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SCIENCE FICTION

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NATURAL STATE
By Damon Knight

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For Your Information

By WILLY LEY

SMALL BODIES NEAR HEAVY PLANETS

ONLY a few issues back, I devoted a portion of this column to the moons of Mars, prompted by repeated questions from readers who wondered whether they might not actually be Martian space stations, possibly still active, but more likely abandoned for ages. Well, they are unquestionably small natural moons.

The reason I have to return

to them today is an interesting thought advanced by the German astronomer Professor Dr. Werner Schaub, a former president of the *Gesellschaft für Weltraumforschung*, the new German Rocket Society. In fact, Prof. Schaub spoke about his idea for the first time at a regional meeting of this society in May, 1953. Even more to the point is the fact that his idea grew out of a study of the forces which will act on a space station's structure.

The idea is that the inner moon of Mars might be slowly—very slowly indeed — disintegrating under our very eyes. Professor Schaub is careful to call this a "working hypothesis," but until it might be demolished by a detailed mathematical analysis it sounds like a good one.

However, a little background is needed first.

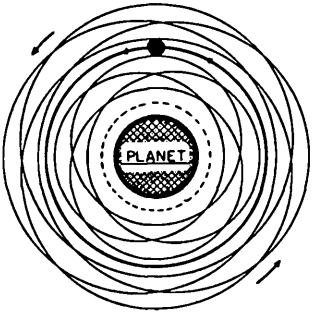
AS some readers are likely to know, the two small moons of Mars were discovered in August, 1877, by Asaph Hall with the 26-inch telescope of the Naval Observatory. The discovery was a great surprise, not only because of the oft-told story of their "prediction" by Dean Swift, but because the two satellites of Mars were strange in several respects.

They were tiny, appearing as luminous dots in even the biggest telescopes. Present estimates — which are a downward revision of earlier guesses—assign a diameter of not more than 10 miles to the inner moon (Phobos) and about 5 miles to the outer (Deimos).

They also were most unusually close to their planet, the distance from the Martian surface to the outer moon being only 12,500 miles and, from the surface to the inner moon, a mere 3700 miles, about the width of the Atlantic Ocean. This unheard-of nearness means that Phobos races around Mars in 7 hours and 39 minutes; its orbital velocity is 1.32 miles per second.

The latter figure, incidentally, shows the weakness of the gravitational field of Mars. If the same moon circled Earth at the same distance from the Earth's center (5800 miles), it would be 1850 miles from the surface and would need an orbital velocity of about 4 miles per second to stay in its orbit. Because the moonlet would need this much more orbital velocity to balance the Earth's stronger pull, it would also complete a full revolution in a much shorter time, namely a little more than 2½ hours.

It took half a century, counting from the original discovery by Asaph Hall, to find out that *the orbital velocity of Phobos*



A small moon circling its planet near Roche's Limit, losing portions of its surface due to the tidal forces of the planet. The dotted line around the planet indicates the approximate limits of its atmosphere. The heavy circle is the orbit of the satellite. The fine lines show the orbits of the separated particles.

is slowly increasing! Such an increase in orbital velocity can mean only one thing—the distance of Phobos from Mars is slowly decreasing. As I understand it, the decrease of the distance has not actually been measured yet, but the increase in speed has. It probably is easier to observe a small increase of the orbital velocity than a tiny shrinkage of the orbital distance. But that the two go together is established beyond a doubt.

The next question, of course, is "Why?"

Generally speaking, a moon will increase its speed if it finds a small amount of resistance along its orbit. This statement may seem paradoxical to somebody not used to the workings of celestial mechanics, but it is true just the same.

The first result of finding some resistance along the orbit would be to slow the movement of the moon. But that would result in the moon no longer having enough speed to balance the pull of the planet for the distance at which it is located. The planet could pull it a little nearer, but in "falling" toward the planet, speed would be gained and the moon would establish a new balance slightly closer to the planet at *a slightly higher speed.* So if cosmic dust got in the way of Phobos, the observed increase in orbital velocity could be explained. And from the observed increase in speed, one could calculate the density of the cosmic dust which caused it.

SUCH calculations were made by Kerr and Whipple, but no acceptable results could be obtained. If cosmic dust near Mars were as thick as required, we should be able to see it. After all, one cannot very well postulate that the dust is only in the moon's orbit and not anywhere else. Besides, dust of the proper density and spread through a large volume of space, as would be likely, should slow down

Deimos, too, but Deimos is not affected. If Mars had as much water as our own planet, one might try to explain the misbehavior of Phobos by tidal action—but Mars does not have much water.

Yet this apparently impossible assumption of a cosmic dust handicap for Phobos, which can be found only in and near its orbit, is Dr. Werner Schaub's "working hypothesis." One can make this assumption if it is also assumed that the dust comes from Phobos itself, for Phobos is rather close to Roche's Limit.

Roche's Limit, as has been stated many a time in many science fiction stories, is the distance inside of which a moon cannot exist any more, since the gravitational force of the planet would break it up and scatter the remains along its orbit to form a ring. This explanation is essentially true, except that things aren't quite that simple. The distance R′ (Roche's Limit) for a given planet is

$$R' = 2.4554\ R$$

(where R is the planet radius) measured from the planet's center *if* both planet and moon have the same specific gravity. If they haven't, the figure must be modified by multiplying it with the cube root of the ratio of their densities.

Without such modification, R′ equals 9700 miles for our own planet and 5155 miles for Mars. Since Phobos is 5800 miles from the center of Mars, its distance is about 2.75 R, so that, for equal densities, it would be safely outside of R′. If Phobos were a ball of liquid, it would be badly deformed even where it is, but it is obviously some kind of rigid rock.

Now there is another kind of limit proposed by Dr. Schaub specifically for rigid bodies and bodies with considerable structural strength, such as space stations, which lies at 1.3 R. At a distance of 3/10th of a planet radius from the planet's surface, the tidal forces of the planet become stronger than the gravitation of the moon at its surface. The result is that the existence of the moon itself is not endangered, but that everything lying around loose will be pulled off its surface!

Like Roche's Limit of 2.45, this limit of 1.3 is modified by the ratio of the densities of the two bodies involved. To make Phobos fall inside this limit, or rather to expand this limit to the distance of Phobos, one would have to assume that its overall density is half of that of an equal volume of water. If Phobos consists of very porous rock, this is possible. In this case, nothing could lie around on its surface, anchored

only by the moonlet's gravitational pull. But whatever has been pulled off by Mars would not fall to the planet at once. It would form two very tenuous rings, one outside the moon and one inside. Each one of these tenuous rings would have a thickness about equal to the diameter of the moon and a width of at most three times the diameter of the moon. (See diagram.)

AT first, the moon would move in an empty space between the two rings, but this space would not remain empty for long. As soon as there are enough particles in the rings, there will be collisions. Normally, when two particles collide, one can expect both of them to lose speed, so that they would cross from the outer ring into the inner ring. The outer ring, then, would steadily lose mass to the inner ring—which is likely to get into Phobos' way while crossing over —but the inner ring would lose mass in the same manner. If a particle collision occurs in the inner ring, the new orbits of the particles can be eccentric enough to graze the atmosphere of Mars, which obviously means their end as independent molecular satellites.

More "loose mass" on Phobos will be created steadily, some of it by meteorite impact, most of it probably by cosmic rays. Their microscopic impacts cause the crystalline structure of the surface rocks to decay, thus creating dust. This is happening on our moon, too, but there the dust stays where it is, protecting the layers of rock underneath. On Phobos, if Dr. Schaub is right, the dust would be pulled off the satellite as quickly as it is formed.

It is admittedly somewhat farfetched to extend the second limit so far out by assuming an unusually low density for the satellite. But remember that Phobos *does* show the acceleration which started the whole trend of thought.

And it is, at any event, interesting that Jupiter V, the moon closest to the giant planet, shows a similar acceleration. Jupiter V is also comparatively small (estimated diameter is 100 miles) and moves at a distance of 112,600 miles from Jupiter's center or about 70,000 miles from its "surface." R' for Jupiter (unmodified) is 108,800 miles. In short, the situation is about the same—theoretically, the moon just manages to stay outside of Roche's Limit, but if we knew all the other factors, most especially the satellite's density, we might say otherwise.

Let's close with a look at our planned space station in Dr. von Braun's two-hour orbit, 1075

miles above sea level. This is a geocentric distance of 5025 miles and R' for Earth, as mentioned, is 9700 miles. The space station would be well within Roche's Limit, but would hold together easily because of its structural strength. (Just to keep air inside, it has to have a higher structural strength than required to withstand the forces exerted by the Earth.) Since the space station's distance amounts to 1.27 planet radii and Dr. Schaub's limit is 1.3 R, the space station would also be inside that limit.

This would not endanger people in spacesuits working near it in space. Even if not hooked to a line, they would have personal rocket propulsion guns which can easily overcome the forces involved.

But the Earth would keep the space station spotlessly clean by attracting any debris that might accumulate on it—a cosmic vacuum cleaner, you might say.

EUROPE'S UNKNOWN POISONOUS LIZARD

At about the time you read this, West Germans and West Berliners will be able to buy and read a German edition of my book *The Lungfish, the Dodo and the Unicorn.* In East Germany, it will indubitably be banned because animals fail to conform to Marxist-Leninist-Stalinist principles (it being known, furthermore, that Beria occasionally petted animals, never tractors). I did not do the translation myself, but I checked it and in the course of this work I came across some old correspondence and notes which had half-slipped my memory. They dealt with the question of poisonous animals in general and specifically with the number of poisonous lizards.

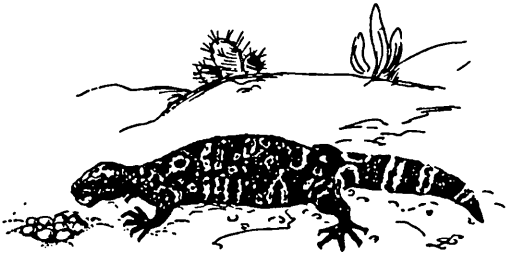
One hundred years ago, zoological textbooks were quite definite on that point. The majority of poisonous creatures were invertebrates — spiders, scorpions, centipedes and certain true insects. Of the vertebrate animals, only some snakes were known to be poisonous, although a few fishes were said to have poisonous spikes, something that still needed verification (which has been supplied in the meantime). No lizard or amphibian had any venom, the book said.

As for amphibians, it became known during the following fifty years that the skin secretions of several varieties are rather poisonous and that one frog (the beautiful "painter frog," *Dendrobates tinctorius* of Central and northern South America) is dangerous to handle. It can kill you if you happen to have fresh cuts on your hands. Logically,

the natives use its skin secretion for a highly effective arrowhead poison.

About 1900, the textbooks, after much reluctance, suspicion and cross-checking, admitted that there is a poisonous lizard. The lizard thus accepted is, of course, the Gila monster, a native of Arizona and New Mexico. The popular name is derived from the name of the Gila (prounced Hee-la) River. The scientific name is *Heloderma suspectum.*

It is a creature that nobody who has seen one will ever forget, partly because of its coloration, partly because its shape is rather different from the ideas evoked by the word "lizard." Yes, it has a head, a body, a tail and four legs, but that's as far as the resemblance goes. The head is flat, the body like a stuffed sausage, the tail more so and only about one-third the length one would expect a lizard's tail to be. The legs are short and small and the whole animal looks as if it were normally a dirty black, but has been spattered with brick-red paint.



Heloderma suspectum.

While normally lazy, the Gila monster can develop a fit of temper at short notice. It will hiss loudly and can jump, especially making a 180 degree turn in one jump that puts the head where the tail was a moment ago. And when it bites, it does not strike like a snake. It is a bite more like that of a dog and it will hang on for as long as ten minutes.

NOBODY seems to know who produced the first comprehensive description of this lizard. European works name Francesco Hernandez, body physician of

Philip II of Spain, as the "discoverer"(1), but I have some doubts about that. Hernandez collected — from 1593-1600 — in Mexico, where the Gila monster does not live.

Even though *Nueva España,* if it could be pinned down on a map, probably comprised Gila-monster habitat, Hernandez hardly traveled that far west. It is far more likely that he "discovered" Gila monster's close relative, the Mexican Beaded Lizard (*Heloderma horridum*), which is similar in appearance, but of a more slender build, somewhat larger (or at least longer) and with bright yellow blotches on a shining dark background. It was this Mexican version that forced its way into the textbooks as the *second* poisonous lizard, though it was the first historically.

Among the venomous snakes, there are some with hollow poison fangs and some with grooved poison fangs. The two types of Heloderma have grooved teeth, but unlike those of the venomous snakes, these teeth are not in front of the mouth and are in the *lower* jaw. So is the poison gland which supplies them. Another difference is that they need time to inject their poison, and a man bitten by Heloderma may get away with "just a bite" if he succeeds in tearing the reptile off at once. Normally, the Gila monster has little use for its poison apparatus, for its favorite food seems to be bird and snake eggs.

So far we have stayed in the territory of well-known and established facts. The story has many loose ends, since very many facts about the two Helodermas are still unknown. But the most interesting loose end is that they may have unknown relatives elsewhere.

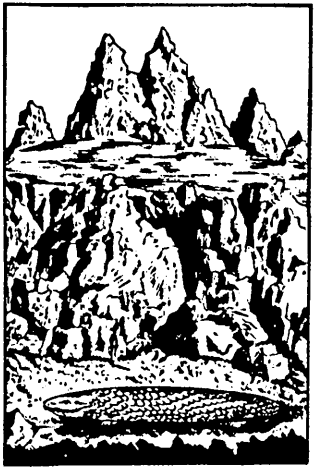
One such suspected relative has a name of its own, *Lanthanotus,* and it lives, of all places, on Borneo. The trouble is that very little is known about it—so little, in fact, that we cannot yet say with certainty whether *Lanthanotus* actually is a close relative to the Gila monster.

Another suspected relative might live in Europe. The trouble here is the same as with *Lanthanotus,* but to a higher degree —it hasn't been discovered yet.

All along the European Alps, but especially in the sections belonging to Switzerland and to Austria, there has been talk for centuries about a rare, small and dangerous animal. It is said to be some two feet long—which is

[1] Doctor Hernandez' work never appeared in its original Latin version. It was printed in 1615 as *Quatro libros de la naturaleza y virtutes de las plantas y animales que estan recevidos en el uso de medicina en la nueva España.*

slightly larger than Heloderma—and of the general appearance of a fat lizard. It is reported to hiss and whistle, and its bite is described as deadly. Witnesses claim that it can make jumps without preparation. Since the Alpine farmers and cattle ranchers were not in the habit of traveling, the animal has a name



The only published picture of a *Tatzelwurm*, dating from 1836.

of its own in almost every valley. The most common names are *Stollwurm, Springwurm* and *Tatzelwurm*, which can be translated, in the same order, as "Cave Worm," "Jumping Worm" and "Worm with Paws" and it may be added that the term "worm" is not used in its zoological sense among those peoples, but a general term for anything alive of wormlike or snakelike shape.

IN some older works, the existence of this animal is mentioned as a matter of course. The chronicle of a monastery in the Swiss Canton of Uri referred to it as occurring in the vicinity. A "Pocketbook for Amateur Naturalists and Gentleman Hunters," printed in 1836, even printed a picture (not a good one) and a Bavarian writer by the name of Kobell listed the animal in 1859 as one "permitted to be hunted." He did not shoot one himself, but knew people who had.

There is one more curious "document." In the Bavarian and Austrian Alps, it is customary to erect little monuments to people who perished because of avalanches or falling stones as close as possible to the spot where they died. One of these monuments—their local name is *Marterln*—has the inscription "In sudden fright died here, pursued by jumping worms, Hans Fuchs of Unken, 1779." The painting shows the dead Hans Fuchs lying on the ground, with two large lizards perched on a nearby rock. These two lizards are ordinary

in shape, just large; obviously the local artist not only lacked talent, but also a model.

The animal is still undiscovered. For some time, from about 1870 to 1930, zoologists were inclined to consider the whole story a legend. In 1930, a scientific publication began to collect eye-witness reports and got around two dozen first-hand stories, most of the reporters stating emphatically that the animal was not an otter, which had been cited as an explanation of the legend by some. But none of the reporters had any proof—no skins, no skulls, not even photographs.

At about that time, somebody sent me a clipping from a small provincial Austrian newspaper, saying in so many words that the late Austrian General von Poser had killed two of the animals and that their bodies were preserved in Castle Grubhof near the city of Lofer.

I had no idea where Lofer was located (I still don't know), but trusted that the Austrian Post Office did. Nor did I know who owned the castle at that time, but since every castle has a Superintendent General, I put that on my letter, which was aimed at somebody who could tell horses and cattle apart, but had never tried to distinguish a lizard from a newt.

The result was similar to the scene they used to have in the early talkies, where an American traveler in Hongkong addresses a Chinese in pidgin and gets an answer with an Oxford accent. A Mr. Schmidtmann informed me that the two preserved animals were specimens of the East North African monitor, probably *Varanus niloticus,* shot by General von Poser during a vacation in Egypt. Besides, Mr. Schmidtmann added, even though some witnesses claim they know an otter when they see one, the reports still concern otters.

ABOUT a month later, I read an article by the former Austrian Court Councellor, Dr. Nicolussi, in which he stated that, after examining all the evidence, he felt so certain about the existence of the animal and its essential relationship to the American Gila monster that he proposed the scientific name of *Heloderma europaeum.* At about that time a Swiss photographer took a picture of something that might be the animal, half hidden under dead leaves, but a search failed to yield results.

One more item: After the first edition of my book *The Lungfish and the Unicorn* had been published, I received a letter from a reader in Virginia who, in 1900, had seen a big lizard in the Ital-

ian Alps. His friends to whom he told the tale scoffed, so he went back to the same spot the next day, saw two of the big lizards and caught one with a butterfly net. When dumped at the inn, the lizard scared him so much with loud hissing that he caught it in the net again, obtained a glass jar and two liters of pure alcohol from the local druggist and drowned the animal in the liquid. Unfortunately he left the specimen in the small Italian town. But he remembered that it was 20 inches long, which is at least twice the length of any other lizard known to occur in that region.

Well? So? Nobody knows. As in many other places in science, the motto which applies is "wait and see."

I'm afraid the same is true of the letter section of this department. I've used up all my room, so the questions from readers will have to wait until next month. Sorry.

—WILLY LEY

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