

Implantable Biosensors for Chronic Diseases & Conditions

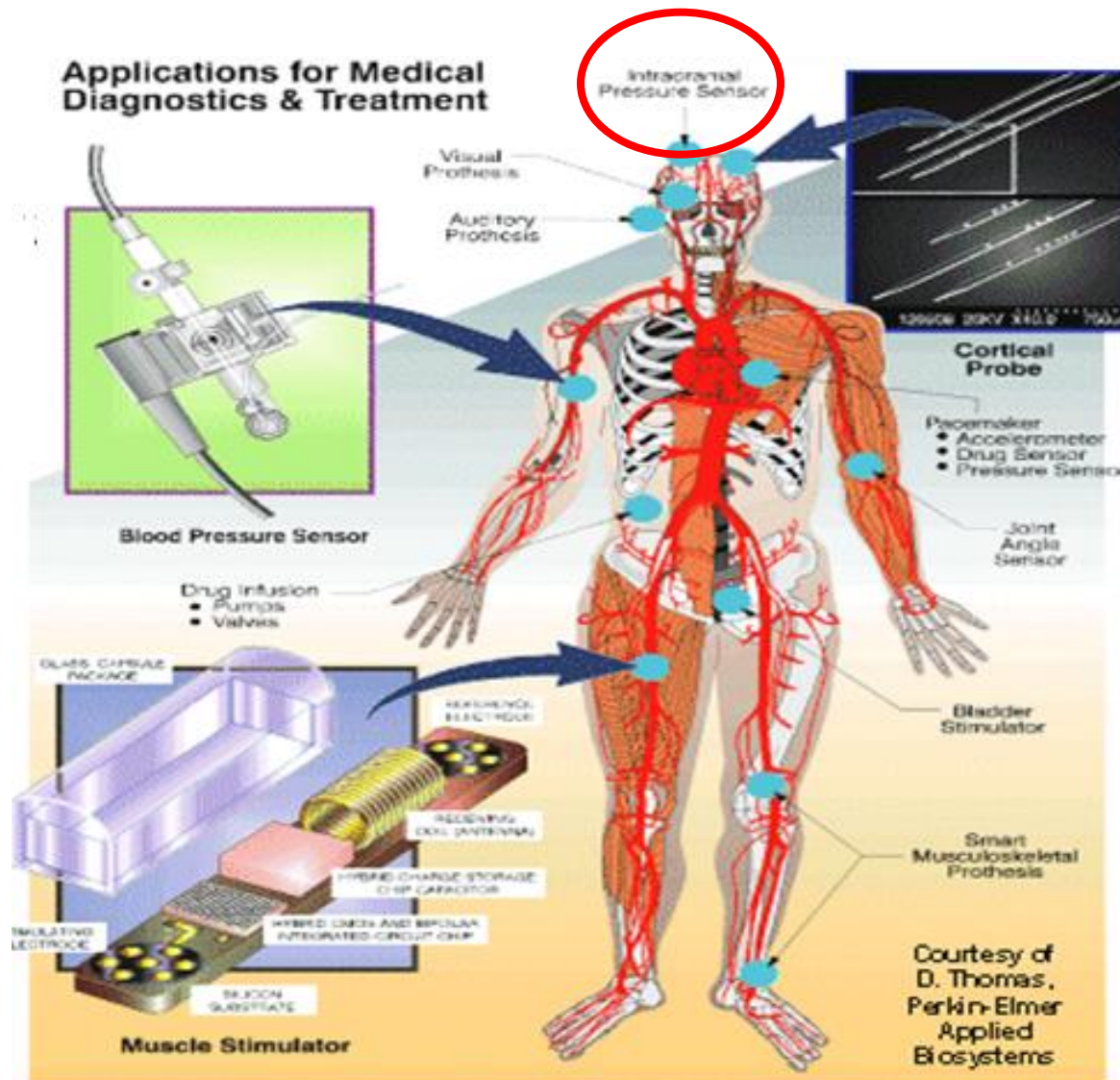
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Visiting Professor at 'Demokritos'

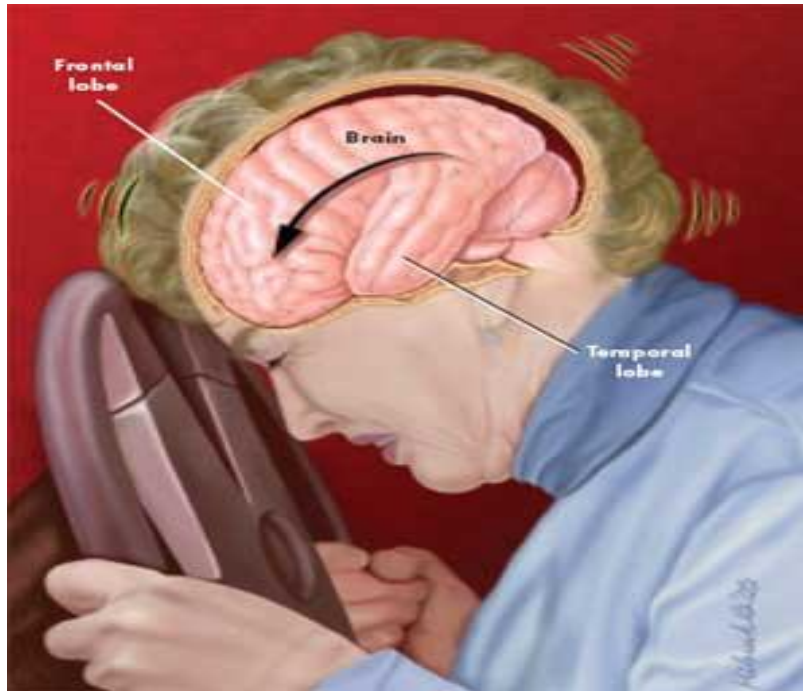
Implantable Biosensors & Actuators



Measure IntraCranial Pressure (ICP)?

1. Needed after a Traumatic Brain Injury (TBI)

In car accidents



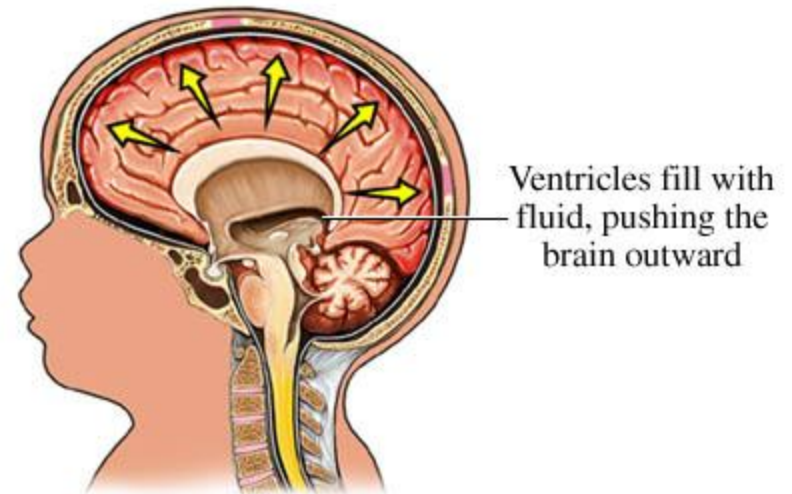
In sports



**1,5 million cases of TBI every year in the US...
50,000 deaths...**

Measure Intracranial Pressure (ICP)?

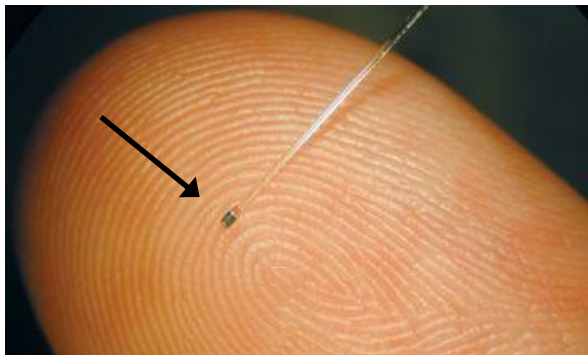
2. Needed for people with Hydrocephalus



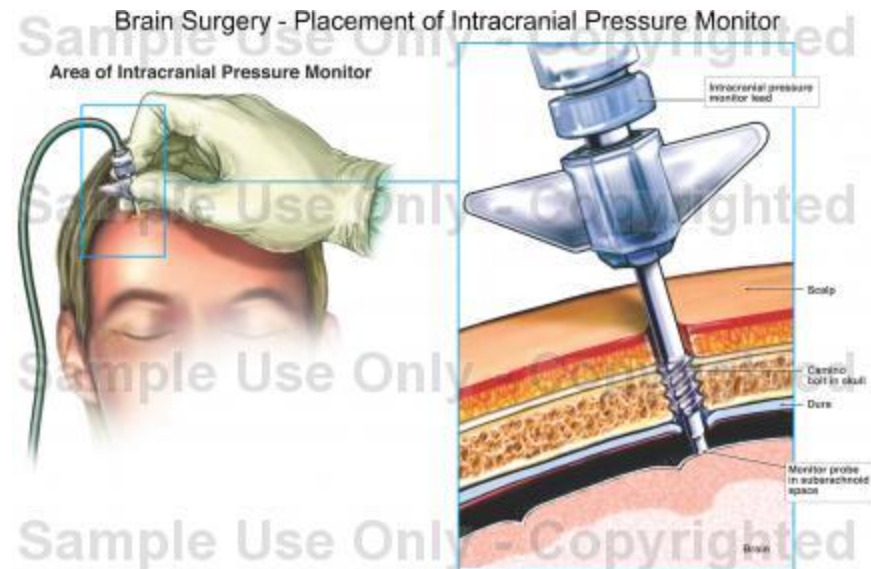
...3 to 4 cases per 1,000 births

How ICP is measured?

You need a microsensor...



...A drill and a surgeon



...a readout system

It is working?

It **DOES** work for TBI cases, BUT:

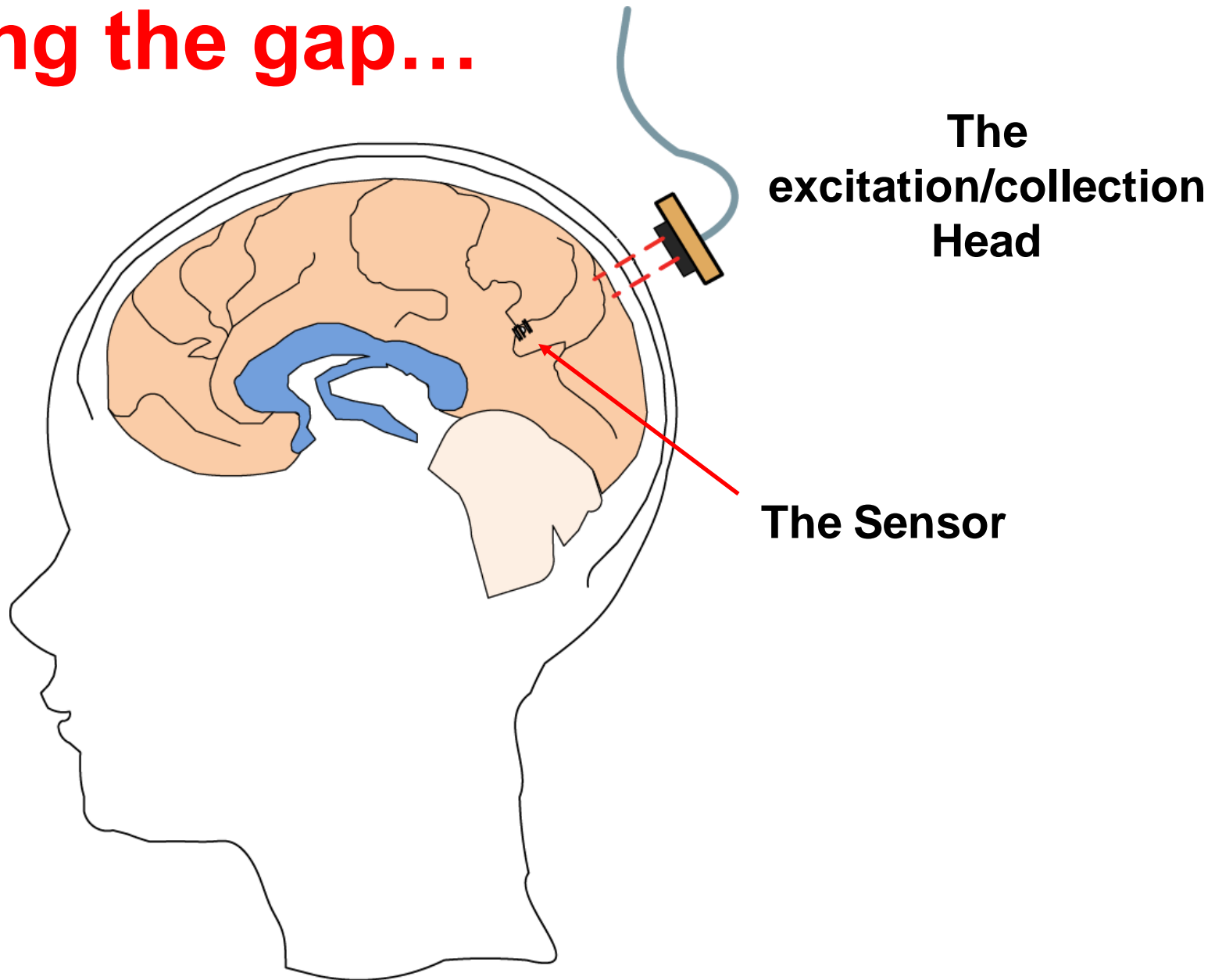
1. The sensor has to be removed after 5-6 days
2. The patient cannot move

-Not a solution for long term monitoring

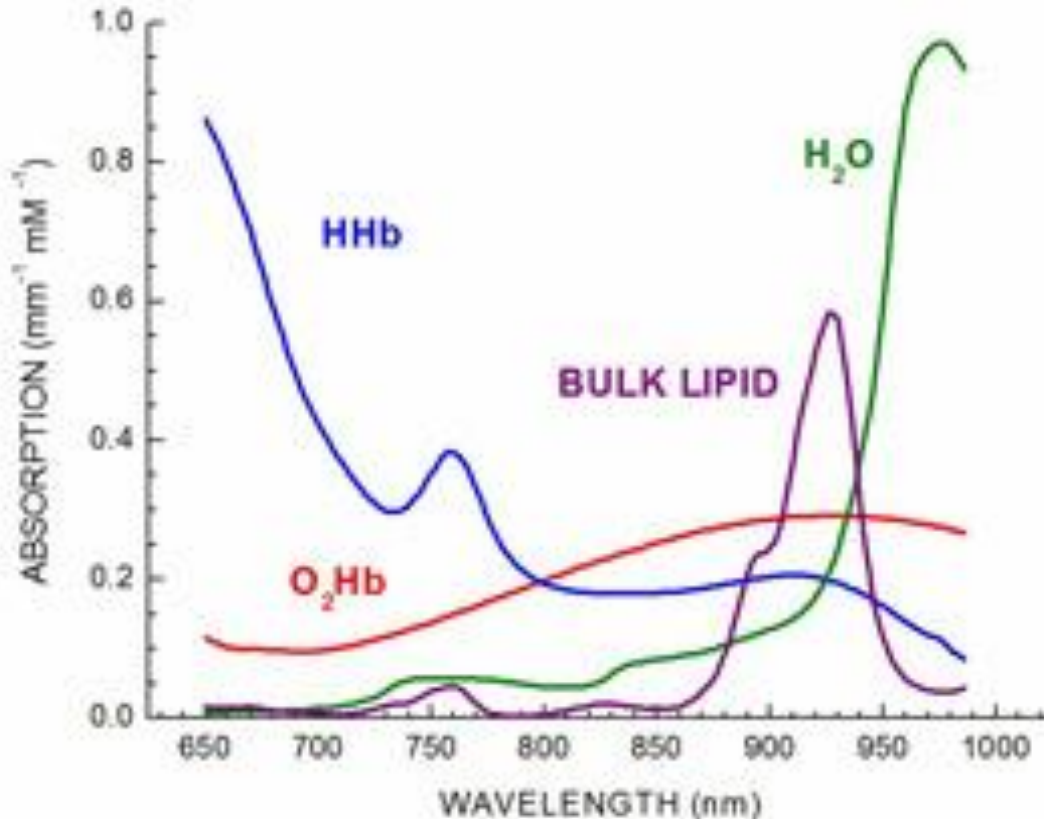


It does **NOT** work for Hydrocephalus cases...

Filling the gap...



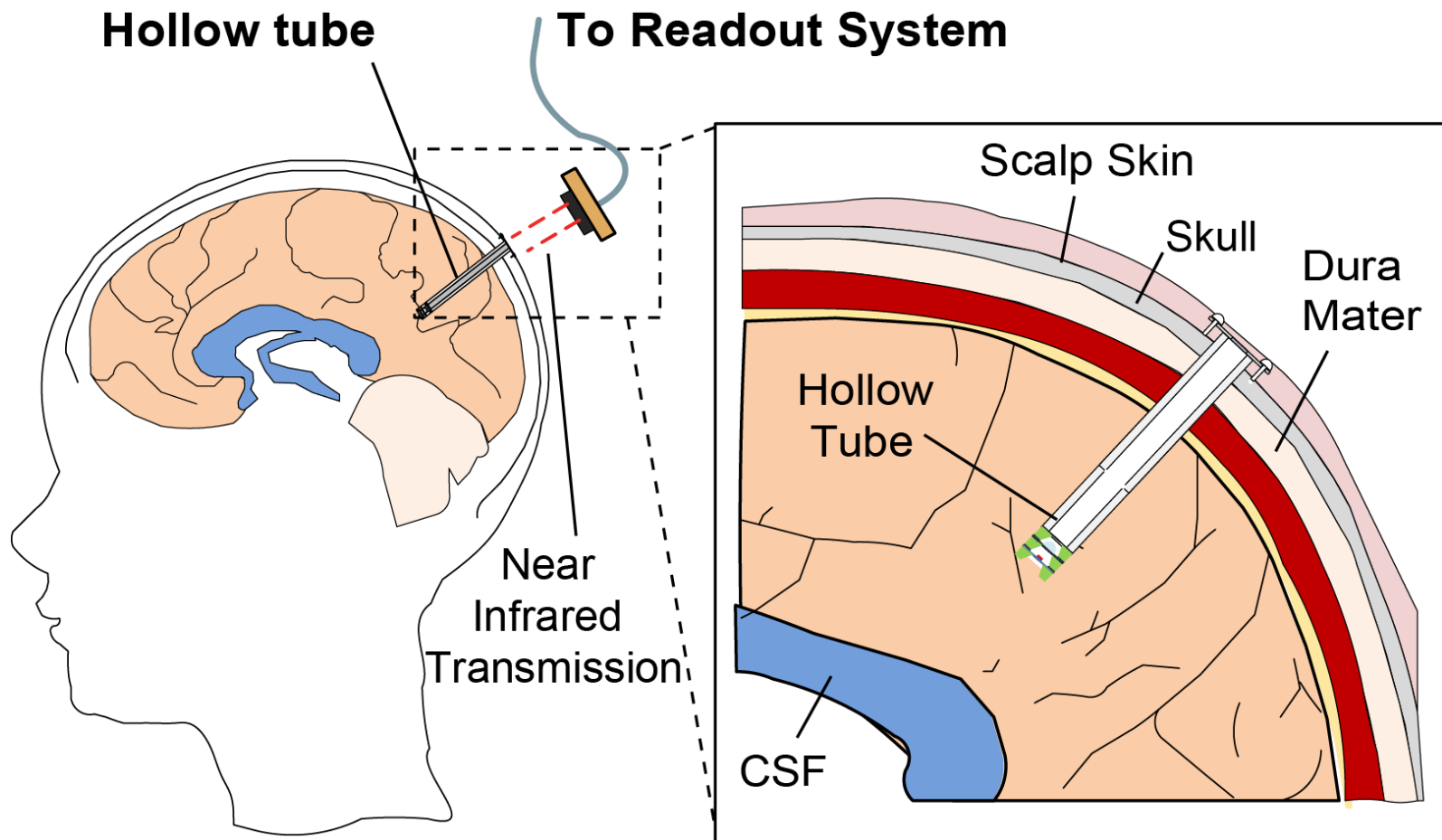
The Near Infrared (NI) Optical Window in the Human Body



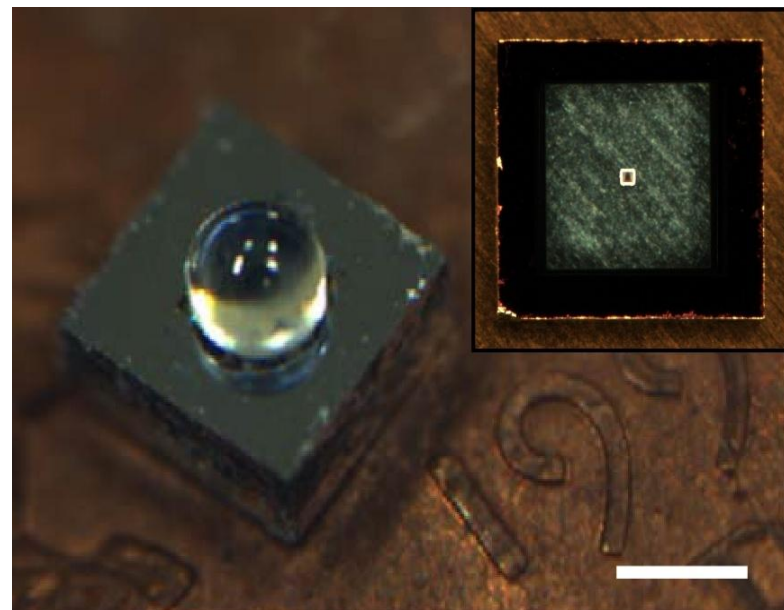
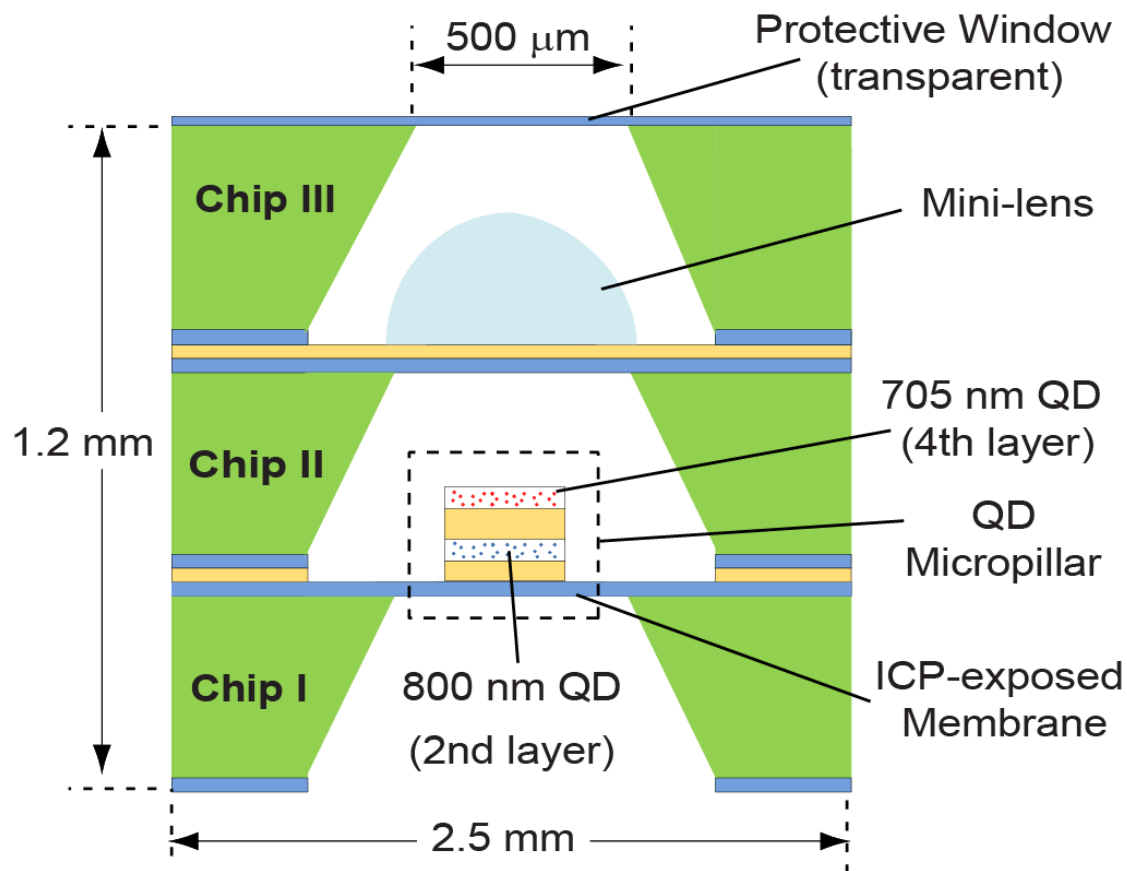
- **HHb** (deoxy hemoglobin) = Hb not bound to O₂
- **O₂Hb** (oxy-hemoglobin) = Hb bound to O₂
- **H₂O** (water), unbound to proteins
- **Bulk Lipid**, e.g., oils

There is an optical window between 700-900 nm when light absorption is MINIMUM !!

The Implementation

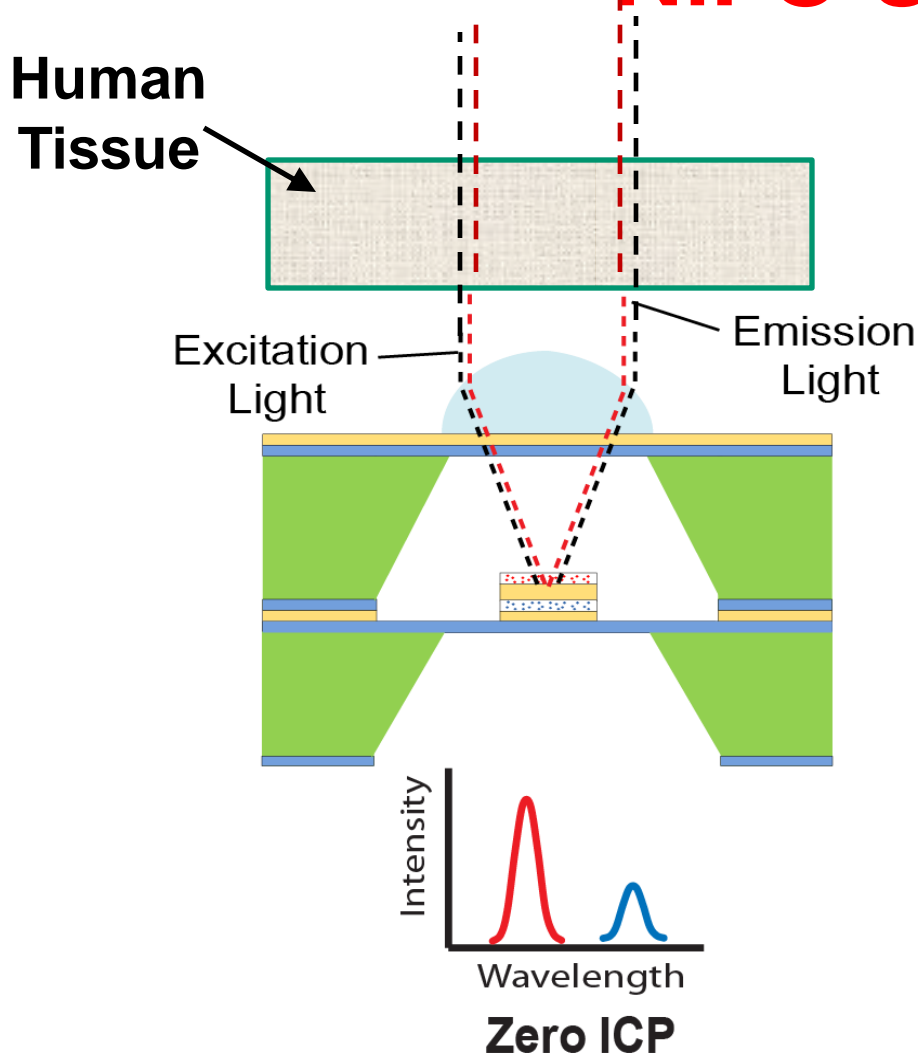


Architecture of the NiFO MicroSensor

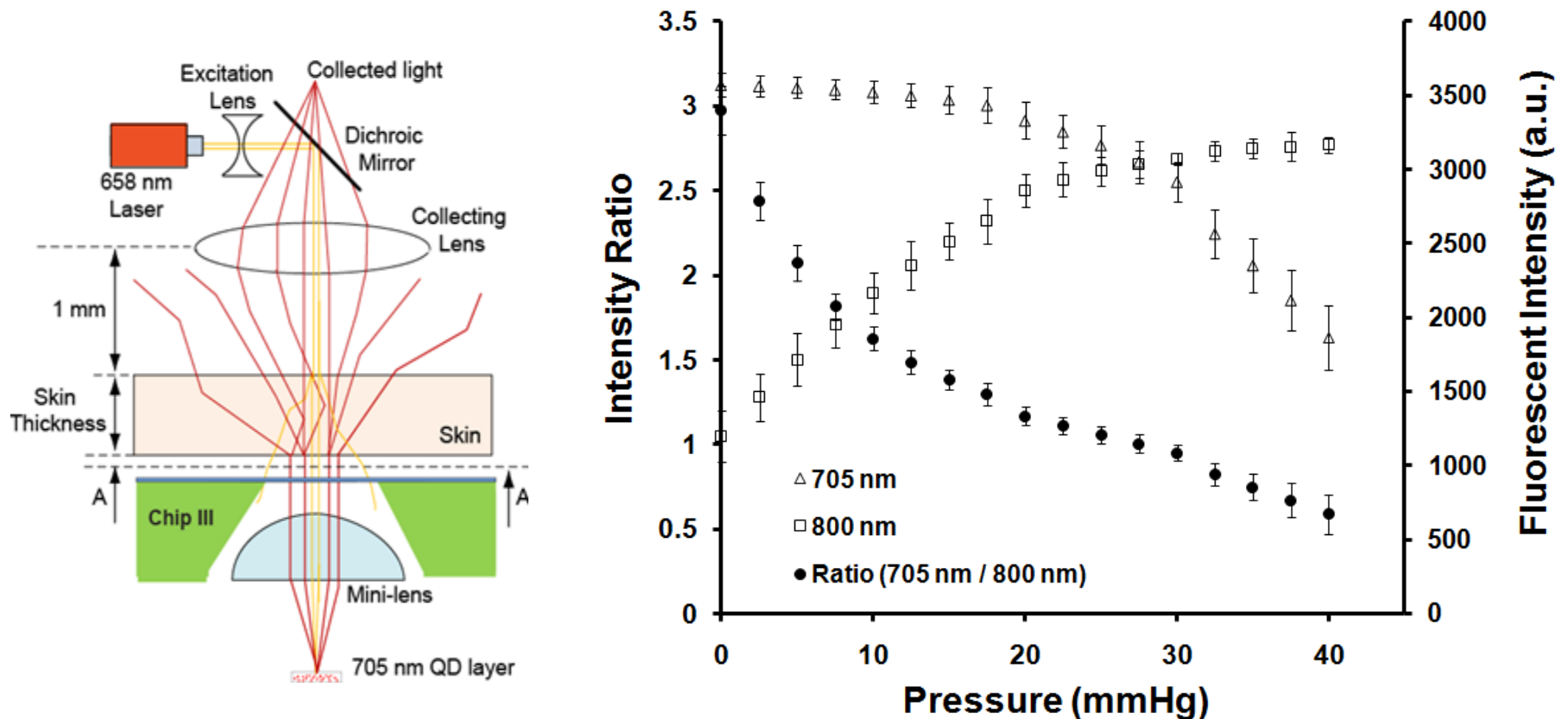


The NiFO (Near-Infrared Fluorescent Optomechanical) sensor is:
Small, powerless and electronic-free!!!

The Working Principle of the NiFO Sensor



It does work (*ex vivo*)!

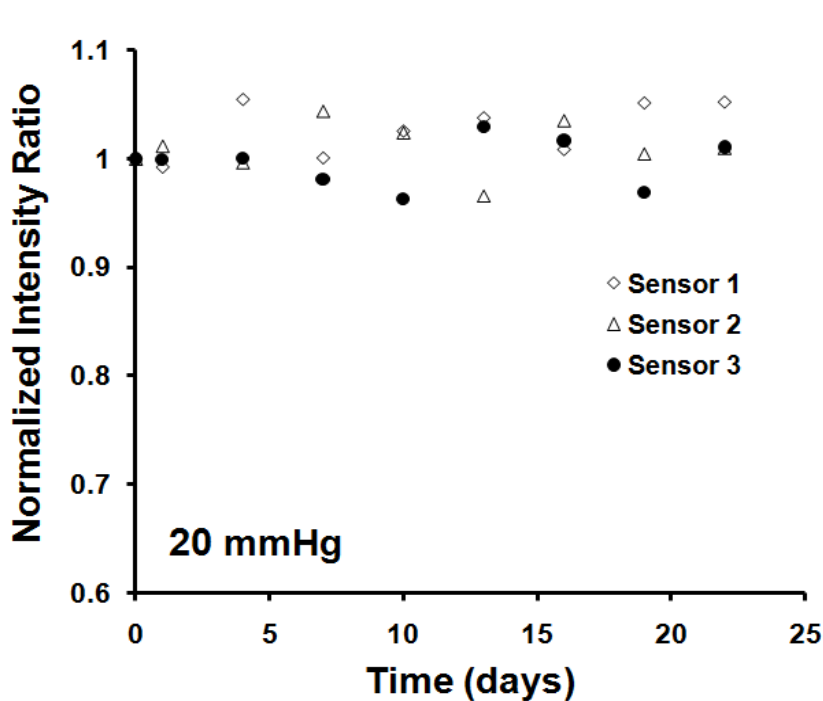


The Sensor has a dynamic range that is clinically relevant!

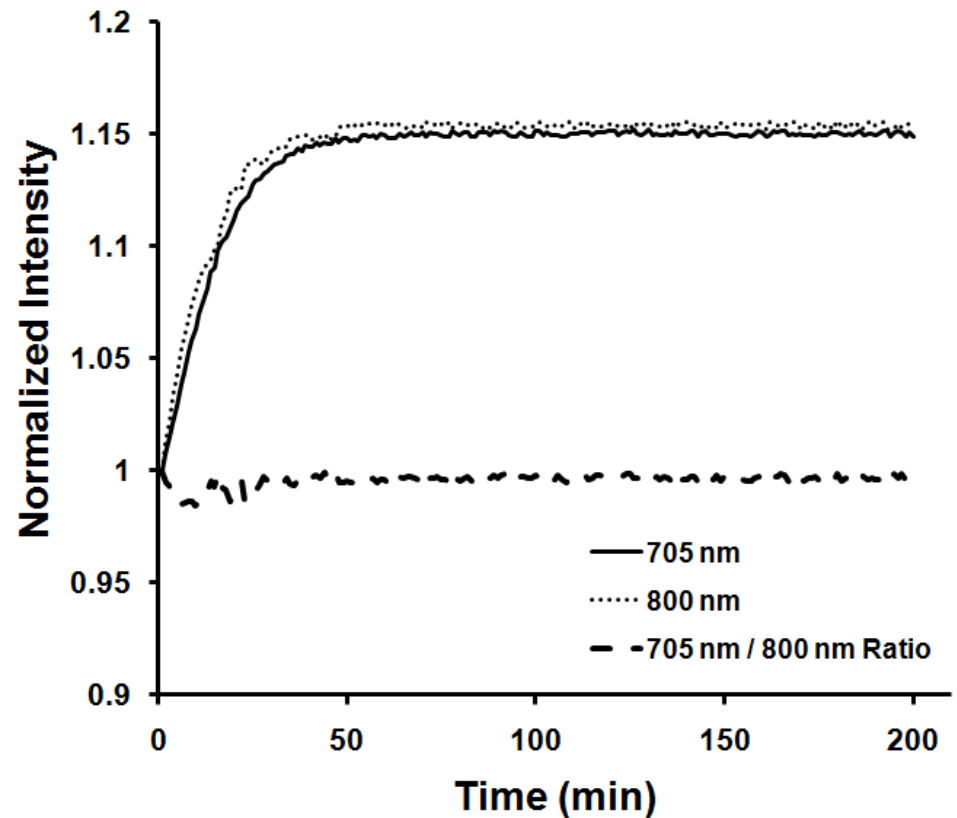
Normal ICP: 5-15 mmHg

High ICP : > 15 mmHg

...and it is also very stable →
good for long-term monitoring



Minimum drift over
a 3.5 week period

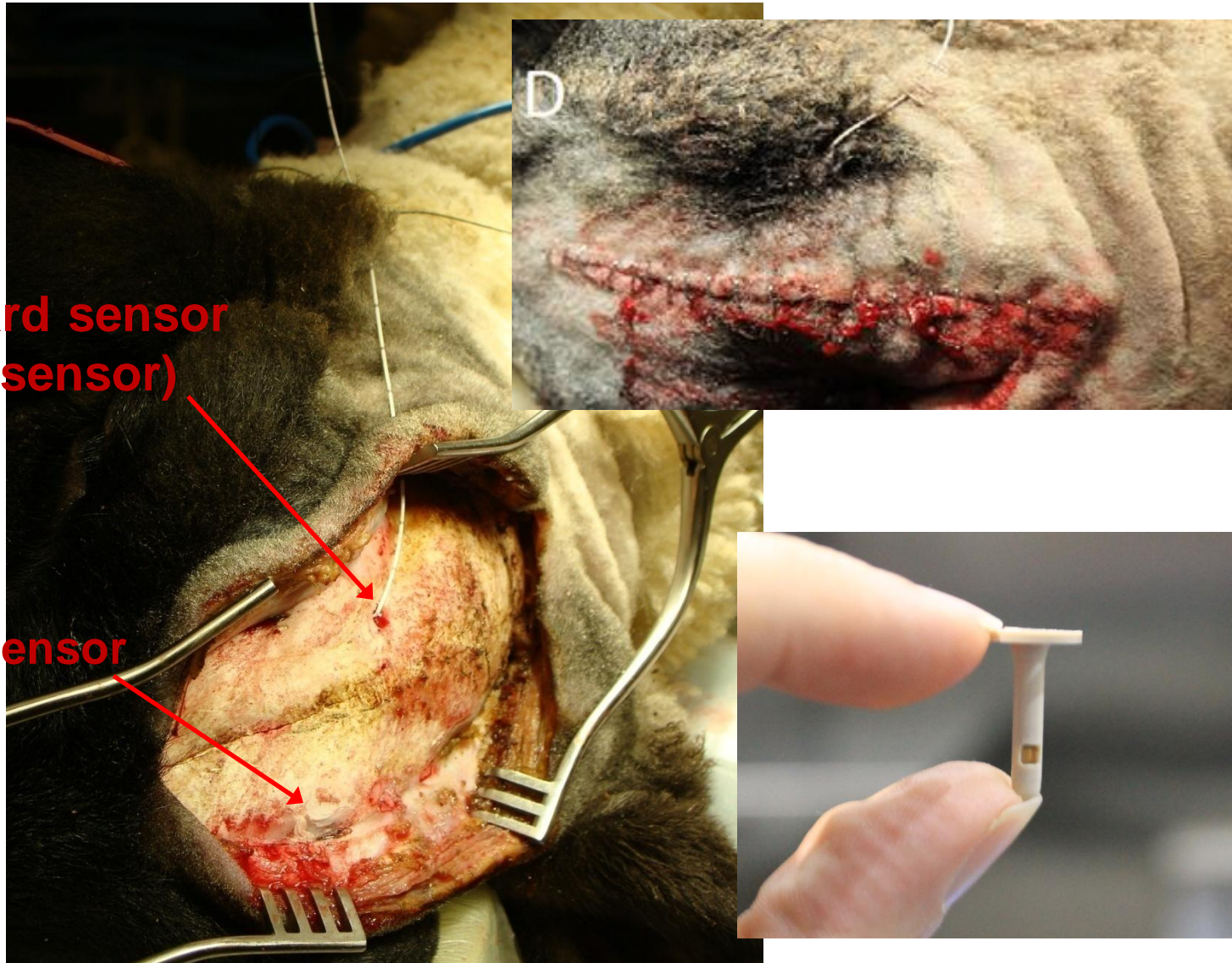


The QDs are extremely stable!

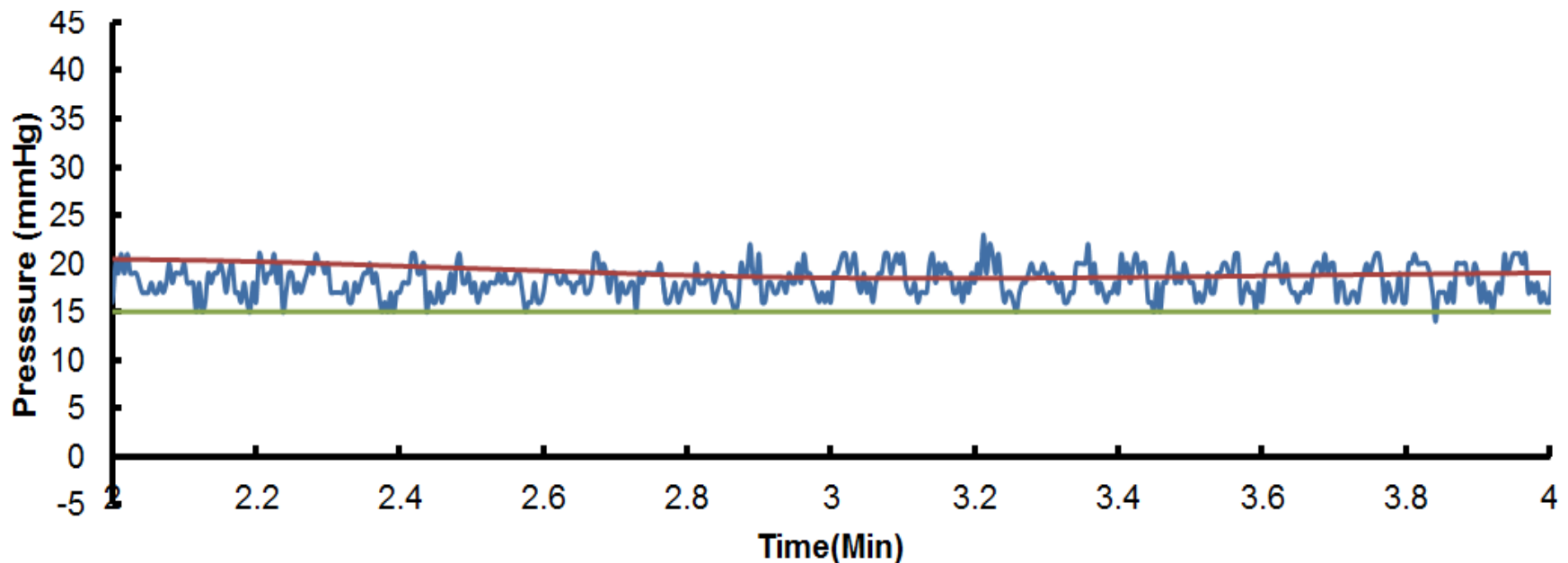
In vivo ICP monitoring in Sheep

The gold-standard sensor
(the Codman sensor)

The NiFO sensor



First *In-vivo* Study: Monitor ICP fluctuations in an anesthetized animal



Green Line = Breathing Rate (BR)

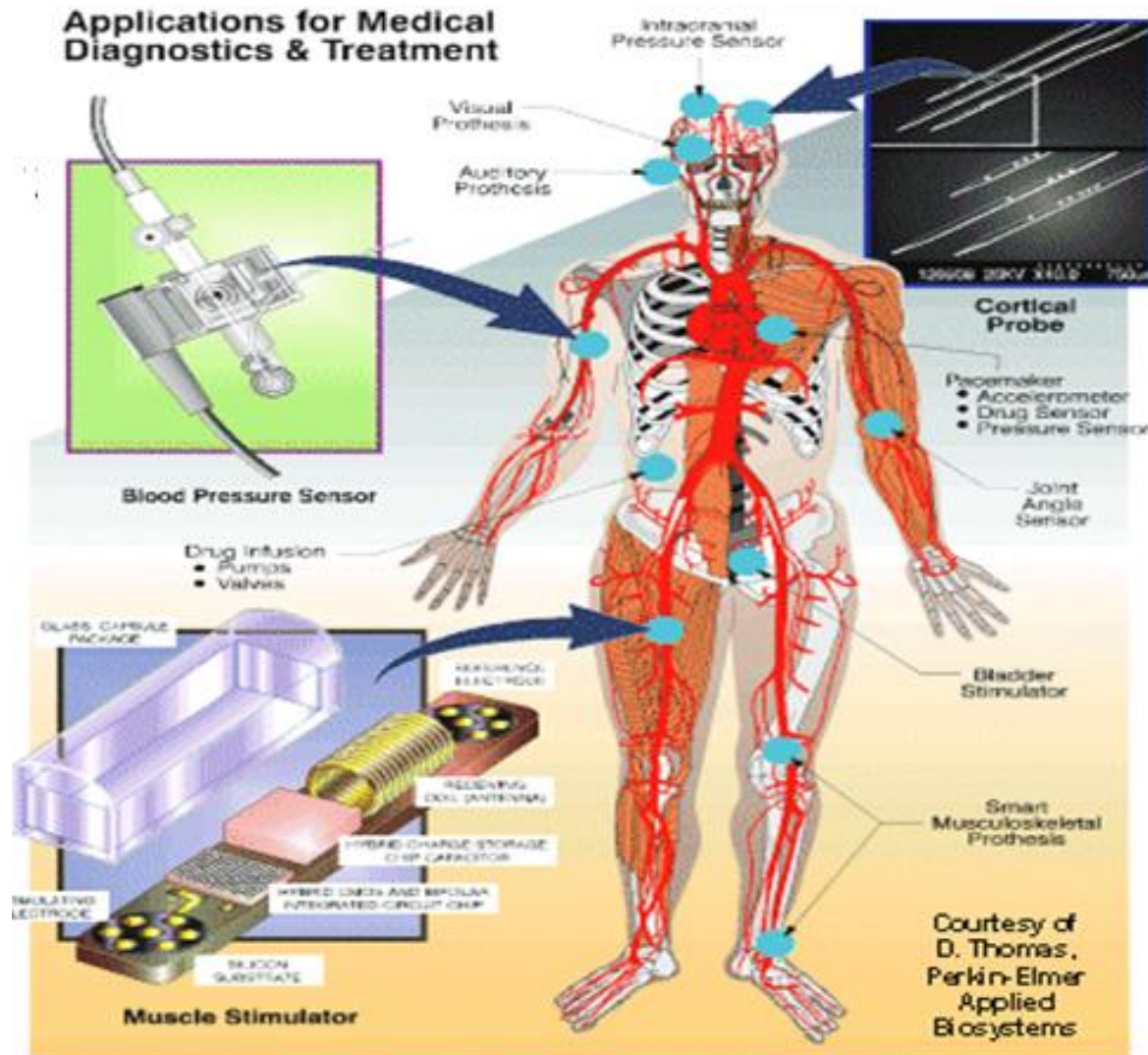
Red Line = Oxygen Level

Blue Line = ICP level from the NiFO sensor

Third *In-vivo* Study: Long-term monitoring...in progress

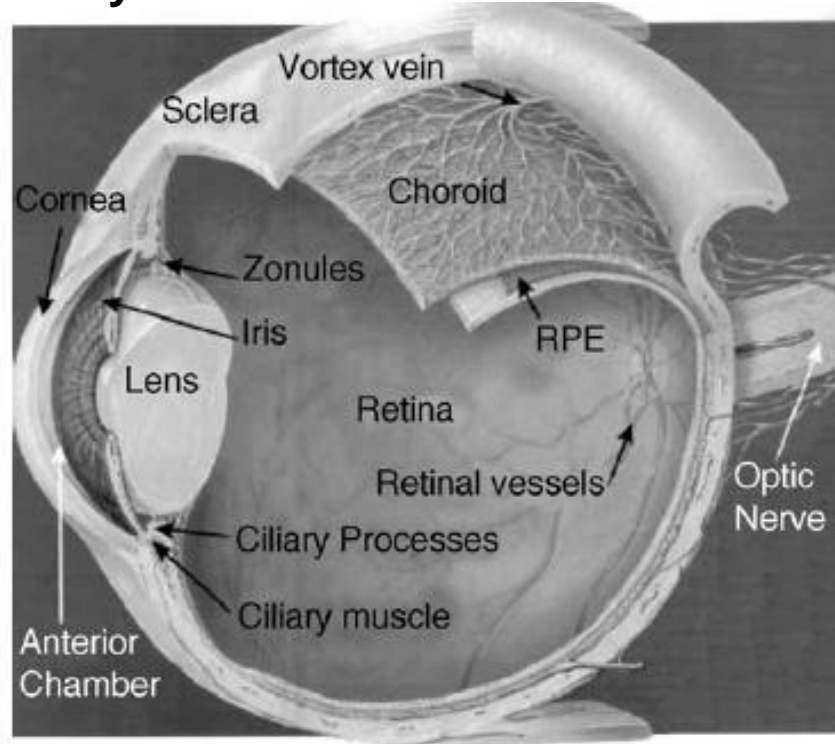


Other Applications?



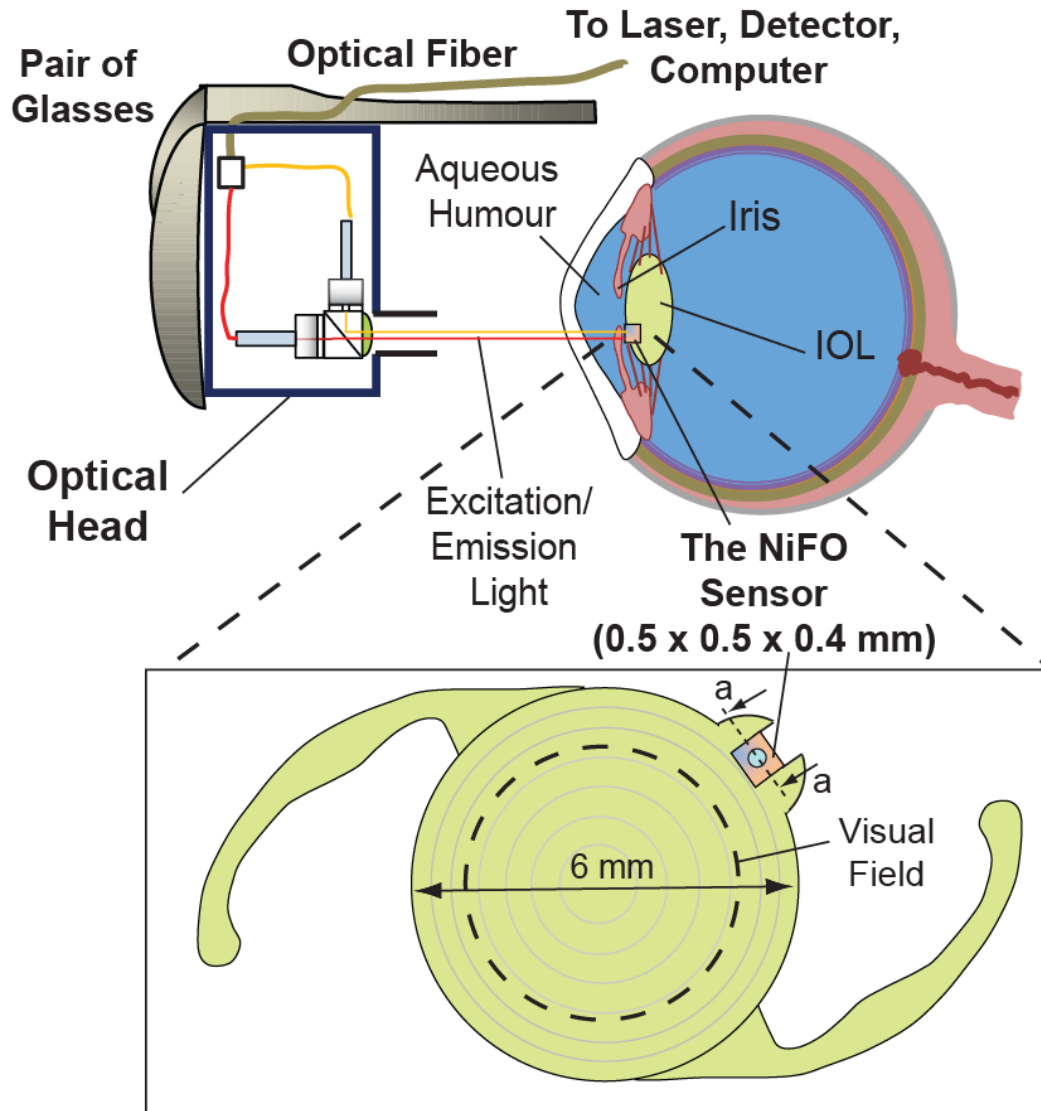
IntraOcular Pressure (IOP) Sensor

Eye Anatomy

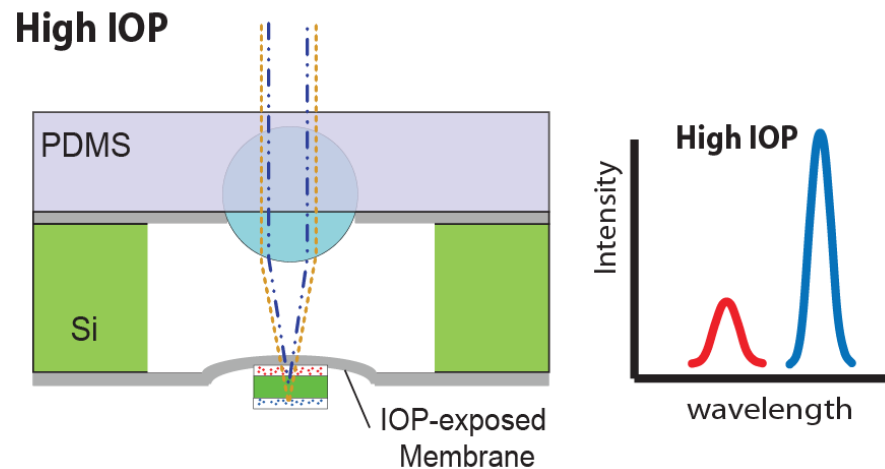
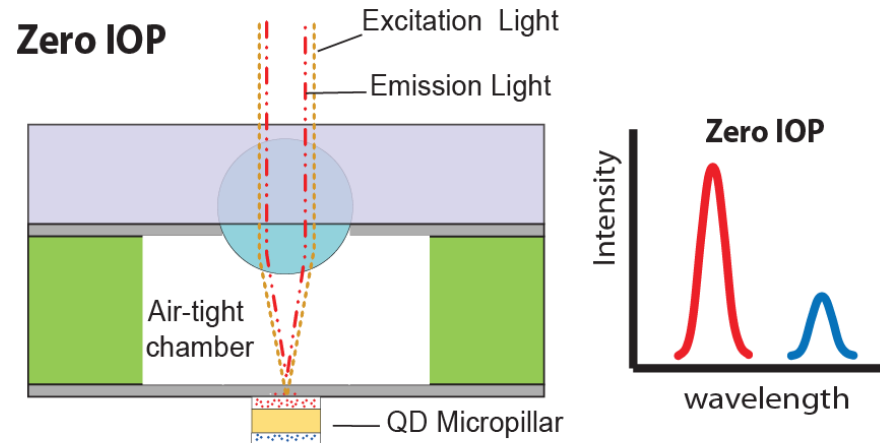


- High IOP is a risk factor for developing Glaucoma
- Glaucoma is a chronic disease and the leading cause of blindness

The NiFO Sensor for IOP monitoring

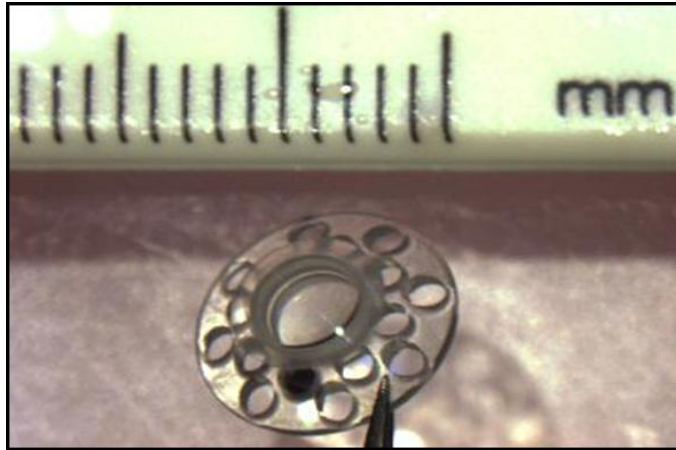


Same working principle, different microfabrication process

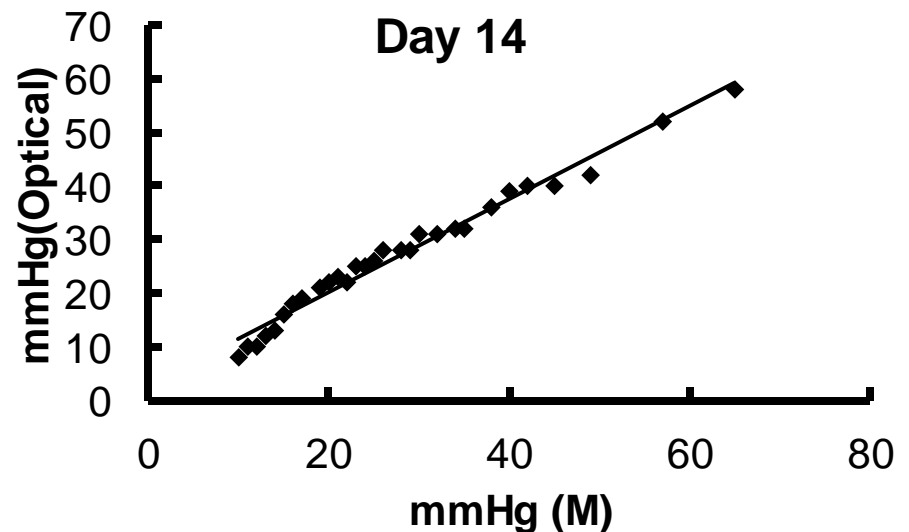
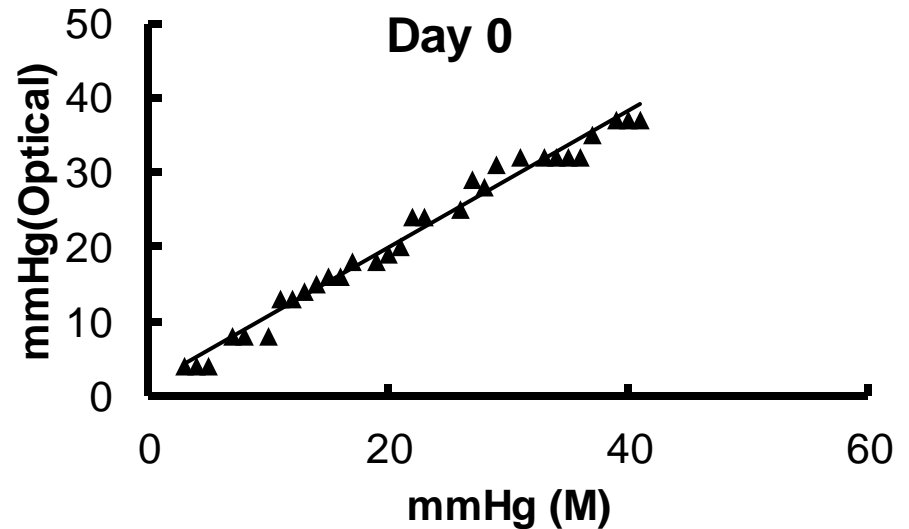


First study: Cadaver eyes

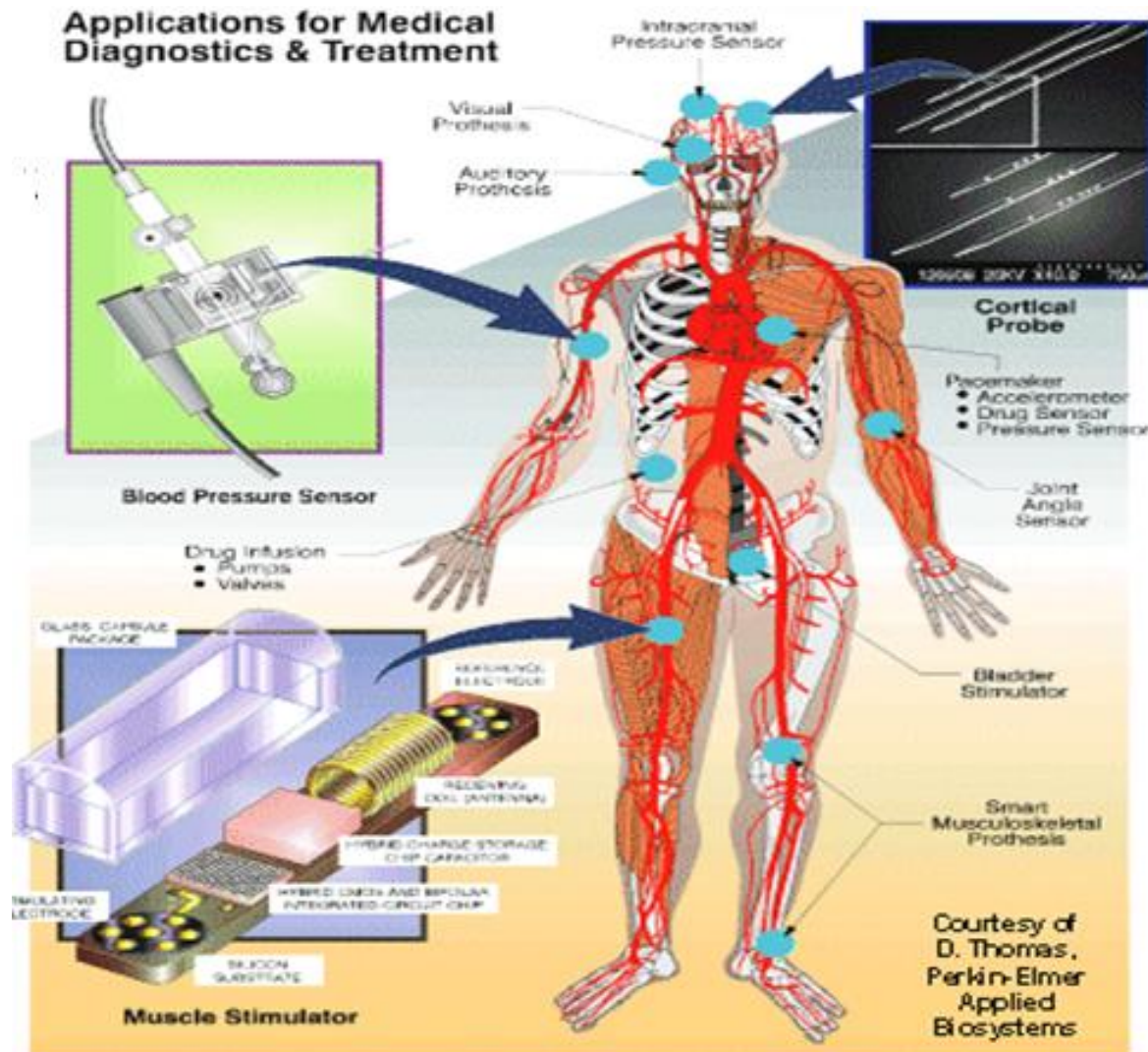
1. We integrated the sensor into a Keratoprosthesis device



2. and implant it into cadaver eyes



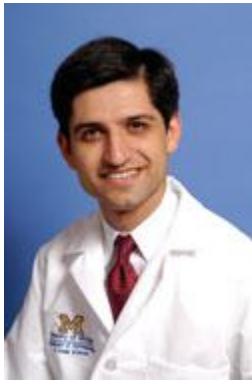
NiFO technology for *in vivo* pressure monitoring



Behind the scene...



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