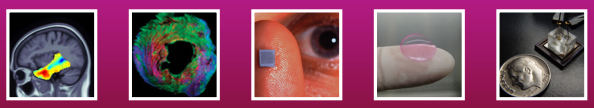
NATIONAL INSTITUTE OF BIOMEDICAL IMAGING AND BIOENGINEERING



Sensors

National Institutes of Health

What are sensors?

In medicine and biotechnology, sensors are tools that detect specific biological, chemical, or physical processes and then transmit or report this data. Some sensors work outside the body while others are designed to be implanted within the body.

Some monitoring devices consist of multiple sensors that measure a number of physical or biological parameters. Other devices may be multifunctional, incorporating sensors and then delivering a drug or intervention based on the sensor data obtained. Sensors may also be components in systems that process clinical samples, such as increasingly common “lab-on-a-chip” devices.

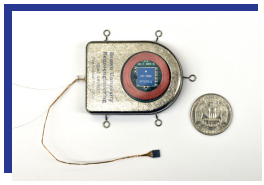
Sensors help health care providers and patients monitor health conditions and ensure that they can make informed decisions about treatment. Sensors are also often used to monitor the safety of medicines, food, environmental conditions, and other substances we may encounter.

How are sensors used in current medical practice?

Many different types of sensors are already used in health care, including self-care at home. Thermometers translate the expansion of a fluid or bending of a metal strip in response to heat into a number corresponding to body temperature. Paper-based home pregnancy tests contain a substance that changes color in the presence of hormones indicating pregnancy. In hospitals and other provider-based settings, you can find more complex types of sensors like pulse oximeters (also known as blood-oxygen monitors), which measure changes in the body’s absorption of special types of light to provide information on a patient’s heart rate and the amount of oxygen in the blood.

Thermometers are a type of sensor commonly used in health care.

How might novel sensors improve medical care or biomedical research?



Wireless, implantable brain sensor, shown next to a U.S. quarter for size comparison.
Source: David Borton, Ph.D., Brown University

Advances in technology, engineering, and materials science have opened the door for increasingly sophisticated sensors to be used in medical research. For example, a group of NIBIB-funded researchers developed a compact, wireless, implantable brain sensor that can record and transmit brain activity data. Building on previously developed brain-computer interfaces that used wired connections, this new sensor may someday lead to unobtrusive, thought-controlled prosthetics and other assistive devices for people with amputated limbs, paralysis, or other movement impairments.

Researchers at NIBIB aim to improve existing sensors through a variety of means, such as making fluorescent probes easier to see and increasing the capabilities and enhancing efficiency of individual sensors.

Test tubes containing purified proteins made to fluoresce in different colors.
Source: NIBIB

While many advanced sensors aren’t practical for routine medical care, they allow researchers to study the basic foundations of disease in more detail than previously possible, and to develop new technologies that could dramatically improve the quality of life of people with severe disabilities.

What technologies are NIBIB-funded researchers developing with sensors?

Sensors play key roles in all aspects of health care—prevention, diagnosis, disease monitoring, treatment monitoring—and the range of research involving sensors is equally broad. In addition to health-related applications, NIBIB funds studies to test new materials and technologies for building sensors, to develop new sensors that can advance medical research, and to promote healthy independent living through home-based and wearable sensors.

New Materials & Technologies

Good health requires not only protecting our bodies but safeguarding things we put into our bodies as well. NIBIB-funded researchers developed a sensor using a thin membrane made from of a special kind of plastic. The researchers loaded the membrane with a compound that creates a voltage difference across the membrane in the presence of OSCS, a potentially deadly contaminant sometimes found in preparations of the commonly used blood thinner heparin. By measuring the voltage, scientists

can quickly identify OSCS-contaminated samples before the heparin is administered to a patient. The reaction between OSCS and the membrane is also reversible, so the sensors can be used repeatedly.

Advancing Medical Research

Many illnesses develop and progress as a result of faulty regulation or dysfunction of a range of hormones, neurotransmitters, or other important body chemicals. Tracking such chemical activity is key to unraveling disease processes. NIBIB-funded researchers seek to improve on biosensors in a variety of ways, such as creating novel types of coatings that improve sensor sensitivity, selectivity, and stability; and developing a fluorescence-based strategy to detect proteins in living organisms and in real time.

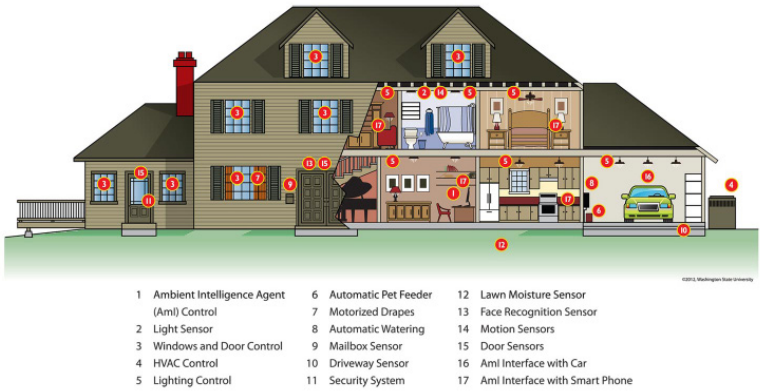


Illustration of a "smart home" showing some types of environmental sensors that can be useful for daily life.
Source: Diane Cook, Washington State University

Healthy Independent Living

Environmental and mobile sensors are already a part of many people's everyday lives, including things like faucets that automatically start when you place your hands under them and shut off when you're done washing. NIBIB supports initiatives to develop improved sensor and related information technologies for home and mobile use that will sustain wellness and facilitate coordinated management of chronic diseases. For example, one research team is working to improve the ability of "smart homes" to make sense of real-time sensor data and to recognize changes in a resident's activity patterns that may signal changes in well-being, such as a fall or disrupted meal schedule.

What are important areas for future research on sensors?

The types of sensors being developed and studied currently may play key roles in expanding and greatly changing the delivery of health care. One area in particular that may benefit from sensor research is point-of-care (POC) technologies.

Point-of-care refers to the place where patients receive health care, which may be anywhere from primary care offices or community clinics to emergency rooms or even patients' own homes. POC research seeks to address barriers to health care that have arisen from the concentration of services in highly specialized medical centers and labs. POC technologies may allow providers to diagnose and treat a particular health condition in a single visit, so patients don't need to make additional appointments or wait for test results.

NIBIB-funded efforts are already underway to develop cost-effective POC solutions for detecting a range of medical conditions, including H5N1 influenza and allergies and other autoimmune diseases. Integrating compact, wireless sensing technologies into medical devices or chronic treatments like long-term oxygen therapy may help lower treatment costs and be easier for patients to use. Such technologies may also be compatible with mobile devices, allowing for remote monitoring and assessments in real-time.

The MIMED system is a universal point-of-care pathogen detection system. The 6x1 cm disposable chip integrates sample preparation and sequence-specific detection and can identify microbes in unprocessed biological, water, food, and forensic samples.
Source: H. Tom Soh, University of California, Santa Barbara

Some of the challenges to sensor research include simplifying and automating the preparation of patient samples to be used at the point-of-care and overcoming the body's natural rejection response to implantable or minimally invasive sensors.

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