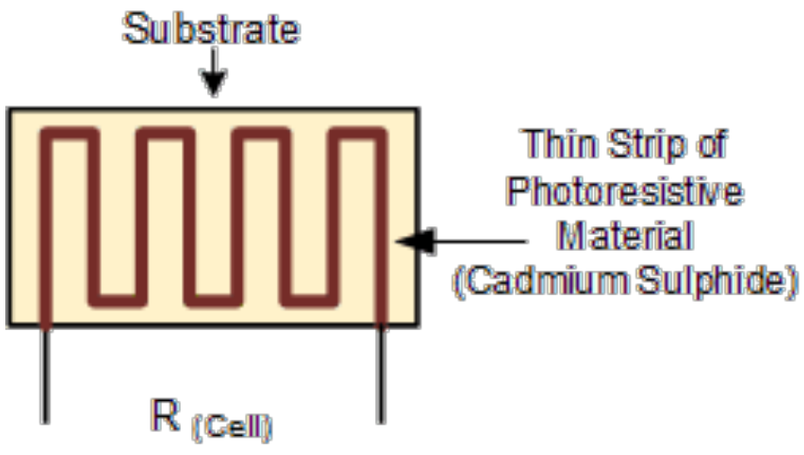
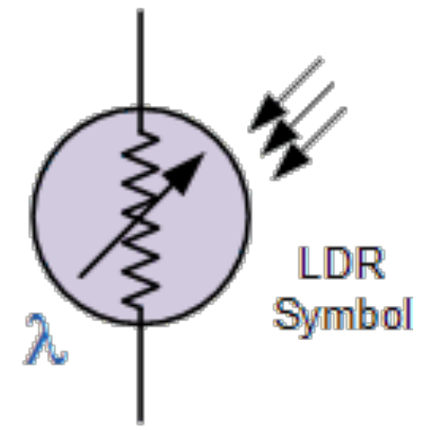
Sensors and Artificial Perception

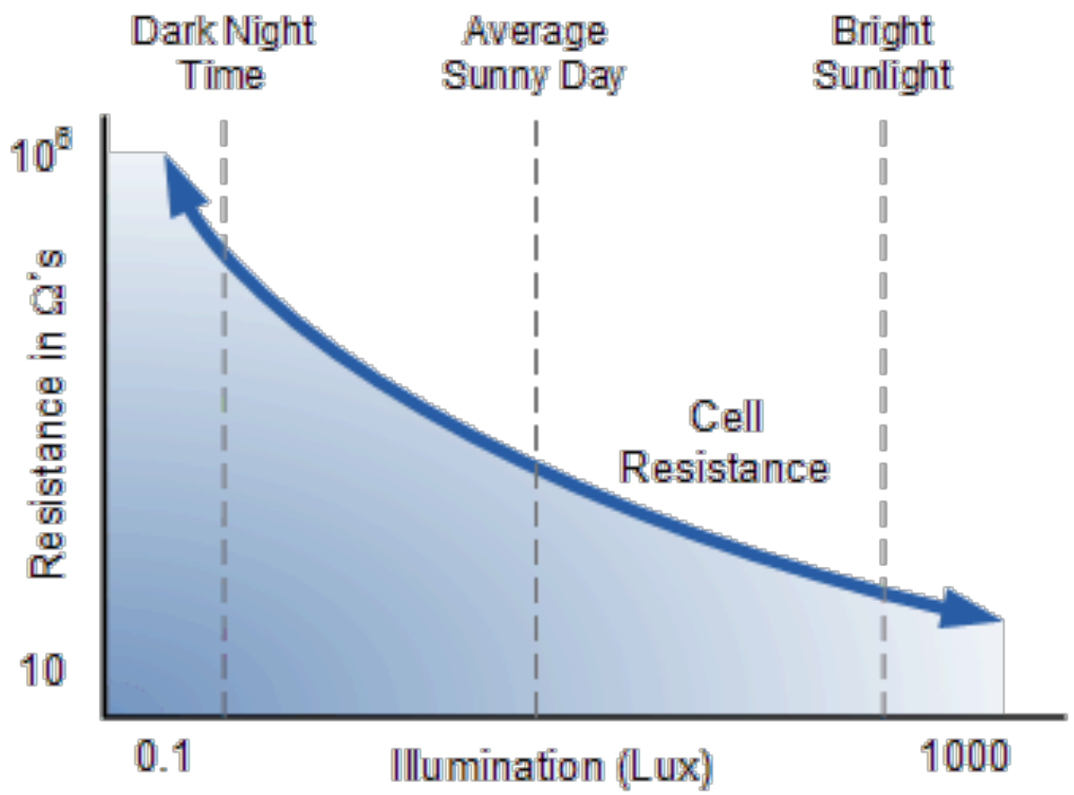
DfPI

What's a sensor?

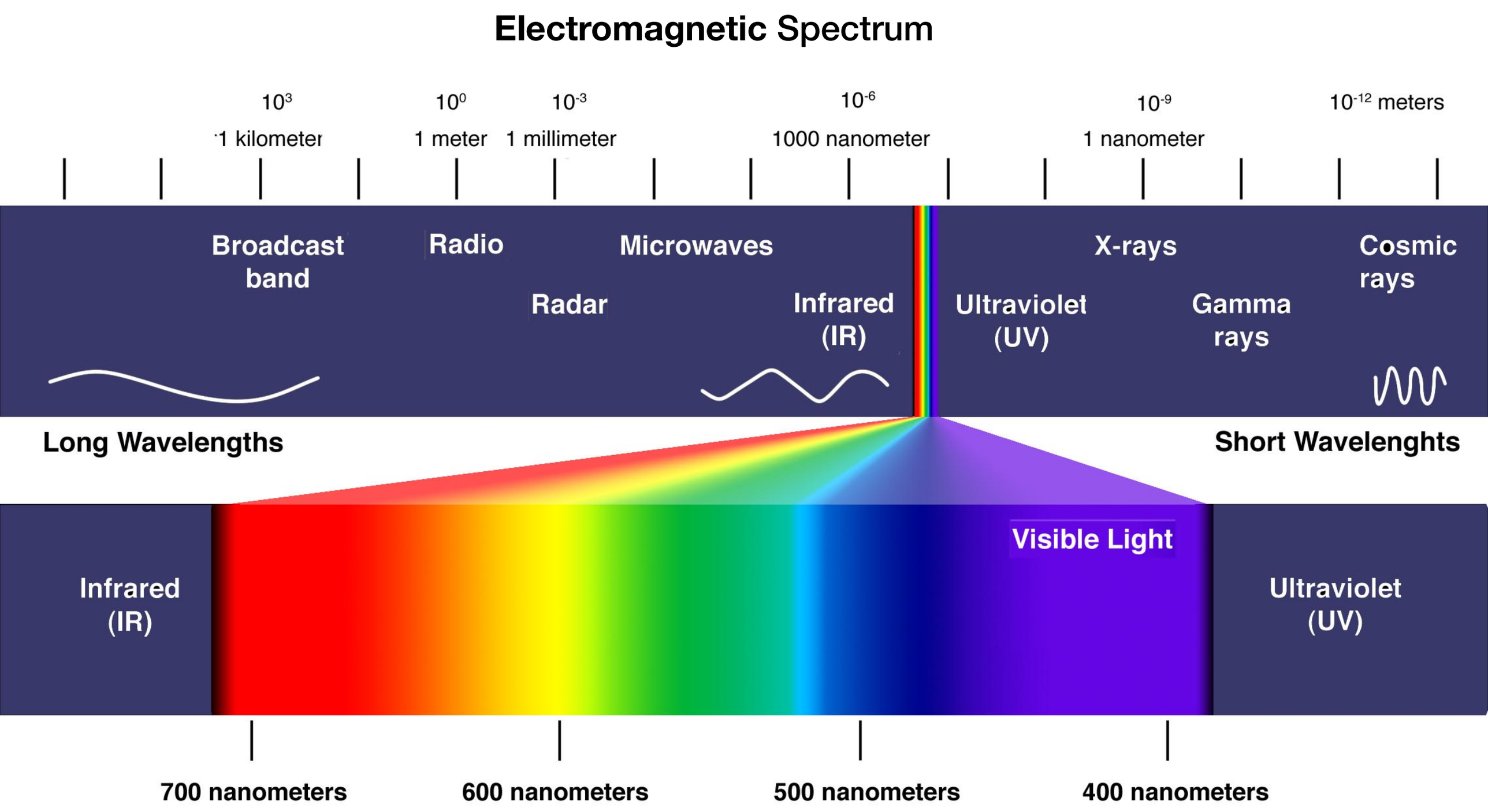
"A device which converts one physical quantity some sort of useful other physical signal" - Sean





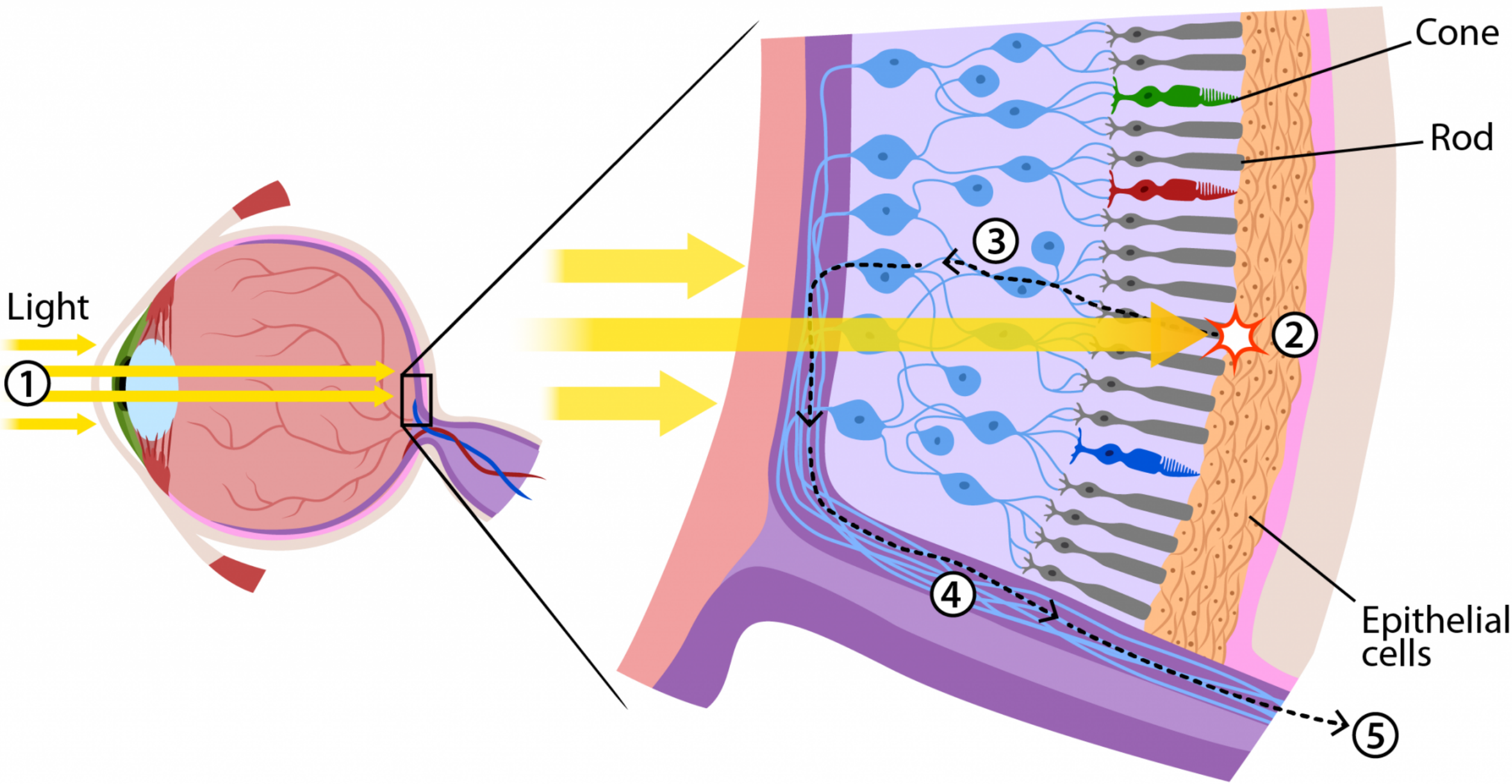


Light Sensing

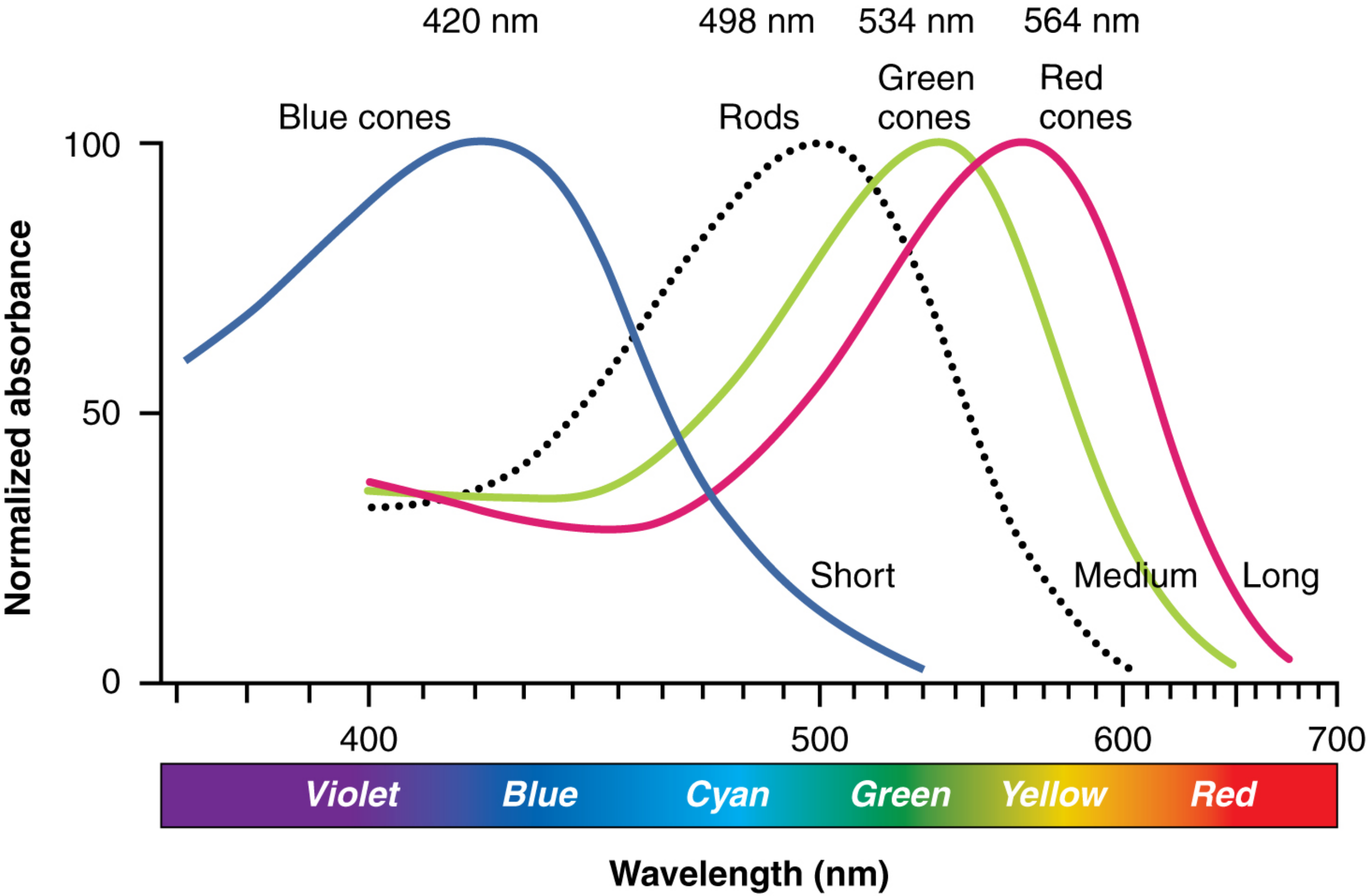


Human Vision

Receives light reflections off surrounding objects to create 3D Map of environment.

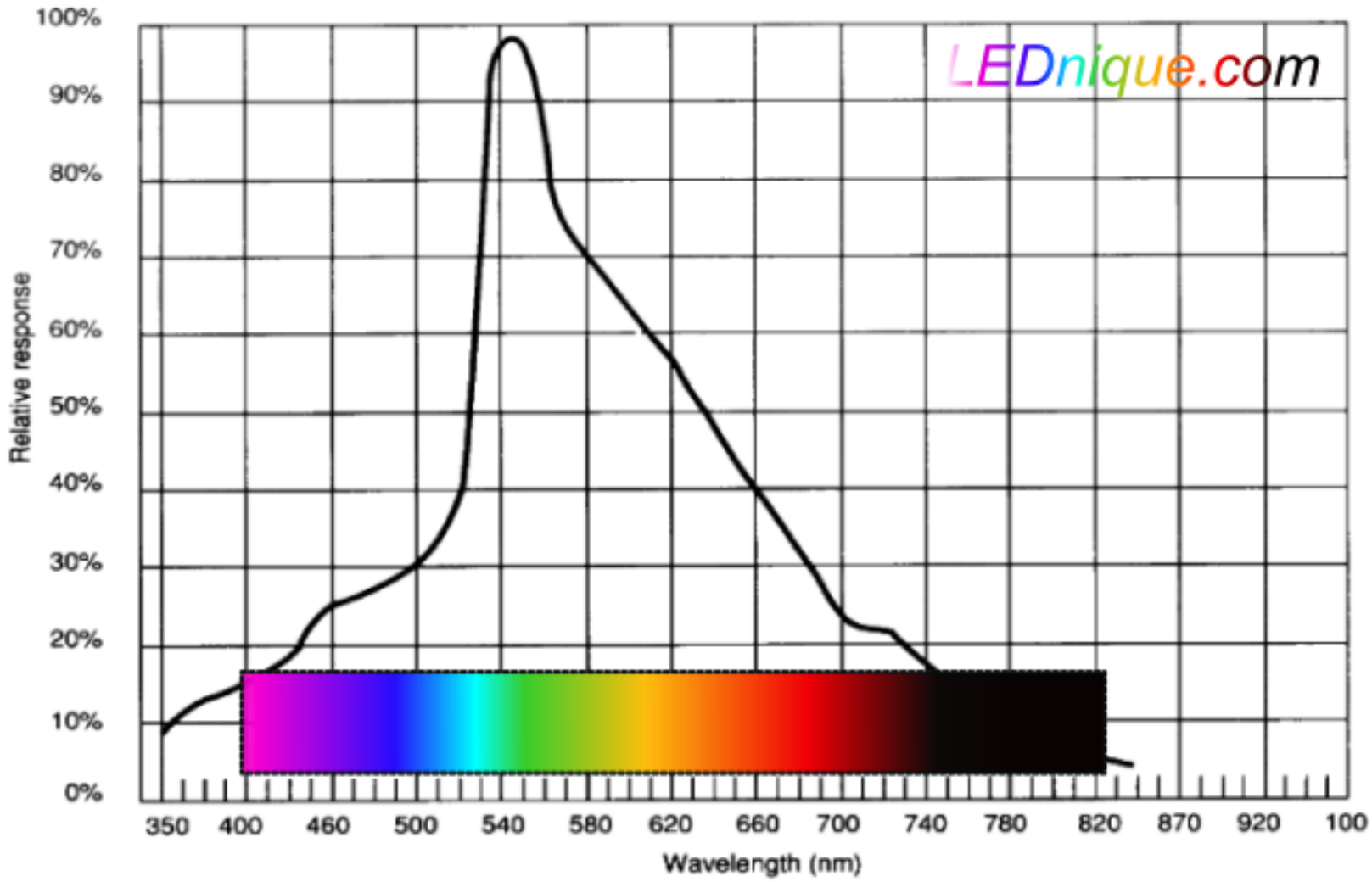


Human Vision



Robot Vision - Light and Colour

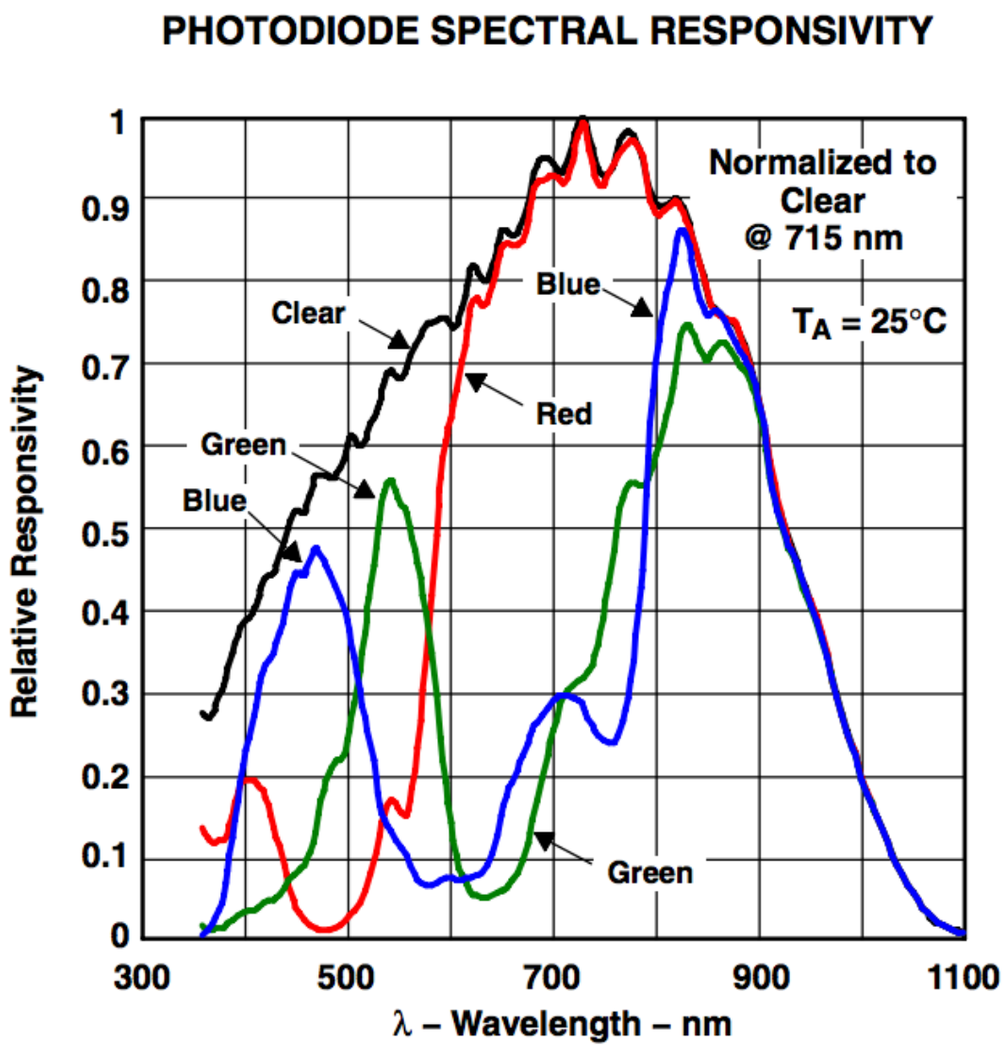
Light intensity - A sensor like an LDR can be used to measure light intensity over the visible spectrum. This sensor cannot however definitively differentiate colour.



IMPORTANT TO READ DATASHEET!

Robot Vision - Light and Colour

Light Colour - RGB colour sensors are also easily available to use with your micro controller.

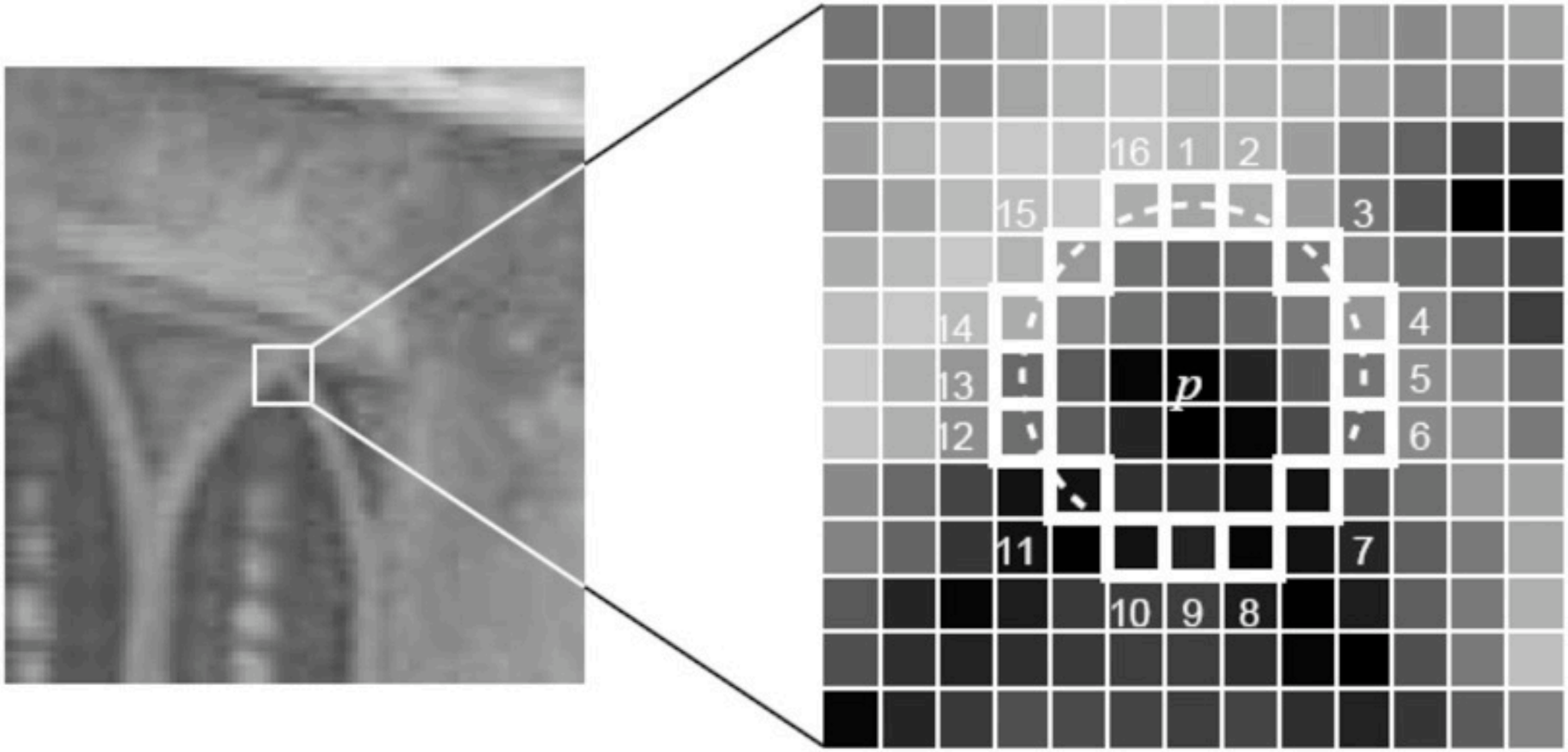


Robot Vision - Image

Images can be constructed with a number of integrated optical sensors, forming something like a CMOS sensor.

Robot Vision - Image

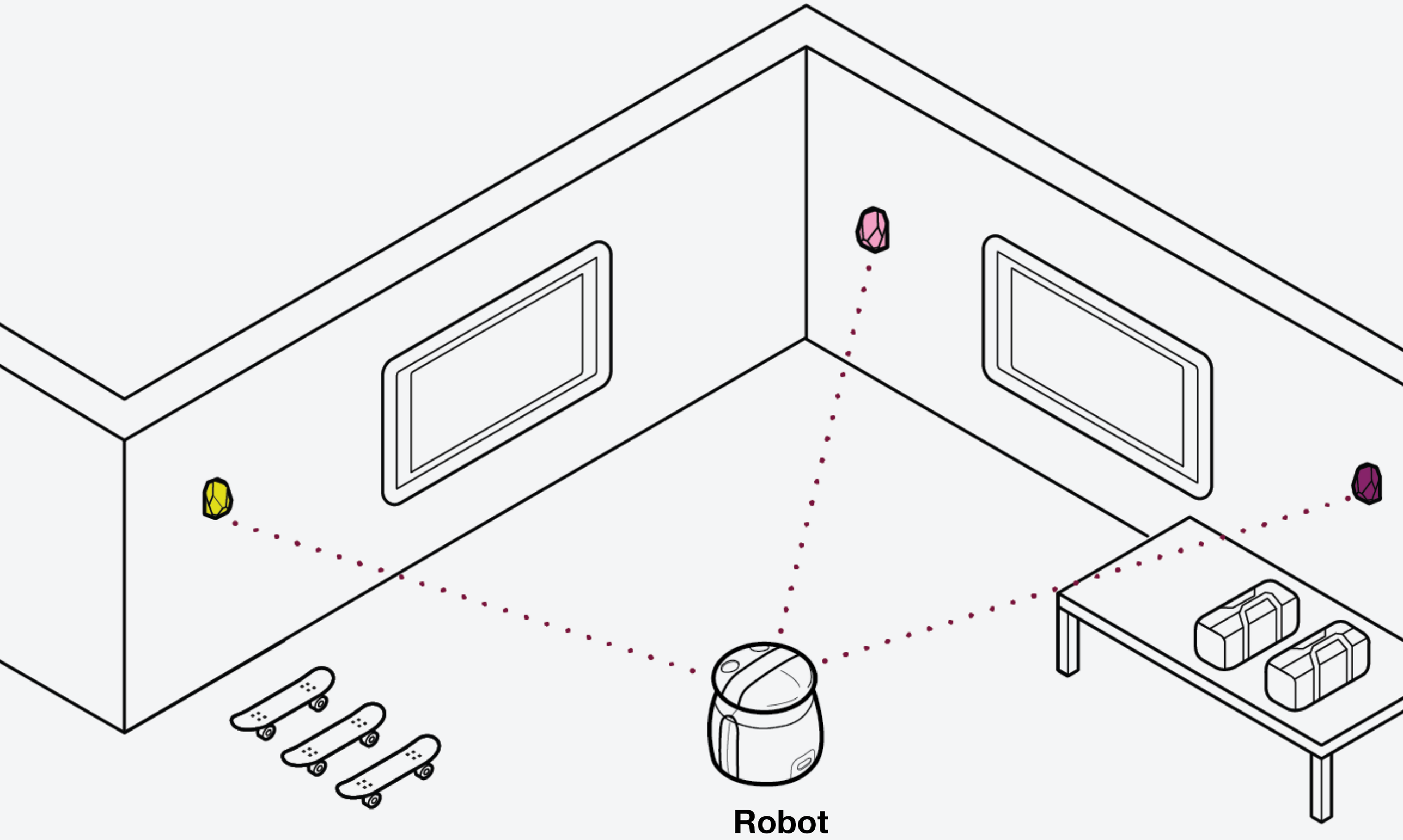
Computer vision algorithms become super complicated, the moment you want to do something useful. They are also extremely computationally expensive.



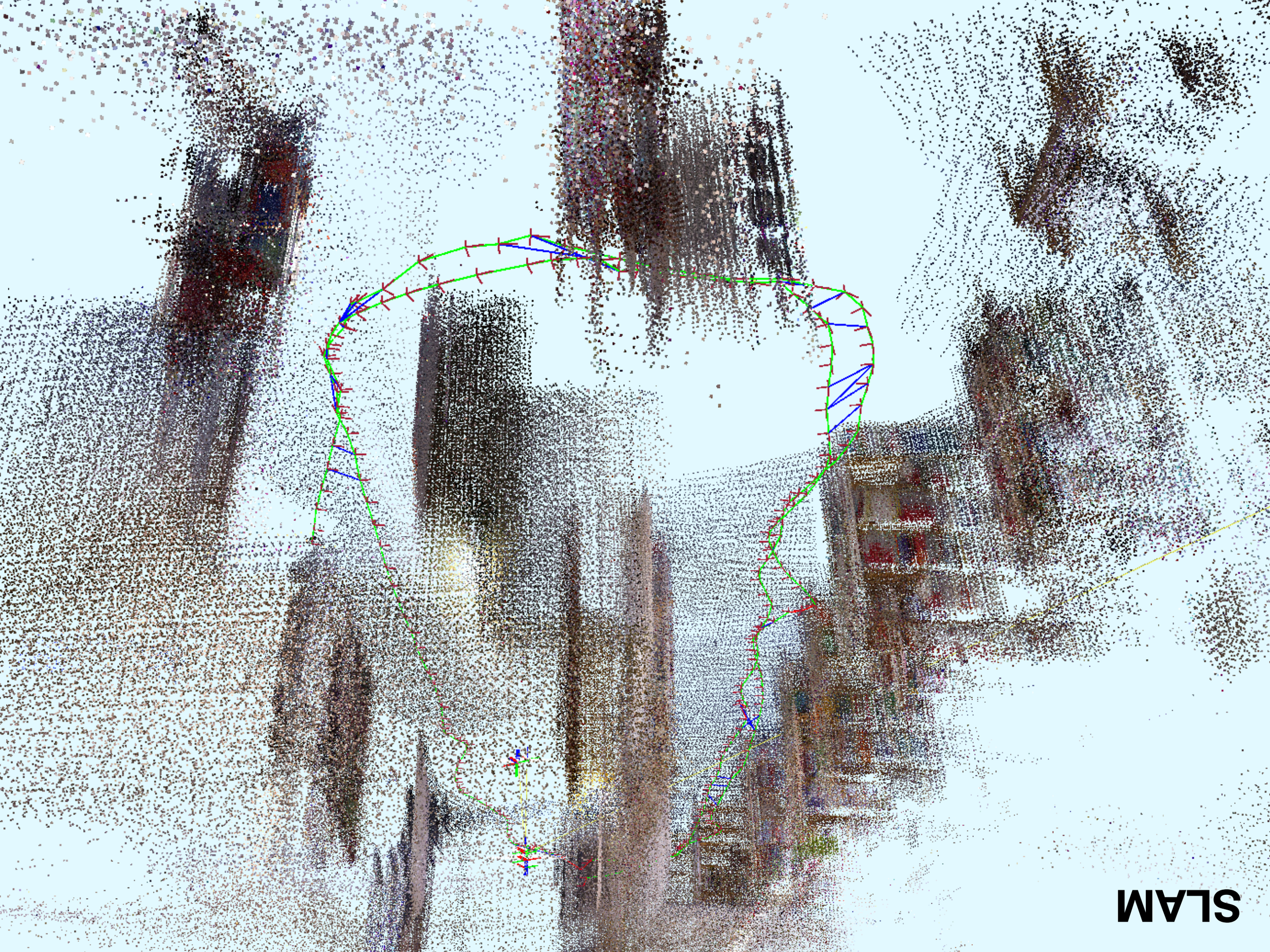
Could an Arduino crunch these numbers?

Spatial Awareness

How can a robot be spatially aware.

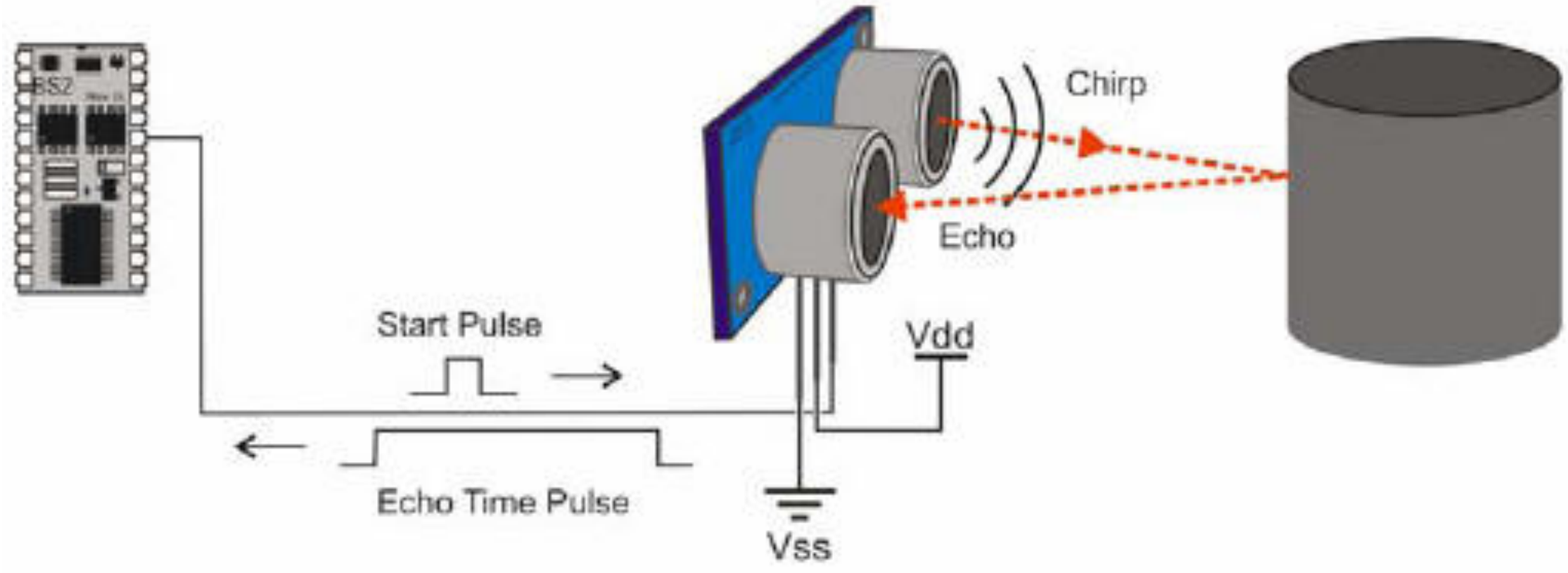


Robot


SLAM

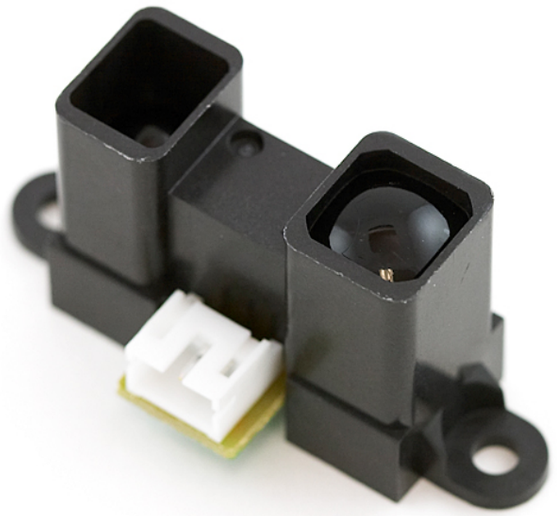
Proximity **Sensing**

- **Ultrasonic proximity** works by sending a pulse of ultrasound, then awaits a response measuring the time of flight.

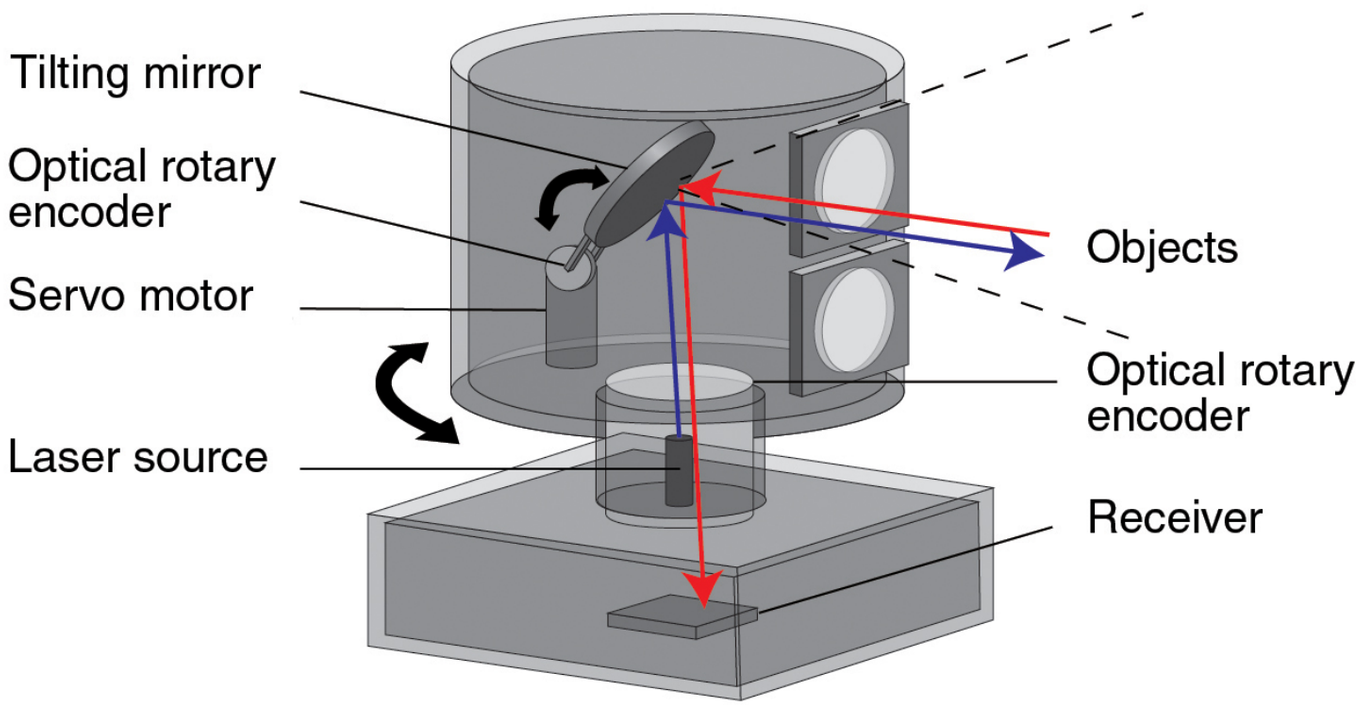


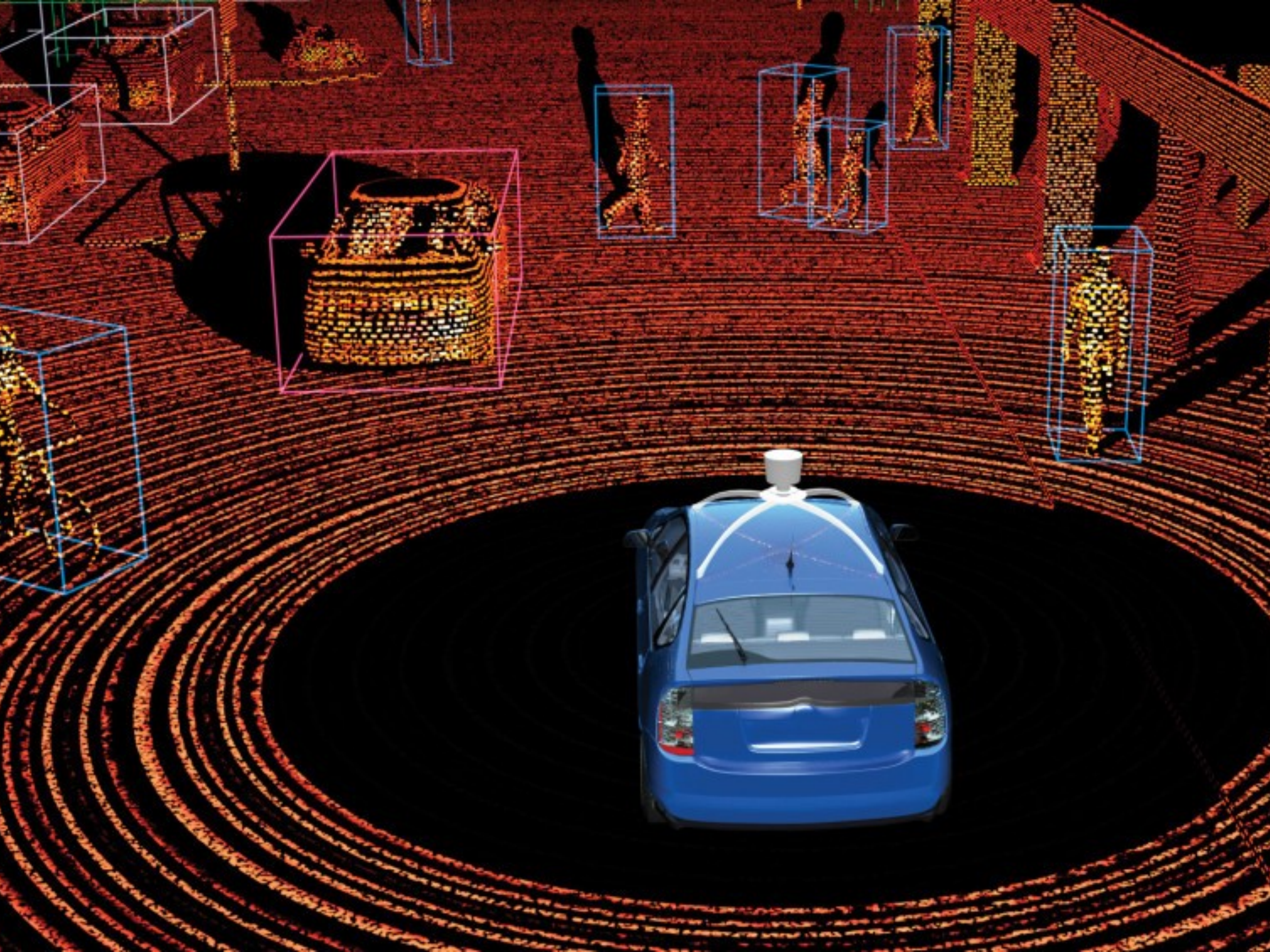
Proximity **Sensing**

- **Infrared proximity** Sends a pulse of infrared light, and approximates the distance from the intensity of reflected light.



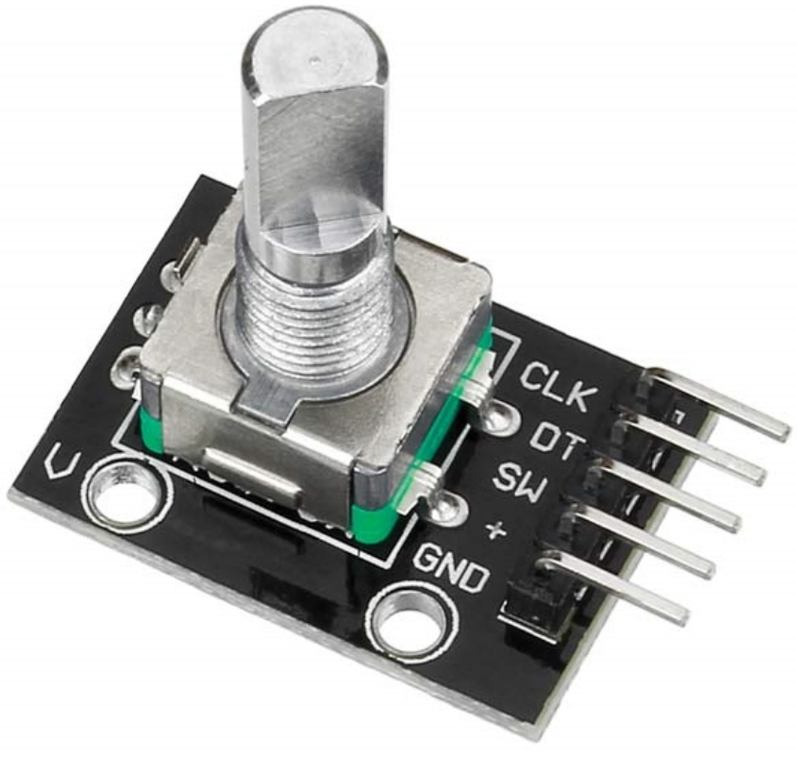
- **Lidar Proximity** Sends a pulse of laser light, and approximates the distance.





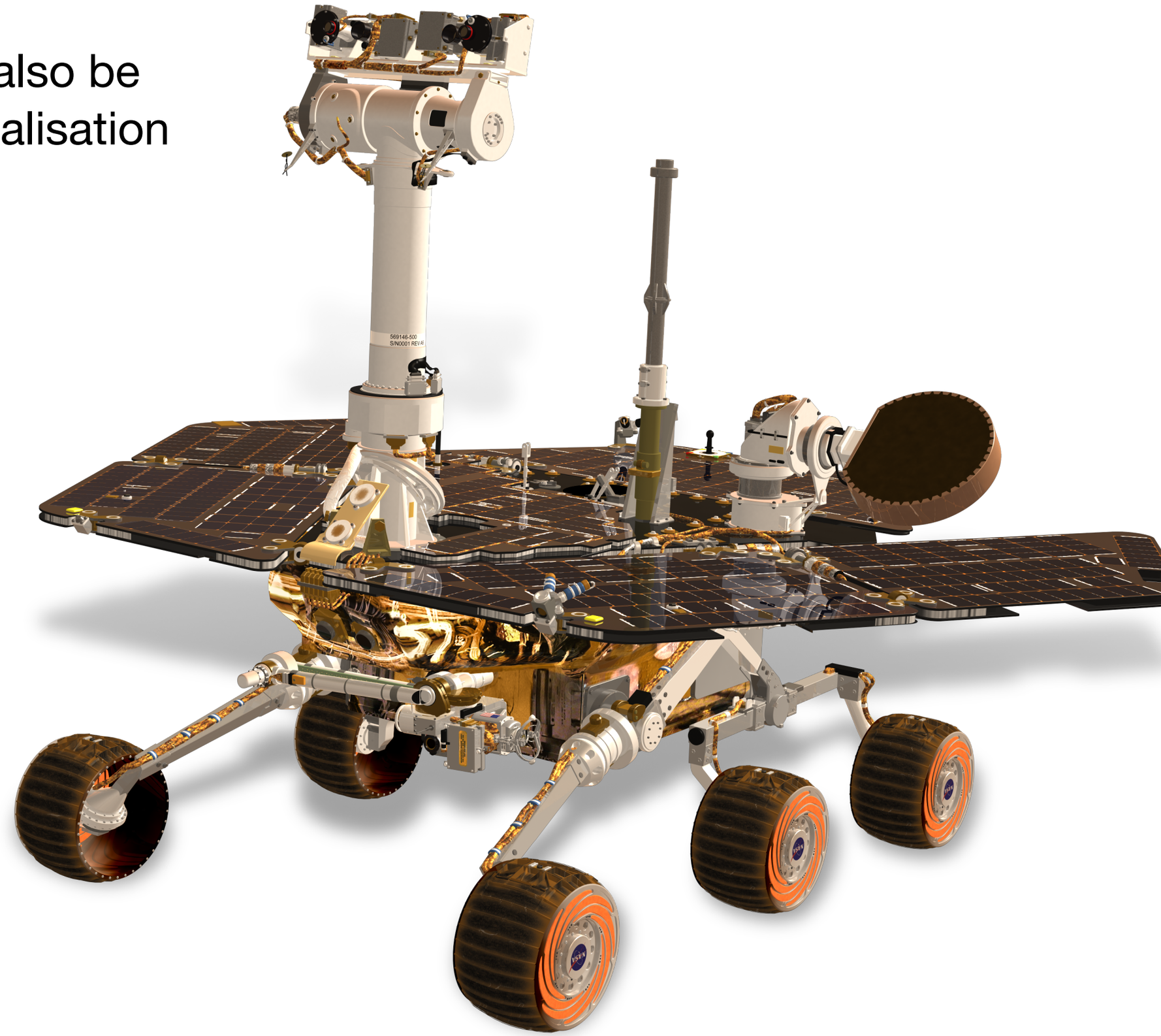
Rotational **Sensing**

Rotary Encoders are an electrical device which convert rotation in degrees to a useful electrical signal.



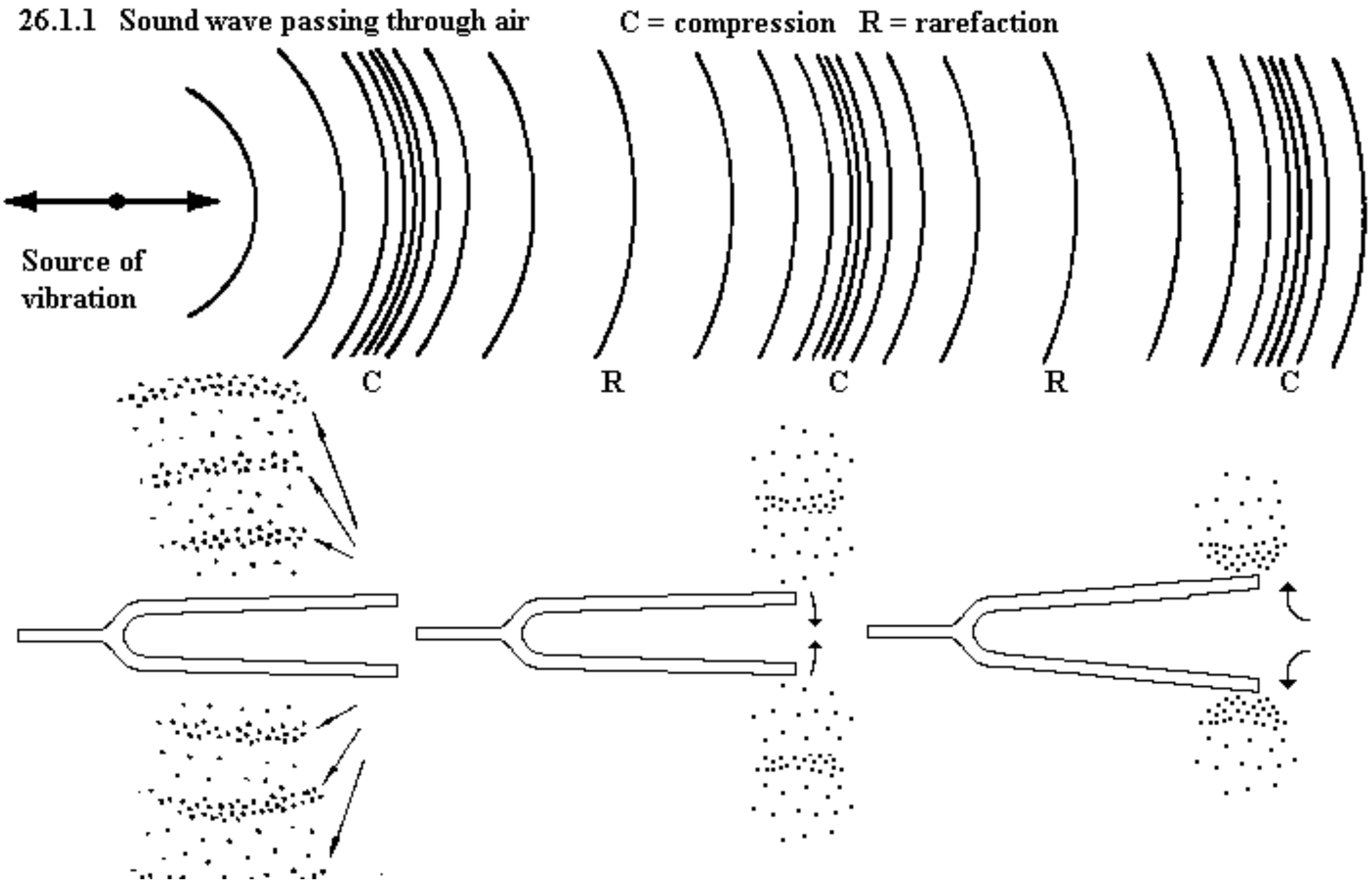
Rotational **Sensing**

Rotary Encoders can also be extremely useful for localisation and positioning



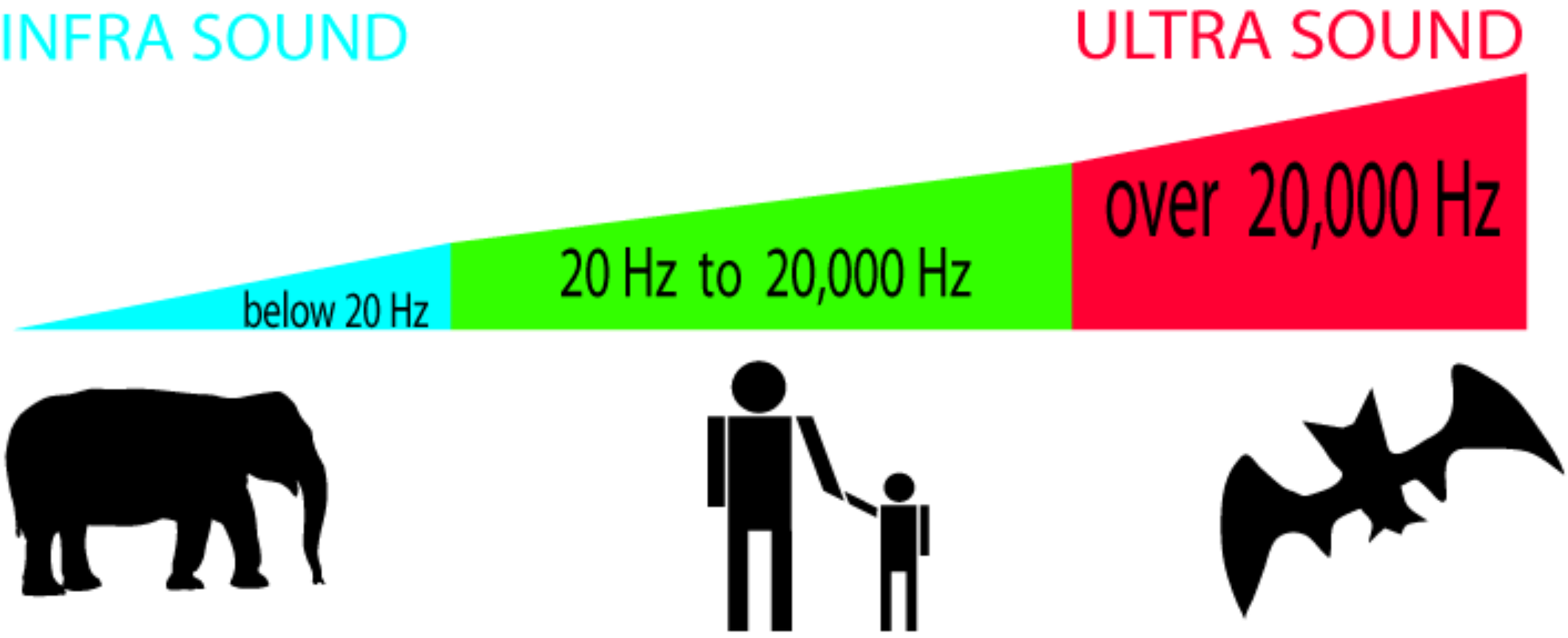
Sound **Sensing**

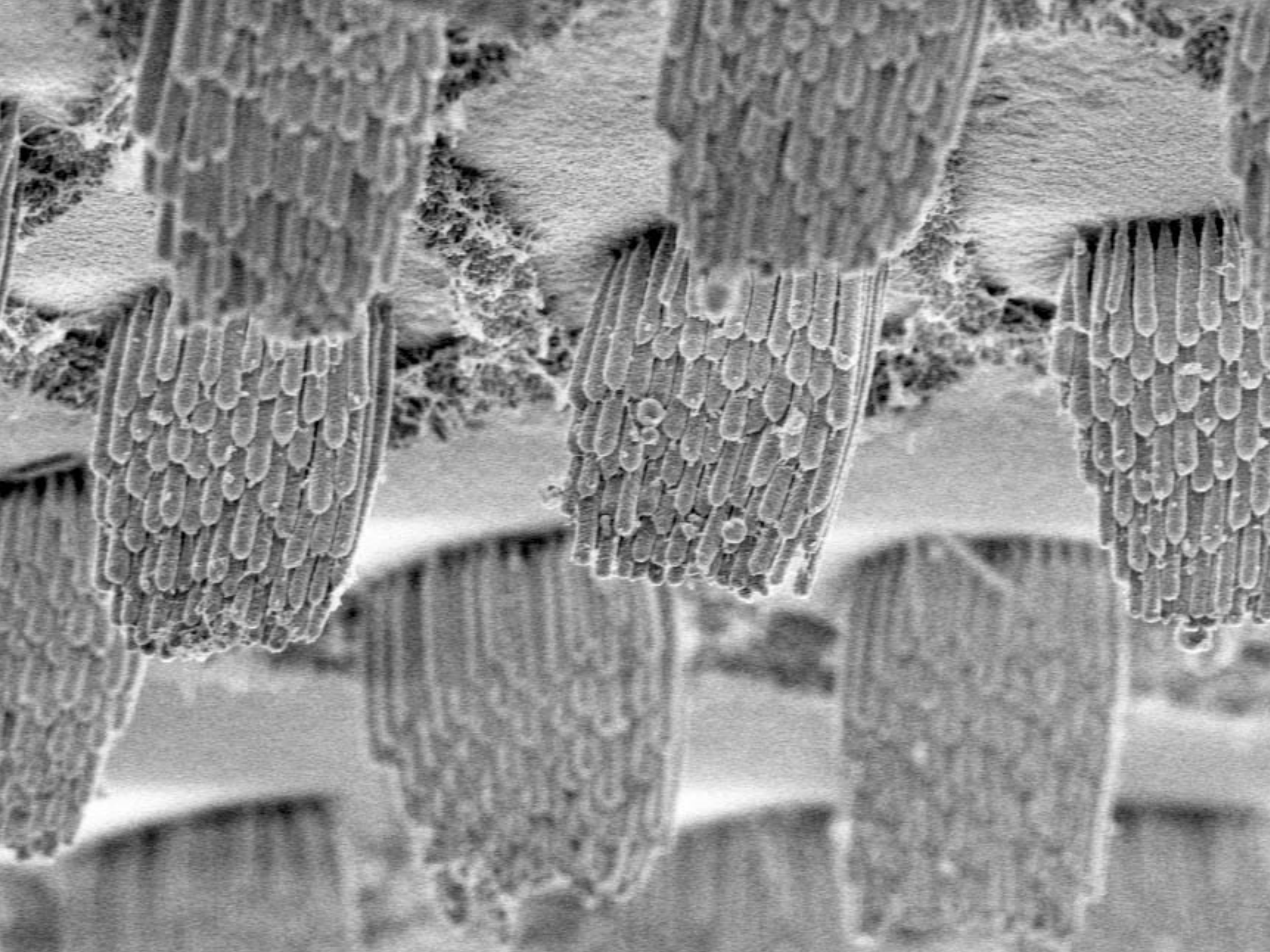
Sensing sound involves the detection of acoustic vibration.



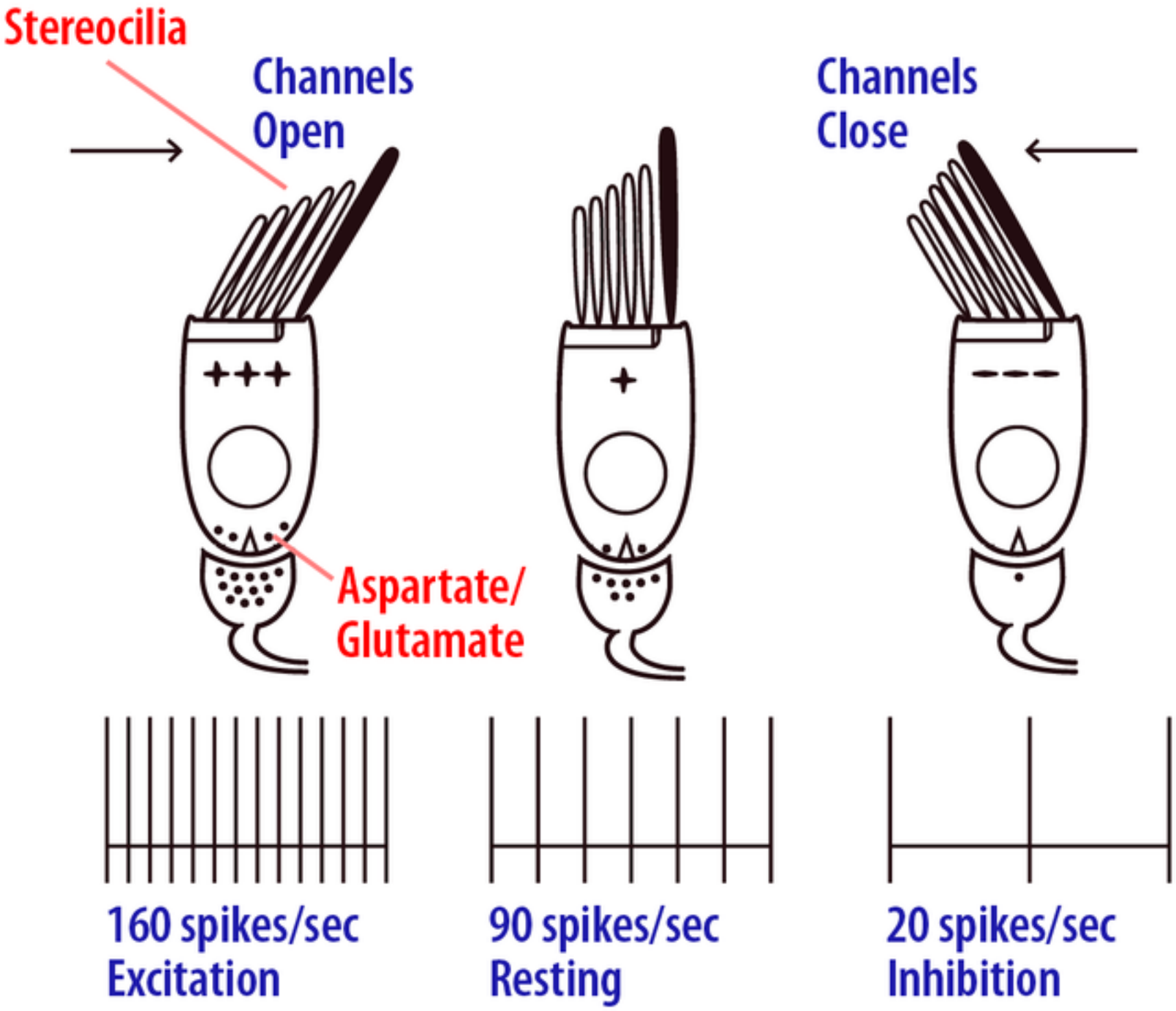
Human Hearing

Humans can sense acoustic vibrations in within the range of 20Hz to 20kHz.



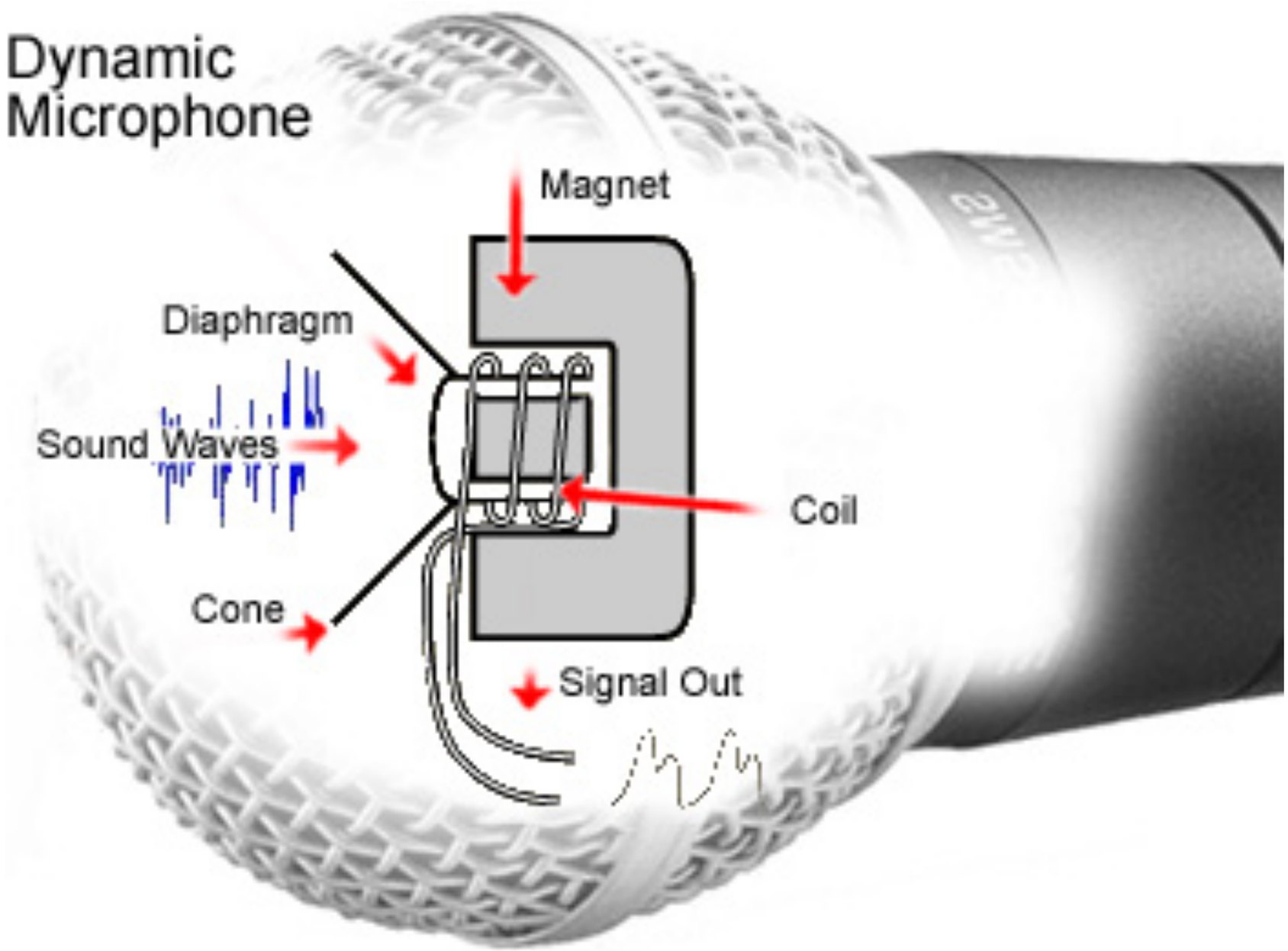


Ear Hair **Mechanics**



Sound **Sensing**

Microphones are the electrical equivalent of the ear, however microphones can be tuned to be sensitive to acoustic vibration far greater than the rang of the human ear.



Temperature

Temperature sensors can convert **thermal energy** to a change in voltage. You can determine from the data-sheet the expected change in **electrical signal** for a given change in temperature.

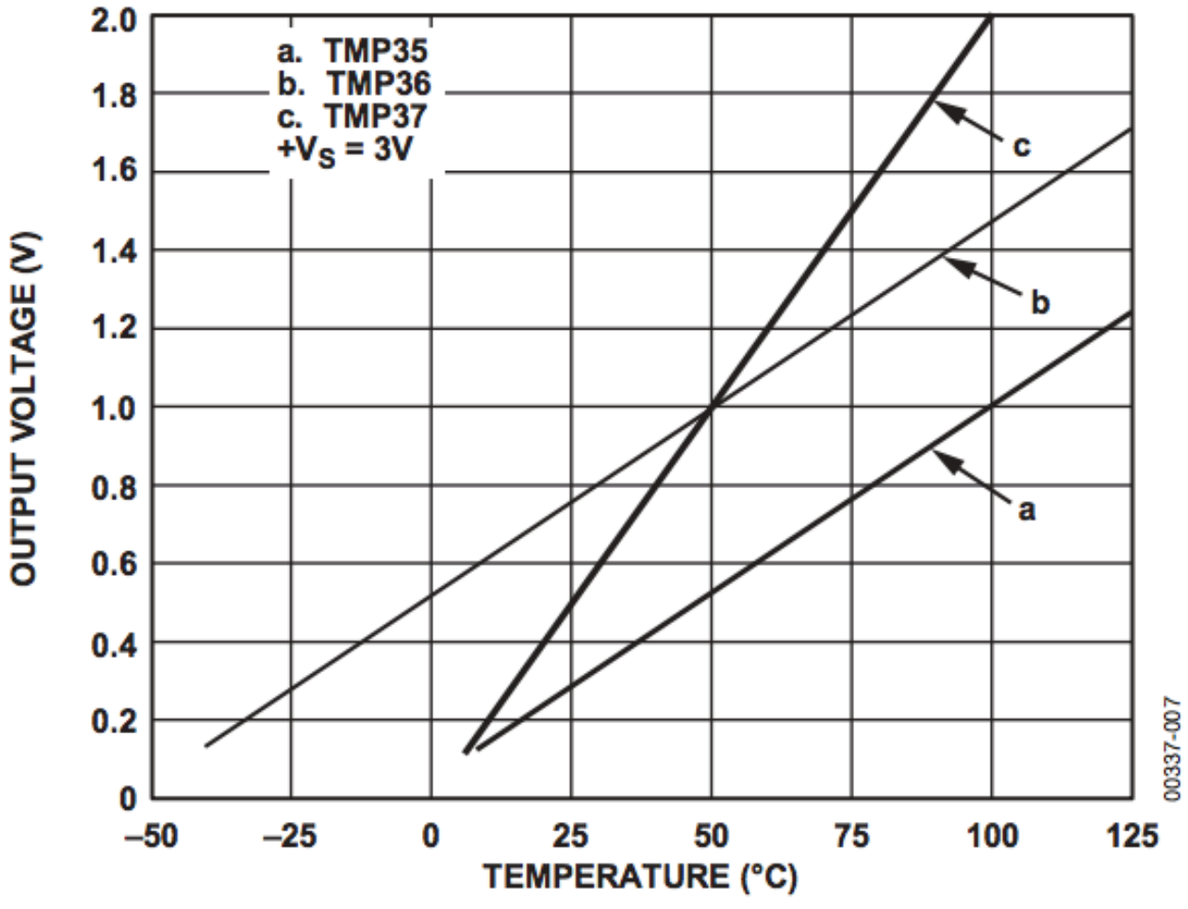
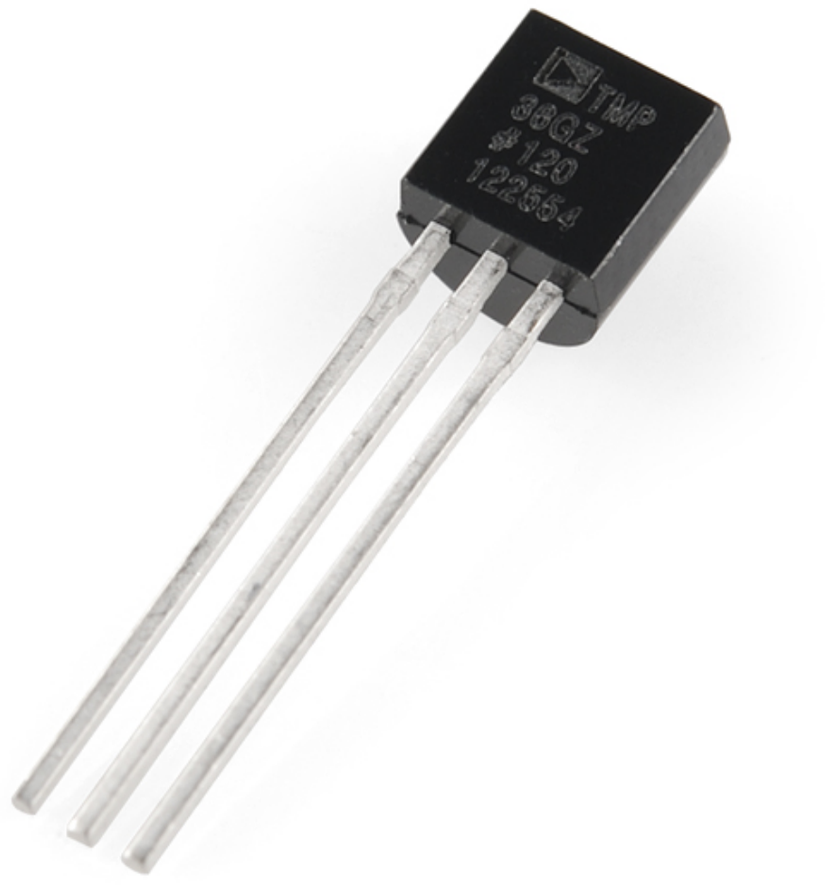


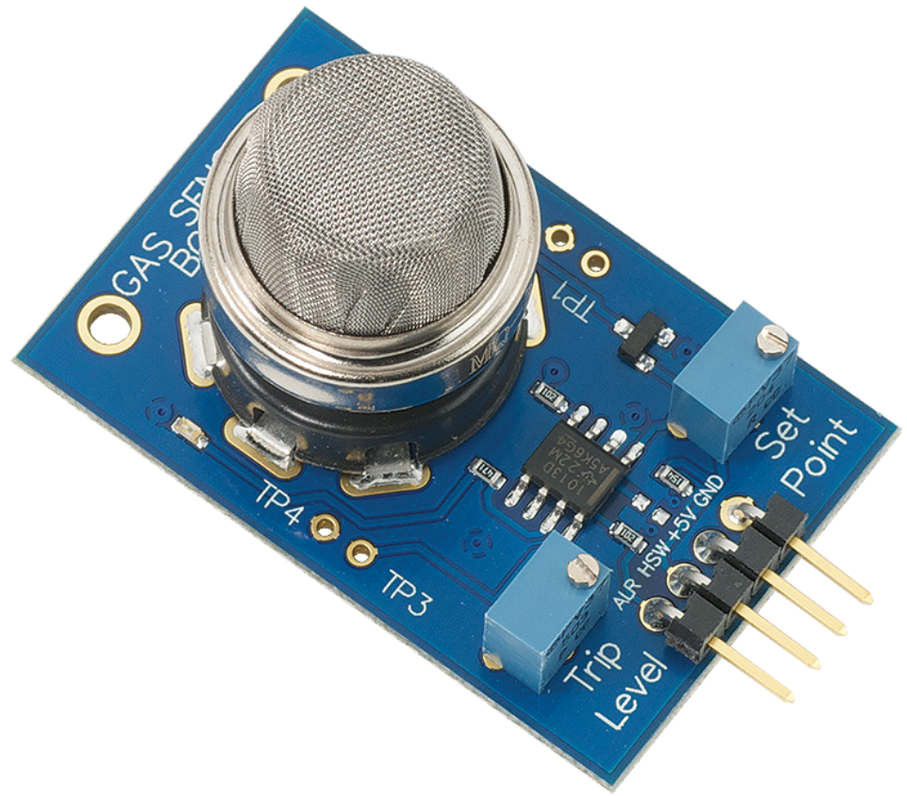
Figure 6. Output Voltage vs. Temperature



Gas

Sensors able to detect the concentration of various types of gaseous matter, and convert this into an electrical signal. Usually tuned to a specific gas.

- CO2
- Smoke
- Alcohol
- Flammable gas
- Taste/Odour
- ect…



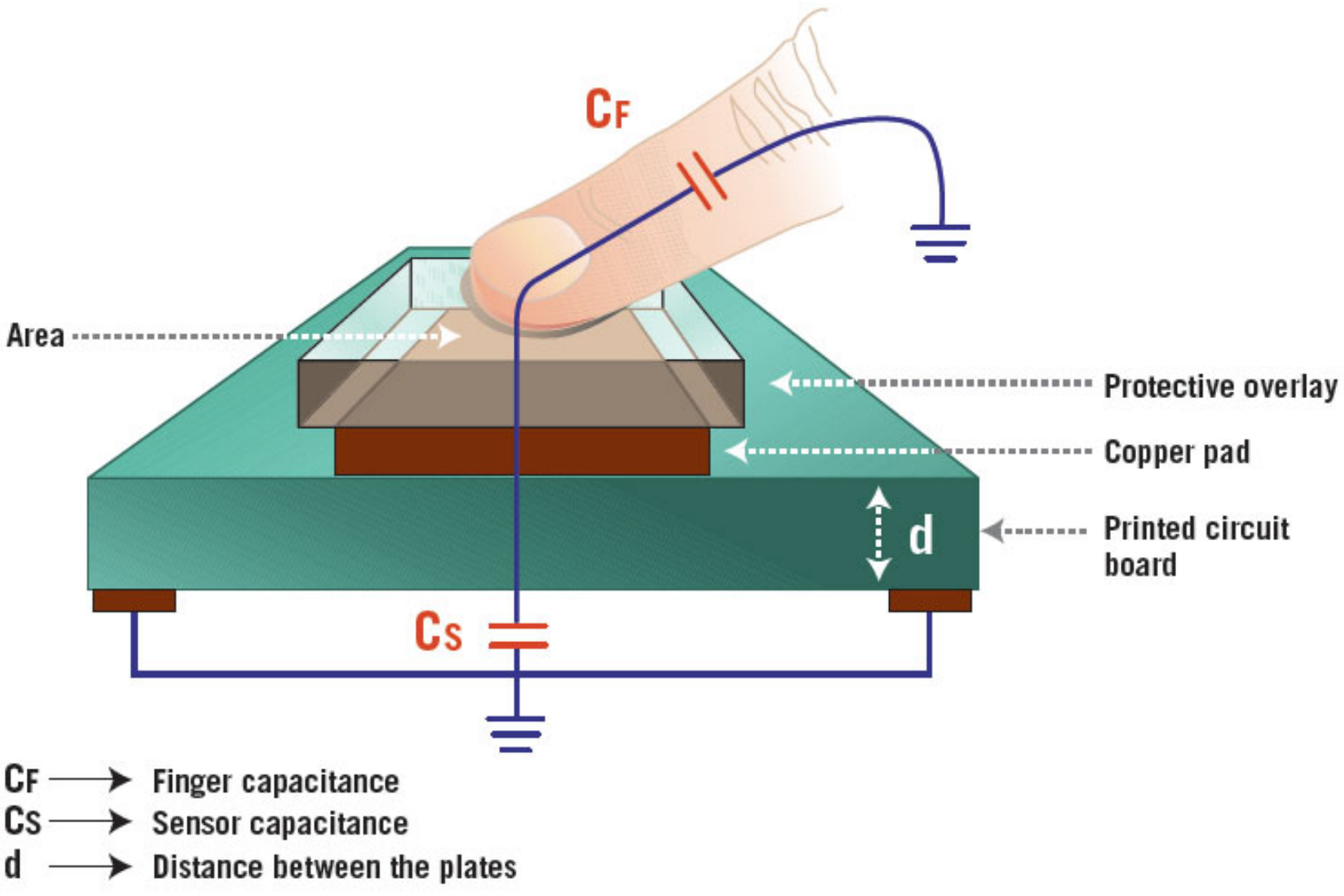
Touch - Mechanical

Mechanical touch sensing can be achieved through the use of a simple button/switch.

Touch - Capacitive

Capacitive touch sensing measures the change in capacitance on a surface when touched.

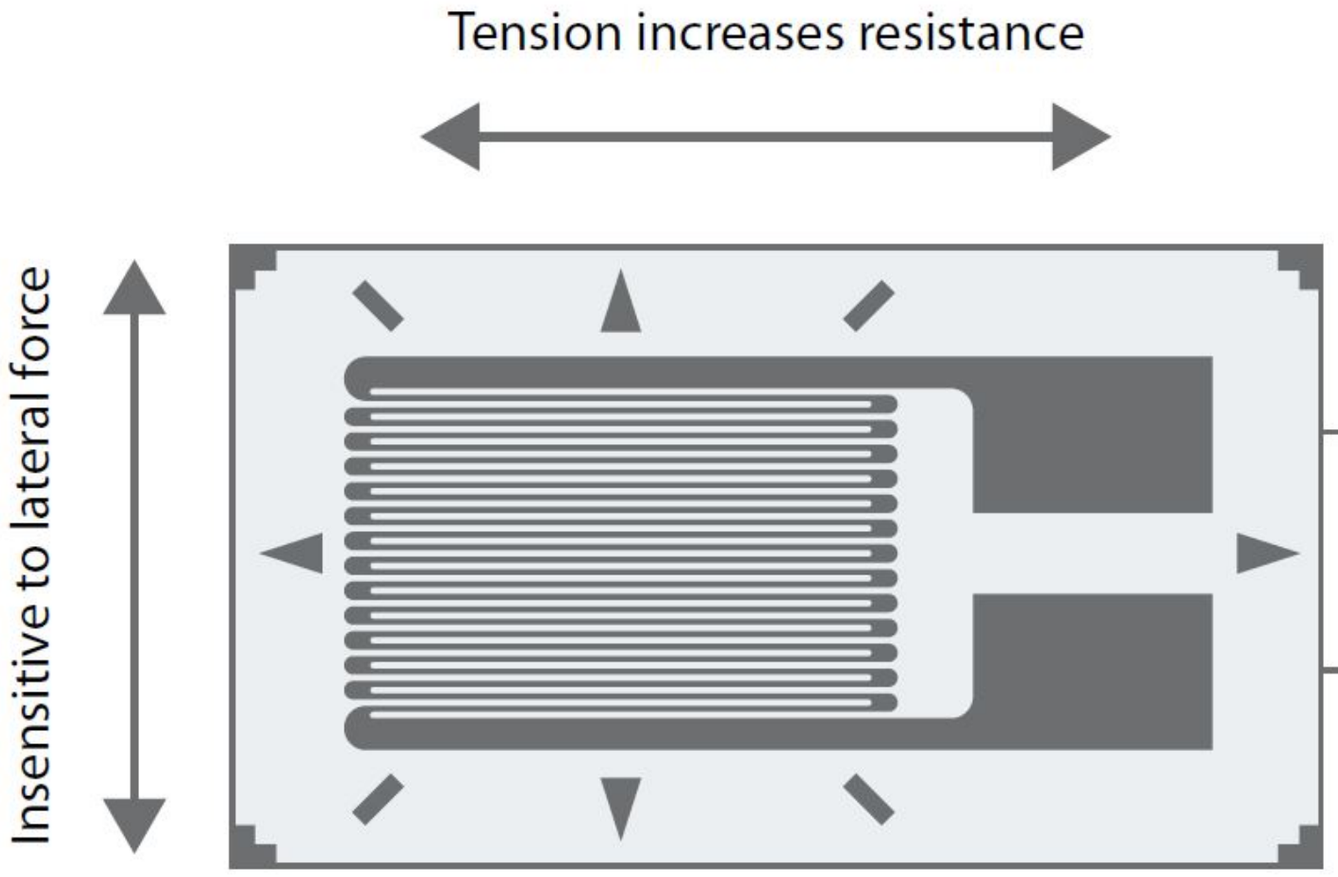
The principles of capacitive touch sensing.



CF → Finger capacitance
Cs → Sensor capacitance
d → Distance between the plates

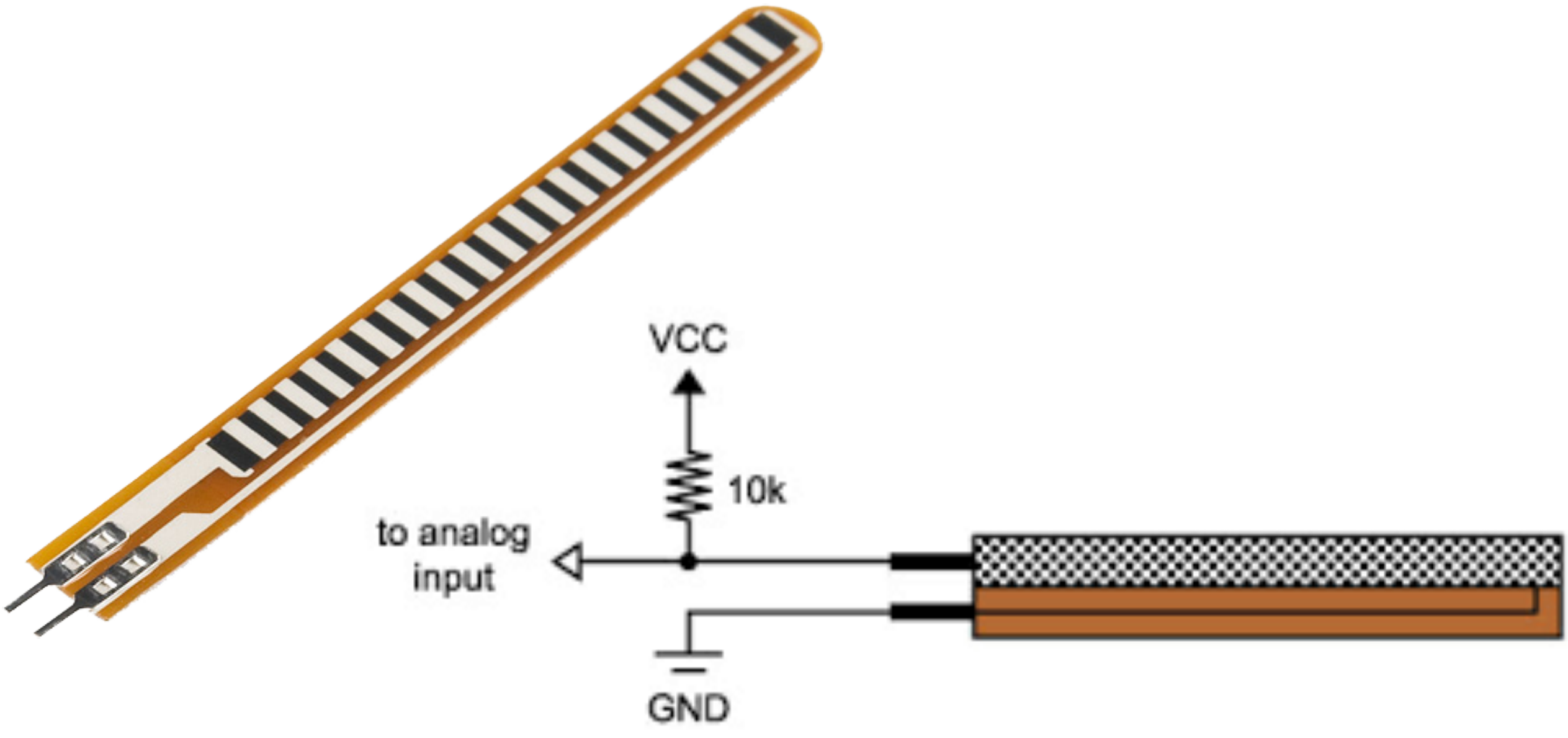
Force

Strain gauges/force sensing devices are able to measure exerted force. They do so by varying resistance under load.



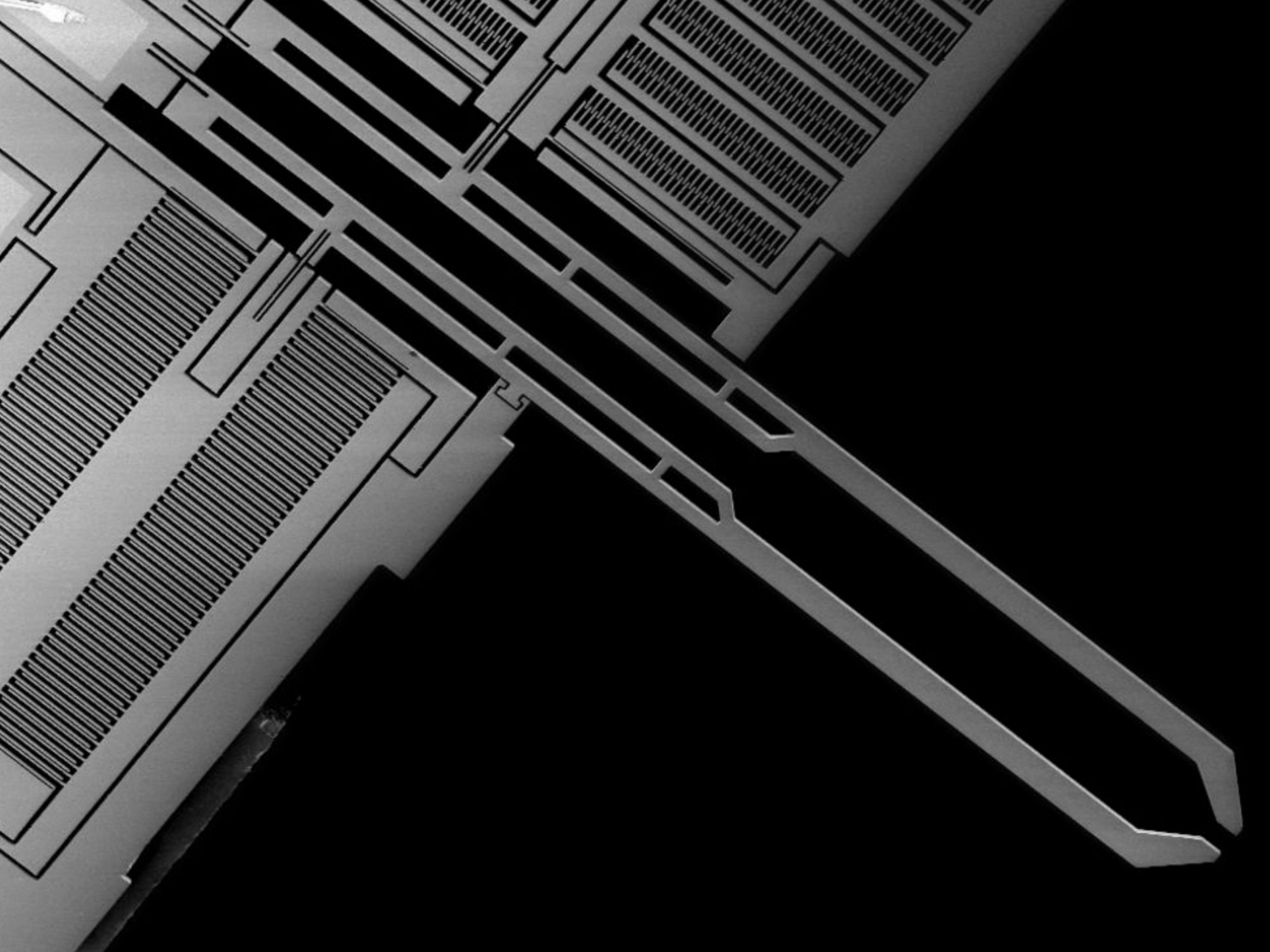
Flex Sensors

Flex sensors are devices which convert flex into a change in resistance. These can be really useful for wearable devices, or close proximity object detection.



Force feedback

Force feedback is extremely useful for allowing robots to **perceive** how much force they are exerting.



20kV X18 1mm

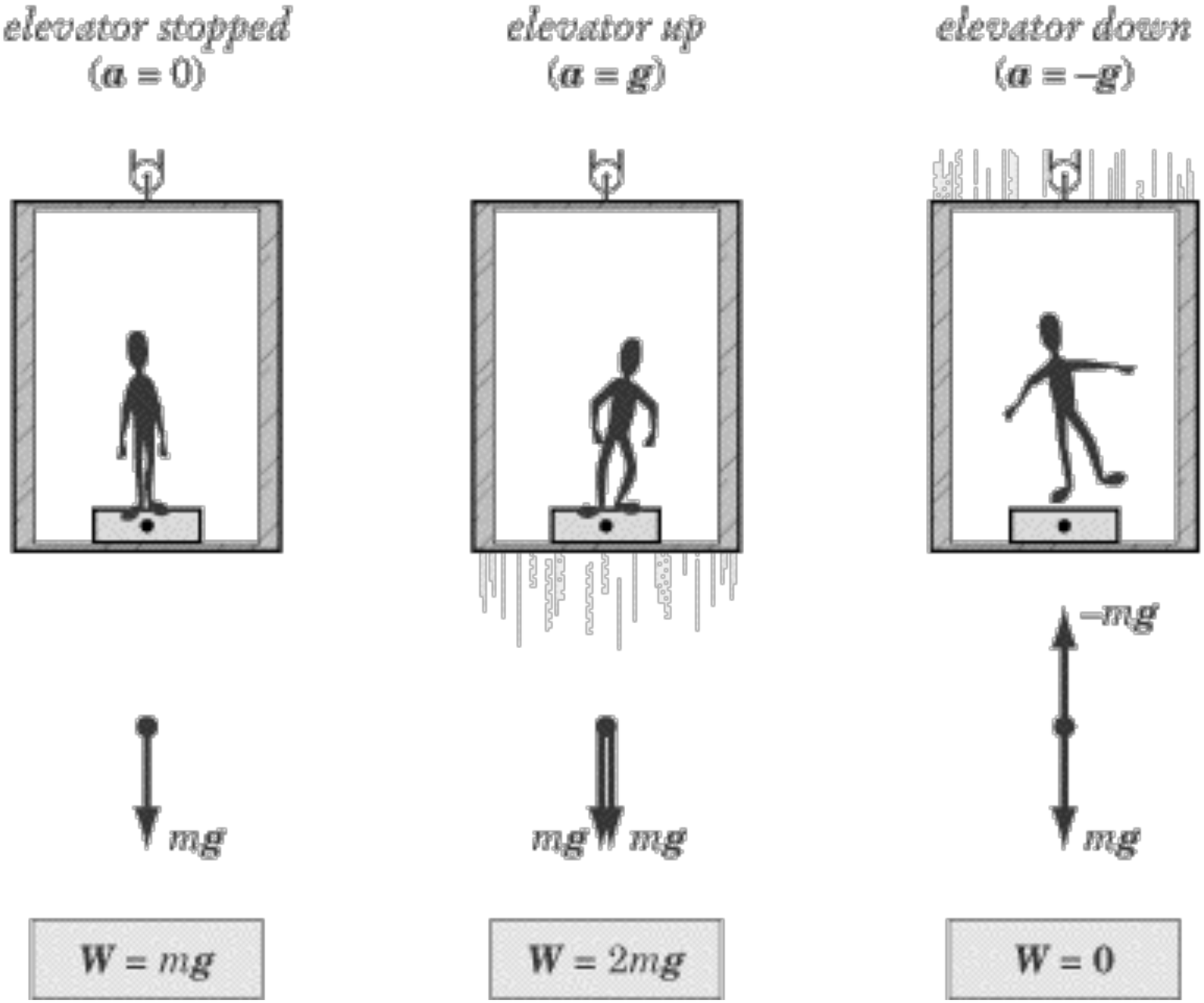
150µm

biological cell

How do drones stabilise?

Inertial Measurement

Inertial measurement is about detecting a change in angular or linear acceleration.



Vestibular System

Two classes of sensory subsystems:

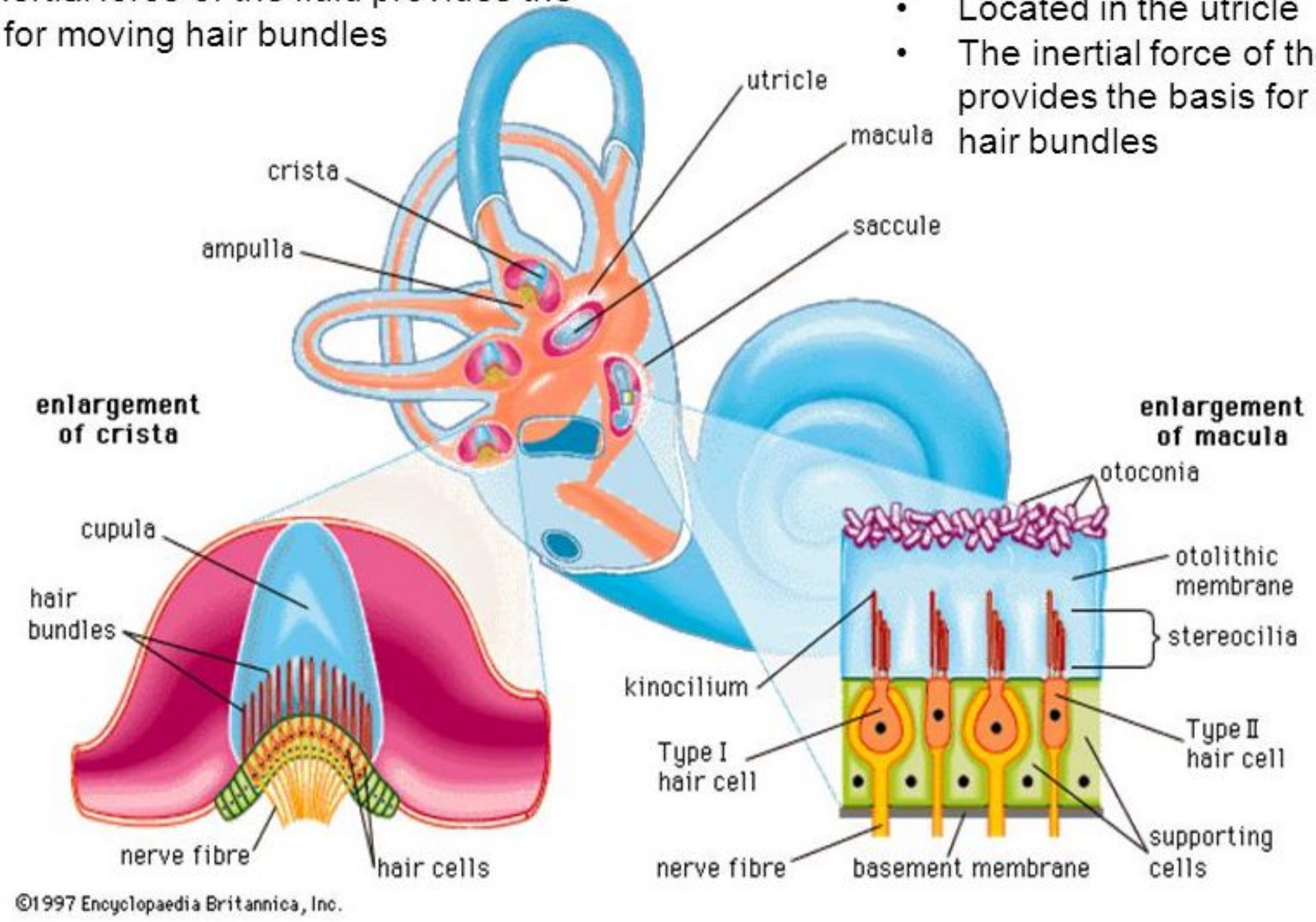
3 crista: encode angular acceleration

- Located in the ampulla at the terminus of each of 3 fluid-filled semi circular canals
- The inertial force of the fluid provides the basis for moving hair bundles

Otolith organs: encode linear acceleration

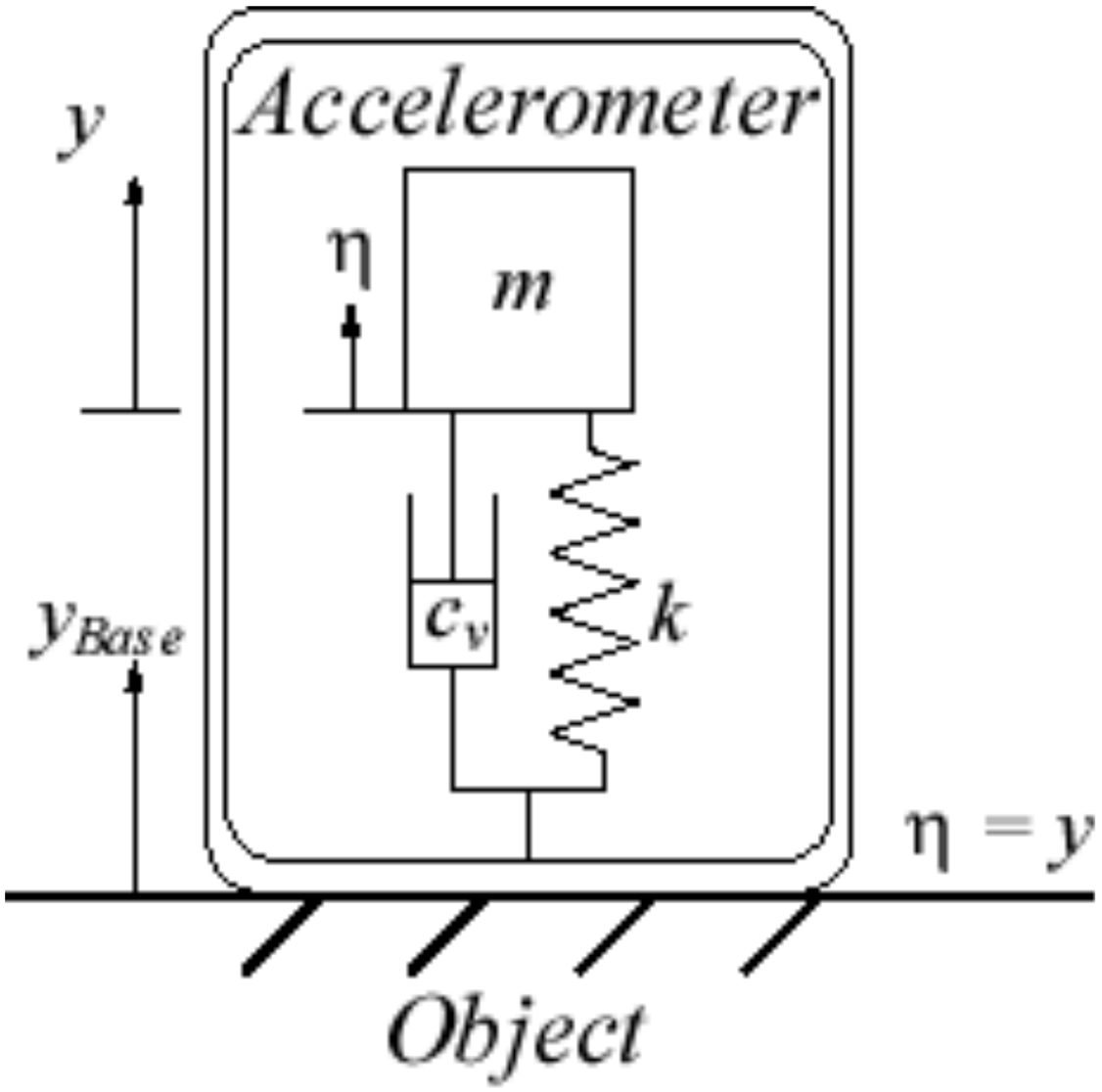
Two types:

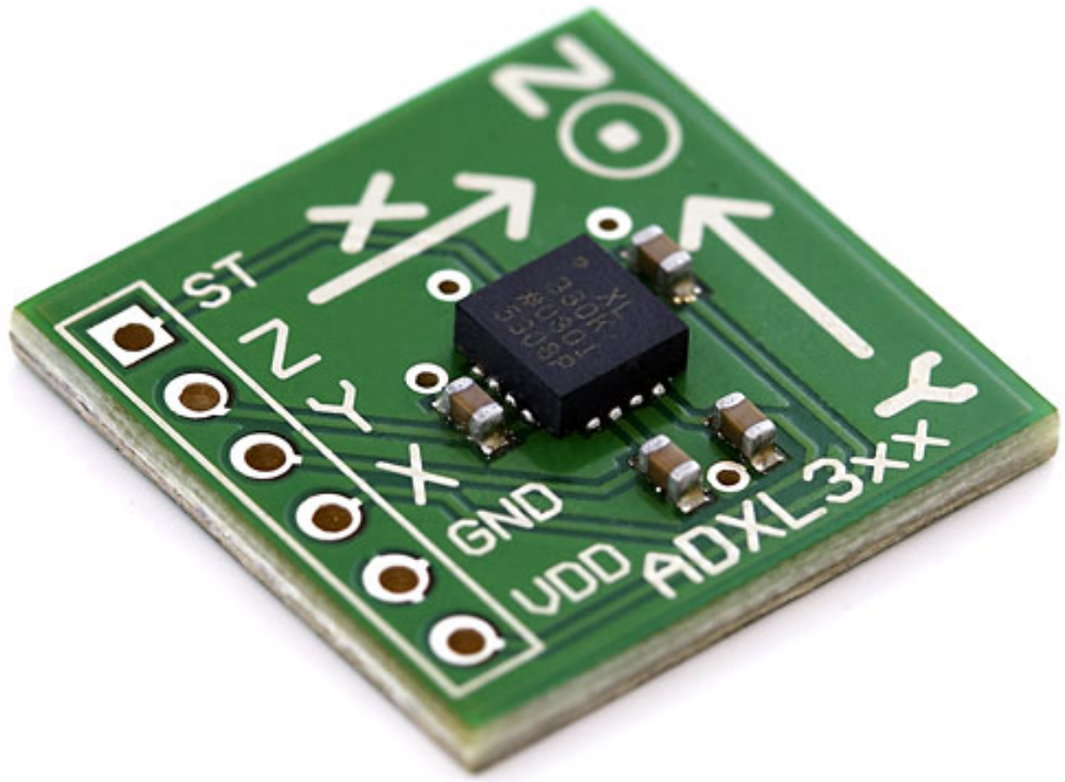
- Utricle (Horizontal acceleration)
- Saccule (vertical acceleration)
  - Located in the utricle
  - The inertial force of the otoliths provides the basis for moving hair bundles

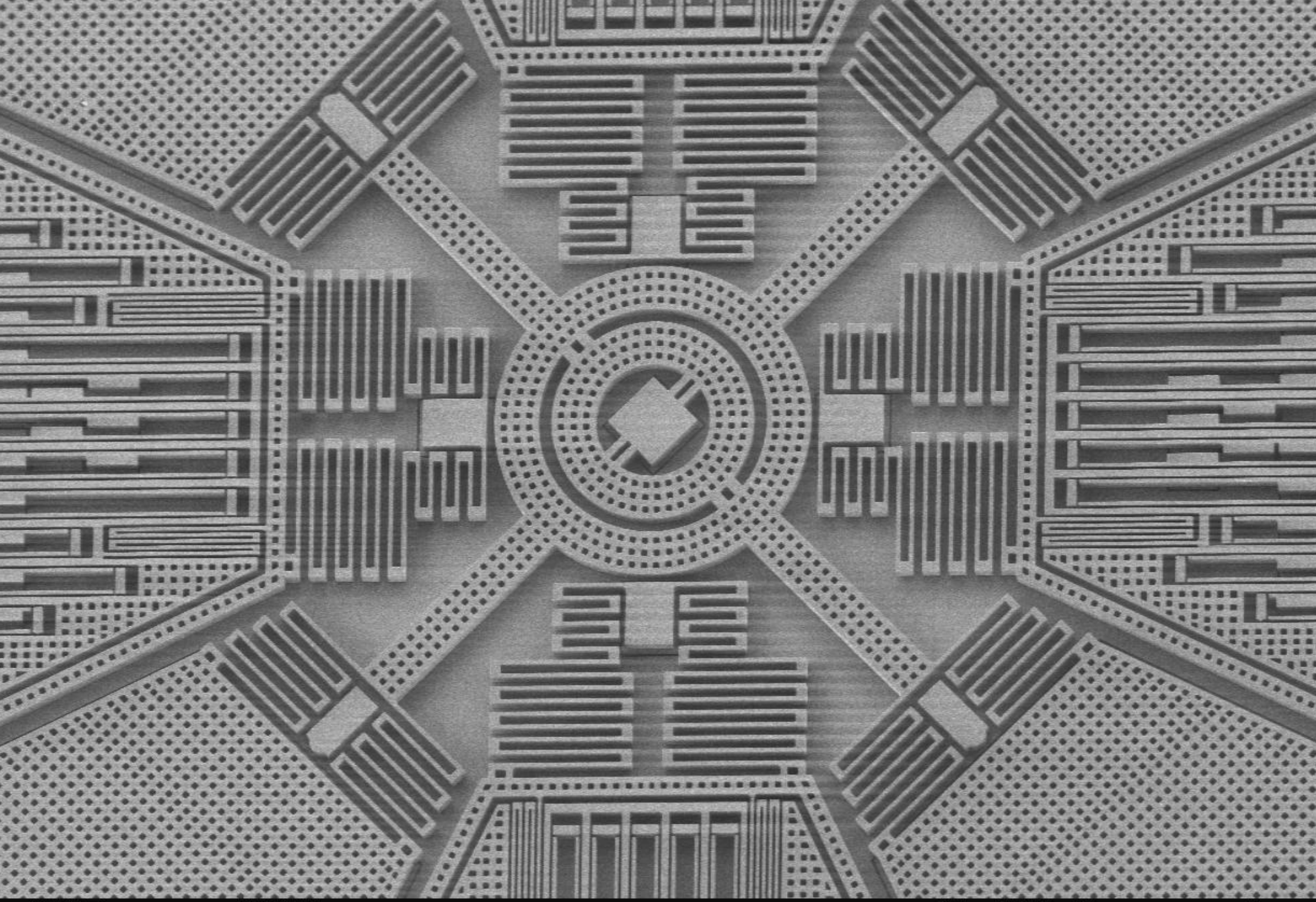


Acceleration

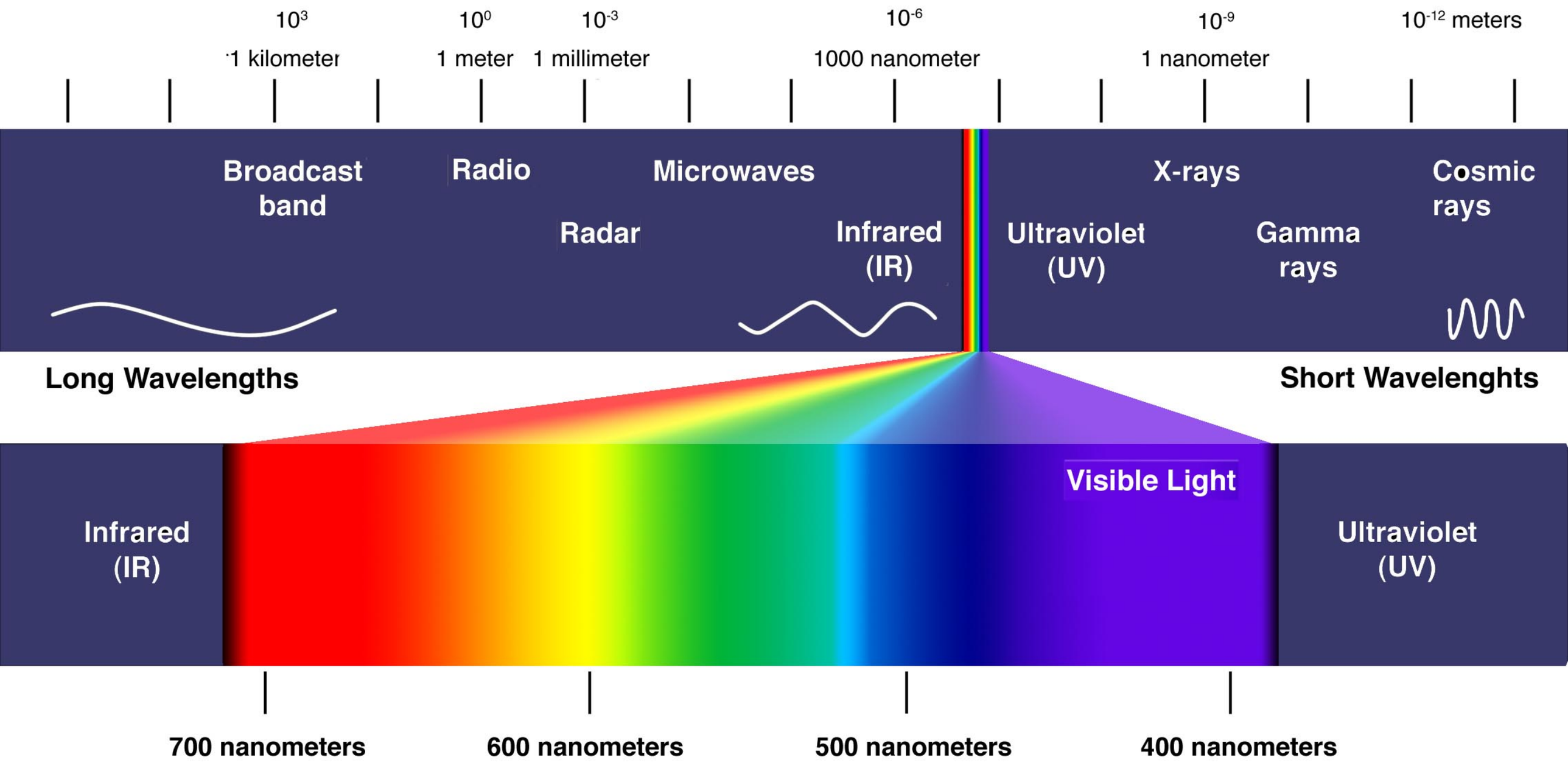
Electrical inertial sensors work in a very similar way to the human vestibular system.





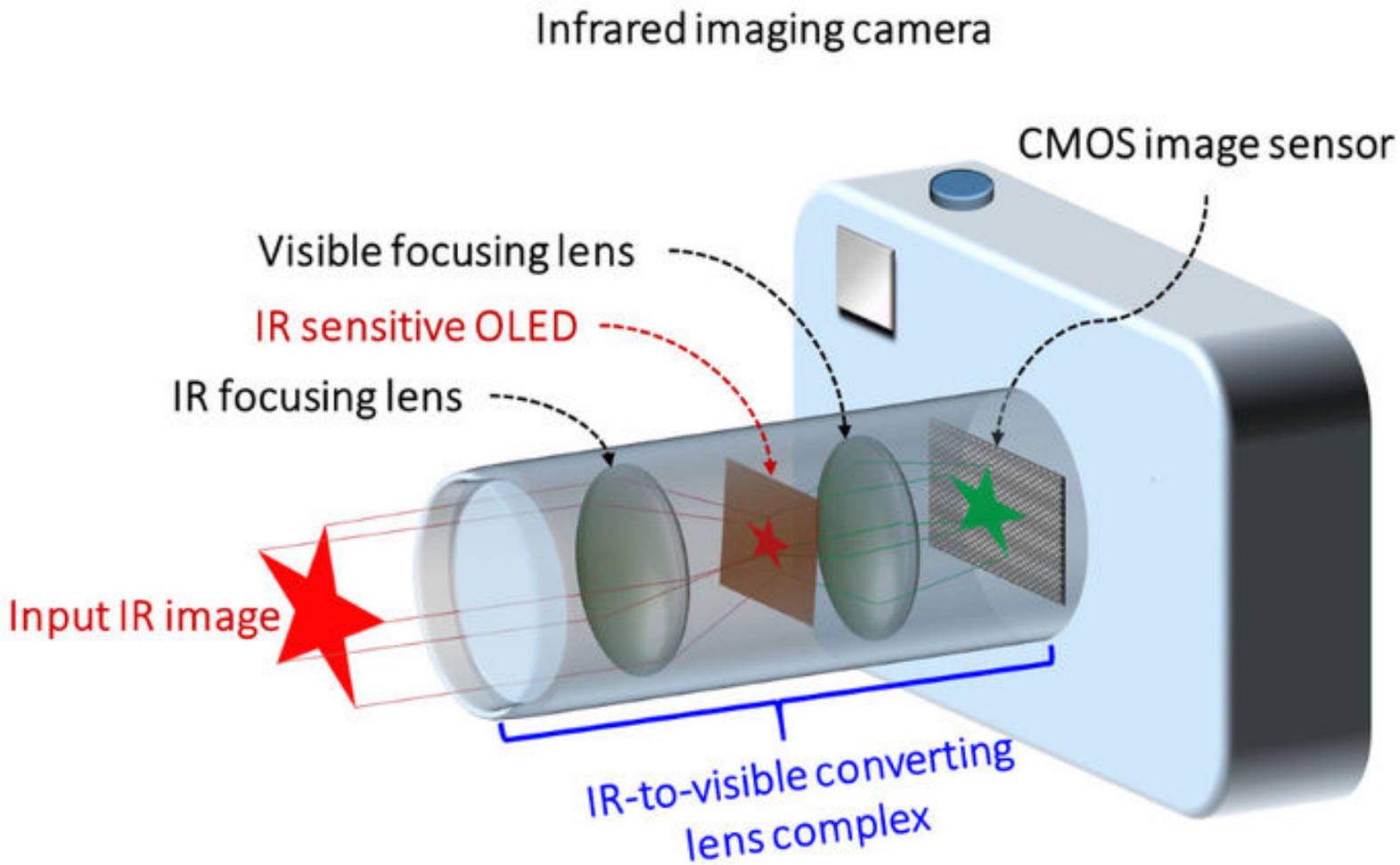

x135 200µm 3.00kV 4mm
#------- 19.03.2010 SDCSP1
1024 x 1024 V9.TIF

Sensing beyond **human perception**



Infrared **detection**

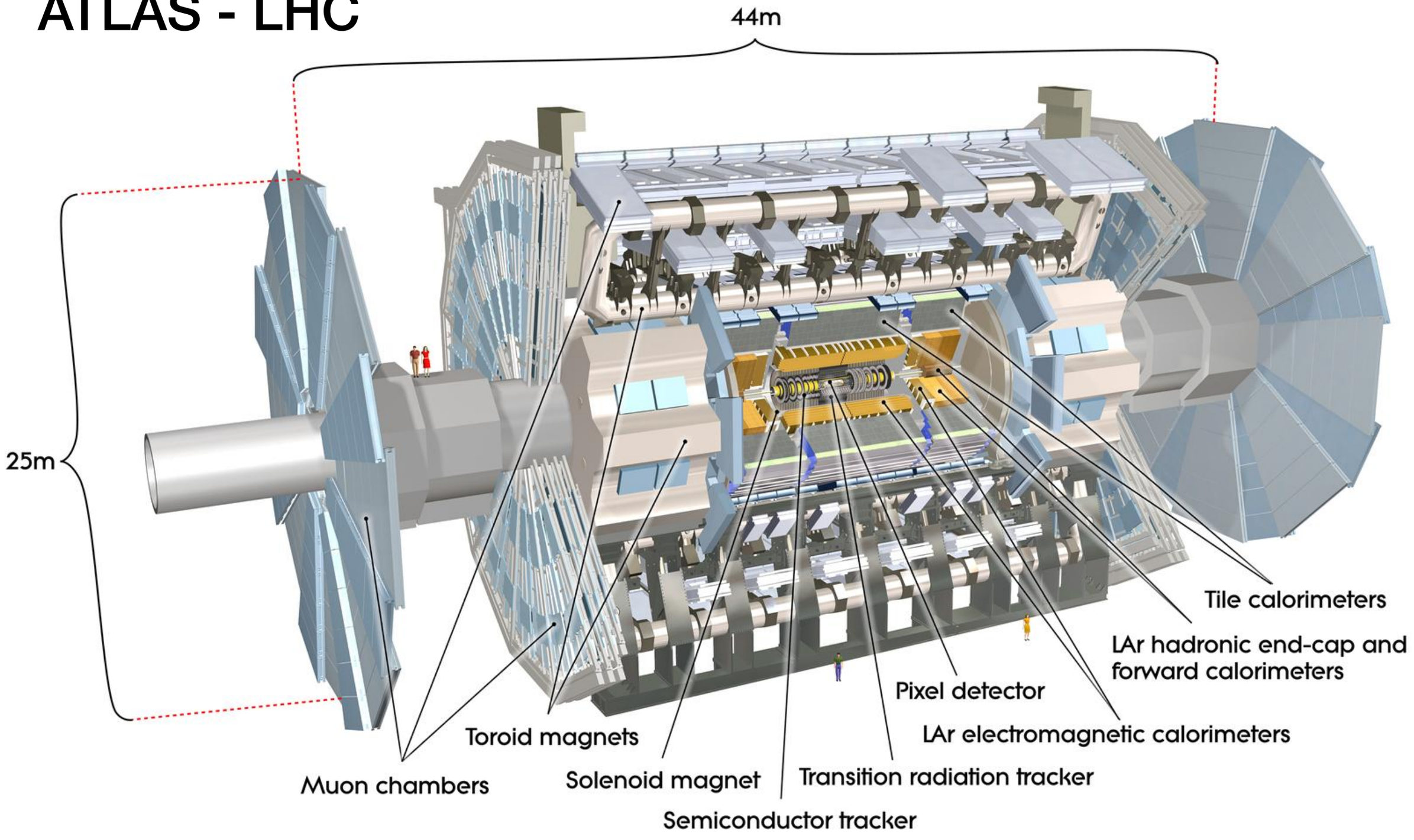
Infrared cameras allow you to measure infrared signals emitted from objects, to create a sort of heat map.

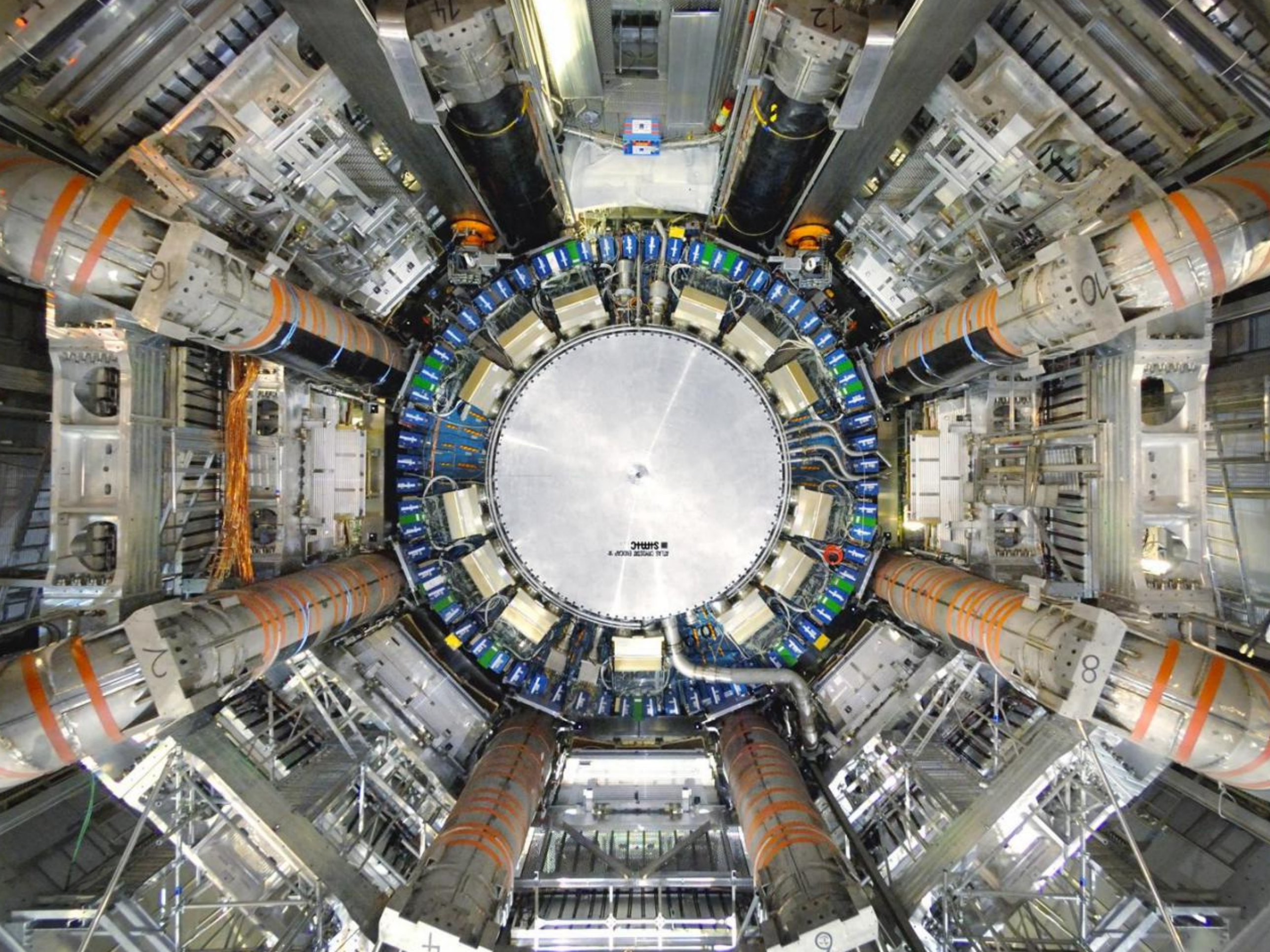


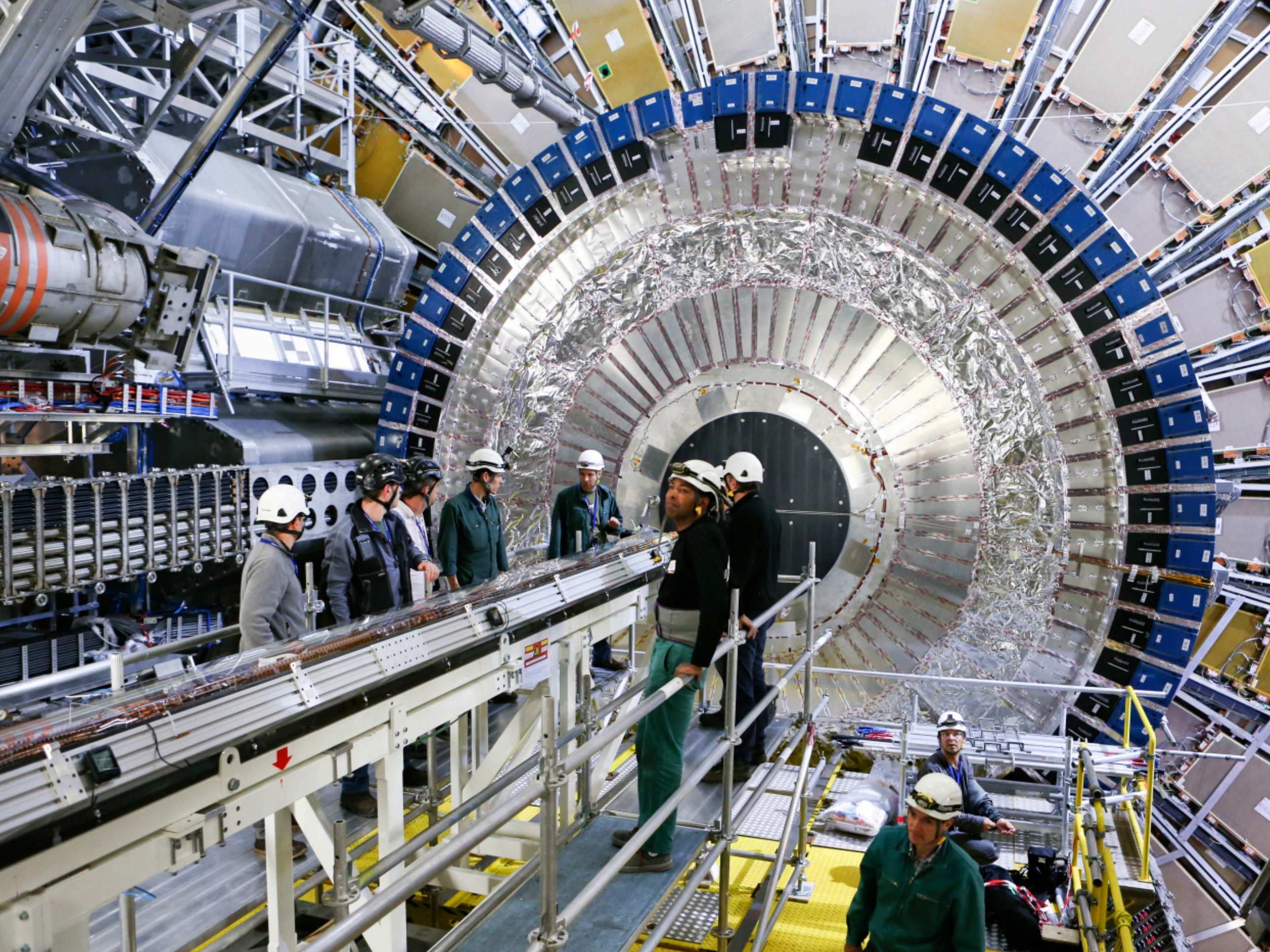
Xray detection

The Ultimate Sensors

ATLAS - LHC







Very Large Array (VLA)