

Visitors from Space - Comets!

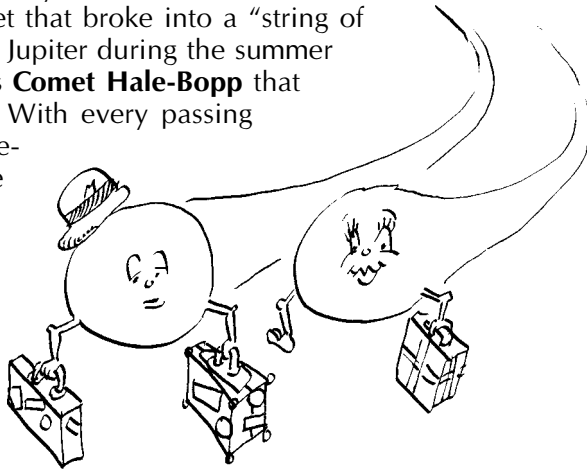
Become a Comet Expert

- ✓ Take a Comet Quiz!
- ✓ Make your own Comet Model!
- ✓ Observe Comet Hale-Bopp!

Visitors from Space

*"Somewhere in the cold vacuum of space it hurtles towards us. It is moving faster than any earth space probe and is as big as a mountain. The last time it visited the inner solar system, Stonehenge was about to reach its final configuration and the great Ziggurat of Ur was about to be built. It is Comet Hale-Bopp."*¹

Every year, about a dozen new comets are discovered and another dozen or so make a return trip through our part of the solar system. Some of these visitors you may have heard of: **Comet Halley**, who swings by every 76 years (most recently in 1986) and **Comet Shoemaker-Levy 9**, the comet that broke into a "string of pearls" and crashed into Jupiter during the summer of 1994. Right now it is **Comet Hale-Bopp** that captures our attention. With every passing day, it appears that Hale-Bopp will live up to the spectacular predictions of incredible brightness and favorable visibility for viewers in mid-northern latitudes. With this brochure, we intend to supplement your local headlines about **Hale-Bopp** with information of value in the classroom, information that will help you experience and understand this spectacular visitor to our neighborhood.



¹ Copyright 1996, Russell Sipe. These dramatic words are from the Comet Hale-Bopp Home Page at <http://www.halebopp.com> on the Internet's World Wide Web (WWW). The pages at this site introduce people not only to Comet Hale-Bopp, but to comets and astronomy in general. For more recommended WWW sites and sources of additional information, see the back page of this brochure.

Cover Photo: Comet Hyakutake is seen rising over the hills near Faraway Ranch in Southern Arizona's Chiricahua National Monument. The photo was taken about 8:30 pm on the night of 24/25 March, 1996, the comet's night of closest approach to earth. The bright stars near the top of the image are in the handle of the Big Dipper. The exposure was made on a Nikon FM2 with a 50mm lens working at F/1.4. The exposure was about 30 seconds in length on Fujicolor Super G plus, at its normal rating of 800 ASA. This photograph was provided by Dean Ketelsen who is a member of the Tucson Amateur Astronomy Association.

Acknowledgements: This brochure was created by Suzanne Jacoby: Education Officer of the National Optical Astronomy Observatories, Suzanne Maly: science teacher at Safford Middle Magnet School in Tucson, AZ., and Joyce DuHamel: graphic artist in the NOAO Photo Lab. Tucson artist Richard Hicks drew the original artwork seen on these pages.

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This false color image of Comet Halley, from an original black and white photograph taken at Lowell Observatory in 1910, has been labelled to show the coma and tail. The nucleus is too small to be seen and is not visible in this image. Photo Credit: NOAO

Cast of Comets



Wet Head Comet: If you count the number of molecules found in a comet nucleus, about 85% of them are water ice. Some of the water that exists on earth, and that which was recently discovered on the moon, may have come from comet impacts which took place early in the solar system's history.



Supersized Comet: The largest known comet nucleus is that of Chiron (Ki'ron) with a radius of 90 km. Chiron was originally classified as an asteroid, but in 1989 a coma was detected, meaning Chiron is really a comet and not an asteroid.



Dancing Comet: Some comets show dynamically excited rotational motion, i.e., wobbling, due to powerful gas jets turning on in the comet nucleus. These gas jets are caused by the sublimation of molecules in the nucleus. They can make the comet spin faster and even alter its orbit.



Prehistoric Comet: Comet nuclei have spent much of their lifetimes far from the sun and are among the least processed objects in the solar system. For this reason, they give valuable clues to the origin and early environment of our solar system.



Airhead Comet: A coma of a comet is as close as *something* can come to being *nothing*. The amount of matter in a comet's coma is very small when compared to the nucleus. The density of a comet's coma is very low, and is actually a better vacuum than we can produce on earth in our laboratories.

Take the Comet Quiz

Mark each of the following statements about comets with a T if it is TRUE and an F if it is FALSE.

The nucleus of a comet is too small to be seen from earth, even with binoculars. _____

Sublimation is a process where a solid turns directly into a gas. _____

Comets that come close to the sun produce a tail. _____

Some comets come from a faraway region which surrounds the solar system called the Oort cloud. _____

Comets are very hot objects and that is why they glow brightly. _____

A comet nucleus is composed mainly of water ice. _____

Comets came from planets that blew up into many pieces. _____

The coma is made up of gases and dust that stream off the nucleus during sublimation. _____

The Sun is the original source of all energy in a comet. _____

An average comet nucleus is the same size as a city on earth. _____

A comet nucleus could be described as a dirty snowball or icy mudball. _____

It would be accurate to describe a comet as a small star. _____

Some comets come from a region in the plane of our solar system beyond neptune called the Kuiper disk. _____

Most of what we see of a comet is the coma and the tail. _____

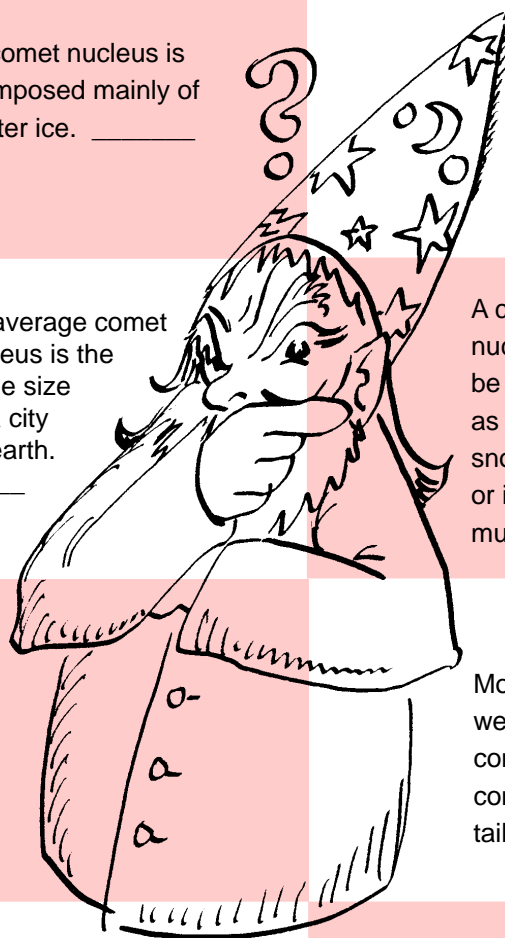
A comet is a chunk of frozen rock that broke off a star. _____

It is very cold inside the nucleus of a comet. _____

A comet appears bright because it is on fire. _____

Comets are bright because they generate their own light like stars. _____

Compared with other objects in the solar system, comet nuclei have not evolved much since formation. _____





Discovery!

Copyright 1996, Don Machholz

What were **you** doing on the night of July 22, 1995? Alan Hale, of Cloudcroft, New Mexico, set up his Meade reflector telescope (with a 16" diameter mirror) in the driveway of his mountainside home because he wanted to observe a couple of known periodic comets.



Comets are not new to Alan Hale. He has observed over 200 of them and has been asked by the Central Bureau for Astronomical Telegrams (CBAT) to confirm new comet discoveries. Dr. Alan Hale was between observing comets on the night of July 22 when he turned his telescope toward the southern sky in order to view some star clusters. One such cluster, known as M 70, is brought into the field of view, when he notices a fuzzy object nearby. This object had not been there when he last observed this cluster, about two weeks earlier. His first step is to confirm that he is looking at M 70; with several clusters in this part of the sky it is easy to find the wrong one. A check with several star atlases proved that he is indeed seeing M 70.

check for motion, for a comet should drift amongst the background stars. They draw a map of the area and wait.

Back in Cloudcroft, New Mexico, Alan Hale logs onto the computer at the CBAT and reports that he has a cometary suspect. After re-observing the object and determining that it has moved in reference to the background stars, Hale sends another message to report his certainty that this is a new comet.

Out on the desert of southern Arizona, an hour has passed. The members of the star party conclude that the mysterious fuzzy object near M 70 has certainly moved and is indeed a comet. Tom drives 90 miles to his house and gets a telegram to the CBAT to announce the discovery.

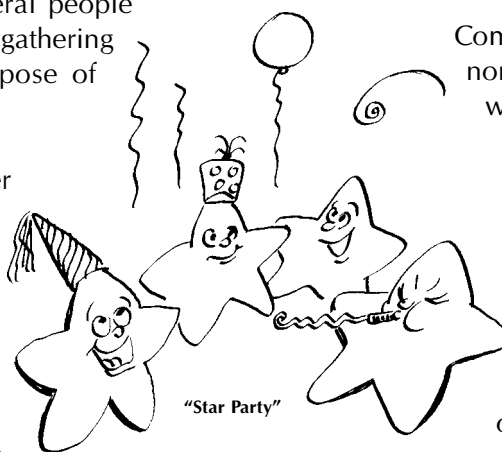
The above text was reprinted with permission from Don Machholz's book "An Observer's Guide to Comet Hale-Bopp." Ordering information is found on page 8 of this brochure.

Meanwhile, 380 miles to the west, at Vekol Ranch, near Stanfield, Arizona, we find several people with telescopes having a "star party": a gathering of amateur astronomers for the purpose of viewing the wonders of the night sky.

Jim Stevens is observing with his rather large (17.5" mirror) reflector telescope. He and Tom Bopp are looking at star clusters through Jim's telescope.

Jim observes M 70 for some time and then turns to the star charts to determine which object to find next. Now it's Tom Bopp's turn to view M 70. He peers through the eyepiece. M 70 is clearly visible, and since the telescope is stationary and the earth rotates, M 70 is drifting across the field of view. Tom watches. Suddenly another, fainter fuzzy object drifts into the eyepiece field. Tom is curious. He calls Jim over. Jim isn't familiar with the object and it doesn't show up on the star charts either. They are beginning to think they may have discovered a new comet. Within a few minutes Tom suggests that they

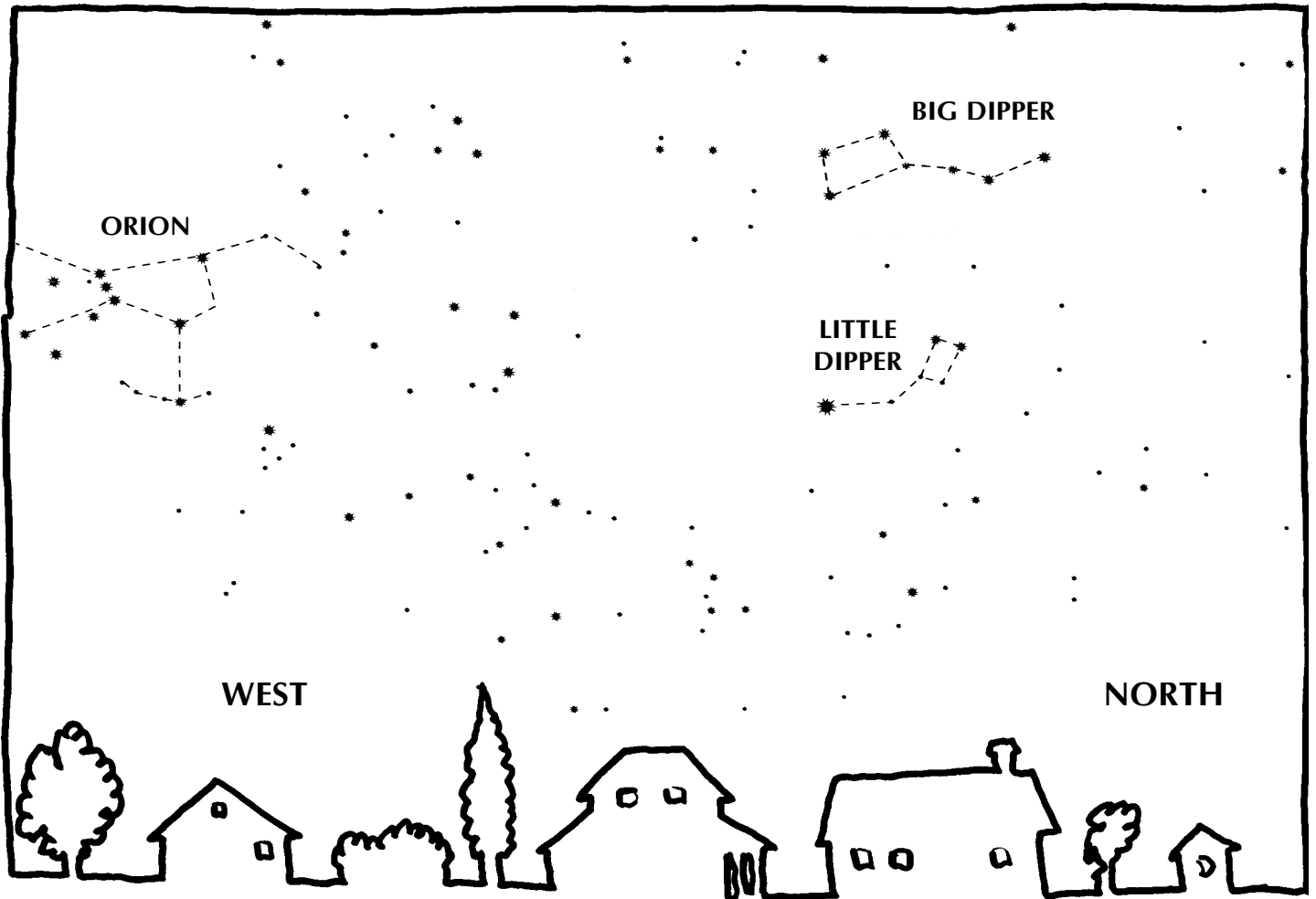
Comet Hale-Bopp is visible to viewers in the northern hemisphere right now! This comet was discovered far from earth, giving us plenty of time to prepare for its arrival. Comet Hale-Bopp is larger than an average comet and is predicted to be extremely bright. Some have described it as "the comet of the century". You can track Comet Hale-Bopp as it travels through your night time sky this March and April using the star chart and observing tips on the following page.



Comet Hale-Bopp clearly shows a well-defined gas (blue) and dust tail in this February 19, 1997 photograph by Dean Ketelsen

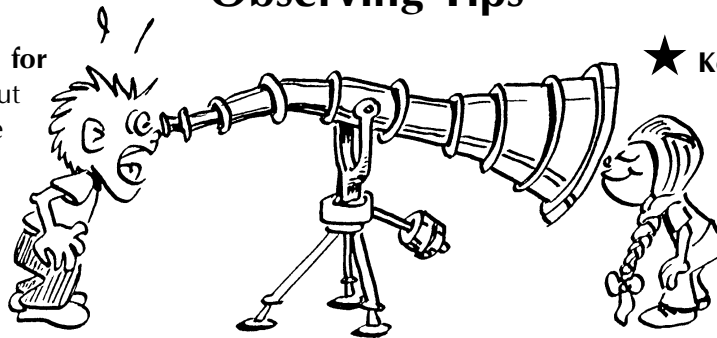
You Be The Scientist

Directions: Go outside and observe Comet Hale-Bopp as many nights as possible from late-March through mid-April and mark its position on the star chart below. The chart shows what the NW sky looks like about 8:30 pm from mid-northern latitudes. The comet will set about one hour after the Sun in early March and more than three hours after sunset on April 1st. The comet becomes brighter and higher in the night sky from mid-March into April.



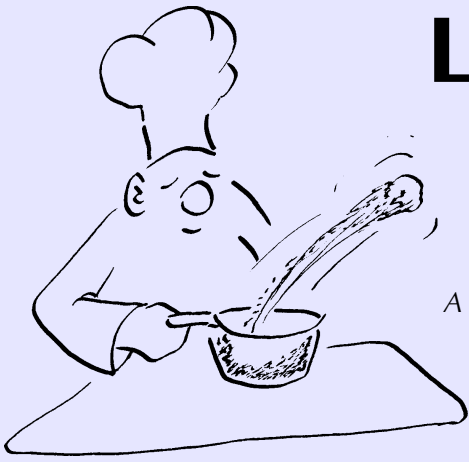
Observing Tips

★ **Stand in the same place for each observation.** Pick out a reference point, like a tree or pole on your local horizon, and use it each night to notice how the stars move relative to your horizon and how the comet moves relative to the stars.



★ **Keep an observation notebook.** Write down the time and date of your observations and other details you may notice. For example, how bright is the comet compared to nearby stars? Does its brightness change compared to some nearby stars? Can you see a tail? Can you see more than one tail? What does it look like - can you describe the comet's color, or shape?

★ **Look on WWW page <http://www.noao.edu/education/noaoeo.html>** after April 15th to see how students in Tucson, AZ, completed their sky chart and observing notebooks.



Let's Cook up a Comet!

Making a Comet in the Classroom

by Dennis Schatz, Pacific Science Center

Copyright 1985 by Dennis Schatz

A dramatic and effective way to begin a unit on comets is to make your own comet right in front of the class. The ingredients for a comet are not difficult to find and watching a comet being "constructed" is something the students will remember for a long time.

The "ingredients" for a six-inch comet are:

- 2 cups of water
- 2 cups dry ice (frozen carbon dioxide)
- 2 spoonfuls of sand or dirt
- a dash of ammonia
- a dash of organic material
(dark corn syrup works well)

Other materials you should have on hand include:

- an ice chest
- a large mixing bowl (plastic if possible)
- 4 medium-sized plastic garbage bags
- work gloves
- a hammer, meat pounder, or rubber mallet
- a large mixing spoon
- paper towels

Here are the steps for making a 6-inch comet (students make good baker's assistants for this exercise!):

1. Cut open one garbage bag and use it to line your mixing bowl.
2. Have all ingredients and utensils arranged in front of you.
3. Place water in mixing bowl.
4. Add sand or dirt, stirring well.
5. Add dash of ammonia
6. Add dash of organic material (e.g. corn syrup), stirring until well mixed.
7. Place dry ice in 3 garbage bags that have been placed inside each other. Be sure to wear gloves while handling dry ice to keep from being burned.
8. Crush dry ice by pounding it with hammer.
9. Add the dry ice to the rest of the ingredients in the mixing bowl while stirring vigorously.
10. Continue stirring until mixture is almost totally frozen.
11. Lift the comet out of the bowl using the plastic liner and shape it as you would a snowball.
12. Unwrap the comet as soon as it is frozen sufficiently to hold in shape.

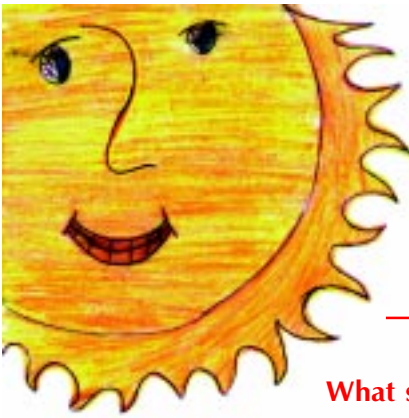
Dry Ice

Dry Ice is the solid form of carbon dioxide gas, a normal part of our earth's atmosphere. Dry ice is available from ice companies in most cities (look under "ice" in your Yellow Pages). CAUTION: Dry ice temperature is -109.3°F . (-78.5°C). Always handle dry ice with care, wearing gloves at all times.

Now you can place the comet on display for the students to watch during the day as it begins to melt and sublimate. The comet is reasonably safe to touch without getting burned by the dry ice, but it is still best to have a spoon or a stick for the students to use while examining it.

As the comet begins to melt, the class may notice small jets of gas coming from it. These are locations where the gaseous carbon dioxide is escaping through small holes in the still frozen water. This type of activity is also detected on real comets, where the jets can sometimes expel sufficient quantities of gas to make small changes in the orbit of the comet.

After several hours, the comet will become a crater-filled ice ball as the more volatile carbon dioxide sublimates before the water ice melts. Real comets are also depleted by sublimation each time they come near the Sun. Ultimately, old comets may break into several pieces or even completely disintegrate. In some cases, the comet may have a solid core that is then left to travel around the comet's orbit like a dark barren asteroid.



Meet the Scientists

Both Nalin and Beatrice are astronomers who became interested in comets after observing Halley's Comet in 1986. They were in different parts of the world: Nalin in Maryland and Beatrice in Germany. Now they work on a team with a third astronomer, Dr. Michael Belton, at the National Optical Astronomy Observatories (NOAO) in Tucson, Arizona.

What she does:

Dr. Beatrice Mueller studies comets and asteroids. She does this by making observations with telescopes, including those of Kitt Peak National Observatory, near Tucson, AZ. Beatrice is especially interested in understanding what comets are made of and what they tell us about the origin of our solar system.



What she was like in high school:

Beatrice grew up in Switzerland and describes herself as a bookworm. She still loves to read, and her favorite types of stories remain mysteries and science fiction. As a girl, Beatrice always liked going to school and was interested in everything. Her fondness for solving mysteries led her academic interests to neurology, then the study of white dwarf stars, and finally comets, after seeing images returned by a spacecraft observing Comet Halley during its 1986 appearance.

What amazing things she has found out:

Beatrice's studies of Comet Hyakutake helped to determine how fast the nucleus rotates by studying the motion of the comet's jets. This in turn gives scientists clues about the form and structure of the coma. Periodic comets rotate in a manner similar to planets as they orbit within our solar system.

What she plans to do next:

She has applied to observe Comet Hale-Bopp in April 1997 with the WIYN telescope on Kitt Peak. She will take visual images of the comet and collect information about the coma's form and structure and how the comet's jets evolve.

What she wants to tell young people:

Beatrice said, Students growing up now may themselves be involved in spacecraft missions making close-up observations of comets. These are very exciting missions which involve a large number of people. You don't have to be a scientist in order to be involved in a mission to space.

What he does:

Dr. Nalin Samarasinha is an astronomer who studies comets. He uses computers to model comets and determine the rotational motions of comets. He uses data from observations in visible wavelengths as well as millimeter wave radio observations to identify and study the chemical species present in the coma.



What he was like growing up:

Nalin grew up in Sri Lanka with his three brothers and sister. Nalin has always liked understanding how things work. He studied physics in Sri Lanka, and then attended the University of Maryland in the USA for a Masters and Ph.D. in astronomy.

What mysteries he has helped uncover:

Nalin used computer modeling together with observations to help uncover secrets of the motions of the nucleus of Comet Halley. He showed that Comet Halley has a wobbling nucleus!

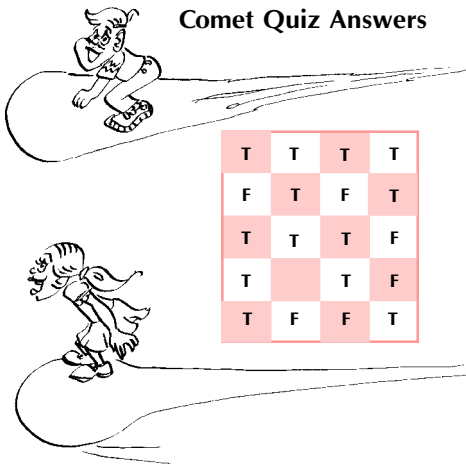
What he plans to do next:

He will study Comet Hale-Bopp as he did Comets Halley and Hyakutake, working on a team with other scientists as part of a combined study approach where all scientists collect their data, then analyze and eventually publish their findings. Nalin will make both optical and radio observations, as well as computer models, to study Hale-Bopp.

His advice to students today:

It is important that as citizens of the 21st century, you do well in math and science. Even if you will be in a non-scientific career, the training you get by learning math and science will help you think in a logical and clear manner and benefit you in our increasingly technological society.

Comet Quiz Answers



T	T	T	T
F	T	F	T
T	T	T	F
T		T	F
T	F	F	T

More Please!



There is a lot more to know about comets than we put in this brochure. Some sources of electronic and printed information are listed below. You should also check out resources in your area such as newspapers, the library, a local amateur astronomy club, or college astronomy department. To really experience Comet Hale-Bopp, you've got to see it for yourself. Those who observe it frequently will get the most out of it. And remember, if you miss it - Comet Hale-Bopp won't make another visit for about 4000 years!

Electronic Sources of Information

The WHY? Files, at <http://whyfiles.news.wisc.edu>

The WHY? Files is an electronic magazine. Updated every two weeks, current science topics from the headlines are presented in a colorful, readable format. The February 20th issue features Comet Hale-Bopp.

**NASA JPL (Jet Propulsion Lab) Comet Page
at <http://newproducts.jpl.nasa.gov/comets/index.html>**

Here you will find current Hale-Bopp information, spectacular images, news releases, and an exciting online Near-Live Comet Watching System to view images of the Comet almost as they are taken around the world.

**NOAO K-12 Educational Outreach Activities
at <http://www.noao.edu/education/noaoeo.html>**

The programs and products of NOAO Educational Outreach are described on these pages of interest to teachers and students. Highlights include a list of *Frequently Asked Questions* about being an astronomer and a classroom activity using NIH Image and data from Kitt Peak to measure the motion of Comet Hyakutake.

Printed Sources of Information

Astronomy Magazine, Sky & Telescope Magazine

Both of these excellent monthly magazines offer current information to astronomy enthusiasts. Recent issues have given extensive coverage of Comet Hale-Bopp; all issues contain sky maps, beautiful color pictures, and updates on issues of interest to amateur and professional astronomers. You can find the magazines in bookstores, libraries, and even grocery store magazine racks in some areas. Anyone with an interest in experiencing Comet Hale-Bopp should pick up a current copy of these magazines.

Machholz, D.E., ***"An Observer's Guide to Comet Hale-Bopp"***, 1996, MakeWood Products. This informative, readable book can be ordered from MakeWood Products, P.O. Box 1716, Colfax, CA 95713. Send \$12 plus postage (\$2 book rate or \$3 priority mail). For more information call (916) 346-8963 or go to URL <http://members.aol.com/donm353259/index.html>.

David Levy's book ***"The Quest for Comets,"*** 1994, Plenum Press, A personal account of comet discovery and comet science from the co-discoverer of Comet Shoemaker Levy-9.



The 4-meter Mayall Telescope on Kitt Peak watches Comet Hyakutake embellish the night sky in March of 1996. Photo copyright, Tod Lauer.

