THE INTERMEDIATE TEACHER AND ASTRONOMY

by Roland Petersen

This essay was presented as a speech by Mr. Roland Petersen at one of the sectionals of the annual convention sponsored by the P.R.T.I. in October, 1975. Mr. Petersen serves as principal at Covenant Christian High School and teaches an Earth-Space Science course.

This is not intended to be an "apologia" for the teaching of astronomy at intermediate level. This could easily be the subject of another paper at a later date. Let it suffice to say that the writer considers that astronomy should and must be taught in the intermediate grades and that the objective of the teacher is that the students gain mastery of a certain mass of material.

The main difficulty in science instruction today is not paucity of material. Texts, numerous high-interest books, and easy-to-use equipment are readily available. If there is a problem, and I believe there is, the problem is teacher preparation. Most of us, even those who have majored or minored in the sciences, have never had the opportunity to take a formal course in astronomy or teaching astronomy. At best (or worst!) most intermediate teachers have studied astronomy only as a short unit in a watered-down physical science course, a course that is required by many colleges of "non-science majors." In the remainder of this paper I would like to suggest and briefly comment upon the content of a minimum course which we shall entitle "Astronomy for the Intermediate Teacher."

Before we begin to develop this course of study let's emphasize once again that science below junior high school level should stress **observation** and **identification** rather than theory. The formal study of matter, mass, energy, atoms, molecules, elements, weight, gravitation, inertia, the kinetic theory, motion, and so forth can well wait until the seventh or eighth grades. By the time the student enters junior high school, however, the bright stars and well-known asterisms, several planets, the sun and the moon, and certain "deep-sky" objects should be old friends, friends to be called by name. Polaris, Vega, Arcturus, Cygnus, Orion, Betelgeuse, Alcor-Mizar, Luna, Sol, M-13, M-31, The Pleiades, the Milky Way, the Great Square, the Summer Triangle, the Keystone, the Northern Crown... are but a sampling of the riches of the celestial sphere, one of the pages of that "most elegant book" of God's universe. The student also should have made the acquaintance of the more common trees and shrubs, wild and garden flowers, birds, insects, fishes, and mammals, both wild and domestic - to name a few. It is a sad commentary upon education that, of all those who graduate from high school or college, only a small handful learn to read and enjoy the magnificent pages of God's "Book of Creation."

I am reminded of my father, and others like him, who, with only an eighth-grade or lesser education, put me and most of us to shame. As, in his old age, he walks the fields and woods of his native Michigan, he reads the book with profound enjoyment, calling things animate and inanimate by their names - often by their Latin names! To this day a walk with my father through the fields and woods of his small farm ranks as one of

life's greatest pleasures. Geology, botany, zoology, astronomy, meteorology, ecology, chemistry, and other disciplines of science are formally unknown yet practically well-known. A lifetime of observation has given an understanding of nature which is without doubt one of my father's most-prized and most-enjoyed earthly possessions.

Now, then, back to the course of study for teachers of astronomy in the intermediate grades. To begin with, the teachers should be familiar with two cosmologies. The first, of course, is the present system based upon the work of Copernicus, Galileo, Kepler, Newton, and others, as confirmed, expanded, and modified by astronomers up to the present day. We will return to this cosmology presently.

The second cosmology had its roots in ancient Greece, grew to maturity in Egypt, and flowered in Europe. It was transplanted in Rome where it grew vigorously and soon became part of the thick forest of dogma that was both the glory and the shame of the medieval Church.

We begin with this second and scientifically discredited cosmology not only because it is a major part of the history of astronomy, but we **must** study it because without is one cannot understand medieval science, medieval theology, or medieval literature! The late C.S. Lewis in his excellent little book, **The Discarded Image, an Introduction to Medieval and Renaissance Literature**, mentions three works which he calls "perfect examples" of medieval thought. They are as follows: Aquinas' **Summa Theologica**, Dante's **Commedia Divina**, and the **medieval cosmological model**. Lewis' book, although intended for the serious student of literature, is required reading for our course! Let's listen to Lewis on one of his favorite topics, the "discarded image," medieval thought and medieval cosmology.

At his most characteristic, medieval man was not a dreamer nor a wanderer. He was an organizer, a codifier, a builder of systems. He wanted a 'place for everything and everything in the right place'. Distinction, definition, tabulation were his delight. Though full of turbulent activities, he was equally full of the impulse to formalize them. War was (in intention) formalized by the art of heraldry and the rules of chivalry; sexual passion (in intention) by an elaborate code of love. Highly original and soaring philosophical speculation squeezes itself into a rigid dialectical pattern copied from Aristotle. Studies like Law and Moral Theology, which demand the ordering of very diverse particulars, especially flourish. Every way in which a poet can write (including some in which he had better not) is classified in the Arts of Rhetoric. There was nothing which medieval people liked better, or did better, than sorting out and tidying up. Of all our modern inventions I suspect that they would most have admired the card index.1

This impulse is equally at work in what seem to us their silliest pedantries and in their most sublime achievements. In the latter we see the tranquil, indefatigable, exultant energy of passionately systematic minds bringing huge masses of heterogeneous material into unity. The perfect examples are the **Summa** of Aquinas and Dante's **Divine Comedy**; as unified and ordered as the Parthenon or the Oedipus Rex, as crowded and varied as a London terminus on a bank holiday.

But there is a third work which we can, I think, set beside these two. This is the medieval synthesis itself, the whole organization of their theology, science, and history into a single complex, harmonious mental Model of the Universe. The building of this Model is conditioned by two factors I have already mentioned: the essentially bookish character of their culture, and their intense love of system.2

In speaking of the perfected model as a work to be set beside the **Summa** and the **Comedy**, I meant that it is capable of giving a similar satisfaction to the mind, and for the same reasons. Like them it is vast in scale, but limited and intelligible. Its sublimity is not the sort that depends on anything vague or obscure. It is, ... a classical rather than a Gothic sublimity. Its contents, however rich and various, are in harmony. We see how everything links up

with everything else; at one, not in flat equality, but in a hierarchical ladder. It might be supposed that this beauty of the Model was apparent chiefly to us who, no longer accepting it as true, are free to regard it -- or reduced to accepting it -- as if it were a work of art. But I believe this is not so. I think there is abundant evidence that it gave profound satisfaction while it was still believed in. I hope to persuade the reader not only that this Model of the Universe is a supreme medieval work of art but that it is in a sense the central work, that in which most particular works were embedded, to which they constantly referred, from which they drew a great deal of their strength.3

Now what was this Model of which Lewis writes really like? To answer would require volumes and the study of a lifetime. There were almost as many variations upon certain basic themes as there were astronomers, theologians, and philosophers. But there were basic themes. The Model was geocentric. The Model stressed perfection of shape and motion. The Model was hierarchical. A spirit world of angels and archangels, the Devil and demons, of "Intelligences" was an integral part of the Model. Man and the Earth stood at the center of the universe but at the bottom of the celestial hierarchy.

> And if the reader will suspend his disbelief and exercise his imagination upon it even for a few minutes, I think he will become aware of the vast re-adjustment involved in a perceptive reading of the old poets. He will find his whole attitude to the universe inverted. In modern, that is, evolutionary, thought Man stands at the top of a stair whose foot is lost in obscurity; in this, he stands at the bottom of a stair whose top is invisible with light.4

The cosmology of the medievals was that of Claudius Ptolemy. It had been altered and bent in many efforts to conform it to observed data, but it had survived, largely intact until the day of Johannes Kepler. Here is Lewis' description of the classic geocentric universe.

> The central (and spherical) Earth is surrounded by a series of hollow and transparent globes, one above the other, and each of course larger than the one below. These are the 'spheres',' 'heavens', or (sometimes) 'elements'. Fixed in each of the first seven spheres is one luminous body. Starting form Earth, the order is the Moon, Mercury, Venus, the Sun, Mars, Jupiter, and Saturn; the 'seven planets'. Beyond the sphere of Saturn is the **Stellatum**, to which belong all those stars that we call 'fixed' because their positions relative to one another are, unlike those of the planets, invariable. Beyond the **Stellatum** there is a sphere called the First Moveable or **Primum Mobile**. This, since it carries no luminous body, gives no evidence of itself to our senses; its existance was inferred to account for the motions of all the others.
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> And beyond the **Primum Mobile** what? The answer to this unavoidable question had been given, in its first form, by Aristotle. 'Outside the heaven there is neither place nor void nor time. Hence whatever is there is of such a kind as not to occupy space, not does time affect it.' The timidity, the hushed voice, is characteristic of the best Paganism. Adopted into Christianity, the doctrine speaks loud and jubilant. What is in one sense 'outside the heaven' is now, in another sense,' 'the very Heaven', **caelum ipsum**, and full of God as Bernardus says. So when Dante passes that last frontier he is told, 'We have got outside the largest corporeal thing (del maggior corpo) into that Heaven which is pure light, intellectual light, full of love' (**Paradiso** XXX, 38).5

The Model was a satisfying sort of universe. The common man, standing in the darkness, could observe a meteor's passage and feel certain that he had witnessed the fall of some celestial being who, like Satan, had been cast out of Heaven. The stars could easily be identified with the Heavenly Host. The "music of the spheres" was not a figment of the poetic imagination. It was a real celestial harmony, although spoiled, as Milton points out, by the loss of the bass through the fall of man and the curse. Read the "Nativity Ode." Read a portion of the **Comedy** and, while reading, try to put yourself back on that central Earth surrounded by crystal spheres, each of which is inhabited by celestial creatures,

all singing the praises of God. Finally, one last comment concerning Lewis and his obvious love for the "Discarded Image." The Narnia books and the fiction trilogy of Lewis contain numerous references to the medieval Model. How many can you find?

The first cosmology mentioned is that of the present. To me, this one isn't half as much fun. It has none of the obvious orderliness of old systems. The spiritual world, angels, demons, Intelligences, has no place in this system. There is no obvious perfection of shape and motion. Everything is in motion, but those who seem to know tell us that the whole business is running down! The only real advantage that the present system enjoys over the old is that the present seems - especially as far as the Solar System is concerned - to be true while the old is obviously false.

Well then, if we must discard uniform circular motion, perfect sphericity, crystal spheres, celestial harmony, the Heavenly Host, and all the beautiful yet erroneous bases of the medieval Model, what can we substitute as a basis or bases for a modern cosmology? Perhaps the best starting point is the idea of "orbiting bodies" as this includes a number of fundamental ideas.

Johannes Kepler (b. 1571), an eccentric genius of the early seventeenth century, derived three "laws" from his analysis of the positional data of Mars, data that had been painstakingly compiled by his even more eccentric mentor, Tycho Brahe (the man with the golden nose). These three "laws," although without formal mathematical basis at the time, finally sounded the death knell of the Model and all geocentric systems. One must not suppose that the scientific, theological, and philosophical communities received Kepler's work with open arms. Heliocentricity, although it had been around for two-thousand years or more simply was not an easy pill to swallow!

> Luther, in one of his Table Talks, had in his usual blunt way given his opinion of the 'new astrologus' who would prove that the earth moves. 'The fool will upset the whole science of astronomy, but as the Holy Scripture shows, it was the sun and not the earth which Joshua ordered to stand still.'... Already two years before the publication of the book of Copernicus, Melanchton wrote to a correspondent that wise rulers ought to coerce such unbridled license of mind. And in his **Initia Doctrinae Physicae**, published in 1549, he goes fully into the matter in a chapter headed: 'Quis est motus mundi?' First he appeals to the testimony of our senses. Then he serves up the passages of the Old Testament in which the earth is spoken of as resting or the sun as moving. Finally he tries his hand at 'physical arguments,' of which the following is a specimen: 'When a circle revolves the center remains unmoved; but the earth is the center of the world, therefore it is unmoved.'6

A beautiful proof... .

The writer obviously is not sympathetic to a Christian point of view. Nevertheless, the arguments are typical of the sixteenth century mind. He wrote, a generation before Kepler, against Copernicus, but the same reasoning was directed against Kepler and his cosmology.

What are Kepler's three "laws?" (Remember, the teacher must know them!) Briefly and as simply as possible they are as follows:

1. The planets, including the Earth, move around the Sun in elliptical paths. The Sun is at one focus of the ellipse.
2. The radius vector (line connecting the Sun and the planet) sweeps equal areas in equal times.
3. The squares of the periods of any two planets are proportional to the cubes of their mean distances from the Sun.

This new model was still imcomplete. Although Kepler had accurately described the planetary motions and had reintroduced order into God's cosmos (an order far more profound but far less poetic than the old), he could not answer a

number of fundamental questions. He had told us "what"; the "why" remained unanswered. Why does planetary motion continue, apparently unchanged, over long periods of time? Why is the velocity of the planets not constant? What keeps the planets in their appointed paths?

It remained for Isaac Newton, who possessed one of the keenest minds of all history, to finish the work. His "laws of motion" and his "law of universal gravitation" tied together the remaining loose ends, except for a few special cases best left to Dr. Einstein, and started a new era in astronomy. Newton's "laws," and you should know these, too, are as follows:

1. Every body remains in a state of rest or uniform motion unless acted upon by an outside force.
2. Acceleration is directly proportional to the force in the direction of the straight line in which the force acts.
3. For every action there is an equal and opposite reaction...
4. Gravitation. Every particle in the universe attracts other particles with a force that varies directly as the product of their masses and inversely as the square of the distance.

Before we leave Newton, it should be said that his work with the calculus and the reflecting telescope are but a few of the things for which he is remembered!

Instead of examining the new model from the Earth outward, let's use the reverse technique and begin with the largest known celestial objects and work back down to the Earth. These largest known objects are the clusters of galaxies that seem to extend endlessly into the vastness of space. The billions of stars that constitute a single galaxy all orbit - following Kepler's three "laws" as refined by Newton - slowly around the galactic center. Globular clusters, satellites of the galaxy, each containing as many as a hundred-thousand (or more!) stars bound together by mutual gravitational attraction, also swing around that center of mass in the galactic nucleus. Scattered throughout the galaxy, but particularly in the spiral arms, smaller open clusters of hundreds of stars are found. The best known open cluster is the Pleiades. Joining them in the orbital motion of the galaxy are multiple star systems. These celestial whirligigs, binary and larger systems, also revolve around their common center of mass. Then, there are stars with a planet or planets, stars like our sun with its nine known planets and its collection of those cosmic ice cream cones called comets. Here and there throughout the galaxy are immense clouds of gas and dust, some of them visible to the unaided eye, the nebulae which glow in the light of nearby stars or which glow redly in the light that characterizes the excited hydrogen atom.

So here we stand on a smallish satellite orbiting a rather ordinary yellow star (The astronomer would say, "type G star.") and look outward into the almost unthinkable immensity of the cosmos. The star around which we make our yearly orbit - elliptical, of course - is located well out in one of the spiral arms of a rather ordinary galaxy which in turn is one of an association of galaxies. This group of galaxies includes the Magellanic Clouds and the great spiral in Andromeda. Where the greater associations of galaxies lead us, no one knows!

The center of the universe, then, is unknown and probably unknowable. Yet in a very real sense, and this must be imparted to your students, man does stand at the center of the Cosmos. This ordinary, smallish planet is unique in that it is the home of man. On it God calls His People out of a fallen race. It is on this planet that the sovereign Creator calls the Church of Christ to His service that His name may be glorified. God has given us the Earth and the Cosmos to use to His glory. But this is a matter for yet another paper...

Finally, it is necessary that the teacher become familiar with the night sky. This requires repeated observation. One can work alone, but viewing with an experienced observer is best. No apparatus is necessary although a pair of low-power binoculars is helpful. (7 X 35 or 7 X 50 binoculars are best. Higher powers are difficult to hold still without a tripod.)

You will need a good star map, a map of the type that shows the heavens as they appear during the evenings of a particular month. The best of these, in my opinion, are those found in the magazine **Sky and Telescope**. Printed white on dark blue, they are easy on the eyes. Simple enough for beginners, they contain sufficient detail to satisfy even experienced observers. **Astronomy** and **Natural History** magazines also publish monthly maps, but I find them somewhat inferior to the above.

Begin your observations with the stars near the north celestial pole. Then, having learned the circumpolar constellations, move southward. A few evenings should suffice to familiarize you with the basics. Where you go from there is up to you.

When I heard the learn'd astronomer,
When the proofs, the figures, were ranged columns before me,
When I was shown the charts and diagrams, to add, divide, and measure them,
When I sitting heard the astronomer where he lectured with much applause in the lecture room,
How soon unaccountable I became tired and sick
Till rising and gliding out I wander'd off by myself,
In the mystical moist night-air, and from time to time
Look'd up in perfect silence at the stars.7

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1 Lewis, C.S., **The Discarded Image, An Introduction to Medieval and Renaissance Literature**; Cambridge University Press, 1964; p. 10
2 **Ibid**, p. 10-11
3 **Ibid**, p. 12
4 **Ibid**, p. 74-75
5**Ibid**, p. 96-97
6 Dreyer, J.L.E., **A History of Astronomy From Thales to Kepler**, Dover Publications, 1953, p. 352,353
7 Whitman, Walt, **Leaves of Grass**; J.M. Dent and Sons, 1947

THE BICENTENNIAL YEAR

by Mr. Fred Hanko

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I know that I really don't have to remind you that this is the beginning of the Bicentennial Year. In fact, I suspect that already with the year just beginning you would prefer not to be reminded. For months now we have been bludgeoned with that information by means of coins, books, advertising, and all sorts of means. It is not my purpose to add to the clamor. I just want to make a few observations that may help to retain a proper perspective and to point out some direction for Christian parents and teachers during this year.

In the first place, we are going to have to work hard to counteract the great barrage of propaganda that is already beating upon us. The Declaration of Independence, which is the focus of this year's celebration, was an act of rebellion supported by ideas that are contrary to the