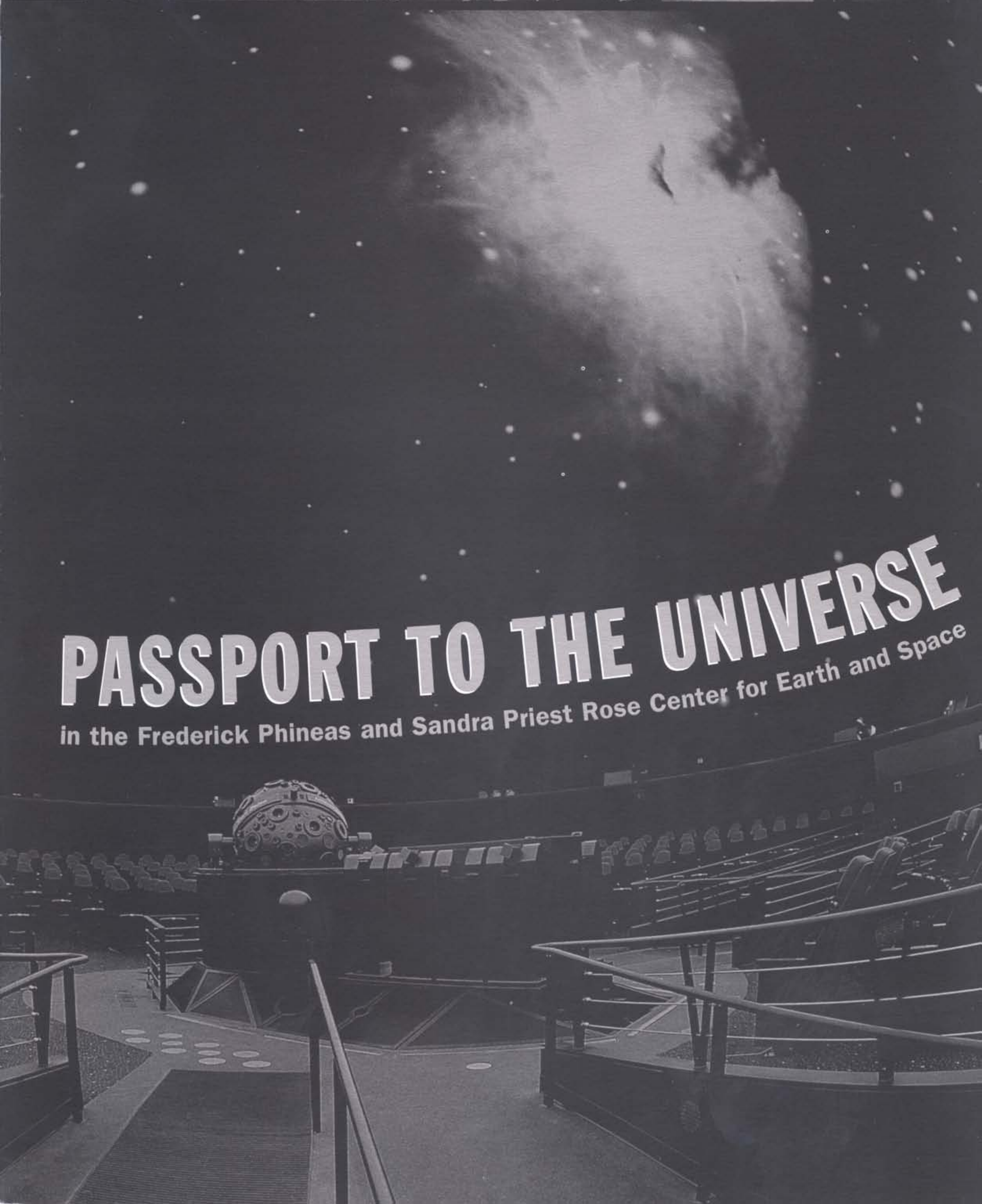
AMERICAN MUSEUM OF NATURAL HISTORY

PASSPORT TO THE UNIVERSE

in the Frederick Phineas and Sandra Priest Rose Center for Earth and Space



TO BEGIN YOUR JOURNEY...

Students can observe the night sky, record their observations, and discuss what they saw in class. Try asking the following questions:

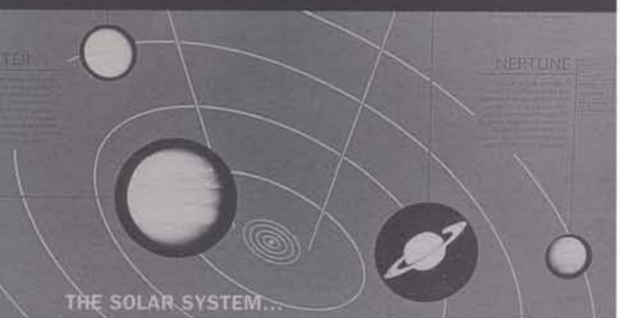
Do you know how many stars you can see with the naked eye?
ANSWER: About 6,000.

How many stars are there in one galaxy?
ANSWER: Over 100 billion.

How many galaxies can we possibly observe with giant telescopes? ANSWER: Scientists estimate the number is over 100 billion.

ON YOUR JOURNEY YOU WILL VISIT...


THE EARTH...


THE SOLAR SYSTEM...


THE MILKY WAY...


THE VIRGO SUPERCLUSER...


AND THE OBSERVABLE UNIVERSE.

TEACHER INTRODUCTION

Passport to the Universe, the inaugural show in the new Hayden Planetarium, will take you and your students well beyond the two-dimensional view of the night sky. Your students will take a virtual voyage through the three-dimensional universe and come to understand, in a way never before possible, the astronomical meaning of space and scale. Museum scientists have taken data from the Hubble telescope, star catalogs, and observatories, and loaded them into computers. From that data they have modeled pieces of the universe, turning them into representations of three-dimensional worlds for the first time. These images of planets, stars, nebulae, and galaxies are projected onto the inner surface of the dome by seven powerful video projectors and a customized, one-of-a-kind Zeiss Star Projector, the most advanced in the world.

With this Guide, you can follow the itinerary of this virtual voyage: from Earth to the edge of the Solar System, to the edge of the Milky Way, to the Virgo Supercluster, to the farthest limits of the observable universe.

BEFORE YOUR VISIT TO THE SPACE SHOW

Astronomy is a big subject. It's full of gigantic objects, enormous distances, incredible speeds, and vast spaces—"it's astronomical." As Neil de Grasse Tyson, director of the Hayden Planetarium explains it, astronomers are constantly comparing BB's to beach balls to get across the bigness of the universe.

The Space Show takes students far beyond anything they can observe with the naked eye. On a clear night, outside of urban areas, you can typically see 3–4,000 stars in the night sky. With the Zeiss, we can project 9,000 stars. And the database of the digital video system contains millions of stars.

Another way to prepare students is to help them learn their "long address," also known as the Cosmic Address. This Guide and the accompanying Rose Center Guide have images that explain the concept of the Cosmic Address. **Each level, starting with Earth, is part of the next level**. You can also use the magazine *Our Place in Space* "Don't Be Lost in Space, Learn Your Long Address." (Your students will each receive a copy of this magazine when they visit the Rose Center).

Younger students may need to start the address with the school, city, and state, which will help them understand changes in scale. Then continue with the Earth, the Solar System, the Milky Way Galaxy, the Virgo Supercluster, and the Observable Universe. These will all be "stops" in "Passport to the Universe." Assign your students a single level of the address and ask them to speculate on what it would be like to travel to this level and look back at how far they have come. Use the information in this guide to help your students research each level.

Older students can do mathematical exercises to explore the sizes and scales at each of these levels (also use the number exercises featured in the article "The Milky Way Galaxy" in *Our Place in Space*). The Rose Center Teacher's Guide will help students use the Hayden sphere and the Size Scales of the Universe walkway to explore scales in three different ways: algebraically, kinesthetically (by taking steps), and visually.

Finally, review the glossary in the Rose Center Teacher's Guide with your students before their visit, particularly the terms **light year, planet, star, galaxy, nebula**, and **universe**.

THE SPACE SHOW: *PASSPORT TO THE UNIVERSE*

Pre-show

As you await clearance to enter the Space Show, you'll be introduced to the concepts of light years and the Cosmic Address again. You'll learn how scientists used information gathered over centuries to arrive at our current view of the universe.

Prologue

At the start of the show, the new Hayden Edition Zeiss projector rises into view and students are given information about the kind of data they are about to see —the data that make the show possible. Schematic computerized structures of the various databases and coordinate systems supporting the digital universe

ON YOUR JOURNEY YOU WILL LEARN...

THE EARTH is about 8,000 miles in diameter and is one of eight planets orbiting the Sun (a star), ranging in distances from the Sun of tens of millions of miles to billions of miles.

The Planet Zone, in the Cullman Hall of the Universe, and the Gottesman Hall of Planet Earth have additional information on the Earth and our solar system. Students can also learn about Mars and why scientists think there are eight, not nine, planets on page 4 of *Our Place in Space*.

The Sun and its orbiting planets make up our **SOLAR SYSTEM**. The Sun is one of millions to billions of stars in our immediate neighborhood, each one of which may also have a system of planets like our solar system. The nearest star is 4.1 light years away. To understand this distance, students might want to use the average speed of a passenger jet (about 600 miles per hour) to calculate how long it would take to get to the next star.

There are billions of stars, along with clouds of gas and dust, in the **ORION NEBULA**. In the show, the size of the stars in the nursery may seem small. Students may need to discuss the continually changing scales in the Space Show, relating size to distance. The **MILKY WAY GALAXY** (MWG) contains at least 100 billion stars, along with regions called nebulae, where gas and dust are concentrated. A galaxy, seen from a distance, looks like a cloud of stars.

The Star Zone in the Hall presents information about the variety of stars; students can compare our sun to other stars. The Big Bang Theater captures the first moments of the cosmos, from which all elements, including those that make up stars and our bodies, derived.

The Galaxy Zone in the Rose Center has information and images of galaxies of different shapes.

The **LOCAL GROUP** and other clusters of galaxies are themselves clustered into superclusters. Ours is called the **VIRGO SUPERCLUSTER** because its center is in the direction of the constellation Virgo. It contains thousands of galaxies, each with as many as a billion stars.

The Milky Way does not extend indefinitely. Near its edge, the density of stars diminishes greatly. To understand this structure, think of the sky on a partly cloudy day. One cloud ends, there is blue sky and then the next cloud begins. Similarly, in space, one galaxy ends, there is virtually starless space and then the next galaxy begins. There are perhaps 100 billion galaxies in the observable universe, arranged in clusters. Our cluster is called the Local Group and consists of about 20 galaxies, each separated from its nearest galactic neighbor by several times its own diameter.

The Galaxy Zone has information about colliding galaxies. Galaxies are separated by distances 20 times their diameters on average, but stars within a galaxy are separated at distances of a hundred million times their diameters. Students can investigate stellar and galaxy collisions at **www.amnh.org**.

When we look out into the deepest space in any direction, we see galaxies organized into clusters and superclusters. The limit of our observation is roughly 20 times the size of the average supercluster. That defines our **OBSERVABLE UNIVERSE**.

Looking out into space is essentially looking back in time. But just how old is the universe? In the Universe Zone of the Hall your students can find out how the universe began, how forces like gravity have shaped the universe, and how scientists use light to measure distance.

are introduced. For the planets, the celestial coordinates, solar system orbits, moons, and rings are needed. The star representations require local positions, colors, and magnitudes. The galaxy program includes images of the Milky Way and galactic coordinates, as well as gas and dust nebulae, globular clusters, extra-solar planetary systems, and pulsars. For the observable universe, the local group of galaxies and the Virgo Supercluster complete the checklist. Even late-breaking astronomical images can be added.

THE EARTH

The first image your students will see is a dazzling spectacle of the night sky free of clouds and pollution. Even the dusty band of the Milky Way can be seen arcing across the sky. Ancient people studied the sky and discovered patterns that could be shaped into pictures. They named these constellations after mythical creatures and heroes.

Even today students can study and learn about constellations to recognize the patterns in the night sky. Using telescopes, we discovered that the sky has a third dimension—depth—and that the universe is far grander than anyone could have imagined.

THE SOLAR SYSTEM

In the second level of the Cosmic Address, our place in space as one of a series of planets orbiting a central star, our sun, is revealed. Moving out to the edge of the solar system, our virtual voyage takes us through a series of near-encounters with planets. As we leave the solar system, we look back to see where we came from. This is a powerful way to grasp the place of the Earth and the other planets in the larger scheme of things. From out here, the sizes of and distances between the Earth, Sun, and other planets appear relatively small. On our trip, we pass three of the eight planets—Mars, Jupiter (and its moons, Io and Europa), and Saturn.

We now head out for the stars, but the nearest star (after our sun) is more than 5,000 times farther away than the distance traveled so far—the radius of the planetary system.

THE ORION NEBULA IN THE MILKY WAY GALAXY

The Orion Nebula is one of many nebulae that produce stars. In this next level, students will visit this vast cloud of gas in which new stars and planets form—a stellar nursery. Stars are not permanent; they are born from the substance of these clouds, live out their lives converting some of their matter to energy, then ultimately die. The most massive stars live short, energetic lives and burst apart in great explosions, while others experience a more moderate life and death. The Sun, born in a cloud like the Orion Nebula almost 5 billion years ago, will live another 5 billion years before it swells into a larger, redder form, then shrinks to about the size of Earth and gradually cools to a dim, burned-out object.

Students may wonder what possible relevance the births and deaths of distant stars (other than the Sun) have for us. The answer is that without them, we would not be here to ask the question. The complex chemistry of life would be impossible without the heavy elements that make up the bulk of living things. In the moments following the Big Bang, about 13 billion years ago, only the lightest chemical elements—hydrogen and helium—formed. It was not until the first stars formed in these stellar nurseries some time later that heavier elements like carbon and oxygen could be forged from the lighter ones in the furnace-like cores of stars. Many of these stars exploded at the end of their lives, spewing out heavy-element products to mix in with clouds from which new stars and planets formed. Thus, the heavy elements from which Earth and the living things upon it (including us) formed were cooked up long ago inside stars that have long since died.

THE VIRGO SUPERCLUSTER AND THE LOCAL GROUP

Our virtual journey in *Passport to the Universe* now takes us outside our Milky Way Galaxy to our Local Group. Galaxies exist in many different sizes and shapes; for the most part they are grouped in clusters by the binding force of gravity. The force of gravity holds these clusters of galaxies in still larger groups—superclusters throughout the universe.

THE OBSERVABLE UNIVERSE

As the voyage continues to the edge of the known universe, 13 billion light years from Earth, we look back and try to find the Milky Way Galaxy and home. There may be as many as 100 billion galaxies in the observable universe, each with millions of stars, many perhaps with planets.

The Return to Earth

For a number of years, astronomers have speculated that black holes—extremely dense collapsed matter—might provide "tunnels" for quickly traveling from one part of the universe to another. This is scientific speculation with no observed evidence to support it. But everything else you have experienced in this tour is based directly on observations.

Visit the Cullman Hall of the Universe

After the Space Show, continue your exploration of the universe in the Cullman Hall of the Universe and visit the four Zones.

BACK IN THE CLASSROOM

To consolidate the concepts introduced in the Space Show, hold a post-visit discussion about the virtual voyage. One way to start is to ask students what they found most interesting, or what part of the show they liked most.

Can the class collectively recall the sequence of objects visited? Have them create a mural or collage illustrating the concept of the Cosmic Address.

Can your students estimate the magnitude of the distances covered? In the Space Show, the scale of the map changed: first at lift off, to get from the Earth out into the Solar System; next, to leap from the Solar System to the realm of the stars in the Orion Spiral Arm; finally, to enter intergalactic space from the Milky Way Galaxy to other galaxies in the Local Group.

In addition to writing their thoughts, younger students can draw pictures or build physical models, then arrange them in sequence. Using excerpts from this Guide and their own words and images, they can create a collage of the show or a brochure for other classes in the school. Older students who are skilled in mathematics can use distance data to calculate speeds or other correlations.

See the Rose Center Teacher's Guide for more suggestions on Hall activities relating to scale and distance.

NEW YORK STATE LEARNING STANDARDS

(For all levels—Elementary, Middle, and High School)

Standard #4—Science

Students will understand and apply scientific concepts, principles, and theories pertaining to the physical setting and living environment and recognize the historical development of ideas in science. KEY IDEA: *Physical Setting*—The Earth and celestial phenomena can be described by principles of relative motion and perspective.

Standard #6—Interconnectedness: Common Themes

Students will understand the relationships and common themes that connect mathematics, science, and technology and apply the themes to these and other areas of learning. KEY IDEA: *Magnitude and Scale*—The grouping of magnitudes of size, time, frequency, and pressures or other units of measurement into a series of relative order provides a useful way to deal with the immense range and the changes in scale that affect the behavior and design of systems.

The accompanying Rose Center Teacher's Guide supports these and other New York State teaching standards.

FOR MORE INFORMATION ON THE ROSE CENTER FOR EARTH AND SPACE, go to our website at www.amnh.org

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