city’s dropout rates. Our goal is to end poverty through education and the social/economic breakdown of families by ending the family dropout cycle. We realized the existing system just did not know how to re-engage, welcome or serve dropouts, so we started a charter school where the dropout is the customer. We see our role as advocates for the poor and disengaged, with one goal: all youth deserve a high school diploma.

Learn more about our school online at:

http://www.publicworksinc.org/lw

Section 2

About IPAC

The Infrared Processing and Analysis Center (IPAC) is based at the California Institute of Technology, in Pasadena, and is the leading data center for NASA's infrared and submillimeter telescopes, both in space and on the ground. The IPAC Communications and Education team (ICE) provides full media relations, graphics, video, website, and education support for a host of NASA's missions, including the Spitzer Space Telescope, the Herschel Space Observatory, WISE, Kepler, NuSTAR, Planck, GALEX, NEOWISE and NEOCam.

The ICE team is dedicated to bringing the science of NASA's missions to the public in a friendly, exciting, engaging, open and accurate way. Our team has won a number of awards for our educational programs and videos, and regularly works with celebrities to bring our science to a wider audience.

To see our video podcasts, including the award-winning short M51 & Gizmo, and the celebrity-studded Robot Astronomy Talk Show, go to our website at:

spitzer.ipac.caltech.edu/video-audio

To learn more about infrared light and astronomy, to download educational resources, or to find more of our astronomical images, see our educational website, Cool Cosmos:

coolcosmos.ipac.caltech.edu

Section 3

About the Faulkes Telescopes

The Faulkes Telescope Project, part of the Las Cumbres Observatory Global Telescope Network (LCOGTN), provides access to a global network of robotic telescopes, and supplies free resources for science education.

The Faulkes Telescope Project's aim is to provide free access to robotic telescopes that can be controlled over the internet, alongside a fully supported education program to encourage teachers and students to engage in research-based science education.

LCOGTN operates a network of research-class robotic telescopes. Currently there are two telescopes, one based on Mauna Kea in Hawaii, and one in Siding Springs, in Australia. These telescopes are available for educators to use, and can be controlled remotely over the internet from the classroom. Thanks to the time difference between the telescopes and the classes using them, they can often be used live during class time. The telescopes are fully supported by educational materials, and a team of educators and professional astronomers.

For more information about the Faulkes Telescopes and about how to book observing time for your class, please visit the Faulkes website:

www.faulkes-telescope.com

Chapter 2

The People

Many, many people were involved in this project, from the students themselves, to the scientists at IPAC and the teachers at Learning Works. We asked everyone to answer a few questions about themselves and their lives.

Image Credit: NASA/JPL-Caltech

The Students

The students involved in the project were all part of the Grade-9 class at Learning Works. Each of the students in the class answered a few questions about themselves and their lives.

Brandon

What has been your favorite class at Learning Works so far and why?

My favorite class at Learning Works is the astronomy class. I learned a lot about the planets and the Solar System which is really interesting. I learned a lot of things that I didn't know about the planets and about black holes.

What do you want to do as a job/career after you graduate?

After I graduate I would really like to pursue the career of being an oncologist, because I like to help people and I would like to help people who are in need of help. Or I would like to go to culinary school because I love to cook.

What is the coolest thing you have learned from this astronomy class?

The coolest thing we learned from this class was how to build the telescope, and that for every star there's a planet. I learned that there are a lot of planets in space. And Pluto is a dwarf planet. They determined that a long time ago, but I forgot why.

What do you like to do outside of school? What are your hobbies and interests?

I like to just hang out with my homies or go swimming or go bike riding on my own time. I like to go to the boxing gym whenever I can. One of my other hobbies is I like to cook. I love cooking, making shrimp cocktail.

Daniel

What has been your favorite class at Learning Works so far and why?

My favorite class at Learning Works has been astronomy. It has been my favorite class because I have learned a lot of new things I never knew about space. Plus the teachers were nice and fun.

What do you want to do as a job/career after you graduate?

What I want to do as a job after I graduate is to go to college. While at college, I would have little side jobs so I have money. I would work at Target or Best Buy.

What is the coolest thing you have learned from this astronomy class?

The coolest thing I learned in astronomy is about light. The teacher said that X-rays could kill you. I also learned about galaxies and supernovas. I also liked the very first class where we learned how to build a telescope.

What do you like to do outside of school? What are your hobbies and interests?

What I like to do outside of school is play sports. I like to play basketball, baseball and football. If I were to put all of my favorite sports in order it would be baseball, football, and basketball. I started playing sports when I was young, so I'm used to it.

David

What has been your favorite class at Learning Works so far and why?

My favorite class at Learning Works is math class. I like math because I'm good at it. I like numbers and math.

What do you want to do as a job/career after you graduate?

I want to work as a Chaser at Learning Works Charter School. I want to help students get a better education because I don't want students making bad choices throughout their life. I will help students graduate.

What is the coolest thing you have learned from this astronomy class?

That the stars are special in their own way. We made a telescope from scratch and looked up into space. We also learned about constellations and other galaxies.

What do you like to do outside of school? What are your hobbies and interests?

I like going motorcycle riding and going camping. I also like sports like soccer and basketball. I like to play video games in my spare time.

Gerardo

What has been your favorite class at Learning Works so far and why?

My favorite class so far is health. I think health class was pretty good because I learned different things about diseases you can catch. You have to be careful with who you mess with in a sexual way.

What do you want to do as a job/career after you graduate?

When I graduate I want to work as a top-notch mechanic, or at least go to school and learn everything about being an engineer. I want to have a steady job.

What is the coolest thing you have learned from this astronomy class?

I learned how to build a telescope, and learned about all kinds of stars. I learned that the brightest star in the sky is a planet.

What do you like to do outside of school? What are your hobbies and interests?

I like hanging out with friends, playing basketball and joking around.

Jashon

What has been your favorite class at Learning Works so far and why?

My favorite class is history because you don't have a class for it, and you work independently.

What do you want to do as a job/career after you graduate?

When I get a job I want to be a lawyer. I love to argue with people, so I think that's a good thing for me. Also, I will want to be a judge to be able to give orders to people.

What is the coolest thing you have learned from this astronomy class?

The coolest thing I have learned was how to make a telescope. I never thought I was going to be able to make one. That was the coolest and I loved it. Hope we could make some more cool things.

What do you like to do outside of school? What are your hobbies and interests?

Outside of school, I like to go shopping to get new shoes and clothes. Another thing I like to do is run track. When I run track it lets all my anger out.

Kimberly

What has been your favorite class at Learning Works so far and why?

My favorite class at Learning Works is math and astronomy. Math is my favorite because it is easy, and it is fun to do graphs. Astronomy is my favorite class because we get to study stars and planets.

What do you want to do as a job/career after you graduate?

I want to graduate and then I want to work as a baker. I want to make my own business as a baker. I want to sell cakes and save money, then at Christmas donate toys to the Children's Hospital in Los Angeles.

What is the coolest thing you have learned from this astronomy class?

The coolest thing I've learned in astronomy is the Sacred Mushroom galaxy because no-one has ever looked at it in color. No-one has seen it with the Faulkes Telescope.

What do you like to do outside of school? What are your hobbies and interests?

What I do outside of school is help my little sister with her homework. I help my uncle walk the dogs. I help my Mom with my brothers and sisters.

Martin

What has been your favorite class at Learning Works so far and why?

My favorite class so far was my math one. I like it because it was never boring. It is easy. The teachers were helpful a lot to me. They were always helping me.

What do you want to do as a job/career after you graduate?

I want to be a bartender because I would like to work at a bar and know how to make drinks. I will make the best drinks, have everyone talking about me.

What is the coolest thing you have learned from this astronomy class?

I learned how to look up at the sky with a telescope. They taught me how to make a telescope too. They taught me about different planets. I learned about different light the planets have.

What do you like to do outside of school? What are your hobbies and interests?

I like to do a lot of things. I like to chill, do creative things. Do fun stuff. I like to go out and party.

Mayra

What has been your favorite class at Learning Works so far and why?

My favorite class at Learning Works is Biology. I chose biology because you get to study different things. Biology has always been my favorite class.

What do you want to do as a job/career after you graduate?

After I graduate I want to be a dentist. I have been interested in dentistry because it has to do with science. I hope my dreams come true.

What is the coolest thing you have learned from this astronomy class?

The coolest thing I learned in astronomy is about stars. I really don’t like stars. They made me get inspired by stars.

What do you like to do outside of school? What are your hobbies and interests?

My hobbies are playing soccer, hearing music, and baseball. I’m into sports. It doesn’t matter what sport it is, I’ll play. Only that soccer is my favorite sport and I enjoy playing it.

Michael

What has been your favorite class at Learning Works so far and why?

Algebra used to be my favorite class and also English, but it got frustrating. ArtWORKS is my favorite class now. It is not stressful, it's a class where I can focus on my work.

What do you want to do as a job/career after you graduate?

I would like to join the Marines and after I get out, I would like to be a fireman. I'll be 2 years in the Marines and then a fireman until I retire.

What is the coolest thing you have learned from this astronomy class?

I don't like this class at all. It's not something I'm interested in.

What do you like to do outside of school? What are your hobbies and interests?

I like to go for a jog, go to boxing, listen to music, or hang out with friends.

Victor

What has been your favorite class at Learning Works so far and why?

Math, because I have a very good and better understanding of it than I did in my last school. Here at Learning Works I get more one-on-one time with my teachers.

What do you want to do as a job/career after you graduate?

Well, first I want to work at a Footlocker or shoe store during college. In college, I want to work my way towards being a translator for the deaf, and work my way to the top from there.

What is the coolest thing you have learned from this astronomy class?

The coolest thing I learned about astronomy were the constellations in the sky.

What do you like to do outside of school? What are your hobbies and interests?

I like to associate with other people, tell jokes, make people laugh. Boxing, basketball, and shoes are my interests.

The Science and Education Team

Dr. Carolyn Brinkworth

Carolyn works as the Education and Outreach Scientist for IPAC, supporting many different NASA missions. She led the scientist team for the Learning Works astronomy project.

Carolyn earned her PhD in Astrophysics from the University of Southampton in the U.K, studying binary stars with an ultra-high-speed camera to directly measure their evolution. She moved to California in 2005 to continue to do astronomy research, but her real passion lay with education instead. She feels very lucky to work in astronomy, because most people are excited by it. She sees astronomy as a “gateway drug” into the other sciences - not only does it get people hooked on science, but it can also be used to teach many other subjects, such as physics, biology, chemistry and engineering.

Carolyn is now studying for her MA in Education at the Claremont Graduate University, with an interest in how to improve science education in schools, particularly those catering to underserved students.

What is the coolest thing you learned while helping with this astronomy class?

I really looked forward to seeing the students every week! They’re a lot of fun, and it’s been really great seeing and teaching them for more than just one session. I hope we get to come back and keep working with the school.

What is something cool about astronomy that you really like?

I love the fact that almost all of the atoms inside our bodies were created inside of stars, and that the building blocks of those atoms were created in the Big Bang, almost 14 billion years ago. All of us are, quite literally, made of star stuff, and we are just borrowing these atoms for the blink of an eye on the timescales of the Universe around us. When we die, our atoms go back into the cosmos, to be recycled into new stars, planets, and maybe even distant life.

What do you like to do outside of school/work?

Well, I'm studying for my MA in Education at CGU right now, so most of my evenings and weekends are taken up with studying. When I do get some free time, I do a lot of different things, including reading and hanging out with my friends. I play drums, so I spend time either practicing or playing with my band. I also volunteer for a non-profit called the Trevor Project, and go into schools to run workshops on suicide prevention, particularly focused on LGBTQ youth.

What are you doing with your life/for your career/as a job?

I'm working in my dream job right now, right on the boundary between science and education. As the Education and Outreach Scientist at a NASA centre, I'm close to all the research action, but I also get to work on press releases, create educational videos and websites, and go out into schools to talk to students and the public about astronomy. I genuinely look forward to going to work every day (...ok, most days)! I feel very lucky.

Alexandra Lockwood

Alex is in her final year of graduate studies in Planetary Sciences at the California Institute of Technology (Caltech). Her PhD thesis is titled "Understanding Planet Formation and Evolution Through High Dynamic Range Near-IR Spectroscopy." She co-led the scientist team for the project and is very grateful to have worked with such an amazing group of scientists and students.

Alex has always enjoyed working with people, and especially helping others. She feels lucky to have been exposed to astronomy in her youth, and wants to share her passion for science, and especially astronomy, with young people. Science and curiosity are the keystones for innovation, and Alex wants to inspire children and teenagers to learn more about the Universe around them, in hopes of bringing about a better future. Alex will be pursuing a career in science outreach and education when she graduates.

What is the coolest thing you learned while helping with this astronomy class?

I was very impressed by how the students remembered so many things from week to week. In helping to make and teach lesson plans, I learned about how to engage students better, so that teaching becomes learning.

What is something cool about astronomy that you really like?

One of my favorite things in astronomy is Hawking Radiation. This happens when a particle-antiparticle pair spontaneously

separates just outside a black hole, and then one part falls into the black hole and the other part escapes. And it means we can actually increase the amount of antimatter in the Universe!

What do you like to do outside of school/work?

I spend most of my time outside of work either exercising or with my friends. I like to run and do yoga, and I just finished my fifth half marathon.

What are you doing with your life/for your career/as a job?

I am currently finishing up my PhD in Planetary Sciences at Caltech. After I graduate I hope to pursue a career in science education and outreach, focused on K-12.

Eric Glenn

Eric is the 9th grade teacher at Learning Works Charter School. This is his third full year teaching at Learning Works with Master's Degree in Education and a credential in Mathematics. Before becoming a teacher, Eric worked as the Junior High Mentor coordinator for Lake Avenue Community Foundation in Northwest Pasadena. He is married, lives in Pasadena, and is the owner of the cutest dog in the world.

What is the coolest thing you learned while helping with this Astronomy Class?

Maybe not the "coolest," but I learned just how expansive space is. After watching the Astronomy teachers show the students a program that can zoom out to the outermost parts of space, I was able to visualize just how infinite it is. It kind of hurt my brain to think about what could be out there.

What is something cool about astronomy that you really like?

I like looking at the pictures of the astronomical objects that we took. The shapes and colors of each object we looked at are awe inspiring and beautiful.

What do you like to do outside school/work?

I am a huge baseball fan. My wife and I love going to baseball games. We are a split household however, as she is a huge Dodger fan, and I am a lifelong fan of the Angels. It certainly makes our marriage interesting. Especially when the two teams are playing each other.

What are you doing with your life/for your career/as a job?

For the last 11 years, I worked with students living in Northwest Pasadena either as a mentor, mentor coordinator, or

as an assistant coordinator for an after-school program. Now, I am a teacher at Learning Works and I LOVE it!

Dr. Jeff Rich

Jeff is a Postdoctoral Scholar studying galaxy evolution at the Carnegie Observatories and IPAC in Pasadena. He got involved in outreach as a graduate student while studying at the University of Hawai'i. He worked with other grad students, visiting local schools and community groups to teach about astronomy and the night sky. He still helps with outreach when he can, and enjoys teaching people about space and the new discoveries that scientists are still making.

What is the coolest thing you learned while helping with this astronomy class?

I learned that the Faulkes Telescope is an interesting and easy-to-use tool for getting astronomy into classrooms.

What is something cool about astronomy that you really like?

I think the most exciting thing about astronomy is the fact that the stuff we are made of was created in stars billions of years ago.

What do you like to do outside of school/work?

I like to go hiking and surfing when I can find the time, I like to watch movies when I can't.

What are you doing with your life/for your career/as a job?

I am working as a postdoctoral researcher, both assisting with parts of larger astronomy research projects and also conducting my own research. I would like to continue both researching new things in astronomy as well as find more time to teach astronomy and science.

Dr. Christopher Tibbs

Christopher is a Postdoctoral Scholar at IPAC, Caltech. His research interests include the emission originating from the gas and dust that exist within our galaxy, and the oldest light in the Universe - the Cosmic Microwave Background.

When Christopher is not performing research, he likes to bring astronomy to the attention of the general public. Christopher first got involved in astronomy outreach when, as a graduate student at the University of Manchester, U.K., he got involved in producing an astronomy podcast with his fellow graduate students. Buoyed by this experience, Christopher has since

gone on to help organize and participate in a variety of events, all aimed at making astronomy more accessible and engaging.

What is the coolest thing you learned while helping with this astronomy class?

This was the first time I had heard about Learning Works, and to me, just finding out about all the great work they are doing is the coolest thing I have learned while helping with this program.

What is something cool about astronomy that you really like?

I really like the fact that astronomy is one of the oldest sciences. As a human race, we have always been fascinated by the night sky, and the fact that even after all these years, we still find the night sky fascinating just highlights how captivating astronomy is.

What do you like to do outside of school/work?

When I have free time, I like to relax by reading a good book. I am also an avid soccer fan and try to watch and play as often as possible.

What are you doing with your life/for your career/as a job?

I think my biography covered it!!

Chapter 3

Our Images

On June 4th, 2013, we took control of the Faulkes Telescope South, in Australia, to take pictures of some of the astronomical objects we had talked about in class. The pictures were taken in three different color filters and merged to make full-color images, very close to the view we'd have with our eyes if we were able to travel across the Universe to take a closer look. The following pages show the pictures we took with the telescope, along with a description of what we're seeing.

Image Credit: NASA/JPL-Caltech

Section 1

M16: The Eagle Nebula

M16, also called the Eagle Nebula, is a huge star-forming region that can be found in the constellation of Serpens, “the Serpent”. This nebula is a giant, interstellar (between the stars) cloud of dust and gas where brand new stars are being born. It already holds some young, giant stars that are so bright and hot that they glow with ultraviolet light. This light heats up the surrounding hydrogen gas, causing it to glow red.

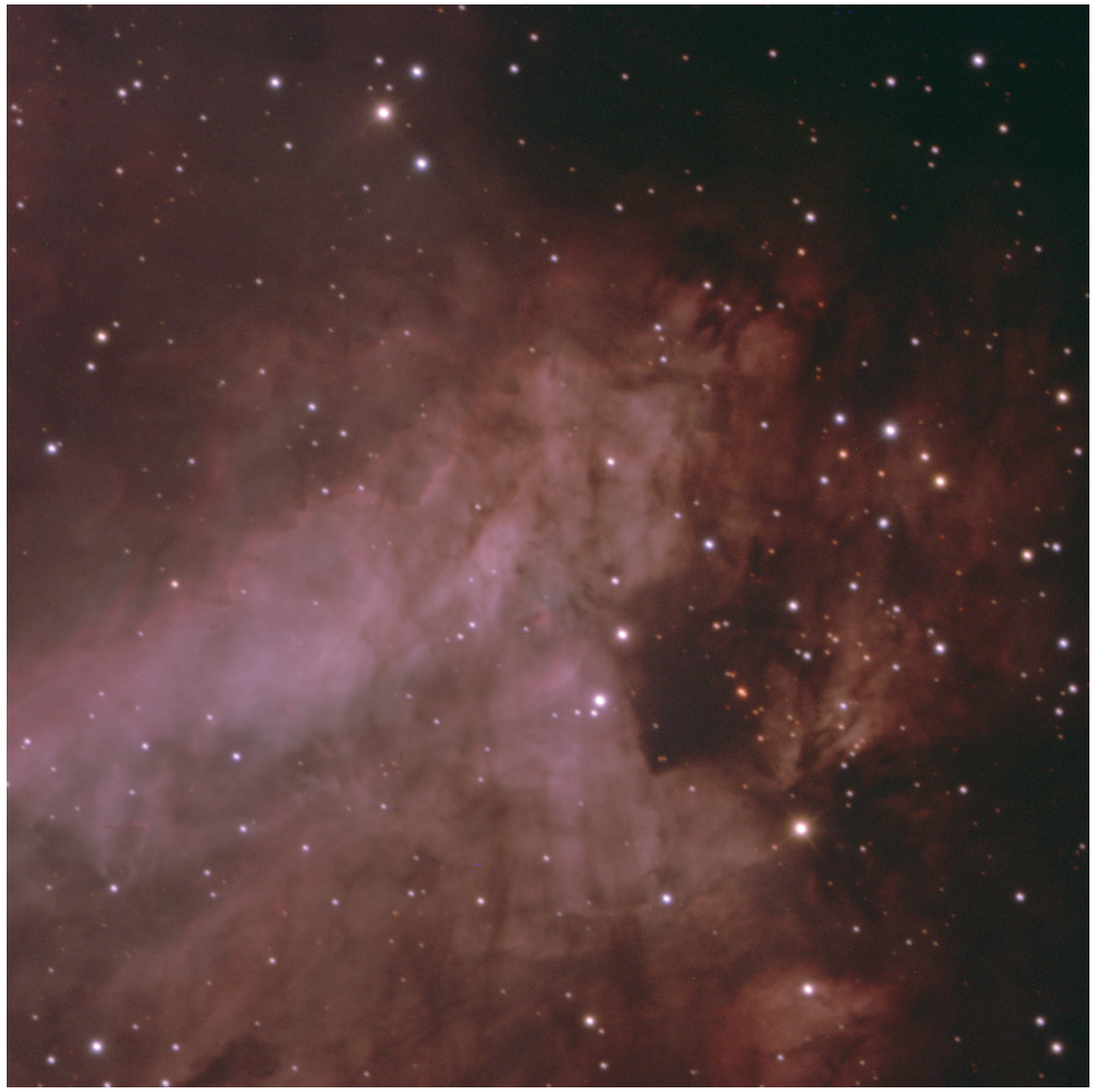
New stars are being born in our galaxy in many star-forming regions like this one. Stars are created when dense pockets of the gas and dust are pulled together by gravity. As the material collapses into a smaller and smaller volume, it heats up and becomes more dense, pulling more and more of the surrounding material in. Eventually the clump becomes so hot and dense that a nuclear reaction can start in the center, and a new star is born. A nebula like M16 can make many stars before it uses up all of its gas - M16 has already made a cluster of about 460 of them.

M16 was discovered in 1745 by the astronomer Jean-Paul Cheseaux. A famous Hubble Space Telescope image of part of the nebula, called the “Pillars of Creation” shows large towers of dust and gas where the new stars are being born. These pillars can be seen here as the dark clouds in the center of our Faulkes Telescope image. They are nine light years, or over 50,000,000,000 km, high.

Section 2

M17: The Omega Nebula

M17 is also known as the Omega Nebula, or the Swan Nebula. The Omega Nebula is a large area filled with dust and hydrogen gas, which is in the process of clumping together to form new stars. It is located in the constellation of Sagittarius. M17 was discovered by Philippe Loys de Cheseaux in 1745.



The Omega Nebula is part of our own galaxy, the Milky Way. It is about 5,000 - 6,000 light years from Earth, which is about 30 million billion miles away. The size of the nebula is about 70 trillion miles across. M17 is just one part of a larger cloud of dust and gas that has enough material to make about 30,000 stars like our Sun.

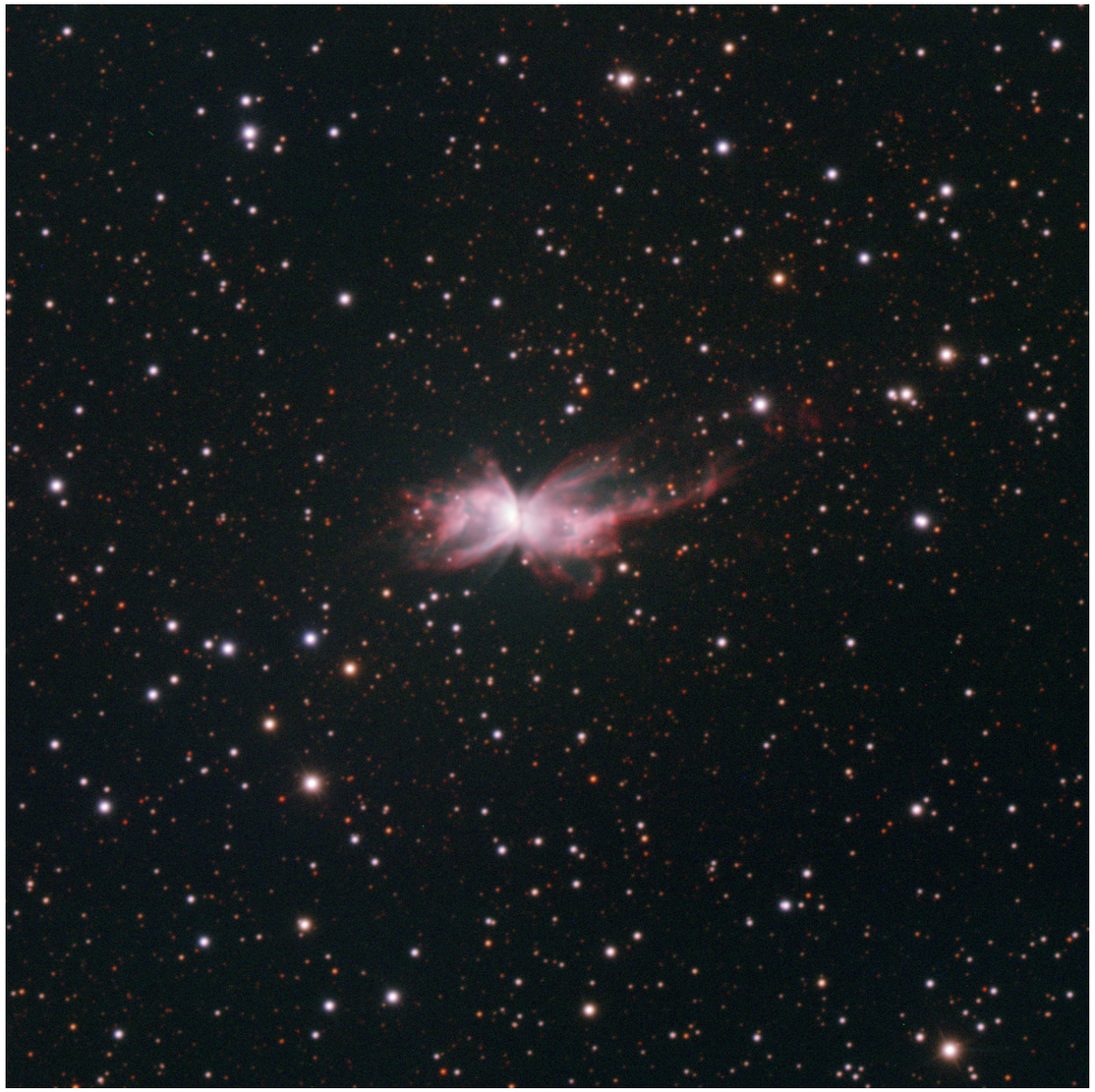
The Omega Nebula has a cluster of 35 hot, young stars that are buried in the cloud. They emit light and make the nebula shine. However the actual number of stars in the nebula is much higher - up to 800, plus another 1,000 or so that are currently being formed in the outer regions of the cloud. It's also one of the youngest clusters known, with an age of just 1 million years.

Newly forming red-colored stars can be seen in this image, mainly in the dark cloud to the right of center. The bright white stars are not part of the nebula, but lie between us and M17.

Section 3

NGC 6302: The Bug Nebula

NGC 6302, also called the Bug Nebula, is a planetary nebula in the constellation Scorpius. It is a glimpse of what will happen to our Sun in about 5 billion years, when it finally runs out of hydrogen and dies.



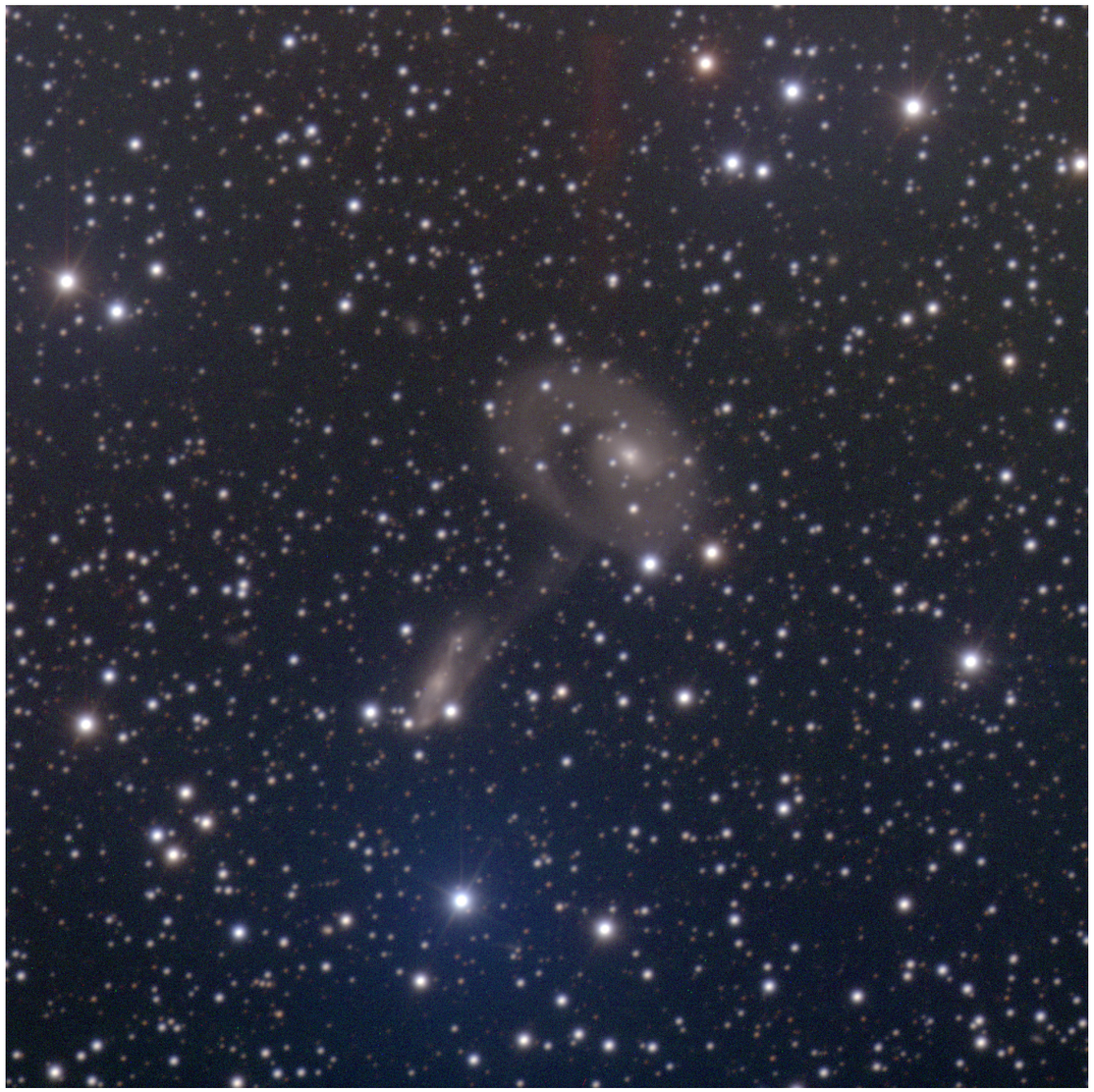
Stars are mainly made of hydrogen, and they shine because they are turning hydrogen into helium in a massive nuclear reaction in their cores. These reactions create as much energy every second as the human race has used in its entire existence. As long as there is hydrogen in the core to burn, the star will continue to shine for billions of years. Eventually, though, the hydrogen runs out and the star becomes unstable, collapsing and throwing its outer layers out into space in a vibrant spray of patterns and colors. We call these objects planetary nebulae. This whole process happened to NGC 6302 about 5,300 years ago.

The patterns and colors seen in NGC 6302 are caused by variations in the amount and density of the gas, and on the elements that are found in there - for example, oxygen glows a different color to carbon and hydrogen.

Left behind in the very center of the nebula is the cooling ember of the star's core, called a "white dwarf." The white dwarf in NGC 6302 is one of the hottest stars in the galaxy, at over 200,000 degrees Celsius.

Section 4

AM1724-622: The Sacred Mushroom



AM1724-622 is a galaxy, nicknamed “The Sacred Mushroom.” Galaxies are huge collections of billions of stars that are held together by gravity. Our own Sun is just one star in a galaxy called the Milky Way.

AM1724-622 is a type of galaxy called a “collisional ring galaxy,” which has a circular ring-like appearance. The ring contains many big young stars that burn very brightly. A ring galaxy usually forms when a smaller galaxy crashes through the middle of a large one. As most of a galaxy consists of empty space, this “collision” rarely results in any actual collisions between stars. However, the gravitational forces caused by the crash can cause a wave of new stars to form throughout the larger galaxy, which blaze brightly in the shape of a ring.

In this case, the two galaxies are still in the process of colliding with each other. The smaller galaxy (the white smudge to the lower left of the ring) has punched through the larger ring-shaped galaxy to the upper right. There is a faint “bridge” between the two galaxies, made up of stars torn from one or both of the galaxies as they collided. AM1724-622 is moving away from us through space, at a speed of 4600 km/s.

We are the first team to make a full-color image of AM1724-622, and this image is the only one of its kind in the Faulkes Telescope archive.

Section 5

M83: The Southern Pinwheel

Messier 83 (also known as the Southern Pinwheel Galaxy, M83 or NGC 5236) is a barred spiral galaxy approximately 15 million light years away in the constellation of Hydra. Galaxies are vast collections of billions of stars, all held together by gravity. M83 is one of the closest and brightest spiral galaxies in the sky, and is visible from the Southern Hemisphere with binoculars.

M83 looks quite similar to our own galaxy, the Milky Way. It has a bright central area that is teeming with stars, and contains a supermassive black hole at the very center. From there, spiral arms wind their way out to the edges. M83 is called a “barred” spiral because it has a straight bar of stars stretching across its middle. Astronomers think that these bars might come and go throughout a galaxy’s lifetime.

The spiral arms of M83 are thick with dust and gas, which you can see in this picture as dark lanes running through the arms. These are vast star-forming regions that have already formed many billions of stars, and are continuing to create more every year. The young stars shine with a bright blue light, while the older stars in the center look more yellow.

M83 is one of a small group of galaxies called the Centaurus Group. The group may one day merge to become one single enormous galaxy.

Many thanks to everyone on the team - the students, for being awesome, the school and teachers for encouraging and helping the project to go ahead, the scientists for helping to run the show and take the data, and IPAC, for paying for the materials!

Much thanks and gratitude also to the Mayor of Pasadena, Bill Bogaard, and his team, for agreeing to come and visit the school to be presented with this book. His support is very much appreciated by everyone.

Finally, a big thank you to Dr. Paul Roche and the Faulkes Telescope team, for giving us time on the telescopes to take our data.