Exploration missions beyond low Earth orbit greatly limit allowable consumables and require development of innovative low maintenance, reconfigurable, reusable, or self-sufficient food production. Advancements are necessary to develop a combination of extended duration shelf life stored foods augmented with fresh foods grown within the spacecraft. Crop systems, in addition to producing fresh vegetables, storage roots, grains and legumes may contribute to air revitalization and utilize wastes from water recovery and waste management systems.

**Crop Systems**

The production of biomass (in the form of edible food crops) in closed or nearly closed environments is essential for the future of long-term planetary exploration and human settlement in lunar and Mars base applications. These technologies will lead not only to food production but also to the reclamation of water, purification of air, and recovery of inedible plant resources in the comprehensive exploration of interplanetary regions. Areas in which innovations are solicited include:

- Crop lighting, such as LED, solar collectors and innovative technologies. Lighting transmission and distribution systems, luminaries, fiber optics, water jackets, and other heat removal technologies are also areas of interest;

- Water and nutrient management systems such as hydroponics and/or solid substrates for food production and separation of nutrients from waste streams are solicited. In this area, regenerable media for seed germination plant support are also of interest as is separation and recovery of usable minerals from wastewater and solid waste products for use as a source of mineral nutrients. Consideration should be given for systems operation in microgravity and hypogravity (1/6 g on Moon, 3/8 g on Mars) environments; and

- Other areas of interest: crop mechanization and automation, facility or system sanitation, crop health measurement, flight equipment support, structures and environmental monitoring and control technologies that are specific to crop systems (e.g., ethylene detection and removal, sensors for root zone oxygen and water content, etc.).
Food Provisioning

- Safe, nutritious, acceptable, and varied shelf-stable foods with a shelf life of 3 to 5 years will be required to support the crew during future exploration missions to the Moon or Mars. Shelf-life extension may be attained through food preservation methods and/or packaging. Packaging materials must provide sufficient oxygen and water barrier properties to maintain shelf life. Food packaging technologies are needed that minimize a potentially significant trash management problem by using packaging with less mass and volume and/or by using packaging that is biodegradable, recyclable, or reusable;

- Processing crops or bulk ingredients into edible food ingredients or table-ready products will be necessary to provide a self-sustaining food system for an exploration mission. Equipment that is highly reliable, safe, automated, and minimizes crew time, power, water, mass, and volume will be required. Equipment for processing raw materials must be suitable for use in hypogravity (e.g., 1/6g on Moon, 3/8g on Mars) and in hermetically sealed habitats;

- Food preparation systems will be required to heat and rehydrate the shelf stable food items and to prepare meals from the processed and re-supplied items. Technologies to support on-orbit crew meal storage, preparation, dining activities, and trash dispensing are being sought; and

- Food quality and safety are essential components in the maintenance of crew health and well being. Efforts should be focused on control of food spoilage and food quality throughout the entire shelf life of the food. Effects of radiation on crop functionality and the stored food system quality are also needed.