THE THOUSAND-YARD MODEL (OR THE EARTH AS A PEPPERCORN)

ACTIVITY D-7

GRADE LEVEL: ALL

What's This Activity About?

On the surface, this activity is very similar to "Toilet Paper Solar System Scale Model," and also to "Solar System Scale." The Thousand-Yard Model is both a participatory activity and a teacher-led tour. What really sets it apart is Ottewell's wonderful narrative and encouragement for relating more about the planets and their unique characteristics while the tour proceeds. This is an outstanding activity for teachers new to astronomy. Depending on the facts included, this tour can be done for any grade level.

What Will Students Do?

Using mostly common objects (pinheads, foods, and balls of various sizes from BBs to eight-inches across), students help to create a distance and scale model. The resulting tour of the solar system is based on pacing off the approximate distances to the planets.

Tips and Suggestions

- The actual distances used here are not as precise as those in the other two activities mentioned above, since the lengths of students' and teachers' paces will vary.
- The activity is useful as an introduction to the planets, relating their position about the Sun to some of their characteristics like temperature, size, number of moons, and composition.
- For earlier grades, the spacing of planets will probably be the most dominant concept. Consider using larger color pictures of the planets in addition to the scaled objects.

What Will Students Learn?

Concepts
Planetary Size and Spacing

Inquiry Skills
Comparing
Describing
Measuring
Inferring

Big Ideas
Scale
Structure
Models and Simulations

Can you picture the dimensions of the solar system? Probably not, for they are of an order so amazing that it is difficult either to realize or to show them.

You may have seen a diagram of the Sun and planets, in a book. Or you may have seen a revolving model of the kind called an orrery (because the first was built for an Earl of Orrery in 1715). But even the largest of such models—such as those that cover the ceilings of the Hayden Planetarium in New York and the Morehead Planetarium at Chapel Hill—are far too small. They omit the three outermost planets, yet still cannot show the remaining ones far enough apart.

The fact is that the planets are mighty small and the distances between them are almost ridiculously large. To make any representation whose scale is true for the planets' sizes *and* distances, we must go outdoors.

The following exercise could be called a Model, a Walk, or a Happening. I have done it more than twenty times with groups of varied ages (once we were televised) or with a single friend; and others, such as elementary-school teachers, have carried it out with these instructions. Since it is simple, it may seem suitable for children only. It can, indeed, be done with children down to the age of seven. Yet it can also be done with a class consisting of professors of astronomy. It will not waste their time. They will discover that what they thought they *knew*, they now *apprehend*. To take another extreme, the most uncontrollable high-school students or the most blasé college students unfailingly switch on their full attention after the first few paces of the excursion.

There is one other party that may profitably take the planet-walk, and that is yourself, alone. Reading the following description is no substitute: you must go out and take the steps and look at the distances, if the awe is to set in.

First, collect the objects you need. They are:

Sun—any ball of diameter 8 inches.
Mercury—a pinhead, diameter .03 inch.
Venus—a peppercorn, diameter .08 inch.
Earth—a second peppercorn.
Mars—a second pinhead.
Jupiter—a chestnut, pecan, or gooseberry, diameter .9 inch.
Saturn—a filbert (hazelnut) or acorn, diameter .7 inch.
Uranus—a peanut or coffeebean, diameter .3 inch.
Neptune—a second peanut or coffeebean.
Pluto—a third pinhead (smaller, if possible, since Pluto is the smallest planet).

You may suspect it is easier to search out pebbles of the right sizes. But the advantage of distinct objects such as peanuts is that their rough sizes are remembered along with them. It does not matter if the peanut is not exactly .3 inch long; nor that it is not spherical.

A standard bowling ball happens to be just 8 inches wide, and makes a nice massive Sun, so I couldn't resist putting it in the picture. But it may not be easy to find and certainly isn't easy to carry around. There are plenty of inflatable balls which are near enough in size.

The three pins must be stuck through pieces of card, otherwise their heads will be virtually invisible. If you like, you can fasten the other planets onto labeled cards too.

Begin by spilling the objects out on a table and setting them in a row. Here is the moment to remind everyone of the number of the planets—9—and their order—MVEMJSUNP. (This *mvemonic* could be made slightly more pronounceable by inserting the asteroids in their place between Mars and Jupiter: MVEMAJSUNP.)

The first astonishment is the contrast between the great round looming Sun and the tiny planets. (And note a proof of the difference between reading and seeing: if it were not for the picture, the figures such as "8 inches" and ".08 inch" would create little impression.) Look at the second peppercorn—our "huge" Earth—up beside the truly huge curve of the Sun.

Having set out the objects with which the model is to be made, the next thing is to ask: "How much space do we need to make it?"

Children may think that the table-top will suffice, or a fraction of it, or merely moving the objects apart a little. Adults think in terms of the room, or a fraction of the room, or perhaps the corridor outside.

To arrive at the answer, we have to introduce scale. *This peppercorn is the Earth we live on.*

The Earth is eight thousand miles wide! The peppercorn is eight hundredths of an inch wide. What about the Sun? It is eight *hundred* thousand miles wide. The ball representing it is eight inches wide. So, one inch in the model represents a hundred thousand miles in reality.

This means that one yard (36 inches) represents 3,600,000 miles. Take a pace: this distance across the floor is an enormous space-journey called "three million six hundred thousand miles."

Now, what is the distance between the Earth and the Sun? It is 93 million miles. In the model, this will be 26 yards.

This still may not mean much till you get one of the class to start at the side of the room and take 26 paces. He comes up against the opposite wall at about 15!

Clearly, it will be necessary to go outside.

Hand the Sun and the planets to members of the class, making sure that each knows the name of the object he or she is carrying, so as to be able to produce it when called upon.

You will have found in advance a spot from which you can walk a thousand yards in something like a straight line. This may not be easy. Straightness of the course is not essential; nor do you have to be able to see one end of it from the other. You may have to "fold" it back on itself. Ideally, it should be a unit that will make a good story afterwards, like "All the way from the flagpole to the Japanese garden!"

Put the Sun ball down, and march away as follows. (After the first few planets, you will want to appoint someone else to do the actual pacing—call this person the "Spacecraft" or "Pacecraft"—so that you are free to talk.)

- 10 paces. Call out "Mercury, where are you?" and have the Mercury-bearer put down his card and pinhead, weighting them with a pebble if necessary.
- Another 9 paces. Venus puts down her peppercorn.
- Another 7 paces. Earth.

Already the thing seems beyond belief. Mercury is supposed to be so close to the Sun that it is merely a scorched rock, and we never see it except in the Sun's glare at dawn or dusk—yet here it is, utterly lost in space! As for the Earth, who can believe that the Sun could warm us if we are that far from it?

The correctness of the scale can be proved to skeptics (of a certain maturity) on the spot. The apparent size of the Sun ball, 26 paces away, is now the same as that of the real Sun—half a degree of arc, or half the width of your little finger held at arm's length. (If both the size of an object and its distance have been scaled down by the same factor, then the angle it subtends must remain the same.)

- Another 14 paces. Mars.

≈ 36 paces to Asteroid Belt

Now come the gasps, at the first substantially larger leap:

- Another 95 paces to Jupiter.

Here is the "giant planet"—but it is a chestnut, more than a city block from its nearest neighbor in space!

From now on, amazement itself cannot keep pace, as the intervals grow extravagantly:

- Another 112 paces. Saturn.
- Another 249 paces. Uranus.
- Another 281 paces. Neptune.
- Another 242 paces. Pluto.

You have marched more than half a mile. (The distance in the model adds up to 1,019 paces. A mile is 1,760 yards.)

To do this, to look back toward the Sun ball which is no longer visible even in binoculars, and to look down at the pinhead Pluto, is to feel the terrifying wonder of space.

That is the outline of the Thousand-Yard Model. But be warned that if you do it once you may be asked to do it again. Children are fascinated by it enough to recount it to other children; they write "stories" which get printed in the school paper; teachers from other schools call you up and ask you to demonstrate it.

So the outline can bear variation and elaboration. There are different things you can remark on during the pacings from one planet to the next, and there are extra pieces of information that can easily be grafted on. These lead forward, in fact, to the wider reaches of the universe, and make the planet walk a convenient introduction to a course in astronomy. But omit them if you are dealing with children young enough to be confused, or if you yourself would prefer to avoid mental vertigo.

I recommend that you stop reading at this point, carry out the walk once, and then read the further notes.

Establishing the scale

While you are talking and introducing the idea of the model, it may be helpful (depending on the age of the audience) to build up on a blackboard something like this:

	real		*in model*
Earth's width	8,000 miles		8/100 inch (size of peppercorn)
Sun's width	800,000 miles		8 inches
therefore scale is	100,000 miles	⇨	1 inch → = 1 pace
therefore	3,600,000 miles	⇨	36 inches or 1 yard
and Sun-Earth distance	93,000,000 miles	⇨	26 yards

Follow-up

Having come to the end of the walk, you may turn your class around and retrace your steps. Re-counting the numbers gives a second chance to learn them, and looking for the little objects re-emphasizes how lost they are in space.

It works well, in this sense: everyone pays attention to the last few counts—"240 . . . 241 . . . 242"—wondering whether Neptune will come into view. But it does not work well if the peanut cannot be found, which is all too likely; so you should, if you plan to do this, place the objects on cards, or set markers beside them (large stones, or flags such as the pennants used on bicycles).

Also, the Sun ball perhaps cannot be left by itself at the beginning of the walk—it might be carried off by a covetous person if not by the wind—so send someone back for it when the walk has progressed as far as Mars.

(I once, having no eight-inch ball, made a colored paper icosahedron, and had to give chase from afar when I saw someone appropriating it. On the return from another walk, I met a man holding his mouth while his worried companion said "Did you bite it?"—incredibly, he had picked up one of the peppercorns! The other edible planets are, of course, prey for passers-by. Hazards like these may be regarded as our model's counterparts of such cosmic menaces as supernovae and black holes.)

On each card, the child who recovers it may write briefly the place where it was—"At 5th Street," "At John Cabonie's house" . . . Then, back in the classroom, the objects are kept in a row on a shelf, as a reminder of the walk. Or they may be hung on strings from a rafter.

Since pecans, pinheads, peanuts and especially peppercorns cannot always be readily found when another demonstration is called for, I keep at least one planetary system on hand, in one of the small canisters in which 35-millimeter film is sold.

Looking at the real things

Anyone you take on this planet-walk may finish it with a desire to set eyes on the planets themselves. So it is best to be able to do it at a date when you can say: "Look up *there* after dark and you will see [Jupiter, for instance]."

Thus on the first nights of 1990, when darkness falls, Jupiter will be the brightest "star" high in the east of the sky, and Venus will be the brightest one setting in the west.

For any other specific times, consult the *Astronomical Calendar*, the magazines *Sky & Telescope* or *Astronomy*, or a local college science department, planetarium, or amateur astronomer.