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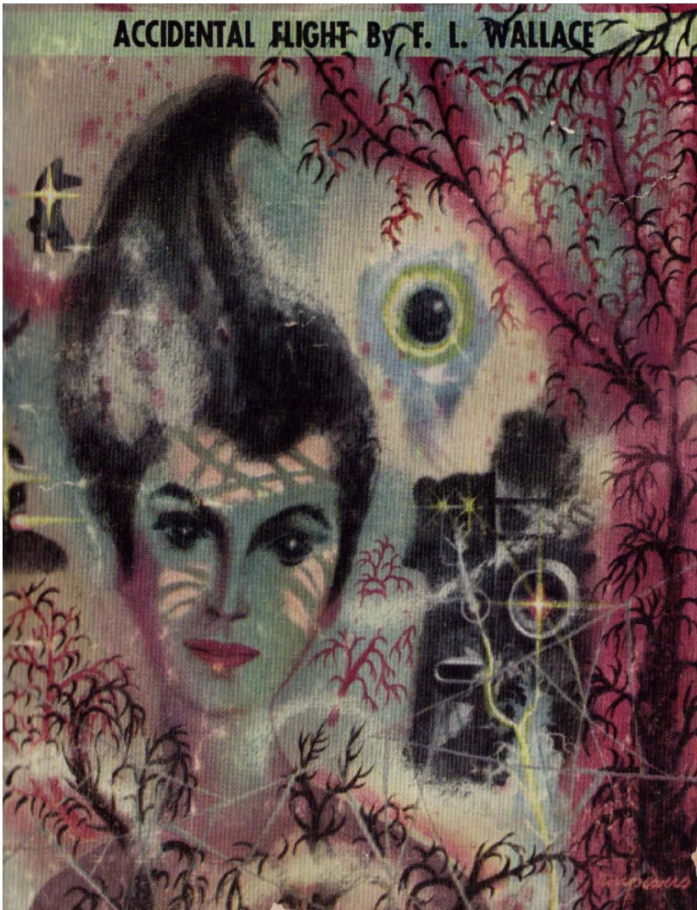

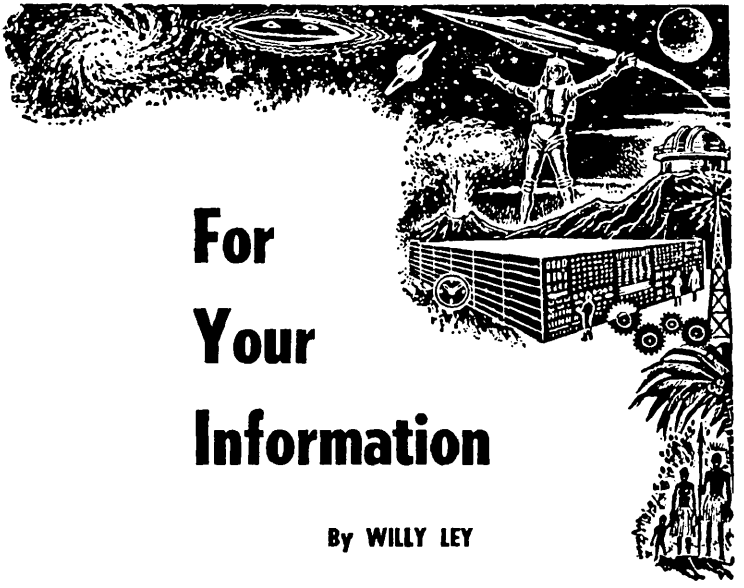

For Your Information

By WILLY LEY

CARBON-14 AND THE ICE AGE

THE man who is used to distances expressed in miles and to time intervals measured in years always feels at a loss when it comes to astronomical distances and to geological times. He hears an astronomer refer casually to "a comparatively near star, only eleven light-years away"—each light-year being 5,880,000,000,000 miles! Or he hears a geologist say that a lump of coal was forest 400 million years ago. Of course, scientist

are now generally believed to know what they are talking about, but the astronomical measurement is still one thing, for after all, that star can be seen and photographed, while the time measurement is another. Who, I was once asked acidly, kept a calendar?

There is a one-word answer to that question. Not who, but *what*. Answer: radioactivity.

Just about half a century ago it was realized that the radioactive decay of uranium produces helium. The late Lord Rutherford of Nelson realized one possible application of this phenomenon immediately. This, he said, would permit dating the age of minerals, provided the minerals had trapped the helium. All one had to do was to measure the helium content of a mineral, then its uranium content, and make a good guess how much helium has escaped. That way the age of the oldest minerals was determined as 700 million years. If one assumed that half of the helium had managed to seep out, the true age would be double that figure.

A few years later Prof. Boltwood came up with a better suggestion. Helium, just because it could and probably did escape, was not reliable enough. But meanwhile it had been found that uranium changed ultimately into lead, which did *not* escape. One merely had to measure and compare the uranium and lead contents. With his method Prof. Boltwood determined the age of the oldest minerals as 2,200,000,000 years. When this figure was first announced, about 1910, it seemed so fantastic that it was generally disbelieved. But it was accepted only a few years later, especially since a number of scientists had done their best to accelerate or decelerate natural radioactive processes. They had tried heat and cold, pressure and vacuum, electric and magnetic field, and every combination of them. The very fact that they had failed utterly was important. If nothing they could think of and apply made any impression on the rate of change, it was likely that nothing that would happen in Nature would change the rate.

But this uranium-lead method, joined some time later by the thorium-lead method, was applicable only for long intervals. One could measure 20 million years, but not 900 years. It was like the speedometer of a car which will tell you that you have driven 150 miles, but which cannot be used to measure two yards of cloth. For that you need a tape measure.

One of the most important developments of the postwar years is that a reliable method for dating comparatively short periods

of time is now in existence. Developed originally by Drs. J. R. Arnold and W. F. Libby of the University of Chicago, it also relies on the measurement of residual radioactivity. But the radioactivity element involved is not one of the heavy elements which stays active for millions and millions of years. It is a comparatively short-lived isotope of carbon with the mass 14, consequently, the method is known as the carbon-14 or C-14 method.

C-14 has a so-called "half life" of 5,568 years (with an uncertainty of 30 years either way), which means that at the end of 5,568 years a piece of pure C-14 would be half gone as far as radioactivity is concerned. With such a short half life, C-14 would have vanished from the face of the Earth long ago and would by now be something which might be determined by theory—if it were not formed constantly.

Cosmic rays transform a few nitrogen atoms in the atmosphere into C-14 at a steady rate. Combined with oxygen, these C-14 atoms appear as carbon dioxide, are absorbed by plants, go into starches, are eaten by animals and men. In short, every living thing is permeated to a known extent with the "hot" atoms of C-14. As soon as the living thing dies, it stops absorbing C-14. A beam fashioned from a tree that was felled 5,600 years ago will show half as much radioactivity from C-14 atoms as a beam from a tree felled last year.

It is easy to understand the principle. If the C-14 activity of a living thing is known, one only has to measure the radioactivity of a no-longer-living substance. If one can be sure that there is no radioactivity from other sources around, the two figures can be compared directly.

When Dr. Libby began his work, he naturally first tested his method by measuring the age of things which did not need measuring, because their age was known. One of the first objects he tested was a piece of wood from a fallen sequoia tree which had been sawed through. Botonists had counted the tree rings to determine its age. It must have been a tedious job, for there were 2,928 of them! Dr. Libby reduced his sample to pure carbon and went to work with Geiger counter and slide rule. The result was 3,005 years, which is close enough for any purpose.

Then he tested a piece of wood from a Hittite palace in Syria. Historians had dated the palace as having been built not earlier than 725 B. C. and not later than 625 B. C. The C-14 method gave the age of the wood as 2,600 years. Another test was a piece of wood from an Egyptian sar-

cophagus which actually had a date on it. That date read, in our terminology, 330 B. C. The C-14 method said that the wood was 2300 years old.

Some of these tests, besides proving the acuracy of the C-14 method, incidentally show that the methods of dating developed by the historians were correct too. All historical objects that could be dated were found to agree within a few years with the dates assigned to them by the historians.

I wrote "all historical objects that could be dated," for not every historical object can be tested by the C-14 method. The method works only with things which were once alive. You cannot date an old armor, nor a stone ruin, nor an old sword. But if that sword has a bone handle, you can date the handle.

The restriction to objects of organic origin is one of the four limitations of the C-14 method. The second is that the object to be dated must weigh at least one ounce. The third limitation is that the object is destroyed in the process. And the fourth is that there is a time limit. Because of the short half life of C-14, the method begins to waver when the object is 20,000 years old; at such an age, there is very little radioactivity left. And 25,000 years is as far as it will go.

The C-14 method has led to a number of surprising results, especially when applied to Indian relics. For reasons not known to me, archeologists thought that the Indians of the Hudson Valley area had settled there in fairly recent times. But C-14 measurements of relics gave rather high ages, the oldest of them dating back to 3,000 B. C. Fiber sandals found in eastern Oregon, completely undatable in any other way, were found to be 9,000 years old.

In addition to having improved archeology, the C-14 method has also had some influence on recent geology. On a map of the State of Oregon, you'll easily locate Crater Lake National Park, with Crater Lake in the center. It was obvious from geological evidence that the volcano which is now water-filled must have exploded at a comparatively recent time. But geologists could only say that it was sometime between 15,000 and 25,000 years ago, maybe a little longer, possibly somewhat less. Then somebody found a tree which had been destroyed by a lava flow from that eruption. Of course it had been burned to charcoal, but charcoal can be tested. It turned out that the eruption had taken place 6,300 years ago, just about half the time of the lowest estimate made.

The most important result so far is the actual dating of the Ice Age. The whole Ice Age, consisting of four glaciations interrupted by much longer interglacial periods, is estimated to have lasted one million years, from its very beginnings to the melting of the glaciers during their last retreat. The customary figure given for the melting away of the glaciers of the last advance was 20,000 years. Since this was a figure that was still within reach of the C-14 method, some Ice Age material was tested. In Wisconsin there was a forest which had been pushed down by the glaciers of the last advance, and this was worked on.

The result sounded incredible at first: 12,000 years. This was more recent by far than anybody had believed, especially since it marked the last advance, not the last retreat. The retreat could not be studied in Wisconsin; but in Nebraska they found an old forest which had grown up after the retreat of the last ice sheet. They gave an age of 10,500 years. Comparable material from Europe, procured in a great hurry, gave figures which differed from the Wisconsin and Nebraska result only within the expected margin of error. The overall length of the Ice Age probably was what geologists say, but the last glaciation was much closer to our time than believed. It was still going strong 12,000 years ago, but it lasted for less than 20 centuries.

THE ROBIN THAT HIT THE BOTTLE

DID you ever miss making an interesting observation just because you didn't know there was something to see? I did, and if I hadn't been behind in my reading, I might have contributed to something which is still a controversial matter. And every time I see a robin . . .

But let me begin at the beginning, which happens to be in Australia, even though the story itself is essentially an American one. Australia is, as everybody knows, the land of strange animals. But it seems as if the Australians did not know as much of their animals as one would wish—it also seems that they "knew" a lot of things that weren't so—and a quarter-century ago the Australian publishing firm of Angus & Robertson decided to do a set of books on Australian Natural History, written by Australians for Australians. One of these was about Australian birds, written by Alec H Chisholm and published in 1935.

I own a copy of that book, on page 153 of which there are two paragraphs reading:

> Early in 1934 a boy living near Melbourne wrote to me, stating that he had seen English Starlings picking up ants in their beaks and placing them under their wings. If this had been the first report of the kind I should have doubted the evidence of the boy's eyes. However, seven years previously a Sydney man, one who had watched birds in aviaries and in the wild during many years, had asked me: "What is the reason why soft-billed birds such as starlings, jays, etc., when on the ground, pick up soldier ants, put them under their wings, and after a while take them out again?"
>
> Now, the bare facts having been stated, the reader knows as much of this matter as I do, and probably as much as anyone else does. As far as I have been able to ascertain, there is nothing in text-books to indicate that starlings in Britain place ants beneath their wings.

I have to add that I got the book in 1936 and must have read these paragraphs then, but that they evidently made no impression on me, for I had to look them up later.

Now the scene shifts to Washington, D. C., where I lived for several years in a rented house on Rhode Island Avenue, the typical two-story one-family Washington home, with a front lawn and a back yard and big old trees all around. Also much birdlife, yellow finches and English sparrows, cardinals and catbirds, blue jays and starlings.

On a hot afternoon in late summer 1948, I sat on my front porch, reading, paying very little attention to the robins on the lawn. There were some more on my neighbor's lawn and my neighbors, an old couple, paid as little attention to them as I did. Among the robins on their lawn was a young one which finally attracted notice by behaving queerly. It ran back and forth with short, quick steps, moved in a small circle with one wing and tail dragging on the grass, then tumbled and fell. It sat still, apparently exhausted.

My neighbor went to pick the bird up, which he permitted her to do without a struggle. Naturally the woman assumed that the young bird was hurt. She looked unsuccessfully for a wound and then called my wife Olga to her, exclaiming: "The poor thing is all covered with ants." The two women brushed the ants out of the feathers with a soft brush; the bird did not protest and sat quietly.

Somewhat at a loss what to do next, they called me in. It was decided to perch the bird on top of the garage, out of reach of the cats of the neighborhood. The young robin stayed put for a few minutes, then walked to the rim of the garage's roof, looked down with some curiosity, and suddenly flew away.

It was at about that instant that Olga realized what we had seen. Just a few days earlier, a book by Frank W. Lane had arrived from England—it has been issued in Spring 1952 in the United States under the title *Animal Wonder World*—but I had as yet merely looked at it, my mind being on missiles, and Olga read it first.

Lane told what had transpired since Chisholm had inserted that short statement in his book. A copy of Chisholm's book had come to the University of Berlin and Prof. Erwin Stresemann had wondered whether the English starling had actually picked up a new habit in Australia. Stresemann published a translation of Chisholm's statement in the German *Ornithological Monthly*. He received an astonishing volume of mail, but because of the war this did not become known. Shortly after the war, Frank W. Lane published an article on this habit in the British magazine *Country Life*, whereupon he found himself at the receiving end of lots of letters. Scores of people have watched scores of birds put ants under their wings.

The champion "anter" in England is a thrush; in America it seems to be the robin which, zoologically speaking, is also a thrush. H. R. Ivor in Canada decided that an aviary should be a convenient place to observe "anting." He was right. But other observers, who made the same decision, did not see anything unusual happen.

These are the ones who claim that it is all a superstition. Of course, their position is difficult, for it is much harder to prove that something does not happen than it is to prove that it does. And the ones who say it does happen because they watched it happen number among them some people with a reputation to uphold. The American reports seem to indicate that thrushes, including robins, crows and starlings seem especially addicted to "anting." Blue jays and pigeons do not do it at all, it seems.

The main question, since the fact can hardly be doubted, is "why?" Chisholm advanced the suggestion that the formic acid, sprayed into the feathers by the trapped ants, kills off parasites. He probably does not hold that opinion any more. Those birds which do not "ant"—which is most of them—have parasites, too. So far there is no definite answer. But several observers stressed "the evident enjoyment" of the birds and their exhaustion afterward. That, to me, sounds like a binge. On formic acid!

Wish I had really watched that afternoon in Washington.

—WILLY LEY

ANY QUESTIONS?

Is it legal to use the metric system in the United States?

Not only did our Congress make the metric system legal in the United States in 1866, it also defined the inch and the foot in terms of centimeters, the mile in terms of kilometers and so on. In addition to that the weight of the coins were fixed in metric weights, the nickel at 5 grams, the dime at 2½ grams, the quarter at 6¼ grams and the half dollar at 12½ grams.

Is there such a term as "explosion limit" and what does it mean?

I probably could give a better answer if my correspondent had quoted the whole sentence or at least told me what he was reading about. The term may refer to the limits of the danger area of an explosion, or it may refer to the admixture of explosive gases to the air of a closed room. If there is not enough of the explosive gas present, no explosions will occur. If there is too much, no explosion will occur either. These "explosion limits" vary widely for different explosive gases. Expressed in percentages of the available space, the values for some substances are:

Hydrogen	9.4	66.5
Alcohol	3.9	13.7
Marsh gas	6.0	13.0
Ether	2.6	7.9
Benzene	2.6	6.7
Ill. Gas	7.8	19.2

These limits explain a few other things too. You can smell an admixture of illuminating gas to the air long before it has reached the lower limit. Conversely, the explosion limits for hydrogen are rather wide, which helps to make hydrogen leaks so dangerous. Those of carbon monoxide are even wider (16.4—75.1), but since the lower limit is high, poisoning occurs long before there is danger of explosion.

I wonder where the pilot and crew will get the energy for keeping warm in space. As long as the rocket is burning, some of that might be piped into the cabin, but I understand that in any space trip the rockets will burn for a short time only.

Strangely enough, we now know that the main engineering problem will be to keep the cabin cool enough! I'll explain more about that in the main section of this department in the near future.