Galaxy
SCIENCE FICTION

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THE YEAR OF THE JACKPOT by ROBERT A. HEINLEIN

In This Corner

WITH this issue, Willy Ley begins his monthly department "For Your Information." It should be interesting and useful in many ways. For one thing, Mr. Ley proposes to have a good deal of variety, ranging from complete articles, like this month's study of moons, to brief reports on significant developments in science.

In addition, he has undertaken the job of answering all questions submitted by readers, *either in the magazine or by mail.* Please be reasonable, though — it isn't fair to ask him to write a complete thesis. If that sounds preposterous, you don't know the crust of some people. Names and addresses will be used unless there is a specific request to withhold them. The ones in this issue were sent directly to Mr. Ley and not to the magazine, so there is a legal barrier to printing the names, even though the senders may approve or actually desire it.

In addressing your queries to Mr. Ley, send them to GALAXY Publishing Corp., 421 Hudson Street, New York 14. *If you have other matters to discuss at the same time, please put them on one sheet and the question(s) on another.* We don't want to cut up letters so that Mr. Ley will get whatever applies to his department and we retain the rest. Very untidy and hell on filing.

Willy Ley is precisely the man to run a feature like this, which provides a fine opportunity to tell you something about him.

He was born in Germany in 1906, and, like many of us who belong roughly to the same generation, spent considerable time hunting through the libraries for science fiction in his youth. However, he was hit by a stroke of luck that might have killed us with joy—he became an officer of the German Rocket Society in 1927, and then technical adviser for UFA on such dream movies as "The Girl in the Moon," "Metropolis," etc.

By the way, if you happen to have a print of "The Girl in the Moon," or know someone who has, he and Fritz Lang, the director, would be enormously grateful for the chance to make a print at their own expense. You will naturally be given credit for your invaluable aid.

Mr. Ley's life, as well as many others', became complicated by a painter of exceedingly mean ability and even meaner politics and ethics. In 1935, Mr. Ley

thought it advisable to go elsewhere. Hence, America has a pretty wonderful citizen, who has helped greatly in the development and popularization of rocketry. His books are authoritative; he is consulted as an expert and is in hot demand as a speaker.

One specialty might be enough for most people, but Willy Ley is also a noted naturalist and has never been referred to as a slouch in the physical sciences.

Mr. Ley is about five-eleven and seems to weigh 190 pounds; he has a calm and reasonable disposition, but I would not advise anyone to ask him to take off his black-rimmed eyeglasses and step outside.

He is married to an artist and ballet dancer named Olga, a dainty creature of astonishing grace and endurance. Keeping two small girls disentangled from piles of research material is a major job, but she also manages to illustrate much of his work.

It's an honor to have Willy Ley as a contributing editor. He is waiting for your questions; don't let him go to waste.

A GRATIFYING number of readers have asked what I'm like. This should be one of my favorite subjects, but the truth is that my life is an old story to me.

I'm five-nine, 155 stripped (I just weighed myself at the corner drugstore to verify). Born in Montreal in 1914 in the first month of World War I. Named H(orace) L(eonard) after a prompt casualty in the Princess Pat Regiment. I can't pretend to be fond of my name, but I don't use initials to escape it; that was decided upon by an editor, though other editors have used the whole thing. Having had 32 pen names, I find the problem shrug-worthy.

Educated in the U. S., though frustrated as a small boy when all history books agreed England lost the Revolutionary War.

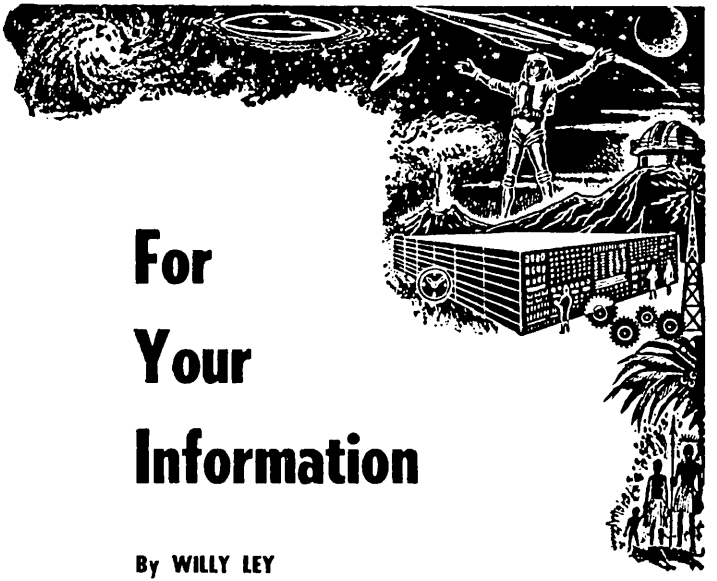
Married (September, 1939) and have one son (born December, 1941) and am not superstitious, knock on wood, but hesitate to get born or married again or have another kid.

Had the usual jobs while learning to write: junior pharmacist, shoe salesman, floor scraper, apprentice upholsterer, etc. Wrote and sold over 5,000,000 words and edited or published more than two dozen magazines of all kinds.

GALAXY, of course, is my own dream come true. I know I sometimes push too hard, but that's because everyone wants his dream to be perfect.

Apprehensive readers have asked if I'm susceptible to "scientific" fads or cults. I'd turn in my blue pencil first.

—H. L. GOLD



For Your Information

By WILLY LEY

ASTRONOMY books and science fiction stories are, I have come to realize, unfair to satellites. Astronomy books are in the habit of merely listing them, while stories usually treat them as mere props. "One expedition was sent to the single barren satellite," or, "The ship was in hiding on the third satellite, a useless hunk of rock, but it made radar detection impossible."

Such slighting treatment may

be expedient, but it is hardly polite. Satellites, or at least some of them, do have as much individuality as the planets to which they belong. And they have their mysteries too.

Moons come in all sizes, from the estimated five mile diameter of Deimos, the smaller moon of Mars, to the 3550 mile diameter of Titan, the largest moon in the Solar System. Titan is larger than the smallest planet of our system, Mercury (3100 miles in diameter) and so are two of Jupiter's moons, namely III (Ganymede) and IV (Callisto). Neptune's larger moon Triton falls short of Mercury by just a few score miles. And fourteen of all the moons, roughly half their total number, are larger than the largest of the planetary worlds of the so-called asteroid belt.

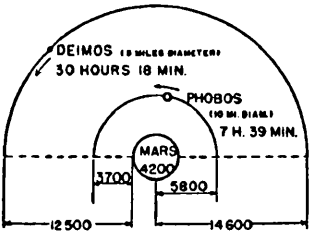
The largest of the planetoids, as they should be called since *aster* is Greek for "star" and they are not little stars but little planets, is Ceres with a diameter of around 480 miles. The next one in size, Pallas, measures very slightly over 300 miles in diameter, while Vesta, the third largest of the planetoids, has a diameter of only about 240 miles.

So it is not a question of size. A satellite is a satellite *because it moves around a planet.*

Our own moon is one of the largest, ranking sixth in absolute size among the satellites. But it is the largest by far in relation to the size of its planet. Its diameter of 2160 miles is more than one-fourth of that of Earth (7900 miles). No other satellite is anywhere near as large in relation to the size of its planet. Next largest relative size is that of Neptune's larger moon Triton, whose diameter of 3000 miles is roughly 10 per cent of Neptune's 31,000 miles, while Titan's impressive 3550 miles are just about five per cent of Saturn's 71,500 miles.

Looking at these figures, it becomes understandable why some astronomers in the past preferred to speak about Earth and its moon as a double planet.

If Earth has relatively the largest moon, Mars has the smallest, at least in absolute size. It is fairly well known that Dean Jonathan Swift, in the story in which his long-suffering Captain Lemuel Gulliver visits the flying island of Laputa, "prophesied" the existence of the two moons of Mars one and a half centuries before they were actually discovered. It was a mere guess, based on the "theory" that Mercury was the moon of the Sun, that Venus had no moon and Earth one, so that Mars had to have two. But it is less well known how closely Swift guessed. His Laputan astronomers, he wrote, had discovered the two satellites revolving around



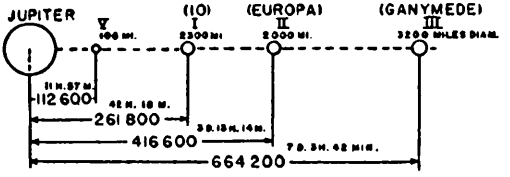
Mars and its two moons. To scale, except for the size of the moonlets.

Mars, "whereof the innermost is distant from the Center of the Primary Planet exactly three of its Diameters, and the outermost, five; the former revolves in the space of ten hours, the latter in twenty-one and a half."

Now look at the diagram (Fig. 1) which contains the correct values. Since a Martian day lasts 24 hours and 37 minutes, Phobos, the inner moon, has a period of revolution which is shorter than the period of rotation of its planet. Even though it moves in the same direction as the outer moon, Deimos, and most of the other moons of the Solar System, it will seem to go the wrong way when viewed from the surface of the planet. It will rise in the west and set in the east twice every day, going through its phases as it does so. Although small, it is so close to the planet that it will appear about one-third as large as our moon does to us. Deimos, on the other hand, will rise in the east, but needs almost three Martian days to reach the opposite horizon. During this interval it will run through its phases twice, but Earthmen on Mars would need binoculars to see the phases.

One of the things we can't tell from Earth is whether Deimos is actually spherical. It probably is, but it does not have to be. The sphericity of celestial bodies is due to the fact that gravitation is a mass force while the tensile strength of a material is a molecular force. Since molecular forces do not grow with mass, and gravity does, you probably couldn't have a thirty-mile diameter mass of any thing that is not pretty spherical. Deimos, however, measures only five miles in diameter and, while it is apt to be reasonably spherical, a noticeable deviation from the "pure shape" is possible.

The probability is very high that Mars' two moons were once members of the asteroid belt. Of the 1300 or so planetoids now known, most move in the belt between Mars and Jupiter. There is no visible or imaginable reason why multitudes of tiny planets should have formed at that particular distance from the Sun, so the customary assumption is that the planetoids once formed a



Jupiter with moons V, I, II and III. To scale, except for the size of the moons.

single planet, which was destroyed by the vicinity of mighty Jupiter at the outer edge of the belt. The planetoids in the belt (by tradition, they have all been given female names) move with orbital velocities varying from around 14.5 miles per second at the inner edge to about 8.5 miles per second at the outer edge. Since Mars itself moves with an orbital velocity of 15 miles per second, which is more important than its feeble gravity, it could have captured its two moons from the belt. It may have captured more in the course of geological time, but these others, instead of becoming moons, probably crashed on the planet.

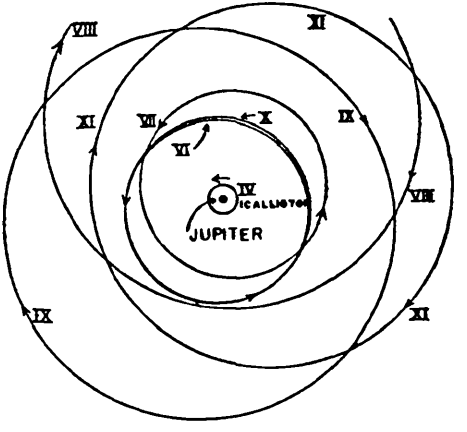
In addition to the planetoids in the belt, there are some which travel around the Sun outside the belt—they were given male names to distinguish them from the well-behaved members. Most of them cross the orbit of at least one of the larger planets. Their own orbits, therefore, are highly eccentric; that is to say, elongated ellipses. A concomitant of such an orbit is that the orbital velocity varies considerably. Such a planetoid may move four times as fast when near the Sun, at perihelion, than it does when farthest from the Sun, at aphelion.

This means that the male planetoids that cross the orbit of Earth are considerably faster at Earth's distance from the Sun than Earth itself. We have an actual example on record, the close approach of the planetoid Adonis in early February 1936. When crossing the orbit of Earth, its velocity was 23 miles per second relative to the Sun and 16.8 miles per second relative to Earth. The actual distance at the instant of closest approach was roughly twice as far as our moon. At another time Adonis may come closer to Earth than the Moon. But even at the closest possible approach its relative velocity would have to be just one mile per second, instead of the actual

16.8, if a "capture" were to be accomplished. At the orbit of Venus, the planetoid velocities are even higher, which explains why neither Earth nor Venus ever succeeded in capturing one.

The planet at the outer edge of the belt is not much slower than the nearer planetoids, and, in addition, it happens to be the most massive of all planets—Jupiter. Even if we were not able to see and photograph them, we could be certain that Jupiter should have a number of moons which are captured planetoids.

Our own moon obviously is not a captured planetoid, but a body which formed near Earth from the same cosmic material and in the same manner as the planets. This would be a far better statement if one could also say just how Earth and the other planets did form. Most of the recent ideas on this difficult problem work with the gradual aggregation of small particles of cosmic material, aided by turbulence in a rotating dust cloud. Whatever the precise mechanism of planet formation may have been, the larger moons probably formed in the same manner, presumably beginning



Jupiter's outer moons. Calliste or No. J-IV, is 1,169,000 from the planet, has a diameter close to 3200 miles and needs 16 days, 16 hours and 32 minutes for one revolution. All the outer moons are less than 100 miles in diameter. VI, VII and X are slightly over 7 million miles from the planet with a period of revolution of about 260 days, while XI, VIII and IX are on the order of 14½ million miles from the planet with periods of revolution from 690 to 760 days.

their existence as satellite accumulations long before either the planets or the satellites had reached their present sizes.

The planetoids, female, male and captured, must then be distinguished from the planets as "second-hand bodies," having originated via the destruction of

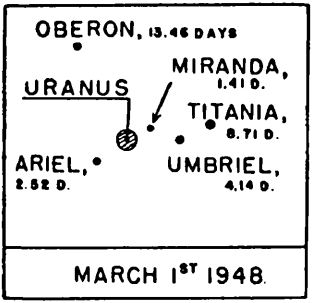


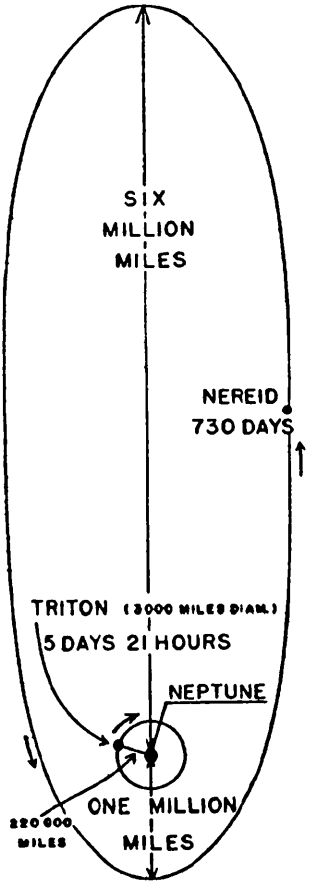
Diagram of the photograph which led to Miranda's discovery, taken by Dr. G. P. Kuiper. At that time we saw Uranus' system straight on, so that the satellites described circles around Uranus. (Edge-on view will not occur until 1966.)

one of the original planets.

As for Jupiter's moons, twelve by latest count, they seem to belong to both types. The large ones are evidently original satellite bodies; of the small ones, at least some behave as one would expect of captured planetoids. The moon closest to Jupiter (called J-V because they are numbered not in the order of distance from the planet, but in the order of discovery) may be a captured body, too, even though it is fairly large. Any moon which needs only two hours more for one complete revolution around its primary than the planet needs for one rotation is at least under suspicion.

The four large moons are big and brilliant enough to be easily visible with a good pair of binoculars. With a good astronomical telescope it is even possible to distinguish some faint surface markings. J-I (or Io) shows a very wide equatorial belt which is definitely brighter than both polar areas. J-II (or Europa) was always thought to be featureless until E. M. Antoniadi, some 25 years ago, saw an extensive dusky spot in the central portion of the disk. J-III (or Ganymede) has one large and at least one smaller darkish spot and a round white area near its southern pole. If that actually is a polar cap, it would not be frozen water but a frozen gas. Though I have never seen frozen methane, I presume that it forms crystals when freezing so that the general effect would be about the same as snow.

J-IV (or Callisto) does not have any markings, but presents color changes at rare intervals. Normally its disk is reddish-yellow. It has been seen perfectly black, however, *as if it had suddenly developed a light-absorbing atmosphere!* Before anybody



Neptune and its two moons.

starts a story that an expedition from Arcturus-IV has established an outpost on Callisto and is generating an absorbing screen to get the radiant energy, I have to advise him to think up a different explanation for Plato. Plato is a large crater on our own moon which has been black quite often. But Plato becomes black just when the Lunar day has progressed to about its middle, which is the time when one would want to keep radiant energy *out*, instead of *absorbing* it.

No trace of an atmosphere has been found otherwise on any of Jupiter's moons. And in all the cases where their rotation could be established at all, it was found to be the same as their revolution around their primary. Like our moon, Jupiter's satellites always turn the same side toward their master.

If the picture of the five inner moons is a well-ordered cosmos, that of the outer moons is one of complete confusion (see Fig. 3). Not only do their orbits intersect and cross, they are also at all possible angles to the plane of Jupiter's equator. Furthermore, No. VIII, No. IX and No. XI are "retrograde"—they move in the opposite direction than the Solar System. This fact might be considered favorable to the captured theory; a planet of the mass of Jupiter could force a

planetoid into an orbit which points either way. As for No. XII, discovered in 1951 by Dr. Seth B. Nicholson, we don't know yet in which direction it moves. But it is so small—an estimated 15 miles in diameter—that it probably is a captured planetoid, too. If fact, if we were nearer Jupiter, we would probably find a few dozen additional moonlets, in all kinds of orbits, each smaller than ten miles in diameter and every one a captured planetoid.

Navigating in the Jupiter system is apt to be quite hazardous; it may be as bad as going through the asteroid belt itself. In one respect worse, for ships could avoid the asteroid belt quite easily by traversing it "above" or "below," north or south of the ecliptic, like crossing a busy highway on a bridge. But if they wanted to go to one of the large moons of Jupiter, they'd have to head into the medley of moonlets we don't even see from here. Incidentally, a ship which wanted to land on a retrograde satellite would not have any special troubles. It only would have to catch a retrograde satellite on the "wrong" side of the planet, the opposite side from which the captain would catch a "direct" moon.

In contrast to Jupiter's complex and confused system of satellites, the nine moons of Saturn are so orderly that it was not even necessary to draw a diagram.

Except for Phoebe (200 miles) they are all quite massive and, as has been mentioned before, Titan is the biggest of all the satellites in the Solar System. It is so large that it has an atmosphere, the only satellite capable of holding one. It is the same as the composition of Saturn's own atmosphere, methane (CH_4) and ammonia. Brownish markings have been seen on Titan on occasion, but their nature is unknown.

Every moon from Mimas to Hyperion is lined up to please a drill sergeant. Hyperion does have a slightly eccentric orbit, to about the same extent as that of the planet Mars, but is still in line. Iapetus, though not in line as regards inclination, has a nearly circular orbit. Only Phoebe is a black sheep, retrograde and with a fairly eccentric orbit. Phoebe might be a captured planetoid. One male planetoid, Hidalgo, is known to break out of the belt, cross the orbit of Jupiter and come close to that of Saturn. The biggest puzzle in this orderly system is probably Iapetus. *One* side of it is *five* times as bright as the *other!* Don't ask why; we just know the fact.

The satellite system of Uranus became "news" in 1948 because Dr. Gerard P. Kuiper added a fifth satellite, Miranda, to the

four which had been known for over a century. Miranda, with an estimated diameter of 150 miles, is closest to the planet (80,800 miles) and gets around it once in 30 hours. Ariel, the next one out, at 119,100 miles, has a diameter of 600 miles and a period of 2 days, 12 hours and 29½ minutes. Umbriel, the next satellite at 165,900 miles, measures 400 miles in diameter and has a period of 4 days, 3 hours and 27½ minutes. Titania, at 272,000 miles, measures 1000 miles in diameter and has a period of 8 days, 16 hours and 56½ minutes. Oberon, finally, farthest out at 364,000 miles and almost as large as Titania (est. diam. 900 mi.), needs 13 days, 11 hours and 7 minutes for one complete revolution.

Uranus' system is just as orderly as that of Saturn, but has a peculiar twist—literally. The axes of most planets are reasonably vertical in relation to their orbits, like spinning tops, Jupiter's almost upright with a tilt of only 3° 7', Earth canted a good deal at 23½° tilt, Mars at 25° 10' and so on. But Uranus' axis, *tilted 98° degrees from the vertical,* practically points at the Sun on occasion! Its five moons, however, have maintained the customary orbital plane of satellites, roughly the equatorial plane of their primaries, and are, therefore, tilted by a little more than a right angle, too. Since one cannot imagine a force which could do this to a *finished* planetary system, the most logical assumption is that there was a major eddy of that tilt in the cosmic dust cloud *before* it condensed.

Pluto being moonless, the most distant satellites are in the Neptune system. For a long time only the large moon Triton was known and its main feature was that it was retrograde, tilted some forty degrees against the orbit of the planet. For an almost equally long time it was believed that the planet itself rotated in the "wrong" direction (the "right" direction in our solar system is counter-clockwise when seen from the celestial north pole). Astronomers speculated on the problem of what could flop both a planet and its satellite over almost completely. But then it turned out that Neptune's rotation is normal and we are simply dealing with the largest of all retrograde moons. In 1949 Dr. Gerard P. Kuiper, the discoverer of Miranda, found a second small satellite of Neptune which is *not* retrograde. But that small satellite, Nereid, with a mass only slightly above 10 per cent of that of Triton, has an elongated orbit of a type considered *characteristic of comets!*

Such an orbit, combined with

so low a mass, should spell "capture" in large letters. Now the idea of capture has worked out neatly elsewhere. Mars and Jupiter, close to the belt, could and did. Saturn still had a chance and probably did. Uranus no longer had a chance and did not. Neptune, of course, has less of a chance than any other planet. Then *what* did it capture? And from *where?*

—WILLY LEY

ANY QUESTIONS?

Is there any connection between the names of the planet Uranus and the element uranium?

Yes, but that's only one-third of the answer. When the scientist Klaproth came to the conclusion that pitchblende contained a new and unknown element, he named it *uranium* in honor of the recent discovery of Uranus by Herschel. Modern physicists have continued this tradition and named the elements beyond uranium after the planets beyond Uranus, hence *neptunium* and *plutonium.*

How high is our atmosphere and how high have we gone?

The altitude records as of December 1st, 1951, are: manned balloon, *Explorer II,* 72,400 feet; unmanned balloon, 125,000 feet; manned rocket airplane, *Skyrocket,* estimated 78,000 feet (correct value is classified); unmanned single stage rocket, *Viking VII,* 135 miles; two-stage rocket, *Bumper I,* 250 miles. The height of the atmosphere depends on definition. For practical purposes, everything above 50 miles is a vacuum.

You have used the term "living fossil" in your books and assumed the reader knew what you meant. I don't; sounds like a paradox to me. Would you explain the term?

A living fossil is an animal or plant species known both living and fossil, or a living form closely resembling a fossil type. There are many examples: horseshoe crabs, sharks, ferns, etc. Whatever its form, experts are delighted to have it still around.

How would an atomic drive for a large rocket or spaceship work?

You'll find the answer in any textbook on the subject published in 1975 and after.

I wish I had a copy of one myself.