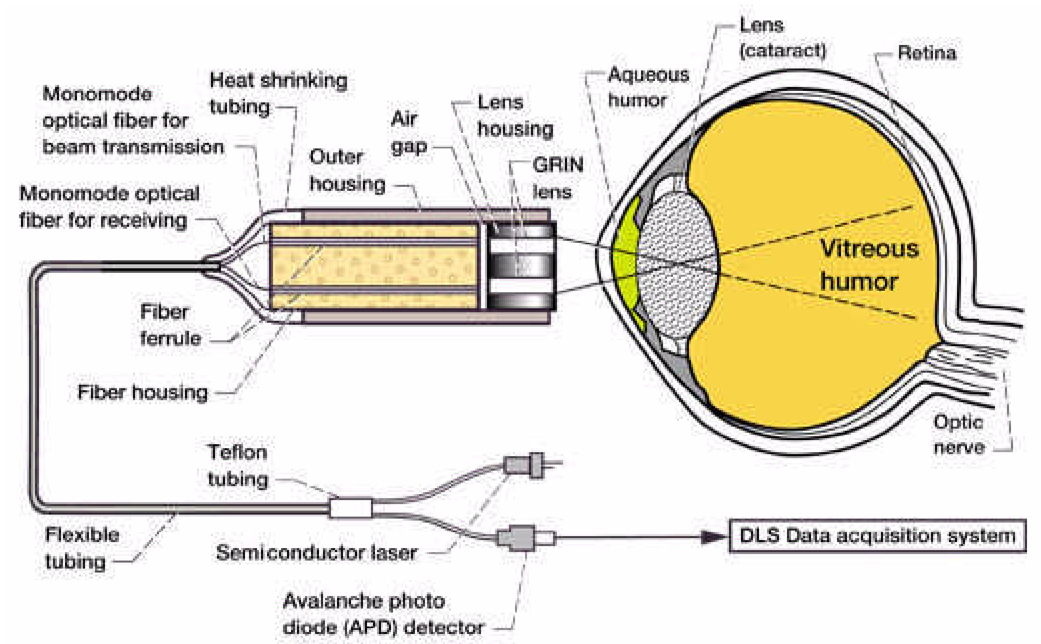
Fiber-Optic Imaging Probe Developed for Space Used to Detect Diabetes Through the Eye

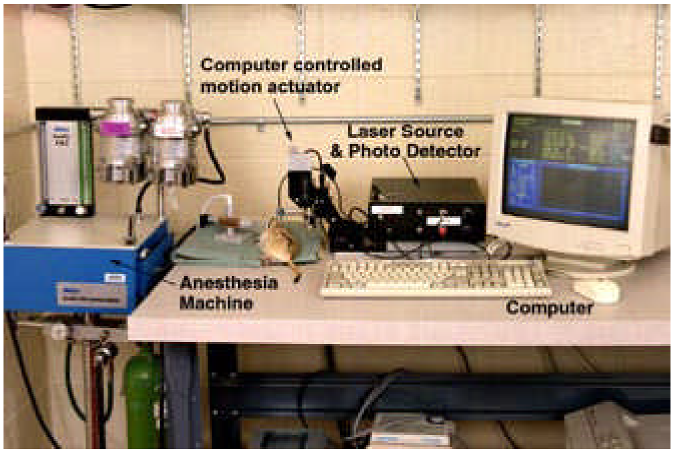
Approximately 16 million Americans have diabetes mellitus, which can severely impair eyesight by causing cataracts, diabetic retinopathy, and glaucoma. Cataracts are 1.6 times more common in people with diabetes than in those without diabetes, and cataract extraction is the only surgical treatment. In many cases, diabetes-related ocular pathologies go undiagnosed until visual function is compromised. This ongoing pilot project seeks to study the progression of diabetes in a unique animal model by monitoring changes in the lens with a safe, sensitive, dynamic light-scattering probe.



Dynamic light scattering (DLS) probe.

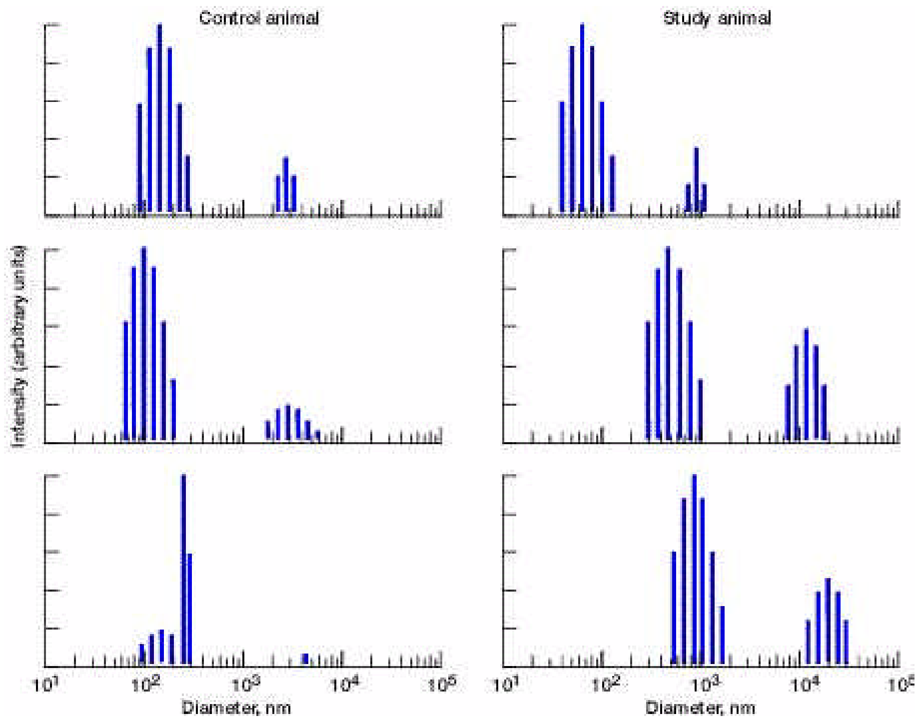
Dynamic light scattering (DLS), has the potential to diagnose cataracts at the molecular level. Recently, a new DLS fiber-optic probe was developed at the NASA Glenn Research Center at Lewis Field for noncontact, accurate, and extremely sensitive particle-sizing measurements in fluid dispersions and suspensions (ref. 1). This compact, portable, and rugged probe is free of optical alignment, offers point-and-shoot operation for various online field applications and challenging environments, and yet is extremely flexible in regards to sample container sizes, materials, and shapes. No external vibration isolation and no index matching are required. It can measure particles as small as 1 nm and as large as few micrometers in a wide concentration range from very dilute (waterlike) dispersions to very turbid (milklike) suspensions. It is safe and fast to use, since it only requires very low laser power (10 nW to 3 mW) with very short data acquisition times (2 to 10 sec).

The new DLS probe has been applied to characterize protein solutions and protein crystallization processes in NASA's flight hardware (ref. 2), but it can be quickly adapted to the various state-of-the-art ophthalmic instruments (e.g., the slit-lamp and Scheimpflug imaging) presently in use at the National Eye Institute of the National Institutes of Health. This modification advances the cataract diagnostic process from mere visual and photographic observations to molecular level investigations (ref. 3). Detection of lens changes may enable the early identification of diabetes in the many millions of people worldwide, including 8 million Americans, who have undiagnosed diabetes. DLS also detects and quantifies the early changes associated with diabetes in the vitreous (ref. 4) (the fluid that occupies 80 percent of the volume of the eye).



Experimental setup at the Food and Drug Administration for diagnosing diabetes through the eyes of sand rats.

Desert rodents, commonly called sand rats, are being used in a Food and Drug Administration study with the DLS probe. This animal is unique in that it develops diabetes in a manner similar to humans. Typical results are shown as histograms of protein size distribution in the eye lens for a control animal and a diabetic animal over a 3-month period. The DLS probe can discern subtle and diffusive changes in the lenses, specifically the shift in the size of the proteins, which increases during the initial stages of diabetes in these animals. Our preliminary results also demonstrate that there are subtle changes in the lenses of diabetic sand rats when the rats are kept on a diabetogenic diet (one that will produce diabetes) for 2 months. The minor changes over time seen in the control animals are attributed to age and instrument conditions and are considered to be insignificant.



Macromolecular size distribution (a crystalline protein) in the eye lens of a sand rat on a normal (control) diet (left) and a diabetogenic diet (right). Top: Baseline—All animals on the control (normal) diet. Center: 30 days after initiation of diabetogenic diet. Bottom: 60 days after initiation of diabetogenic diet.

The DLS probe is proving to be a practical, noninvasive diagnostic tool that is useful for the early detection of ocular pathologies and for understanding the mechanism of cataract formation (ref. 5). In the long term, it may be possible to use DLS data obtained from the eye to predict diabetic status. In addition, a noninvasive diagnostic method of molecular evaluation would enable repeat measurements to gauge response to therapy. The NASA probe seems to hold particular promise for ocular diagnostic work.

References

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National Center for Microgravity Research (at Glenn) contact: Dr. Rafat R. Ansari, (216) 433–5008, Rafat.R.Ansari@grc.nasa.gov

Authors: Dr. Rafat R. Ansari, Dr. Michelle V. Chenault, Dr. Manuel B. Datiles III, Dr. J. Sebag, and Dr. Kwang I. Suh

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