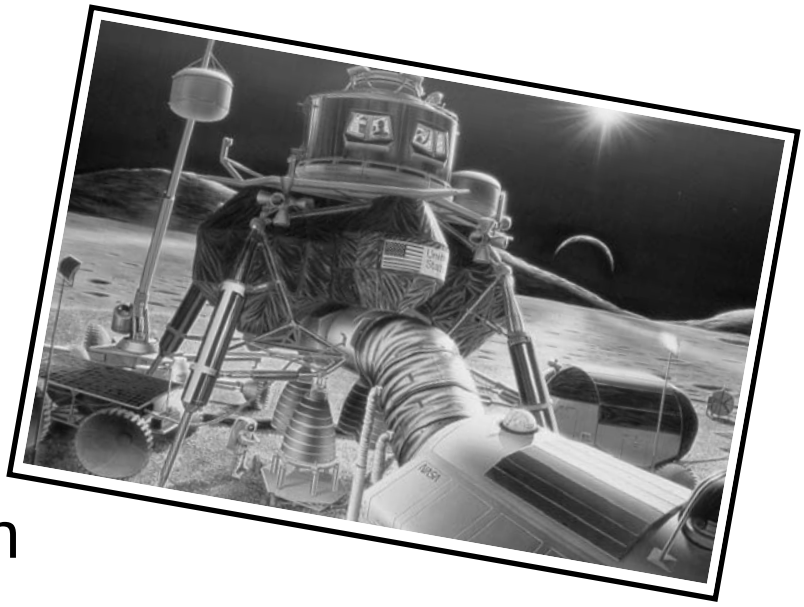
CLASSROOM ACTIVITY



Building a Colony on the Moon

General Information

★ Level: all levels.

★ Students per group: four or five.

★ How long: about a day of work spread over a week.

★ Where: classroom.

★ Type of activity: solving problems, building a model.

★ Key words: Moon — lunar colony — self-sufficiency — life — model and simulation.

★ Subjects covered: science and technology, language, math, art.

Starting Point

If I had to design and build a self-sufficient colony on the Moon, what type of equipment and buildings would I need? How would I ensure that the colonists had enough water, oxygen and food supplies? What energy source would I use? How would I protect colonists and survival equipment from the inhospitable conditions reigning on the surface of the Moon?

Preconceptions

Students are generally familiar with the conditions reigning on the surface of the Moon (no atmosphere, very cold temperatures, reduced gravity). They've all seen images of astronauts in spacesuits walking on the Moon. Yet they have trouble comprehending all the consequences of this type of environment on human life. They imagine, for instance, that you need only hold your breath to walk a few seconds on the Moon without a spacesuit. Or they believe large amounts of water are buried under the lunar surface.

Basic Concepts

Many people have already thought very seriously and very concretely about the steps that could lead us one day to colonize the Moon. Appendix 1 gives a rundown of their work and presents the numerous benefits these visionaries cite as a reason for pursuing their dream.

Goals

By the end of this activity, students should be able to:

- Identify basic human needs (water, air, food, protection) whether on Earth, on the Moon or in space.
- Reflect on the physical characteristics of the lunar environment.
- Design and build a model of a lunar colony.
- Convey their concept and ideas to other students.

You can easily adapt this activity to the age of your students. Older students are able to reflect on the problems posed by the inhospitable conditions on the lunar surface and think up realistic solutions. For younger kids (kindergarten and grades 1 to 4), the activity can evolve into a more open creative process in which they'll dream up, draw and then build a lunar structure.

Steps in the Activity

Preparations

Collect a wide range of arts and crafts supplies using the list on pages 2 and 3. Together with your students, draw up a list of things they can bring from home. Leave these supplies out in a corner of the classroom so students can become familiar with the material they'll use. Encourage them to collect any objects that, with a little imagination, could become building materials for outer space. Avoid, however, all organic material that might end up rotting or spoiling.

Ensure that each team is given a firm work surface large enough to build its colony on. Gather the arts and crafts supplies for each group (glue, scissors, pencils, tape) in a container or on a tray for quick distribution. Keep close at hand all tools that require your supervision as students use them (pliers, knives and such).

Supplies

For the entire class:

Gather various material to be used to build lunar colonies. Here are a few suggestions: different kinds of milk cartons, plastic, paper and Styrofoam cups, small plastic containers (empty yogurt or fruit-juice containers), packing material (Styrofoam moulding, bubble wrap, Styrofoam peanuts),

empty egg cartons, paper and Styrofoam plates, cardboard tubes, corks, straws, empty boxes of camera film, coffee stirrers, construction paper in various colours, tape, rope, coloured thread, yarn, wire, metal hangers, aluminum foil, sheets or rolls of transparent plastic, toothpicks, blank labels and masking paper.

Also provide tools that students can use under your supervision, such as pliers for cutting and twisting wire, an all-purpose knife for cutting tubes or Styrofoam, and a saw, hammer and stapler. If you have a tool belt, carry your tools in it as you circulate among the groups.

For each team:

- A rigid work area of 60 cm by 60 cm (a large piece of embossed board such as from a large cardboard box, or a piece of rigid Styrofoam) to be used as a base for building the colony.
- One or two bottles or sticks of glue.
- One or two pairs of scissors.
- Felt pens of various colours.

Assignment

Part 1: Planning a Lunar Colony

❶ Tell your students they've been chosen to design and build the first self-sufficient colony on the Moon. They'll need to set up a lunar base that can ensure the survival of colonists for periods ranging from a few weeks to a few months. Of course, a supply ship would take only a few days to travel between the Earth and Moon and bring water, air and food to the colonists. But because the cost of such trips is exorbitant, students must attempt to create a self-sufficient colony. Tell them they'll work in teams to design and build a model of a lunar colony.

❷ Tell your students that to complete their mission successfully, they must first think about the living conditions the colonists will face. How much water, air, food and energy will they need? How will they control the temperature inside their colony? How will they travel over the lunar surface? How will they communicate with Earth? How much space will they need for their work, food production and recreation? How will they dispose of their garbage? Can your students imagine living on the Moon? How greatly will life on the Moon differ from life on Earth? Note the following points on the blackboard and have your class think about how these points affect the setup of a lunar colony.

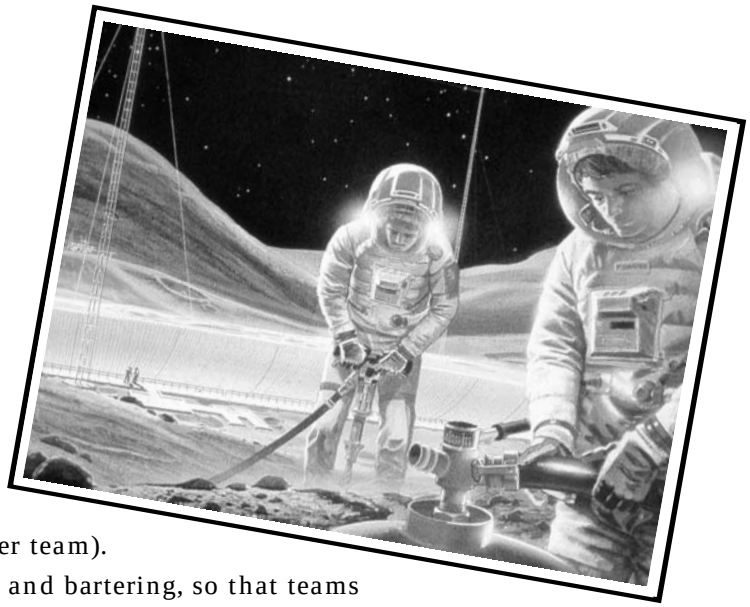
- The Moon's gravitational field is weaker than the Earth's (an object on the Moon will be six times lighter than on Earth).
- The lunar "day" (the period between two consecutive sunrises) lasts 27 1/3 days. During this period, the Sun is constantly above the horizon for just under 14 days. After the Sun sets, nighttime lasts an equivalent length of time. Discuss with your students how this fact affects the use of solar panels as an energy source.
- The average temperatures at the equator vary from +107ºC in the day to –153ºC at night.
- The Moon has no atmosphere and therefore no air. Without an atmosphere, its surface is constantly bombarded by meteorites of all sizes. For any inhabitants of the Moon, even micrometeorites pose a real threat.
- Unlike the Earth, the Moon has no magnetic field to act as a natural shield against dangerous solar radiation, a deadly threat for humans.
- The Moon has no liquid water (there may be frozen water buried at the bottom of craters near the Moon's north and south poles, but this is still unconfirmed).
- The lunar soil contains a wide array of useful chemical elements like hydrogen, oxygen, carbon and nitrogen.

❸ Help students determine what equipment will be needed to ensure the survival of colonists, how the areas for living, working, sleeping and recreation will be organized, and what essential items will be required. Remind students that the colonists must live in the colony for several months without returning to Earth. To reinforce scientific thinking, ask students to justify each of the lunar facilities they propose. Write their ideas and suggestions on the blackboard.

For younger students, focus their attention on the equipment and facilities that meet basic human needs (housing, water, air, food, energy). Older students can create a more complex colony, keeping in mind the characteristics of the lunar environment, the mission's aim, and the material available on site.

During such brainstorming sessions led by experts (particularly NASA engineers), lunar facilities deemed essential included living quarters, laboratories, a greenhouse, solar panels and/or generators, an antenna for communicating with Earth, a shed, and a landing ground.

❹ Form teams and ask students to sketch a plan of their lunar colony. Give teams enough time to develop a realistic plan without delving too far into how their model will be built.



Part 2:

Building the Model of a Lunar Colony

❶ If you haven't yet done so, show students all the material available for building a model of their lunar colony. Show them the piece of cardboard or Styrofoam they'll use as a base. If some material is in short supply, place a limit on its use (for example, one plastic tube per team). Suggest strategies, such as swapping and bartering, so that teams share the material fairly.

❷ While students are building their models, circulate among the teams and lend any assistance needed. Ask questions and encourage students to use their brains and imagination.

❸ Suggest that students identify the different parts of their colony (living quarters, greenhouse, landing ground, and such). If you have some blank labels, hand out an equal number to each team.

❹ Leave enough time at the end of each period for students to put away their supplies and tidy the classroom. If they haven't completed their models, plan one or more extra periods later on. In the meantime, encourage students to collect more material at home and to bring it to class to incorporate into their models

Part 3: Visiting the Lunar Colonies

❶ Once they've finished building their models, students can present them to their classmates and perhaps even to the school. Tell them to imagine they're organizing guided tours for visiting dignitaries from Earth. Students will probably have invested a lot of energy and creativity in their model and so will be happy to talk about their colony and explain their clever inventions

❷ Plan a long enough period for these presentations. They can be held during a single period or staggered over two or three days. Reserve a few minutes for questions from other students. You can guide the discussion by asking such questions as:

- How will your colony help humans survive on the Moon?
- What will the quality of life be for the colonists?
- What entertainment and leisure activities will your colony offer?
- What will the food be like?
- Would you like to take part in such a mission when you're older?

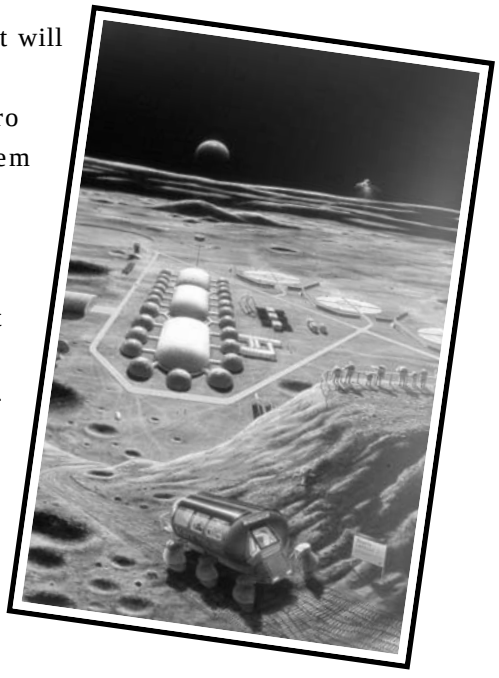
Wrap-up

❶ Suggest that students write a short essay on the daily life of the lunar colonists. They could write a special report on the exploration of topographic features of their new world or describe their scientific experiments. They could also write a letter to their parents describing the unforgettable experience of seeing the Earth in the sky rather than our Moon.

Extra Credit

❶ Invite students to publish the first newspaper or present the first newscast from the Moon. How will they describe their everyday life? What will their point of view be? What will their major discoveries be?

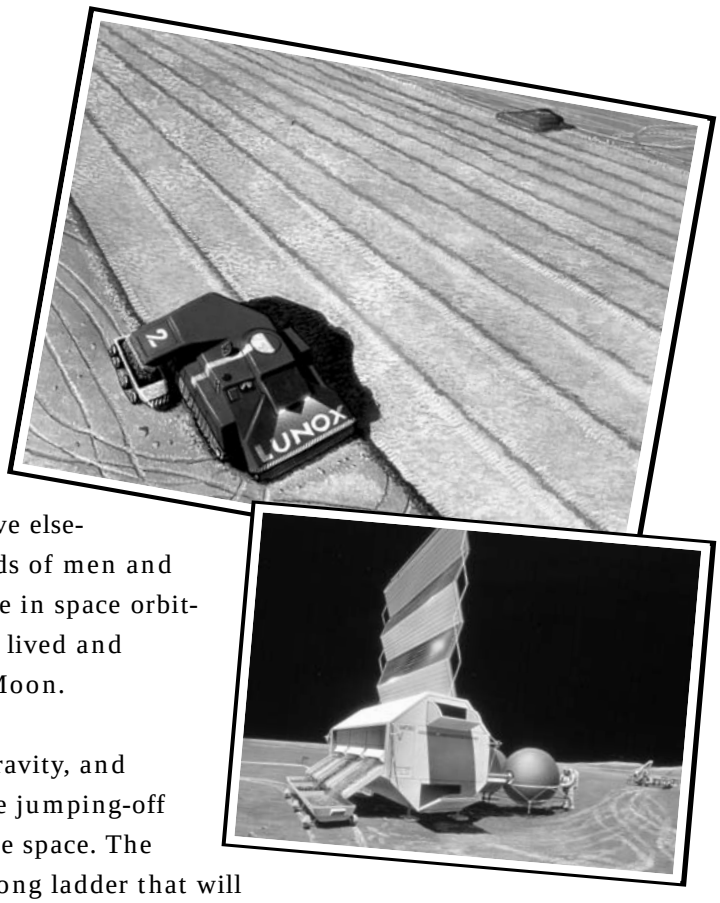
❷ Suggest that students design and build a space station that will remain in orbit around another planet or travel through space. Ask them to think about the problems posed by zero gravity. Most futuristic concepts of space stations have them turning continuously on themselves to create an artificial gravity.



❸ Ask students to respond to critics who argue we shouldn't colonize other worlds. Some claim we shouldn't do so because we risk altering or polluting new worlds irremediably. Others fear the conflicts that might arise from competition between companies or governments vying for control of the resources on the Moon or other planets. Do your students agree? Would they want their missions limited to exploration? Would they accept having mines or factories built on other worlds?

APPENDIX 1

A Colony on the Moon



Colonizing the Moon

Before the early 1960s, specialists agreed it was impossible for humans to live elsewhere than on Earth. Since then, hundreds of men and women have spent various lengths of time in space orbiting the Earth. As well, 12 astronauts have lived and worked up to three straight days on the Moon.

Its proximity, lack of atmosphere, weak gravity, and potential resources all make the Moon the jumping-off point for mankind to explore and colonize space. The Moon is undoubtedly the first rung in a long ladder that will lead us toward the stars.

Still such an undertaking will be no mean feat. The Moon is far from hospitable. It has no food or air. The average temperatures vary from +107ºC in the day to –153ºC at night. Without an atmosphere to protect it, the Moon's surface is hit by deadly doses of radiation from the Sun. We'd need to develop complex survival systems, new construction techniques, and several other scientific innovations before we could colonize the Moon over the long term.

Benefits of Colonizing the Moon

The Moon's proximity makes contact easier between the Earth and its satellite. Indeed, a spacecraft needs only a few days to travel the distance separating us from the Moon. In contrast, trips to Mars and Venus, the Earth's other neighbours, would take months.

Without an atmosphere, the Moon proves an extremely hostile environment. Yet the high vacuum on the lunar surface makes it an ideal place for conducting astronomical observations of the Sun and the deep sky. As well, radio telescopes, if built on the far side of the Moon, could be shielded from radio interference from Earth.

Gravity on the lunar surface is six times weaker than on the Earth's surface. On the Moon, objects therefore weigh only a sixth of their Earth weight. So to blast off from the lunar surface, a rocket needs six times less thrust (and fuel) than when taking off from Earth. The Moon's weak gravity also means we could build much larger structures than on Earth (for example, telescope mirrors and radio telescope antennas) without these structures buckling under their own weight.

We've only just begun to discover the Moon's potential resources. Astronomers believe large deposits of water ice are found near the lunar poles at the bottom of craters permanently shaded from the Sun's rays. This water could become the most precious resource the Moon has to offer. With water, we can feed a lunar colony, supply it with oxygen, make fuel for rockets, and more.

If the Moon doesn't ultimately harbour water, it could perhaps be made from chemical elements present in the lunar soil. The lunar crust is rich in oxygen and permeated by large amounts of hydrogen and helium left behind by solar wind. By heating the soil, we could extract these elements and many others. For example, helium-3 evaporates at 1,100ºC, and oxygen, which represents 40% of the weight of the dust layer covering the surface, evaporates at 1,650ºC. Yet this technique would require processing enormous volumes of lunar soil to extract reasonable amounts of useful elements.

We could also extract water from asteroids (up to 10% of their mass is in the form of water) or from comets and then bring this water to the Moon. Given the fairly weak gravity of asteroids, comets and the Moon compared with the Earth's gravity, this process would be much less expensive than transporting water directly from Earth.

Steps in Colonization

Many feel that the Moon will eventually be colonized and exploited once man has mastered the requisite technologies for living and working in a hostile space environment. Note that building and operating the International Space Station should help us make enormous headway in areas that have a direct application on the Moon. These areas include recycling raw materials necessary for life (water, air, food), human physiology in microgravity, resistance of materials subject to a space environment, and converting solar energy into electricity.

Below are the main steps we must complete before colonizing the Moon and some benefits we hope to derive from this undertaking:

- Send orbital probes around the Moon to enhance our knowledge of the Moon, its environment and its resources.

- Send surface probes to explore the lunar surface and send back soil and subsoil samples to Earth.

- Establish temporary lunar bases, inhabited by two or three astronauts for a few days, to conduct experiments and tests in preparation for the setup of a permanent base.

- Send intelligent robots to the Moon to assist astronauts in setting up a base and in exploring.

- Build astronomical observatories in all frequency domains to observe the Sun, planets (solar and extrasolar), and the deep sky (stars, nebulae and galaxies).

- Develop a reliable, cost-effective transportation system for sending material and supplies from Earth to the future lunar colony.

- Set up a permanently inhabited, autonomous and self-sufficient colony. The buildings must be constructed under a few metres of regolith (the lunar soil) to protect inhabitants from the hostile lunar environment (high vacuum, meteorite bombardment, extreme temperature swings).

- Install large solar collectors to sustain the lunar colony. Export this energy to Earth and orbital stations around Earth.

- Build greenhouses and farms to feed the lunar colony and orbital stations around Earth (producing food on the Moon is less costly than importing it from Earth).

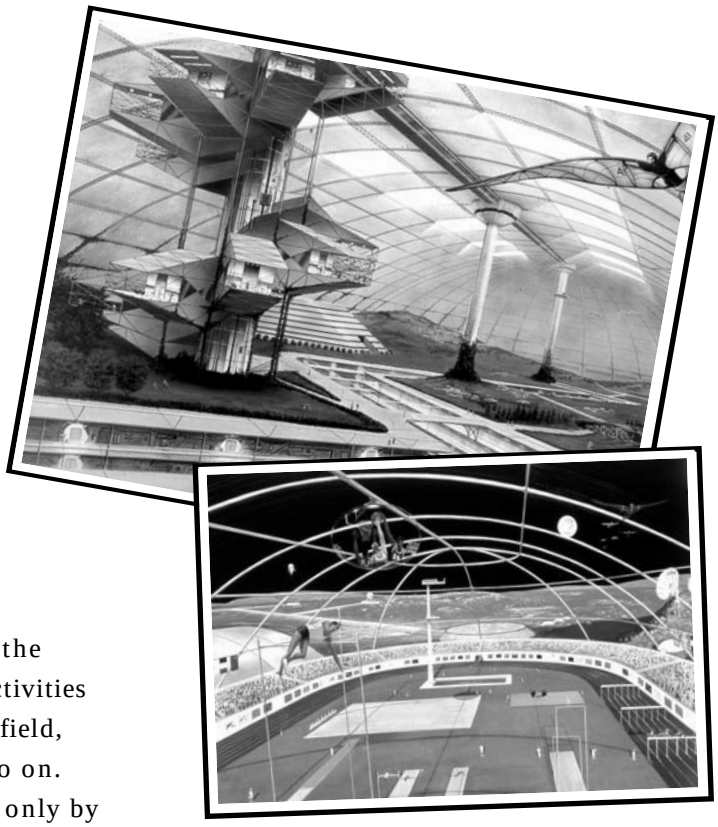
- Set up mobile factories to extract from the soil the basic chemical elements for sustaining life (water, hydrogen, oxygen, carbon, nitrogen). Oxygen and hydrogen could also supply the fuel needed to launch exploration missions toward other planets, making the Moon the main "service station" in the solar system.

- Build giant radio telescopes on the far side of the Moon away from radio interference from Earth.

- Carry out prospecting activities on the Moon (aluminum, iron, titanium, etc.).

- Extract helium-3 (which solar wind deposits in the soil) and export it to Earth. This element is the ideal fuel for nuclear fusion reactions that produce very little radioactive waste.

Commercial Exploitation of the Moon



As we await the setup of a lunar base that will conduct research or harvest the Moon's resources, some promoters suggest using our satellite for commercial purposes. Their ideas include sending the ashes of our loved ones to the Moon and bringing back lunar rocks to sell to the public. Some also suggest putting a remote-controlled robot on the Moon. For a fee based on minutes of use, we earthlings could control the robot's movements from an operating station. This form of "telepresence" might appeal to fans of video games.

And why not tourism on the Moon. Visits to the landing sites of the Apollo missions, sports activities of all kinds in the Moon's weak gravitational field, the Olympic Games in reduced gravity, and so on. Here as elsewhere, our imagination is limited only by our wallets and our technology. One day, the Moon may even open its first Disneyland or McDonald's!