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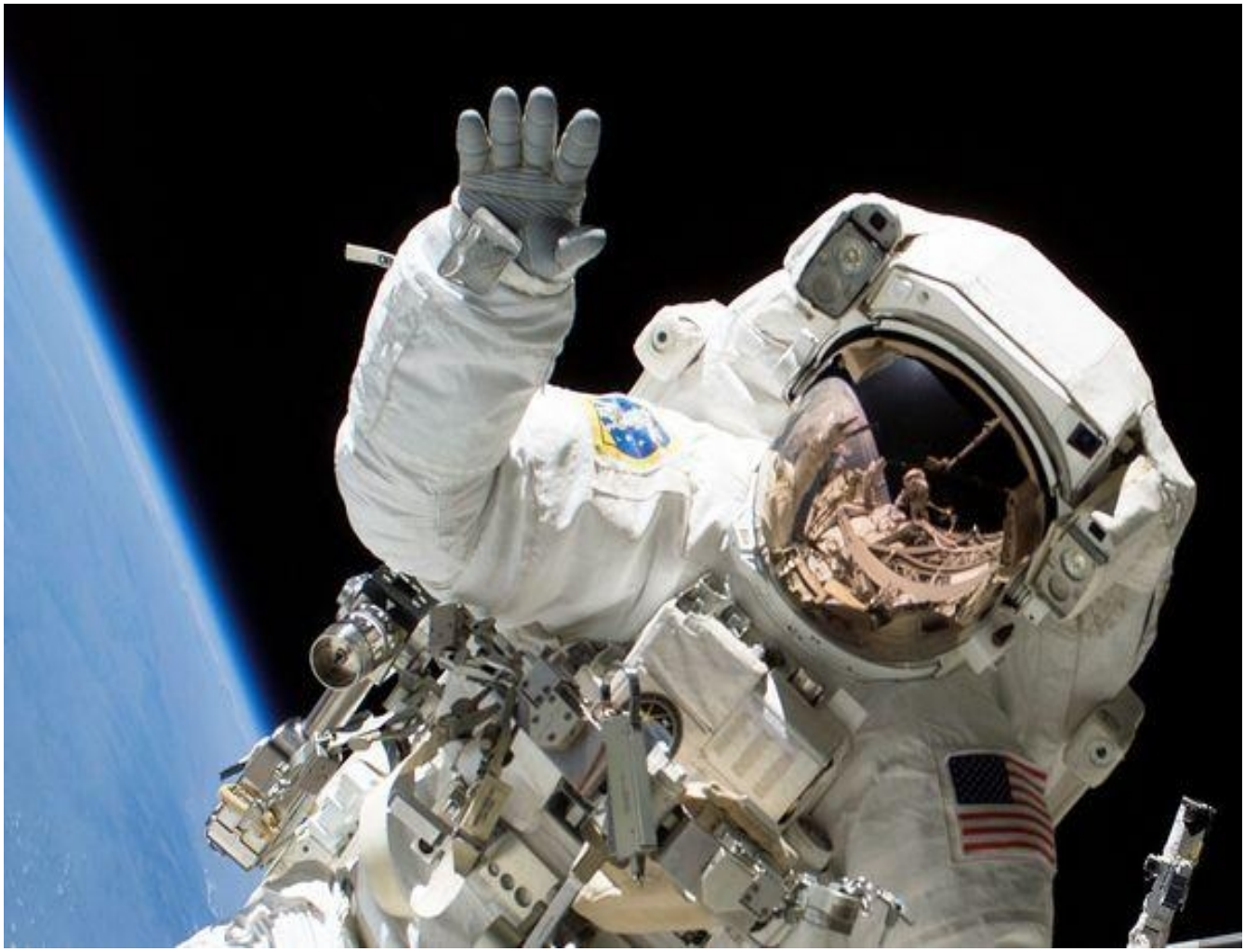
Nutrition and Supplementation for Astronauts During Space Missions



Due to the unique conditions present during space missions, astronauts must be provided with food that not only meets their daily nutritional requirements but is also functional and convenient to use in the specific environment of spaceflight.

Nutritional Requirements

The food supplied to the spacecraft crew is selected according to the individual needs of each astronaut, while also taking into account the specific conditions of the spacecraft environment.

Caloric needs are calculated using the Basal Energy Expenditure (BEE) formula:

$$\text{For women: } BEE = 655 + (9.6 \times W) + (1.7 \times H) - (4.7 \times A)$$

$$\text{For men: } BEE = 66 + (13.7 \times W) + (5 \times H) - (6.8 \times A)$$

Where: W – weight [kg], H – height [cm], A – age [years]

The amount of nutrients required to meet basic physiological needs during spaceflight generally does not differ from the recommendations on Earth. Astronaut meals are designed to provide intake consistent with the Recommended Dietary Allowance (RDA).

One notable exception is iron, whose intake during long-duration or exploration missions should not exceed 10 mg per day for both men and women. This is because exposure to microgravity reduces red blood cell mass, and excessive iron intake could lead to iron accumulation in the body, increasing the risk of health complications.

Sodium intake is also limited, as excessive sodium consumption may contribute to decreased bone mineral density and other health issues. During space missions, astronauts are advised to take vitamin D supplements, since spaceflight foods do not provide sufficient amounts of this vitamin. Additionally, astronauts do not have access to sunlight—spacecraft are shielded from harmful radiation, including UV—which prevents endogenous vitamin D synthesis.

Meal Preparation

Astronauts can choose from a wide range of food items—either the standard, ready-to-eat spaceflight diet or options tailored to their individual preferences. Space Shuttle crew members may also create their own menu, but it must be reviewed by a dietitian to ensure that all essential nutrients are provided. The standard space diet consists of three main meals and snacks, and the menu repeats every seven days.

Meal planning begins 8–9 months before launch. During this period, astronauts receive information packets containing their individualized menus. These packets include details on the standard menu, training menu, and beverages. Astronauts can sample the foods proposed by specialists, modify meals, and select preferred drinks. They are also instructed on how to prepare each item. The final

version of the menu is completed approximately three months before launch, after undergoing analyses such as nutrient-content testing.

During the mission, astronauts prepare their meals in the galley, a dedicated food-preparation area located on the middeck of the Space Shuttle orbiter. The galley includes a water dispenser and a food warmer. The water dispenser is used to rehydrate dehydrated and freeze-dried foods, while the food warmer heats thermostabilized items to the appropriate temperature. Preparing a full meal for a four-person crew takes no more than five minutes, while rehydrating food (by adding the required amount of water) takes about 20–30 minutes. During meals, food is kept on special food trays designed to prevent items from floating away in microgravity. These trays can be attached to the wall or strapped to the astronauts' knees while seated. They function like plates, allowing several components of a meal to be served together, similar to a traditional meal on Earth. If a crew member chooses not to use a tray, they must completely finish one snack before opening another food package to avoid loose items drifting around the cabin. Standard utensils are used during flight —knives, spoons, forks, and special scissors for opening food packages.

Types of Spaceflight Foods

Food selected for space missions is chosen to resemble everyday, home-style meals as closely as possible. Items are typically provided in refrigerated form (vegetables, fruits, dairy products), frozen form (most entrées, vegetables, desserts), or at ambient temperature inside the spacecraft (thermostabilized foods, aseptically packaged items, and dehydrated foods and beverages intended for rehydration). The packaging system is designed for simplicity and ease of use, relying on single-serve, disposable containers. Each portion is packaged individually to allow flexible menu adjustments and to accommodate mission requirements. Because the packaging is disposable, there is no need for washing dishes.

Food containers come in five standardized sizes, selected to match the volume of each portion. There are dedicated packages for soups, salads, desserts, and entrées. Some items are packed in larger containers—for example apples, bread, or spices. Beverages are available only in powdered form and must be reconstituted with water.

In addition to the standard onboard diet, astronauts also have access to specialized food systems such as Safe Haven and EVA food.

Safe Haven Food System

The Safe Haven food system is designed to sustain the crew for 22 days in the event of an onboard emergency. Its key requirement is minimal mass and volume. The system provides at least 2000 kcal per crew member per day. Foods can be stored at temperatures between 15–29°C, and their shelf life is at least two years. The system includes thermostabilized entrées, fruits, intermediate-moisture foods, and completely dehydrated items (including beverages).

EVA Food

During extravehicular activities, astronauts have access to EVA food, which consists of approximately 500 kcal of food and about 1.1 liters of water. This is intended to provide adequate nourishment for up to eight hours outside the spacecraft.

Monitoring Nutritional Status

To monitor their nutritional intake, crew members complete a computerized Food Frequency Questionnaire (FFQ), reporting all foods consumed during the previous week. The results are transmitted to Earth, where nutrition specialists analyze the data and provide recommendations to help astronauts optimize their nutrient intake.

During spaceflight, the human body adapts to numerous changes associated with microgravity, which leads to significant physiological effects. These may include decreased bone mineral density, loss of muscle mass, changes in cardiovascular function, alterations in blood composition, and shifts in body fluid distribution. Astronauts often experience weight loss during missions. For these reasons, proper nutrition is especially critical, as inadequate intake of essential nutrients can exacerbate the negative physiological effects of spaceflight.

Source - NASA:
1. http://www.nasa.gov/pdf/71426main_FS-2002-10-079-JSC.pdf
2. http://www.nasa.gov/audience/forstudents/postsecondary/features/F_Food_for_Space_Flight.html