FOR THE FAMILY OF:

INVESTIGATING Astronomy CONNECTIONS

Investigating the Universe

The arrow points to a supernova, which was discovered in 2006 and was captured in this image at near maximum brightness...
See story on page 3.

INSIDE THIS ISSUE!

TERC NSF ASTRONOMICAL SOCIETY OF THE PACIFIC NOAO

It's a Raisin Bread Universe

RAISIN CINNAMON BREAD

- 1/2 cup sugar
- 1 package rapid-rise yeast
- 1 package regular yeast
- 3 1/2 cups warm water
- 3 tablespoons oil
- 1 teaspoon salt
- 8 cups flour
- 2 cups moist raisins
- 1 cup brown sugar
- 1 tablespoon cinnamon

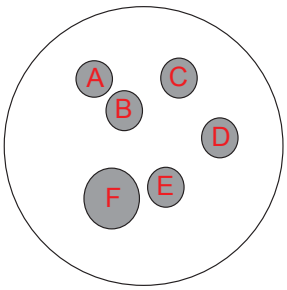
Dissolve 1/2 cup sugar, 1 package rapid rise and 1 package regular yeast in 3 1/2 cups warm water, 3 tablespoons oil and 1 teaspoon salt. Stir to mix. Let stand 5 minutes. Add 8 cups flour; knead, adding flour as necessary to make soft dough. Grease entire surface of dough, place in bowl, and cover with damp dish towel. Let rise in warm place for approximately 1 hour until dough is double in size.

Mix brown sugar and cinnamon. Punch down dough, divide into 4 pieces. Flour surface, roll each piece out (with rolling pin) to approximately 9" x 13". Take 1 tablespoon water, gently rub surface. Sprinkle with ¼ cup cinnamon and sugar mixture. Add 1/2 cup moist raisins. Roll dough, starting at narrow side to form loaf. Place in greased bread pan, pinch down ends to seal filling (seam down). Brush top with melted butter. Let rise until double in size.

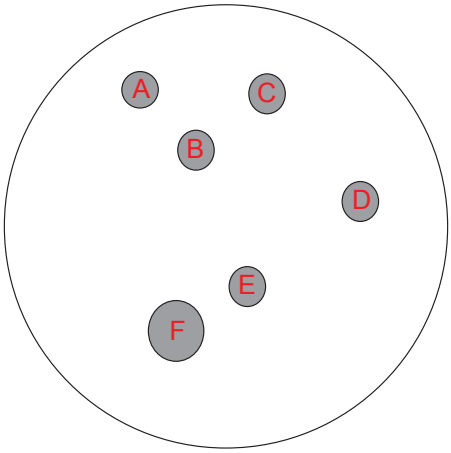
Preheat oven to 400 degrees. Bake in middle of oven for 25 minutes. Remove from pans, cool on rack, butter tops again while hot.

Well, no, it's just a tasty way to help you visualize what it means when we say the universe is expanding and all galaxies are moving away from us. It may seem an outrageous claim at first to say that the universe is expanding, but bake some bread, steep some tea, and ponder the idea for a while.

The dough with all its ingredients represents the known universe at some point in time, and the raisins represent galaxies. No particular galaxy is in a special spot—they are sprinkled throughout the dough. Think about where those raisins are in the dough when you first roll them up and set the mixture aside to rise. The raisins might look something like this:



But after an hour of rising, when the dough has doubled in size, they might look like this:



The raisins are the same size, but they are all farther away from each other. What has expanded is the space between them or the dough.

While your bread is baking, if you'd like to really see the power of this analog, take the time to measure and make a chart of the differences in the distances.

Pairs of raisins	Separation in small raisin bread universe	Separation in expanded raisin bread universe
AB		
AC		
AD		
AE		
AF		
BC		
BD		
BE		
BF		
CD		
CE		
CF		
DE		
DF		
EF		

Do you see a trend? The raisons separated by more distance seem to have moved farther in the same amount of time. That would mean they are moving faster! Edwin Hubble saw a similar trend when he observed distant galaxies. The more distant ones seemed to be moving faster.

If all this makes your mind swim, just cut off a piece of raisin bread and enjoy it with your cup of tea. ★

Telescopes as Time Machines

Have you ever put your eye up to the eyepiece of a telescope and seen a crater on the moon, the rings of Saturn, or a place where a star blew up and left a glowing remnant? If not, you've probably seen lots of pictures of such sights during your studies of astronomy. Consider not just how far away those objects are, but how long it takes the light to get to us. Even traveling at 186,000 miles each second, it could take hours, years, sometimes millions of years, for that light to reach us. In that sense, telescopes can be thought of as time machines, because when they are turned to the heavens, the light they bring to a focus has been traveling a very long time. When it reaches us, it offers a glimpse of the universe as it was hours or years ago.

To put it all in perspective, imagine looking at each of the celestial wonders listed below, starting with our moon. Think back to what you were doing when the light left those objects, if the object is a few light-minutes away, it took the light those few minutes to get to us. If the object is light-years away, its light took years to get to us. To complete the chart, you may have to dig back into family history, and even prehistory!

Hot Link [**To help fill in some gaps:** http://www.archaeologyinfo.com/species.htm]

CELESTIAL OBJECT (1 light year ~ 6 trillion miles)	DISTANCE (1 light year ~ 6 trillion miles)	Family HISTORICAL EVENT
Moon		
Sun	8.3 light-minutes	
Pluto	5.4 light-hours	
Alpha Centauri	4.3 light-years	
Vega	25 light-years	
Betelguese	430 light-years	
Antares	600 light-years	
Orion Nebula	1,600 light-years	
Crab Nebula	63,000 light-years	
Andromeda Galaxy	2.3 million light-years	
Whirlpool Galaxy	37 million light-years	
Giant Elliptical Galaxy M87	60 million light-years	
Hubble Deep Field Galaxies	10 billion light-years	

The distances and times can be mind-boggling when put in human perspective. So go out there and support your local star parties; don't let those hard working photons from celestial wonders go to waste. ★

Hot Link [**For lots of beautiful images of these distant objects:** http://www.seds.org/messier/]

On the Cover

The cover shows a supernova discovered in 2006 in a bright, nearby galaxy called M100. The supernova, dubbed SN 2006X, was near maximum brightness when this image was taken. Although hundreds of supernovae are now discovered each year by automated searches, nearby supernovae are rare and important because they frequently become bright enough to be studied by many telescopes. Supernovae are used as distance indicators because their maximum brightness is always about the same. Supernova 2006X's host galaxy M100 resides in the Virgo cluster of galaxies located about 50 million light years from Earth. (Credit: NOAO)

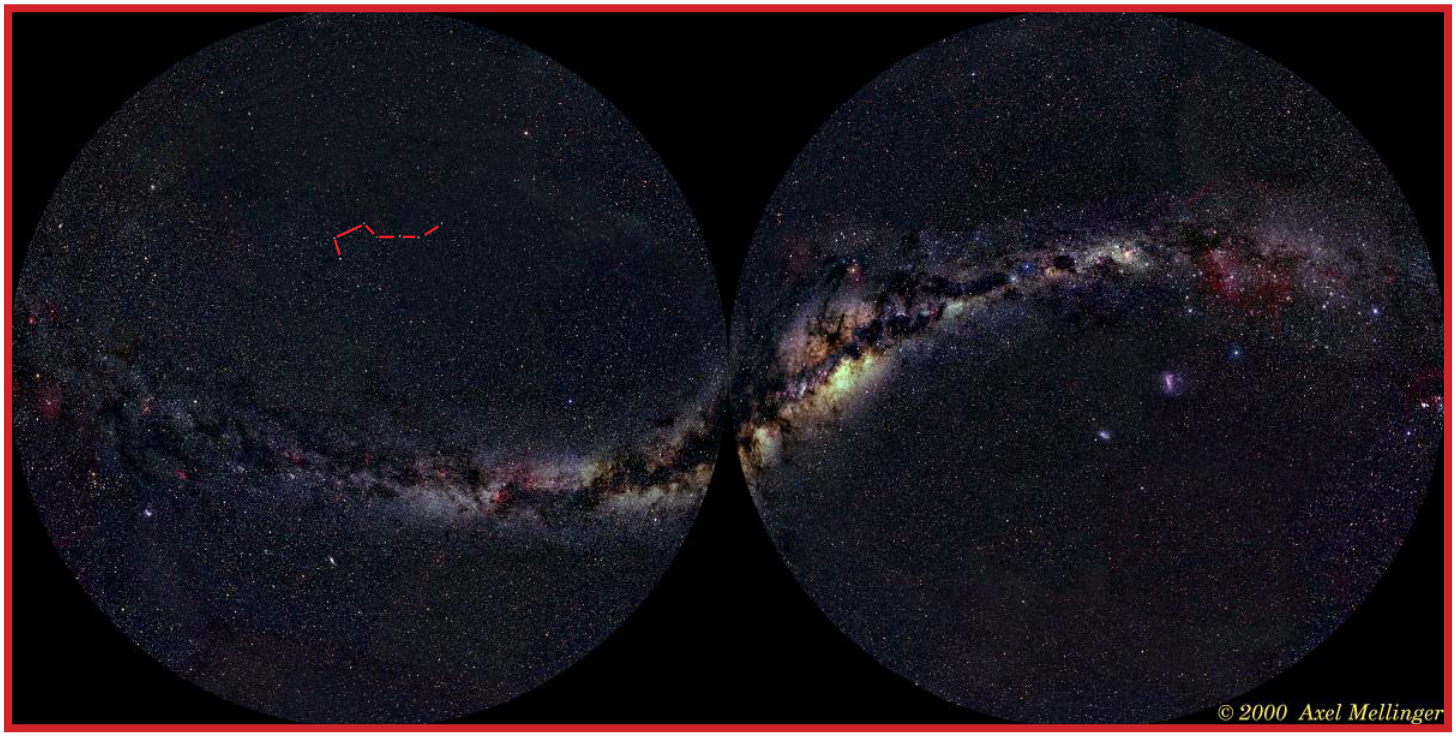
Sky Watch

The Big Dipper is probably the most recognized piece of the sky in the Northern Hemisphere. It is rich in both sky lore and science. Officially, the seven bright stars that make up the dipper's shape are just a section of a much larger grouping called Ursa Major, or the Great Bear. The three stars in the handle of the dipper form the tail of the bear, and the four stars of the bowl mark the back half of the bear's body. The head and legs are composed of much dimmer stars that are more difficult to see. In various Native American stories, the bowl of the Big Dipper is the bear, and the handle stars are three hunters stalking the bear throughout the seasons.

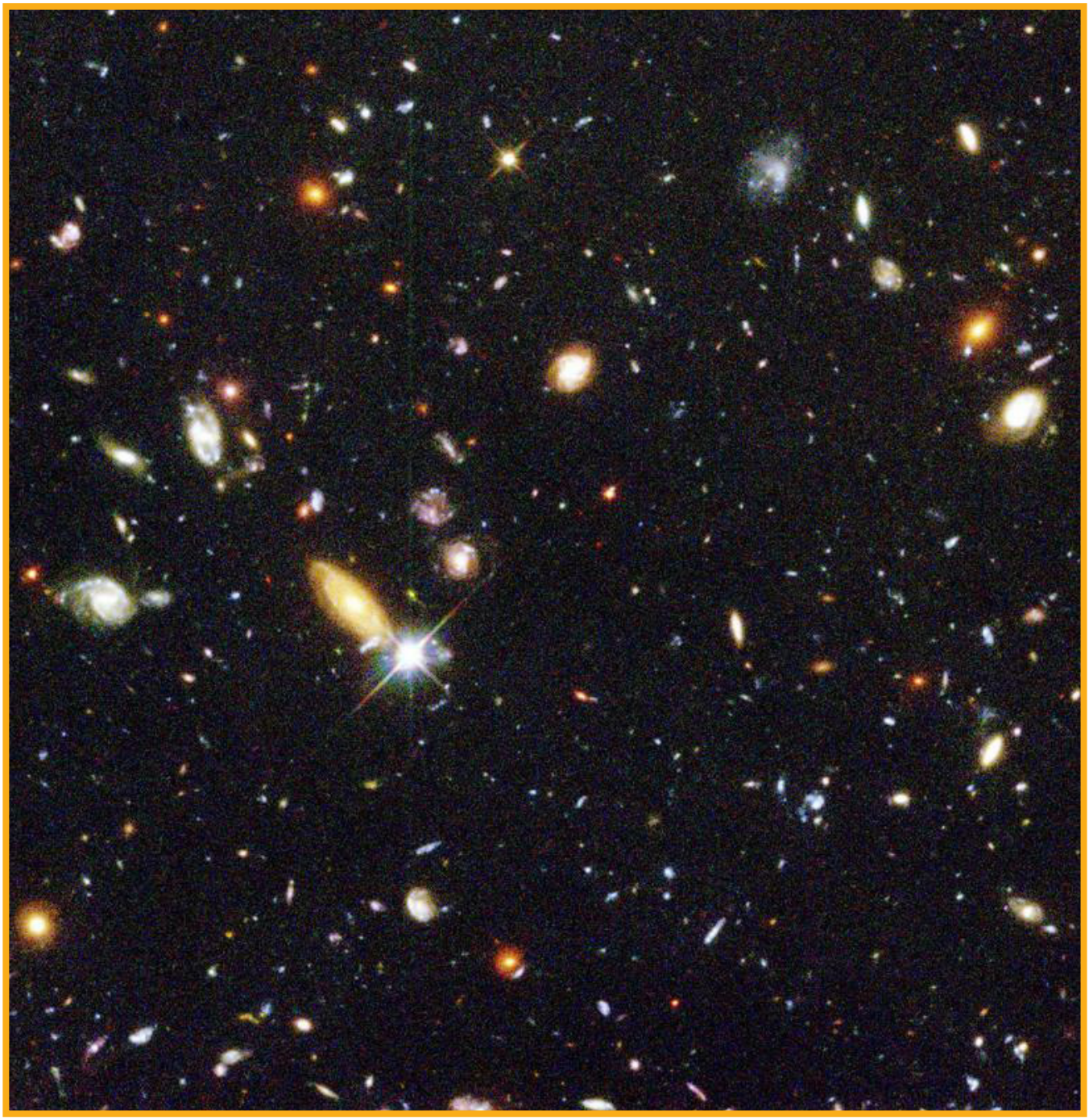
Perhaps one of the reasons there are so many stories about these stars is that they circle the pole star, Polaris. In fact, in more northerly latitudes, they never set. Such stars are called "circumpolar." They also are in an area of the sky called the CVZ, or "continuous viewing zone" of the Hubble Space Telescope. The CVZ is a spot that never goes behind Earth or too near the moon or, as Hubble orbits Earth every 90 minutes. By coincidence then, this tiny spot just above the star that marks the junction of the handle and bowl of the Big Dipper is one of the most studied areas in the entire sky.

When astronomers want to look at other galaxies, they avoid the plane of our own galaxy, the Milky Way.

Looking along this crowded, celestial band, we find many fascinating objects, from glowing star-forming regions to sparkling star clusters to the twisted remains of stars that have self-destructed at the ends of their lives. To find galaxies, however, we have to look away from this crowded region, out of the plane of our galaxy. When you see the Big Bear strolling high across the northern skies in summer, the Milky Way is low on the northern horizon, giving you a clear view out to the distant edges of the visible universe.



A panorama of the sky made by stitching together many photographs; the Big Dipper is marked. (Credit & Copyright: Axel Mellinger)



Credit: NASA/HST

When astronomers wanted to use the Hubble Space Telescope to look deeper into space than they ever had, they looked for a region that is both outside the plane of the galaxy and inside the CVZ. They decided on a tiny spot, just above the base of the tail of the Great Bear, chosen because it was so uncluttered and free of interesting and distracting objects. The results, however, after staring at the spot for 10 consecutive days in 1995, was this history-making image dubbed the Hubble Deep Field.

The image was assembled from 342 separate exposures taken over ten days between December 18 and 28, 1995, and it has provided a wealth of new information for astronomers. It has given us views of the most distant galaxies, which are the youngest galaxies ever seen (see Telescopes as Time Machines in Family Features). Data derived from this field are influencing our ideas of how galaxies are formed and change over time. Thousands of research papers have been published based on data from this image and subsequent observations by other telescopes. In fact, it was believed that many of the questions raised could only be answered by taking more pictures. Since this image was taken, a Hubble Deep Field in the southern sky and an Ultra Deep Field have been captured in images. They reveal shapes of galaxies never seen before. ★

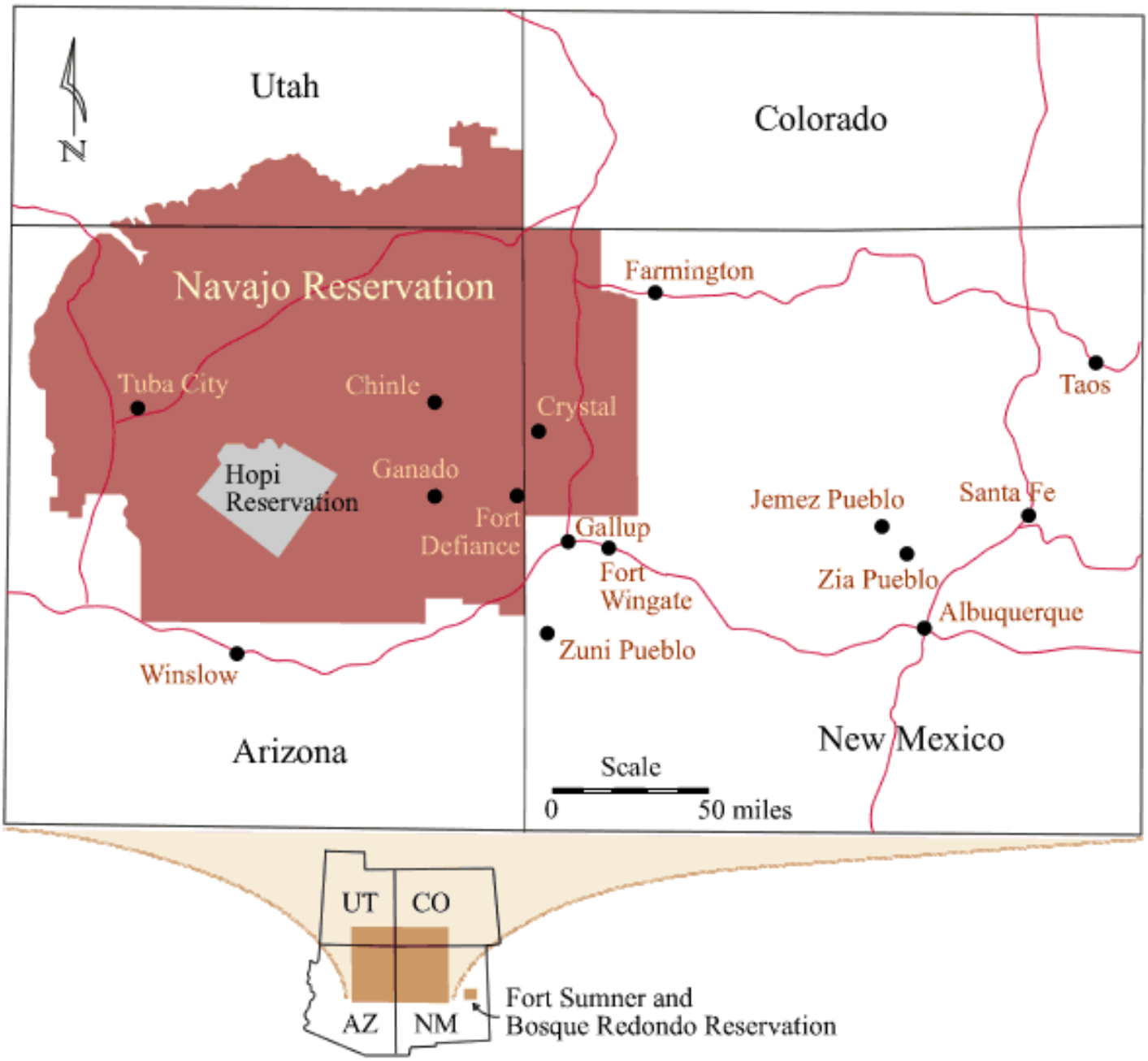
Cultural Connections

In the *Investigating the Universe* module we've explored the size and age of the universe, and we've emphasized scientific inquiry as a way of finding out the answers to our questions. Ancient cultures relied upon their rich traditions to help them understand their place in the universe and how it came to be. The following are summaries only and do not do justice to the richness of the stories or the importance that they have within the cultures they come from. To dig deeper into this cultural aspect of astronomy, check out these Web sites:

http://www4.nau.edu/ifwfd/ts_lessons/SacredMountains/upload/s%20mtns/home.htm

http://www.sacred-texts.com/nam/nav/ncm/ncm4.htm

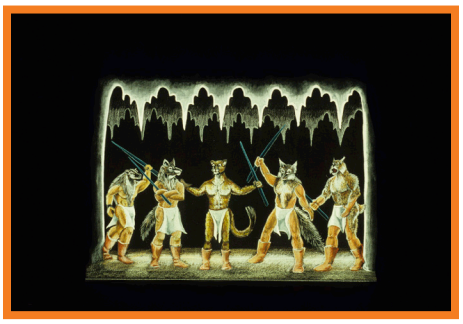
Hot Links



Navajo Creation Myth

This is a long and complex story with a multitude of characters. The basics are that the "Dine" or Navajo people have emerged from four previous worlds before coming to this fifth or Glittering World. The artist's conception reveals a place of wonder with insects, birds, and animal people along with the holy people and gods.

The first world was one of darkness. It was small and crowded and so the people were quarrelsome. The people were not like people today, but like insects, ants, locusts, and others. They left the world of darkness through a hole and crawled into the second world.



Sometimes called the Blue World, this second world was already inhabited by the powerful Swallow People, who did not welcome the newcomers from the first world. There was much fighting and killing there, too, so the people moved on.

In the third world, the Dine learned from the Pueblo people how to plant and build homes. This world was a better place, but they were warned not to bother the water monster. Unfortunately, the trickster coyote did not listen. He stole the children of the water monster, who caused a great flood, so they climbed through a great reed to the fourth world.

This was the White World. Although it was even more beautiful than the third world, this fourth world was in danger because coyote had brought the children of the water monster with him. When this world began to flood, the people used another magic reed to escape to the fifth world, which is defined by four sacred mountains, two in Colorado, one in Arizona, and one in New Mexico.

It was not an easy task. The reed was too short, and spider woman had to weave a rope to let down for them to crawl up. Locust was the first to emerge into this Glittering World. Each of the mountains here is symbolic of different qualities and sacred stones. Mount Blanco in Colorado is the eastern boundary and represents the White Shell. Mount Taylor in New Mexico is the southern boundary and represents the Turquoise stone. Mount Hesperus in Colorado is the northern boundary and represents Black Jet or Obsidian. The San Francisco Peaks in Arizona are the western boundary and represent the Abalone and Coral stones.

Once they had the mountains in place, the Holy People put the sun and moon in the sky and were in the process of placing the stars in the sky. They did this with great care and deliberation, but their process was cut short by an impatient trickster. Coyote, grabbed the blanket where the beautiful stars lay and flung them across the sky. So today there are a few beautiful patterns, but most of the stars are haphazardly scattered. ★

Creation story illustrations courtesy - Flandrau Science Center (University of Arizona), Tucson, Arizona

Images from - "Navajo Nights" planetarium show

Artwork by - Larry Vance, Ben Balistreri, Gilbert Mejia

Talk Like an Astronomer

circumpolar: Stars that neither rise nor set and instead travel in a circle around the pole star are said to be circumpolar.

light-year: The distance that light, traveling at 186,000 miles per second, can travel, or about 5.9 trillion miles.

supernova: An event caused by the collapse of star and subsequent explosion that often obliterates the star completely. Sometimes, a super-compressed remnant of the core remains—a neutron star or black hole.

Star Witness

Chung-Pei Ma

As a child growing up in Taiwan, Chung-Pei Ma was a talented and serious student of the violin. In fact, at the tender age of nine, Ma was asked by her teacher if she was serious about becoming a musician. Ma recalls answering, "Well, I want to be an astronaut, and I'm not sure why." Today she's not an astronaut, but an astrophysicist who ponders fundamental questions about the universe. Her current research is centered on the theme of understanding the formation and evolution of galaxies, the large-scale structure in the universe, and dark matter. In retrospect, the sense of wonder that she feels today is what she thinks she was also feeling at nine. She still wants to find out more about the early universe, the ultimate fate of the universe, and, even more fundamentally, what the universe is made of. Her tools are not telescopes, but large supercomputers.

She says, "My collaborators and I have performed numerical simulations of the clustering of dark matter in various cosmological models of structure formation from the early universe until the present day. By comparing the simulation results with astronomical observations, constraints can be obtained on the nature of dark matter, such as the mass of neutrinos, and on cosmological parameters such as the density and expansion rate of the universe."

Credit: C. Ma

That sounds like a mouthful, but it is actually an expression of her love of math. Ma prefers theoretical physics and astronomy to observational because math is so tidy. "It's very neat. I've always liked math, and I like to do calculations. The beauty of theoretical work is that I can just sit here and think, or I go to the beach and lie there. I used to do it rollerblading on the Santa Monica beach when I was a postdoc [at Caltech]." She does stay grounded, however, and collaborates with observational astronomers who use the largest telescopes in the world, both in southern California and Hawaii.

Ma received her Ph.D. from the Massachusetts Institute of Technology in 1993 She was a Postdoctoral Fellow in Theoretical Astrophysics at Caltech for 3 years before becoming an Assistant Professor of Physics and Astronomy at U Penn in 1996. She was an Associate Professor there in 2001 before she moved to the Department of Astronomy at U.C. Berkeley in 2002, where she is now a Professor of Astronomy.

What an amazing journey for the first-prize winner in the Taiwan National Violin Competition in 1983! ★

Hot Link

[**Check out her Web site at Berkeley to see some simulations of her work on dark matter: http://astro.berkeley.edu/~cpma/**]