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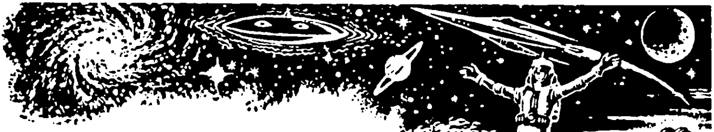

# For Your Information

By WILLY LEY

## The Ice Age (III)

A FEW issues back, I quoted the French astronomer Gérard de Vaucouleurs as having said that the surface of Mars can be likened to a terrestrial desert, moved to the Arctic and lifted to stratospheric heights. I should have added that Monsieur de Vaucouleurs introduced one unnecessary move. Lifting the desert to stratospheric heights would be enough; that would not only thin the air over the desert, it would also cool it.

This thought is the basis of a little known theory of the origin of the Ice Ages, offered by the Austrian geologist Prof. Doctor Franz Xaver Schaffer. It has been mentioned earlier that Schaffer's compatriot, Prof. Melchior Neumayr, had shown that a comparatively slight drop in the average temperature, some 6 to 8 degrees Fahrenheit, would account for all the observed phenomena, provided only that it lasted long enough. Schaffer, about 40 years later, brought in the additional fact that the average temperature of, say, Vienna, is 6 to 8 degrees lower 2000 feet above that city.

So far, this sounds like a wonderfully simple idea. If one could prove that, at the time of the glaciations, the land masses of at least the northern hemisphere had been 2000 feet higher than now, the whole difficult problem would resolve itself neatly and easily.

That figure of 2000 feet must not be misunderstood; it does not have to mean 2000 feet higher above sea level, for the sea level may have been different itself in the past.

Probably the best way of phrasing it is to say that the land level of the northern hemisphere is supposed to have been under an average air pressure of about 700 millimeters, instead of the 760 millimeters which is the present norm.

Unfortunately, Prof. Schaffer could not show any evidence tending to prove such a higher elevation. In fact, he has to torture existing evidence to a good extent by declaring, for example, that this or that glaciation described in the textbooks was not a "true" glaciation at all, but that these geological traces upon which the textbook statement rests "happen to be misleading." In short, the neat idea did not work out.

But the fundamental assumption—namely, that the cause of the ice ages has to be sought in the atmosphere instead of somewhere in space—is rather logical. It was upon this assumption that the noted Swedish scientist Svante Arrhenius began building a famous theory half a century ago.

As for Svante Arrhenius himself: even those who do not confuse him with a Swedish botanist of the same name usually consider him an astronomer or an astrophysicist. Although much of the work done by him in his later life belonged in the realm of cosmology and encroached heavily upon astrophysics, he was originally a chemist.

Being a chemist, he was struck by the thought that the underlying cause for climatic changes might be changes in the chemical composition of the atmosphere.

The present norm, expressed without fractions, is 21 per cent oxygen, 78 per cent nitrogen, 1 per cent argon and "traces." And, of course, a varying amount of water vapor. The radiation of the Sun, the textbooks say, is absorbed by the ground and by the atmosphere. If the ground is covered with snow and ice, it will absorb less radiation, and as regards the atmosphere — wait a minute: just which part of the atmosphere does absorb infrared, or heat? It turned out to be one of the "traces," carbon dioxide ($CO_2$), which constitutes only 0.03 per cent of the atmosphere near the ground. One other gas which is also especially active in retaining heat is water vapor.

Arrhenius made a little calculation. *Supposing that there were no carbon dioxide in the air at all, what would that do to the climate?*

The result was devastating, even though it was merely a figure on paper. *The average would drop by about* 30 *degrees Fahrenheit!*

Furthermore, since a drop of 30 degrees F. would freeze all the water vapor out of the atmosphere, there would be an additional drop due to the absence of water vapor. This would be an estimated 20 degrees—about 50 degrees altogether. It would spell Antarctica for both temperate zones and quite a lot of grief even for the tropics.

The next step in the reasoning ran as follows: if the climatic variations correspond to fluctuations in the carbon dioxide (and alóng with it the water vapor) content of the atmosphere, what could be the reason for such fluctuation? How does the carbon dioxide originate?

The layman is apt to think of gigantic forest fires, presumably caused by lightning. It is true that such fires do contribute, but it isn't so much a question of quantity, since the total in the atmosphere is quite small, but rather of steadiness of supply. Most forests don't burn down. (Actually, industrial activity and households contribute more than natural fires, just because they are steady producers).

The main suppliers of carbon dioxide are the volcanoes and other phenomena associated with them.

The main consumers are the oceans. According to Arrhenius, they absorb slightly more than 80 per cent of the gas. Next biggest consumer is erosion which, like plant life, ties the carbon dioxide chemically. In the seas, much of it is also tied up by organisms other than plants, but they can get only at the carbon dioxide in the water.

PERIODS of volcanic activity with much carbon dioxide in the air—say, ½ of one per cent—would be periods of warmth and of luxurious plant life. But, Arrhenius pointed out, each such period contains the beginnings of its own end. Volcanic activity is somehow connected with mountain building—we don't have to go into the question of whether it causes, is accompanied by, or is the result of mountain building — and these mountains erode while still rising. The plants thrive in the high carbon dioxide content, gulping what they can. The multitudes of sea things do the same, depleting the waters of carbon dioxide so that the ocean will absorb more.

As the Department of Economics would say: with everything geared to high consumption, a slackening of production means depletion of the reserves. In less forbidding language: as soon as the volcanoes calm down, the carbon dioxide content of the atmosphere also goes down, and so does the average temperature.

After Arrhenius had stated his general concept, a professional geologist, Dr. Fritz Frech of Breslau, tried to fit this scheme to the actual geologic past. He claimed that two full cycles could actually be found geologically.

There was this very early Cambrian glaciation near the beginning of the Earth's geological history which we know reasonably well. During the following two geological periods, the Silurian and Devonian, volcanic activity was heavy and the climate apparently grew uniformly warm, for corals from that time have been found in high latitudes. The plants conquered the land and, during the Carboniferous Period which followed the Devonian, they appear in incredible masses. Our coal deposits formed then—all this coal was at one time carbon dioxide which the plants took out of the atmosphere.

Around the middle of that long Carboniferous Period, enormous mountain ranges formed in all continents, many of them eroding fast. Apparently there was little, if any, new volcanic supply for a while and the result was the Permian glaciation.

This, according to Frech, was the first complete cycle. The second began during the middle of the Permian Period, when there were enormous volcanic eruptions in the northern hemisphere. More of the same, especially in North America, occurred during the next period, the Triassic, and the Jurassic which followed after the Triassic. Warm climate, apparently without climatic zones. Corals in the seas above Scotland, marine reptiles as far North as Spitsbergen, palms and cycads near Baltimore. Dinosaurs.

Near the end of the Cretaceous Period which followed the Jurassic, it looked as if there were hints of climatic zones. But before things slipped too badly—possibly because there were no recent mountain chains to erode in addition to the older ones—there were enormous basaltic eruptions in India.

AT any event, the Tertiary Period which followed the Cretaceous began in full tropical splendor with swamp cypresses as far North as Ellesmere Island. Apparently it grew a bit cooler during the Oligocene, the second subdivision of the Tertiary Period, but again a series of gigantic basaltic eruptions intervened. The following subdivision, the Miocene, was warm again; the lignite beds formed. Soon the great mountain chains of today began to grow—the Andes, the Himalayas, the Alps. Volcanism diminished during the last Tertiary subdivision, the Pliocene, and then seems to have stopped almost completely. The Ice Age came in. The volcanic cones we have now, including those which are dead, all formed later.

And that is how Arrhenius and Frech explained the past. It is hardly necessary to state that there is no beautiful and unanimous agreement with them.

Some have pointed at big eruptions of historical times, like the Krakatoa catastrophe, which, by throwing millions of tons of dust into the atmosphere, caused cool summers and cold and wet winters. But it is only a special type of eruption which will do that, and a rare type at that.

Others have found evidence for volcanic activity just at times where Frech said there was none. To which Frech's pupils replied, in essence, that even during a depression there are a few people who have money, but that these exceptions do not make prosperity.

Still others have said that they admit that with 0.001 per cent carbon dioxide in the air, it would be colder, but that a surplus over what we have now won't make it warmer.

Arrhenius stuck to his guns, or rather his calculations.

We don't know the answer yet. But in time, we will.

## THE FOURTH DIMENSION

THERE was an exchange of inter office memos recently, beginning at my end. Mine read: "Horace, please stop printing stories about the fourth dimension like 'Star, Bright' because they cause too many letters." The reply: "Willy, are you really serious about this?" My answer: "Well, no, but I *did* get more letters about four-dimensional problems that month than about any other topic."

These letters ranged from such one-sentence requests as "Please explain the Fourth Dimension" to communications of several pages and single-spaced which amounted to dissertations. If one conclusion could be drawn from all this, it is that the problem of the fourth dimension still excites lots of people. Another conclusion is that we seem to be dealing with a new generation of readers, for the older science fiction fans have been through this two decades ago.

Now let's look at the fourth dimension first from the point of view of elementary mathematics. Reasoning here begins literally with a *point* which has no dimension at all. Move the point and you get a *line* from A to B, A being where the movement began and B where it stopped.

This line has one dimension: *length*.

Now move the line at a right angle to the movement of the original point and you get a *plane*. If the movement was as specified, at right angles and for the same distance as the length of the line, the figure will be a *square*.

Now lift the square from the paper and move it vertically, again for the same distance, and you get a *cube*.

So far, you had a visible, logical progression from dimensionless *point* to one-dimensional *line*, from there to the two-dimensional *plane*, and from that to the three-dimensional *solid*.

But when you move the *solid* through space, all you get is *another* solid of a different *shape*. Offhand, this seems to indicate that the number of dimensions stops with the third, but many people will feel like the philosopher Gustav Theodor Fechner who asked why Nature should be unable to count beyond three.

If you ask for a little more information of what the fourth dimension should be, the mathematician is apt to hold up a box of any kind, point at one of its corners and say:

"The corner of the box demonstrates the three dimensions of space—namely, length, width and height. As one can clearly see, these three dimensions are vertical to each other. The fourth dimension should be a line which is vertical to the other three—and don't think that the simple prolongation of any of the other three lines beyond the corner is the answer to the problem.

"You can't visualize such a fourth line? Of course not, because that would be the fourth dimension and our world is three-dimensional. Hence it is impostible to visualize the fourth dimension, but we can treat it mathematically. Since we call the line a, the square is $a^2$ and the cube $a^3$* and nothing prevents and nothing prevents us from writing $a^4$ and from giving a name to the four-dimensional super-solid thus described."

Obviously, nothing prevents us from doing that, but neither the symbol $a^4$ nor the name tesseract proves or even indicates that there is something in reality which corresponds to this concept.

WELL, *is* there something else which indicates the reality of the fourth dimension? Let's begin at the beginning again.

Take a piece of ordinary writing paper (not a square) and cut it diagonally. You'll get two triangles, visibly congruent since their sides and their angles correspond. Place them on your table, both with the right angle to the left. You can make them cover simply by moving them along the plane of the table top. But place them in such a way now that one has the right angle at the left and the other at the right. They can be made to cover only by turning one of them through the third dimension.

To a two-dimensional being, this would be an impossible move and it was, quite some time ago, the theme of a book called *Flatland* by A. Square. *Flatland* has been quoted in early science fiction stories about as often as the name of Albert Einstein was thrown around.

Now there are a number of three-dimensional bodies which seemed to be analogous to the two planes that would not match. It was Immanuel Kant who was the first to point out that our two hands are examples of such bodies. Your right glove will not fit your left hand, and your left shoe will not fit the right foot, even though they seem to be geometrically alike, having the same measurements in all three dimensions. But maybe they could be made to "cover" by "turning" them through the fourth dimension!

Can they? I don't know—I can't even visualize it, naturally —I'm only a three-dimensional solid myself.

Let's return to the two triangles where things are somewhat simp-

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*Answer to seven correspondents: yes, I do know that a cube has 8 vertices. My statement in reply to a letter that it has 4 is not due to ignorance nor has it, as two correspondents suspected, a "hidden and higher meaning." It was a simple typographical error.

ler. Since the lengths of all three sides correspond, and since all three angles are the same, they should be as congruent as anyone could wish. Our simple experiment proved, however, that they may or may not be congruent.

What is wrong now? Simply this: a description in terms of sides and angles is an incomplete description. To make it complete, a description of arrangement has to be added.

If you keep in mind that such an additional term should be included, you can see clearly that the two triangles, when positioned in such a way that they fail to match, simply are *not* congruent. And the same goes for asymmetrical solid bodies, such as crystals. They may agree in all angles and dimensions, but if you have ( and here the language has supplied a very significant term) one right-hand crystal and one left-hand crystal, they can't match. To insist that they should merely means to insist on an incomplete description.

However, the fourth dimension has one more twist. A solid, in order to exist, has to have length, width, height . . . and duration. If it had no duration, it wouldn't exist. Hence there is a fourth dimension, but we have always used another name for it. We have called it time. Time, therefore, should be considered the fourth dimension.

But you don't have to consider it that way at all.

## MORE ABOUT PLUTO

THE existence of a planet outside the orbit of Neptune was, as is rather well known, suspected since about 1900. The planet, Pluto, was finally found in 1930 by Clyde Tombaugh, and it has been under what surveillance could be managed ever since.

But we now know that Pluto could have been discovered in 1919, for it was photographed twice during that year. The explanation is not, however, that astronomers overlooked it on these two plates. The fact is that they could not help but overlook it; two occurrences effectively hid the still unknown planet.

On one of the two plates, the tiny image of the planet was neatly bisected by a hairline flaw in the plate. Such hairline flaws are rare, but when they do occur, astronomers recognize them at a glance. Naturally, the pinpoint of light, sitting so precisely on a hairline flaw, was taken to be a part of the flaw.

On the other plate, the planet happened to be in line of sight with a small distant star. It was not precisely the line of sight, else it could not have been found later, but almost so. The result was that a star image, known to belong in that spot, was finally elongated, though so faintly that it was not conspicuous.

And that's why Pluto was not discovered until eleven years after it was photographed.

—WILLY LEY

## ANY QUESTIONS?

*What is the reason for all the planets being near the plane of the ecliptic? Why aren't some of them revolving around Sol vertically in comparison with the others?*

*Pat Scholz*
9909 *Fourth Avenue*
*Brooklyn* 9, *N. Y.*

**The reason why our solar system — and presumably all other solar systems, too—is so flat lies in the period before the formation of the planets.**

**Let's assume that the Solar System began with a roughly spherical cloud of gas atoms and dust particles which surrounded the Sun. We can also assume that this cloud rotated around the sun.**

**Now the particles, molecules and atoms which moved in and near the equatorial plane of that cloud did not interfere with each other very much. But those which originally moved in other directions, crossing the equator from "above" and "below," ran into each other and into "equatorial particles" in time. If their movement was stopped completely by the collision, they simply fell into the Sun. Or, if their movement was not stopped completely they "fell in" with the equatorial motion. In either case, the number of particles moving at large angles to the "equator" was diminished.**

**That took place before the planets themselves formed and continued while they were forming and even afterward. A few of the nonconformist particles may still be around, but not enough to see.**

*If the gravitational pull of the Moon is responsible for the tides here on Earth, how would the tides be affected by two or more moons? How about a planet which has rings like Saturn, but no moon or moons?*

*Jean De Grazia*
597 *Hopkins St.*
*Sewickly, Penna.*

**Let's first get a clear mental picture of what the tides are. Seen from space, they are a slight double mountain of water, one directly under the Moon, the other on the opposite side, both of which move around the Earth, inundating those portions of the shore-**

lines which are shallow enough to be inundated.

In the case of a planet without a moon, but with a ring or rings, there would be a slight equatorial bulge all around which does not move. A rotating planet has such an equatorial bulge, anyway, because of its rotation, and the ring would slightly reenforce that bulge. Since this would be stationary, the planet would appear to have no tides.

In the case of a planet with several large moons, the tidal picture would be enormously complicated. Each moon would produce its double bulge and, since the various moons would revolve around the planet with various periods of revolution, so would the bulges. The high tide caused by moon A might increase the high tide of moon B, or else the low tide of moon A might cancel the high tide of moon B.

If you had a fairly watery planet with four large moons, its inhabitants would develop astronomy to a high degree early in their history.

*Could you please explain the ether theory as applied to sound transmission? And what is the accepted figure for the speed of electromagnetic waves?*

*E. A. Lackenbach*
*53 Pine Avenue*
*New Rochelle, N. Y.*

Sound waves are transmitted through the air, not through the (hypothetical) ether. As the air thins out with altitude, there comes a point where it ceases to be a continuous medium, and even though there are still molecules of oxygen, nitrogen and other gases around, sound is no longer transmitted. At present, this is thought to take place at about 40 miles above the Earth, but it may be much lower.

The speed of sound depends only on the temperature of the air, not its density. At normal temperatures, it is about 760 miles per hour. Physics textbooks need revision to bring them up to date on this point; they state that the speed is 660 miles an hour at 25,000 feet, and ascribe it to density. In reality, the figures apply to the prevailing temperatures at those altitudes and not to the atmospheric densities.

Electromagnetic waves of any wave length do not depend on air for transmission, and so they all travel at the same rate, which is roughly 186,000 miles per second, the speed of light.