President's Message

George Fleenor
President
Bishop Planetarium
Bradenton, FL

Each year, thousands of people world wide celebrate the New Year. Many of these individuals also use this time to set New Year s resolutions or to reflect back on the previous year. I am no different. However, when I reflect back, I am not confined to just the previous year but for every year since 1980. It was December 28, 1980, when I began my full time career as a Planetarian.

It was a scary time, a time which is still very much remembered. It wasn t the technology that scared me or the learning of a new trade. It was the fact that I was about to turn a passionate hobby, one in which I had been seriously engaged since 1972, into a full time job. Would I end up burnt out? Could my passion for the sky be tarnished if I was involved with it on a daily basis? These were my fears and the cause of a very unsettling time in my life.

As I sat behind the console and turned the star field on, I felt a rush that con nected me with the Universe. Suddenly, I felt I had a home and this is where I be longed. The stars of the Goto star projector, even for an active experienced observer, were overwhelming, my new boss quickly pointed out . Yes, he put me in my place. Stumped me with star identification that came so easily in the real sky. I was for tunate then to have such a mentor and friend... I still am. This was to be the first of many times he would put me (rightfully so) in my place. Today, I am faced with having to follow in his footsteps as leader of this organization. It will not be an easy task.

But I digress. In 1984, I moved south and furthered my career by working for John Hare. He, too, played a significant role in my growth as a Planetarian. However, it would not be fair if I did not give additional credit where credit is due. There have been so many people in SEPA who have inspired me. Many of those are currently residing on council, many have served in the past, and many are individuals who have yet to serve. Each conference has been a learning and growing experience. I hope everyone else who is a member of our SEPA family feels the same way.

Through your contributions and hard work our organization is strong. Its exis tence relies on your commitment. Yes, it is hard to take time out of a busy schedule to write a column or submit information. As they say, been there, done that. But if you take a couple of minutes and share your ideas with others, even if its only reporting on what you have been doing under your dome, our organization will grow and strengthen more rapidly than ever. It might not seem like much to you, but to someone else it might be very inspiring or give them an idea of how to better their own dome.

Join me as I look back on those who have been so generous in their leadership. Mike has done an outstand ing job as our leader and started several new and worthwhile pro grams. I am thankful that he will still be on council to give valuable input and service to our organization.

Communication and sharing is the key to our continual success. As we head toward the new millennium (2001!), try to take a moment each quarter and drop Duncan (he really works hard for us) or your state representative a note. Council is very interested in hearing your ideas. Please contact us if there is anything we can do for you or the organization.

We have an offer from Jack Fletcher to host the 2001 conference as a joint meeting between SEPA and GLPA. Please read the very important message on page three and the back cover, and send in your response to me via the enclosed post card by March 15. To all of you who have helped SEPA become what it is today, and all of you who continue to be an inspiration Thank you! Thanks, Past President Kris McCall for a job well done. Welcome President Elect Dave Maness.

IPS Report

John Hare
IPS Representative

Dave Menke is chair of the IPS Professional Services Committee. Dave outlined goals to improve the Job Information Service, identify workshops and internships, and continue to document changes and trends in the planetarium profession. Steve Fentress of the Strasenburgh Planetarium in Rochester, NY will continue with the IPS Job Information Service. Any member may furnish a quantity of stamped envelopes to Steve who will disseminate job announcements. Job postings should be sent to Steve for distribution.

Jack Dunn is chairman of the Lasers in Planetariums Committee. Jack will conduct a survey and explore methods to set goals and objectives for the new committee.

The Language Committee, under the chairmanship of Lars Bromen, has been given a mandate to make recommendations to Council to identify ways in which IPS can improve access to people whose language is not English.

The Planetarium Development Group has been revitalized. Chairman Ken Wilson is looking for committee members who have knowledge, ideas, or suggestions regarding planetarium construction.

The Portable Planetarium Committee, chaired by Susan Reynolds, will be completing a Portable Planetarium Users Handbook which will be ready for print sometime this year.

IPS dues increase beginning January 1, 2000.

Current dues are as follows:

Individual membership
1 year, $40.00..... 2 years, $70.00
Institutional membership
1st year, $150.00 ..... renewal, $75.00
Library subscription..... $24.00

Dues effective January 1, 2000:

Individual membership
1 year, $50.00..... 2 years, $90.00
Institutional membership
1st year, $200.00 ..... renewal, $100.00
Library subscription..... $36.00

You will continue to save $10.00 by paying for 2 years at a time. Membership anniversary dates are effective to the nearest quarter so you can beat the increase by joining or renewing no later than September 30, 1999.

New IPS Officers assuming or continuing in office, effective 1/1/99, are:

President Elect..... Martin Ratcliffe
President ..... Dale Smith
Past President..... Thomas Kraupe
Secretary ..... Lee Ann Hennig
Treasurer..... Shawn Laatsch

You can visit the IPS Website at <http://www.ipsplanetarium.org>.

Join IPS!

Farewell from Mike Chesman

Mike Chesman
Past President

As January 1999 arrives, I'm thinking back to my fledgling efforts as SEPA President. Can two years have really gone by that fast! It's been a pleasure to serve this organization, and I look forward to my final two years as Past President. I had some wonderful folks to work with. George and John were always quick to provide valuable input on Council matters, Kris showed me the ropes and set a standard to rise to, Duncan, ever the professional, kept me organized and on time. I can't think of any instance where this Council didn't cooperate to get a job done. With their help, the membership accepted by law changes that redefined our membership structure, we took our first steps onto the Internet by establishing a SEPA Web site, a member's guidebook is being published, and dues increased to help with new projects and services. I want to thank the membership for providing so much support, especially on topics that I expected to be difficult. You made my job easier. There were projects that never were implemented and some that are in progress, but that's what the future is for. Thanks for giving me the opportunity to serve SEPA.

Your Immediate Input Required

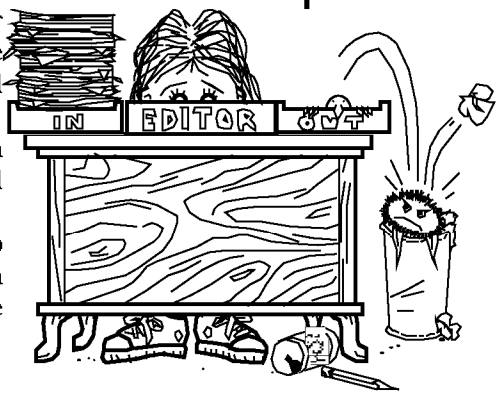
Duncan R. Teague
Secretary/Treasurer
Southern Skies Editor
Craigmont Planetarium
Memphis, TN

Last year at our business meeting the possibility of a joint SEPA/ GLPA conference was mentioned. Initial discussions with GLPA s officers have been very fruitful, and we have a unique opportunity for a 2001 conference. GLPA is willing to meet within the SEPA region and forego their normal October conference date to meet with us during late June. In so doing, the impact on SEPA members schedules and travel plans will be very little.

We have also had a standing invitation from the Hummel Planetarium in Richmond, Kentucky to host such a conference if it ever materialized. Hummel director Jack Fletcher has been contacted and again voiced his support for this event. Hummel can provide the facilities and other amenities that a larger than average attendance would entail. The location is also ideal for those traveling from the GLPA region.

The GLPA board is ready to move ahead with plans if SEPA responds similarly. Because time is of the essence, we would prefer to move forward with this proposal before the annual business meeting in June. Enclosed you will find a printed postcard on which to cast your vote.

We are hoping to get a response from the majority of members so we decide what our next step should be. If we do not hear from enough of the membership we will be forced to postpone any action until the annual meeting in Jacksonville. [Thanks go to Mike Chesman for summing up the discussions so far. Ed.]



Mike Cutrera

Please note the passing of our colleague Gary Close. Information on where to send memorials is included with a tribute written by Drew Foster.

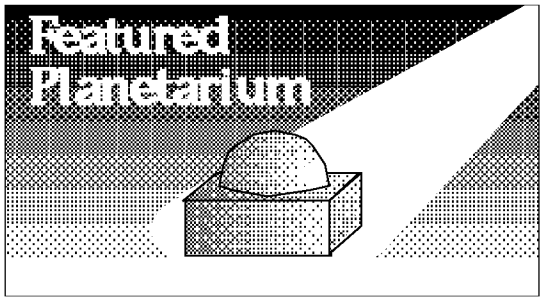
The STScI slides for 1998 are listed elsewhere in this issue of Southern Skies. If you want to order them, please follow the

Send your $25.00 check made payable to SEPA to the following address:
Craigmont Planetarium, 3333 Covington Pike, Memphis, TN 38128 3902

Name			
Planetarium			
Organization			
Address			
City			
State		**Zip**	
Area		**Voice**	
Area		**Fax**	
Position			
E-mail address			

Featured Planetarium:

Bays Mountain Planetarium, Kingsport, TN



Dave Hostetter
Featured Planetarium Ed.
Lafayette Natural History
Museum & Planetarium
Lafayette, LA

Author
Mike Chesman
Director
Bays Mountain Park
Planetarium
Kingsport, TN
baysmtn@tricon.net

Imagine the year is 1969, the Apol lo space missions are in full swing, interest in science education is at an all time high, and school systems across the nation are anxious to have their students at the forefront of the emerging promise of space . Such is the scenario that existed when the City of Kingsport, Tennessee, decided to add a planetarium to the plans for an environmental education center at Bays Mountain. The fruit of those labors was realized in Spring of 1971 with the opening of a forty foot theater equipped with a Viewlex Venus model projector, some special effects projectors by Talent and Sky Skan and a few slide projectors. In 1977 the original projector was replaced with a Spitz/ Goto SG 10.

Today the theater seats 108 visitors in a modified unidirectional arrangement. The projection gallery has been tripled in size, featuring glassed in windows just below the cove and extending two thirds the way around the dome. An eight projector Ektagraphic system provides 360 degree panoramas. Adding to the array of effects are a homemade zoom projector, a Domes and Spaces flyable mirror and video projec tion equipment. The bulk of slide visuals are presented using seven Ektagraphic projectors over a three screen format.

The most recent enhancement has been a total refurbishment of the star projector and its control system by Ash Enterprises. They fully automated our star projector us ing customized East Coast Control System equipment. I believe ours is the first GOTO projector to have ECCS automation, and I have to praise it for its flawless operation. We kept the cabinet of our old console and created custom panels to accommodate the new controls. The photo shows how clean and functional the design turned out. Star projector controls are directly in front of the operator with video displays on angled panels slightly to the left and right. One display is for automation cues; the other, for video images routed to the video projection system. On either side of the operator are panels for controlling special effect projectors. Even though the system is fully automated the flexibility of having manual control for live presentations has been a wise choice.

Other elements of the theater have gone through changes, too. The sound system consists of a QSC power amp through an Altec speaker system. For years we relied on reel to reel tape. We made the move to ADAT a few years ago but found the system finicky and problem prone. We just replaced playback in the theater with a 4 track minidisc system, and initial results have been absolutely wonderful. I highly recommend that small facilities look into these units. Not only will they provide reliable playback but they make viable portable production studios at low cost.

In the near future we expect to move our audio production onto a digital work

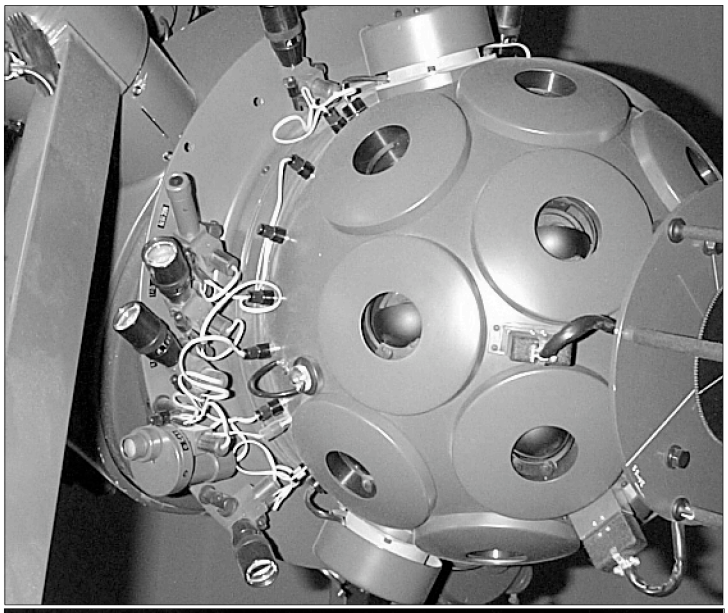
station assembled with the help of Bowen Productions. The Pentium II system will incorporate a Mixtreme board under the control of Cool Edit software. It is amaz ing to me how fast technology is becoming affordable even to those with the most frugal budget. It doesn t bother me to say that Bays Mountain gets roughly $6,000 per year for operations. That has to cover lamps, parts, production of four public shows, any equipment purchases, etc. To some this will seem an extravagance; to others, a mere pittance.

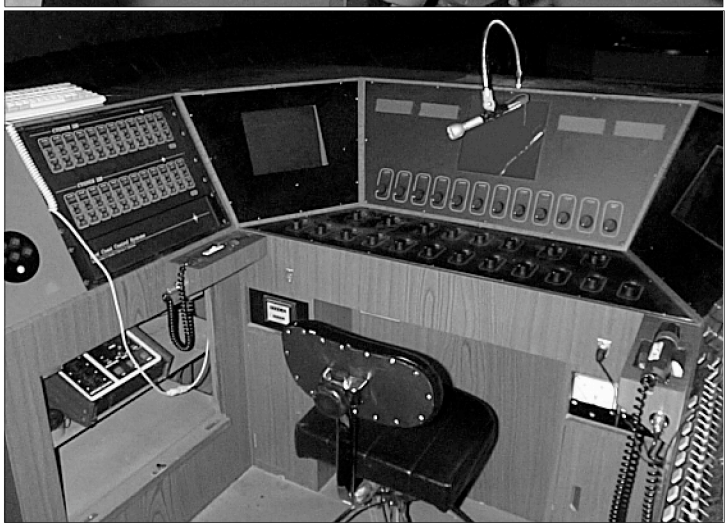
The bottom line for a planetarium is how it uses its resources. Bays Mountain is open six days a week through the school year and seven days a week in summer. Public programs are presented four times each weekend, and school presentations are offered sixteen times each week. Three out of four public programs are produced in house and are full fledged multimedia productions. School programs generally are a mix of live and canned segments. Attendance for the 1990s has ranged be tween 25,000 35,000 per year. Local city and county schools are the only groups who do not pay to visit the planetarium but we have tracked groups from 40 counties in TN, VA, NC, and KY.

A substantial part of our time is fo cused on viewing the real sky. In 1980 a roll off observatory was built to make use of several reflecting telescopes. Then in 1989 we were able to construct a domed observatory to house an 8 refractor. The structures allow for both daytime and nighttime observations. The facility fea tures a hydrogen α solar filter, a stellar spectroscope, and a video feed to the plan etarium theater. For almost twenty years now our astronomy volunteers have hosted an annual StarFest in the Fall for amateur astronomers around the Southeast.

The planetarium department at Bays Mountain consists of two people: Adam Thanz and myself. I have been fortunate over the years to work alongside great peo ple, including Charles Ferguson and your current SEPA president George Fleenor. With a staff of two it takes a real sharing of all responsibilities to keep things running smoothly. I hope it s not asking too much to add a line here to thank Adam for all the extra time and effort he devotes to our operation. I don t know if Bays Mountain will ever get that third staff position I have always dreamed of, but we do a good job with what resources we have.

I ve been at Bays Mountain since 1975 and have seen so many exciting changes in the planetarium profession. When I get to pass the torch in the next millennium I hope that Bays Mountain will continue to be a vital part of the planetarium com munity.





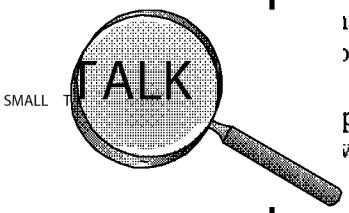
Left: Bays Mountain Observatory s cliff side location provides a scenic vista any season of the year.

Upper Right: A closeup view of the starball of the Spitz/Goto projector. The optically projected sky features more than 6,000 stars.

Bottom Right: The new ECCS control console at Bays Mountain. A deluxe drum mer s throne with back rest has been found to be the best chair for a console operator s comfort.

Small Talk

Elizabeth Wasiluk
Small Talk Editor
Berkeley County Planetarium



Planetarium Director Rod Martin in Hagerstown, MD is getting a complete re haul of his star projector and facility which makes me really jealous. We are so over crowded here, every spare dime goes ıousing students.

ɔu probably read in my last column I received thousands of dollars of puter software at summer astronomy vorkshops. In one workshop, I had to describe how I used the software with my students to get the promised graduate credit, and I felt pretty hard pressed to come up with an answer. Does flinging the CD ROM across the room to calculate radial velocity count?

When I came back from summer break, I was thrilled to begin using the software. When I told my supervisors about it, they said, That s nice, but we ve cut you one period a day from the planetarium to do lunch and bathroom duty.

For those who have never taught in a high school, bathroom duty is monitor ing the bathrooms during lunch to keep smoking down. Notice, I did not say, stop smoking. That s kind of an impossible task since girls smoke in the stalls. There could be a law suit against a teacher who bent over a stall to look at a person to see if they are smoking or not.

Anyway, the school rule states that I can t knab someone unless I can catch them with a cigarette in their hand and since I can t look into the bathroom stall, well you guessed it, I get a lot of second hand smoke in the process. I don t know who deemed me worthy of potty patrol.

Meanwhile, the planetarium suffers since I can t be in two places at one time. I really thought about leaving, but Carol Helper in Macon, GA always jokes that I make more money than everyone else. (God, I sure hope that s not true!) Also, to take another planetarium job, I have to be ready to move and after Florida, Nebraska, and New York, I m rather tired and glad I ve been in the same place for the last eleven years and I d rather not have to go anywhere if I can help it. Besides, if I left, they d probably shut down this place. I thought about leaving the field, but this is all I ever wanted to do.

I was struggling with this problem while teaching my lesson about Tycho and Kepler to my introductory astronomy students. I show the episode on Kepler s Three Laws from the Mechanical Universe video series. They have live actors protray Tycho and Kepler. I must have seen it at least 11 times, maybe more.

It brings out the contrasts in their per sonalities and shows how they both needed the other s contributions to get the correct answers to explain planet motion.

Kepler came from a really broken home. He s just one of the examples I cite when kids give me some sob story about their family problems. He also was poor and rel atively unknown in his lifetime. The thing that really grabbed me is that for a while he taught school and found it frustrating. Hey, wow, you mean, I am not the only person to find it so? You mean teaching was still a stinky job a long time ago?

The movie also goes on to state that Kepler eventually stole the data he needed from Tycho. This was not an ethically sound thing to do, but it didn t diminish his standing as a great astronomer. I guess we are all not perfect people.

Finally the other interesting thing that was stated was that after Tycho s death, Kepler wandered around trying to collect bad debts, and he survived by casting horoscopes for the rich and famous. See, I wasn t the only one forced into doing a yucky job just to survive.

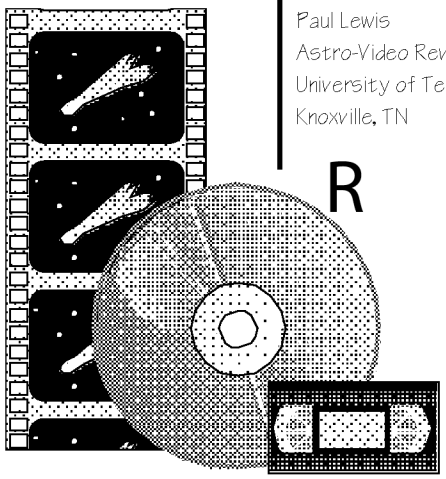
Anyway, I hope 1999 goes well for you and you didn t get too tired of doing that SOB show for the 50th time this Christmas season. If you have any new ideas you d like me to tackle in this column in the new year, just write, phone or fax.

Post Script: How were meteors out there? Leonids, Geminids, and Draconids were all spectacular out here with the dark skies. Drove somewhere to check out the Internet and found out that the super shower for the Leonids never materialized, and the peak came early, and it was pretty good. I saw some great video footage on the mandatory Channel One TV show broad cast in our school. Wish I knew where it came from and could get a copy. Anyone have any ideas?

Astro-Video Review

Space Colonies: Living Among the Stars

Paul Lewis
Astro-Video Review Editor
University of Tennessee
Knoxville, TN



The voice of Star Trek: Deep Space 9 s Captain Benjamin Sisko, Avery Brooks, grips your imagination as he narrates Space Colonies: Living Among The Stars. This video uses the recent past to take us far into the future. Where will we go, how will we get there, and most of all why? These are some of the questions answered by this fascinating one hour program filled with wonderful graphics, computer anima tions, and historical footage that give us insights into our future in space.

Today s NASA launch manifest reads a little like the first three episodes of Star Wars. Science fiction gave us Deep Space 9, and NASA has recently launched Deep Space 1 (DS 1). DS 2 is next in line with more Deep Space missions on the draw ing board. This video gave me a sense of what our future may really be like. Space Colonies uses the amazingly short history of space travel to take us into the future. Visionaries like John Kennedy paved the way for a technology boom in the 60s that put us on the Moon and encouraged us to go farther. Gerard K O Neill envisioned colonies of human beings inhabiting huge rotating rings in space by as early as the 1990s. He wasn t so far off with the International Space Station being born in 1998.

Imagine in 200 years or so, booking passage on a shuttle to vacation on Earth. Living on the Moon in an underground habitat may be commonplace. In 1972 we stopped caring about going to the Moon. Since then, humanity has not brought itself to the gravitational precipice of the Earth.

Will our children s children s children be the Martians we always wanted to be? Will we terraform Mars? Should we? There is already a dichotomy of views on whether to leave Mars in its natural frigid rusting state or attempt to make it Earth like through terraforming. The two sides are referred to as the reds and the greens. It s the stuff of science fiction, but it will most certainly raise debate among those who shape the future of our becoming the first Martians.

Dr. Robert Zubrin, author of The Case For Mars, gives a passionate and convinc ing argument for traveling to Mars. How will we do that? How soon might we undertake such a monumental task? Will we be able to travel beyond our own solar system? Is that something we re destined to do? Will space have to pay our way to make it worthwhile? Can we survive in space? Will we blink and miss our op portunity, or will we do the hard things of which Kennedy spoke?

These are the questions the video asks and to which it attempts to begin pos ing some semblance of answers. We will eventually discover new and better ways to travel. Certainly faster is the word that describes how we ll need to traverse the great chasms of space. Generations will come and go before we arrive at our desti nation. Astronomers, physicists, and sci ence fiction writers tell of the dreams and the next steps into the final frontier.

Space Colonies is exciting and thought provoking and about finding out who we really are. I highly recommend it. You can purchase the video from The Discovery

Screen capture from Space Colonies

The Alchemy of the Heavens:

Searching for Meaning in the Milky Way

Patrick McQuillen
Book Review Editor
Alexander Brest
Planetarium
Jacksonville, FL

When I came across this book in the astronomy section of the local book castle and coffee reading establishment I first thought, Oh, great, now they are putting the New Age, religious, non scientific stuff right in with the real astronomy books. So of course I picked it up to find out just what they were thinking.

It turns out that it is an astronomy book and a very good one at that. The main title refers to humanity s quest to understand of what the universe is made.

Alchemy starts with a quick over view of the galaxy as we currently un derstand its composition. Then we travel back to a time when it was believed that our galaxy was the entire universe.

The book progresses chronologically in time, giving an almost first person look at the progress that was made in our under standing of the structure of the Milky Way and the Universe itself. Mr. Croswell did an excellent job of presenting each new find ing in a way that lets you understand what was known up to that point in time and how the new information changed our views.

This framework continues up to the present time and even discusses ongoing the ories that may eventu ally change some of the firmly entrenched beliefs we hold today.

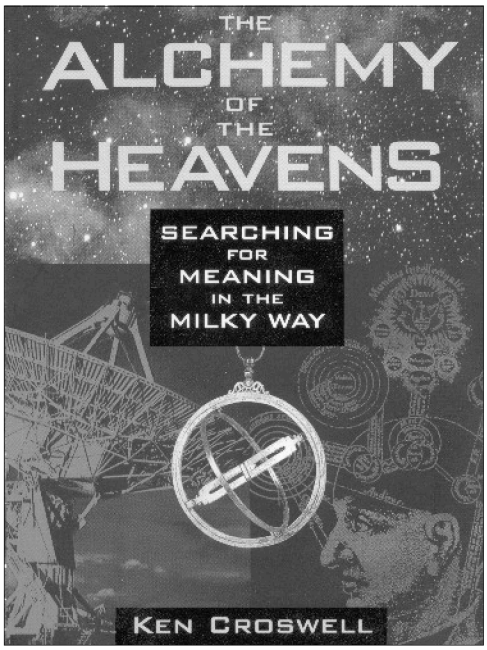
This is a great book to have on your shelf as a reference on who discovered what, when they discovered it, and in what order. The section on how we learned that stars were powered by nuclear fusion processes is very easy to understand and an enjoyable read. The glossary is very extensive. You will not need to pick up another book to look up a term. But, the bibliography alone is worth the cost of the book.

Most of the important articles from the 1940s until now are referenced. If you need to find the exact reference for a future planetarium program about stars or the Milky Way, this is a great place to start.

Another very interesting aspect of the book is that Mr. Croswell personally in terviewed almost every major astronomer who is still alive who has worked on under standing the life of stars or the structure of the galaxy, often times presenting quotes from astronomers who have opposing views in the same paragraph. This lends a very real you are there feel to the book. There are lots of great inside comments from many of the folks we know by name, e.g., Burbidge, Hoyle, Fowler, Schramm, Sandage, Searle, and Zinn.

My only complaint with this book is that there are not enough photos. A small eight page section near the center of the book contains the only actual photos in the book. All of the photos are black and white.

The objects discussed in the book are some of the pretti est in the universe. Galaxies, supernova remnants, star clus ters and nebula are even more enticing when seen in full col or. Imagine a plan etarium program with only a few black and white photos for the entire show. I m sure you will agree with me. But, this is a mi nor complaint. I just like pretty pictures.



While visiting Nashville, Tennessee last year, Waylena McCully and I were fantasy shopping in,

Patrick McQuillen
Reviewer
Alexander Brest
Planetarium
Jacksonville, FL

The Alchemy of the Heavens:
Searching for Meaning in the Milky Way
Ken Crosswell
©1995, Doubleday Books
New York, New York
ISBN # 0-385-47213-7

Starry Messenger:

Galileo Galilei

Patrick McQuillen
Book Review Editor
Alexander Brest
Planetarium
Jacksonville, FL

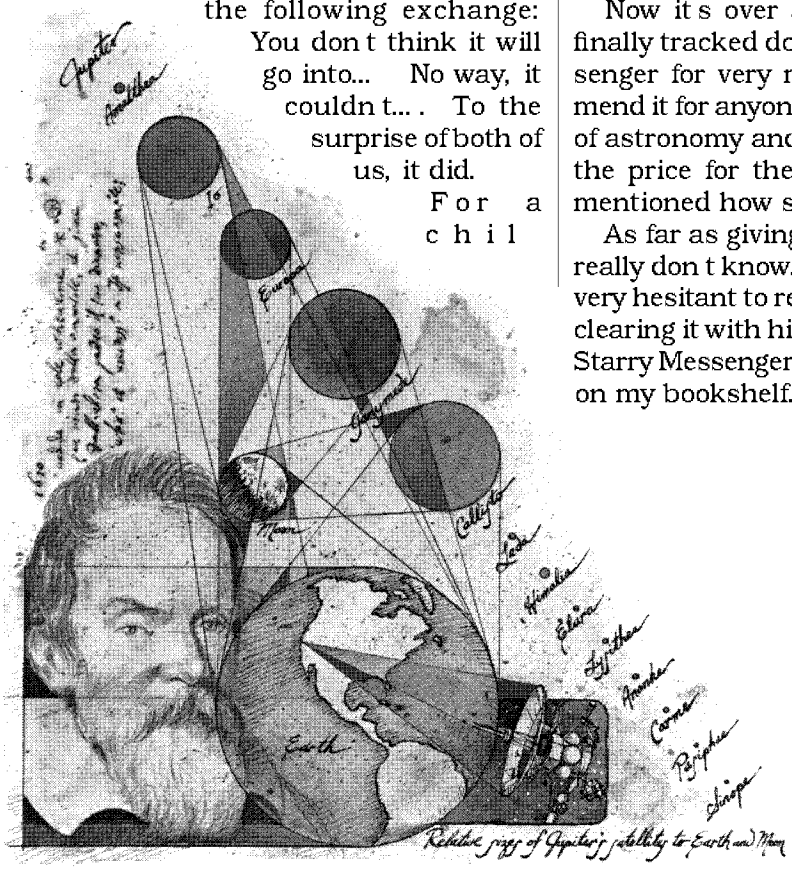
where else, some of the local book stores. Walking that thin line between desire and sensibility is always a risk, but we both managed to escape with our wallets non the worse for wear. This fact was made all the more remarkable when you take into account the surprising find of the year.

Waylena was browsing the children s section when she happened upon a gem of a book. Starry Messenger has the look and feel of a children s book, but its sub ject matter is a little heavier than most of the genre.

Drawn in first by its ornate and beauti ful artwork, we sat and read the whole book right there, mesmerized by each turn of the page. Each page is divided into wonderful drawings and two kinds of text. Large, friendly fonts relate the basics of Galileo s life and his accomplishments. Acting as a supplement to this, handwrit ing gives details for the more curious, but is not needed if reading the book to a child. (More on that later.)

As we read the book there in the store, a passerby would have heard the following exchange: You don t think it will go into... No way, it couldn t... . To the surprise of both of us, it did.

For a child



dren s book, Starry Messenger deals with both the trial and the conviction of Galileo in quite a frank and open manner. One of the passages in the book reads: Galileo was afraid. He knew that people had suf fered terrible torture and punishment for not following tradi tion. We were both quite impressed with the honesty of the statement. I m not sure, however, that all parents would feel the same way that we did.

The artwork is absolutely out standing, and is by far the best part of the book. Large woodcut type color illustrations range from the simply beautiful to downright frightening. Each is superbly detailed, and will supply literally hours of enjoyment examining them.

Now it s over a year later, and I have finally tracked down a copy of Starry Mes senger for very my own. I highly recom mend it for anyone interested in the history of astronomy and science. It is well worth the price for the pictures alone. (Have I mentioned how stunning they are?)

As far as giving this book to a child... , I really don t know. To be honest, I would be very hesitant to read it to any child without clearing it with his/ her parents. That said, Starry Messenger will be proudly displayed on my bookshelf.

Jeff Potter
Reviewer
Alexander Brest
Planetarium
Jacksonville, FL

Galileo Galilei:
Starry Messenger
Created and Illustrated by
Peter Sis
©1996
Frances Foster Books
$16.00, 37 pages

News from SEPA States

George Fleenor
Bishop Planetarium
Bradenton, FL

Bishop Planetarium, Bradenton

George Fleenor reports: Currently, the star shows In Search of New Worlds and Through The Eyes of Hubble are playing as the matinee star shows at 1:00 p.m. and 4:00 p.m. daily. Beginning February 1, 1999 we began to feature Adler Planetarium s newest star show Clouds Of Fire in these time slots.

The Skies Over South Florida series is slowly gaining in popularity. The program offers a live tour of the current evening sky. Immediately following the star show, patrons have an opportunity to visit the observatory for a hands on observing experience through the Cohen Sabin 8 and 6 refracting telescopes, located on the museum rooftop.

The new matinee laser show features Laser Swing, a collection of Big Band swing music from the past as well as modern swing artists. This program runs approximately 35 minutes in length. Saturday morning children s star shows will feature Larry Cat In Space in January, Rusty Rocket s Last Blast in February, The Little Star That Could in March, followed by Bear Tales And Other Grizzly Stories in April.

Weekend evening laser shows, Laser Fantasies, continue as usual. Our special live concert planned for December with Jonn Serrie was a success. Jonn performed his Upon a Midnight Clear cd while accompanied by lasers and lights. Jonn is a true professional and easy to work with. If you are looking for a special event in your theater, Jonn is the man for the job. With little effort, a professionally choreographed show can be easily produced.

The planetarium has also been fighting a major case of light pollution. Having been warned more than a year and one half in advance, the City of Bradenton ignored the Planetarium s plea for proper lighting of the new City Hall Center and Police Department (built across the street from the Museum) and installed 26 light bombs (unshielded, high pressure sodium globe lights). Needless to say, this destroys our observatory program and limits our capabilities. The problem was recognized by several journalist in the local media and the problem became a major issue. The media attention has been very positive for the Planetarium and the City promises to correct the problem. We will see. This is the first step towards getting a lighting ordinance passed for our area of the city. We hope. Keep your fingers crossed.

We are also happy to announce the appointment of our new Executive Director. Dr. Peter Bennett brings to us a vast array of experiences which will be very beneficial to our facility and its future plans for renovations. We are very excited to have Dr. Bennett join our staff. Among his many accomplishments, he most recently served as Director of the Florida Museum of Natural History in Gainesville, Florida from 1986 1996 and served as the President of Science Service, Inc. and Publisher of Science News Magazine from 1996 1998.

We also recently changed our web address to <www.sfmbp.org>. Check us out. We are continuously updating the site and plan for further expansion and dissemination of information.

Buehler Planetarium, Davie

Dave Menke and staff report: They just got their new a/c system installed over Thanksgiving. It works great. It s now 56 F in the theater! Needs some adjustment.

Featured star shows for the next several months will be: January 8 February 7, Larry Cat in Space, January 8 31, Planet Patrol, February 5 28, Light Hearted Astronomer, February 13 May 23, The Little Star that Could, March 5 28, Cosmic Catastrophes, April 2 May 1, The Mars Show, May 7 30, Cowboy Astronomer, May 29 September 19, In My Backyard, June 4 27, Islands in a Sea of Night.

The planetarium is also featuring monthly specials. January will feature Observational Astronomy. Others topics will include: February: The Search for Planet X, March: Blue Moon, April: Extrasolar Planets & SETI, May: Deep Impact, and June will feature: Apollo, Helios, & Aman Rah.

The facility just got a $100K grant to build a new observatory. They already had $50K in the bank and now are going to ask

for a special state grant for another $100K in matching funds. So, it will be $250K, without the optics. They are getting an other grant to cover all the hardware inside separately. It will be a two story building just south of the Planetarium. Ground breaking will probably be in September. They hope.

A couple of staff members also plan to travel to Europe to see the solar eclipse in August.

George Fleenor
Bishop Planetarium
Bradenton, FL

Alexander Brest Planetarium
Jacksonville

Submitted by Patrick McQuillen: The Alexander Brest Planetarium is gearing up to host the 1999 SEPA Conference. It will certainly be a conference not to be missed. Included among the usual activities (pa per sessions, meals, tour of planetarium, vendors) will be a dinner cruise along the Saint John s River and a trip to the Ken nedy Space Center. Conference dates are June 22 26, 1999. Mark you calendar, and ask for those days off now. Beat the rush!

This winter we are bringing back a family favorite: Larry Cat in Space. This program is always well received with children of all ages. In addition to Larry Cat in Space we are running the ubiquitous Winter Skies program. This program is the typical tour of the current night sky program.

Classes continue at the Challenger Learning Center Jacksonville. The CLC is located in one of the counties middle schools. It is owned by the school system, but it is managed and run by the plan etarium. As part of the visit to the CLC, the students visit the museum for a two hour hands on space lab. One of the most interesting parts of the lab this year has been the addition of Star Station One™ demonstrations.

The Star Station One™ program is a cooperative program created by Bishop Museum in Hawaii, funded by The Boeing Corporation, supported by NASA, and pre sented at 60 member institutions around the country. The program was created to provide a fun way to inform the public about the International Space Station. [Also please see Craigmont Planetarium s ThinkQuest competition Web site <http:// library.advanced.org/ 19876>.] The pro gram grant provides most of the materi als to present the demonstrations; the member institutions provide the rest of the materials and the staff to present the programs. We are currently working on finishing a small exhibit on the ISS. This exhibit will have a $^1/_{144}$ scale model of the completed ISS, photos documenting cur rently built components, info on the cur rent/ next mission, and information about where to find the ISS in the skies over Jacksonville. (Which I have seen. ISS was almost as bright as Rigel, when it passed 75 overhead. EASY TO FIND!)

Look for information about the 1999 SEPA conference in your mailbox (if you haven t already received some by the time you read this).

Aldrin Planetarium, West Palm Beach

Erich Landstrom reports: We ve strewn the South Florida Science Museum out side area with hundreds of pounds of dinomight to ensure visitors will be blown away in 1999. From January until May, we reprise our most popular exhibit ever, DINOSAURS OUTDOORS. Fourteen of D inamation s animatronics, including Triceratops, Stegosaurus, D ildophosau rus, and the 22 foot high Tyrannosaurus Rex, return to our Jurassic jungle trail along with in house fossils and the special D ino Store.

The Aldrin Planetarium s mainstay for the duration of the display is D inosaurs! from Joe Hopkins Engineering. This will be our primary public program, although other shows will be offered in conjunction with special events. For example, in honor of Black History Month we offer Follow The Drinking Gourd, except during National Engineering Week, when we present The Voyager Encounters and Hubble Vision from Loch Ness Productions. These spe cial presentation will be worked around our daily afternoon live sky show, Night Sky Over The Palm Beaches. Incidentally, the publication New D irections for Better Living has picked up the text adaptation of Night Sky Over the Palm Beaches for a monthly column Star Power.

Flexibility of schedule is the keyword for planning the summer. The next block buster exposition is Not Of This World: A Journey To The Planets, which celebrates the 30th anniversary of Buzz Aldrin walking on the Moon, the robotic reconnaissance of Mars, and the feasible future exploration of the outer gas giants. So the plan is to revive Wings of Fire, Eyes of Glass and Hansen s Footsteps and Loch Ness All Systems Go! to recap the successes of the Apollo mis sion, and have The Mars Show and The

Voyager Encounters from Loch Ness, and possibly a few others in the rotation. In addition to that, the Summer Motorola Laser Light Show Series will have laser concerts by JHE, Inc., including performances of Laser Jimi Hendrix: Experience, and Laser Pink Floyd: Dark Side of the Moon, on an as yet to be determined basis.

In the even more so tenuous planning stages is a show co produced with the award winning author and all around nice guy Jon Bell, but that s for a future column. In the interim, please visit the South Florida Science Museum Web site at <http: WWW.SFSM.ORG>.

George Fleenor
Bishop Planetarium
Bradenton, FL

Special note: The ASTC 1999 Conference, which targets Science Center Directors, Educators and Exhibit Designers will be hosted by Tampa s Museum of Science & Industry in Tampa, Florida, October 2 5, 1999. The conference is limited to 1500 attendees. The ASTC Annual Conference is the world s leading meeting for science and other science rich museums. More than 1,500 science center directors, scientists, educators, and exhibit creators attend more than 100 conference sessions and workshops, interest group meetings, exhibits, and educational field trips.

For more information contact the following sources:

Conference:
Association of Science and Technology Centers (ASTC)
1025 Vermont Ave., Suite 500,
Washington D.C. 20005
phone: 202 783 7200
<astc@astc.org>

Web Sites Conference Site:
<www.astc.org/ info/ profdev/ confmain.htm>

Organization Site:
<www.astc.org/ astc/ Conference>

Mark Smith Planetarium, Macon

Jim Greenhouse and Carole Helper are busy getting ready for laser shows that the Mark Smith Planetarium will be showing this summer. They are borrowing a laser from ECCS. Jack Frost and the Skies of Winter is the current planetarium show, and Light Hearted Astronomer will start in March.

Jim Greenhouse
and Carole Helper
Mark Smith Planetarium
Macon

They are also planning public observing sessions for the planetary conjunction on February 23, and Astronomy Day on May 22. Jim will be doing planetarium talks about light pollution during the Energy Fair on March 6.

A new Georgia Association of Planetariums (GAP) Web page was created on The Museum of Arts and Sciences site. Links to other Georgia planetariums and observatories are listed along with upcoming events. Please visit the page at <www.masmacon.com/ gap.htm>. If your planetarium has a Web site and you would like to have it added to the page, please email your address to Jim at <jbgreenhouse@masmacon.com>. Also send him any information you would like to have posted, such as program schedules, public observing sessions, and guest speakers. One of the goals for this page is to publicize planetariums that don t have Web sites.

Fernbank Science Center, Atlanta

April Whitt reported on several events at the Fernbank Science Center. They opened two planetarium programs for Black History month: African Skies on January 20 (for the general public) and Lions Tales on January 30 (children s program). Two new programs are in production for the spring: The New Solar System (public show) and Planet Patrol (new children s program produced there, although it has the same name as the Sudekum program).

Carl McNair, brother of Challenger astronaut Ron McNair, will be at Fernbank on Sunday February 7 for a Black History month kick off event. Also included in that afternoon s festivities are the winners of the county wide school art contest.

Claude Nicollier, the first European astronaut to be accepted in the NASA program, visited Fernbank on January 13th, to talk with the staff and give a lecture about living and working in space. His slides and presentation were excellent. He offered assistance in developing the curriculum for the summer program Space Station Fernbank, which is being developed as a month long summer camp for

60 rising 7th graders.

Fernbank is also serving as the Star Station One™ site for Georgia, and will be bringing materials and information to the SEPA conference in Jacksonville.

Georgia Southern University Planetarium, Statesboro

Becky Lowder will be working with Ben Zellner at the Georgia Southern University Planetarium in Statesboro. They will have a Basics of Astrophotography workshop on February 19, presented by Dan Brown, photographer and amateur astronomer from Vidalia. An audience member will be selected to take photos and take the roll of film home for developing.

Walker County Science Center Plan etarium

Bobby Thompson reported that the new planetarium at Walker County Sci ence Center will be built by this summer. They are now in the bid process for a 50 x 50 ft. building attached to the present building.

They have purchased the dome from Jacksonville Florida, a 40 foot with 112 unidirectional seats. Patrick McQuillian has his check by now. Maybe that is how he is throwing the SEPA meeting. They will install the Spitz AP3 that came from Macon. (History Note: The Mark Smith Planetarium bought its current MS 10 from the Alexander Brest Planetarium, and Walker County got the Mark Smith s old AP3. Walker Co. also sold its old projector to someone in the Great Southeast Star Projector Swap of 1989.)

Tony Butterfield
Coca-Cola Science Theatre
Columbus

Walker County has many problems to solve, such as how to get the dome down and install it. Meanwhile they are taking up the slack at University of Tennessee Chattanooga Clarence T. Jones Observa tory.

Freeport McMoRan Planetarium and Ob servatory, Kenner

It s alive! The Kenner Planetarium Proj ect finally has approval from the mayor and city council. Over 75% of the funds are in place for the project, and the current hope is that it will begin in early 1999. I feel that I am Odysseus of the planetarium world. Hopefully this odyssey won t continue for another ten years. Who knows, at the SEPA convention next year, I may be able to give a happy ending to this story.

The opening of the space station was pushed back to February of 1999 to coin cide with our new exhibition hall located next door to the planetarium.

I was fortunate enough to attend the Zeiss 75th Planetarium Anniversary in Jena, Germany in October. This confer ence was held for the 75th anniversary of the first planetarium. At this conference I was able to let planetarians from around the world know a little about our plan etarium project in Kenner.

During winter, we are showing The Sky Tonight amongst many other in house productions. Our Young Astronaut Pro gram wound up with almost 150 partici pants. Our Young Astronaut Program has received national recognition and keeps us very busy. We are also continuing our partnership with the University of New Orleans in providing information, speak ers, and workshops on Astronomy.

Louisiana Nature and Science Center Planetarium, New Orleans

Mark Trotter and Dennis Cowles are currently running The Sky Tonight, The Family Laser Show, and Cosmos. On Fri day and Saturday nights they run laser shows including Pink Floyd s The Wall, Led Zeppelin, The Best of Pink Floyd, Rush 2112, Metallica, Pink Floyd s The Dark Side of the Moon, The Alternative Laser Show, and their latest show, Laser Trash. For school groups, they are offering The Little Star that Could, Planet Patrol: A Solar System StakeOut, and a live pro gram on the seasons. They continue to offer monthly science insight programs on the first Saturday of each month. Recent topics have included the Leonid Meteor Shower, Galaxies, The Sun, Meteorites, and Asteroids.

Michael Sandras
Freeport McMoran
Planetarium

Mark has been busy preparing the 1999 budget and nailing down the details for the purchase of a new three beam video pro jection system. Dennis has already started working on a workshop for the Jacksonville conference on planetary geology. In ad dition to a monthly astronomy column, Dennis is now writing a weekly astronomy column for a local paper. He complains that he never gets to leave the computer. Mark and Dennis are trying to figure out a new filing and documentation system for the planetarium slide collection.

They added two specimens to the plane

tarium meteorite collection: an 11 kilogram Gibeon nickel iron and a 294 gram Tulia (a) H5 chondrite. Dennis went to Nassau in December and met Dr. Theo Habel and Peter Grul of the Adventure Learning Cen tre Planetarium. Both have joined SEPA as associate members and hopefully everyone will have the opportunity to meet them in Jacksonville in June.

Michael Sandras
Freeport McMoran
Planetarium

St. Charles Parish Library Planetarium, Luling

After a fall season in which tropical storms and the flooding caused by them, seemed to threaten the planetarium on a weekly basis. Winter has seemed tame by comparison. Programs currently include The Dawn of Astronomy for our public shows and Larry Cat in Space for our kids matinee on Saturdays.

Lafayette Natural History Museum Lafayette

David Hostetter reports that the Lafay ette Planetarium is presenting Moons of the Solar System and Psudekham s (sic) Worlds in Motion along with other pro gramming.

David participated in the Science Scholars series held by Barnes & Noble on space flight and plans on doing an observing session in February. In October he participated in a telescope class, along with a public star party and a second party for girl scouts at the local camp. In early December, a very successful star party was also put together in which several hundred people showed up.

In mid September David toured the Spitz Factory located in Chadds Ford, Pennsylvania in order to learn about their products and equipment that the museum is considering purchasing for a building project. Currently the city of Lafayette is planning on closing down the current planetarium some time in early 2000 and moving it to its new downtown location sometime in 2001.

SciWorks Planetarium, Winston Salem

Patsy Wilson
Horizons Unlimited
Salisbury

While still maintaining the planetarium s regular show schedule, Duke Johnson and Karen Osterer have already started work to entertain and dazzle you at SEPA 2000. However, the sighting of a woodchuck in the planetarium has not as yet been con firmed. We promise to keep you posted. Meanwhile, the planetarium is gearing up for summer SciCamp with new programs in astronomy, geology, and mystery camps for students of all ages.

Roper Mountain Science Center, Green ville

Todd Slisher
Gibbes Planetarium
Columbia, SC

Doug Gegen and the crew in Greenville are excited about a new arrival. No, not new staff this time, it s a new NGT 18 Dobsonian telescope which was donated by a member of the local astronomy club. Currently the telescope is being used dur ing their public Friday night observing. Eventually they hope to find a site for it at a darker location. Also, under the dome, Gavin Hoffman is working on some new digistar sequences for their Cosmic Reflec tions program and developing a new Web site. Doug is also in the process of creating a new demo program that will introduce science center visitors to the theater.

??? Planetarium, Columbia

The big news from Columbia is your humble author s (Todd Slisher s) departure from the planetarium program. I won t be leaving the SEPA region, however, because I have been named the new Director of the Sharpe Planetarium at the Pink Palace Mu seum in Memphis, TN. Although I regret leaving a project with so much potential, I am excited about the new opportunity as well as the wonderful facility and staff in Memphis. Work on the new project continues under the capable hands of Planetarium Director Jeff Guill. A budget proposal to the legislature to fund the new facility which includes a Planetarium, Ob servatory, and Large Format Theater will be voted on this spring. Lobbying efforts are currently underway.

College Park Middle School Planetarium Ladson

Kathy Sanders reports that the plan etarium has been cleaned and refurbished and is in good working order. She has been busy with students presenting several programs including Worlds of Wonder. After viewing the programs, students are guided through several hands on activities including creating travel brochures for their planet and also creating aliens that might live there. In other promising news,

it is looking favorable that the school board will approve a plan to automate the facility including a new ECCS control system.

Settlemyre Planetarium, Rock Hill

Glen Dantzler s excited about recent upgrades. They ve added two pan pro jectors to bring their system up to six sections. Also they ve added a third laser disk player to their video system, reducing the amount that they need to substitute video tape for a laser disk. This February they plan a show schedule that features black history month. They will be showing Follow the Drinking Gourd and a program featuring sky lore of Nigeria and Kenya. Planning is underway for their Winthrop Jr. Scholars program which occupies their

Todd Slisher
Gibbes Planetarium
Columbia, SC

Craigmont Planetarium, Memphis

A Goals 2000 grant awarded to Duncan Teague and Lisa DuFur from the state of Tennessee paid for the purchase and in stallation of two satellite dishes, program registration fees, and some new Macintosh G3 computer systems and peripherals. With our new GCC Elite 20/ 1200 laser printer we can print our publications in house instead of having them printed by local print shops. The savings in print ing alone will pay for the printer in two years.

The most recent teleconference we hosted with the new equipment was the International Space Station: Some As sembly Required program on February 18. We were one of only about 20 host sites that managed to get through to the constantly busy uplink site, and one of our students was able to ask a question to the four panelists who are involved with the ISS Project.

We taped the program for later distri bution via a connection to Channel One, which will allow every classroom at Craig mont to view the tape of the live event.

Duncan and two Planetarium Interns, junior Alicia Cooper and senior Elizabeth Spilman, co creators of the ThinkQuest Web site, A New Star on the Horizon, spent two weeks converting the study guides for Sudekum s Our Place in Space and Han sen s The Secret of the Cardboard Rocket into PDF files. By allowing teachers in the local schools to download these Adobe® Acrobat Reader® files, we save on more printing costs, and our clientele don t need to wait for us to deliver them.

This was no easy task. Duncan and the students had to re create the study guides completely from scratch, since Adobe® Acrobat Reader® didn t like the fonts embedded in the original PageMaker publications. If you re using either of these two programs, please feel free to download the PDF files from the Skylights Newslet ter online Web page at <http://www.

We re currently running Our Place in Space for kindergarten first grade, The Secret of the Cardboard Rocket for second third grade, and Solar System Adventure Tour for fourth sixth grade. For middle school and high school students we re showing Hubble: From Here to Eternity.

In late winter we ll be doing some spe cial activities for pre calculus students involved in a city wide math program called PaceSetters.

Duncan Teague
Craigmont Planetarium
Memphis, TN

Bays Mountain

The Winter run at Bays Mountain is a new in house production entitled Starlight Nights. It is a basic program for identifying stars, constellations and using binoculars to study the night sky. The 25 minute program will be saved after its public run to be used with scout groups in meeting badge requirements. In February, the planetarium is scheduled to have digital readouts installed at the console to com plete the automation of our Goto star projector.

Albert Einstein Planetarium
Washington, DC

Sean O Brien did a Halloween show called Ghosts, Flying Horses, and Meteors. He had Trick or Treat goodie bags with glow in the dark slinkies and posters from the new show And a Star To Steer Her By with narration by Sir Alex Guinness. On January 30th, Geoff Chester from the Naval Observatory drops down to his old place of business to do Ground Hogs and Cross Quarter Days.

Elizabeth Wasiluk
Berkeley County Planetarium

THE DEADLINE FOR THE NEXT ISSUE OF SOUTHERN SKIES IS APRIL 1. SEND SUBMISSIONS ON A 3.5 DISK OR VIA EMAIL ATTACHED FILE TO STARMANTNG@AOL.COM OR TO TEAGUED1@TEN NASH.TEN.K12.

HST's Greatest Hits of '96

Duncan Teague
DT Publishing
3308 Bluemont Drive
Memphis, TN 38134-8454

The Space Telescope Science Institute (STScI) provides slides of Hubble images to individuals within regional affiliates who arrange to duplicate and distribute them. At our 96 conference, I was designated to receive and coordinate STSci materials and make them available to SEPA members.

Below you ll find a brief description of all 40 images distributed in 1996. Numbers next to the descriptions are shortened versions of STSci press release numbers, e.g., 21a refers to PR 96 21a.

The entire set of 40 slides is $50, includ ing postage and handling. Send your check or purchase order to the address at left.

01.a Hubble s deepest ever view of the universe, revealing 1,500+ extreme ly faint galaxies in various stages of their development

01.b Sample galaxies from the same Hubble deep field

02 The inner region of a warped dust disk around Beta Pictoris once hid den because of the star s glare

03 An image of the Egg Nebula taken by WFPC2; it shows the emergence of mysterious searchlight beams from behind a dying star

04 The first direct image of a star other than the Sun: Betelgeuse.

05 In more detail than has ever been seen before, the process a star like the Sun goes through when it dies

09.a In clear, detailed pictures the first ever images of Pluto s surface; four views

09.b Pluto surface map

10 Gravitational lens effect captures image of primeval galaxy

11 Images of globular cluster Mayall II, consisting of 300,000 old stars, in orbit around the Andromeda galaxy

13.a The Helix Nebula, NGC 7293 show ing collision of gases near a dying star

13.b Helix Nebula detail with cometary knots surrounding the dying star

14 A view of Comet Hyakutake that focuses on the near nucleus region of the comet

15 Three layers of Uranus s atmosphere taken with infrared filters; both clear and hazy layers created by a mixture of gases

16 Image taken of Saturn where its rings appear edge on because of the position of the Earth in Saturn s orbital plane

17 A view of several star generations found in the central region of the Whirpool Galaxy

18.a A rare view of Saturn s rings seen just after the Sun had set below the ring plane

18.b A series of 10 images of several small moons orbiting Saturn

21.a NGC 1365, a barred spiral galaxy located in the Fornax cluster

21.b NGC 4639, a spiral galaxy located in the Virgo cluster

22.a The Crab Nebula and a detail of the pulsar in its center

22.b Sequence of three images showing changes in the Crab Nebula pulsar

23.a Huge, billowing pair of gas and dust clouds in Eta Carinae

23.b Expansion of Eta Carinae debris

25 Hubble s 100,000th exposure cap tures an image of a distant quasar

27 A vast nebula, NGC 604, which is known for a great starbirth region

29.a 18 gigantic star clusters which may be building blocks for a new galaxy

29.b Blue sub galactic clumps which may be galaxies under construction

30 Jupiter s moon Io passing above turbulent clouds

31 Clusters of stars and a fishhook shaped cloud of gases found in NGC2366, a giant star forming region

32 Changes in Jupiter s auroral emis sions

33 Views of weather on opposite hemi spheres of Neptune

34 A Martian dust storm around the edge of the north polar cap

35.a A survey of quasar host galaxies

35.b A quasar caught in the act of collid ing with its companion galaxy

36.a Supersonic comet like objects in the Cartwheel Galaxy

36.b Cartwheel Galaxy composite image

36.c Cartwheel Galaxy illustration

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The entire set of 39 slides is $48.75, including postage and handling. Send a check or purchase order to the address

01 Central supermassive black holes in galaxies NGC 3377, NGC 3379, and NGC 4486B:

03 SN1987A Fireball: One tenth light year long dumbbell structure ex panding at six million miles per hour in supernova 1987A

08 Changes in the nucleus of Comet Hale Bopp as it moves closer to the sun beginning in September 1995

09.a Transition from spring and summer in Mars s northern hemisphere; photo taken shortly before opposi tion

09.b Three photos of Mars taken six hours apart with 90 difference be tween images; photos taken shortly before opposition

11 The Egg nebula in which stars are born and die violently; photo shows jets of gas being blasted into space

12 A supermassive black hole located in galaxy M84

13 NICMOS captures region of the Orion nebula filled with action as a center for the birth of new stars

14 Supernova 1987A: different colors represent different elements in the ring

15.a A view of Mars s cloud cover

15.b Seasonal changes in Mars s north polar ice cap

15.c Four views of Mars rotated 90 between images during summer in Mars s northern hemisphere

16 The Cone Nebula: six baby sun like stars surround their mother

17 A collision between two spiral galax ies in the heart of galaxy Arp 220

18 Fireworks near a black hole in the core of Seyfert galaxy NGC 4151

19 STIS reveals an invisible high speed collision around a supernova

20 Hubble pinpoints the optical coun terparts of a gamma ray burst in a distant galaxy

21 Hubble captures a volcanic eruption plume from Jupiter s moon Io

22 A gamma ray burst blazes from a titanic explosion in deep space

23 Hubble s look at Mars shows a can yon dust storm, cloudy conditions for Pathfinder s landing in July 1997

24.a Dissipation of a large dust storm on Mars

24.b Hubble shows dust and water ice clouds exhibit substantial daily variations

25 Powerful telescopes discover the largest galaxy in the universe

26 Hubble separates components in the Mira binary star system

27 Hubble reveals huge crater on the surface of the asteroid Vesta.

28 Hubble finds a bare black hole pour ing out light.

29 Hubble shows blobs of gas formed by some nova outbursts.

30 Hubble keeps track of a fading g ray burst.

31 Mars at the beginning of autumn in the Martian northern hemisphere.

32 Hubble sees a neutron star alone in space.

33 Hubble identifies what might be the most luminmous star known.

34.a Hubble reveals stellar fireworks ac companying galaxy collisions.

34.b Detailed images of colliding galax ies.

35 Hubble shows images of a blue straggler star.

36.a Hubble tracks clouds on Uranus.

36.b Hubble spots northern hemispheric clouds on Uranus.

37 Hubble shows infrared view of moon, ring, and clouds of Jupiter.

38.a Hubble sees supersonic exhaust

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01 COBE s infrared view of the Uni verse: three maps of the full sky seen in infrared light
02 Distant supernovae: light sources determine universe s expansion rate
03 Beta Pictoris: disk indicates planets, possible brown dwarf companion
04 Jupiter aurorae: a curtain of light extends several hundred miles be yond Jupiter s limb
05 Saturn s aurorae: curtains of light extend 1,000 miles above cloud tops
08 Supernova 1987A: a collision be tween the expanding blast wave and circumstellar ring
10 Serendipitous asteroids: HST images show curved trails of asteroids
11A Planetary nebula NGC 7027: a brief stage in the evolution of a medium mass star
11B Cotton Candy Nebula and Silkworm Nebula: phases of stellar burnout
12 Star birth in barred spiral galaxy NGC 1808 possibly due to interac tion with NGC 1792
14A Centaurus A: nearest active galaxy to Earth shows turbulent firestorm of starbirth
14B Centaurus A: tilted disk of gas at galaxy s core surrounds suspected black hole
15 Stingray Nebula: Henize 1357, the youngest known planetary nebula
16 NGC 1818: globular cluster of over 20,000 stars in the Large Magellanic Cloud
17A GRB 971214: gamma ray burst is most energetic event in the uni verse
17B GRB 971214: gamma ray burst; comparison of Keck Telescope and HST views
18 Saturn: details of the clouds and hazes in atmosphere of ringed planet
19 Possible first extrasolar planet ever to be imaged orbiting about a new born binary star
20 Four of NASA s proposed designs for the Next Generation Space Tele scope (NGST)
21 Galaxy NGC 4314: bright ring of starbirth around the galaxy s core
22 NGC7052: galaxy with 300 million solar mass black hole in its center
25 N81 in the Small Magellanic Cloud: a celestial maternity ward
26A Galaxy Cluster MS1054 03321: thousands of galaxies 8 billion light years from Earth
26B Supernova 1996CL: a March 1996 exploding star in galaxy cluster MS1054 0321
27 Distant galaxy clusters: left, in Virgo; upper right, in Andromeda; lower right, in Taurus
28 NGC7742: a small Seyfert 2 active galaxy probably powered by a black hole in its core
29 Saturn: pastel yellows, browns, and greys distinguish cloud differences
30 Sagittarius Star Cloud: HST peers into the heart of the Milky Way
31 NGC7635, the Bubble Nebula: an expanding shell of glowing gas sur rounding a hot star
32A Infrared views: left: faintest galaxies ever seen; right: objects 12 billion light years away
32B Deep field galaxy: left: visible light areas of starbirth; right, infrared disk structure
34 Neptune: a look at the eighth planet s stormy disposition
35 Uranus, August 8, 1998: its four major rings and 10 of its 17 known satellites; false color
36 NGC6210 planetary nebula de scribed as looking like a turtle swal lowing a sea shell
37 Quasar PG1115+080 and gravita tional lens effect:
38 Nebula M1 67 around star WR124: gas ejected into space at 100,000 mph
39 NGC3132: southern hemisphere s Eight Burst or Southern Ring Nebula
41A HST deep field south: thousands of

JPL '98 Slides

NASA JPL has sent us the following slides for the Galileo Mission and others. Slides are $1.25 each.

P 35036B	Launch of Galileo on STS 34 Atlantis
P 35213	Deployment of Galileo and IUS
P 37218	Venus Colorized Clouds
P 37327	Moon: Western Hemisphere
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A Miraculous Christmas Star

Does it Have a Place in Secular Planetarium Programs?

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In a previous article, I argued that the Shekinah Glory is an appropriate hypothesis for consideration in planetarium Christmas Star shows (Kanagy 1998). The goal of the present paper is to reply to the objection that the Shekinah is an explanation in terms of miracle and, as such, has no place in the secular planetarium.

Historically, many astronomers have regarded the Christmas Star as a miracle. Kepler held that the Star was a miracle not, as the common planetarium myth would have it, a planetary conjunction (Burke Gaffney 1937; Mosley 1981). Various writers for the Griffith Observer (15 (12), 142, Dec. 1951; 4 (12), 146 147, Dec. 1940) likewise have defended a miracle identity for the Star. See also, Pritchard 1889, Proctor 1884, Smyth 1888 and various writers for Sky & Telescope over the years. Is the planetarium an appropriate place to discuss Kepler s views?

Miraculous Phenomena Untestable Scientifically?

The claim has been made often by numerous scholars, e.g., Mosley 1991, p. 26 and E. C. Krupp, that miracles are scientifically uninteresting because they are untestable and thus the discussion of them is outside the proper domain of science: belief in them is personal and private (Mosley 1991, p. 26). Although in many cases this view may be correct, it is not in all cases. A few points:

(1) Semantic confusion is common. A miracle can mean anything from (I) an uncommon event (usually one whose cause we do not understand), (II) a phenomenon caused by a god or other superior being, to (III) a violation of an epistemic or (IV) ontological law of nature (Cf. Hume).

(2) One must be careful to distinguish between (a) the issue of proving that an occurrence is indeed a miraculous one and, (b) given that a miracle involving physical phenomena has occurred, can one scientifically investigate it?

In regard to (a), II, & IV, in science there is no need for such proof because science is non teleological: science seldom, if ever, involves issues of ultimate causation or ultimate reality, although defenders of the Copenhagen interpretation of quantum mechanics seem to treat the Indeterminacy Principle as an ontological feature of the universe. On the other hand, science does involve the evaluation, description, and explanation of physical phenomena. Thus a physical phenomenon, independent of the ultimate nature of its causation, is in the proper realm of scientific investigation. Commitment to metaphysical naturalism is not an essential component of what it means to be a scientist.

In regard to III, the laws of Newtonian mechanics forbid quantum tunneling phenomena. Moral: violation of epistemic laws does not invalidate a hypothesis as science.

(3) Given situation (b), the phenomena are not merely mystical or metaphysical. Objective evidence (measurements, observations of physical phenomena) is relevant and these phenomena do not fit the criterion of not subject to validation by objective criteria that the National Academy of Sciences (1973) used to object to religion in public school science classes.

Faith healings, glossolalia, the Division of the Red Sea, and Joshua making the Sun stand still (Joshua 10) all involve physical phenomena which therefore in principle can be described and otherwise studied by the methods of science, whether in some ultimate sense they were caused by the Judeo Christian God or not (Cf. Sagan & Asimov on Velikovsky). If these phenomena were physical, they were publically observable, objective phenomena not mere subjective, personal, private, mystical experiences.

Amos Nur, geophysicist at Stanford University, as science can study earth quakes that allegedly were responsible for the Falling of the Walls of Jericho, the Rending of the Veil at the death of Jesus, the cessation of flow of the Jordan River in Joshua 4, the destruction of Sodom and Gomorrah (Genesis 19), and that perhaps eventually will cause the splitting of the Mount of Olives prophesied in Zechariah 14 (Nur 1991) all traditionally attributed to miracles by the faithful. In principle at least, one can confirm that some of these phenomena genuinely occurred in space and time. Is it proper to discuss Nur s sci entific writings in a public school geology classroom?

Some events are considered miracu lous merely because of their meaningful occurrence in synchronicity with another event, as when the Red Sea divides just as Moses and Israel are backed against it by the Egyptians (Exodus 14). Many scholars consider the event, if it occurred at all, as merely a miracle of timing, explaining the phenomenon itself naturalistically (tsu nami effect from the eruption of Thera?). Surely geologists can, as scientists not merely as theologians, study the eruption of Thera, its effects on the surrounding regions, evidence for and timing of a tsu nami, and so on.

Darkness at the crucifixion of Jesus (Mosley 1991, p. 30) clearly can be investi gated scientifically (in principle) if it was a real, physical darkness. The darkness was astrological and symbolic in its interpreta tion by the biblical writers the heavens were in sympathy or correspondence with the death of the Son of God. Despite this religious and astrological significance, we properly, as scientists, can investigate it and invent and test various scientific hy potheses (solar eclipse? See Humphreys & Waddington 1990) as to its nature. Even if it was a miraculous darkness, either the landscape was darkened physically or it wasn t science potentially could decide, given appropriate evidence, whether the darkness occurred or not.

(4) Even the specially created star identity for the Star of the Magi could be investigat ed scientifically if the result of the creation were an object that could be seen physi cally. Notice again that to be scientifically investigable, the object need not have be haved in manners consistent with epistemic physical laws: UFOs are investigated by sci entists today, despite reports of their making sudden 90 degree turns, suddenly ap pearing from nowhere and disappearing into nothing, and despite the fact that some people regard them as supernatural phenomena (Sagan & Page, 1972) and often despite having only eyewitness accounts with no physical evidence.

The search for extraterrestrial intel ligence by Sagan and others presupposed that signals from intelligent beings could be recognized by scientists, no matter what the bodily form of the intelligent agents (angels?) sending the signals. Likewise, scientific evidence can support the tradi tional unique to Judeo Christianity claim that the universe appeared out of nothing according to Tryon (1973) and other cosmologists (Kanagy 1994). Anthropic principle arguments have given rise to the claim that an intelligent cause for the universe may be scientifically inferred as well and it is not mere theologians and pseudoscientists who have this view (Owen Gingerich and Fred Hoyle are among the many scientists who find the evidence persuasive).

(5) In the specific case of the Christmas Star, a physical miracle explanation may in principle be in the proper realm of science, whereas in practice the phenomenon may not be scientifically investigable at the present time. The physical phenom ena involved may not have left any traces discernible at present. Even physical phe nomena that have occurred in the past, yet without leav ing a trace in the present, in principle can be investigated using the methods of histo rians without necessitating a categorization of the phe nomena as solely mystical or religious. Planetarians frequently find it acceptable

to use purely historical argu ments in their planetarium shows arguments which may not be strictly scien tific. Planetary conjunctions themselves were physical, yet left no discernible physi cal effects behind for us to measure at present either. Should astronomers qua astronomers be silent on historical planetary conjunc tions? Is it merely because such phenomena can be retrodicted using celestial mechanics that we, as scien tists, can legitimately discuss them?

(6) In the United States anyone is free to believe what he/ she wishes (even if he/ she is irrational in so doing), and if some prefer to believe that the Star was merely a natural phenomenon, so be it. But the public trusts us to leave personal beliefs, whether religious or philosophical, at home. They do not want to be manipulated by subtle philo sophical biases. We wear a scientist s hat when we are in the planetarium theater. We are obligated to present the findings of science and to avoid manipulative use of particular philosophical stances (positivism, meta physical naturalism, and so on). Necessary presup positions, such as (perhaps) methodological naturalism, need to be made explicit. [Note my point elsewhere, however, that the presup position of methodological naturalism does not neces sarily preclude investigation of such phenomena as the Shekinah Glory.] This may make it difficult for some of us with strong private beliefs, in metaphysical naturalism for example, to participate in certain shows, and if so, we should have the courage to stand aside. (Cf. Mosley 1991, p. 26).

Matthew s Intention a Miracle?

David Hughes has said: Even if Mat thew thought the star was miraculous, and there is no indication that he did, there is nothing stopping us today, with our pres ent knowledge, from realizing that it was a perfectly normal astronomical happening. (Mosley 1991, p. 24)

There is nothing stopping us if we don t care about contradicting the gospel writer. If we are liberal or atheistic in our theology, it is fine to say that Matthew was wrong in his opinion that the Star was mi raculous (if indeed that was his opinion). But should we, in state supported plan etarium shows, be attacking the views of a particular branch of Christian believers? In a book on the Star, one can say largely whatever one wants, but not in a public planetarium.

Many scholars disagree with the assertion by Hughes that there is no indication... . Even in Aristotle s time (c. 350 B.C.) the normal motions of the stars and planets were well known, at least to educated people. Matthew probably rec ognized motions such as those suggested in Matthew 2:9 as unusual for stars and planets; many modern non scientists would find moving southward and then standing over a place as highly unusual behavior for a star or planet even in our unenlightened culture (cf. UFO reports). Also, some astronomers seem to think that Matthew was sophisticated enough to use technical astronomical terminology in Matthew 2:2: [in the East] – [at its heliacal rising] and the like (cf. Hughes 1979).

Many astronomers, when they examine the Star account, artificially try to force a naturalistic worldview on a text that is saturated with supernaturalism. The gen eral context of the gospels as well as Acts is blatantly supernatural. Matthew reports many blatantly supernatural events in his gospel in the same non sensational way that he presents the story of the Star. The fact that he does not emphasize their su pernatural nature is typical of the writers of the gospels in contrast to the apocryphal and pseudepigraphic writings.

I am not saying by the above remarks that the interpretation of the Star has to be a supernatural one; rather, I merely am pointing out that there are indeed indica tions that Matthew may have intended such an identity. Clearly, fulfilled prophecy and angelic visitations in dreams are part

of the very same chapter and story as the Star, implying an intent to surround the birth with unusual phenomena. Super natural phenomena likewise were said to attend the births of many ancient religious and otherwise significant people, so that the broader cultural context might also suggest the use of supernatural phenom ena.

Miracles can explain anything

If one always can make a planetary conjunction or similar planetary motion fit any date whatsoever (Mosley 1991, p. 26), then a planetary conjunction is not a scientific answer to the identity of the Star. It is unfalsifiable as an explanation. Inter estingly, many scientists and philosophers of science have excluded supernatural ex planations from science on much the same basis: they allege that because a miracle explanation can fit anything, miracles can explain everything and therefore explain nothing, as Mosley himself claims (Mosley 1988, p. 6).

A miracle, according to Mosley (1988), can explain perfectly anything you want but it doesn t explain anything at all... . The Star might have been a miracle, and if it was (sic), there s not much more we can say about it.

To the contrary, there is much that could be said by scientists. To reiter ate, one must distinguish the issue of ultimate causation from the description and subsequent scientific analysis of the resulting physical phenomenon, just as Sir Isaac Newton did when he elaborated the scientific theory of gravitation yet refused to discuss the ultimate nature of gravitational phenomena (hypothesis non fingo; Koyre 1968). One does not have to know the ultimate nature of any force to describe its characteristics in mathemati cal detail and even to base nearly all of engineering practice on that description: force is the metaphysical cause of the ac celeration of masses as Burtt says in his classic The Metaphysical Foundations of Modern Science (Burtt 1951). Practitioners of quantum mechanics justify the inclu sion of virtual particles in the theory by pointing to observable consequences of their existence despite the fact that v.p.s are themselves inherently unobservable and physically undetectable (they are hid den in the uncertainty in energy given by Heisenberg s Uncertainty Principle).

If the Judeo Christian God exists, He indeed could do virtually anything He wanted including violate both epistemic (as we know them) and ontological (char acterizing ultimate reality) laws of nature. The principle of uniformity might be use less. (I say may because the Deity may choose to behave in a patterned way as opposed to a whimsical way. Many theolo gians over the centuries have argued that the laws of nature are expressions of the activity of a rational God in the world.)

I suppose a woman could give birth to a cow if God wished it so and if He did, arguments that the occurrence violates the laws of genetics would be irrelevant. Notice, though, that if a woman did indeed give birth to a cow, surely the event could be described in detail, its occurrence could be videotaped and scientifically confirmed, and so on. Contrary to Mosley, there would be a lot we as scientists could say about the event if the event actually happened. The presupposition that such events could not happen is an expression of either as sumptions about the capabilities of an immensely superior alien intelligence or an expression of metaphysical naturalism and is not only not a necessary assump tion of science but is more in the proper realm of philosophical and theological argumentation than in the proper pervue of science itself.

Miracles fulfill psychological needs.

Some researchers need the star to have a non astronomical origin. (Mosley 1991, p. 26)

Likewise, some researchers need the Star to have a naturalistic explanation ei ther because their worldview will not allow other possibilities or because of a failure of nerve: Some Christians, for example, will opt for various naturalistic explanations of biblical miracles (a tsunami from the eruption of Thera caused the division of the Red Sea!) because naturalistic science has great prestige and because they have difficulty believing in truly supernatural phenomena, becoming thereby functional deists. They fear the condemnation of the Zeitgeist of contemporary science.

That psychological factors influence beliefs is largely irrelevant, because all hu mans have such psychological influences, as the works of innumerable philosophers of science in recent times amply has dem onstrated (Polanyi, Kuhn, Feyerabend, Lakatos, and others). It is not a malady solely of religious people.

Conclusion

It should be clear that I am neither claiming to have shown that the Christmas Star was a miracle, nor that all miracles are proper subjects of scientific investigation. Krupp is correct that, if miracles are mere untestable claims arising out of irrational religious faith, they have no place among scientific hypotheses and therefore do not belong in the planetarium. Many miracles, however, including the Shekinah Glory as the Star are physical phenomena and as such are in principle testable scientifically. Scientifically testable astronomical hypotheses are proper subjects of planetarium science education.

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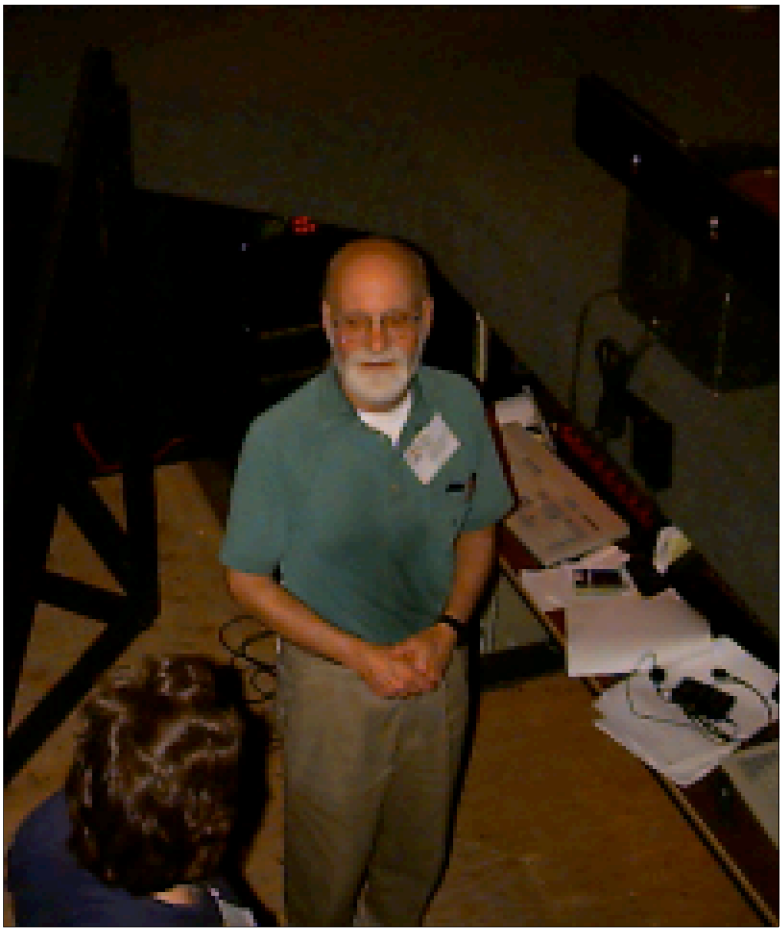
In Memoriam:
Gary Jay Close, 1940 – 1999



Drew Foster

Photograph by
Duncan Teague

Our colleague and SEPA 98 Conference host Gary Jay Close, 59, of Roanoke, Virginia passed away February 1, 1999. Son of Mrs. Helen K. Close of Fairmont, West Virginia and Henry B. Close, deceased, he is also survived by brother H. Scott Close and sister in law Elizabeth Close of Bardstown Kentucky, nieces Jennifer Tillman of Charleston, South Carolina, and Kristina Close of Lexington, Kentucky.

Gary was employed as Director of the Hopkins Planetarium at the Science Museum of Western Virginia, where he worked in various capacities for 18 years.

An active member of the Roanoke Appalachian Trail Club, Gary served as a member of the Board of Directors, Secretary, Hikemaster, and Trail Maintainer of seven miles along the Appalachian Trail between Sinking Creek and Rocky Gap in Craig County.

An active member of the Roanoke Valley Astronomical Society for 20 years, Gary served as their newsletter editor in the late 80s.

Gary was also a member of the International Planetarium Society, the Great Lakes Planetarium Association, and the Southeastern Planetarium Association.

A memorial service was conducted Saturday, February 6, 1999 at 3 P.M. in the Hopkins Planetarium, Science Museum of Western Virginia. Friends were invited to celebrate his life. Gary and his family asked that in lieu of flowers that contributions be made to either the Roanoke Appalachian Trail Club, the Roanoke Valley Astronomy Society (Lynn Slonaker, Treasurer), 3548 Kenwick Trail, Roanoke, Virginia 24011, or the Science Museum of Western Virginia s Hopkins Planetarium, One Market Square, Roanoke, Virginia 24011. Arrangements were by Oakey s Funeral Home, Church Avenue in Roanoke.

Gary was a great guy and I will miss him. We worked together for 8 years, survived numerous changes of directors, policies, and hundreds of volunteers and co workers. We also shared a lot of great benchmarks in the history of the science museum and planetarium.

Never a dull moment. May Gary live on in the work and play that we all know was Gary the astronomer and Gary the trailmaster.

Bays Mountain Astronomy Club Binocular Mount

Introduction by Adam Thanz, Bays Mountain Planetarium

Article by Terry Alford,

At SEPA 96, I led a workshop on making a wooden binocular mount one can attach to a camera tripod. The following is a de scription of how to make one yourself. It s easy and will take just an afternoon.

With this sturdy mount, one can enjoy steady views of the night sky and share it with others of different height without losing the object in sight. I have 8 x 40 binoculars, and I can see to -9.5 magni tude.

Possible improvements include length ening the horizontal arms up to 6 and the vertical pieces so the separation between the bolts is 4 5 . These changes allow for greater range of heights and for children and adults to look at the same object.

Make the counterweight from pieces of PVC tubing and caps with a bolt running down the middle and filled with lead from brake pads. Get these little lead pieces free

If you own binoculars and don t have a sturdy mount to use when stargazing, you re missing out on a major improve ment in observing comfort. Commercial mounts will do the job. Some work better than others. All are rather pricey. The parallel arm bino mount described here is easy to construct, low cost, and works well with binoculars weighing less than 2 lbs.

Gather the following materials:

4 of good 1 x 2 wood (the actual size is 4 x $\frac{3}{4}$ x $1\frac{1}{2}$)
14 of good 1 x 4 wood (the actual size is 14 x $\frac{3}{4}$ x $3\frac{1}{2}$)
(5) 1/ 4 wing nuts
(6) 1/ 4 nylon washers
(5) $\frac{1}{4}$ flat steel washers
(1) $\frac{1}{4}$ thumbscrew, 1 long
(5) $\frac{1}{4}$ carriage bolts, 2, 2 long; 3, 3 long
(2) $2\frac{1}{2}$ long 10 32 round head bolts with 4 matching flat washers and 2 acorn nuts
(1) 2 right angle bracket
(1) $\frac{1}{4}$ x 20 T nut
(1) $\frac{1}{4}$ brass threaded insert
(6) #6 wood screws $1\frac{1}{2}$ long
wood glue
stain or polyurethane
material to make a 1 2 lb counter weight

Now to construct the bino mount.

Cut out the wood to the sizes indicated by the sketch. Round off the corners. The dotted lines indicate optional areas to round off. The placement of the holes marked $7\frac{1}{2}$ on the upper and lower arm and the holes marked $2\frac{1}{2}$ apart on the center posts and vertical arms is critical. Drill one of the $\frac{1}{4}$ holes through the ends of two pieces at once. Then push a $\frac{1}{4}$ bolt through the holes to keep the wood aligned for the next holes.

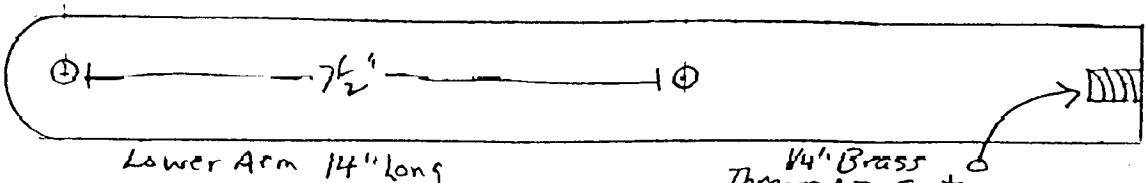
Test assemble the arms with the center posts and base screwed on. The unit should move freely, with the upper and lower arm staying parallel. Stack the side clamps and altitude limiter together to drill the $\frac{3}{16}$ holes. Make a counterweight from a stack of washers and a small hunk of metal. If you screw in a threaded brass insert into the end of the lower arm, you ll have an easy attachment method for a counter weight with a $\frac{1}{4}$ bolt passing through it. The counterweight doesn t have to be the exact weight of your binoculars. There is some friction built into the mount.

Sand the wood smooth. Stain or finish as you like. Start the assembly by attach ing the upper and lower arms to the center posts, making sure you put a nylon washer on both sides of the arms. Screw and glue the base to the center posts. Assemble the rest as indicated in the sketch.

Attach your binoculars with a $\frac{1}{4}$ thumb screw. If they aren t held securely, make a compression fitting out of a small piece of rubber and another $\frac{1}{4}$ steel washer. Insert this between the thumb screw and right angle bracket.

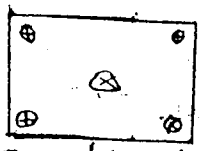
Attach the counterweight last. The mount head should move smoothly in altitude and hold its position when you loosen and tighten the wing nut on the side clamp. Control azimuth movements with the head of your photo tripod. The other wing nuts can be adjusted as appropriate on nights of lesser or greater humidity. Lockwashers can be added for even greater friction.

Congratulations, you have just con structed a parallel arm binocular mount

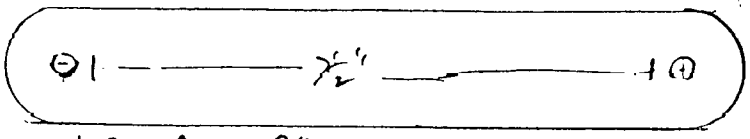


Lower Arm 14" Long

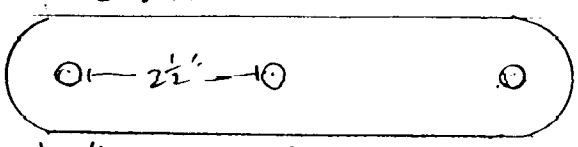
¼" Brass Threaded Insert



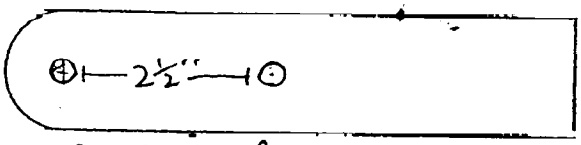
Base 1½" x 2¼"

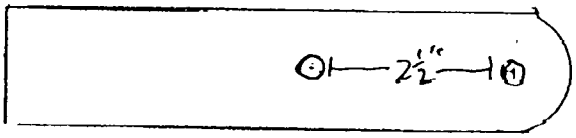


Upper Arm 9" Long

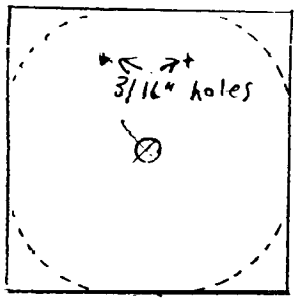


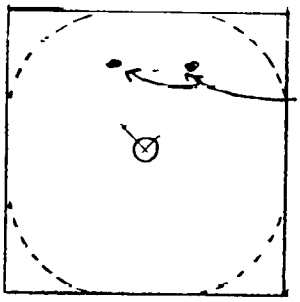
Vertical Arm 7" Long



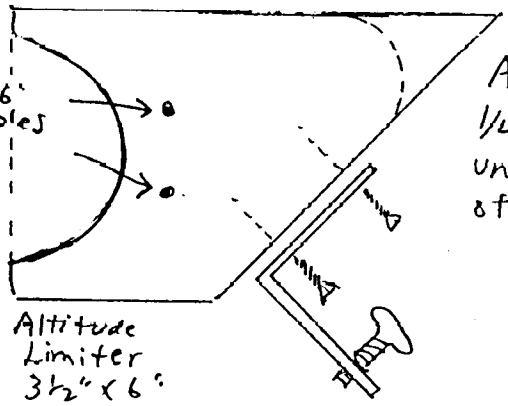


(2) Center Posts, Identical parts, each 7" Long



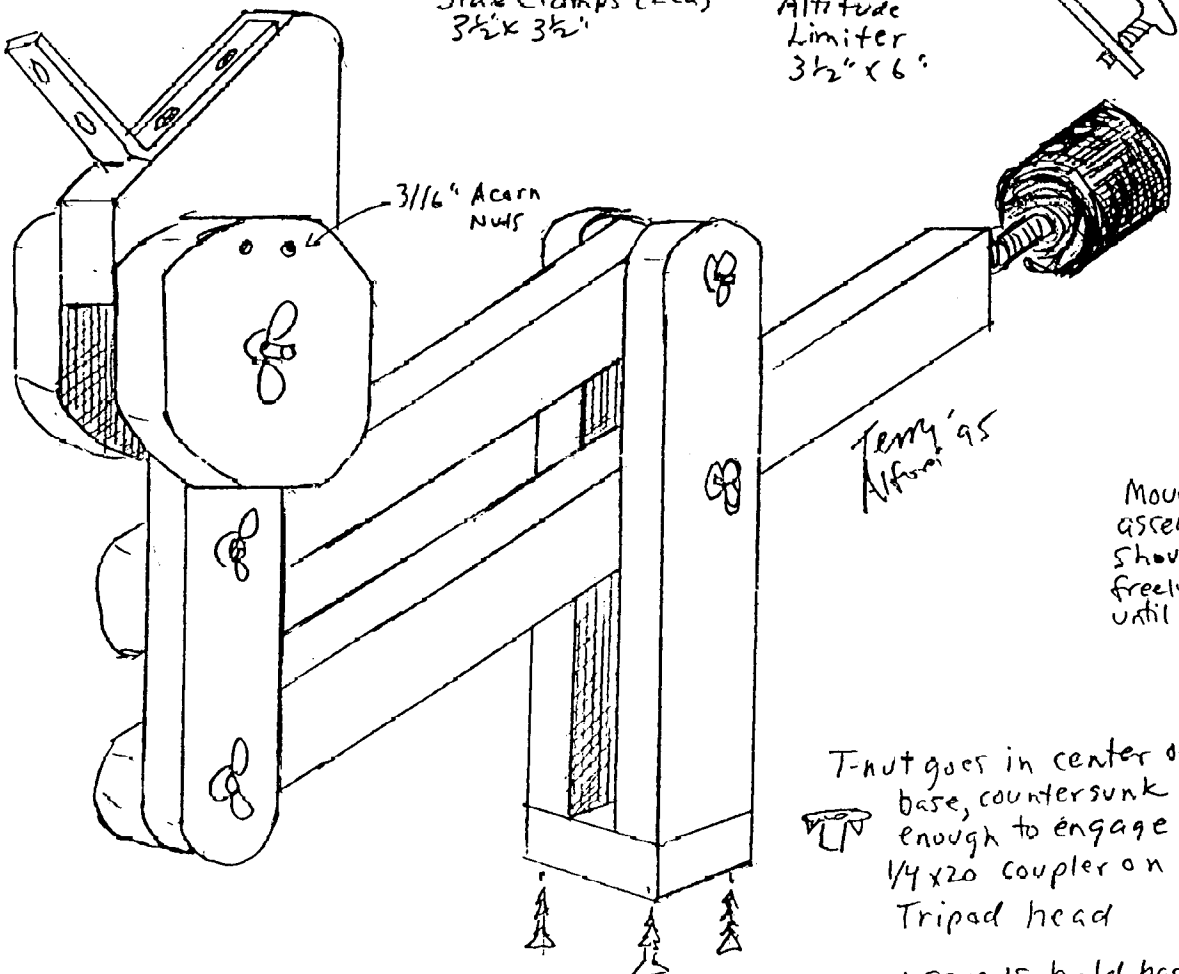


Side Clamps (2 ea) 3½" x 3½"

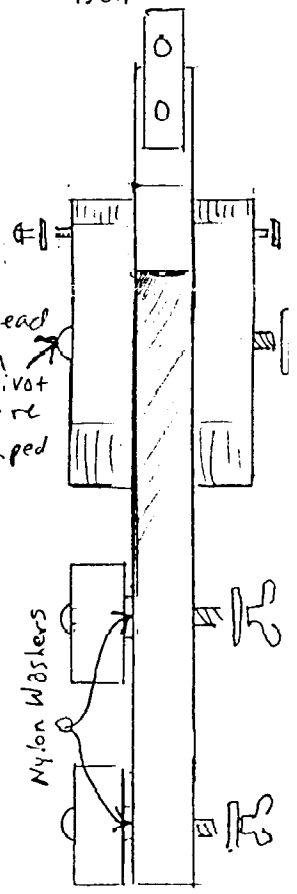


Altitude Limiter 3½" x 6"

All holes are ¼" diameter unless indicated otherwise



View from Behind Mount



T-nut goes in center of base, countersunk enough to engage ¼ x 20 coupler on Tripod head

4 Countersunk wood screws hold base securely to center Posts.

The Formation of the Solar System

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Introduction

This article grew out of some discussions that I had after my chemistry workshop at the Roanoke conference. Several sections of this article were originally envisioned as separate pieces, but each relates to the formation of the solar system so I decided to put all of them together. Some of the information contained in this article comes from the booklet that accompanied my workshop and some comes from previous articles.

Thanks to all who attended the work shop in Roanoke. Many of you shared excellent ideas with me. Special thanks to Barbara Reynolds who urged me to write this when I casually mentioned that I was thinking about it. Thanks to the most sup portive boss in the world, Mark Trotter, who has never once complained when I cover the desk with books and occupy the office computer for weeks on end. Finally, thanks to my fiancée, Carol Wilson, who wields a vicious but useful red pen. Any clarity that my writing might have is due to her suggestions, but any errors remain entirely mine.

How our solar system came to be is the major question in planetary sciences, and it involves many different lines of research in many different fields. Important details are still unknown, and there are many unresolved questions, but we have a pretty good idea of the overall process of the formation of the planets.

In the last few decades, our understand ing of the solar system has grown tremen dously. All of the planets except Pluto have been investigated by spacecraft, as have asteroids and comets. We have now entered the second phase of solar system research. The first phase was preliminary reconnaissance, a survey of our sister worlds. The second phase examines the planets in detail. Since NASA has recently implemented the series of Discovery class missions, planetary scientists now have a capability that sky scientists have had for years the ability to launch a lot of low cost missions.

There are a number of planetary mis sions underway or in planning stages at the present time. Cassini is in flight to Saturn, and Galileo has been at Jupiter for over two years already. Near Earth Asteroid Rendezvous is in flight to the asteroid Eros, and Lunar Prospector and Mars Global Surveyor are in orbit around the Moon and Mars, respectively. There are more missions on the way: two new Mars missions launched in December 98 and January 99 (Mars Climate Orbiter and Mars Polar Lander), Stardust (a cometary sample return mission), and Deep Space 1, which could make as many as three asteroid flybys and a comet encounter. The second of the New Millennium series of spacecraft, Deep Space 2 (also known as the Mars Microprobe), was scheduled for launch in January 99. Two Discovery class missions were approved in October 1997. The Comet Nucleus Tour (CON TOUR) will make flybys of three comets. Genesis will be deployed in a halo orbit around the L1 Lagrange point between the Sun and the Earth, where it will col lect solar wind particles for two years and return them to Earth. NASA is committed to sending more spacecraft to Mars in the near future, so more missions are already in the works. Within the next couple of decades, our understanding of the solar system will increase a thousandfold over our present state of knowledge.

In addition to spacecraft reconnais sance, meteoriticists have done much to increase our understanding of the history of the solar system. Since meteorites come from the asteroid belt, analyses of them has given us a detailed understanding of the history of an important and even crucial region of the solar system. This region is important for understanding the overall composition of the solar system, because, as we shall see later, it is in this region that the composition of the bodies changes from terrestrial and rocky to gas eous and icy. Understanding more about asteroids and meteorites can tell us a great deal about the compositional differences between the inner and outer planets. Some meteorites are extremely primitive (such as the carbonaceous chondrites) and are valuable because they represent some of the first material to form in the solar

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nebula. Many other meteorites show us progressive stages of planetary evolution.

Finally, observational astronomy has uncovered a wealth of evidence of star formation in nebulae. Application of the Principle of Mediocrity assures us that at least some of those newly born stars will eventually have planetary systems.[1] Detailed observations from Hubble have shown newly born stars with protoplan etary disks, and about half of the newly formed stars in the Orion Nebula have disks of material around them. Continued observations with Hubble, the twin Keck telescopes, and other large ground based and space based telescopes will allow astronomers and planetary scientists to examine such disks closely for confirma tion of the theoretical models of planet formation. A large space based telescope might be able to make spectra of small regions in protoplanetary disks to look for evidence of forming planets.

Regularities in the Solar System

The solar system exhibits a certain regularity. The regularity of its motions has been known for some time, but it has been only recently (since the advent of ro botic exploration of the solar system) that we have been able to explore some of the regularities in the chemistry of the solar system and in the physical properties of the planets.

The spacing of the planets is more or less regular (Table 1). In the 18th century, Johann Titius noticed a regular pattern in the distances of the planets from the Sun. Johann Bode noted this pattern a few years later, and it has borne his name since then: Bode s Law. Bode s Law states that the distances of the planets (in AU) are given by a mathematical series. The simplest expression of the series is to take the numbers 0, 3, 6, 12, 24, 48, 96, 192, and 384, add four to each number, and divide by ten. The first four terms of this series are: 0.4, 0.7, 1.0, and 1.6. These correlate reasonably well with the positions of the inner planets. Bode s Law is not exact, however, and it becomes far less accurate for the outer planets. Most scientists think that Bode s Law is just a coincidence. Even if it is mere coincidence, it represents an attempt to understand the relationships between the planets in the solar system.[2]

There are more regularities in the solar system other than just the spacing of the planets. The planets orbit the Sun in the same direction that the Sun rotates. All of the planets except Mercury and Pluto orbit the Sun in roughly the same plane. The orbits of most of the planets are almost circular. Most of the planets (except for Venus, Uranus, and Pluto) rotate coun terclockwise when viewed from above the Sun s North Pole; this is the same direction as the orbital motion of the planets. Most moons orbit in the same direction as their primary rotates, and most orbit very close to the equatorial plane of the primary. Further, some moons seem to be regularly spaced as well.

The planets also exhibit regulari ties in composition. The solar system is neatly divided into two zones: the inner planets, which are terrestrial, and the outer planets, which are gas giants. The inner planets show a general decrease in density with increasing distance from the Sun (uncompressed density; Table 2). The outer planets show the opposite trend the density generally increases with increasing distance from the Sun Saturn is a no table exception (Table 3). The inner planets are composed mostly of rock and the outer planets are composed mostly of gas.

Any model of the formation of the solar system must take all of these regularities into account, and explain most of them if not all of them at the same time.

There is no single model that is uni versally agreed upon to be the best. D if ferent models explain different aspects of the solar system better than others. The dynamical regularities of the solar system can be best understood if we assume that the planets formed from a disk of gas and dust that orbited about the protoSun. The compositional regularities can be best ex plained by assuming that the temperature in this disk of material dropped rapidly with increasing distance from the Sun. The raw material for the disk from which the solar system formed came from the interstellar medium.

Interstellar Medium and Jeans Collapse

Interstellar medium is the term that astronomers use to describe the material found in interstellar space; that is to say, the interstellar medium is the material not incorporated into stars or planets. It is composed of gas and dust. We can see the interstellar medium directly by looking at a bright nebula like the Orion or Lagoon Nebula.

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The material that makes up the interstellar medium comes from several sources. Some of it is residual material left over from the beginning of the Universe, material that has not been incorporated into stars. Some of it is material that has been violently thrown out by supernova explosions, and some that has been sent out more gently from the formation of planetary nebulae. Some of the material comes from stars that throw material into space. Giant and supergiant stars (particularly those of spectral class M) lose mass at an enormous rate compared to other stars (some 10^{-4} solar masses per year, i.e., every 10,000 years, one of these stars loses the equivalent of the Sun's mass to space). Each of these sources adds new material to the interstellar medium.

Sir Isaac Newton was the first to note that a large cloud of gas and dust could collapse under the weight of its own gravity. The British astronomer James Jeans developed an equation that describes the conditions necessary for collapse to occur. The minimum size of the cloud is given by the equation:

$$L = \sqrt{(\pi v^2/Gd)} \qquad (1)$$

L is the minimum radius (in meters) for a spherical cloud of density d (in kg/m^3). G is the gravitational constant ($G = 6.67206 \times 10^{-11}\ m^3/kg\ s^2$) and v is the velocity of sound in the gas, which is given by the following equation:

$$v = \sqrt{(3kT/m)} \qquad (2)$$

T is the temperature of the gas in Kelvins, k is the Boltzmann constant ($k = 1.38066 \times 10^{-23}\ J/K$) and m is the mass of the molecule (use the mass of the hydrogen molecule, $m = 1.67381 \times 10^{-27}$ kg).

We can combine these two equations into one:

$$L = \sqrt{((3\pi kT/m)/Gd)} \qquad (3)$$

To convert L from meters to light years, divide by 9.454×10^{15} meters/light year. This equation allows us to predict the minimum size necessary for gravitational collapse to occur, assuming a spherical cloud of uniform density. If you are interested in knowing the total mass of the cloud, multiply the density of the cloud by the volume of space that it occupies (in meters, not light years), or

$$M = (4/3)\ \pi d L^3 \qquad (4)$$

For purposes of comparison, one solar mass is 1.9891×10^{30} kg. A cloud of material with a density $d = 10^{-20}\ kg/m^3$ at a temperature of 15 Kelvins gives a value of $L = 1.706 \times 10^{18}$ meters, or L = 180.45 light years. The total mass of the cloud is some 2.08×10^{35} kg, or just over 100,000 solar masses. (Verify all of these calculations.)

As clouds of material begin to collapse under the influence of gravity, the density increases in the area that is collapsing. As the density increases, the minimum length L (called the Jeans length) decreases. This explains why nebulae condense into clusters of stars rather than forming one star of colossal proportions.

Star Formation

The collapse of a cloud is initially very fast, but as the central portion of the cloud becomes denser and hotter, pressure directed outward slows the contraction. The collapsing cloud is at first a few light years in diameter. As the collapse proceeds, the center of the cloud becomes more dense, hence more massive, so the contraction occurs faster there. The rest of the material in the cloud contracts more slowly. In the center, the density gets so high that the cloud becomes opaque. The core continues to accrete matter until the temperature is high enough to exert an outward pressure that stops the collapse. A protostar has formed.

The outer parts of the cloud continue to contract, eventually forming a disk of material. Matter falls onto the protostar from this disk, causing it to slowly grow in size and mass. The planets form out of this disk of material. The protostar is visible in the infrared beneath its cloak of gas and dusk.

As the protostar gains more and more mass, a strong stellar wind develops. The protostar has reached the T Tauri stage. This wind carries away a lot of matter along the axis of the disk in a bipolar outflow. This stage lasts only a brief time, perhaps as little as 10,000 years. This wind blows away much of the cloud cloaking the protostar, and it becomes visible. Observations of T Tauri stars hint that such stars have disks of material around them, with diameters on the order of 100 AU. Observations in the infrared imply that up to 50% of all newly formed stars have protoplanetary disks surrounding them.

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Eventually the core of the protostar reaches the critical temperature of about 20 million K, and fusion reactions begin. The protostar has become a star. The entire process takes about 100 million years to complete.

Hubble has taken incredible images of star forming regions in Orion, including some that show protoplanetary disks of material around protostars. The Infrared Astronomy Satellite (IRAS) documented many infrared sources which are stars in the process of formation. Astronomers estimate that about 10 new stars per year form within the Milky Way galaxy.

The Canonical Value Table

The interstellar medium is overwhelmingly composed of hydrogen. Helium is also present, as are trace amounts of other elements. In addition, many molecules have been detected in the interstellar medium.

The original composition of the solar nebula can be found in the Sun. Although the Sun is producing new elements via fusion reactions, essentially all of those new elements are still in the core. (Half of the Sun s mass is found in the core. The convective zone within the Sun only reaches down about 20% of the radius of the Sun, so convection is not dragging up new material from the core.) Examining the relative abundances of elements in the Sun tells us the original composition from which the solar system formed it represents ground truth for the solar system. The relative abundances collectively form what are known as the Canonical Values for the solar system. Table 4 is the Canonical Value Table.

The Canonical Value Table is useful. It provides a standard against which to measure chemical and physical changes in the various bodies in the solar system. For example, planetary scientists can tell that carbonaceous chondrite meteorites are primitive because they have elemental abundances that closely match those of the Sun minus the hydrogen and helium. If we could take a gaseous mixture of solar composition, drive off the light gases and let it condense to solid rock, it would be essentially identical in composition to a carbonaceous chondrite. If we take any rock and compare its relative abundances with those of the Canonical Value Table, any deviation from the canonical values means that some process was at work when the rock formed that altered its original composition.

The gas giant planets have a composition that closely matches that of the Sun. Most meteorites and all of the terrestrial planets do not, however, and this is indicative of chemical fractionation during the formation of those bodies or chemical changes after they formed.

Condensation of the Elements in the Solar Nebula

As the Sun formed, the temperature in the inner regions of the solar nebula reached about 2000 K and dropped rapidly further from the center. Chemists have done a lot of laboratory work to investigate the sequence of condensation of the elements in the solar nebula. Their results appear as Table 5. These temperatures represent the temperatures at which these elements would condense into to solid form in an uncombined state. Many elements would condense out of the nebula in a combined form, so the temperatures would be different depending on what compound condenses. Also, many elements will condense out as trace elements contained within minerals (Table 6 lists some of trace elements that will appear in some minerals).

In the inner part of the solar nebula, the temperature was 2000 K. At this temperature and at the pressures believed to have existed when the solar system formed, all of the elements are in the gaseous state. The first elements condense from the nebula at about 1800 K. These are called refractory elements. At somewhat lower temperatures, around 1700 K, the first major minerals condense out of the mixture: corundum (Al_2O_3) and perovskite ($CaTiO_3$). Note that both of these minerals contain oxygen they are oxide minerals. Many metals condense out of the mix at this temperature, because they are trapped in the interstices of the perovskite crystal lattice. (Table 6)

Many trace elements, such as rare earth elements, condense out of the nebula between 1800 K and 1300 K. At 1300 K, metallic nickel and iron condense, as well as the first major silicate mineral, enstatite ($MgSiO_3$).

As materials condense from the nebula, chemical reactions take place between the newly condensed material and the gases in the nebula. The calcium rich plagioclase mineral anorthite ($CaAl_2Si_2O_8$) forms at around 1200 K. Just under 1000 K, the

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feldspars albite ($NaAlSi_3O_8$) and orthoclase ($KAlSi_3O_8$) form. At 700 K, hydrogen sulfide gas reacts with metallic iron and produces troilite (FeS).

The first major hydrous mineral, tremolite $Ca_2Mg_5Si_8O_{22}(OH)_2$, forms at around 500 K. Another hydrous mineral, serpentine $Mg_3[SiO_5](OH)_4$, condenses at 400 K. At 200 K, water ice condenses out of the nebula; at 125 K, ammonia gas reacts with the water to form ammonia monohydrate. At 50 K, methane forms and can be incorporated into the voids in a water ice crystal to form a clathrate. At lower temperatures (less than 50 K), other clathrates may form, such as clathrates with argon (Ar) or molecular nitrogen (N_2), and methane will freeze into ice. Table 7 lists the major minerals from which each of the planets formed and the condensation temperature for each planet.

From the condensation sequence, we can predict where specific minerals will form in the nebula. It is possible to use the condensation sequence to try to unravel some of the complicated history of the solar system (see The Problem of Pluto later).

Making Planets

The philosopher Immanuel Kant was the first to note (in 1755) that the structure of the solar system implies that the planets formed from a rotating disk of material and they were built up from smaller bodies. Those smaller bodies are planetesimals.

In the inner solar system, the solid particles that condensed out of the nebula grew into larger aggregates of particles through collisions. They probably formed fluffy aggregates of particles, which migrated toward the central plane of the protoplanetary disk. In a planetary ring system, repeated collisions tend to cancel out differences in velocity and direction in individual particles and thus lead to the formation of a thin disk of material; a similar process probably operated in the protoplanetary disk. Some models suggest that the dust would settle into the plane of the disk in as few as 1000 solar rotations, if the particles are sticky (if not, then the settling time is about 1000 times longer). Continued aggregation could lead to bodies on the order of 1 cm in diameter or larger.

A thin sublayer of dust particles is believed to have formed after the solid particles settled into the plane of the disk, and the development of a gravitational instability within this sublayer is considered important for the formation of the planets. Such an instability leads to the formation of ringlike areas within the disk, which divide into multiple rotating condensations of dust. Contraction of these areas leads to the formation of planetesimals.

Planetesimals probably formed in nearly circular orbits, but gravitational interaction from repeated close encounters nudged them into orbits that crossed. This led to collisional accretion of planetesimals into larger and larger bodies.

There are two main scenarios for the formation of the planets from planetesimals. In the first scenario, the planetesimals form into many large bodies of comparable size. This process doesn't build up large, planet sized bodies until the last stages of planet formation, and features a rather slow accumulation. The second scenario features the rapid formation (runaway formation) of a few very large bodies. This continues until most of the material in the feeding zone has been swept up.

The runaway formation scenario seems to be currently favored because it leads to the fast formation of the cores of the gas giants. With the slower model there doesn't seem to be enough time available to form the cores of the giant planets so that they will accumulate enough gas to reach their present sizes. Recall that when the Sun was in the T Tauri stage, a strong solar wind blew away much of the solar nebula. The gas giant planet cores must have formed quickly to have been able to accumulate enough mass to capture a lot of gas from the nebula.

With the runaway scenario, the embryonic terrestrial planets are formed within about 10,000 years, and the cores of the gas giants are formed in about 1 million years. This formation time is consistent with the observed rates of nebular clearing of T Tauri stars.

The observed rotations and axial tilts of the planets may be ascribed to giant impacts early in the history of the solar system. For Earth to have its present axial tilt, an impactor that is about $^1/_{1000}$ the size of the Earth is needed, and the axial tilt of Uranus (97.9) could have resulted from the impact of an object with $^1/_{10}$ the mass of Uranus. The regular spacing of the planets is a natural outcome of the accumulation of the planets from smaller bodies.

We can see evidence for the very last stages of this process on almost all of the

surfaces in the solar system: impact craters. Estimates of the cratering rates for the Moon, Mercury, and Mars imply that an era of heavy bombardment occurred early in the history of the solar system. This heavy bombardment era ended some 3.8 billion years ago, and the rate of impact has been steadily decreasing ever since. The era of heavy bombardment cleared out most of the remaining material left from the formation of the planets. Some of this material still exists, as comets and asteroids. The process of impact is merely the continuation of a process that began at the very beginning of the solar system, when the planets first started to form.

Subsequent Evolution

The larger solid bodies in the solar system (large asteroids and terrestrial planets) have evolved internally through radiogenic heat production in their interiors. Even though the amount of radioactive material present in the rock from which the planets formed was low, heat from radioactive decay steadily accumulated until the interiors of large bodies melted and differentiated into core, mantle, and crust. One outcome of this for large terrestrial bodies has been the outgassing of atmospheres from planetary interiors.

It is important to understand that the accretion of most of the planets was a cold accretion. There was some heat available from the gravitational contraction of material and from the collisions, but not enough to melt the material until after the planets had formed. There is evidence, however, that the Jovian system was hot at formation.

Jupiter and Its Moons

Jupiter and the Galilean moons form a miniature version of the solar system. The Galilean moons are regularly spaced, and there is a decrease in density with increasing distance from Jupiter (Io: 3.55, Europa: 2.94, Ganymede: 1.94, and Callisto: 1.85). This density decrease implies that Jupiter was hot during formation. The source of the heat was probably the release of gravitational energy from the collapse of material which formed the planet. As material falls together under the influence of gravity, its kinetic energy is converted to heat when the material reaches the forming body. In the case of small bodies this heat is quickly lost to space, but in the case of a gigantic planet like Jupiter, gravitational heating becomes important. Jupiter is still radiating away the heat from its formation; Jupiter s temperature is 125 K at the cloudtops, so Jupiter is radiating almost 1.7 times the amount of energy that it receives from the Sun. A hot formation of Jupiter would lead to a density decrease with increasing distance for its moons and give a regular spacing to the orbits of the major satellites.

The Problem of Pluto

Pluto is the most irregular of the planets. Its orbit is highly inclined and is the least circular orbit of the major bodies in the solar system. The orbit is so eccentric that it crosses Neptune s orbit, a fact which has caused some to speculate that Pluto and its moon Charon were once satellites of Neptune that somehow escaped its gravitational bonds. There is a way to help determine whether Pluto is an escaped satellite or just a highly irregular planet.

Based on the condensation sequence, Pluto could have either methane ice or carbon dioxide ice as its major constituent the temperatures are consistent with either. If Pluto formed close to Neptune, the pressure would have been higher than if Pluto formed away from it.

The chemical equilibrium of the solar nebula was very sensitive to pressure. If the pressure was low, the equilibrium reactions would have favored the formation of carbon dioxide ice. If it was high, the reactions would have favored the formation of methane ice. So, if Pluto is predominantly made of carbon dioxide ice, then it must have formed away from Neptune and if Pluto is mostly methane ice, then it must have formed close to Neptune and is thus an escaped satellite. Determining the origin of Pluto may be as simple as determining its bulk composition.

Methane has been detected on Pluto spectroscopically, but carbon dioxide is more difficult to detect than methane. The inferred mass and density of Pluto are consistent with either one. Some argue that the spectroscopic observation of methane is evidence of Pluto s formation close to Neptune, but an equally plausible argument can be made that Pluto is made mostly of carbon dioxide ice but we cannot detect it yet.

The advocates of Pluto is a planet can also argue that there are a lot of dynamical difficulties involved in freeing Pluto and Charon from Neptune. The amount

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of energy necessary is enormous. The advocates of Pluto is a moon can argue back, however, that Neptune s moon Triton is now in a retrograde orbit and that the amount of energy needed to turn the orbit from prograde to retrograde is about the same as the amount of energy needed to free Pluto and Charon from Neptune. A single massive event in the past could have turned Triton s orbit around and at the same time set Pluto on its present orbit.

This is why a Pluto flyby mission is needed. We need better constraints on the mass and density of both Pluto and Charon. More accurate knowledge of both should enable planetary scientists to esti mate the bulk composition and figure out where Pluto and Charon formed.

Miscellaneous Notes on the Formation of the Solar System

The Allende carbonaceous chondrite is widely believed to represent some of the first solid material to form in the solar system. Embedded in the matrix of Al lende are white inclusions which contain interstellar dust grains. At the 26th annual Lunar and Planetary Science Conference (in 1995), a research team reported the startling results of a series of isotopic analyses which they had done on the white inclusions. The measured isotope ratios of silicon carbide (SiC) in the inclusions indicated that at least four supernovae contributed material to the nebula from which the Sun and planets formed.

Certain isotopes are extremely rare. The ones found in the white Allende inclusions are believed to form under very specific conditions in the supernova explosion of a star with a specific and limited range of mass. The analyses done on the inclusions showed several unusual isotopes which must have formed in such supernova events. What is more staggering than the news that at least four supernovae con tributed material is that the analyses can be combined with the current models of supernova nucleosynthesis to predict the masses of the progenitor stars. In other words, the white inclusions in Allende contain clues to the masses of stars which exploded before the Sun even formed.

The Near Earth Asteroid Rendezvous (NEAR) mission is the first mission that is exclusively dedicated to an asteroid, and will be the first spacecraft to go into orbit about one. The NEAR mission will help decide an important question: Do the most common types of meteorites (the ordinary chondrites) correspond to the most com mon types of asteroids (the S class)? The target of the NEAR mission is an S class asteroid, Eros.

It is possible to estimate the surface composition of an asteroid by measuring the reflectance spectrum of the sunlight reflected off of it. In some cases, the re flectance spectrum of certain classes of asteroids closely matches the reflectance spectrum of a category of meteorites. For example, many meteoriticists believe that the HED class of meteorites (Howardites, Eucrites, and Diogenites) come from the asteroid Vesta because the reflectance spectra are identical. The spectra of C class asteroids seem to match the spectra of carbonaceous chondrites as well.

Reflectance spectra of S class aster oids do not match the spectra of ordinary chondrites, and this presents us with a problem. If the S class asteroids are not the parent bodies of ordinary chondrites, then where are they? Most asteroid classes seem to match to one or more categories of meteorite. If S class asteroids don t match the ordinary chondrites, then we have to explain which meteorites represent S class material and we have to explain where the ordinary chondrite parent bodies are. Some investigators believe that S class asteroids are in fact the parent bodies of ordinary chondrites, but some mechanism is causing reflectance spectra to indicate otherwise. Perhaps there is some unknown process taking place which changes the surface of the asteroid or the meteorites, or both. It is also possible that there is no correspondence between S class as teroids and ordinary chondrites, and we must look elsewhere for chondrite parent bodies. NEAR was designed to find out whether Eros has an ordinary chondrite composition, and thus tell us whether S class asteroids are the ordinary chondrite parent bodies.

Continued observation of newly born stars from large ground based and space based telescopes will certainly help resolve some of the outstanding problems with the models of the formation of the solar sys tem. It s possible that the next generation of telescopes will be able to gather direct evidence of the various stages of planet formation, stages which we are just begin ning to understand.

There are aspects of planet formation which are unknown. There were physical processes operating in the solar nebula which we do not yet know. We need to improve our understanding of the formation of planetesimals. We need more detailed information about the composition of the entire solar system to refine our understanding of the condensation sequence. We need to gain a much better understanding of the heavy bombardment era early in the solar system s history. The cratering rate for the inner solar system was different from the cratering rate for the outer solar system. The cause of the difference is understandable there were different populations of impacting objects in different parts of the solar system. Having a much better idea of the cratering rates will tell us about the planetesimal and accretion stage of formation. Understanding the heavy bombardment era may explain the origin of the Moon (giant impact into the Earth), the strange axial tilt of Uranus, and the orbits of Pluto and Charon and the retrograde orbit of Triton about Neptune. As a corollary to this, we need to know how the rate of impact in the inner solar system has decreased over time to get a better idea of the threat that we currently face from impacts. (By the way, NASA has announced the establishment of a Near Earth Object program office at JPL headed by Donald Yeomans).

We need to understand more about the formation of comets. Where specifically did they form? Were they ejected from the outer solar system to the Oort Cloud, or did they form there? Detailed chemical analyses of comets should help to answer these questions because the chemistry of cometary ices can tell us where they formed, just as the bulk composition of Pluto can tell us where it formed.

These are just a few of the things which we need to know if we are going to arrive at a better understanding of the origin of the solar system. Some of these questions can be answered by observation of planetary systems that are forming now. Others of them can be answered with continued exploration of the solar system. Other problems demand better computer simulations and better mathematical models.

Included below are a couple of activities related to some of the topics in this article. If you have an activity that supports any of the material in this article, please send it to me, and send it to Duncan for publication in Southern Skies.

Activity: The Marble Game

Materials:

1 container for marbles (I use a lunch box.)
100 white marbles (represent hydrogen)
7 blue marbles (represent oxygen)
3 black marbles (represent carbon)
1 green marble (represent nitrogen)

Put the marbles into the box, and mix them well. The marbles represent the relative abundances of H, O, C, and N in the interstellar medium. (Actually, there would have to be 10,000 white marbles in the box rather than 100 to represent the abundance of hydrogen.)

Allow students to draw marbles two at a time from the box to represent what types of molecules would form in an interstellar cloud of this mixture. Note that practically all of the molecules that form are H_2 and only rarely do other types form (HO, HC, CN). It is extremely rare for a molecule to form without hydrogen in it.

Place all of the marbles back into the box, and have the students draw them out in groups of three, four, or more. Have the students estimate the difficulty of forming stable molecules (like CH_4, HCN, HCO, C_3N, NH_3, H_2O, etc.) in interstellar space based on their experience of drawing marbles from the box. Which molecules would they expect to find in interstellar space? Compare the ones formed in this game to the ones listed on Table 8.

Show the students pictures of different nebulae. Talk about the ions and molecules which are found in them, and point out the different colors which can be seen in the pictures. Have the students do research to find out which ions and molecules give which colors.

Activity: Planet Matching

Before doing this activity, you will need to prepare some materials. This activity is geared toward high school students, but it could be adapted toward lower classes. It would probably work well in a college course, too (but make the students justify each decision).

Materials: Make 11 planet cards by taking 11 sheets of heavy cardstock paper and writing the names of the Sun and planets on them. Make an additional one for the asteroids. If you want to, you can find

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pictures of the various bodies and paste them onto the cards. On each card, write the condensation temperature from Table 7 on it. You may laminate each card if you wish. Punch a couple of holes in the upper corners of each card, and string a length of yarn through and tie on both ends. Use enough yarn on each to make the card hang around the neck.

Make 10 composition cards in a similar fashion, using the following compositions: mostly metal, metal and rock (make two of these), more rock than metal, mixture of rock and ice, gas and ice (make up four of these)[3], mostly ice. The mostly metal card is Mercury; the metal and rock cards are Venus and Earth; more rock than metal is Mars; the mixture of rock and ice card is for the asteroids; the four gas cards are the gas giant planets; and the mostly ice card is Pluto. Note that there is no composition card for the Sun. For this activity, the Sun is used as a place holder so no composition card is needed.

Pre Game Instruction: Talk about nebulae and the gases found there. Discuss observations of young stars and protoplanetary disks. There are some incredible Hubble images of protoplanetary disks.) Discuss the temperature gradient within such a disk hot in the center, temperature rapidly falling off with increasing distance from the protostar.

You might want to ask them to visualize a lump of cold solid material that contains lots of different chemicals in it metals, ices, rock, etc. Ask them to imagine that the temperature is slowly increasing. As the temperature increases, what will happen? (Material will melt and then turn into a gas.) What will turn into a gas first? (Low boiling point substances, i.e., volatiles, like ice.) If the temperature gets high enough, what would happen? (Eventually everything would turn into a gas.) What would be the last thing to turn into a gas? (the metals) This is the reverse of the situation in the solar nebula. Instead of heating up, things are cooling down.

Tell them that they are going to play a game in which they will try to predict the composition of the planets.

The Game: Pick eleven volunteers to represent the Sun, planets, and asteroids. Have the students stand at the front of the planetarium in proper order of Sun to Pluto. Hang each planet card on the student representing each body. Remind the students of the temperature differences at various places in the solar system. Have them try to guess which planets have which compositions. When the group has decided the composition for a planet or the asteroids, hang the composition card on the student representing that body. Make sure that the students choose as a group. Let them discuss the problem, argue their positions, etc. If the group cannot come to a consensus decision, have it split into two groups and have each group present its arguments before the entire group.

Background: This game is designed to show students how powerful models can be. We can make predictions based on a model and then perform observations to determine whether the model made good predictions. If the students do not make the correct choices for the composition the planets, question them to try to understand why they made the choices that they did. You might want to carefully guide them, but do not give them the correct answer. They need to try to reason it out for themselves, or resort to observation to confirm their choices.

This game also is meant to give them some insight into how scientists work together to solve problems by combining their knowledge and their opinions together to arrive at a consensus decision. It is important to let them figure out the compositions for themselves. If they cannot arrive at the correct answer, suggest that they try to do some research to find out the compositions of the planets. Suggest using the World Wide Web, if possible, since they can get information there about missions to the planets (it would be better for them to get the information from a mission Website than from an encyclopedia, because some missions post the data on the site.)

If you wish, you may let the students see samples of minerals from which the planets formed. Local rock shops are a possible source of samples, as are scientific supply companies.

Notes:

1. The Principle of Mediocrity states that there is nothing particularly special about our planet, or our Sun, or our solar system, or our galaxy, or the region of the Universe in which we live. This principle

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makes generalization possible, because it implicitly states that the known laws of physics, chemistry, etc., are universal, i.e., our theories are applicable everywhere. The speed of light in a vacuum doesn t change from one region of the Universe to another. Nor do the fusion reactions that take place inside stars. The gravity that we experience here in our solar system is the same gravity that is experienced everywhere else in the Universe.

If scientific laws are truly universal, and there is nothing particularly special about our solar system, then it is likely that planet formation is a natural outcome of the formation of stars.

2. A few years ago, I recall seeing an article (I think it was in the Publications of the Astronomical Society of the Pacific.) that dealt with the positions of three newly discovered planets in orbit around a pul sar. The article presented an analysis of the combined motion of the system and the pulsar s spin rate to resolve mathemati cally the orbital motions of the three plan ets. The estimated orbital distances were given in the article. When the orbits were normalized, the relative positions of the three planets were 0.4, 0.7, and 1.0 the first three terms of Bode s Law. I know that most planetary scientists and astronomers believe that Bode s Law is a coincidence, but it makes me wonder if some physical reason exists for such a spacing.

In 1972, M. M. Nieto discovered that a semi logarithmic plot of the positions of the planets (with Earth–0) yields a curve that is almost a straight line (the straight line fit slope has a slope of 1.7275). This can be taken as evidence for the formation of planets from smaller bodies. See the article Titius Bode Law in the Encyclopedia of Planetary Sciences for more information.

3. For groups of high school students with previous exposure to chemistry, or for a group of college students, I would probably make these cards read: gas and water ice, gas and ammonia ice, gas and methane ice (two of these). The gas and water ice is Jupiter, Saturn is the gas and ammonia ice card, and the other two are Uranus and Neptune.

Table 1: Semimajor Axes for the Planets

Planet	Orbit Semimajor Axis(AU)
Mercury	0.387
Venus	0.723
Earth	1.000
Mars	1.524
Jupiter	5.203
Saturn	9.530
Uranus	19.200
Neptune	30.100
Pluto	39.800

Table 2: Densities for the Inner Planets

Planet	Bulk Density	Uncompressed Density
Mercury	5.430	5.3
Venus	5.240	4.0
Earth	5.515	4.1
Mars	3.940	3.7

Density is measured in either $^{g}/_{cm^3}$ or in $^{kg}/_{m^3}$. The numbers above are $^{g}/_{cm^3}$. To convert to $^{kg}/_{m^3}$, multiply each by 10^3. The uncompressed density represents the density of the material forming the planet without effects such as internal heating, which decreases density, and the size of the planet, which tends to compress mate rial and increase the density (a kilogram of rock 1,000 km below the surface of the Earth has 1,000 km of rock pressing down on it; all this rock compresses it and thus makes the rock more dense).

Table 3: Densities of the Outer Planets

Planet	Bulk Density
Jupiter	1.33
Saturn	0.69
Uranus	1.27
Neptune	1.64
Pluto	2.00

Table 4: The Canonical Values for the Solar System

Note: The values in the table are normal ized to silicon (i.e., Si – 1). The table was compiled from spectroscopic data from the Sun and laboratory analyses of carbona ceous chondrite meteorites.

Element	Z	Abundance
H	1	26,600.0000
He	2	1,800.0000
O	8	18.4000

C	6	11.1000
Ne	10	2.6000
N	7	2.3100
Mg	12	1.0600
Si	14	1.0000
Fe	26	0.9000
S	16	0.5000
Ar	18	0.1060
Al	13	0.8500
Ca	20	0.0625
Na	11	0.0600
Ni	28	0.0478
Cr	24	0.0127
Mn	25	0.0093
P	15	0.0065
Cl	17	0.0047
K	19	0.0035
Ti	22	0.0024
Co	27	0.0022
Zn	30	0.0013
F	9	0.0078
Cu	29	0.00054
V	23	0.00025
Ge	32	0.00012
Se	34	0.00006
Li	3	60.00 ppm
Kr	36	41.00 ppm
Ga	31	38.00 ppm
Sc	21	31.00 ppm
Sr	38	23.00 ppm
Zr	40	12.00 ppm
Br	35	9.20 ppm
B	5	9.00 ppm
Te	52	6.50 ppm
As	33	6.20 ppm
Rb	37	6.10 ppm
Xe	54	5.80 ppm
Ba	56	4.80 ppm
Y	39	4.80 ppm
Mo	42	4.00 ppm
Sn	50	3.70 ppm
Pb	82	2.60 ppm
Ru	44	1.90 ppm
Cd	48	1.60 ppm
Pt	78	1.40 ppm
Pd	46	1.30 ppm
I	53	1.30 ppm
Be	4	1.02 ppm
Ce	58	1.20 ppm
Nb	41	0.90 ppm
Nd	60	0.79 ppm
Ir	77	0.72 ppm
Os	76	0.69 ppm
Ag	47	0.46 ppm
Element	Z	Abundance
Gd	64	0.420 ppm
Rh	45	0.400 ppm
Cs	55	0.390 ppm
La	57	0.370 ppm
Dy	66	0.370 ppm
Sb	51	0.310 ppm
W	74	0.300 ppm
Sm	62	0.240 ppm
Er	68	0.230 ppm
Au	79	0.210 ppm
Hg	80	0.210 ppm
Yb	70	0.200 ppm
In	49	0.190 ppm
Tl	81	0.190 ppm
Pr	59	0.180 ppm
Hf	72	0.170 ppm
Bi	83	0.140 ppm
Eu	63	0.094 ppm
Ho	67	0.092 ppm
Tb	65	0.076 ppm
Re	75	0.051 ppm
Th	90	0.036 ppm
Tm	69	0.035 ppm
Lu	71	0.035 ppm
Ta	73	0.020 ppm
U	92	0.010 ppm

Table 5: The Condensation Sequence

The condensation temperatures for Iodine, Cesium, and Mercury have not been determined. Oxygen is not listed because it condenses out of the solar nebula in combined form and not as O_2.

Temperature (K)	Element
1818	Rhenium
1812	Osmium
1794	Tungsten
1717	Zirconium
1690	Hafnium
1670	Aluminum
1652	Scandium
1634	Calcium
1622	Yttrium
1603	Iridium
1600	Titanium
1598	Terbium
1598	Dysprosium
1598	Holmium
1598	Erbium
1598	Thulium
1598	Lutetium
1598	Thorium
Temperature (K)	Element
1597	Gadolinium
1595	Molybdenum
1580	Uranium

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1565	Ruthenium
1563	Neodymium
1560	Samarium
1557	Praseodymium
1544	Lanthanum
1543	Tantalum
1529	Silicon
1517	Niobium
1493	Ytterbium
1490	Beryllium
1455	Vanadium
1440	Cerium
1411	Platinum
1392	Rhodium
1356	Cobalt
1354	Nickel
1340	Magnesium
1338	Europium
1337	Iron
1320	Palladium
1301	Chromium
1284	Gold
1225	Lithium
1217	Strontium
1190	Manganese
1170	Copper
1162	Barium
1151	Phosphorus
~1080	Rubidium
1012	Arsenic
1000	Potassium
993	Silver
970	Sodium
964	Boron
918	Gallium
912	Antimony
863	Chlorine
825	Germanium
736	Fluorine
720	Tin
713	Sulfur
684	Zinc
684	Selenium
680	Tellurium
520	Lead
472	Bismuth
470	Indium
448	Thallium
430	Cadmium
~350	Bromine
180	Hydrogen
120	Nitrogen
78	Carbon
74	Xenon
54	Krypton
50	Argon
~5	Neon
<5	Helium

Table 6: Trace Elements in Minerals

The following table lists two major minerals that were found in the solar nebula and the elements which are dissolved in them.

Iron alloy:
- Chromium
- Cobalt
- Nickel
- Copper
- Zinc (as ZnS)
- Gallium
- Germanium
- Arsenic
- Selenium (as FeSe)
- Palladium
- Silver
- Cadmium (as CdS)
- Indium (InS)
- Tin
- Antimony
- Tellurium (as FeTe)
- Gold
- Thallium
- Lead
- Bismuth

Perovskite ($CaTiO_3$):
- Vanadium
- Strontium
- Niobium
- Barium
- Lanthanum
- Cerium
- Praseodymium
- Samarium
- Europium
- Gadolinium
- Terbium
- Dysprosium
- Holmium
- Erbium
- Thulium
- Ytterbium
- Lutetium
- Tantalum
- Thorium
- Uranium

Table 7: Minerals and Condensation Temperatures for the Planets

Planet	Temp. (K)	Minerals

Mercury	1700	Metallic iron, enstatite
Venus	900	+feldspars, olivine
Earth	600	+FeS, some FeO, tremolite
Mars	400	+serpentine, all FeO (no FeS)
Asteroids	300	Hydrated minerals
Jupiter	200	+plus water ice
Saturn	125	+plus ammonia ice
Uranus	100	+plus methane clathrate
Neptune	75	+plus more methane?
Pluto	50	methane? or carbon dioxide?
Comets	25	Water, carbon dioxide, methane, nitrogen ices

Table 8: Interstellar Molecules and Ions

Diatomic:	
H_2	Molecular hydrogen
OH	Hydroxyl radical
CN	Cyanogen radical
CS	Carbon monosulfide
CH	Methylidyne
CH+	Methylidyne ion
SiO	Silicon monoxide
NS	Nitrogen sulfide
SO	Sulfur monoxide
C_2	Diatomic carbon
CO	Carbon monoxide
Triatomic:	
SO_2	Sulfur dioxide
HCO+	Formyl ion
C_2H	Acetylene radical
N_2H	Protonated nitrogen
HCO	Formyl
HNC	Hydrogen isocyanide
HNO	Nitroxyl
O_3	Ozone
H_2O	Water
HCN	Hydrogen cyanide
H_2S	Hydrogen sulfide
COS	Carbonyl sulfide
Tetratomic:	
NH_3	Ammonia
H_2CO	Formaldehyde
H_2CS	Thioformaldehyde
C_3N	Cyanoethynyl
HNCS	Isothiocyanic acid
HCNO	Hydrocyanic acid
HC_2H	Acetylene
Pentatomic:	
NH_2CN	Cyanimide
CH_2CO	Ketene
C_4H	Butadiynyl
CH_4	Methane
HCOOH	Formic acid
HC_3N	Cyanoacetylene
CH_2NH	Methylenimine
Hexatomic:	
CH_3SH	Methyl mercaptan
CH_3OH	Methyl alcohol
CH_3CN	Methyl cyanide
$HCONH_2$	Formamide
Heptatomic:	
HC_5N	Cyanodiacetylene
CH_2CHCN	Vinyl cyanide
CH_3NH_2	Methylamine
CH_3C_2H	Methylacetylene
$HCOCH_3$	Acetaldehyde
Octatomic:	
CH_3C_3N	Methyl cyanoacetylene
$HCOOCH_3$	Methyl formate
Nonatomic:	
CH_3CH_2OH	Ethyl alcohol
CH_3CH_2CN	Ethyl cyanide
CH_3CH_3O	Dimethyl ether
HC_7N	Cyanotriacetylene
Others:	
HC_9N	Cyanooctatetrayne
$HC_{11}N$	Cyanopentaacetylene

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It's in the Stars

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ACROSS

2. The Eagle Nebula and the Orion Nebula are representatives of regions of star _____.
6. The brightest star in a constellation usually has this designation.
7. Postscript (abbreviation)
8. Washington College (abbreviation)
10. Abbreviation for radical group in Ireland
12. Abbreviation for the agency which the Nuclear Regulatory Commis sion replaced
13. Beta Aquilae
16. Stone from space
17. Environmental Protection Agency (abbreviation)
19. Constellation The Altar
21. Gamma Orionis
25. Beta Ursa Majoris
26. Beta Ursa Minoris (spelling variant)
29. ___de Janeiro
30. Constellation between Virgo and Scorpius
32. Covered with fine carbon ash

DOWN

1. American astronomer who studied the relationship between galaxies and quasars
2. Igneous rock
3. Postal Service abbreviation for Illinois
4. Symbol for thorium
5. Keck Telescope location
7. The Beehive
9. Belonging to the constellation which contains the nearest star to the Sun
11. 17th letter of the Greek alphabet
14. Ellie Arroway s research program in Sagan s book Contact (abbrevia tion)
15. Constellation The Ship
17. Tides ___and flow
18. Gamma Andromedae
19. Whether prior or posterior, Beta Sagittarii
20. Chopping tool
22. French preposition
23. Radio Telescope in Puerto Rico
24. Teaching assistant (abbreviation)
27. Familiar winter sky constellation
28. Blood pipe
30. Learning support (abbreviation)
31. Irish exclamation of surprise

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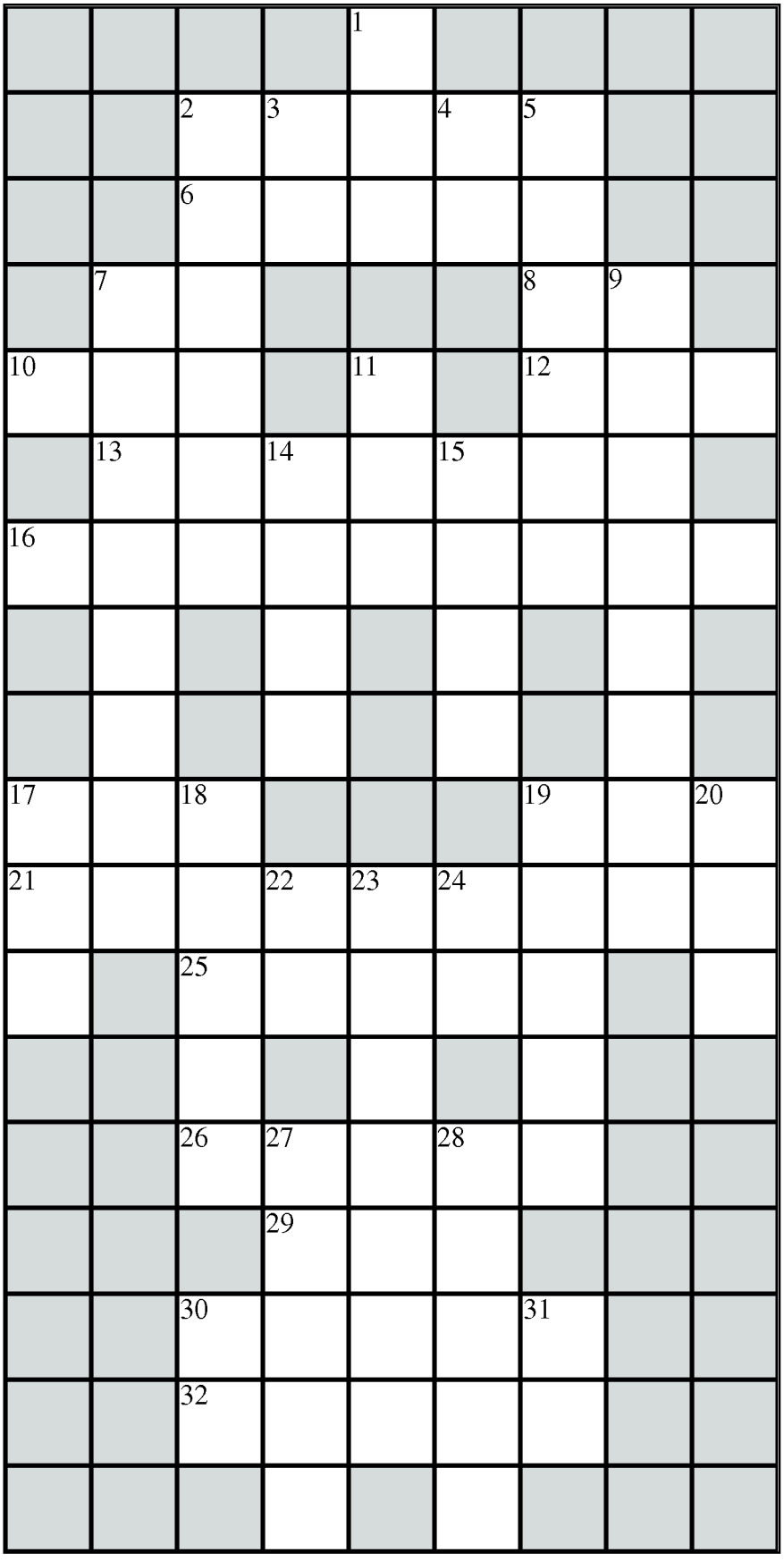
It's in the Stars



Southern Skies

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In This Issue

Please read an extremely important message on page 3 about a possible SEPA/GLPA conference in 2001. Return the enclosed post card with your response by March 15.

Southern Skies is the quarterly journal of the Southeastern Planetarium Association published for the purpose of communicating association news, reports, reviews, and resources to its members.

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Thanks again for your dedication to improving students understanding of science. I look forward to hearing from you at your convenience.

Karen Leichtweis
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Important Announcement

Last year at our business meeting the possibility of a joint SEPA/GLPA conference was mentioned. Initial discussions with GLPA s officers have been very fruitful, and we have a unique opportunity for a 2001 conference. GLPA is willing to meet within the SEPA region and forego their normal October conference date to meet with us during late June. In so doing, the impact on SEPA members schedules and travel plans will be very little.

We have also had a standing invitation from the Hummel Planetarium in Richmond, Kentucky to host such a conference if it ever materialized. Hum mel director Jack Fletcher has been contacted and again voiced his support for this event. Hummel can provide the facilities and other amenities that a larger than average attendance would entail. The location is also ideal for those traveling from the GLPA region.

The GLPA board is ready to move ahead with plans if SEPA responds simi larly. Because time is of the essence, we would prefer to move forward with this proposal before the annual business meeting in June. Enclosed you will find a printed postcard on which to cast your vote.

We are hoping to get a response from the majority of members so we decide what our next step should be. If we do not hear from enough of the member ship we will be forced to postpone any action until the annual meeting in Jacksonville.

Please respond by March 15.