

ACHIEVEMENT #2:

Apollo Moon Landing

Teacher's Guide

Introduction

Since the beginning of time, people looked into the night sky and wondered what was out there. In the last century engineers began looking at the same sky, planning how to get there. Engineers like Robert Goddard and Werner von Braun experimented with rockets. They understood that a major force would be necessary to escape Earth's gravity - but how much force?

The engineers who worked on the Apollo mission had a huge challenge. The ship that took Neil Armstrong and his crew to the moon weighed 40 tons. They had to make sure they had enough fuel to launch it and bring it back. The first stage rocket alone burned 15 tons of fuel per second.

Engineers had a lot of detective work to do before the Apollo missions could be launched. They had to develop new materials, communications systems, energy supply systems and life support systems. Sensors so doctors could monitor the health of the astronauts, and computers that would fit on a spacecraft. And they did it all in less than a decade.

More than 60,000 products were developed from the space program that have improved life for all of us. These materials are now being utilized in more commercial ways, like making skateboards and snowboards more light weight, helmets more durable. Apollo set us on a course that would continue to bring us knowledge of the universe. Perhaps, most importantly, Apollo allowed us to become explorers in outer space - thanks to the efforts of thousands of engineers who believed nothing was impossible.

Lesson Focus: Spinoff Technologies

Lesson Synopsis: Students explore paper rockets, learn about the Apollo Program and Apollo spinoffs, and use simple office supplies to design and create a new useful product.



Teacher's Guide (Continued)

Related National Science Education Standards:

Content Standard B (Physical Science):

As a result of their activities in grades 5-8, all students should develop an understanding of Motions and Forces. Fundamental concepts and principles that underlie this standard include:

- ◆ Unbalanced forces will cause changes in the speed or direction of an object's motion.

Related Benchmarks from Benchmarks for Science Literacy:

Section 3C (Issues in Technology):

By the end of 5th grade, students should know that:

- ◆ Once an invention exists, people are likely to think up ways of using it that were never imagined at first.
- ◆ Scientific laws, engineering principles, properties of materials, and construction techniques must be taken into account in designing engineering solutions to problems.

By the end of 8th grade, students should know that:

- ◆ Technology ... is largely responsible for the great revolutions in agriculture, manufacturing, sanitation and medicine, warfare, transportation, information processing, and communications that have radically changed how people live.

Related Standards for Technological Literacy:

Standard 1 (Characteristics and Scope of Technology):

In order to comprehend the scope of technology, students in grades 6-8 should learn that:

- ◆ The development of technology is a human act and is the result of individual or collective need and the ability to be creative.
- ◆ Technology is closely linked to creativity, which has resulted in innovation.

Glossary:

spinoffs Products and services in such areas as health and medicine, environment, public safety, consumer/home/recreation, transportation, computer technology and industrial productivity that incorporate a technology developed in a different area or for a different reason.

fin A projection shaped like a fish fin, attached to a rocket to increase control over the direction the rocket moves.

Important Concepts:

Many technological achievements are ultimately applied in ways different from those first imagined.

Teacher's Guide (Continued)

Materials for Each Inquiry Team:

Materials for Engagement:

Scrap bond paper	Milkshake straw (slightly thinner than pencil)
Cellophane tape	Eye protection
Scissors	Metric ruler
Sharpened fat pencil	

Materials for the Extension (Engineering Challenge):

Cellophane tape	Paper clips
Index Cards	Variety of other office supplies

Suggested Materials for Further Exploration:

Masking tape	Pictures of the Sun and planets
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Materials for Setting up Target Range:

10-meter tape measure	Copies of planet drawings
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Safety Precautions:

Because the rockets are projectiles, make sure students wear eye protection.

Procedure:

Engagement: Have students make and test Paper Rockets as follows:

1. Demonstrate a completed paper rocket to the students.
2. Distribute the materials and construction tools to each student. (Students may work individually or in pairs.)
3. Have students each construct a rocket as shown in the instructions on the student sheet.
4. While students are constructing their rockets, select a location for flying the rockets. (A room with open floor space or a hallway is preferable.) Prepare the floor by marking a 10-meter test range with tape measures or meter sticks laid end to end.
5. Tell students to predict how far their rocket will fly and record their estimates in the test report sheet.
6. When students complete the rockets, distribute straws.
7. Have students record data from each launch on the Paper Rocket Launch Record Report form. (The form includes spaces for data from three different rockets.)
8. After the first launches, and as time allows, have students construct new and "improved" paper rockets and attempt a longer journey through the solar system. (Encourage the students to try different sized rockets and different shapes and number of fins. After test flying the rocket and measuring the distance it reached, students should record the actual distance and the difference between predicted and actual distances on the Paper Rockets Test Report.)

Teacher's Guide (Continued)

Exploration, Explanation: Have students use the **Student Handout** to read about the Apollo Program and some of its spinoffs. Have them use the **NASA Spinoff Database** online to research additional Apollo Spinoffs.

Extension: Have students complete the **Engineering Challenge**.

Evaluation:

- ◆ Have students complete test reports that will describe the rockets they constructed and how those rockets performed. Ask the students to create bar graphs on a blank sheet of paper that show how far each of the three rockets they constructed flew. Have students write a summarizing paragraph in which they pick which rocket performed the best and explain their ideas for why it performed as it did.
- ◆ Have students reexamine the Timelines in this unit for other examples of spinoffs.

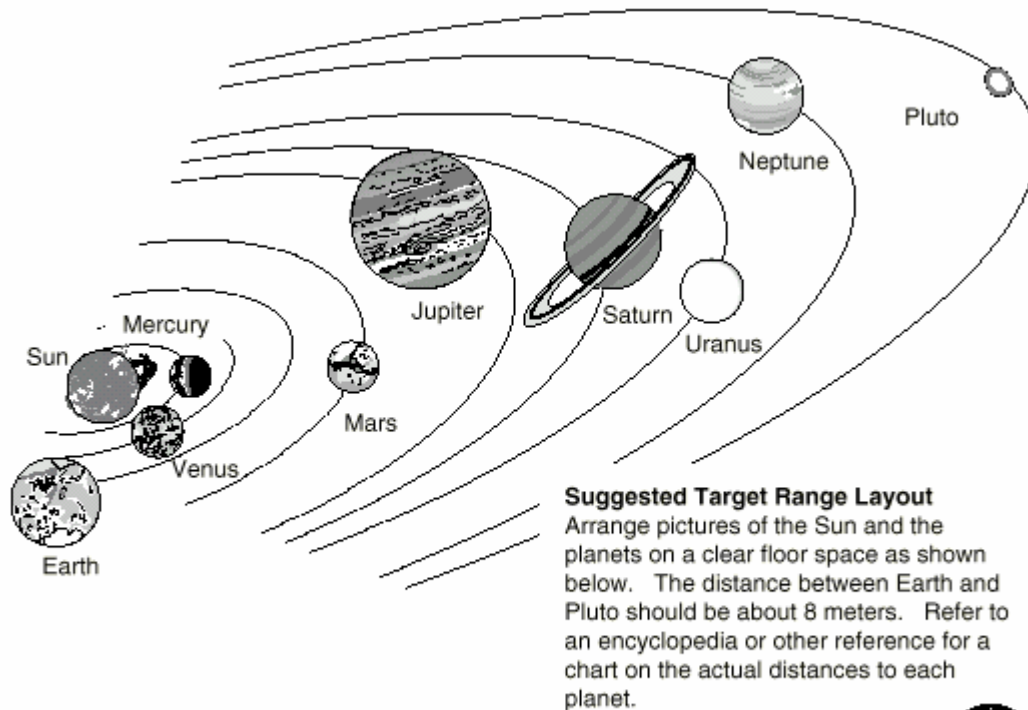
Ideas for Further Exploration:

For younger students, create a chart listing how far each planet target actually is from Earth and have them arrange the pictures to scale. (Older students can look up these distances for themselves.)

Have students try to determine how high the rockets fly. (To do so, place masking tape markers on a wall at measured distances from the floor to the ceiling. While one student launches the rocket along the wall, another student compares the height the rocket reached with the tape markers. Be sure to have the students subtract the height from where the rocket was launched from the altitude reached. For example, if students held the rocket 1.5 meters from the floor to launch it, and it reached 4 meters above the floor, the actual altitude change was 2.5 meters.)

As an alternative to the 10-meter test track, lay out a planetary target range and have students launch from planet Earth, telling them to determine the farthest planet they are able to reach with their rocket. Use the planetary arrangement shown below. (Pictures for the planets are found at the end of the Teacher's Guide. Enlarge as desired.)

Teacher's Guide (Continued)



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Rockets: A Teacher's Guide with Activities in Science, Mathematics, and Technology

EG-1999-06-108-HQ



Additional Background Information for Teachers:

Although the activity suggests using a solar system target range, the Paper Rockets activity actually demonstrates how rockets fly through the atmosphere. An important improvement in rocketry came with the replacement of sticks by clusters of lightweight fins mounted around the lower end. Fins could be made out of lightweight materials and be streamlined in shape. They gave rockets a dart-like appearance. A rocket with no fins is much more difficult to control than a rocket with fins. The placement and size of the fins is critical to achieve adequate stability while not adding too much weight. Some experimenters even bent the lower tips of the fins in a pinwheel fashion to promote rapid spinning in flight. With these “spin fins,” rockets become much more stable in flight, but this design also produces more drag and limits the rocket’s range.

References:

- ◆ **I Have the Heart of a Rocket**, online article of the development of the Ventricular Assist Device, available at: <http://www.nasaexplores.com/lessons/01-005/fullarticle.html> (The student reading in this lesson is based on this article.)
- ◆ **Spinoff**, NASA online publication on NASA spinoff technologies, available at: <http://www.sti.nasa.gov/tto/spinoff.html>
- ◆ **NASA Spinoff Database**, online at: <http://www.sti.nasa.gov/tto/spinselect.html>
- ◆ **Rockets: A Teacher's Guide with Activities in Science, Mathematics, and Technology (EG-1999-06-108-HQ)**, a NASA-created curriculum supplement that can be downloaded from: <http://spacelink.nasa.gov/products/Rockets/> (The background on the Apollo Program and the Rocket Activity used in this lesson are taken from this publication.)



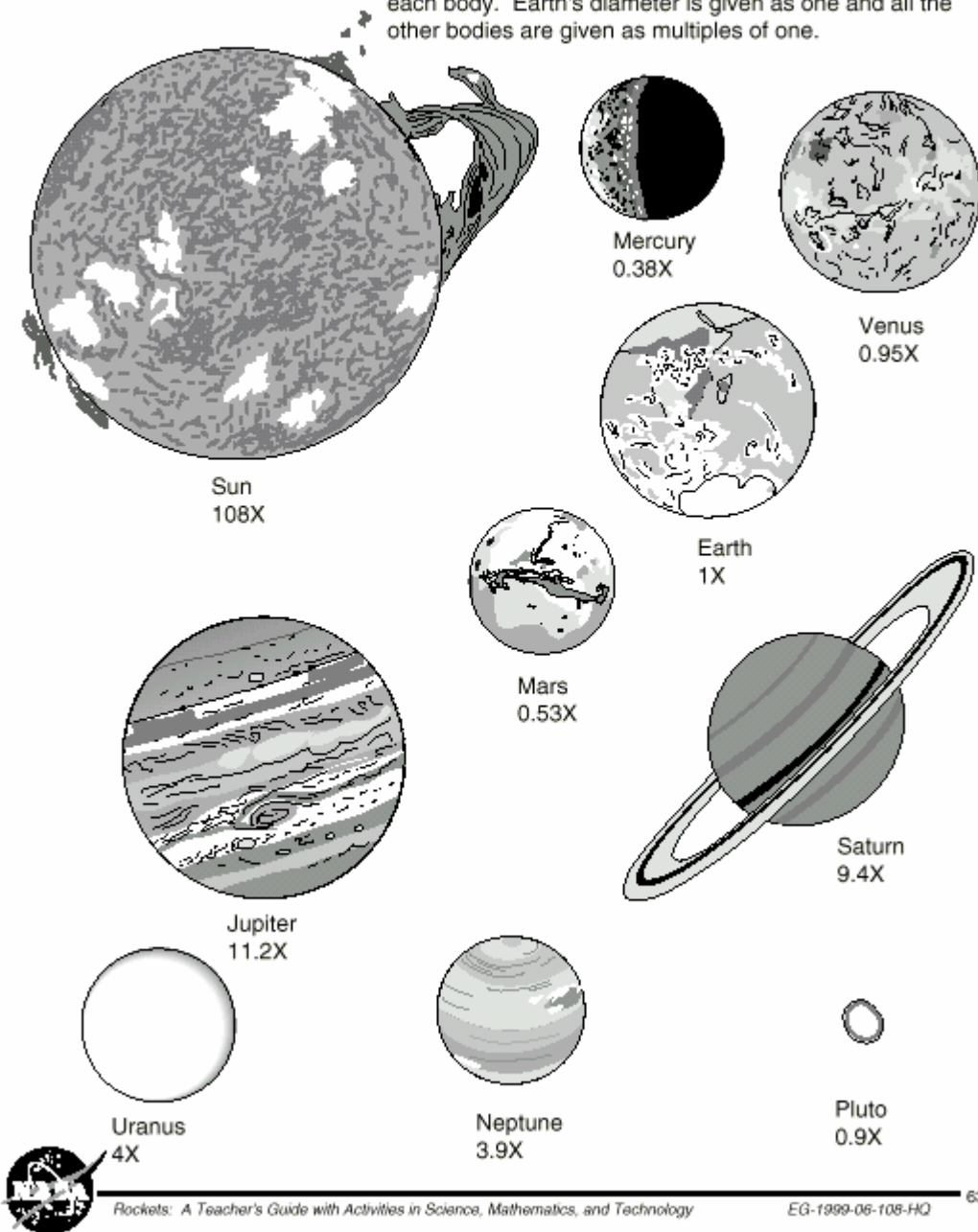
The American Society of
Mechanical Engineers

Teacher's Guide (Continued)

Planet Targets

(Not Drawn To Scale)

Enlarge these pictures on a copy machine or sketch copies of the pictures on separate paper. Place these pictures on the floor according to the arrangement on the previous page. If you wish to make the planets to scale, refer to the numbers beside the names indicating the relative sizes of each body. Earth's diameter is given as one and all the other bodies are given as multiples of one.



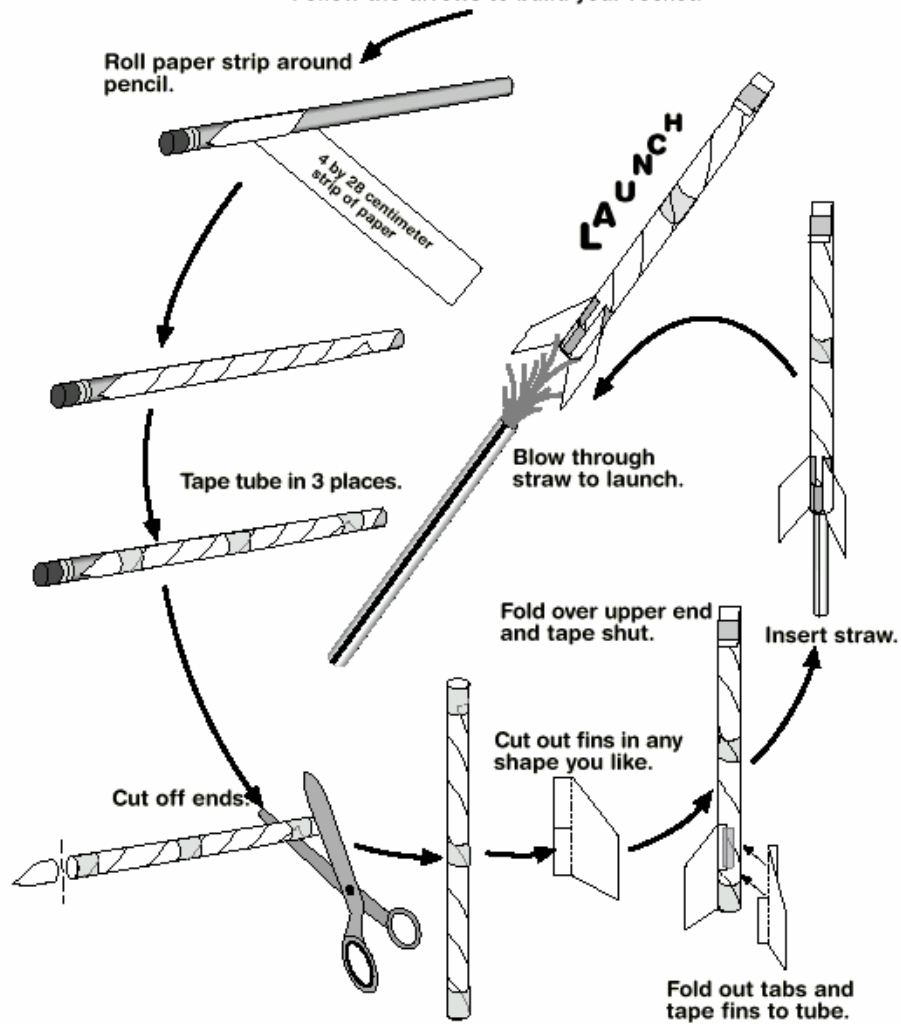
ACHIEVEMENT #2:

Apollo Moon Landing

Student Handout

PAPER ROCKETS

Follow the arrows to build your rocket.



Student's Handout (continued)

Names: _____

Paper Rocket Test Report

1. Launch your rocket three times. How far did it fly each time. What is the average distance your rocket flew? Write your answer in the spaces below.
2. Build and fly a rocket of a new design. Before flying it, predict how far it will go. Fly the rocket three times and average the distances. What is the difference between your prediction and the actual average distance?
3. Build a third rocket and repeat step 2.
4. On the back of this paper, write a short paragraph describing each rocket you built and how it flew. Draw pictures of the rockets you constructed.

Rocket 1

Make notes about the flights here.

How far did it fly in centimeters? <div style="display: flex; justify-content: flex-end; margin-left: 20px;"> 1. _____ 2. _____ 3. _____ </div>	
Average distance in centimeters? _____	

Rocket 2

Make notes about the flights here.

Predict how many centimeters your rocket will fly. _____	
How far did it fly in centimeters? <div style="display: flex; justify-content: flex-end; margin-left: 20px;"> 1. _____ 2. _____ 3. _____ </div>	
Average distance? _____	
Difference between your prediction and the average distance? _____	

Rocket 3

Make notes about the flights here.

Predict how many centimeters your rocket will fly. _____	
How far did it fly in centimeters? <div style="display: flex; justify-content: flex-end; margin-left: 20px;"> 1. _____ 2. _____ 3. _____ </div>	
Average distance? _____	
Difference between your prediction and the average distance? _____	



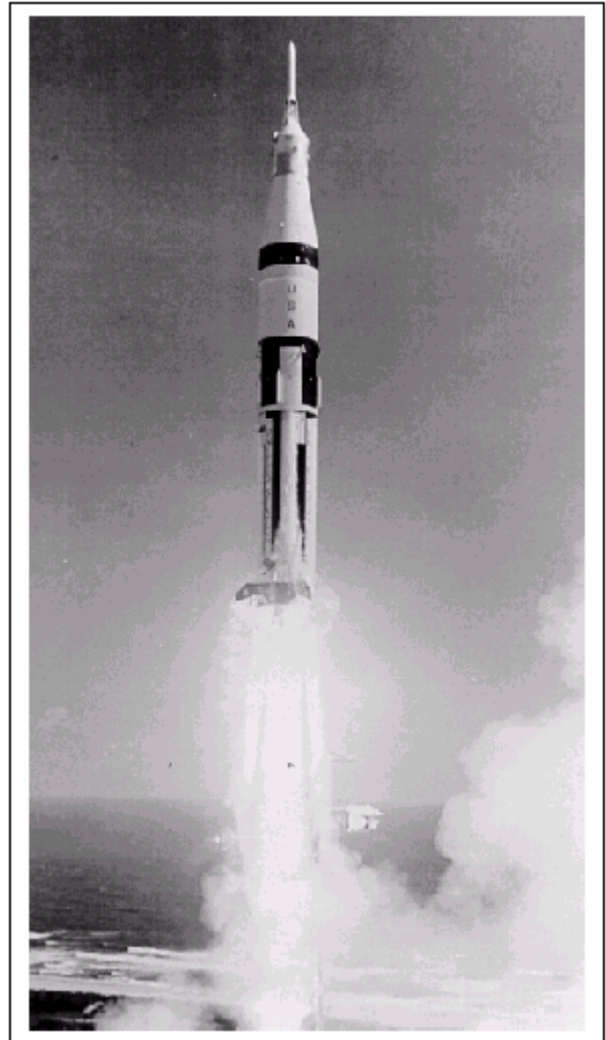
Student's Handout (continued)

The Apollo Program

The Gemini was the second manned capsule developed by the United States. It was designed to carry two crew members and was launched on the largest launch vehicle available - the Titan II rocket. President Kennedy's mandate significantly altered the Gemini mission from the general goal of expanding experience in space to preparing for a manned lunar landing on the Moon. It paved the way for the Apollo program by demonstrating rendezvous and docking required for the lunar lander to return to the lunar orbiting spacecraft, the extravehicular activity (EVA) required for the lunar surface exploration and any emergency repairs, and finally the ability of humans to function during the eight day manned lunar mission duration. The Gemini program launched ten manned missions in 1965 and 1966, eight flights rendezvoused and docked with unmanned stages in Earth orbit and seven performed EVAs.

Launching men to the moon required launch vehicles much larger than those available. To achieve this goal the United States developed the nearly 7-meter tall Saturn launch vehicle, shown in the picture. The Apollo capsule, or command module, held a crew of three. The capsule took the astronauts into orbit about the Moon, where two astronauts transferred into a lunar module and descended to the lunar surface. After completing the lunar mission, the upper section of the lunar module returned to orbit to rendezvous with the Apollo capsule. The Moonwalkers transferred back to the command module and a service module, with an engine, propelled them back to Earth.

After four manned test flights, Apollo 11 astronaut Neil Armstrong became the first man on the moon. The United States returned to the lunar surface five more times before the manned lunar program was completed. After the lunar program the Apollo program and the Saturn booster launched Skylab, the United State's first space station. A smaller version of the Saturn vehicle transported the United States' crew for the first rendezvous in space between the United States and Russia on the Apollo-Soyuz mission.



Student's Handout (continued)

Timeline of Events Related to Achievement #2:

- 1926** Goddard launches first liquid-fuel rocket engine.
- 1932** Wernher von Braun begins experimenting with rocket engines.
- 1934** Von Braun builds his first successful rocket, the A-2.
- 1950** A two-stage bumper rocket is launched from Cape Canaveral.
- 1957** Sputnik I is launched by liquid-fueled rocket built by Sergei Korolev.
- 1958** The U.S. launches Explorer 1, beginning of the US space program.
- 1959** Russia lands a probe on the moon and takes the first pictures of its far side.
- 1961** Russian Yuri Gagarin orbits Earth one time.
- 1961** Alan Shepard is launched 115 miles into space, lands 15 minutes later in Atlantic Ocean.
- 1962** John Glenn orbits Earth three times in a Mercury capsule, Friendship 7.
- 1962** Mariner 2 flies past Venus, the first probe to fly beyond another planet.
- 1963** The first communications satellite to reach synchronous orbit is launched.
- 1964** First space walk, U.S. Gemini program.
- 1969** Apollo 11 moon landing, Neil Armstrong is first person to walk on moon.
- 1971** Earth-orbiting space station, USSR.
- 1973** Skylab is placed in orbit.
- 1976** Mars space probes, NASA's Viking I and Viking II, launched.
- 1977** U.S. Space Shuttle program begins.
- 1981** Columbia Space Shuttle, the first reusable winged spaceship, is launched.
- 1997** The robotic explorer, Sojourner, lands on Mars.
- 1997** Discovery Shuttle mission with John Glenn aboard at age 77.

Student's Handout (continued)

Spinoffs from the Apollo Program

Many product and services incorporate NASA technology, in such areas as health and medicine, environment, public safety, consumer/home/recreation, transportation, computer technology and industrial productivity. These are called **spinoffs**. Here are some of the contributions of the Apollo program:

CAT Scanners and MRI technology (Computer-Aided Tomography and Magnetic Resonance Imaging) used in hospitals world wide, came from technology developed to computer-enhance pictures of the moon for the Apollo program.

Cool suits, which kept Apollo astronauts comfortable during moon walks, are today worn by race car drivers, nuclear reactor technicians, shipyard workers, people with multiple sclerosis and kids with a congenital disorder known as hypohidrotic ectodermal dysplasia.

Kidney dialysis machines were developed as a result of a NASA developed chemical process that could remove toxic waste from used dialysis fluid.

A cardiovascular conditioner developed for astronauts in space led to the development of a physical therapy and athletic development machine used by football teams, sports clinics and medical rehabilitation centers.

Cordless power tools and appliances are one of the most successful commercial spinoffs of space-based technology.

Athletic shoe design and manufacture also benefited from Apollo. Space suit technology is incorporated into a shoe's external shell.

Insulation barriers made of aluminum foil laid over a core of propylene or mylar, which protected astronauts and their spacecraft's delicate instruments from radiation, is used to protect cars and trucks and dampen engine and exhaust noise.

Exploring Apollo Spinoffs

The NASA Spinoff Database at <http://www.sti.nasa.gov/tto/spinselect.html> is easy to search. Just enter the word Apollo and press the Submit Query button. The database contains nearly 150 examples of products developed based on technologies originally created for the Apollo Program. (To see the entire list, select Display a maximum of 150 reports.)

Select a product different from those described below and be prepared to give a brief oral description of it to the class. Try to imagine how someone got the idea of applying NASA technology outside of the space program.

Student's Handout (continued)

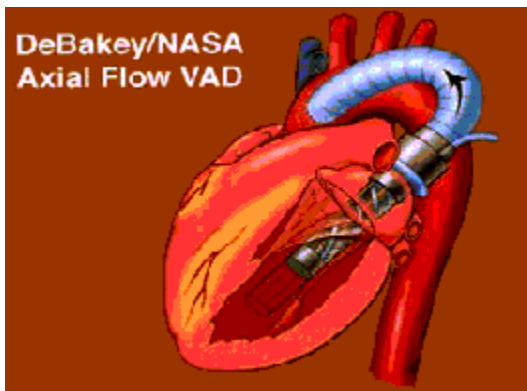
The Heart of a Rocket?

(Information courtesy of NASA'S Aerospace Technology Enterprise)

The last place you'd expect to find part of a rocket engine is attached to the human heart. Rocket engines are notoriously fickle and demand pampering to pump strange fluids like liquid hydrogen for even just a few minutes of pump life. The human heart, on the other hand, is a durable device, changing its output to meet new demands and enduring a range of stresses for decades.

Merging the two was the brainchild of NASA engineer David Saucier of the Johnson Space Center, who received a heart transplant in 1984 after a wait of several months. Why not borrow some space technology, he asked his doctor, to give a failing heart a boost while a patient is waiting for a heart? In response to this question, his doctor, Dr. Michael DeBakey (a pioneer in heart transplants), DeBakey's team at Baylor College, and biomedical experts at MicroMed Technology, worked together to develop a **Ventricular Assist Device (VAD)**.

The human heart (like those of all mammals and birds) has four chambers. The right auricle and ventricle receive blood from the body and pump it into the lungs to exchange carbon dioxide for oxygen. The left auricle and ventricle receive blood from the lungs and pump it out to the body. Because it has to push blood out to the entire body, the left ventricle is under the greatest strain and often fails first. The VAD was designed to reduce the left ventricle's load while keeping blood flowing to the rest of the body.



On paper it looked great. In clinical trials with animals, it only worked two days. Longer life of the pump was needed to give longer life to patients. Such differences between planning and testing are not unusual in engineering development work. Soon, design changes increased pump life to an impressive 120 days. In practice, it has operated for five to six months, thus giving patients a longer time to wait for a donor.

For now, the U.S. Food and Drug Administration classifies the VAD as “an experimental device”. One day soon it may be approved for general use.

This story illustrates one way that spinoffs occur – when someone’s past and present experiences combine with their creativity to trigger new ideas.

Engineering Challenge: Design and make a new useful product using only paper clips, index cards, transparent tape, and other standard office supplies.