SPEAKER 1: Some 60% of the people in this country die from diseases of the circulatory system. By far the most prevalent of circulatory diseases is atherosclerosis. Atherosclerosis is simply a disease in which blockages are deposited in the larger vessels of the body. Those blockages are mostly made up of tissue very similar to scar, but sometimes some deposits of fat or calcium in them. Currently, there are two main ways of dealing with atherosclerosis, and both of them have major problems. The first is bypass surgery. Bypass surgery is a major surgical procedure. It involves a lot of time and money. It requires that the patient's heart be stopped for a relatively long period of time, and a machine must take over its function. The second technique is balloon angioplasty. It's more recent and overcomes some of the problems in that it is not a surgical procedure. However, it has some disadvantages also in that, because it only involves inflating a balloon at the blockage in the artery, the blockage is merely shoved out of the way and not removed. The procedure often must be repeated soon afterwards because the blockage comes back.

Here at the MIT spectroscopy lab, in conjunction with the Cleveland Clinic Foundation, we're working on a new technique using lasers that we call laser angiosurgery. The technique is actually quite simple in concept. It involves taking a tiny bundle of optical fibers and inserting them into an artery through a small tube called a catheter. Then follow the artery up into a blockage and put a lot of laser light in one end of the bundle and vaporize the blockage at the other end. Now, the procedure itself has some complicated aspects to it. And we've divided the project into two main areas to investigate those.

The first is to design a catheter system that can deliver laser light in a very controlled way and therefore vaporize tissue of a known volume so we know where and how much tissue is being removed. The second is to develop a way of sensing what kind of tissue is at the other end of the catheter. Since laser light will remove good tissue as easily as bad, we need to make sure that it is bad tissue that we're pointed at. Then we'll talk a little bit about how we're combining both of these aspects of the project into a system that can safely remove atherosclerotic blockages using laser light.

SPEAKER 2: We are now going to introduce you to our laser catheter. We want to give you an idea of its components and an overall picture of how it works. We start with the quartz optical fiber. We are now transmitting blue-green light from our argon ion laser. We take many of these optical fibers, bundle them together, and encase them in a transparent, protective optical shield. This constitutes the working end of our laser catheter. This diagram illustrates. The optical fibers are placed in predetermined distance from the output surface of the shield. By knowing this distance and the angle at which the light diverges from the fiber, we can determine the spot size on the output surface of the shield. Each fiber is aimed at a different location on the shield, so there is full shield overlap. The shield is then placed in contact with tissue. This is one such laser catheter. We then set the laser power and exposure time by the computer. With the spot diameter, laser power, and exposure time, we can deliver our photon dose and remove a very precise amount of tissue. Each optical fiber is fired individually, creating its own unique nibble. Nibbles are combined to create one large composite hole through which the catheter can advance.

SPEAKER 3: The part of the project that I work on is spectral diagnostics. The goal of this part of the project is to develop a system to guide the laser catheter once it is inside a blood vessel. There are three things that the guidance system must be capable of. First, it must tell us what type of tissue a particular fiber the laser catheter is viewing, be it plaque, normal artery wall, or blood. Secondly, if the fiber is viewing plaque, the guidance system must be able to tell us how much plaque is there, so we can determine what photon dose to deliver to remove only the diseased portion of the vessel wall. Finally, the guidance system must be capable of telling us when we have hit normal tissue in an ablation procedure. Our research centers on using fluorescent spectroscopy as a tool to accomplish these things.

Fluorescent spectroscopy is a technique that allows one to identify substances based on the unique way that they interact with laser light. When low power laser light of a particular color or wavelength hits molecules of one substance, they absorb this light. Those molecules then re-emit light that have different colors or wavelengths. Plaque, normal artery, and blood all have different fluorescent spectra, and this allows us to develop a guidance system for the catheter. One of the problems with this technique is the fact that tissue spectra change after they've been exposed to moderately intense laser light as an ablation. The top row shows spectra of normal and atherosclerotic tissue prior to exposures of intense laser light. The bottom row shows the same normal tissue and atherosclerotic tissue spectra after an exposure to intense laser light. Although this exposure was below that required for ablation, spectral differences are dramatic. And differences between normal and atherosclerotic tissue spectra are very diminished.

SPEAKER 4: The part of the project that I'm working on is an overall system for the diagnosis and treatment of atherosclerosis. The process consists of five steps. The first step is looking into the artery and seeing what's there. Conveniently, this bundle of fiber optics can be used to look into the artery as well as carry the high power laser light. So what, in effect, we have is a remote camera that gives us an image of the inside of the artery. The catheter that we used in this particular example had 19 fibers in it. So once we've collected fluorescence from all 19 fibers and transferred all the data over to the main computer here, this computer displays the 19 spectra in the form of this 19 pixel image. And what this is is a map of the fluorescence coming from the tissue in contact with the catheter tip. Step two of the process is taking the 19 fluorescent spectra and determining what kind of tissue is at the end of the catheter. Step three, we take that fluorescence map and we run it through another computer algorithm, which basically makes intelligence decisions about what fibers to send high power laser light down. All the results are displayed on the screen so the surgeon can monitor or abort the procedure. The fifth and final step is to go ahead and remove the tissue. So in effect, what we have here is a smart catheter that can look into the artery, diagnose what's there, make a computer-based decision, then go ahead and remove the bad tissue. Potentially, this system could remove most of the need for bypass surgery.