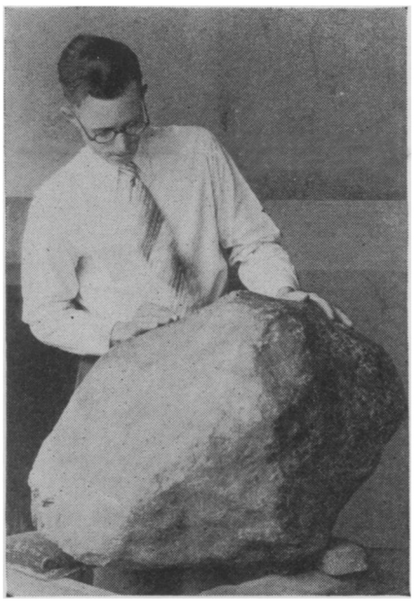

The largest stone messenger from the heavens and the largest meteorite of any kind ever seen to fall, and recovered. Weight, 820 pounds. Iron meteorites weighing many tons have been found.

Shooting Stars, The Story-Tellers of The Universe

Astronomy

By PROF. CHARLES P. OLIVIER
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Of fortunate rarity are celestial visitors like the huge meteoric mass that dug the famous Meteor Crater in Arizona about 2,000 years ago. This scar on the face of the earth near Winslow, Ariz., is four-fifths of a mile across and 450 feet deep. It is shown on our cover this week in a photograph taken recently for Science Service from a transcontinental airplane.

Far more common are the shooting stars that are seen every clear night but are especially numerous in August. In this article, which was given as a radio talk under the auspices of Science Service through a nation-wide network of the Columbia Broadcasting System, a distinguished meteor authority tells the interesting story of these August meteors and how your observation of them can greatly aid scientists.

EVERYONE has frequently seen a shooting star or meteor, but few people know what they are. Even in our own supposedly educated country many persons still think meteors are real stars that have somehow broken loose from their moorings and taken a sudden journey across the sky. It is fairly safe to say that many other people do not take time to think about them at all, any more than they do about the fireflies of a summer night, which are sometimes mistaken for meteors.

However, there are many others—and I believe the growing majority—who have a real desire to know about the phenomena of nature. They want to know the causes and effects of what they see.

Supposing, therefore, that the audience of this afternoon is made up largely of such persons, the speaker will attempt to give a few facts about meteoric astronomy, especially those which may be of interest to amateurs. And there is no science which has a larger group of enthusiastic amateurs than astronomy.

Before going further it should be said that the reason this talk is being given at this time is because the month of August is, of all months in the average year, the one during which most meteors are likely to be seen.

The explanation is of course that the Earth, in its annual path around the Sun, passes through some regions of space where it meets more meteors than elsewhere. August is the month when we run into the densest part of that meteor stream known as the Perseid. Some Perseids may be seen every clear night after July 20 and up to August 16. Their greatest numbers are seen on the nights of August 11 or 12, usually the former date. On this night, if the Moon is not shining, and one watches from a place with unobstructed view, and the sky is perfectly clear, sometimes over 100 meteors per hour may be seen.

The Debris of Evolution

However, nearness to the lights and smoke of a city, the least fog or haze, or moonlight, will any one of them cut down the numbers seen greatly, for naturally there are more fainter than brighter meteors, and the former are those not visible unless the sky is very clear.

Persons desirous of seeing the Perseids should therefore try to observe from a favorable place in the country. This year, unfortunately, the Moon will be full on August 9, hence it will still be very bright on August 11 and 12. Nevertheless, it will be in the far south, while the Perseid radiant rises in the northeast and will be on the meridian, overhead, by dawn. So all fairly bright Perseids in the northern half of the sky will be readily visible.

Returning to meteors in general, they may be defined as the debris of evolution. For instance, after a great building has been constructed, all sorts of waste material are found, pieces of stone, brick, wood, scraps of steel, nails, etc. So after a solar system of planets and satellites, asteroids and comets, has been formed, waste material is left over. This becomes meteors. But a study of the scraps of material around a building would teach a man who was not al-

lowed to see the edifice itself something about the completed structure. So the study of meteors leads to most important conclusions as to the evolution of the Solar System—and other similar systems in space.

Meteors are in general small bodies, far smaller than is generally thought. The faintest we see with the naked eye are probably no larger than a grain of sand, the larger ones may be as large as a boy's marble. Great fireballs, which are occasionally seen, are due to bodies of a few hundred pounds weight at most.

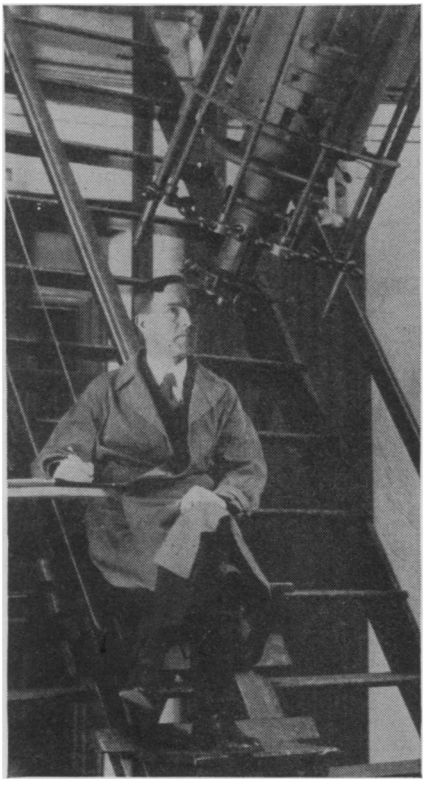
The Danger of Meteors

The average meteor is luckily destroyed by its passage through our atmosphere. Were it not so the Earth would be uninhabitable, for 20 million (not counting vastly more numerous telescopic meteors) enter our atmosphere daily. They move with velocities of from about eight to 50 miles per second. A grain of sand moving with such a velocity would kill as surely as a shell from a rifled cannon, if it hit a vital spot. It would in any case certainly go right through the body of whoever was hit.

But the air, which extends upwards at least 200 miles, forms an elastic but impenetrable shield to most meteors. Only the largest get through, and these are so infrequent that we need scarcely fear them. When a meteor does penetrate to the Earth's surface, it is called a meteorite. A few are found yearly, but there are few if any authentic accounts of a fatality therefrom. It is true that a big one did nearly strike two children in Hungary, some years ago. It fell through the ceiling of the room they were in, but did not harm them though smashing up everything else.

Again, four small stones fell in the neighborhood of a negro funeral procession about five years ago in Virgina. Except for a great scare among the mourners no damage was done. The speaker has handled these stones; they are about the size of a large orange and weigh only a few pounds each. Almost all large scientific museums have some meteorites on exhibition. The largest now in captivity may be found in the American Museum of Natural History in New York City. One weighs over 36 tons, is mostly of iron, and was (along with two somewhat smaller ones) brought back by Peary from Greenland. Their fall is not recorded, even in the traditions of the Eskimos, but their meteoric origin is quite certain, proved as it is by their locality and internal structure.

An even larger one has recently been found in southwest Africa, but no attempt has been made to move it. One still larger, of almost incredible dimensions as meteorites go, was reported a few years ago by a French military column, operating in the desert region of Morocco. The speaker has in vain sought to obtain further details about this object. Failure was probably due to the disturbed condition of that country, and the unwillingness of the French to penetrate again into any battle region without imperative cause. But we all eagerly await more news about this monster.



Prof. Olivier, at his telescope in the Flower Observatory of the University of Pennsylvania. He thinks many of the meteors which bombard the Earth continually are fragments from other solar systems.

If a person is in the open country with a clear sky, during the first six months of the average year, he should see from four to eight meteors per hour; during the second six months from eight to 15 per hour. Also he will see fewest at six p. m., most about two hours before sunrise. This rule holds all the year. This last fact is due to a question of relative velocity, a geometrical or physical problem fully understood. The smaller numbers met in the first half of the year is obviously explainable by the mere fact that there are less meteors to be met in the regions then traversed by the Earth, as well as to the position of the meteoric apex as seen in the northern hemisphere. Again the richest annual showers come in the second half of the year, for instance: Delta Aquarids in late July, Perseids late July and August, Orionids in October, Leonids and Bielids in November, Geminids in December.

Meteors come to us from two sources, some from our own Solar System, others from outer space. A sharp line can be drawn between them, for if a meteor passes our orbit with a velocity much under 26 miles per second, it is a home product, as it were. But if the velocity is over 26 miles per second it originated in some distant stellar system, and has traversed immeasurable reaches of space to come to us.

Visible Only in Atmosphere

Of course we see none of the innumerable meteors that pass us by closely, much less those at a distance. Only when the meteor plunges into our atmosphere does it become visible, due to the sudden turning of its great kinetic energy of motion into light and heat. Even then the most of its light and apparent size come from the envelope of superheated air which it carries along with it. For instance, the speaker has seen more than one fireball which had the apparent size of one half the Moon's diameter, *i. e.*, 15′, or approximately 1/230 of a radian. Therefore if the object was 50 miles away—and it was actually farther—that would mean the fireball was 1150 feet in diameter. Probably the solid mass was of the order of one foot, not 1150. Then the extra apparent size was due to heated gas around it, and also to a lesser extent to irradiation.

The beautiful trains left by some bright meteors were once thought to be actual sparks left behind. We now know such an explanation is absurd, for some of these remain visible a quarter of an hour or more. It appears most probable that they are due to phosphorescence. The long enduring ones seem sharply limited to the stratum between 45 and 65 miles above the ground. They do not last long higher up, and those very much lower are actual trains of smoke, which show up by reflected sunlight. These latter are seen only after the passage of a great fireball (*Turn to page* 76)

Shooting Stars—*Continued*

in the daytime, for of course there are as many meteors during the day as at night, only we do not see them.

Many meteors, particularly members of some of the main streams which give us the annual showers, follow the same orbits as do certain comets. For instance, the Perseids, of which we have spoken so much, follow Tuttle's Comet. The Leonids, the most famous stream of all for they give the "great showers" as of 1833, when it was said "the stars fell," follow the path of Tempel's Comet; the Bielids that of Biela's Comet, the May Aquarids that of Halley's Comet, etc.

Comets Make Meteors

This connection between comets and meteors has proved of great importance in our study of the former, for we are quite sure that the nuclei or central parts of the heads of comets consist of nothing other than meteorites. And when a comet disintegrates, which apparently will be the ultimate fate of all comets, its debris simply becomes meteors. Hence the Mazapil meteorite which fell during a shower of Bielid meteors in 1885 is rather confidently spoken of as a part of Biela's Comet.

The study of meteors from the observational standpoint takes up so much time that professional astronomers cannot spare enough from their great telescopes to do much on meteors. Hence their actual observation is rather largely left to amateurs. In this country we have a flourishing organization known as the American Meteor Society, formed mostly of amateurs, but with some professional astronomers also. The headquarters is at the Flower Observatory of the University of Pennsylvania, of which the speaker is director. All the members send to us copies of their observations which are then carefully worked up and the results published at intervals. In this way we are able to coordinate and discuss the work more fully than any individual could do, using only his personal observations and experience.

Besides our regular members we aim to secure the help of all others, even temporarily interested. Such observers cannot, as a rule, send in as complete observations as our trained members, but they can do something very useful indeed. This is to help us get the hourly rates of all meteors, from widely scattered stations. From such data we are able to deduce a true picture of the density of the cross section of the meteor stream, and tell more about it generally.

To do this one should choose a favorable place, and provide himself with a watch, notebook, flashlight and pencil. Then, watching as large an area of the sky as possible he should count every meteor certainly seen during each half hour. As each interval is up, the record should be made in the notebook, along with notes as to any changes in the sky like passing clouds, etc., or any especially fine meteor seen. The watching should be done toward one direction only, during each half hour. What direction it is should be recorded. If desired, other directions may be chosen for other half hours. No meteor should be counted unless seen with certainty. Full notes as to condition of the sky should always be made.

Such records, conscientiously made by intelligent people, over periods of two or more hours near the dates of maximum of the Perseids, for instance, have a real value as explained above. When reported to us, they are published in due time, proper acknowledgments being made to each contributor, by name, in the publication. We also desire all observations of any very bright meteor, casually seen, no matter on what night.

For those who would like to take part in more detailed observations than those briefly outlined, a request mailed to the Flower Observatory, Upper Darby, Pa., will bring a bulletin with further instructions and descriptions of the work of the American Meteor Society.

Great Showers Coming

Finally, it is quite possible, if not probable, that 1932, 1933, or 1934 may see the Leonids return in sufficient strength to give again one of the truly great meteoric showers. They come about the middle of November. As world-wide preparations will doubtless be made for their observation, we desire some years ahead to interest and train a large corps of volunteer observers, who will be available if indeed a magnificent display should appear. This is an added reason for the increasing attention being paid to meteoric astronomy.