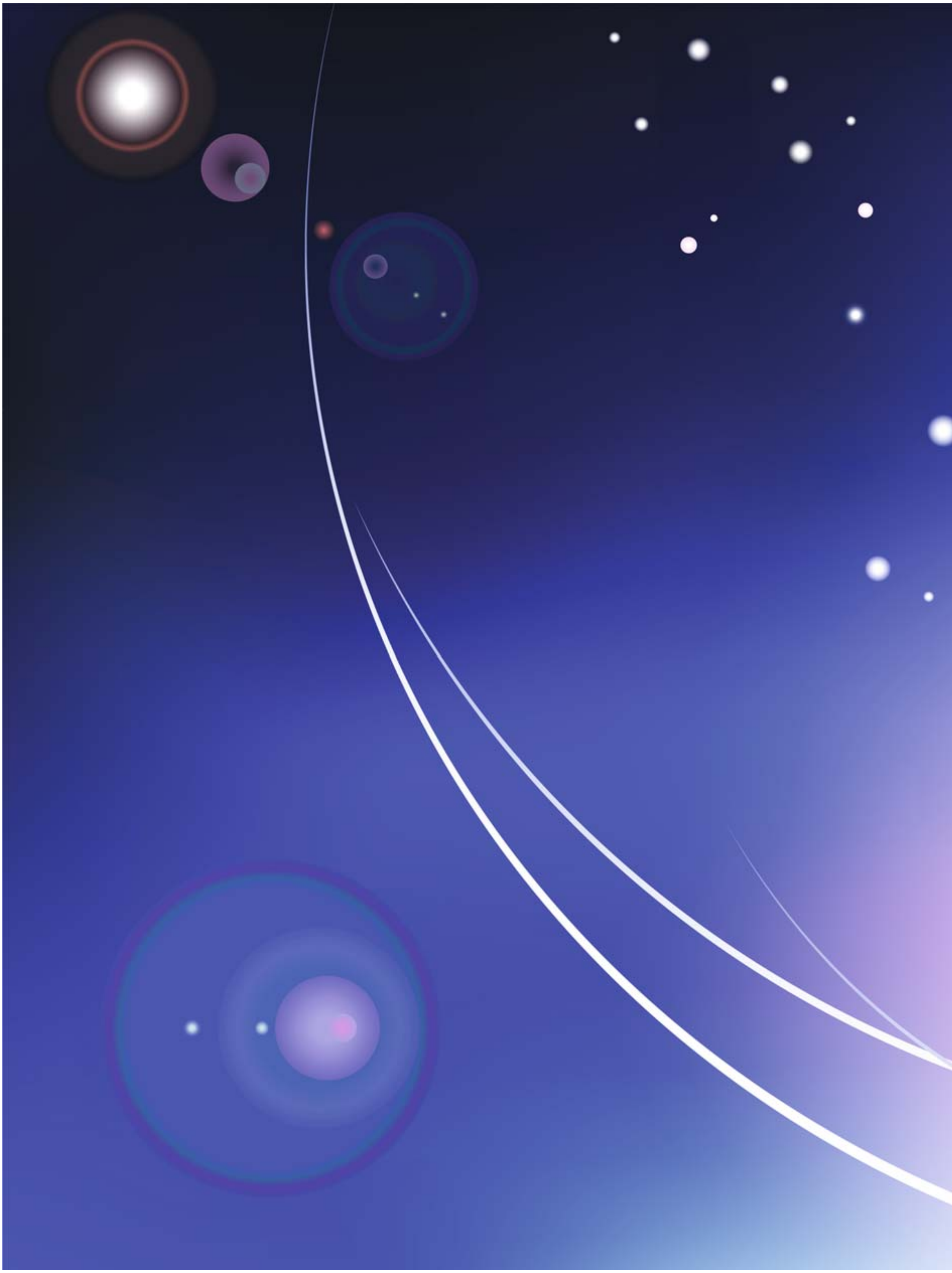
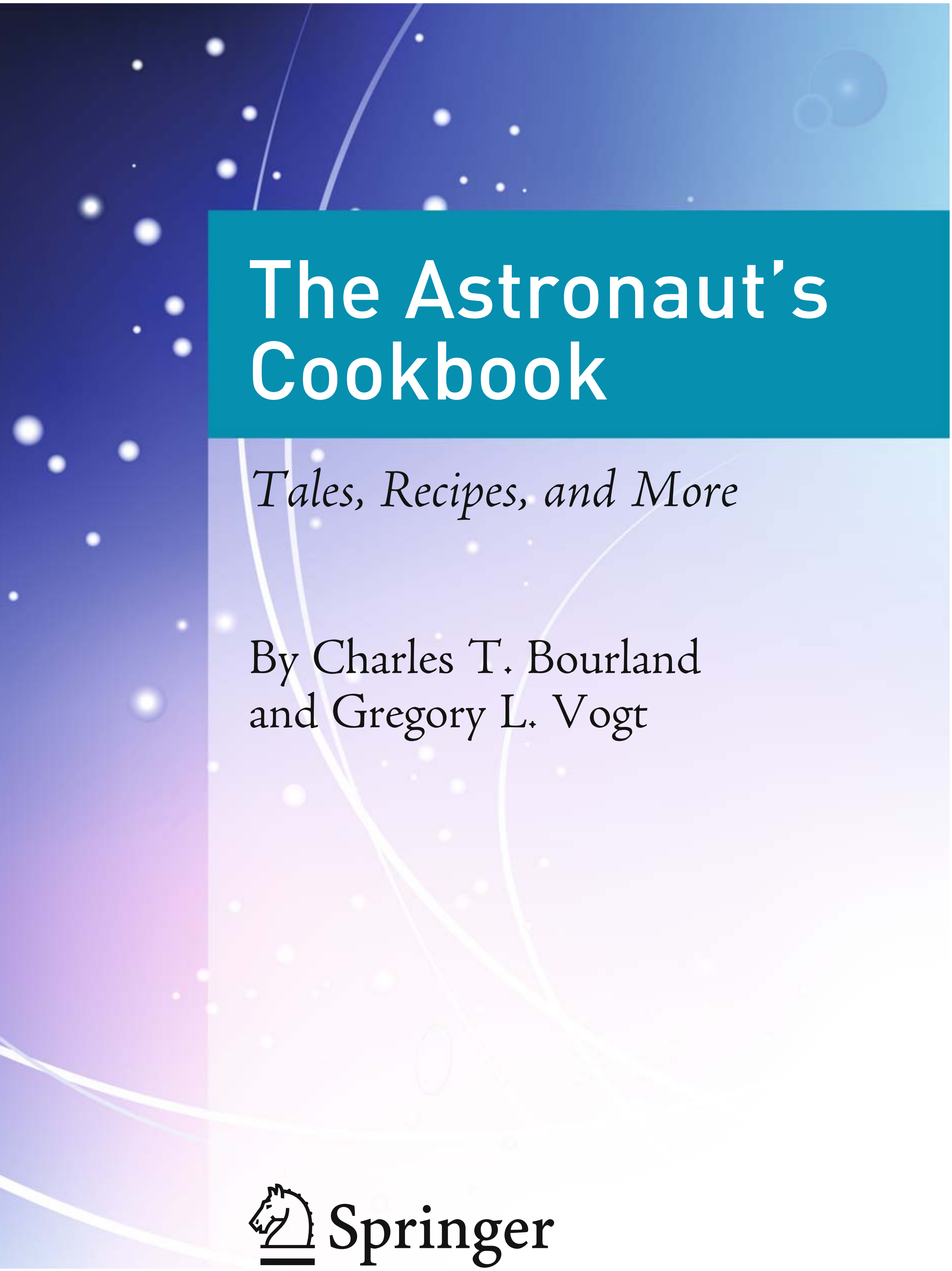
The Astronaut’s Cookbook





The Astronaut’s Cookbook

Tales, Recipes, and More

By Charles T. Bourland
and Gregory L. Vogt

Springer

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This book is dedicated to the astronauts who lost their lives pursuing their dreams to explore the frontier of space.

Apollo 1, January 27, 1967
Virgil “Gus” Grissom
Edward H. White II
Roger B. Chaffee

Shuttle STS-51L Challenger, January 28, 1986
Francis R. (Dick) Scobee
Michael J. Smith
Ellison S. Onizuka
Judith A. Resnik
Ronald E. McNair
Sharon Christa McAuliffe
Gregory Jarvis

Shuttle STS-107 Columbia, February 1, 2003
Rick D. Husband
William C. McCool
Michael P. Anderson
David M. Brown
Kalpana Chawla
Laurel B. Clark
IIan Ramon

FIGURE 1 Lost mission patches.

Acknowledgements

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About the Authors

Charles T. Bourland spent 30 years at the NASA Johnson Space Center developing food and food packages for spaceflight. He began his work during the *Apollo 12* program and continued through the early years of the International Space Station. During his career at NASA he was involved in the *Apollo* recovery ship food, Zero G testing aboard the Zero G plane, quarantine food systems, and planetary-based food systems for the Apollo program, Skylab, the Apollo-Soyuz Test Program, the shuttle program, and the International Space Station.

Gregory L. Vogt is a veteran writer, science consultant, and developer of science and technology materials for schools. A former science teacher himself, Vogt has been director of an interactive science museum, an education specialist with the Astronaut Office at the NASA Johnson Space Center, and a consultant to museums, Challenger Learning Centers across the United States, and foreign space agencies. Author of more than 80 trade books, Vogt's latest book is a newly published Springer title called *Landscapes of Mars: A Visual Tour*. Currently, he works at the Center for Educational Outreach at the Baylor College of Medicine in Texas.

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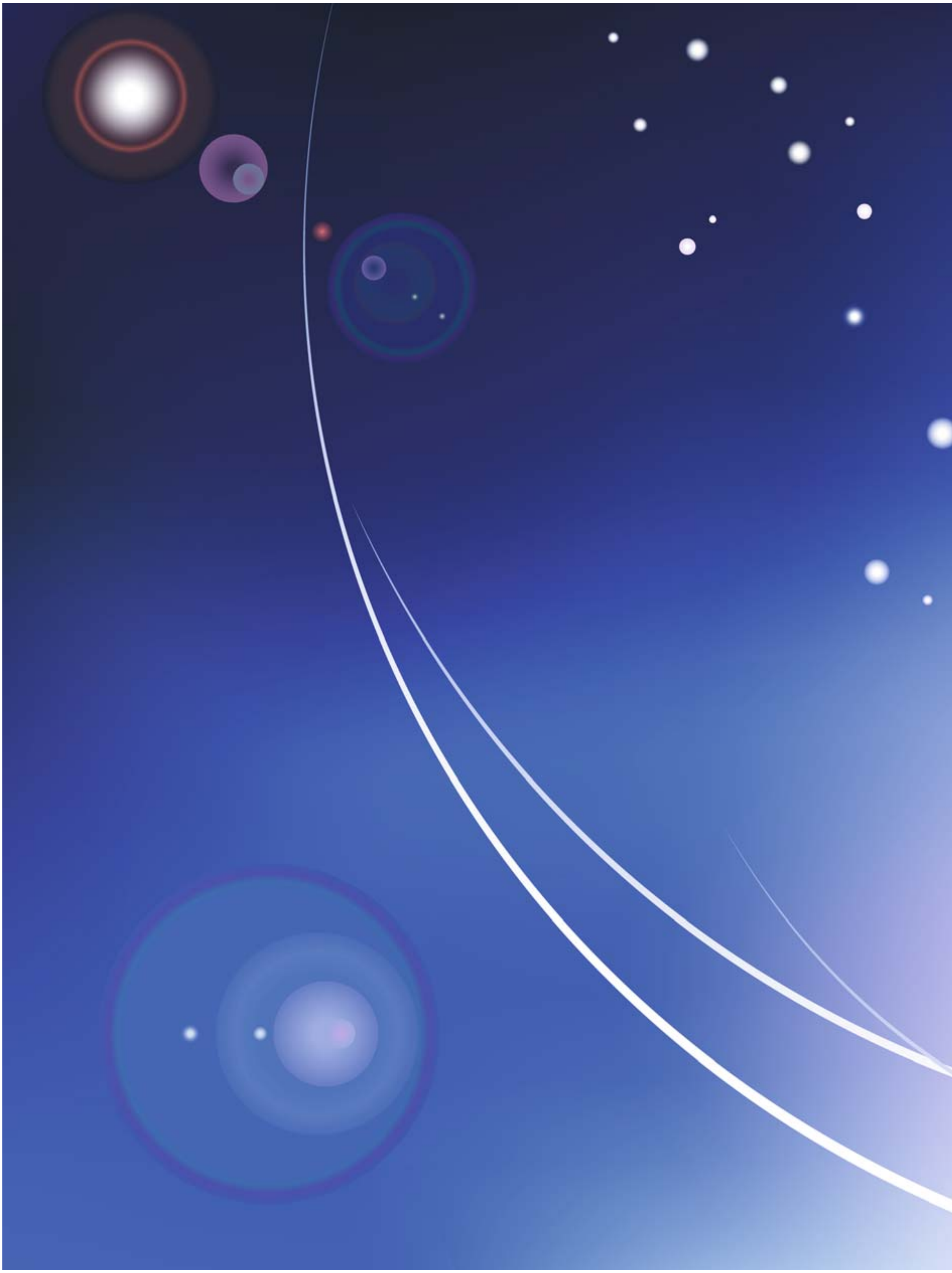

CHAPTER 1

Introduction

Half a century has passed since humans began the conquest of space. Satellites, lunar landings, space stations, robot rovers on Mars, solar and deep space observatories, and probes to the edges of interstellar space have sent back a flood of scientific information. Space exploration has fundamentally changed our lives, from the classroom to the marketplace to cyberspace.

Space scientists and mission planners will tell you that the exploration of space is vital to our economic and environmental survival and essential for our security in a dangerous world. We've heard all this before, but what really convinces us that we should go into space is that exploration is just plain exciting, and much of that excitement is in the details. . .

- What is it like to fly in space?
- Why do you float?
- Can you see any manmade objects from space?
- How does it feel to travel 25 times the speed of sound?

Of course, there are the more mundane questions. How to go to the bathroom in space is tops on the "enquiring minds want to know" list. But after that, the next most popular questions have to do with space food—how do you eat it, what do you eat, how does food taste in space, how do you cook it, and so on.

C.T. Bourland, G.L. Vogt, *The Astronaut's Cookbook*, DOI 10.1007/978-1-4419-0624-3_1,

For many of us, especially those of us old enough to have been around at the beginning of the space age, our concept of space food is limited to Tang, food sticks, goop squeezed out of toothpaste tubes, and freeze-dried ice cream. We remember old science fiction movies where intrepid space explorers dined entirely on nutrient-packed pills.

We also remember space experts speculating on the problems the first astronauts might encounter in space. Continuous floating inside a spaceship might cause astronauts to go insane from the stress of the sensation of falling and waiting for the impact that never comes. Astronauts could get fried by cosmic radiation. It might not be possible to swallow food, making long space missions impossible.

Fortunately, none of those concerns proved true. Astronauts delight in the floating effects and don't go crazy in space. While in Earth orbit, they are protected from radiation by the Van Allen radiation belts, an early discovery of the *Explorer* satellite program. Eating and swallowing turned out to be easy. This was proved during the second manned spaceflight, in 1961, when Soviet cosmonaut Gherman Titov became the first human to consume food in space. A few months later, John Glenn, Jr., became the first American to consume food in space. He ate applesauce dispensed from a squeeze tube during his February 1962 *Mercury* flight. The experiences of these early space explorers began what is, to this day, an ongoing process of space food development.

Space food is a unique branch of food and nutrition science. It is far more than just selecting tasty and healthy things to eat. Creating space food is also about packaging, preparation, consumption, and disposal. The primary driving force behind space food development is weight and volume. The less the total payload carried by a rocket weighs, including the weight of the astronauts, the less thrust the rocket has to generate to reach space. In relation to volume, the less space occupied by space supplies and tools needed by the crew, the more room there is in the capsule for the crew.

Especially in the early days of spaceflight, everything placed on board for liftoff was measured to the last fraction of an ounce and to the last cubic inch. Space food was no exception. In Project Gemini, the two astronauts jammed into the *Gemini* capsule were each allowed 1.7 lb of food per day. Because of the tightness, it was a Herculean task to provision the *Gemini 7* mission, where astronauts Frank Borman and Jim Lovell remained in close quarters for 14 days in space.

Today's space shuttle crews are allowed 3.8 lb of food per person. The difference in food weight between the two spacecraft has to do with water content. The *Gemini* spacecraft was a tight fit. Astronauts liked to joke, "You don't climb into a space capsule. You put it on!" John Young, one of two astronauts for the first *Gemini* mission, likened the capsule to "sitting in a phone booth that was lying on its side." Because interior space was at a premium, food for the *Gemini* crew had to be as compact as possible. Most *Gemini* foods were dried for launch and rehydrated in space from the spacecraft's water supply.

The space shuttle, flown for the first time 15 years after the last *Gemini* mission, is a much larger spacecraft than the *Gemini* capsule. The orbiter payload bay alone could hold three *Gemini* capsules end to end. Though carrying up to eight astronauts at a time, the shuttle crew cabin has plenty of room for food for all the crew for a two-week mission. The great lifting power of the shuttle's engine permitted food scientists to leave some of the natural water in space shuttle foods, which made them taste better and easier to prepare (Figure 1.1). This is why daily rations for shuttle crews could weigh more than *Gemini* rations.

FIGURE 1.1 Early Shuttle foods (NASA photograph).

Space foods are individually packaged and stowed for easy handling in space. All food is precooked or processed, so it requires no refrigeration. It is either provided in a ready-to-eat form, or it can be prepared simply by adding water or by heating.

Because of significant safety issues, astronauts do not really cook food in space. A spacecraft is a closed environment. If an astronaut burns a steak, he or she cannot open the window and let the smoke out. Smoke contains toxins and is a serious health hazard in a closed environment. If the smoke never gets out, it circulates until its soot particles are deposited on every bit of interior surface, including the insides of astronauts' lungs.

Modern space menus also include a small amount of fresh fruits and vegetables that are stowed in a fresh food locker. Without refrigeration, carrots and celery must be eaten within the first two days of the flight, or they will spoil. Other fresh items include tortillas, which have an exceptionally long shelf life. Preferred over sliced bread, tortillas do not easily break down into crumbs that would clog air vent filters and get sucked up into astronauts' nostrils.

Space Food Types

Space food falls into several categories, depending mostly upon how astronauts prepare the food at meal time. In each category, making food easy to handle is of prime importance. Astronaut time in orbit is extremely valuable, and the less time involved in meal preparation and clean up, the more time is available for accomplishing the goals of the mission.

Rehydratable Food

Rehydratable items include both foods and beverages. Water is removed during Earth processing, making it easy to stow the foods and extend the shelf life. During flight, water is added back to the food.

Regardless of how this sounds at first, the strategy of rehydrating food in space actually saves launch weight. How? Why should it make a difference if you send up the food with its water or dry it first and add the water back later?

The space shuttle orbiter, like the *Apollo* and *Gemini* spacecraft previously, generates electricity with fuel cells. Fuel cells combine hydrogen and oxygen to make electricity. Water is a byproduct of the generation process. Since you have to send up the hydrogen and oxygen for power anyway, why not use fuel cell wastewater for rehydrating food and drinking? This means it is unnecessary to launch more than a starter supply of water. In no time, there is plenty of water for food preparation!

Rehydratable foods are packaged in containers that have some sort of port through which water can be added. A label indicates how much water is to be added and whether the water should be hot or cold. The crew member doing the "cooking" inserts the water using a large gauge needle and then kneads the package for a moment to spread the water around so it will make contact with all parts of the food. If need be, the package can be placed in a convection oven to raise its temperature beyond that provided by the hot water. When the food item is ready, it is consumed directly from the package (Figure 1.2).

Rehydratable foods include chicken consommé, cream of mushroom soup, macaroni and cheese, chicken and rice casseroles, shrimp cocktail, and various breakfast foods such as

FIGURE 1.2 Shuttle rehydratable food (NASA photograph).

scrambled eggs and cereals. Breakfast cereals are prepared by packaging the cereal with nonfat dry milk and sugar. Water is added to the package to rehydrate the milk just before the cereal is eaten.

Fewer rehydratable foods are consumed on the International Space Station (ISS) than on the space shuttle. The ISS generates power with huge solar panels that make electricity directly from sunlight. Water is not a byproduct, and consequently, all water is brought to the ISS by the space shuttle or by the Russian *Progress* resupply spacecraft. ISS astronauts must be careful with their water use, and they stretch water supplies by recycling what they can. Thus, there is little advantage in launching large quantities of rehydratable foods.

Thermostabilized Food

Thermostabilized food refers to canned food, like your standard canned peas, beans, or artichokes. The foods are heat-processed to destroy deleterious microorganisms and enzymes. Once made specifically for spaceflight, individual servings of thermostabilized foods are now commercially available in flexible pouches. (Military MRE's, or meals ready to eat, are staples of spaceflight.)

Most of the fish, such as tuna and salmon, and fruit are carried into space in thermostabilized cans or pouches. The cans open with full-panel pull-out lids. Puddings are packaged in plastic cups with pull-off foil lids. Most of the entrees are packaged in flexible retort pouches, similar to MREs. These include products such as grilled chicken, tomatoes, eggplant, beef with barbecue sauce, and ham. After the pouches are heated in the onboard convection oven, the food is cut open and eaten directly with conventional eating utensils. The only space food utensil usually not found on Earth dining tables is a scissors for opening the packages.

Intermediate Moisture Foods

Intermediate moisture foods are those preserved by restricting the amount of water available for microbial growth, while retaining sufficient water to give the food a soft texture. Examples are dried peaches, pears, apricots, and beef. Except for cutting open the package, no preparation is needed. Intermediate moisture foods usually

FIGURE 1.3 Shuttle/ISS dried peaches (NASA photograph).

range from 15 to 30% water, but the water is chemically bound with the sugar or salt (Figure 1.3).

Natural Form Foods

Nuts, granola bars, M&Ms^{TM}, and cookies are classified as natural form foods. They are packaged ready to eat in flexible pouches.

Irradiated Meat

Irradiated meat includes beefsteak, fajitas, breakfast sausage, and smoked turkey. To insure long shelf life at the ambient temperatures found inside the spacecraft, the meat is cooked, packaged in flexible foil-laminated retort pouches, and sterilized by zapping it with ionizing radiation (Figure 1.4).

Condiments

Condiments include commercially packaged individual pouches of catsup, mustard, mayonnaise, taco sauce, and hot pepper sauce. Polyethylene dropper bottles contain liquid pepper and liquid salt. The pepper is suspended in oil and the salt is dissolved in water. Drops are pressed directly onto the food.

FIGURE 1.4 Irradiated Smoked Turkey (NASA photograph).

Liquefying pepper and salt may seem strange, but the spaceflight environment requires it. Shake out dry pepper and salt on Earth, and it falls onto your food. Doing the same thing in space would create a "cloud" of seasoning, leading to a sneeze-fest and very irritated eyes and nasal passages.

Although salt and pepper can boost the taste of various foods, it is challenging to apply the liquids properly. Shaking salt and pepper on Earth uniformly spreads out the particles. Pressing liquid salt and pepper drops directly on foods in space often leads to "hot spots."

Space Food Menu Development

Developing space food menus is challenging. One of the obvious objectives is to have food that the astronauts will eat. If not eaten, it doesn't matter how healthy and nutritious the food is. Good-tasting food means happy astronauts. Bland or bad-tasting food means leftovers. In space, leftovers are *bad*. Even if a spacecraft has a refrigeration unit, storage space is very limited. Eventually, moldy refrigerator science projects have to be disposed of. The trouble with spaceflight is that you can't pitch the garbage bag out the door. It has to be held until it can be returned to Earth.

Step one in food menu development is to create a potential list of foods. Items on the list have to be available through current food processing technologies. They also have to meet certain constraints imposed by spacecraft, crew members, and the flight environment. For example, a rehydratable food item has to be rehydratable even with cold water in case the hot water supply fails. The food has to have a long shelf life. It must have a good nutritional balance and be available at a reasonable cost. Finally, it has to taste good. That means more than just flavor. It has to have a pleasing texture and color. (The psychology of food is important. Try dyeing a glass of milk green and see how many people will drink it!)

After the food list is settled upon, dietitians extract specific foods from the list to create breakfast, lunch, and dinner menus. They also make recommendations for improvements and add items for balance.

To ensure the food items will be accepted by flight crews, each is tested in a food laboratory. Flight crews are invited to lunch at the lab. With hungry astronauts sitting around a counter, food technicians prepare samples of all the foods to be considered for flight. With pencil and paper, the crew gives every item a score of from 1 to 9. Unlike golf, a low score is bad. A score of 1 means "dislike extremely." A 9 means "like extremely." Crew members not only rate taste but also texture and appearance. Foods must receive an overall score of 6 or better for further consideration.

Dietitians use the ratings to establish a preliminary standard menu. Astronauts are free to pick the standard menu or create their own menu from the approved choices open to them. A crew member may also choose a menu he or she used on a previous space mission.

After menus are selected, crew members try them out during the frequent training simulations. Ground-based trainers that look identical to the real space shuttle orbiter are used for practicing every step and action that will take place during the real mission.

Simulations can take days, and the crew has to eat. It is a great time to test the menus and preparation techniques. Using the same food during simulations is especially beneficial to the food laboratory staff. Having the astronauts involved in choosing their menus significantly reduces the complaints!

The final menus are submitted to a dietitian, who checks them for compliance with established medical requirements. Calories are one of the first items to be evaluated. The number of calories that are required are based on the World Health Organization (WHO) formula:

Men 18–30 years: $1.7(15.3\,W^{*}+679) = \text{kcal/day required}$
30–60 years: $1.7(11.6\,W+879) = \text{kcal/day required}$

Women 18–30 years: $1.6(14.7\,W+496) = \text{kcal/day required}$
30–60 years: $1.6(8.7\,W+879) = \text{kcal/day required}$

*W = weight in kg.

Calories must be divided along the following guidelines:

Protein = 12–15%
Carbohydrates = 50–55%
Fat = 30–35%

NASA nutritional requirements are the same for both male and female astronauts. This varies from the National Academy of Sciences Dietary Reference Intakes (DRI), which recommends slight variations in diet based upon gender. Vitamin and mineral requirements for astronauts are basically the same as the DRI’s, with the exception of iron. Astronauts are limited to 10 mg/d versus the DRI recommendation of 8 mg/d for men and 18 mg/d for women. This is a response to one of the physiological changes that occur in microgravity. Microgravity causes a slight fluid shift in the upper body. Body systems interpret this shift as an excess of blood and increase fluid excretion until a new balance is achieved, resulting in a total blood volume decrease while in flight. Once balance is achieved, red blood cell turnover slows. The need for iron, an oxidant, is reduced.

Another significant physiologic change occurring in microgravity is increased bone loss. Weight-bearing bones lose between 1 and 2% of their calcium mass per month. This amounts to a total loss of approximately 10% of their skeletal calcium in the weight-bearing bones on a 5–6 month mission. The loss is due to the lack of stress placed on the skeleton on a normal day on Earth. The bone loss in 1 year in space is equivalent to the loss a typical person would experience on Earth over a 10-year period starting at age 50. Bone loss could be a “show stopper” for space missions to Mars that could last 2 or more years.

One would think the solution to this problem would be simple—increase calcium by giving astronauts calcium supplements during flight. This seems like it would be a good idea, but it doesn't work. Without skeletal stress, bone-building cells do not capture the extra calcium. Instead, the calcium is excreted through urine, increasing the potential for kidney stones. NASA has studied the problem for many years and found that exercise helps to slow calcium loss. Some drug therapies show promise, but the problem is not yet completely solved.

What does a space menu generally look like? The one below was typical of what the *Apollo* astronauts ate during their Moon missions.

DAY 1

Meal A
Peaches (R)
Bacon Squares (IMB)
Cinnamon Bread Toast Cubes (DB)
Breakfast Drink (R)

Meal B
Corn Chowder (R)
Chicken Sandwiches (DB)
Coconut Cubes (DB)
Sugar Cookie Cubes (DB)
Cocoa (R)

Meal C
Beef and Gravy (R)
Brownies (IMB)
Chocolate Pudding (R)
Pineapple-Grapefruit Drink (R)

ABBREVIATION KEY:
R = Rehydratable
DB = Dry Bite
IMB = Intermediate Moisture Bite