In order for humans to live and function safely and efficiently in space or in the hypogravity of the Moon (1/6g) or Mars (3/8g), a good understanding of the effects of micro- and hypogravity and other factors associated with the space environment on human physiology and human responses to the space and extraplanetary environments is required. A variety of countermeasures must be developed to oppose the deleterious changes that occur in space and upon subsequent exposure to other gravitational fields. The ability to monitor the effectiveness of countermeasures and alterations in human physiology during space exploration missions, particularly when several countermeasures are used concurrently, is equally important. This subtopic seeks innovative technologies in several very specific key areas.

As launch costs relate directly to mass and volume, instruments and sensors must be small and lightweight with an emphasis on multi-functional capabilities. Low power consumption is a major factor, as are design enhancements to improve the operation, design reliability, and maintainability of these instruments in the environment of space and on planetary surfaces. As the efficient use of time is extremely important, innovative instrumentation setup, ease of usage, improved astronaut (patient) comfort, noninvasive sensors, and easy-to-read information displays are also very important considerations. Extended shelf-life and ambient storage conditions of consumables are also key necessities. Ability to operate in 0g, 1g, and 3/8g become more important as we push for future human Moon and Mars missions.

Immersive Virtual Scene Display System

Development of an immersive visual display system is required to be interfaced with treadmill exercise devices. This system would not be head-mounted but would be free standing and provide at least a 180° field of view. This visual display would allow visual flow patterns to be displayed to a non-encumbered subject during inflight or on-surface treadmill exercise. Ultra-long duration missions to the Moon or Mars will especially benefit from such technology that encourages crew to spend more time exercising by enriching the environment and contribute to psychological well being by mimicking the terrestrial exercise experience.

Measurement of Emboli in the Brain
A small Doppler ultrasound device (need not be oxygen compatible), emboli recognition system/software, and solid-state recorder of detected events. This would be worn in a fashion similar to a Holter monitor and help to monitor blood clots in the brain for those at risk for embolic stroke. This is especially valuable for ensuring the safety of Extra-Vehicular Activity (EVA) on planetary surfaces, as well as during orbital flight.

Noninvasive Pharmacotherapy and Monitoring

Development of innovative technologies resulting in noninvasive methods for diagnosis, treatment, and therapeutic drug monitoring is needed to facilitate effective pharmacotherapy of humans in space. Many questions remain about the effectiveness of pharmaceuticals in micro- and hypogravity environments, which may interfere with their activity by sensitizing or desensitizing the crew member or interfering in other ways with the desired physiological effect.

MEMS-Based Human Blood Cell Analyzer

Development of a small, automated, micro- and hypogravity capable, lightweight, low power instrument that will analyze a small sample (microliter quantity) of human whole blood and provide a complete blood cell count (RBC, WBC, platelet, hemoglobin concentration, hematocrit, WBC differential, and calculated RBC indices) that correlates with traditional ground-based impedance or light-scattering technologies is needed. Likely devices based on MEMS will employ a biocompatible combination of microfluidics, micromechanics, micro-optics, microelectronics, and data telemetry capabilities in an integrated handheld package with a simple, user-friendly operator interface. Such technologies will be critical to the implementation of future missions beyond low-Earth orbit to the Moon or Mars. Proper medical care and valuable research contributions will be dependent on such technologies in these exploration class missions.

Human-Worn Whole Body Biomechanical and Movement Analysis Suit

A whole-body suit and analysis system worn by human subjects is needed, which records and measures biomechanical movements and biomechanical characteristics in order to provide an assessment of total body physical activity during human space missions, especially missions to hypogravity environments such as the Moon or Mars. Measurements to be made and recorded would include upper and lower limb segment displacements along with related joint angular velocities and accelerations. The system would allow entry of limb segment and trunk mass and center-of-mass data specific to the individual wearing the suit and then would provide data analysis related to work and power across different body segments and for the whole body based on analytical algorithms. Other capabilities include storage of raw data and the ability to download the data to other computer-based storage and data analysis systems through either hardwired connections or via telemetry. Many differences may be noted in the way humans move in micro- and hypogravity environments. These differences may suggest better ways to perform work or to design tools, workstations, or procedures for accomplishing critical tasks in the future beyond low-Earth orbit missions.

Body Composition Hardware for Spaceflight

Development of on-orbit instrumentation for determining body composition. Specific parameters of interest include lean body mass, total fat mass, and total body water. Validation data will be required using the current gold-standard techniques in this field. This information will be used in conjunction with nutritional status protocols to assess crew health. The effects of the hypogravity environment of planetary surfaces on body composition are not known. Any future mission to the Moon or Mars will certainly measure these changes to detect and combat potential adverse changes. Such an instrument must work in 0g, 1/6g, and 3/8g environments.
Device for Providing Increased Neuromuscular Activation During Spaceflight

Astronauts returning from spaceflight exhibit post-flight postural and gait instabilities that are a result of neural adaptation to microgravity. A small, lightweight countermeasure device is required to stimulate somatosensory receptors on the plantar surface of the feet during in-flight exercise with the goal of increasing neuromuscular activation and enhancing sensorimotor integration. This system would integrate with in-flight exercise hardware and coupled with visual stimulation systems would allow a more complete sense of immersion to enhance in-flight postural and locomotor training.