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PIONEER TO JUPITER

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JUPITER ... AS A PLANET

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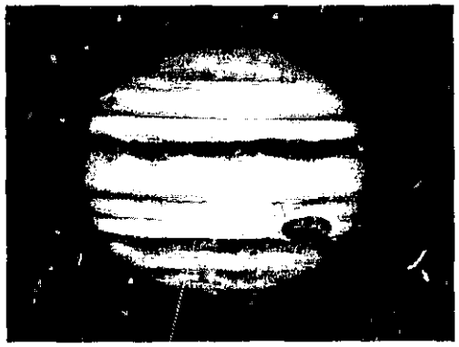
PHYSICAL CHARACTERISTICS

Jupiter is the largest planet of the Solar System—more massive than all the other planets combined. Its diameter from pole to pole is 77,000 miles compared with Earth's 8,000 miles. And the planet rotates faster than any other in the Solar System, turning completely on its axis once in every ten hours. This means that any point on its equator races along at 22,000 miles per hour compared with 1,000 miles per hour for a similar point on Earth's equator.

This high speed of rotation urges material on the equator to fly off into space. So the equatorial regions bulge outwards to make the equatorial diameter 1,900 miles greater than the polar diameter. The Earth is flattened at the poles in this same way but proportionately much less.

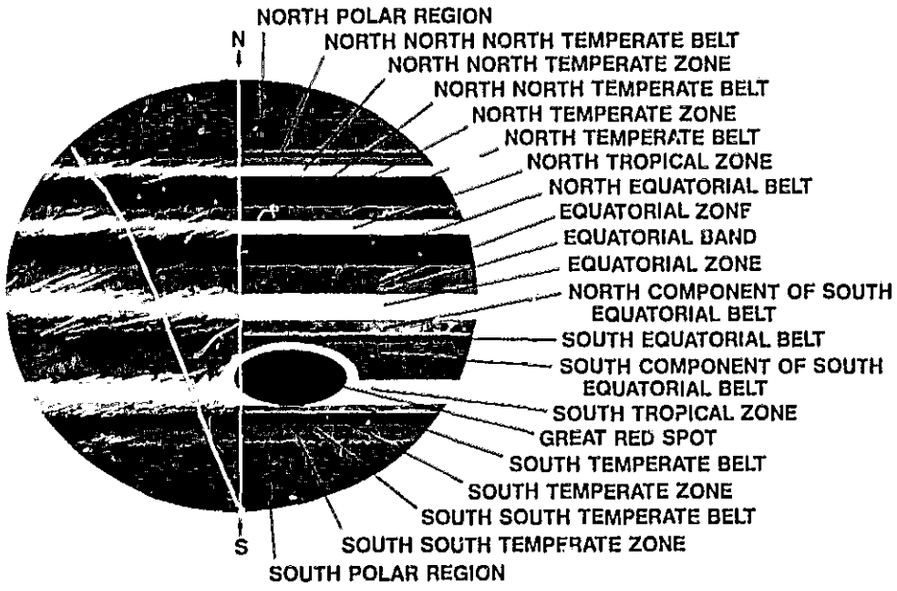
Although Jupiter's value is 1,000 times that of Earth, the planet has only 318 times the Earth's mass; it is said to be less dense. In fact it is only about one and one-third times as dense as water. Hence Jupiter cannot be a solid sphere like the Earth. Instead it must mainly consist of gas with possibly a small solid core. At least three-quarters of Jupiter probably consists of the lightest gases, hydrogen and helium, the same gases that are most common in the Sun and the stars. Jupiter is thus more like the Sun in composition than like the Earth.

Astronomers have detected other gases in Jupiter's vast atmosphere: methane and ammonia. But astronomers have not been able to see any solid surface, only masses of turbulent clouds.



Through a telescope from Earth (Figure 1), Jupiter appears as a striped, banded disc, with all the stripes parallel to the equator. Large dusky gray regions cover each pole. The dark, slate-gray stripes are called belts, and the lighter, salmon-colored bands between them are called zones. Several of the markings are permanent enough to be given names as shown in Figure 2.

JUPITER'S VISIBLE SURFACE



Over the years colors on Jupiter change; the zones vary from yellow and delicate gold to red and bronze, while the belts vary from gray to blue-gray. And the bands fade and darken as well as change color. They also widen and narrow and move up and down in latitude, that is, further from or closer to the equator. Some changes of color in the equatorial region appear to coincide with the 11.8 years period of Jupiter's revolution around the Sun.

It is thought that the cold tops of the Jovian clouds in the zones consist of ammonia crystals and vapor, while the gray bands may consist of condensed methane.

There is also a transparent atmosphere rising some 30 to 40 miles above the visible cloud tops.

Many smaller features are sprinkled among the zones and bands—streaks, wisps, arches, loops, patches, lumps, spots, some of which are probably knots of clouds. These small features often change form rapidly in days or even hours. Many are thousands of miles in size.

The cloud features of Jupiter move around the planet at different rates. For example, a great equatorial current sweeps around the planet at 255 miles per hour faster than regions on either side. And astronomers have detected that the clouds move at different speeds at different levels.

In the southern hemisphere of Jupiter there is a 30,000 mile long oval feature known as the Great Red Spot. It has intrigued astronomers since first observed several centuries ago. The spot varies in intensity and several times it has completely disappeared. The spot presents the appearance of something floating in the atmosphere, like a raft or an island. One cloud current appears to sweep around it. Over several centuries the spot has drifted around the planet relative to the average movement of the clouds.

Some scientists believe that the Red Spot may be a column of gas, the center of an enormous whirlpool-like vortex rising from the surface to the top of the atmosphere. But it would have to be anchored in some way to the surface far below, perhaps by a deep hole or a high mountain.

There are also white spots which suddenly appear on Jupiter; they seem to be some kind of storm and can become quite bright for short periods of time. These, too, move relative to the other clouds.

RADIO WAVES FROM JUPITER

Jupiter emits three different types of radio waves. These radio waves are not like the signals that carry programs on our Earth radios but more like the static or noise that interferes with a program when lightning flashes or electric motors run nearby. The radio noise reaching Earth from Jupiter is greater than from any other source except the Sun. The three types are called thermal, decimetric, and decametric radiation.

Thermal radio waves are produced by molecules moving about in the atmosphere of

Jupiter. Decametric radio waves are produced by electrical discharges, like lightning flashes, in the upper atmosphere of Jupiter. Decimetric radio waves are produced by electrons moving about—oscillating—above the atmosphere.

The thermal radiation is at wavelengths less than a few centimeters. Decimetric are radio waves—about one tenth of a meter, to several centimeters (2.54 centimeters equals 1 inch). Decametric refers to wavelengths of tens of meters.

One interesting and as yet unexplained occurrence is that the decametric radio signals seem somehow to be linked to the passage of Jupiter's close moon, Io. In some unknown way Io appears to trigger the electrical discharges that cause these radio signals. These bursts of energy from Jupiter are equivalent to billions of simultaneous lightning flashes on Earth.

The decimetric radio waves from Jupiter lead scientists to conclude that the planet has radiation belts similar to those of Earth, and consequently that Jupiter must also possess an intense magnetic field that may be 20 times as strong as Earth's magnetic field.

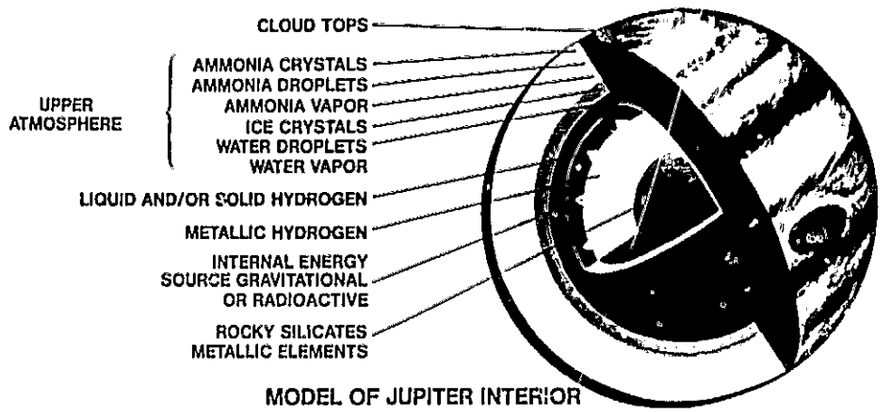
Radiation belts are produced by the magnetic field which traps electrons and protons (the nuclei of hydrogen atoms) that constantly flow through space from the Sun. These electrically charged particles oscillate backwards and forwards across the equator of the planet. This pendulum motion causes electrons to gyrate along the lines of force of the magnetic field. It results in radio waves being emitted similar to when electrons are caused to oscillate within a radio transmitter.

Thus, among the nine planets of the solar system, only Earth and Jupiter are known to have strong magnetic fields and radiation belts.

INTERNAL STRUCTURE OF JUPITER

Astronomers generally agree to a basic internal structure of Jupiter although they differ in detail (Figure 3). The average temperature on the top of the cloud layer is very low by Earthly standards, probably about -239 degrees Fahrenheit. Below the cloud tops the temperature rises steadily. The topmost regions consist of supercold ammonia crystals, ammonia droplets, and ammonia vapor. As temperature rises with increasing depth into the atmosphere, there may be ice crystals, water droplets, and water vapor present.

Estimates of the depth of the Jovian atmosphere below the cloud layer vary from 60 to 3,600 miles before any surface is reached, and this surface might be an ocean of liquid hydrogen rather than a solid surface.



MODEL OF JUPITER INTERIOR

At the bottom of the atmosphere the weight of all the gas above is enormous. The pressure exerted could reach a million times Earth's 14 pounds per square inch sea level pressure.

The great pressures can convert hydrogen into a special form in which the gas behaves like a metal: it readily conducts both heat and electricity as metals do. So beneath a sea of liquid hydrogen could be a shell of metallic hydrogen surrounding some final core consisting of rocky material and other metals somewhat the same as the composition of the inner planets including Earth. Jupiter's core has been estimated as ten times the mass of Earth.

This core might be very hot, as high as 20,000 degrees, because of pressure caused by the gravitational collapse of the huge planet due to the weight of the myriads of tons of matter above it. Such a hot core could account for Jupiter radiating into space about 3 times as much energy as it receives from the Sun.

LIFE ON JUPITER?

At first Jupiter might be considered an inhospitable planet on which life could never survive. This is not so. Since there are liquid water droplets in an atmosphere of hydrogen, methane, and ammonia, Jupiter provides the same kind of primordial 'soup' in which it is believed the first life evolved on Earth. And temperatures may be just right at some level in the atmosphere between the frigid cloud tops and the very hot core. In fact the heat coming from the core may supply the energy to make the atmospheric gases into complex carbon-based compounds needed to sustain life. On Earth, energy from the Sun makes these compounds through a process known as photosynthesis whereby simple life forms known as plankton assemble the chemicals in the oceans and higher life forms feed on the simple forms.

Floating in the Jupiter atmosphere there may be the equivalent of Earth's plankton, and Jupiter life might float and swim on the Jovian atmosphere and consume these carbon-based compounds as feed.

But this is all speculation at present, and even the Pioneer probes aimed to fly past Jupiter soon will not be able to detect whether or not such life forms do exist on Jupiter.

STUDY PROJECTS

ONE

Make a large copy of the drawing of Jupiter shown in Figure 2, and lightly pencil in the various bands and zones. Obtain several astronomical textbooks from the library and read the sections on Jupiter. Examine any photographs and drawings in the textbooks. Then use your imagination to fill in details in the bands and zones even though these may not be shown clearly in any textbook illustrations. Color the resulting picture as you might imagine it might be seen from a spacecraft close to the planet.

When Pioneer 10 passes close to the planet early in December, 1973, it will radio back to Earth television pictures of Jupiter. These will appear on television screens and newspapers a few days later. Examine these pictures and see if they show the kind of detail you have drawn on the planet. Although the really close-in pictures will not show the whole of the planet they will provide details in parts. Check if your imaginary cloud patterns are similar to the close-up cloud patterns sent back by Pioneer.

TWO

By reading the textbooks make a list of great unknowns concerning Jupiter: its structure, its atmosphere, its radiation belts, its Great Red Spot. Check with the later pamphlets in this series as to what the instruments of Pioneer will reveal, and identify those unknowns that can be solved by Pioneer.

Later check these with the actual results sent back by Pioneer as it passes close by Jupiter in early December.