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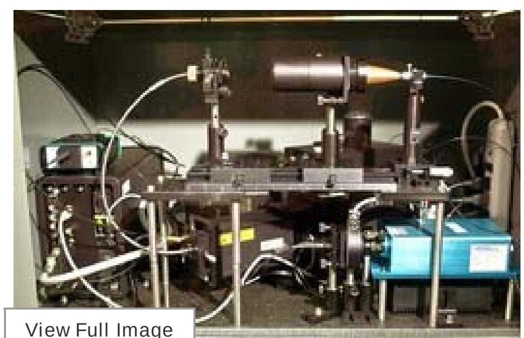
Researchers Beaming at Light's Medical Uses

By SHIRLEY S. WANG

Using beams of light for diagnosis and monitoring disease may sound like something out of science fiction.

But scientists at the Massachusetts Institute of Technology are trying to use light so people with Type I diabetes can test their blood sugar levels with light, instead of with a needle, a painful and burdensome task they must do as many as a dozen times a day.



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This shopping-cart-size contraption aims to use light to monitor blood glucose through the skin. MIT researchers plan to shrink it small enough to be worn by diabetics to continuously detect their blood sugar.

The research is the latest work with light at MIT. For 80 years, scientists there have been analyzing the way light moves and bends, hoping to develop it as a tool to study atoms, molecules and phenomenon impossible for the naked eye to see. In the last two decades, they have expanded their work to study its potential for aiding people with diseases such as cancer, malaria, and diabetes.

Light is already used for purposes such as activating medicines after a drug reaches a certain part of the brain, hardening dental sealants on teeth and during eye surgery like LASIK. There have been disappointments as well, such as failed attempts to use lasers to remove plaque from arteries.

Bright Lights, Big Advances

A look at how light and lasers are used in medical treatments today:

LASIK eye surgery: A laser is used to cut a flap in the cornea, which is then repositioned to improve sight.

Dental sealants: Liquid plastic sealant is painted onto tooth and light is shined on it, activating an ingredient in the sealant that

Light is made up of wavy streams of tiny energy particles called photons. When these particles hit an object—say a cell in the body—they can be absorbed, scattered or continue to travel the cell through undisturbed. How the light reacts when it hits the cell can yield a lot of information, such as the cell's shape, size and what is inside of it. Using light to observe how drugs affect cells also has activating an ingredient in the sealant that makes it set.

Cosmetic skin procedures: Lasers can reduce pigment at certain parts of the skin, "resurface" away wrinkles and shrink varicose veins.

Macular degeneration: The drug Visudyne from Novartis is injected into arm and activated when it reaches the retinal blood vessels using a laser beam shined in the eye.

Seasonal affective disorder: White or blue light emitted from above eye-gaze level appears to help some curb a depression that occurs at the same time each year.

Laser hair transplantation: Lasers create the holes into which hair grafts are placed.

Source: WSJ reporting

implications for improving drug development.

A big advantage of using light for medical purposes is that it is non-invasive, says Ramachandra Dasari, associate director of MIT's G.R. Harrison Spectroscopy Lab. No chemicals or devices need to be injected or implanted into the body, so the cells aren't harmed while they are being studied, and patients don't have to go through the pain of a shot or incision.

MIT scientists are building huge mechanical contraptions with light using mirrors, crystals and cameras. One device that researchers have been trying to fashion for years is a non-invasive monitor that measures blood sugar simply by touching a light "wand" to the forearm. It uses a type of light, known as near infrared, also used in television remote controls.

Type I diabetics must test their blood sugar anywhere from six to 12 times a day, and those with Type II diabetes once or twice daily. A non-invasive method would potentially provide a means of continuous monitoring that would also alert the patient of dangerous drops or spikes in blood sugar.

Several problems have hindered progress. The light-measured sample is filled with molecules other than glucose. Sugar comprises approximately 0.2% of the collection and must be separated and extracted from the unwanted background "noise."

Also, getting a measurement can be difficult because light is affected by many components in the skin, including skin color and fat deposits. Much of the light simply travels through the skin and doesn't yield any useful information for scientists. For some techniques to measure light, only one out of a million photons contributes meaningful data for measuring glucose, researchers say.

And, because light can penetrate only about one millimeter into the skin, the glucose actually being monitored is contained in fluid found around blood vessels, called interstitial fluid, not within the vessels. Sugar from blood spreads into this fluid, but there is a lag time. Without accounting for this delay, the measurement would be inaccurate, which could be dangerous for diabetics with unstable and very high or very low blood sugar levels.

Ishan Barman and Chae-Ryon Kong, two MIT graduate students, tackled this problem of lag time in a study recently published in the journal Analytical Chemistry. They collected multiple blood samples from 10 healthy volunteers who drank a sugary solution, and compared the actual blood glucose level with their measurement from the light device.

This enabled them to calculate the time it took for the sugar in the blood to reach the surrounding fluid—approximately 8 to 10 minutes. By adjusting for the lag, they improved prediction accuracy by 15% to 30% and precision by 3- to 6-fold. They are now embarking on a bigger clinical study of the tool, which will include diabetics, whose lag time may vary more because the disease has affected their blood vessels, say Mr. Barman and Mr. Kong.

For a patient, this means just a single set of finger pricks (five to 10) may be all that is necessary to calibrate the device for years. And, if the monitor could be worn, such as on a waistband or wrist, blood sugar could be monitored continuously and the patient could be alerted if there was a dangerous drop coming.

One of the other challenges of building such a device, however, is miniaturizing it enough to make it portable. Currently their device—which took two years to build—is the size of a shopping cart.

They hope to whittle it down to laptop-sized—and a cost of $20,000—in two years, and eventually —in about five years—they envision shrinking it to the size of a handheld device that could be purchased for $2,000 to $3,000.

The same technology could also be adapted to measure other chemicals in the blood, such as cholesterol and alcohol. In the long run, it could potentially replace blood sticks altogether.

Others in the lab, like graduate student Yongjin Sung and post-doctoral fellows Jeon Woong Kang and Dan Fu are using light technology to distinguish diseased or damaged cells from healthy cells, which can be used in cancer and malaria diagnosis as well as to pick the healthiest embryos for implantation for in vitro fertilization.

Some cancer tissue, for instance, has more small blood vessels and calcium in them, and light can be used to measure these changes without adding fluorescent or radioactive dyes.

The hope is to be able to create a light-based application to measure cancer tissue in real-time, like during a surgery in which a tumor is being removed. Currently, about 50% of women who undergo breast cancer surgery must have a repeat operation because the entire tumor hasn't been removed. If a surgeon could better detect all the cancer tissue during the first operation, the patient may be able to avoid a second surgery.

And, light can be used to measure the "sound," or vibrations, of the walls of red blood cells containing malaria. Cells infected with the malaria parasite get stiffer and move less. Currently, a trained doctor must examine blood samples under a microscope to determine if someone has malaria. A portable malaria-detecting light device would allow for easier diagnosis in the field.

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