Moon colonists will live almost entirely underground—yet perhaps face fewer dangers than New World pioneers.

A noted science writer,

Why We

WHEN THE astronauts set foot on the moon July 20, a wave of optimism swept mankind.

Vice President Spiro Agnew announced that by year 2000, men would stand on Mars.

President Nixon even more joyously said, "In the year 2000 we on this earth will have visited new worlds, where there will be a form of life."

Perhaps he meant Mars, too, for of all the worlds in the solar system, Mars is the most likely to possess some simple form of life (though even this much is not very likely).

Mars is not as easily reached as all that, however. It represents a giant jump beyond the moon. The moon is never farther than 250,000 miles away, while Mars is never closer than 35 million miles.

It takes three days for a spaceship to reach the moon, with a total round trip of about a week. It would take many months, cramped into a spaceship, for astronauts to reach Mars, and a round trip might take something like two years.

Are we ready for a Mars voyage? Will we ever be ready? Can we build a ship that will keep astronauts healthy, comfortable, and amused for a couple of years? Even if intrepid volunteers manage the trip once as a *tour de force*, how often would we care to repeat it?

But then is Mars *really* our next goal? Most people seem to think there's no alternative. The nearest world after the moon is Venus and that is far too hot for manned exploration. The next nearest is Mars. What else can we do, then, but head for it?

Surely, though, that is not all there is to space exploration. We can't go through space touching all the planets of the solar system, as though they were bases in a cosmic game of baseball. What would the purpose of that be?

Do you think that once Columbus returned from having discovered the New World, old King Ferdinand said, "Well, that takes care of the Americas. Now let's go down and discover Australia."

No! The next step in space, after reaching the moon, is the same as the next step in overseas exploration after reaching the American continent. The new land, having been reached, must be colonized.

In some ways, the moon can be colonized in the 20th century more easily than the Americas could be colonized in the 16th. In those days it took many weeks of isolation to cross the Atlantic. Now it takes just three days to reach the moon, days in which the astronauts are in constant communication with home.

The Europeans, penetrating the new continent in the 16th century, had to face disease, wild animals, hostile natives. The moon, on the other hand, offers no competing life at all; not even dangerous germs.

To be sure, the moon lacks air and water; it has a long burning day and a long freezing night; it lies under a shower of murderous radiation from the sun and a drizzle of small meteorites.

These are problems which can be beaten, given the present state of technology and its steady rate of development. For one thing, moon colonists need not remain on the moon's surface. A cavern carved beneath the surface could make a comfortable home, free of either radiation or the danger of meteorites.

Underground, there will be no slow alternation of day and night, and the colonists can set their own light-dark rhythm. Nor will there be temperature extremes; that applies only to the moon's outermost skin.

But what about air and water?

When we say there is no water on the moon, we mean no free-running water; no oceans, lakes, or rivers. But there may be water just the same; perhaps as underground deposits of ice or at least as molecules in loose chemical combination with the rocks themselves.

Water can be mined or baked out of the rock in quantity sufficient to supply the cavern colony with what it needs. Some of the water molecules could be split electrically to yield hydrogen and oxygen. The oxygen can be used for the cavern's air supply; the hydrogen can help feed the yeast cells or other quick-growing life forms which can serve as home-grown food.

Naturally, water and air will be cycled and recycled. The carbon dioxide formed in breathing can feed green plants, which will restore oxygen. The various types of human wastes, properly sterilized and distilled, will restore water, and the residue can be used as fertilizer.

This is not exactly a glorious prospect, to be sure. Few earthmen would look forward with pleasure to living underground in a precariously engineered environment.

But as in the case of the American colonies, we can be certain that, with the years, the moon colony will expand, develop, and grow more advanced and more comfortable.

And the added knowledge will be

foreseeing great technological benefits as well as far-reaching space explorations, tells

Must Colonize the Moon

By ISAAC ASIMOV

Author of "Twentieth Century Discovery" and "Life and Energy"

monumental. The moon's airless world would be an astronomer's dream. Here on earth, the skies are obscured by clouds and city lights.

On the moon, however, everything would be sharp and clear. What's more, the moon rotates at a rate only 1/30 that of the earth, so that the objects in its sky move that much more slowly and can be watched and studied without interruption for that much longer.

Larger radio telescopes could be built, too, and located on the side of the moon that forever faces away from earth. Without interference from earth's increasing output of radio interference, it could receive the dim crackling of radio waves from distant galaxies.

The moon's crust, attentively studied, can be a vast library of knowledge for us, for it is possible that some 4½ billion years ago, earth and moon formed out of the same cloud of dust and gas.

The earth's surface has, however, vastly changed since those early days. The wind and the sea have worn it down and overlaid it with new sediment. The action of living things has changed it chemically. Most of what we can reach of the earth's crust is not old at all, and what is old is so changed we can find little in it. It is all we can do to trace earth's past back about half a billion years, only a ninth of its total age.

The surface rocks brought back by the Apollo 11 astronauts seem, however, to be 4½ billion years old. The moon's crust, in the absence of air and water, is comparatively unchanged from the day of creation on. That crust will tell us all the history of our satellite, and all the early history of the earth as well, perhaps.

For instance, the simple chemicals in earth's air and water were built up and made more complicated by the energy of sunlight, billions of years ago. Eventually, they became complicated enough to possess the spark of life. Life spread over all of earth and obscured its very early chemical history.

On the moon, however, the simple chemicals are present in smaller quantities, and the process was slower. The growth in complexity has apparently stopped far short of life. The moon's crust may have preserved that early chemical evolution, therefore, and will then tell us things we cannot discover on earth. It may even help us understand some of the fundamental properties of life beyond the point where our earthbound research can lead us.

Astronomy and geology may seem ivory-towerish to the average earthman, but one can argue that all knowledge is useful. To lift the curtain of darkness in any corner of the realm of the mind is to brighten the light everywhere.

However, for those who lack faith in this view, there remains the strong possibility that the colonization of the moon will bring immediate material benefits.

Consider that the moon is covered with a vacuum. There are many processes that require a vacuum. There are electronic devices that must be evacuated if they are to work. There are techniques of plating, welding, purification, distillation, that require vacuum or are benefited by it.

On earth, the necessary vacuum can be formed but only with an effort, at great expense, and over limited volumes for limited periods. On the moon, the vacuum is there, an infinite quantity of it for all eternity.

It may be that the moon cavern will become a highly specialized factory, making and shipping to earth unusual devices and rare chemicals that could be produced only with difficulty, if at all, on the earth.

Nor is the vacuum the only unusual aspect of the moon's environment. During the long 354-hour night, the surface temperature on the moon drops as low as —245F.

That is much closer to absolute zero (—459F.) than the temperatures available on earth. Near absolute zero, certain types of miniaturized computers can be made to work with great efficiency; very powerful magnets can be constructed, which consume almost no power; and so on. Such devices can help our moon colonists supply them to earth.

One thing we cannot expect of the moon colony: it can't possibly help relieve earth's overpopulation problem. At the present moment, earth's population is increasing at something like 200,000 per day, and no one expects we can ever transfer that many people there.

Even if we could, the moon's cavern could not be expanded quickly enough to support it, and if that could somehow be done, then the moon would be as crowded as we in a few decades, and we'd be back where we started. No, earth's overpopulation is a problem that must be solved right here on earth.

Nevertheless, the moon colony can offer us the benefit of an example. It would be a small world that would have learned how to conserve its limited resources efficiently and how to keep down pollution. (It would have to have learned how or it wouldn't survive a week.)

We, on the other hand, have lived for so many thousands of years on a planet that seemed enormous without limit, that we never bothered to learn how to preserve it.

Most important of all, however, is the fact that the moon colonists will be used to a life unlike anything on earth, and this may be crucial in space exploration.

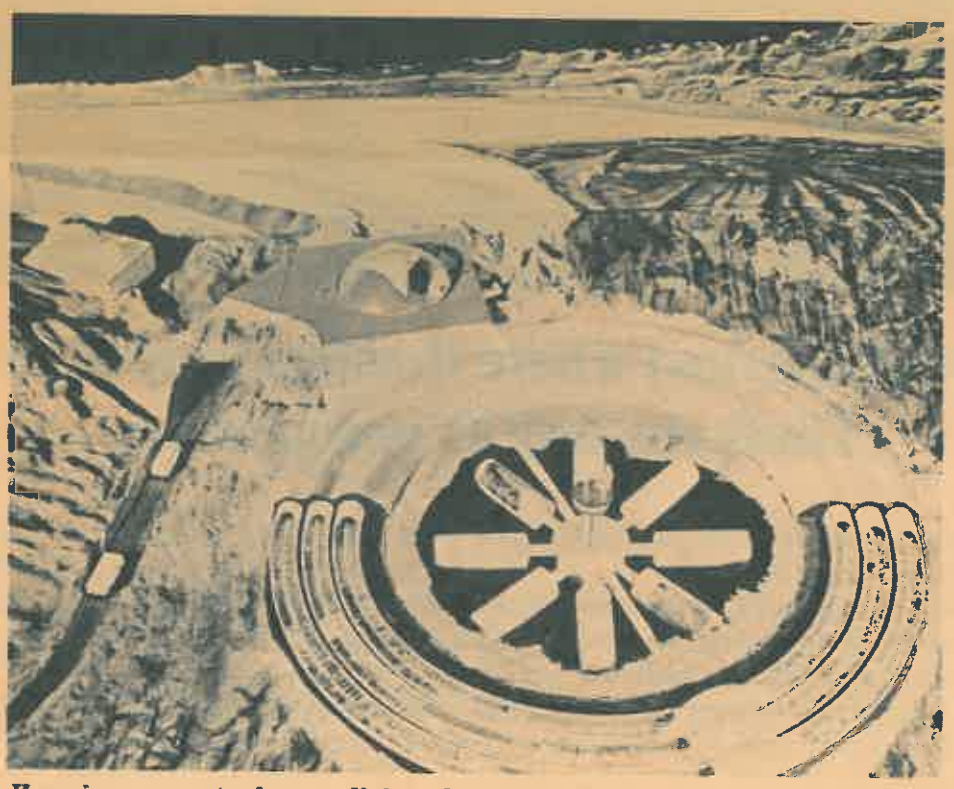
It is hard, after all, for earthmen to get into a spaceship and look forward to a journey of months or years.

The moon colonists, on the other hand, will be born, live, and die on the moon. They will be accustomed all their life to low gravity, and to surroundings that are artificial, and engineered. They will accept as normal the absence of free sunlight, open air, rain, and blue sky.

To a moon colonist, a spaceship would not seem so different. He would already have been living in a spaceship with the moon's crust as its walls. He would be giving up very little to move into a metal spaceship heading for Mars.

It is the moon colonists, then, not we earthlings, that could face the long voyage to Mars and beyond.

Yes, human beings can reach Mars easily (and not just as a one-shot demonstration) and can even reach life-bearing worlds as warm and pleasant as earth, if we go about it the right way—if we colonize the moon *first.* ◆



Here is a concept of moon living: booster tanks are arranged in a cluster, connecting living quarters, medical center, leisure areas, and work center.