

# SPACE FOOD

By Kathy De Antonis

Eating in space goes as far back as John Glenn's first orbit around the Earth in 1962. Given the magnitude of his accomplishment, not much attention was paid to the food that he ate, a paste that he squeezed into his mouth from what looked like a toothpaste tube. It was nutritious for sure, but not very appetizing.



The National Aeronautics and Space Administration (NASA) has come a long way in its effort to provide a variety of appetizing foods for its astronauts in space. Based upon extensive studies by food scientists working closely with astronauts, different types of foods are now prepared and packaged to make them last longer and taste better and to make them easier to transport in space.

Vickie Kloeris, a NASA food scientist, leads a team of food scientists, engineers, dietitians, and technicians who work at the Johnson Space Center in Houston, Texas, on testing and making many different foods for astronauts.

One of the main challenges for NASA food scientists is to make these foods tasty, so they try different recipes and keep the ones that work best. It is a lot of work, but you need to keep the astronauts happy, especially if they have to stay in space for months or years on end!

## Meeting astronauts' nutritional needs

At the Johnson Space Center, the Space Food Systems Laboratory develops food used on the space shuttle and the International Space Station (ISS) and is working on ways to feed astronauts on longer trips in the future.

An interesting finding made by NASA scientists is that some nutrients in the body behave differently in space than they do on Earth.

For example, astronauts don't need as

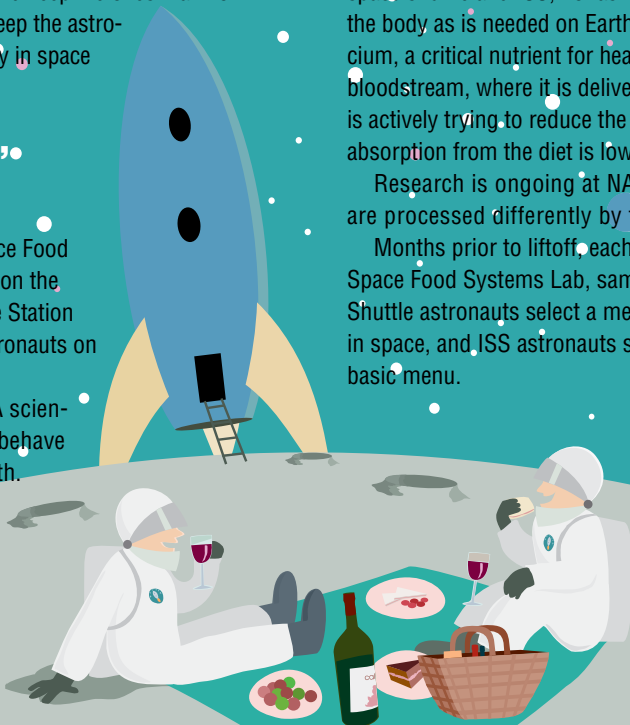
much iron in microgravity. In the body, iron is found in the blood. In microgravity, the body does not need as much blood, so it reduces the total volume of blood by destroying red blood cells as soon as they are produced, leading to about 15% less blood in the body than on Earth. The iron that is bound to these red blood cells is released and stored elsewhere in the body. An excess of iron in the body can be harmful, so dietary intake of iron is reduced in space to help reduce the amount of extra iron in the body.

Likewise, astronauts are prone to bone loss during extended missions in space because the body senses that the skeleton is not required for support in flight as it is on Earth. In the low gravity of the space shuttle and ISS, not as much bone mass is needed to support the body as is needed on Earth. When people eat food containing calcium, a critical nutrient for healthy bones, calcium is absorbed into the bloodstream, where it is delivered to the bones. But because the body is actively trying to reduce the amount of bone, the rate of calcium absorption from the diet is lower in space than on Earth.

Research is ongoing at NASA to learn more about how nutrients are processed differently by the body in space and on Earth.

Months prior to liftoff, each astronaut spends some time in the Space Food Systems Lab, sampling an assortment of space foods. Shuttle astronauts select a menu for every meal that they will eat while in space, and ISS astronauts select food items that complement their basic menu.

***Eating in space is no picnic, but it would be cool to have a picnic on the moon!***



## What is space food like?

The Space Food Systems Lab faces many constraints when producing space food. Food must be lightweight, compact, and require minimal preparation. Also, the food must be well preserved, so it does not spoil in space in the absence of refrigerators or freezers. Even food consistency is considered. Crumbly foods don't work well in space because small particles will float in near-zero gravity and potentially get into the workings of the spacecraft.

To take all these restrictions into account, scientists at the Space Food Systems Lab have come up with different categories of food. For example, soups, casseroles, and scrambled eggs are "freeze-dried." After they are prepared, water is almost entirely removed prior to packaging, making these foods lighter to carry and more compact. Once astronauts are in space, they add water back to these foods before eating them.



NASA

Some foods, such as tuna, are "thermostabilized," that is, they are heat-processed after they are packaged. Other foods, such as some meats, are irradiated after they are cooked and packaged. Thermostabilization and irradiation are ways of sterilizing food so that it can be stored in the absence of refrigerators and freezers. Unlike freeze-dried food, these two types of food do not require the addition of water and are edible as is.

Salt and pepper are also modified for use in space. They cannot be shaken over food because the particles will float away. So, salt is dissolved in water and pepper is mixed with oil.

## Does it taste good?

Bill Daley, a food critic at *The Chicago Tribune*, ventured to answer that question. He sampled and critiqued a dozen space food



rations that were delivered to him as they would be delivered to astronauts in space. He quickly realized the challenges that astronauts face in eating a simple meal.

The serving-size portions were delivered in plastic pouches, each labeled with preparation instructions, such as how much water to add or how long to warm it. He was unprepared for the awkwardness of rehydrating freeze-dried foods by injecting water into the pouches with a 60-milliliter syringe and reheating thermostabilized food pouches in a warm water bath. These are cooking techniques that chefs don't frequently use here on Earth.

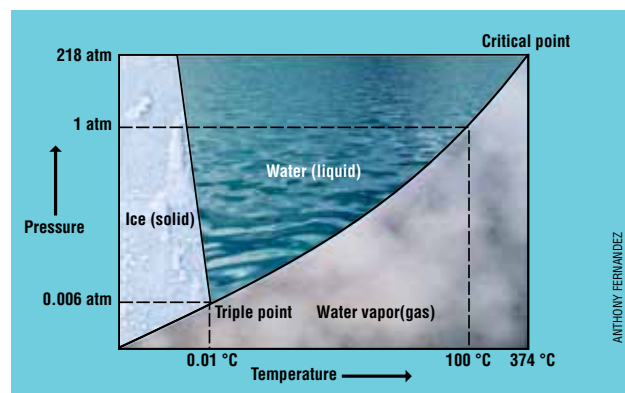
Daley was surprised to find he needed a pair of scissors among his utensils. He found it to be a critical tool—and astronauts use scissors during every meal to open their food pouches. Fastened to each pouch is a Velcro disk, which is of no use here on Earth, but in space, it is critical for fastening the pouches to a tray so they don't float.

Once he worked past the preparation, Daley found that most of the foods did not meet his standards. "Space food isn't restaurant cooking; it's not even takeout. If anything, it's more along the lines of a frozen dinner—but you get bigger portions from the frozen-food aisle." That said, he was satisfied by some things. "I particularly enjoyed the dried peaches, because of their intense flavor and a satisfying, chewy texture," he says.

## Freeze-drying food

Freeze-drying is probably one of the most fascinating ways of preparing space food. This process not only removes as much water as possible from a given food but also preserves it for as long as possible.

Food spoils when microorganisms, such as bacteria, feed on the matter and decompose it. Bacteria may release chemicals that cause disease or may just release chemicals that make food taste bad. Bacteria need water to survive, so if you remove water from food,



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Figure 1. Water can take the form of solid, liquid, or gas, depending upon different values of temperature and pressure.

it won't spoil. Freeze-dried foods can be stored for years and then be restored with just a little water.

Freeze-drying is different from dehydration, which involves heating food in dry air until the moisture is gone. But dehydration usually doesn't remove more than 90% of the water, so bacteria can still grow. Freeze-drying more successfully removes a much higher percentage of the water. Typically, the foods have less than 3% of the remaining water, and the food's composition remains otherwise unchanged.

Freeze-drying relies on a natural process, called sublimation—the conversion of frozen water present in foods directly to gaseous water. Depending upon the surrounding

## Try it!

You may be able to buy space food at your local science museum.



MIKE DIEBELSKI



temperature and pressure, water can exist as a solid, a liquid, or a gas. By varying the temperature and pressure, it is possible to see water go from one of these forms to another.

The temperatures at which water goes from solid to liquid (melting), liquid to gas (boiling), and solid to gas (sublimation) vary with the surrounding pressure (Fig. 1). There is one value of temperature and pressure (0.006 atmosphere of pressure and 0.01 °C)—called the triple point (Fig. 1)—for which water coexists at equilibrium as a solid, a liquid, and a gas. At any pressure below 0.006 atmosphere, liquid water cannot exist and ice is converted directly to water vapor—that is, it sublimates—when heated.

The process of freeze-drying takes advantage of this property, as follows: First, the temperature is reduced below 0 °C until all water present in a given food is frozen solid. Then, pressure is reduced below 0.006 atmosphere, and the food is slowly warmed to a temperature above the freezing point. With time, the water sublimates and is drawn away by vacuum. Over many hours—sometimes even days—97% or more of the water is removed, leaving the freeze-dried food.

## Rehydrating freeze-dried food

Aboard the space shuttle, water is produced by battery-like devices, called fuel cells, which also provide electricity. Each space shuttle is powered by three fuel cells that are tucked beneath the cargo bay. Each one weighs about 225 pounds and is 45 inches long, 15 inches wide, and about 14 inches high.

Like a standard battery, a fuel cell converts energy produced through chemical reactions

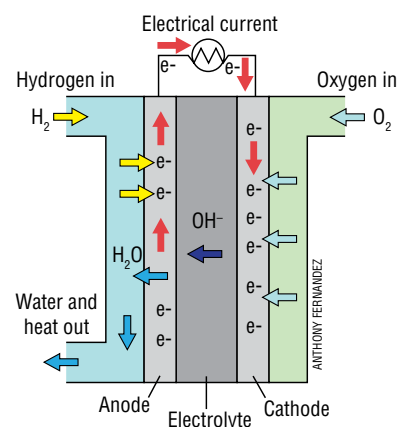
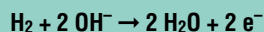


Figure 2. Schematic representation of what happens in fuel cells used on the space shuttle.

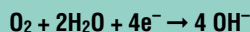


into electricity. In a battery, the chemical reactants are limited to what is contained inside; so, once they are consumed, the battery runs out of power. In contrast, a fuel cell can continue working as long as the chemical reactants are added to the cell from the outside. A byproduct of the chemical reactions occurring in a fuel cell is water vapor, which can be condensed into liquid water and stored.

In a fuel cell that is used on the space shuttle, electricity is produced via two reactions that occur simultaneously near two conducting materials, called anode and cathode (Fig. 2). Hydrogen gas (H<sub>2</sub>) is delivered to the anode and oxygen gas (O<sub>2</sub>) is delivered to the cathode. Near the anode, hydrogen reacts with hydroxide ions (coming from the cathode) to produce water and electrons:

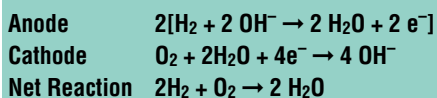


Near the cathode, oxygen reacts with water and the electrons to produce hydroxide ions (OH<sup>-</sup>):



The hydroxide ions then move to the anode, and the cycle starts again. The electrons that are produced at the anode are routed into an electrical circuit that powers the shuttle.

The net result of the two reactions, called oxidation (at the anode) and reduction (at the cathode), is water:



Taken together, the fuel cells can produce up to 25 pounds of water per hour, which is more than enough to meet the astronauts' needs.



## Space food of the future

In the future, NASA is looking to send astronauts to outposts on the moon and Mars. Although the target for liftoff for the moon mission is not until 2020, efforts are already under way at the Space Food Systems Lab. Scientists in the Advanced Food Technology group, led by NASA food scientist Michele Perchonok, are developing foods that are “nutritious, good tasting, and provide variety for a 3-year mission.”

The biggest challenge for these future missions is a food’s shelf life. “For an initial trip to Mars, you will need products that have a 5-year shelf life,” Kloeris says. The only foods that have currently shown such a long shelf life are a few thermostabilized foods, which is not enough to provide a balanced diet, Kloeris says.

Perchonok and her team are looking at ways to improve packaging materials that will provide a better barrier to water and oxygen—which can cause food to spoil. This way, the shelf life for many current food items can be extended. Another area of research is to develop ways to transport some foods—such as wheat berries and soybeans—in bulk to reduce the amount of packaging materials used and to minimize waste.

“A 1,000-day mission to Mars for a crew of six will need about 10,000 kilograms if we went with our packaged food system,” Perchonok says. “If we can save on that by growing some items, by bringing some items up in bulk, it will be a lot easier.” ▲

### SELECTED REFERENCES

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