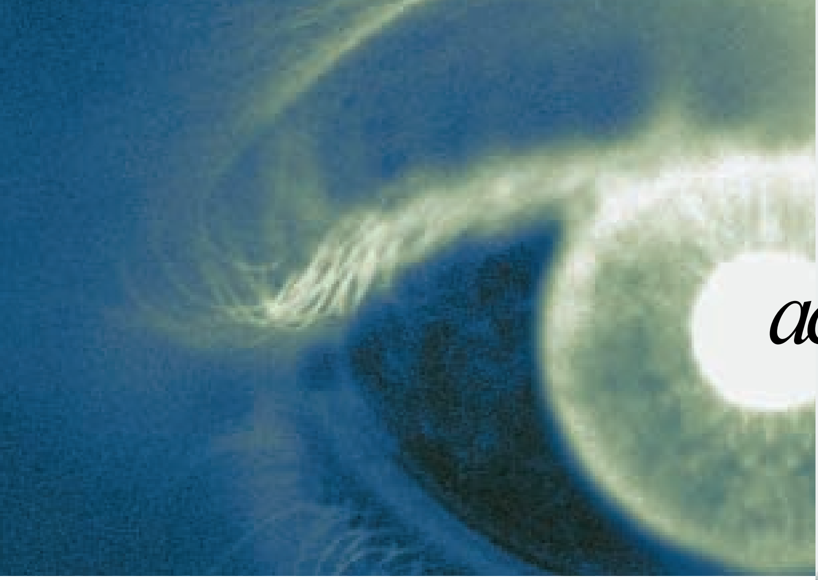


achieving a vision

Biomedical Research and Countermeasures

JOHNSON SPACE CENTER
Space & Life Sciences Directorate

SPACE & LIFE SCIENCES

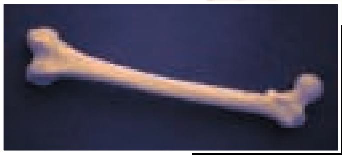
Since the first days of space flight, NASA has sought to understand how space flight affects the human body. Today, scientists in NASA's Biomedical Research and Countermeasures program (BR&C) conduct research to characterize the effects of space flight on the human body and to protect astronauts from the risks of space flight. Protective measures developed from this research are called countermeasures. These countermeasures ensure healthy and safe space travel and bring new insight into the workings of the human body on Earth. This brochure is one in a series that explores NASA's multilateral activities in the space and life sciences.

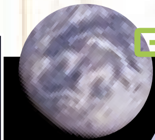
NASA's biomedical researchers work to understand how exposure to microgravity changes the human body. Data from each mission provide scientists with new insights into the reaction of the human body to space flight. Investigations like these led to the realization that the effects of space flight bear some correlation to the aging process.

the human body

As early as the first Mercury flights, astronauts began to report a wide range of physical and mental changes during and after space flight. Over the years, scientists have studied the effects of microgravity on the human body, creating an impressive space medicine database that demonstrates these effects on virtually every system in the body.

Loss of bone and muscle mass, changes in cardiac performance, variations in human behavior, and alterations initiated by the nervous system are among the most readily apparent effects of microgravity. Scientists characterize these changes as disuse, a state in which some organs or systems are not used as much as they are on Earth, or adaptation, a process in which the body alters how it functions to compensate for the lack of gravity. These changes may occur rapidly, within the first few hours of flight, or gradually over several days, weeks, or even months.





Getting Down to Earth

Osteoporosis is a major health threat for over 28 million Americans. Research on the weakening of bones in space allows scientists to better understand and treat osteoporosis on Earth.

Changes to muscle and bone are particularly significant results of life in microgravity. In microgravity, the muscles that typically support the body against gravity's pull work much less than they do on Earth. As a result, muscles begin to atrophy, or waste away. Atrophied muscles are weaker, tire easily, do not respond as quickly as normal muscle, and offer less support to the skeletal system — a system also weakened through exposure to microgravity. Like muscles, bones have less work to do in microgravity. In fact, the amount of weight that bones must support in space is reduced to almost zero. Stresses that stimulate weight-bearing

launch

First Week of Flight

Symptoms of space motion sickness appear (abate within a few days); fluid shift begins (steady-state reached within first week); orthostatic tolerance drops; hormone levels begin to change	*Red blood cell mass and blood plasma volume decrease; bone loss and muscle atrophy begin*	*Cardiac changes have become apparent*

bones to maintain strength and structure simply do not exist in microgravity. Subsequently, the calcium that gives bone its strength is broken down and released into the bloodstream, increasing the risk of kidney stone formation. This loss of bone mass, known as disuse osteoporosis, leaves bones weak, less able to support the body's weight, and susceptible to fracture.

Getting Down to Earth

Techniques developed to help astronauts improve muscular control also benefit people on Earth. Bio-Ball, a game that uses deep muscle relaxation to play a video-game style of baseball, is now a commercially available stress-management device.

Research into muscle reaction and bone density alterations has resulted in a program of exercise that combats the gradual weakening of muscle and bone. Current BR&C investigations study how exercise combined with supplemental nitrogen, dietary calcium, vitamins, and hormones may protect astronauts from bone and muscle loss during flight.

The heart and its supporting network of arteries, veins, and capillaries are also affected by space flight. During extended stays in microgravity, the heart becomes deconditioned; because it exerts less effort to pump blood against gravity's pull, the heart muscle loses strength. The heart slightly shrinks in size, blood volume and blood pressure decrease, and blood and fluids migrate from the legs towards the chest and head. When the astronaut returns to Earth, the heart must once again work harder to overcome the effects of gravity. Although the heart will gradually readapt and recondition itself to perform effectively in Earth's gravity, astronauts risk low blood pressure, a feeling of faintness, and reduced physical stamina during landing — a critical time at which they must be alert and responsive to unexpected events.

Armed with a better understanding of why these changes occur, BR&C scientists are now researching ways to minimize changes in the cardiac function of astronauts. In the past, the ingestion of salt water and electrolytes and the wearing of "g-suits" have helped maintain normal blood pressure, volume, and circulation during landing. New arenas of BR&C investigation into cardiac changes involve in-flight exercise, medication, and even biofeedback training, which teaches astronauts to exert some control over otherwise involuntary heart muscle action.

Getting Down to Earth

Technologies first developed to control the blood flow of astronauts during landing now save lives on Earth. Paramedics use the new Dyna Med Anti-Shock Trousers to apply pressure to shock victims' extremities so oxygen continues to flow to critical organs like the brain, heart, and lungs.

Microgravity also affects the nervous system (including the brain, spinal cord, and a network of nerves), which commands nearly every system of the body. Researchers have found that the nervous system takes many of its cues from gravity

Cardiac deconditioning, muscle atrophy, and bone loss continue

Red blood cell mass stabilizes; cardiac deconditioning, muscle atrophy, and bone loss continue

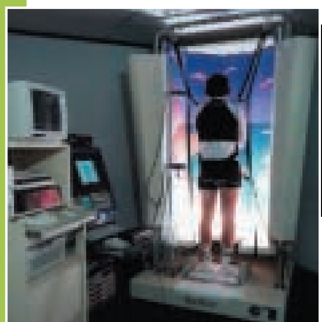
Cardiac deconditioning, muscle atrophy, and bone loss continue for duration of mission

Heart begins to readapt to gravity; fluids shift back towards legs; muscle begins to rebuild; bone begins to rebuild (time to recovery is related to time spent in space)

This affects a multitude of processes, from relatively simple tasks like maintaining balance and recycling essential nutrients, to complex tasks, like the body's regulation of temperature, metabolism, sleep cycles, and immune response.

BR&C researchers work to limit certain effects of microgravity on the nervous system and to ease astronauts through adaptations that occur during space flight. Preflight briefings and training simulations prepare astronauts for the nervous system alterations they may experience during their mission. The BR&C program is also examining new medications, special exercises, and specific head movements that may limit the effects of in-flight neurological change.

Microgravity-induced changes to the nervous system cause balance problems for astronauts upon their return to Earth. Although they eventually regain their sense of balance, the time it takes to completely recover is directly related to how long the astronaut has been in microgravity. Virtual reality models of the inner ear help researchers understand our balance system and how the human body compensates for microgravity.



Getting Down to Earth

RETURNING ASTRONAUTS AND PATIENTS WITH BALANCE DISORDERS EXPERIENCE MANY OF THE SAME NEUROLOGICAL EFFECTS. NEUROCOM INTERNATIONAL HAS ADAPTED TWO DEVICES — ORIGINALLY DEVELOPED FOR ASTRONAUTS — TO ASSIST PATIENTS WITH BALANCE DISORDERS.

Living in space has consequences for both the body and mind; consequences that, like those arising from changes in heart function or bone structure, must be understood and controlled in order to ensure the productivity and happiness of astronauts. Astronauts live in an isolated environment away from their families and loved ones, while facing the constant stress and challenge of working in space.

Contact with loved ones is very important on long-duration missions. One of the most effective ways of combating the psychological effects of life in space is increased communications between astronauts and their family and friends on the ground.

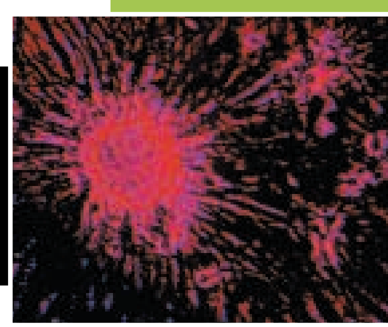
To aid in the adaptation to life in space, the BR&C program also focuses on increasing psychosocial support. Current and future plans incorporate additional communication between astronauts and their loved ones, research into "optimal" crew size and composition, and innovative human-machine interfaces that help crews perform efficiently and safely.

the space environment

In addition to microgravity exposure, space flight presents environmental obstacles. Even within the closed confines of the spacecraft, space travelers face a number of additional health challenges.

Getting Down to Earth

UNDERSTANDING AN ORGANISM'S RESPONSE TO RADIATION IS FUNDAMENTAL TO ENABLING LONG-DURATION SPACE MISSIONS. BR&C RESEARCH INTO THE EFFECTS OF RADIATION ON THE HUMAN BODY ALSO PROVIDES DOCTORS WITH A BETTER UNDERSTANDING OF CANCER PATIENTS' RESPONSES TO RADIATION THERAPY, PAVING THE WAY TO MORE EFFECTIVE TREATMENTS OF THIS DEADLY DISEASE .



Radiation exposure is one of these challenges. On Earth we are protected from naturally-occurring space radiation by the upper atmosphere and magnetosphere. When astronauts venture beyond these protective layers into low-Earth orbit or to other planets, they face exposure to high doses of cosmic and solar radiation.

In conjunction with programs like the Advanced Human Support Technology program (see accompanying AHST brochure), the BR&C program is developing technologies and medical interventions that will detect radiation and protect astronauts from its effects.

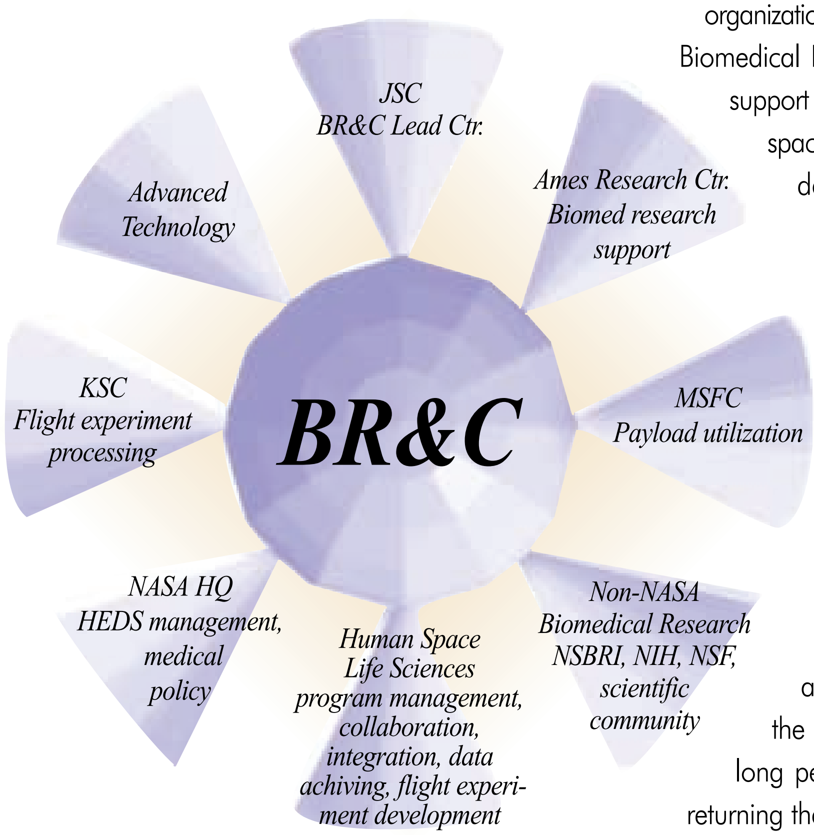
Astronauts performing extravehicular activities (EVAs) in the vacuum of space face additional challenges. They need a cool, pressurized breathing environment as well as protection from radiation. Astronauts rely on their space suits to provide this. However, working in a space suit can be difficult, and astronauts on EVA perspire and run the risk of overheating. To remove the perspiration and body heat that the astronauts generate, NASA developed the Liquid Cooling Garment (LCG) to be worn under the space suit. Today's LCG is a zippered one-piece suit made of stretchable material, laced with plastic tubing. The plastic tubing circulates chilled water to cool the astronaut, and draws perspiration away from the astronaut's skin. Together, the space suit and the LCG keep astronauts safe from the dangers of the external environment during an EVA.

Getting Down to Earth

BR&C TECHNOLOGY, ORIGINALLY DEVELOPED TO REGULATE AN ASTRONAUT'S BODY TEMPERATURE INSIDE A SPACE SUIT, IS NOW WORN AS A "COOL SUIT" FOR CHILDREN BORN WITH TEMPERATURE REGULATION DISORDERS. THE SUIT MONITORS BODY TEMPERATURE AT MULTIPLE LOCATIONS AND ADJUSTS THE FLOW OF COOLED LIQUID THROUGH A SYSTEM OF COILS TO KEEP ITS OCCUPANT FROM OVERHEATING. SIMILAR SUIT TECHNOLOGY CAN ALSO BE USED BY PEOPLE WITH MULTIPLE SCLEROSIS, CYSTIC FIBROSIS, SEVERE BURNS, SENSITIVITY TO LIGHT, OR HEAT-INTENSIVE OCCUPATIONS.

the scientific community

The BR&C program is centered at NASA's Johnson Space Center. It acts in concert with numerous other agencies, organizations, and universities, including the National Space Biomedical Research Institute. Together, these groups work to support human health in the exploration and development of space through both short- and long-duration studies. The development of biomedical countermeasures is initiated with ground-based research and is concluded with in-flight evaluation and verification before the countermeasure is implemented. This holistic approach to research maximizes the benefits to astronauts and the general public alike.



With each passing mission, the BR&C adds to its understanding of how the human body adapts to life in space and how to limit, overcome, or prevent the changes induced by the microgravity and spacecraft environments. Eventually, the work of the BR&C will allow us to send humans into space for long periods of time and to colonize other worlds, while returning the benefits of this new knowledge back to Earth.

contact information

Johnson Space Center - homepage
http://www.jsc.nasa.gov/

The Office of Life and Microgravity Sciences and Applications - homepage
http://www.hq.nasa.gov/office/olmsa/

Biomedical Research and Countermeasures Program - homepage
http://www.hq.nasa.gov/office/olmsa/lifesci/biomed.htm

NASA Human Spaceflight
http://spaceflight.nasa.gov

International Space Station - science and research
http://spaceflight.nasa.gov/station/science/index.html

The International Space Station - *Research Plan* online
http://www.hq.nasa.gov/office/olmsa/ISS/cover.htm

National Space Biomedical Research Institute - homepage
http://www.nsbri.org/

Life Sciences Data Archive
http://lsda.jsc.nasa.gov

This brochure was developed for NASA by Futron Corporation.