

The dark moonless night was only halfway through. Ramu was enjoying a well earned sleep out on his farm. But tonight he was not destined to get his quota of eight hours. He was woken up by what he first thought was the noise of a persistent mosquito. But there was no mosquito nearby....

The eerie noise was coming from afar and when Ramu turned his sleepy eyes towards the direction of the sound he suddenly became wide awake. A strange thing was standing in the middle of the field and Ramu had to pinch himself to ensure that this was not a nightmare.

The thing began to move.....

If this is what you were expecting to read when you turned to this article, you are in for a disappointment. This is no science fiction creepie about little green men from outer space invading the Earth. However, science facts can be stranger than science fiction for a very simple reason. Facts discovered by science are from nature's limitless storehouse of riddles and time and again these have turned out to be far more intriguing than the fiction originating from the limitations of human imagination.

As we go about our daily chores for existence, we hardly worry about the global problems of Earth's *existence and survival*. We take the former for granted and assume that the latter is not threatened by anything visible or invisible. After all, we have our powerhouse, the Sun, at a comfortable distance, we are blessed with a satellite, whose beauty we can admire from afar and whom we can visit if we want to, and our close neighbours, the planets are a bunch of law-abiding neighbours who have been going about their set orbits for hundreds of millions of years. Certainly, no one looking at the serene star-studded night sky could imagine that there could be any peril lurking out there.

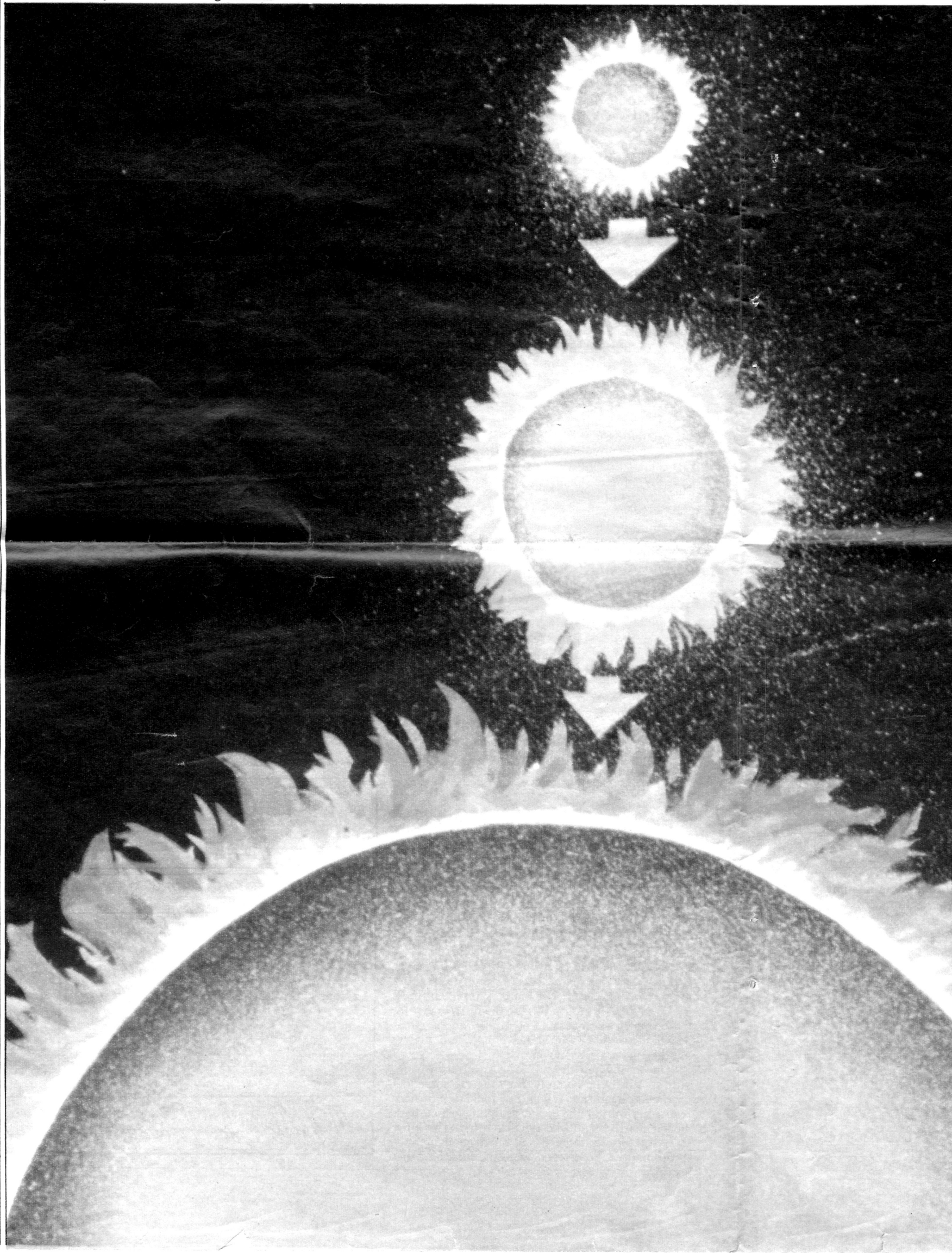
But, like the undercurrent of violence in the most cultured of human societies, there is more to this vast space around us than meets the starry eyes of a poet. Not satisfied by the maxim 'seeing is believing', the astronomer has probed deeper into the universe. And his findings do not guarantee a steady and sedate existence for the Earth for ever.

Let us look at a few of these findings and see how they point to the likely perils in space.

From the days of Copernicus we know that the Earth moves round the Sun. Likewise other planets move in different orbits. Except for the outermost planets, these orbits do not intersect and like trains running on parallel tracks, the probability of the Earth colliding with another planet is zero.

However, there are other things in the solar system, besides the planets and their satellites. There are minor planets, asteroids and meteorites

The Sun's transformation into a giant star





The Crab Nebula: the star that was

PERILS FROM OUTER SPACE

SCIENCE / JAYANT NARLIKAR

The next millenia could see sweeping changes in the universe. The Sun could grow bigger. Planets may change their orbits. Some stars may explode. And fallout from these bodies may devastate the Earth and other planets.

Will these extra-terrestrial dangers destroy life? Or are there greater perils lurking on Earth itself?

Astrophysicist Jayant Narlikar investigates.

that are considerably smaller than planets. Asteroids as a rule move in a belt between the orbits of Mars and Jupiter; but some of them have highly eccentric orbits which can bring them close to the Earth's orbit occasionally. In 1937 the asteroid Hermes came within a distance of 400,000 miles from the Earth. Although the distance appears enormous, in terms of the dimensions of the solar system the encounter has to be considered moderately close. Encounters closer than this and even direct collisions cannot be ruled out, if not with this asteroid, with other similar ones.

What would happen in the event of a head-on collision? The impact

would cause devastation over an area the size of an entire hemisphere. While the population of all living beings in the direct-collision area would be instantly annihilated, the population 'on the other side' will not escape either! For, the heat of impact will disturb the protective layers of the atmosphere and make human survival impossible anywhere.

More limited disasters will be caused if a comet or a largish meteor collides. It is known that the largest meteor to fall in modern times appeared over Siberia in 1908, but it exploded before reaching the ground. Still it set fire to about 50 square kilometres of forest wiping

out a herd of 1500 reindeer. What would have happened had it fallen on New York, London or Bombay?

Fortunately such impacts are rare. Perhaps once in a few million years we may be directly hit by a comet. The number of large meteorites in the vicinity of the Earth is likewise small enough to make a destructive collision improbable if not impossible. The Earth does get bombarded by small objects many of which burn up by the frictional heat caused by their passage through the atmosphere.

What about collisions with other stars? Imagine what will happen if a

star as massive as the Sun passes close by, say, at a distance of the outermost planet Pluto. The star will attract nearby planets and will take them with it if the encounter is close enough. But it will exert a perturbing force on other planets like the Earth which may change its orbit. Even a one per cent change in the Earth's orbit is sufficient to set in motion enough disturbances to upset the balance of nature and cause loss of life on a mammoth scale.

Again, the prospects of this actually happening are happily very slim. Take the few neighbouring stars which lie at distances of the order of a few light years. Light from a star five light years away will reach us after five years. If the star itself is travelling at a uniform speed of 30 kilometres per second in our direc-

in its evolution.

Using this analogy we can say that the Sun is passing through the adult phase, from youth to middle age. This is the longest phase in a star's life and in astronomical jargon it is called the 'main sequence'. A star continues to be on the main sequence as long as it is powered by a central fusion reactor that converts hydrogen to helium.

This last sentence contains the solution of a riddle that man has tried to solve for centuries: 'What makes the stars shine?' It is now known that the temperatures in the central regions of stars, like the Sun, run to millions of degrees and are high enough to trigger nuclear reactions that lead to fusion of smaller atomic nuclei into bigger ones. The fusion of hydrogen nuclei to form

in which its inner parts shrink while the outer parts expand. The shrunk-en core heats up and in this process sets off another chain of nuclear reactions that fuse helium nuclei to form nuclei of (the still bigger element) carbon.

But it is not what goes on in the inner parts of the Sun that will matter to our descendants on the Earth. They will have to worry about the behaviour of the outer parts of the Sun. These outer parts will grow bigger and bigger while the colour of the Sun will take on an increasingly reddish hue. And during this transformation, the total radiation coming from the Sun will also increase.

Thus as time goes on, the Earthmen will find their existence more and more difficult to sustain. Perhaps, with better technology,

very remote descendants.

The *History of Sung Dynasty* in China contains the following statement: 'On a *Chi-Chhou* day in the fifth month of the first year of *Chi-Ho* reign period, a guest star appeared at the south-east of *Thien-Kaun* measuring several inches. After more than a year, it faded away' (Ho Peng Yoke, 1962).

This matter of fact statement contains the description of one of the most spectacular events in the annals of observational astronomy. It describes the explosion of a giant star in the constellation of Gemini; and thanks to the meticulous records kept by the Chinese and Japanese astronomers, we can actually pinpoint the date when the event was observed from the Earth. It was July 4, 1054 AD.



The crater near Winslow, Arizona, formed by the impact of a substantial meteorite

tion, it will reach us in fifty thousand years!

To sum up then, while collisions in space would be devastating, they are very rare. You face a far greater chance of destruction while crossing a busy street in Bombay.

A casual glance at the night sky gives the impression that all stars are alike. This impression is false. Stars differ in their physical characteristics like size, mass, colour, composition etc, just as human beings differ in their heights, weights, complexions, etc. Indeed this analogy with the human population can be pushed further to argue that as a star ages, its physical characteristics change. Like the different stages in human life, from childhood to old age, the star also has several stages

nuclei of helium is the first step in this nuclear ladder, and it takes the longest period.

What has all this to do with any future threats to the Earth's existence?

To begin with, our existence is closely tied with the behaviour of the Sun. Although a temperature drop on the Earth of, say fifty degrees, makes a hot summer into an icy winter, this range is relatively narrow and shows how finely tuned human survival is to the conditions on the Earth. While the Sun continues on the main sequence, these conditions will operate. But what happens next?

Astrophysicists tell us that after its hydrogen fuel is exhausted the Sun will enter into a different phase

they will manage to prolong their survival for a while. But eventually they will have to rely on space travel to seek cooler abodes, perhaps on Mars or even beyond.

For, a stage will come when the Sun will become so gigantic in size that it will steadily swallow the inner planets, Mercury and Venus, and will next gobble up the Earth! This scenario is not astronomical fiction but is backed by sound physical principles. Moreover, giant stars actually observed elsewhere clearly tell us what lies in store for the Sun.

Again, there is no need to panic in the face of this future catastrophe. The Sun will not enter the red giant stage for several billion years to come. Let us leave the worries to our

In those days, European culture was still shrouded in medieval darkness. North India was still recovering from the raids of Mahmud Ghazni, which had ended three decades earlier. In the South, peace prevailed under the Chola dynasty. Yet we do not find any records of this event in India or Europe. On the other hand, indications of rock drawings and paintings in Northern Arizona suggest that the native tribes had witnessed the event. More recently, evidence has come to light that the event had been recorded in the Middle-East by a Christian physician named Ibn Batuta, from Cairo.

From these records it appears that the 'guest star' was initially so bright that it could be seen in broad day-

light. Even by July 27, 1054 it was as bright as Venus. By April 17, 1056 it had faded so much, as to be invisible to the naked eye. Today, long-term exposure on a photographic plate attached to a very good telescope reveals a nebulous mass where the 'guest star' should have been. Because of its filamentary appearance, it is called the Crab Nebula. (Owing to the precession of the equinoxes the nebula lies in the constellation of Taurus now, instead of in Gemini.)

Today, astrophysicists can piece together all evidence and arrive at the conclusion that what was seen in 1054 AD was the explosion of a supernova.

What is a supernova? We have already seen that in the course of its evolution a star becomes a red giant. What happens to it next? Again we may draw analogy with human life. When a man reaches middle age he is told by doctors to watch his weight. An overweight person is considered more likely to be prone to various dangerous diseases than a person who keeps within a prescribed weight limit.

For stars a similar limit exists around five to six times the mass of the Sun. A star whose mass is less than this limit has to put up with minor surface explosions but it eventually winds up as a white dwarf star with mass less than about 1.4 times the Sun's mass. This important result was derived in the 1930s by S Chandrasekhar who shared the 1983 Nobel prize in Physics (*Weekly*, November 6, 1983).

For stars which unfortunately find themselves above the six solar mass limit, the future is more catastrophic. When they become red giants they are unable to keep their internal balance intact and explode. The explosion ejects the majority of the material in the outer parts of the star out into the surrounding space. At the time of the explosion the star brightens up enormously and can outshine the entire galaxy (which contains hundreds of billions of stars).

It is small wonder then that the Chinese astronomers record that the star could be seen even during the day in the first few hours. Exploding stars, or supernovae, as they are called have been seen elsewhere since 1054, twice in our own Milky Way system.

The distance of Crab Nebula is estimated at around 5000 to 6000 light years. Imagine what would have happened if we were located considerably closer to the exploding star, say at a distance of 30 light years. Clearly we would have seen a much more spectacular event. The star would not only have been visible in daytime, it would have outshone the Sun in the initial few hours.

But the event would, however, have turned out to be more dangerous than spectacular so far as the Earth is concerned. What would

happen if a supernova were to explode within about 30 light years from us?

The explosion would release a gigantic shock wave compared to which the shock waves released in the man-made nuclear explosions on the Earth would be less than mere ripples. Admittedly the wave would weaken in intensity as it progresses and by the time it reaches the Earth it would have lost much of its original intensity. But still it would be strong enough to disturb the protective layers of our atmosphere in a significant way.

However, there would be greater perils in store. The explosion releases a vast flux of cosmic rays—these are subatomic particles carrying a lot of energy with them. Travelling at near light speed, they would arrive at the Earth sooner than the shock wave would. If the explosion occurred 30 light years away, the cosmic ray particles would reach only after 30 years. These particles would rip most of the protective layer of ozone gas in the atmosphere that at a height of 30 kilometres shields us from the deadly ultraviolet rays emitted by the Sun. While the cosmic rays directly will not cause much harm, their destruction of the ozone layer would lead to catastrophic results. All biological species would die from the exposure to solar ultraviolet radiation.

It is estimated that in the entire galaxy there may be around three supernova explosions per century. What is the likelihood of an explosion in our vicinity, within say 30 light years? The chance is less than one part in ten million that a supernova may go off within the next two decades. Or, to put it in another way, we may have to wait for about two hundred million years before a supernova explosion occurs in our vicinity.

Our present knowledge of living systems in outer space is nowhere as advanced as our knowledge of inanimate matter. What is said below is therefore based on conjectures, and controversial ones at that.

The well established fact about outer space that has a bearing on living systems is the detection by radio and microwave surveys of complex organic molecules in large inter-stellar clouds. These organic molecules are also found as sub-units of the so called DNA molecule that is the basic building block of most living systems on Earth. Can we suppose, therefore, that living systems also exist where these component molecules are found?

At the turn of the century, the Nobel prize winning chemist Svante Arrhenius had suggested that living spores may transport life in space; but this idea received no support from other scientists. More recently two scientists in the UK, Sir Fred

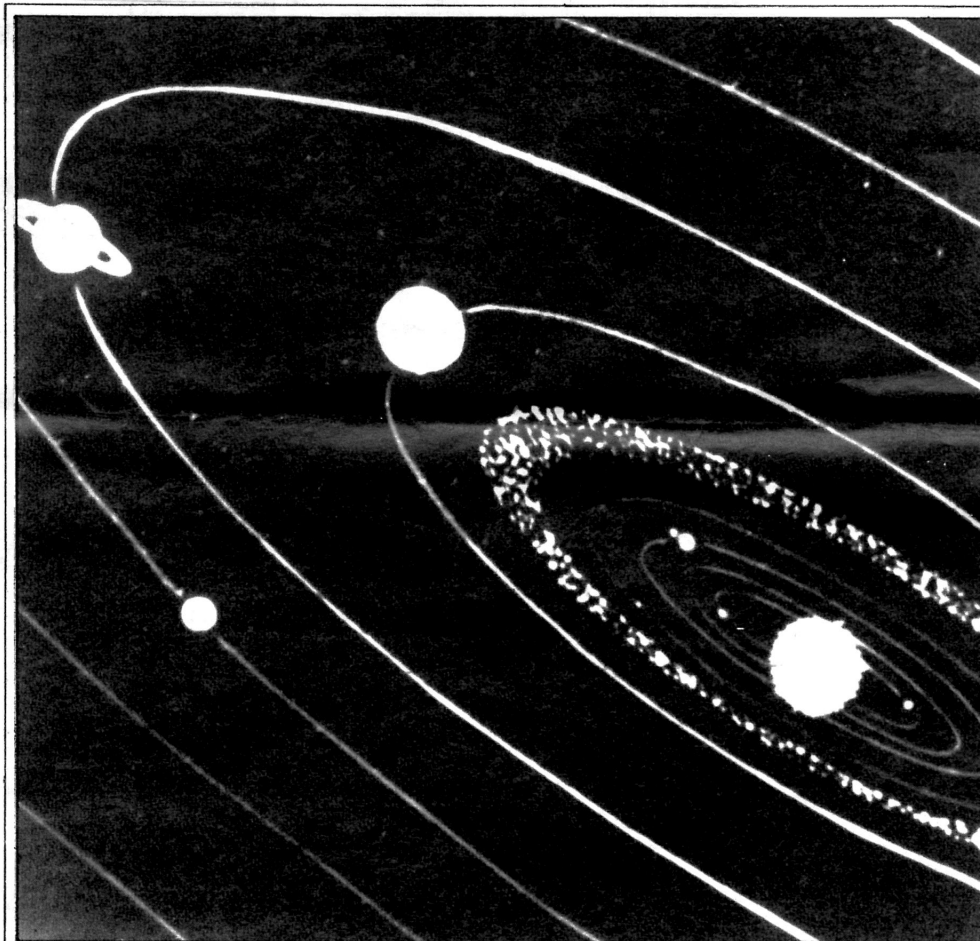
Hoyle and Prof Chandra Wickramasinghe, have proposed somewhat similar ideas more forcefully and against a good deal of hostile opposition from biologists as well as astronomers. A discussion of their ideas and their merits as well as demerits will take us further from our present subject. Let me assume for the time being that Hoyle and Wickramasinghe are correct and describe a perilous consequence of their hypothesis.

If viruses and bacteria exist in outer space, they might occasionally percolate through the Earth's atmosphere where they might be dumped by passing comets that serve as carriers. Some of these viruses may be alien to the living systems on the Earth and if so, their interaction may lead to new epidemics or diseases.

comets are harbingers of diseases.)

However, as I have said before, most scientists are not yet convinced of the correctness of this argument and many doubt if elementary life forms like cells, viruses and bacteria exist at all in outer space. As our space technology improves, we may be able to find direct experimental proofs or disproofs of this hypothesis. Till then the controversy is expected to continue.

To sum up then, the dangers from outer space, whether from collisions of heavenly bodies, or from the evolution of the Sun to a red giant star, or from the explosion of a nearby supernova are either very improbable or (where they are certain) lie in a very distant future. Therefore even though the destructive ability of these events is pheno-



The elliptical orbits of planets never intersect the orbit of the earth

Hoyle and Wickramasinghe have argued that highly destructive diseases like the plague of Athens in 430 BC or the great plague in Europe were caused by strains which did not originate on the Earth but came in from outside. Even influenza, according to these authors, suddenly covers a large portion of the Earth not through person to person transmission but through virus descending from outer space.

If this theory is correct, it implies grave possibilities of sudden eruptions of new diseases on the Earth to whom our bodies cannot offer resistance or for whom adequate cures are not available. (Although based on modern scientific logic this hypothesis unexpectedly offers some backing for the ancient superstitions that

menal, they need not cause you to lose your sleep. The biological dangers from outer space are less well understood and their true implications can be appreciated only after decades of research still to come.

Anyone who has read Carl Sagan's recent article on 'Nuclear Winter' or Arthur C Clarke's talk on 'War and Peace in Space Age' will realise that the real and immediate danger to man's existence on Earth is not from heavenly bodies several light years away, but from man here on the Earth. The growing pile of nuclear weapons today is already estimated to be far in excess of what is needed to annihilate the entire mankind.

This sobering information is enough to cause anyone a sleepless night.