waves and earthquakes," he complained.

"It is necessary to have scientists express themselves as scientists in issues of major importance for which their knowledge is relevant to the process of decision making. At the same time, scientists should refrain from speaking as scientists (they are of course at liberty to speak as citizens) on issues where their knowledge is inadequate or too peripheral. More important, they should make their premises clear. If they are against any atomic armaments, let them say so; it is a respectable and completely understandable position, but it makes further criticism of the testing or development of an atomic weapon irrelevant."

Mayer termed recent disputes between pro-environmentalists and pro-agriculturalists on DDT [undoubtedly referring primarily to Barry Commoner vs. Norman E. Borlaug] a "dialogue of the deaf" filled with "wild statements on both sides" that failed "to point out that what you're dealing with is a risk-benefit ratio that makes it very important to understand the facts."

Scientists have a responsibility to speak out in areas of their competence, Mayer concludes. "At the same time, if we want our fellow citizens to believe what we say or even simply to take it seriously . . . we must refrain from being carried away by advocacy to the extent that we pick and choose among facts only those which support the cause we are advocating . . . ."

Mayer's adjuration raises many difficult questions: What exactly is one scientist's area of competence? Don't some scientists have a broader range than others? Can a scientist himself determine when he is speaking as a scientist and when as a citizen? All these matters are sure to be brought into future discussions of scientists' ethical responsibilities. □

Bye-bye, galaxies: The universe may be twice as large as thought

Measuring the distances to external galaxies can help astronomers in attempts to determine the size, shape and history of the universe. Particularly important is the relationship between the distance of a galaxy and the velocity at which it appears to be receding from the observer. An observer standing anywhere in an expanding universe should see all external galaxies receding from him, and the farther away they are, the faster they should be going.

The recession velocities can be determined from the redshifts of the galaxies' light. The velocities should be in direct proportion to the distance, but translating one to the other is difficult because the constant of proportionality, the Hubble constant, is a matter of dispute. Its value has been mostly estimated rather than observed, and there have been 50 years of argument over how to do that. Now astronomers are attempting to measure galactic distances independently of redshift, thereby hoping to get a good observational value for the Hubble constant, which measures the age of the universe as well as distance.

One such attempt, reported at the AAAS meeting in Philadelphia last week by George O. Abell of the University of California at Los Angeles, may double the size and age of the visible universe.

One way to measure the universe is to rely on the apparent dimming of distant objects: An object of the same intrinsic brightness (magnitude) will appear dimmer the farther away it is.

External galaxies come in clusters, and one way used to obtain a scale of distances is to compare the apparent magnitude of the brightest galaxy in each with that of the brightest galaxy of a nearby cluster, the Virgo cluster, whose distance has been measured by other means.

Abell objects that this is not a very reliable method. The assumption that the brightest galaxies in all clusters have about the same intrinsic brightness may not hold. If some are brighter than others, he says, "you might get a ringer," a cluster that appears to be closer than it really is.

Working with graduate students John Mottman, Donald Gudehus, Edwin Krupp and Stephen Eastmond, Abell found a feature that he believes makes a more accurate comparison possible. They were tallying the numbers of galaxies in each of several distant clusters with various apparent magnitudes. They found that in each case the graph of number versus apparent magnitude assumed a similar shape: The very brightest galaxies were few. At a few magnitudes below the brightest was a clump of galaxies, dozens to hundreds, says Abell, of nearly the same apparent magnitudes.

It is this hump at the bright end of the graph that Abell thinks is a better criterion for distance measurement. It appears in all the clusters studied, including the Virgo cluster, and it is less likely statistically to be biased by a few extrabright ringers. Applying it, Abell and his students get a value for the Hubble constant of about 47 kilometers per second per megaparsec (a megaparsec is about 3.26 million light-years). This compares to a value of 75 obtained by Allan R. Sandage of the Hale Observatories using the other method. The Abell value for the constant increases the size of the observed universe and its age by 50 percent or more: to 15 or 20 billion years (and light-years) rather than the currently accepted 10 billion.

The accuracy of distances measured by Abell depends not only on the appropriateness of his method but also on the accuracy of the distance to the Virgo cluster, which is derived from the distance to one of its members, M87.

Sandage determined the distance to M87 by comparing the brightness of globular star clusters associated with it with the globular clusters of a nearer galaxy, the Andromeda nebula. If the distance to M87 should have to be revised upward, Abell's distances would go up, and his value of the Hubble constant would go further down.

The Hubble constant is a constant for galaxies fairly near to us, the observations of which represent a situation that is more or less contemporary with us in cosmological terms. At the edges of the observed universe we are seeing things as they appeared billions of years ago. In those days the Hubble constant may have been different.

The space of the universe is supposed to be curved, and whether that curvature is open (the three-dimensional analogue of a curve like a hyperbola) or closed (the three-dimensional analogue of a circle) is a matter of dispute. Temporal changes in the Hubble constant depend on the curvature. Abell and Laura Pat Bautz of Northwestern University and W. W. Morgan of the Yerkes Observatory have begun a study of the velocity-distance relation for the most distant galaxy clusters. So far they have found such a wide scatter of data that they cannot say the data favor one or the other possibility. But this itself is significant, says Abell, because earlier attempts to determine the universal curvature all came out on the closed side. This one would allow the open curvature equal possibility.