The Secret

of the

Cardboard Rocket

Teacher's Guide

Produced by:

Hansen Planetarium
15 South State Street
Salt Lake City, Utah 84111

Featuring exerpts from:
"Your Child's Imagination" by Nissa Simon

The Secret of the Cardboard Rocket

TEACHER'S GUIDE

THE SECRET OF THE CARDBOARD ROCKET is a planetarium star program designed using Utah State Curriculum Guidelines for grades K-3 in science. Our story begins when two youngsters discover a cardboard box and decide to make it into a rocket. After asking permission from their mother, they set off on an amazing voyage of exploration through the solar system.

They have brought along everything they need including balloons full of air and an astronomy book. The book talks, but turns out to be a bit timid when it comes to exploring the Sun and planets. The book does provide useful information.

"How are they able to travel to the Sun, Moon and planets in a rocket made of cardboard?" asks their father. The answer to that question is the Secret of the Cardboard Rocket and the theme of the program -- with knowledge and imagination, not even the sky is the limit!

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Imagination , 1. the power of forming pictures or images in the mind of things not present to the senses. A poet, artist, or inventor must have imagination to create new things or ideas or to combine old ones in new forms. **2.** a thing imagined; creation of the mind; fancy. n.

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Summary of "Your Child's Imagination" by Nissa Simon

Below are excerpts from an article which appeared in the August 1985 edition of Parents Magazine.

Whether or not a child lives up to his creative potential depends on the message the child receives from home and school. In the past few years, many teachers expressed concern that the educational system was stifling children's creativity.

True creativity, says the author, requires more than a child's spontaneity and imagination. Dr. Albert Rothenberg defines creativity as "a capacity to produce works that are *both* new and valuable." Dr. Howard Gardner says that creativity is, "the capacity to do something novel or original that will ultimately be accepted as significant by a society."

Dr. Gardner goes on to say that children are not truly creative but instead display originality and imagination. He defines imagination as, "the ability to create worlds that are in some sense counter to fact. Imagination is connected to the world of fantasy, dreaming, and myths."

The article asks the question, "are schools stamping out... imagination and killing creativity in children by teaching them to conform to established ways of working and thinking?" The author of the article seems to think that schools are not to blame for the decline in creativity as students grow older. Instead she cites a normal development toward conformity in children as they grow older.

Teachers can encourage curiosity, imagination, and self-confidence by encouraging children to be independent in their work and their thinking at a very young age. The article recommends "intrinsic motivation," and defines this as, "doing something just because you're interested in it, because you enjoy it, want to learn something from it and feel challenged by it."

The author cautions against rewards: "if children think they are doing something as a means to an end--a reward--it has a negative effect on their originality... A school can promote the notion that there are many different ways of doing things or it can promote the notion that there's only one way of doing things, the right way."

"**Skills are essential**... instilling self-confidence and imagination isn't enough... and that means learning the skills. There are a lot of skills involved in creativity... Good writing, for instance, requires a command of grammar and vocabulary."

Dr. Gardner provides a summary: "The lesson is to allow your children to develop skills and motivation. If you can do that, you'll give them a gift they'll have for the rest of their lives."

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"Mere imagination would indeed be mere trifling; only no imagination is *mere*."
-Charles Sanders Peirce

* * *

"Imagination, not invention, is the supreme master of art as of life."
-Joseph Conrad

* * *

"As a rule, grown-up people are fairly correct on matters of fact; it is in the higher gift of imagination that they are so sadly to seek."
-Kenneth Grahame

* * *

Activities for the Imagination

The objectives of these activities are: to learn about Earth and other planets, use language and art skills, encourage use of libraries, and help develop creativity. The scientific accuracy of the creations may not be as important as the learning, reasoning, and imagination used to construct each invention.

Invent a Planet: Students may create (draw, paint, montage, build from household or classroom items, whatever!) a planet. Does it have air? What color is its sky? Does it have ground? What is its ground made of? What is it like on this world?

Invent an Alien: Students may create (paint, draw, montage, build from household items, etc.) an alien. To be fair to the alien, they should be sure to provide for a way for the alien to get food (what is that food?), a way to breathe (if it needs to), ways to sense the environment, and perhaps a way to move around its planet.

Invent a Rocket Ship: Students may create (paint, draw, montage, build from household or classroom items, whatever!) a rocket ship. How is it powered? How do they provide for the human environment? Have students research basic human needs: food, air, water, temperature.

* * *

"Vision is the art of seeing things invisible."

-Jonathan Swift

* * *

"Without this playing with fantasy no creative work has ever yet come to birth. The debt we owe to the play of imagination is incalculable."

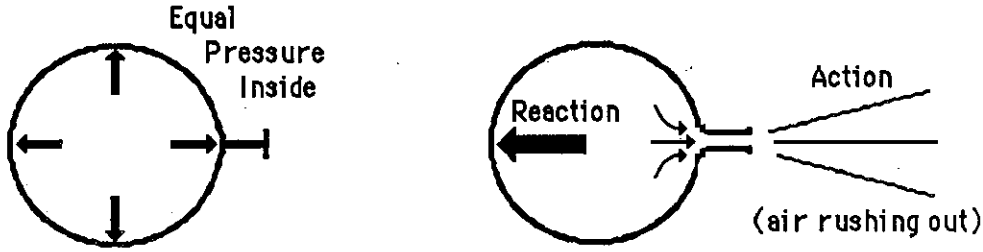
-Carl Gustav Jung

* * *

"Grown-ups never understand anything for themselves, and it is tiresome for children to be always and forever explaining things to them."

-Antoine de Saint-Exupery in The Little Prince

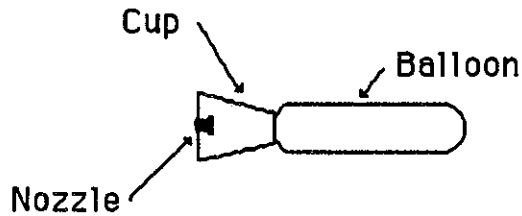
BALLOON ROCKET



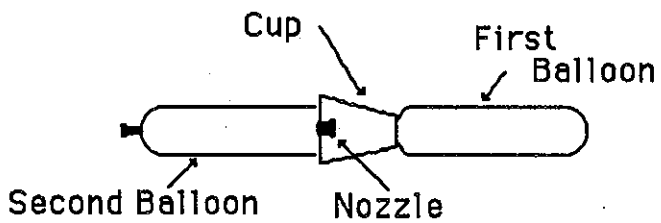
Rocket engines produce "thrust" or push by throwing a large volume of gas at high speeds from the rocket nozzle. The **action** of throwing gases in one direction causes an equal **reaction** in the opposite direction.

TWO-STAGE BALLOON ROCKET

Try this two-stage balloon rocket. **1**) remove the bottom from a styrofoam cup. **2**) Inflate a long balloon and stick the nozzle through the center of the cup. Keep the cup bottom against the balloon. Pull the nozzle through the cup and fold up around the side of the cup. **3**) Hold the nozzle tight against the cup side.



4) Inflate a second balloon and force the end of the second balloon into the top of the cup. This should prevent the first balloon from leaking air. **5**) Launch by holding structure vertically and releasing nozzle of second balloon.



Models of The Solar System

To help students visualize the size of the solar system, models may be used.

Model #1: the space between the planets

Prepare a string about 12 meters long (so that this can be done in the classroom) and mark the positions of the planets with pieces of paper or tape. Have one student hold one end and represent the Sun and other students hold the string at each marked location. Depending on the ages, students may hold cards with the names of the planets written on them or cut-outs representing each planet.

Planet	Average Distance from Sun (in millions of kilometers)	Model Distance	
Mercury	58	11.6 cm	
Venus	108	21.7 cm	
Earth	150	30.0 cm	
Mars	228	45.7 cm	
Jupiter	778	156.1 cm	(1.56 m)
Saturn	1,431	286.2 cm	(2.86 m)
Uranus	2,886	575.4 cm	(5.75 m)
Neptune	4,529	901.8 cm	(9.02 m)
Pluto*	5,936	1183.2 cm*	(11.83 m*)

* Note that although Pluto has a greater average distance from the Sun than Neptune, it is now <u>closer</u> to the Sun than Neptune due to its peculiar (elliptical) orbit. Pluto moved inside Neptune's orbit in 1979 and will remain closer to the Sun until the year 1999.

Model #2: the relative sizes of the planets

	Actual Diameter (in kilometers)	Model Size
Sun	1,400,000	Hot air balloon
Mercury	4,880	Marble
Venus	12,104	Ping Pong Ball
Earth	12,756	Golf Ball
Mars	6,787	Strawberry
Jupiter	142,800	Beach Ball (11 golf balls in dia.)
Saturn	120,000	Basketball (9 golf balls in dia.)
Uranus	50,800	Soccer Ball
Neptune	48,600	Soccer Ball
Pluto	3,000 *	Pea

* Note: The actual diameter of Pluto is uncertain.

Model # 3: the baby and the spaceship

If you were born in a special spaceship at the center of the Sun and immediately sped away at 8,000 kilometers per hour (5,000 miles per hour), which is about ten times faster than commercial jet airliners, you would be 3 1/2 days old when the ship passed through the Sun's surface! You would be 9 months old when you reached Mercury, 19 months old at Venus, 2 years and 2 months old at the Earth, 3 years and 2 months old at Mars, 11 years old at Jupiter, 20 years old at Saturn, 41 years old at Uranus, 64 years old at Neptune, and 84 years of age when you finally reached Pluto!

Background Information on
THE SOLAR SYSTEM

The Solar System consists of the Sun and everything orbiting around it, including nine planets, at least fifty satellites of planets, and countless asteroids, meteoroids, and comets. Planets are bodies which orbit the Sun while satellites of planets are bodies which orbit planets, such as Earth's Moon.

The Solar System can be divided into the "Inner Solar System," and the "Outer Solar System." The Inner Solar System contains small rocky planets with hard surfaces--the "Rocky Midgets:" Mercury, Venus, Earth, and Mars. The Outer Solar System is the realm of the large gaseous planets--the "Gas Giants:" Jupiter, Saturn, Uranus, and Neptune. Pluto belongs to the "Rocky Midget" category. For an explanation of this, see "PLUTO" below.

The Inner Solar System

THE SUN

The Sun is a star. The reason the other stars are not as bright is that they are much farther away. There are many stars bigger that the Sun and many more are smaller. If you weighed fifty pounds on Earth, you would weigh 1,395 pounds at the surface of the Sun. The Sun is about 1,392,000 kilometers in diameter and if it were hollow, more than one million Earths could fit inside.

MERCURY

Mercury, the closest planet to the Sun, is a small, rocky world. Because of its small size (and therefore its weak gravity), it has no atmosphere. On the daytime side, the Sun heats the surface to 425° C, hot enough to melt lead; while the nighttime side cools to -180° C. The surface of Mercury resembles the cratered Moon. Numerous cliffs and scarps, some of which are 2,500 meters high and hundreds of kilometers long, show that the planet probably shrunk as it cooled billions of years ago. One of the largest features on Mercury is the huge Caloris Basin, formed when a large meteroid collided with the planet early in the history of the Solar System. Mercury takes just 88 Earth-days to orbit the Sun and it rotates on its axis only 1 1/2 times during each revolution; there are 1 1/2 "Mercury days" in each Mercury "year."

VENUS

Although Venus is only a little smaller than Earth, it is very different. The thick atmosphere of Venus is mostly carbon dioxide. The clouds, which are made of sulfuric acid, descend no lower than fifty kilometers from the surface and completely blanket the upper atmosphere. Acting like the glass in a greenhouse,

the atmosphere traps radiation from the Sun raising the temperature at the surface to 470° C on the entire planet. The crushing pressure at the surface is 90 times the pressure on the surface of Earth. At high altitudes, wind velocities are hundreds of kilometers per hour, but at the surface, there is almost no wind.

The surface of Venus was mapped using radar signals from a spacecraft, the Pioneer-Venus Orbiter, in orbit around the planet. Two continent-sized land masses were found, along with huge shallow craters and mountains. Lightning near some mountains indicates that these may be active volcanoes. Four Soviet spacecraft have landed on Venus and sent back images for short periods of time until the harsh conditions destroyed their instruments.

EARTH

The water planet, Earth, is about 70% covered with liquid water. Water also exists as a gas in the clouds and as a solid as ice and snow. This planet has a thin crust of rock which is made up of ten gigantic plates. These plates move causing earthquakes and volcanic activity. Earth is the only planet we know of that has living things. Earth is the planet we know best.

MARS

The red planet, Mars, has always fascinated people. With the invention of the telescope, surface features could be detected and those features seemed to change periodically. Thus, Mars was a prime candidate in the search for life beyond Earth. Mars has about half the diameter of Earth. The orbit of Mars is about 78 million kilometers farther from the Sun than the orbit of Earth. For this reason, Mars does not receive as much radiation from the Sun and is cooler, with temperatures ranging from a high of about 5° C to lows of -130° C. Mars has been likened to a cold desert.

The atmosphere of Mars is thin, only about 1/100 as dense as Earth's atmosphere, and is made up mostly of carbon dioxide, with traces of nitrogen and water vapor. Thin, wispy clouds of water vapor are seen at high altitudes and water vapor fog forms in canyons and craters, evaporating each Martian day. Frost forms on the surface of Mars, but there is no liquid water. The north and south polar regions are covered with permanent water ice caps thousands of meters thick, with additional thinner layers of frozen carbon dioxide (dry ice). During the Martian spring, the carbon dioxide in the ice caps evaporates and high speed dust storms traveling at over 300 kilometers per hour race across the surface.

In 1972, the Mariner 9 spacecraft orbited Mars and sent back detailed images of its surface. Surface features showed evidence of wind and puzzling features which looked like dried up river beds. Mariner 9 found a huge canyon 4,000 kilometers long (2,500 miles) and as much as 200 kilometers wide (120 miles), dropping to depths of six kilometers (four miles). Mariner also found a giant extinct volcano, Olympus Mons, three times higher than Mount Everest on Earth,

with a base approximately as big as the state of Utah.

Two Viking spacecraft, launched by the United States in 1975, landed on Mars in the summer of 1976. The information and images they sent back to Earth showed the surface to be desert-like with rocks, bedrock, and wind-blown sand. The reddish color of the soil is due to the presence of iron oxide--rust. The pink color of the sky is caused by suspended dust particles raised by the winds on the surface.

The "Rocky Midgets"

	MERCURY	VENUS	EARTH	MARS
Time to go Around the Sun Once (in days)	88	225	365	687
Average Distance from the Sun (in Millions of Kilometers)	58	108	150	228
Diameter (in kilometers)	4,878	12,104	12,756	6,787
If you weighed 50 pounds on Earth, here is what you would weigh on the planets:	19 lbs	46 lbs	50 lbs	19 lbs
Length of a "day" (time to turn once on its axis).	59 Earth Days!	243 Earth Days!	~24 hours	~24+ hours
What the air is primarily made of:	No air	Carbon Dioxide	Nitrogen & Oxygen	Carbon Dioxide

Earth's Moon, at about 3,500 kilometers in diameter, is about one quarter the size of Earth and orbits Earth at an average distance of about 400,000 kilometers. If you weighed 50 pounds on Earth, you would only weigh about eight and a half pounds on the Moon. The Moon has no air.

The Outer Solar System

JUPITER

Jupiter is the largest planet in the solar system, with 318 times the mass and 1,300 times the volume of Earth. All the other planets could fit inside this giant with room to spare.

Jupiter is covered with a colorful, turbulent, lightning-filled layer of clouds thought to be approximately 1,000 kilometers thick. Jupiter has a rapid rotation (it rotates on its axis once every ten hours), which, combined with the heat radiated from within the planet, creates a turbulent pattern of weather in the atmosphere. Bands of clouds move rapidly past each other in opposite directions with rising and descending areas in between. The Great Red Spot, which has been observed by astronomers for over three hundred years, is a gigantic storm about twice the size of Earth.

Below the clouds, the crushing temperature and pressure would cause hydrogen, the chief component of the planet and its atmosphere, to exist as a liquid. Within this liquid layer, Jupiter may have a solid iron core.

Jupiter has at least sixteen natural satellites orbiting it, and four of them are visible with small telescopes from Earth. These four satellites, which are about the size of the Moon, were discovered by Galileo in 1610. One of the satellites, Io, has active volcanoes.

Other interesting features of Jupiter include auroras near the poles and a thin ring.

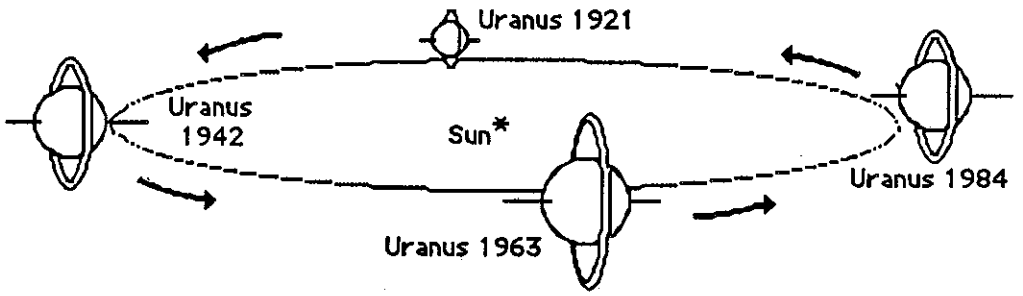
SATURN

Saturn is similar to Jupiter -- a Gas Giant with highly compressed gasses and heat flowing from within the planet. Saturn, like Jupiter, has a turbulent atmosphere. The beautiful ring system extends 100,000 kilometers (62,000 miles) into space, but is only a few kilometers thick (a mile or so). The rings consist of pieces of ice and ice-covered rock. Theories to explain the origin of the rings includespeculation that they were a satellite that got too close to the planet and was ripped apart by gravity. The rings go around the planet about once every fifteen hours.

Saturn has at least seventeen natural satellites. Most are small and are a mixture of ice and rock. One of them, Titan, is larger than the planet Mercury and has an atmosphere.

URANUS

Uranus is another Gas Giant with fifteen satellites and a set of narrow, dark rings. Uranus is pecular in that it lies on it side (the axis of the planet is nearly in the plane of its orbit), as it orbits the Sun.



As Uranus goes around the Sun, the north and south poles periodically point toward the Sun, causing the polar regions to alternately be in sunlight and darkness for up to about 40 years. Uranus takes about 84 Earth years to complete one orbit of the Sun.

NEPTUNE

Little is known about Neptune because it is so far away and no spacecraft has yet passed by this planet. It probably has a solid core of iron and rock about the size of Earth covered with a thick layer of ice and a deep atmosphere of hydrogen, helium, ammonia, and methane. Neptune has two known satellites. One, Triton, may be the largest satellite in the solar system.

PLUTO

Pluto is the smallest planet in the Solar System; its diameter is only about 2,300 kilometers making it smaller than the Moon. It is a frozen, dark world where the Sun appears as a bright star. Pluto's average distance from the Sun is 5,900 million kilometers making it normally the farthest planet from the Sun. Its peculiar orbit occasionally carries it inside the orbit of Neptune, where it is now and will be until the year 1999. It is so cold on Pluto, -230° C, that the atmosphere lies on the ground as ice. Pluto has a natural satellite, Charon, which is about a third the size of the planet. Pluto takes about 248 Earth years to orbit the Sun once. A "day" on Pluto, is 6 1/2 Earth-days long. If you weighed fifty pounds on Earth, you would only weigh two and one half pounds on Pluto! To explain why Pluto, a "Rocky Midget," is found far from the Sun with the "Gas Giants," scientists speculate that Pluto may be a former satellite of Neptune which was drawn away from that planet by an encounter with some large body.

COMETS

Comets, such as the famous Halley's Comet, are like giant dirty snowballs --chunks of ice, gravel, and dust--up to a few kilometers in diameter. Comets seem to originate in a spherical cloud called the Oort Cloud, which surrounds the Sun at a great distance. A disturbance from a passing star may dislodge one of these icebergs and cause it to begin a long journey toward the Sun. As the comet nears the Sun, the solar heat evaporates some of the surface ice and the solar wind pushes the material away forming a thin tail. Astronomers study comets to learn about the composition of the cloud which condensed to form the solar system.

ASTEROIDS

Asteroids are like huge floating mountains of rock orbiting the Sun. They are too small to be called planets but are sometimes referred to as "minor planets." They range in size from boulder-sized chunks of rock to 1,000 kilometers (600 miles) across. Most asteroids are found in a band between the orbits of Mars and Jupiter called the Asteroid Belt.

The "Gas Giants"

	JUPITER	SATURN	URANUS	NEPTUNE
Time to go Around the Sun Once (in years)	12	29	84	165
Average Distance from the Sun (in Millions of Kilometers)	778	1,431	2,886	4,529
Diameter (in kilometers)	142,800	120,000	50,800	48,600
If you weighed 50 pounds on Earth, here is what you would weigh on the planets:	127 lbs	58 lbs	46 lbs	60 lbs
Length of a "day," time to turn once on its axis	~10 hours	~10 hours	~17 hours	~19 hours
What the air is primarily made of:	Hydrogen & Helium	Hydrogen & Helium	Hydrogen & Helium	Hydrogen & Helium

Selected Bibliography

Beatty, O'Leary, Chaikin. The New Solar System. Cambridge: Sky Publishing Corp., 1981. (224 pages, photographs and illustrations) Comprehensive and detailed technical material on the Sun and planets for the teacher.

Bendick, James. The Big Strawberry Book of Astronomy. New York: Strawberry Books, Larousse & Co., 1979. (61 pages, illustrated) Clear, basic explanations and current information on the planets, stars, comets, and asteroids on an elementary student level.

Branley, Franklyn. The Planets in Our Solar System. New York: Thomas Y. Crowell Junior Books, 1981. (34 pages, illustrated) Information and simple activities for students.

Clapham and Taylor. Astronomy Encyclopedia. Chicago: Rand McNally & Co., 1984. (140 pages, photographs & illustrations) General information for students.

Gallant, Roy A. Our Universe. Washington, D.C.: National Geographic Society, 1980. (277 pages, photographs & illustrated) Excellent overview of the Sun and planets, stars, Milky Way Galaxy, and the Universe for students and teachers.

Kaufmann, William J., III. Planets and Moons. New York: W.H. Freeman & Co., 1979. (229 pages, photographs & illustrations) General and technical information for teachers.

Moche, Dinah L.. Astronomy Today. New York: Random House, 1982. (96 pages, illustrated) Covers planets, stars, and space exploration. Excellent diagrams explain day/night, seasons, and night sky for students.

Muirden, James. Our Universe. New York: Warwick Press, 1980. (91 pages, photographs and illustrations) Good detailed information, current and comprehensive -- for students.

Raymo, Chet. 365 Starry Nights. Englewood Cliffs, New Jersey: Prentice-Hall, 1982. (225 pages, illustrated) Best book for learning the constellations and naked-eye astronomy for students and teachers.

Sagan, Carl. Cosmos. New York: Random House, 1980. (363 pages, photographs & illustrations) The best overall book covering history of astronomy, planets, stars, galaxies, and life in the Universe for teachers.

Additional Resources

ABRAMS SKY CALENDAR
Abrams Planetarium
East Lansing, MI 48824-1324
($5.00/year)

Outstanding monthly sky guide. Shows only sky events and planets positions visible to the unaided eye.

ASTRONOMY
Box 92788
Milwaukee, WI 53202
($21.00/year)

Excellent articles and astro-photography. Contains monthly guide to the night sky.

WONDERS of the UNIVERSE CALENDAR
Hansen Publications
15 South State Street
Salt Lake City, Utah 84111
($7.95)

Contains beautiful photographs of astronomical objects and much information on sky viewing and astronomy subjects.

ODYSSEY
Box 92788
Milwaukee, WI 53202
($16.00/year)

Geared for younger readers. Contains will written articles and photographs on science and astronomy.

NATIONAL GEOGRAPHIC WORLD
17th & M Streets, N.W.
Washington, D.C. 20036
($9.95/year)

Student level articles on science, geography, people, and other topics.

NATIONAL GEOGRAPHIC SOCIETY
BOX 2895, WASHINGTON, D.C. 20013
($15.00/Year)

Teacher and student level articles.

Articles on the Solar System from National Geographic:

Weaver, K.: "Mariner Unveils Venus and Mercury" (June 1975)
Weaver, K.: "First Explorers on the Moon" (December 1969)
Schmitt, H.: "Exploring Taurus-Littrow" (September 1973)
Gore, R.: "Sifting for Life in the Sands of Mars." (January 1977)
Gore, R.: "Voyager Views Jupiter." (January 1980)
Gore, R.: "Saturn: Riddle of the Rings." (July 1981)
Weaver, K.: "What You Didn't See in Kohoutek." (August 1974)