National Aeronautics and Space Administration
Glenn Research Center
Cleveland, Ohio

John Glenn
Biomedical Engineering Consortium
Helping Astronauts, Healing People on Earth

The Eye: Window to the Body

A noninvasive diagnostic instrument is being developed that can use the eye as a "window to the body" to detect illnesses in the entire body. The device can be used to detect early changes in the eye associated with infection, allergic reactions, autoimmune diseases, glaucoma, age-related macular degeneration, and diabetic retinopathy.

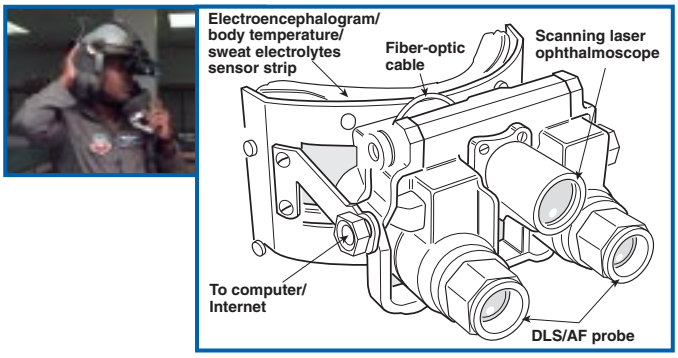
Space radiation is one of the greatest dangers astronauts on space exploration missions will face. Radiation exposure during a space exploration mission to Mars could cause cataracts and cancer by damaging the basic cell DNA structure and causing gene mutation.

Relatively low doses of radiation cause an increased incidence of cataracts. Additionally, the zero-gravity environment in which crew members live causes fluid shifts in the upper extremities of the body and changes the way blood flows and organ systems perform.

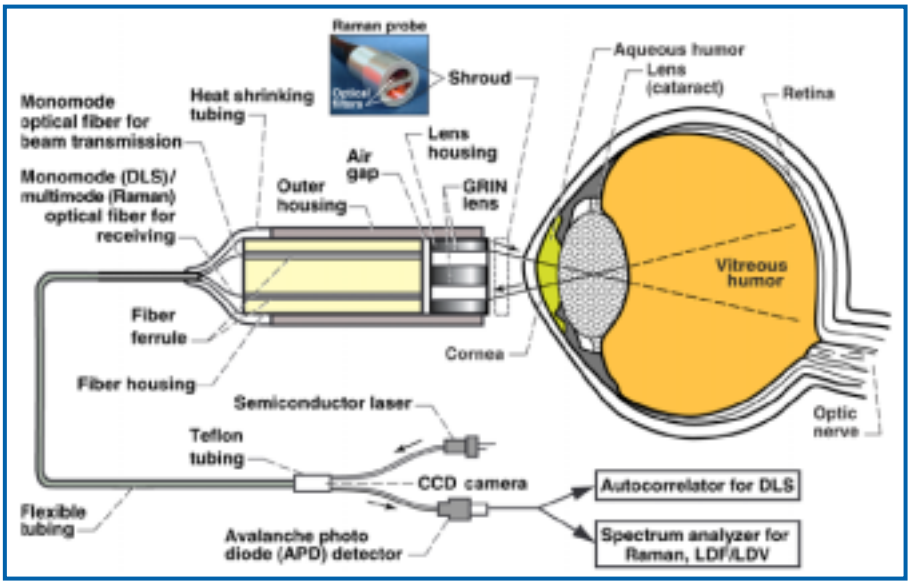
To protect astronauts from the effects of exposure to radiation and reduced gravity conditions and to detect problems early, powerful and compact noninvasive diagnostic technologies must be perfected. Within the Glenn Biomedical Engineering Consortium (GBEC), a new head-mounted device is being developed that will integrate several noninvasive technologies into one portable, easy-to-use piece of equipment.

Rafat Ansari of Glenn Research Center, and Marco Cabrera of Case Western Reserve University and University Hospitals of Cleveland, plan to develop an instrument that will detect early, subtle signs of changes in the fluids, tissues, and blood vessels of the eye and brain. The new instrument, which resembles night-vision goggles, uses light in various forms to detect ocular and systemic abnormalities long before clinical symptoms appear.

The beauty of using the eye as an access point is that noninvasive optical measurements can provide health indices not just for these organs, but for the entire body. For every tissue type in the body, there is a corresponding tissue type in the human eye. Using the eye as a "window to the body," Ansari and Cabrera, in collaboration with a team of renowned scientists, engineers, and clinicians, hope to create an advanced warning system to detect problems without discomfort and to assess the effectiveness of preventative and therapeutic countermeasures.



The proposed apparatus will house miniaturized fiber-optic probes to collect health data, a computer for data analysis, and Internet connectors for data transmission to NASA's Mission Control. A unique feature of this design is that it combines systems that are common to various technologies—lasers, detectors, a correlator, and a spectrum analyzer—into a single unit that will fulfill the technical requirements of all the different technologies.

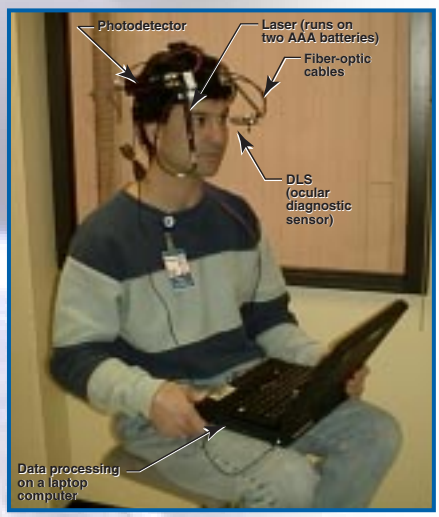


Several optical technologies are being considered for integration into this miniaturized design, such as dynamic light scattering (DLS), laser-Doppler flowmetry (LDF), autofluoresence (AF), Raman spectroscopy, polarimetry, and reflectometry and oximetry. Optical coherence tomography and a scanning laser ophthalmoscope can be integrated later.

Polarimetry is used to monitor blood glucose through optical activity measurements. The amount of glucose present in a solution can be deduced by measuring the rotation of linearly polarized light. The glucose concentration of the aqueous humor of the eye closely matches blood glucose levels.

Researchers are developing a noninvasive optoelectronic device based upon reflectometry and oximetry that measures the effects of oxygen saturation on light reflected from the inside of the back of the eye (retina). These measurements are useful for evaluating the effects of prolonged weightlessness on ocular and central nervous system circulatory physiology.

When completed, the new device may also serve as a platform to incorporate future medical diagnostic capabilities now being developed by other researchers.



Prototype head-mounted eye disease monitoring system.

Benefits on Earth

This device may ultimately prove useful for several medical applications on Earth. A DLS instrument originally developed at Glenn is already being used in studies at the National Institutes of Health to detect early cataract formation. It can also detect the early changes in the eye associated with infection, allergic reactions, autoimmune diseases, glaucoma, age-related macular degeneration, and diabetic retinopathy.

The ability to read blood glucose levels through a noninvasive examination of the eye would have a profound effect upon our ability to easily diagnose the early stages of diabetes. Early treatment would help to improve the health of people who are diabetic without being aware of it. Reflectometry and oximetry can also be used to detect hidden signs of diabetes, diabetic retinopathy, and occult blood loss.

For more information about the John Glenn Biomedical Engineering Consortium or consortium projects, please contact
Marsha M. Nall
NASA Glenn Research Center
21000 Brookpark Road MS 77–7, Cleveland, Ohio 44135
grcbio@grc.nasa.gov

http://microgravity.grc.nasa.gov/grcbio

Glenn Research Center

The Research Institute
University Hospitals of Cleveland

THE CLEVELAND CLINIC FOUNDATION

CASE WESTERN RESERVE UNIVERSITY

NCMR

M–1043–01
May 02