Maynard F. Jordan Planetarium

Hubble Vision 2

Edited by Leisa Preble

Mission Statement:
The mission of the Maynard F. Jordan Planetarium of the University of Maine is to provide the University and the public with educational multi-media programs and observational activities in astronomy and related subjects.

Cosmic Classroom

Looking for fun and interesting space activities? The planetarium staff has prepared a collection of materials we call the Cosmic Classroom for you to use before and/or after your visit. These materials are entirely for use at your own discretion and are not intended to be required curricula or a prerequisite to any planetarium visit. The Cosmic Classroom is one more way that the Jordan Planetarium extends its resources to help the front line teacher and support the teaching of astronomy and space science in Maine schools.

The lessons in this Cosmic Classroom have been edited and selected for the range of ages/grades that might attend a showing of this program at the Jordan Planetarium. Those activities that are not focused at your students may be adapted up or down in level. Our staff has invested the time to key these materials to the State of Maine Learning Results in order to save you time.

The State of Maine Learning Results performance indicators have been identified and listed for the program, the Cosmic Classroom as a package, and each individual activity within the package. The guide also includes related vocabulary and a list of other available resources including links to the virtual universe. We intend to support educators, so if there are additions or changes that you think would improve, PLEASE let us know.

Thank you, and may the stars light your way.

The Maynard F. Jordan Planetarium Staff

The Program – Hubble Vision 2

Hubble Vision combines the splendor of the cosmos, brought into focus by the Hubble Space Telescope, with a spellbinding narrative to take you on a journey through the universe. Using the latest images from the orbiting observatory, we uncover new views of the planets; peek into star birth nurseries; catch visions of star death in its many forms; explore distant star clusters and galaxies; and experience views of the universe when the earliest galaxies were first coming into being.

We catch glimpses of solar system objects, including Comet Shoemaker-Levy 9's crash into Jupiter. We witness the cataclysmic aftermath of supernovae in the Crab Nebula. We see breathtaking views of colliding galaxies; jets shooting from active galactic nuclei, powered by super massive black holes; the eerie effects of gravitational lenses; and deep-field views of the most distant galaxies ever seen.

We're very glad that you have chosen to visit our planetarium with your group. We hope that this guide either will help you prepare your group or help you review their experience at the University of Maine's sky theater.

State of Maine Learning Results Guiding Principles

The lessons in this guide, in combination with *Hubble Vision 2*, help students to work towards some of the Guiding Principles set forth by the State of Maine Learning Results. By the simple act of visiting the planetarium, students of all ages open an avenue for self-directed lifelong learning. A field trip encourages students to think about learning from all environments including those beyond the schoolyard. A Jordan Planetarium visit also introduces visitors to the campus of the largest post-secondary school in Maine and encourages them to think of this as a place which holds opportunities for their future education, enjoyment and success.

Other sites on the University campus, including three museums, explore a variety of subjects, and the Visitors Center is always willing to arrange tours of the campus. A field trip can contribute to many different disciplines of the school curriculum and demonstrate that science is not separate from art, from mathematics, from history, etc. The world is not segregated into neat little boxes with labels such as social studies and science. A field trip is an opportunity for learning in an interdisciplinary setting, to bring it all together and to start the process of thinking. For a more complete discussion of field trips, please visit the Jordan Planetarium web site at http://umainesky.com.

If used in its entirety and accompanied by the Planetarium visit this guide will help students to:

Become **a clear and effective communicator** through

A. oral expression such as class discussions, and written presentations
B. listening to classmates while doing group work, cooperation, and record keeping.

Become **a self-directed and life long learner** by

A. introducing students to career and educational opportunities at the University of Maine and the Maynard F. Jordan Planetarium.
B. encouraging students to go further into the study of the subject at hand, and explore the question of "what if?"
C. giving students a chance to use a variety of resources for gathering information

Become **a creative and practical problem solver** by

A. asking students to observe phenomena and problems, and present solutions
B. urging students to ask extending questions and find answers to those questions
C. developing and applying problem solving techniques
D. encouraging alternative outcomes and solutions to presented problems

Become **a collaborative and quality worker** through

A. an understanding of the teamwork necessary to complete tasks
B. applying that understanding and working effectively in assigned groups
C. demonstrating a concern for the quality and accuracy needed to complete an activity

Become **an integrative and informed thinker** by

A. applying concepts learned in one subject area to solve problems and answer questions in another
B. participating in class discussion

State of Maine Learning Results Performance Indicators

In conjunction with the Maynard F. Jordan Planetarium show *Hubble Vision 2,* this guide will help you meet the following State of Maine Learning Results Performance Indicators in your classroom.

Grades 6-8

Science and Technology –

A2. Models

a. Compare different types of models that can be used to represent the same thing in order to match the purpose and complexity of a model to its use.

A4. Scale

b. Use proportions, averages, and ranges to describe small and large extremes of scale.

B1. Skills and Traits of Scientific Inquiry

a. Identify questions that can be answered through scientific investigations

b. Design and safely conduct scientific investigations including experiments with controlled variables.

c. Make accurate observations using appropriate tools and units of measure.

C1. Understandings of Inquiry

b. Explain why it is imp0rtant to identify and control variables and replicate trials in experiments.

C4. History and Nature of Science

c. Describe scientists' exploration of space and the objects they have found.

D1. Universe

b. Explain the motions that cause days, years, phases of the moon, and eclipses.

c. Describe the location of our solar system in its galaxy and explain that other galaxies exist and that they include stars and planets.

D3. Matter and Energy

a. Describe that all matter is made up of atoms and distinguish between/among elements, atoms, and molecules.

e. Explain how the relatively small number of naturally occurring elements can result in the large variety of substances found in the world.

i. Use examples of energy transformations from one form to another to explain that energy cannot be created or destroyed.

9-D

Science and Technology -

A4. Scale

b. Mathematically represent large magnitudes of scale.

B1. Skills and Traits of Scientific Inquiry

b. Design and safely conduct methodical scientific investigations, including experiments with controls.

c. Use statistics to summarize, describe, analyze, and interpret results.

e. Use a variety of tools and technologies to improve investigations and communications.

C2. Understandings About Science and Technology

a. Provide an example that shows how science advances with the introduction of new technologies and how solving technological problems often impacts new scientific knowledge.

D1. Universe

a. Compare and contrast distances and the time required to travel those distances on Earth, in the solar system, in the galaxy, and between galaxies.

c. Outline the age, origin, and process of formation of the universe as currently understood by science.

D4. Force and Motion

a. Describe the motion of objects using knowledge of Newton's Laws.

Performance Indicators Snapshot

The Show

<u>Grades 3-5</u>

Science and Technology
C2.a;D1.c
English Language Arts
E1.a

<u>Grades 6-8</u>

Science and Technology
B1.e,f; C4.b;D1.b,c; D3.b,f; D4.c;
Social Studies – Geography
D1.b

<u>Grades 9-D</u>

Science and Technology
C3.a,b,c; C4.d; D1.a,b,c;

The Guide

<u>Grades 6-8</u>

Science and Technology
A2.a; A4.b; B1.a,b, c; C4.b; D1.c; D3.a,i

<u>9-D</u>

Science and Technology
A4.b; B1.b,c,e; C2.a; D1.c; D4.a

Seeing Stars

Objectives and State of Maine Learning Results Performance Indicators:

1. Learners will be able to demonstrate how the Hubble Space Telescope “sees” stars. (9-D. Science and Technology. C2.a)
2. Learners will be able to describe how telescopes are one of the ways that scientists explore space and gather data about the universe (9-D. Science and Technology. C2.a)
3. Learners will be able to explain how the Hubble Space Telescope has helped scientists learn more about stars. (6-8. Science and Technology. C4.b)

The General Idea:

The reconfigured Hubble Space Telescope has been producing incredible high-resolution pictures of celestial objects that are superior to any produced by a land-based telescope. The Hubble will remain in space for years, capturing light from distant objects and radioing images to NASA scientists on Earth. The images are transmitted byte by byte in numerical form (binary code) to waiting computers that store the data and interpret the numbers used to reassemble the images into high resolution photographs.

There’s no way you're going to duplicate the imaging process in a classroom, of course. What you can do, though, is demonstrate in simple terms just how the process works. (This activity is adapted from an activity created by the Exploratorium, San Francisco, CA.)

Getting Ready:

- Set up the slide projector in a large dark room (We recommend a gymnasium) and focus a recognizable slide at a distance of about 20 feet.
- Hold up a sheet of paper in the beam to focus the projector. Be sure the focus point is in the middle of the room. If it's near a wall, the image will be too easy to make out (you want the image to be in focus on the paper you hold in the middle of the room, NOT on the wall).

What You Need:

Slide projector
A color slide of a clearly defined object, such as Saturn
One flat, white dowel rod, 1/2" x 36"
A sheet of white paper
A very dark room

What To Do:

1. Turn on the projector to reveal the unidentifiable image on the wall.
2. Hold the white dowel rod in one hand, and slowly move it up and down, perpendicular to the projector beam, at the focus distance. Ask the students to try to make out the picture.
3. Gradually increase the speed of the rod's movement. When the rod is moving very fast, the image will become very clear.

What To Discuss:

1. This activity demonstrates the imaging process used by the Hubble Space Telescope. By slowly moving the rod across the projector's beam, at a point where a projection screen is usually located, small fragments of the

image are captured and reflected ("radioed") toward the students. Because the fragments are quickly forgotten, the addition of many more fragments, as the rod continues to move, confuse the image in the student's mind. However, as the rod is moved more rapidly, an important property of the eye comes into play. Light images are momentarily retained on the retina of the eye. This property is called "persistence of vision." As the rod is moved rapidly, each image fragment remains just long enough to combine with other fragments to form a recognizable image. In this activity, the eye is an analogy of the image processing computer that stores numerical image fragments - collected and radioed to Earth by the Hubble Space Telescope - and reassembles them for use.

Continuations/Extensions:

1. Using a flat rod positioned at varying heights on "hurdle" supports, project the image as in step #1. The images "data" can then be recorded on graph paper by the students. This also accurately exemplifies the light detector matrix or CCD (Charge Coupled Device) sensor in the telescope, digital cameras, and camcorders.

Black Holes: The Ultimate Abyss

Lee Ann Hennig, Thomas Jefferson High School for Science and Technology, Alexandria, Virginia.

OBJECTIVES:

1. Learners will be able to understand essential ideas about the composition and structure of the universe and the Earth's place in it. (9-D. Science and Technology. D1.c)
2. Learners will be able to understand energy types, sources, and conversions, and their relationship to heat and temperature. (6-8. Science and Technology. D3.i)
3. Learners will be able to understand basic concepts about the structure and properties of matter. (6-8. Science and Technology. D3.a)
4. Learners will be able to understand motion and the principles that explain it. (9-D. Science and Technology. D4.a)

Materials:

Only research materials are required for this activity. You might want to have a selection of sources on hand in the classroom, but students should go to the library or the Internet for additional research.

- Reference materials on black holes
- A computer with Internet access

Procedures:

1. Review with your students what they have learned about black holes.
2. Make sure they understand that, while black holes have characteristics in common, they differ with regard to size. Explain that black holes come in three sizes: stellar mass black holes,` supermassive black holes, and mini-black holes. Explain further that particular characteristics are associated with each size.
3. Divide the class into three teams, and assign each team to research one of the black-hole types discussed above.
4. Tell students that each team will prepare a presentation based on its research, which should include the following:
   - characteristics of the type of black hole
   - lifetime of the type of black hole
   - locations (or suspected locations) of the type of black hole
   - evidence for existence of the type of black hole
5. Tell students to keep track of the sources for their facts so that they or other interested classmates can go back to those sources for further information.
6. Encourage students to include visuals in their reports.
7. After each team has presented its report, invite students to participate in creating on the chalkboard a compare-and-contrast chart showing the similarities and differences among the three types of black holes.

Adaptions for Older Students:

Have each team member submit a detailed written report on one of the four items included in the team's report: characteristics, lifetime, locations, and/or evidence of existence.

Discussion Questions:

1. Discuss how Newton's view of gravity differs from Einstein's view of gravity.
2. Describe how a black hole is formed from the time a massive star begins its collapse.
3. Knowing that density is defined as mass per unit volume, discuss the mathematical characteristics of a singularity (values of mass, density, volume, and radius).

4. Describe the steps involved in determining the mass of a black hole. What do you have to measure or observe in order to estimate the mass?
5. If you were observing a probe entering the event horizon of a black hole, you would see it "hovering for an eternity and destroyed in an instant." Discuss the meaning of this phrase as it applies to conditions near a black hole.
6. Discuss the objective of the Gravity Probe B satellite and its relevance to the study of gravity.

Extensions:

Fantastic Tales

Have students discuss the paradoxes associated with black holes and speculate on the possibility of using black holes for time travel. Following the discussion, have students choose from the following activities:

1. Collect several examples of short stories based on black holes. Compare the stories with regard to scientific accuracy and the function of black holes in the plots. In each case, describe how the author portrays the relationship between the characters and the black hole. Is the black hole treated like a character, event, place, or all three?
2. Write an original short story, narrative, poem, song, or news article about space travel near, through, or inside a black hole. Focus on the reactions and experiences of each of the characters as they come face to face with the abyss.
3. Collect examples of references to black holes in music and television. Describe how black holes are used in these works and what reactions they elicit. When have black holes been used as the focus of comedy or as a metaphor for something else (like helplessness or greed)?

Breaking Free

Astronomers use the term *escape velocity* to refer to the minimum speed necessary to break free from the pull of gravity of a planet, moon, star, or black hole and not be pulled back. To appreciate the limits imposed by mass, have students research and compare the escape velocities for objects on the moon, Earth, Jupiter, the sun, Rigel, a white dwarf, a neutron star, and a black hole. With these comparisons in mind, have the class debate future plans for space exploration.

Evaluation:
You can evaluate each group's written product using the following three-point rubric:

- **Three points:** report well-researched, information clearly and logically organized, presentation interesting and lively

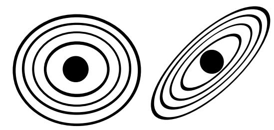
- **Two points:** report adequately researched, information sufficiently organized, presentation dull

- **One point:** report insufficiently researched, information inadequately organized, presentation poorly prepared

You can ask your students to contribute to the assessment rubric by determining a minimum number of facts to be presented in a report and setting up criteria for an interesting and lively presentation.

Classifying Galaxies

<u>Objectives and State of Maine Learning Results Performance Indicators:</u>



1. Learners will be able to describe the different types of galaxies (6-8. Science and Technology. D1.c)
2. Learners will be able to use scale drawings to appropriately represent galaxies (6-8. Science and Technology. A4.b)
3. Learners will be able to place galaxies in their appropriate place on the tuning fork diagram (9-Diploma. Science and Technology. B1.b,c)

<u>The General Idea:</u>

Through this lesson students will become familiar with the Hubble Tuning Fork Diagram, a system of classification, still in use today, for galaxies invented in the 1920's by the noted astronomer Edwin Hubble. Students will practice the technique, useful in science, of engaging a scheme or plan to classify objects in a group. In this lesson you will be able to look at images of different kinds of galaxies, taken by the world's best telescopes. In most high school astronomy texts and in some Earth science texts, the Hubble Tuning Fork Diagram is presented as a way to classify, or put into groups, the various types of galaxies observed in space. This lesson also reinforces the idea that there are many "right" answers in science.

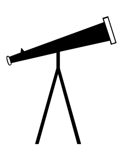
<u>Getting Ready:</u>

- For this lesson you will need nine pictures of galaxies selected for differences in observable characteristics (i.e. color, size, shape, etc.). We recommend photographs from one of these WWW sites http://www.astr.ua.edu/normal2.html OR http://www.astro.princeton.edu/~frei/Gcat_htm/cat_ims.htm Please note that it is helpful if you select one galaxy for each of those on the Tuning Fork Diagram below and all in color. You can also use the images provided at the end of this activity, however they eliminate the category of color when classifying them.

<u>What You Need:</u>

Nine pictures of galaxies
Chalkboard or overhead projector for recording class key.
Paper and pencils for student group recording.

<u>What To Do:</u>



<u>Part I:</u>

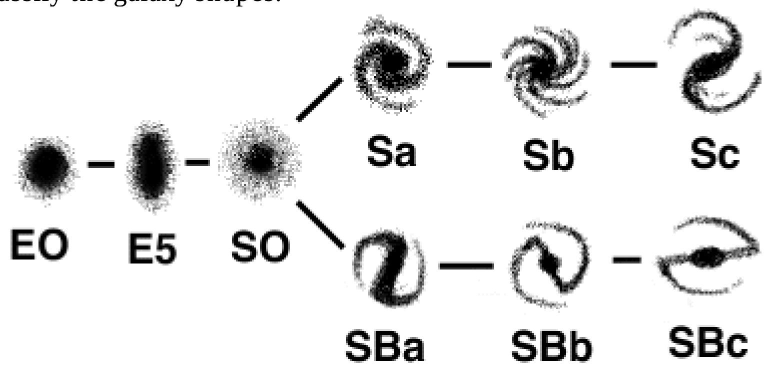
1. Display the pictures of galaxies and discuss their similarities and differences.
2. Ask a volunteer to divide the photographs into two groups using an observable characteristic (i.e. blue and not blue, round and not round, etc.).
3. Record results of first division.
4. Continue to divide groups of pictures, using a different characteristic each time, until only one photograph remains in each group. Continue recording results.
5. Using the class key, identify "unknown" pictures (optional).

Part II:

6. Divide class into groups of four to six students.
7. Provide each group with a sample set of photographs or display the first set (numbered) in a place where all the students can observe them.
8. Ask each group to devise and test a way of classifying galaxies that is different from the class key and have them record their results.

<u>What To Discuss:</u>

1. Tell students about how in the 1920's Edwin Hubble, an astronomer, gathered pictures of many galaxies. When he noticed that they were not all alike, he decided to group, or classify them. To group the galaxies in the photographs he studied, he could have used any of the ways that your students came up with, and perhaps he did. Hubble decided to classify galaxies by their shape or form. He created the following diagram, which is still used today, to classify the galaxy shapes.



The first type of galaxy is an "elliptical" galaxy. The word elliptical refers to its degree of "roundness". Hubble used the letter "E" to stand for elliptical galaxies.

The second type of galaxy Hubble called a "spiral" galaxy. It reminded him of a pinwheel or whirlpool. He used the letter "S" to stand for spiral galaxies.

The third type of galaxy reminded Hubble of a spiral with a solid bar across the center. He called it a "barred spiral" galaxy. He used the letters "SB" to stand for barred spirals.

2. Early photographic processes and small telescopes could not capture color very well, if at all. Especially the most distant galaxies were too faint to capture color. These may have been reasons that Hubble did not clasify galaxies by color.

<u>Continuations/Extensions:</u>

1. Repeat activity with other objects such as potato chips, candy, shoes, etc.
2. Emphasize that the way Hubble chose is not the only way to classify galaxies.
3. After each group has devised and tested a way of classifying galaxies that is different from the class key, have the class discuss the differences and similarities in the systems that were designed.

Numbering the Stars

Objectives and State of Maine Learning Results Performance Indicators:

1. Learners will be able to demonstrate the size of our galaxy (6-8. Science and Technology. D1.c.)
2. Learners will be able to conduct scientific investigations in order to comprehend the number of stars in our galaxy. (6-8. Science and Technology. B1.b)
3. Learners will be able to understand that using sand to represent stars is a practical use of a scale model. (6-8. Science and Technology. A2.a)
4. Learners will be able to use note-taking effectively while gathering data, and separate that data appropriately. (6-8. Science and Technology. B1.a)
5. Learners will be able to use the appropriate unit of measure for the experiment they are conducting. (6-8. Science and Technology. B1.c)
6. Learners will be able to compare sizes and distances of scale stars to those of real stars (9-Diploma. Science and Technology. A4.b)
7. Learners will be able to form generalizations about other galaxies and make predictions about the number of stars in those galaxies (6-8. Science and Technology. D1.c)
8. Learners will be able to use measurement tools and units appropriately and recognize limitations in the precision of the measurement tools. (9-Diploma. Science and Technology. B1.e)

The General Idea:

Comprehending the enormousness of 200 billion of anything is difficult for most people. Take the number itself for instance. How long do you think it would take to count to 200 billion? At one number a second, would you believe almost 6,400 years! Or consider height, a stack of 200 billion pennies would stretch 286,000 km, or three-fourths of the distance from the Earth to the Moon.

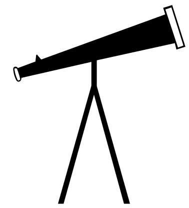
Astronomers often use 200 billion as the approximate number of stars in our galaxy, but most of us really cannot appreciate a number that large. This activity will help students develop a sense of number scale, understand the concept of volume, and develop scientific estimation, measurement and data analysis skills.

Getting Ready:

- The day before this activity, have your students make their own one-centimeter cube. You can photo copy the one at the end of this lesson for your students to cut out and glue together, or have them measure and make their own using a metric ruler. If you use the second option, make sure to tell the groups to use the metric rulers to draw the template accurately!
- Do the activity and calculations yourself before trying it with your class! You need to know how large a resultant volume to expect. This volume can vary drastically depending on the size of the sand grains you are using. The size of the sand grains also affects the length of time the activity takes to do, which needs to be determined in advance. Students may need anywhere from 5 to 30 minutes of counting time, depending on the size of the sand grains. (About 10 minutes is needed for one-millimeter diameter sand grains.)
- Make a set of three demonstration cubes: one each of 1cm, 10cm, and 1m on a side. You can make the cubic-centimeter cube using the template below. Make a similar template for the 10cm cube. You can tape meter sticks together to make a cubic-meter cube (but you will need 12 of them!) or pick up a box from a furniture store and cut it down to the right size.
- Filter the sand using a set of screen sieves to eliminate the finer grains. The sand does not need to be uniform, but all the grains need to be large enough to be easily counted (a diameter of one millimeter, on average). A sieve for flour or sugar works well.
- Introduce your students to galaxies before beginning the activity. This introduction may be handled in many different ways and may combine such elements as class discussion, homework reading selections, viewing and discussion of a video, viewing of slides and photographs, and so on. Your objective with this introduction is to

expose students to basic information such as: the description of a galaxy; the general structure of galaxies; and the name of our own Galaxy, the Milky Way.

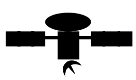
What You Need:



Medium to coarse sand, about 200 ml, sifted to obtain fairly large grains
Paper cubes
Paper and pencils
1cm, 10 cm, 1m demonstration cubes

What To Do:

1. Explain to your students that our galaxy, the Milky Way, consists of approximately 200 billion stars. Ask if anyone can explain their concept of how big a number that is. Ask students how big a box they would need to store 200 billion bricks. (about 525 m on each side). The responses should make the point that students may know that 200 billion is 200 thousand million, but they are not likely to have any idea of the space that would be occupied by that many objects.
2. Tell the students that this activity will help them gain a better understanding of how many stars 200 billion really is. Ask them to imagine that they can take every star in our galaxy and scale it down until it is the size of a grain of sand. Sand grains vary in size and star sizes vary far more drastically, but tell them to imagine that the average star has been shrunk to the average size of a grain of sand which will be used during the following experiment as a model for a star.



3. Count out 10 grains of sand onto a sheet of paper and ask the students to imagine that they continue to count until all 200 billion of them have been piled into a cube. Ask your students to estimate how big a cube they would have in the end. Then show the class the 1cm cube and ask the students to estimate how many would be needed to hold 200 billion grains of sand in total. Do the same with the 10cm cube. Make sure that each student writes down the two estimates records her/his estimates for later reference.

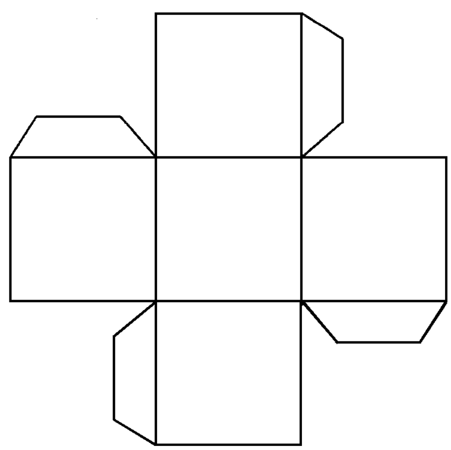
Now we will move on to the "meat" of the activity:

4. Combine your students into groups of two to three students each.
5. Have each group pick up one cubic centimeter of sand by using the cubic centimeter they made the day before.
6. Each group should dump their "stars" onto a piece of scratch paper.
7. Suggest that the groups *do not* count out loud.
8. Record the total count of sand grains from each group in the class, and together with the class calculate a class average for the number of stars in one cubic centimeter.
9. Divide the total number of stars, (200 billion) by the class-average. The number you get is the volume of the pile of stars in cubic centimeters. (i.e. it would take x number of cubic centimeters to hold 200 billion grains of sand). The equation looks like this: 200,000,000,000 / class average.
10. This number is still huge to the point of being meaningless. So a larger unit is needed to express this huge volume in a way that will be more meaningful to the students. The unit one cubic meter should bring the number down to understandable size for the students. To do this, first calculate the number of cubic centimeters in a cubic meter, (there are 100 centimeters in a meter, so the calculation would be 100 X 100 X 100 = number of cubic centimeters in a cubic meter) then use the answer to divide your total (your equation would be answer from first equation / answer from second equation = # of cubic meters needed to hold 200 billion grains of sand).
11. While the results depend entirely on the size of the sand grains being used, your students will generally find that all the stars in our galaxy would be represented by a pile of sand which has a volume of about 500 cubic meters, enough to fill a *very* large classroom to the ceiling!

What To Discuss/Extensions:

1. With the number of cubic meters in mind, ask your students if they think that the room would hold that much sand. Have your students measure the dimensions of your classroom and calculate the room's volume in cubic meters.
2. After the visual image of the room full of sand, or even overflowing, has had some time to sink in, remind students of the true sizes of stars (Most stars like the Sun have an equatorial diameter of about one million kilometers.) and that within our galaxy stars are many trillions of kilometers apart. With this information, your students may finally begin to have some sense of just how big our galaxy is.
3. If the stars were indeed the size of grains of sand, how far apart would they be? You may want to have students do this calculation as homework, using the same math skills developed in this lesson. For this activity students will need to find out how large an average star, such as the Sun, is and also how far apart the stars are, such as from the Sun to the next closest star, Proxima Centauri. (For grains about 1.3 mm on a side, the average spacing of stars in our solar neighborhood would place the grains about 40 miles apart!)
4. Discuss the relationship between the number of stars in our galaxy and the number of stars in the universe. Ask your students to contemplate the fact that there are about as many galaxies in the universe as there are stars in our galaxy. Have them calculate the approximate number of stars in the universe on the assumption that every galaxy has about the same number of stars.
5. Have your students change the scale for a star so that some larger object, such as a baseball, represents a star, and have them calculate the volume of the resulting cube of 200 billion baseballs.

Below is a template for the 1 cm cube. Please note that the size is approximate and that you will need to measure and make your own so that it is exactly 1 cm!



Vocabulary List

Axis	An imaginary straight line around which an object rotates.
Astronomical Unit - AU	The average distance from the Earth to the Sun, 93million miles.
Black Hole	An object with a gravitational field so strong that light cannot escape from it. It is believed to be created in the collapse of a very massive star.
Centimeter	A metric unit of length equal to 0.01 meter.
Classify	To arrange or put objects into categories.
Constellation	A grouping of stars, considered by humans to form a picture in the sky. Often related to mythology.
Data	factual information (as in measurements, statistics, etc.) that can be used as a basis for reasoning, discussion, calculation, etc.
Day	The time it take for a planet to make one full rotation (on Earth, 24 hours).
Diameter	The distance from one side of an object to another as measure through the center.
Elliptical	Shaped like an ellipse or oval.
Galactic cluster	Galaxies tend to cluster together, sometimes in small groups and sometimes in enormous complexes, these are often called galactic clusters.
Galaxy	A very large groups of stars and associated matter of which there are billions found throughout the universe.
Gravity	The force of attraction between two objects which is influenced by the mass of two objects and the distance between the two objects.
Mass	A measure of the amount of material an object contains, which causes it to have weight in a gravitational field.
Meter	The base unit of length in the International System of Units that is equal to the distance traveled by light in a vacuum in 1/299,792,458 second or about 39.37 inches.
Moon	A natural satellite orbiting a planet.
Orbit	A specific path followed by a planet, satellite, etc.
Planet	A massive object orbiting a star.
Radio Galaxy	A galaxy that is a powerful source of radio waves.
Relative Distance	The distance between two objects as compared to something else.
Relative Size	The size of an object as compared to another object.
Revolution	The circling of a smaller object around a larger object.
Rotation	The spinning of an object on its axis.

Scale	Reducing all objects and distances by a percentage so that they are within a workable size.
Scale Model	A model of an object that is a percentage of its actual size.
Singularity	A point or region of infinite mass density at which space and time are infinitely distorted by gravitational forces and which is thought to be the final state of matter in a black hole.
Solar System	The system of planets, moons, and other objects revolving around a star (in our case, the Sun).
Space Probe	A vehicle designed to travel and explore remote locations in space and return information to astronomers and scientists.
Space-time	A system of one temporal (time) and three spatial coordinates by which any physical object or event can be located. Also called the space-time continuum.
Spiral	Winding around a center or pole and gradually receding from or approaching it.
Star	a massive, self-luminous celestial body of gas that shines by radiation derived from its internal energy sources.
Sun	Sol, the star that is closest to Earth and from which we get heat and light energy.
Supernova	The explosion of a very large star in which the star may reach a maximum intrinsic luminosity one billion times that of the sun.
Telescope	A device used to form magnified images of distant objects.
Universe	The vast expanse of space which contains all of the matter and energy in existence.
Volume	The amount of space occupied by a three-dimensional object as measured in cubic units.
Year	The time it takes for a planet to make one full revolution around a star, in our case, the Sun (on Earth, 365.25 days).

Some good books to use with *Hubble Vision 2*

Mysteries of Deep Space: Black Holes, Pulsars, and Quasars
Isaac Asimov. Gareth Stevens Publ., 1994.

Prisons of Light: Black Holes
Kitty Ferguson. Cambridge University Press, 1996.

Our Solar System
Simon, Seymour. 1992, Morrow Junior Books

The Planets in Our Solar System
Branley, F. 1986, Harper & Row.

Postcards from Pluto: A Tour of the Solar System
Leedy, Loreen. 1993, Holiday House.
Dr. Quasar gives a group of children a tour of the solar system

I Didn't Know The Sun is a Star
Petty, Kate. 1997, Copper Beech Books

Galaxies
Ferris, T. 1980 Stewart, Tabori & Chang.
Lavishly illustrated introduction to the large-scale cosmos by a noted science writer.

Galaxies
Hodge, P. 1986, Harvard U. Press.
A thorough introduction to our modern understanding of galaxies.

Galaxies
Simon, Seymour. 1988, Morrow Junior Books.
Identifies the nature, locations, movements, and different categories of galaxies.

Galaxies
Sipiera, Paul P. 1997, Children's Press.
Examines what a galaxy is, the different types that exist, and some facts learned from them.

Galaxies and Quasars
Kaufmann, W. 1979, Freeman.
Clear basic guide to what lies beyond our Milky Way Galaxy.

Our Vast Home: The Milky Way and Other Galaxies
Asimov, Isaac. 1995, G. Stevens Pub.
Provides an insider's view of our own Milky Way and discusses the nature and behavior of galaxies in general.

Some good web sites to use with *Hubble Vision 2*

www.galaxies.com/ start.php?homepage=true
An informative page about galaxies put together by an amateur astronomer

space.jpl.nasa.gov
NASA's Jet Propulsion Laboratory Solar System Simulator web site
tes.asu.edu/dsn_solarsyst.html

A Solar System tour (with images) compiled by Ken Edgett, Arizona State University

ssd.jpl.nasa.gov
A site about our solar system maintained by the Solar System Dynamics Group of the Jet Propulsion Laboratory

www.nineplanets.org
A Multimedia Tour of the Solar System from the Students for the Exploration and Development of Space

Lessons From The World Wide Web

Also, a wide variety of lesson plans and activities can be found on the World Wide Web. These sites are dedicated to lesson planning in a variety of subjects.

btc.montana.edu/ceres
Maintained by the Burns Telecommunications Center, this page links to educational activities and classroom resources

spaceplace.jpl.nasa.gov/en/kids/
This California Institute of Technology and NASA Jet Propulsion Laboratory site for kids offers information and activities

school.discoveryeducation.com/
This Discovery Channel education site allows teachers to search for lesson plans by grade and subjects

www.eduref.org/Virtual/Lessons/index.shtml
Lesson plans submitted by teachers throughout the United States

www.thegateway.org
Sponsored by The U.S. Department of Education's National Library of Education and ERIC Clearinghouse on Information & Technology, this site offers lesson plans for all subjects and all grades

Astronomy Web Sites Worth a Visit

www.galaxymaine.com
The Maynard F. Jordan Planetarium and Observatory home page

www.galaxymaine.com/SA/SA2.htm
The teacher resources and bibliography page on the Maynard F. Jordan Planetarium web site

www.solarviews.com/eng/homepage.htm
This web site presents a vivid multimedia adventure unfolding the splendor of the Sun, planets, moons, comets, asteroids, and more, written and maintained by Calvin J. Hamilton

stardate.org
Learn what’s going on TODAY in astronomy on the “Star Date” web page, maintained by the University of Texas’ McDonald Observatory

domeofthesky.com/clicks/constlist.html
Find out the names of each constellation and the stories behind those names

The Maynard F. Jordan Planetarium does not guarantee that the information given on the above web sites to be accurate, accessible, or appropriate for students.