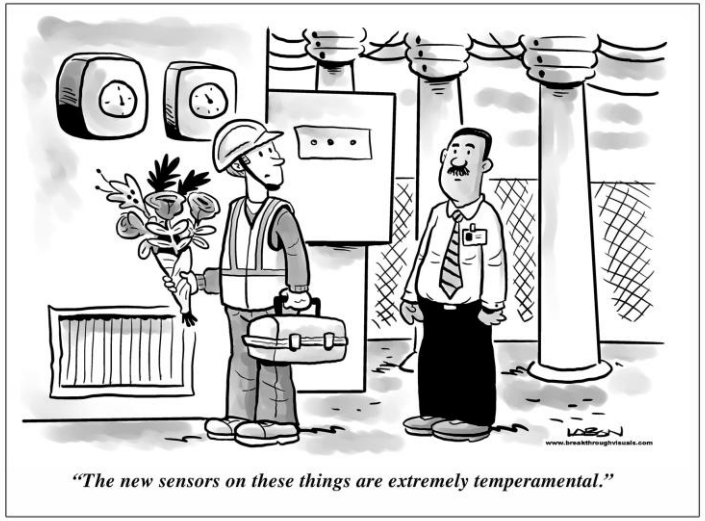
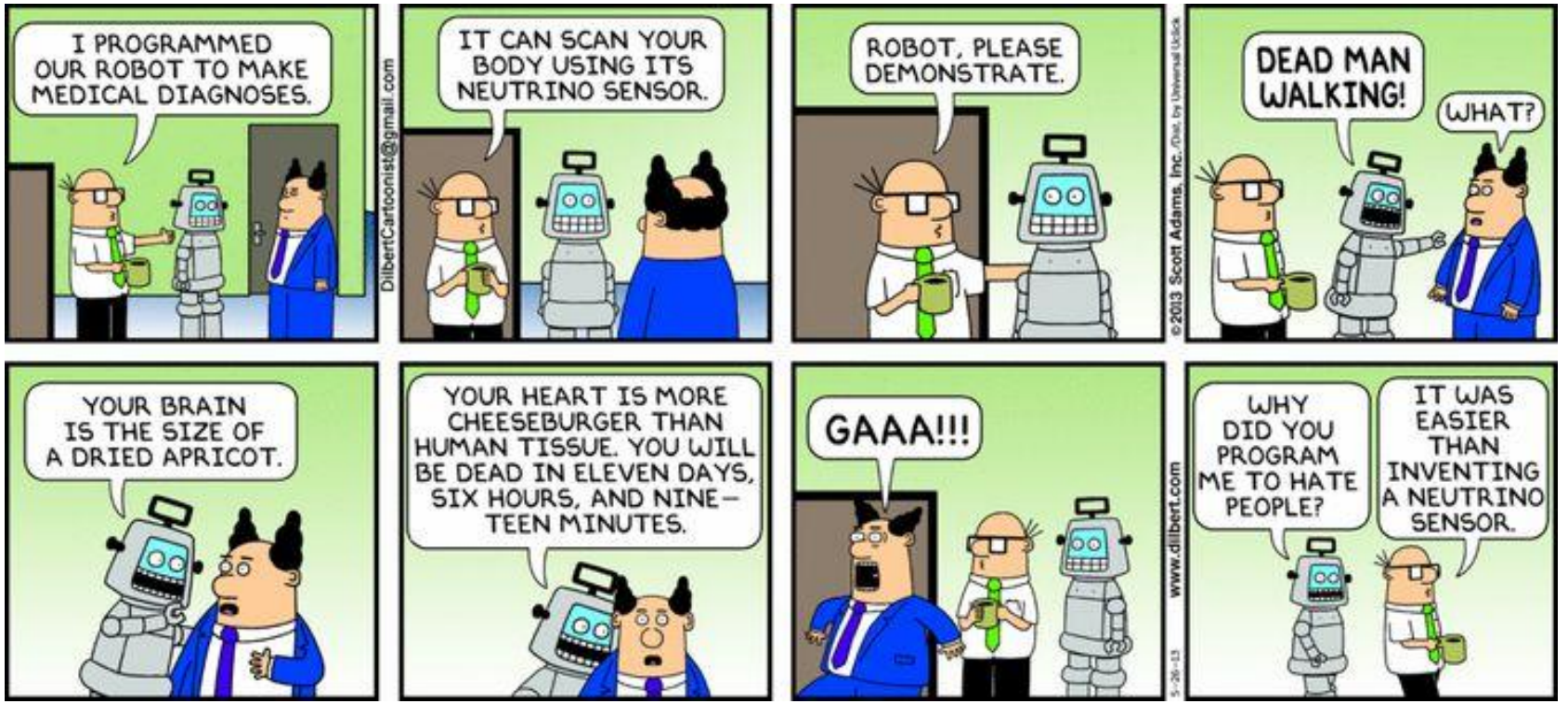
Natural sensors (& sensing)

Why, what, how - & so-what?

- The word “sensor” comes from Latin (sensus: sense) and means feeler





Sensors

- Perform some input function by sensing or feeling the physical changes in characteristics of a system in response to some stimuli

- Example: In a temperature sensor, heat is converted to electrical signals

https://bostondynamics.com/blog/what-is-dynamic-sensing/

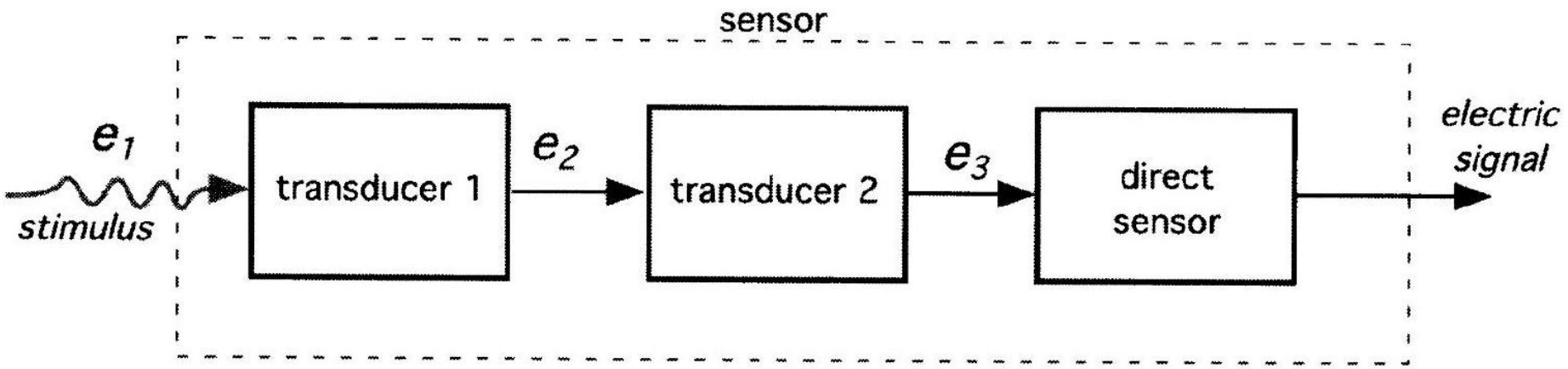
Transducers

- Convert one form of energy into another (https://www.youtube.com/watch?v=9XTqD44Q9WA)

- Example: In a sound system, a microphone converts sound waves into electrical signals, which are then amplified by an amplifier and a loudspeaker converts the electrical signals back into sound waves

- It is a collective term that includes both sensors and actuators

Sensor – Energy Converter



Source: https://www.philadelphia.edu.jo/academics/kaubaidy/uploads/Sensor-Lect2.pdf

- A sensor may incorporate several transducers. The last part is a direct sensor producing electrical output
- Example: A chemical sensor produces electrical signal in response to a chemical reaction. It may have two parts: first one converts the energy of a chemical reaction to heat (transducer) and the other part (thermopile) converts the heat into an electrical signal
- Direct sensor and Indirect Sensor

Sensor Features

- Sensitive only to the measured property (temperature sensor only senses the ambient temperature)
- Insensitive to any other property encountered in the system
- Does not influence the measured property

Why do we need to sense?

- Monitor
- Repair
- Predict
- Maintain
- Analyse
- Understand
- Survive?

What are we sensing?

Visual
Auditory
Movement/direction (is it direct or indirect?)
Touch
Smell
Taste
Vibration

How are we sensing?

- Waves
- Force & strain
- Chemical
- Mechanical
- Electrical
- Thermal
- Quantity
- features

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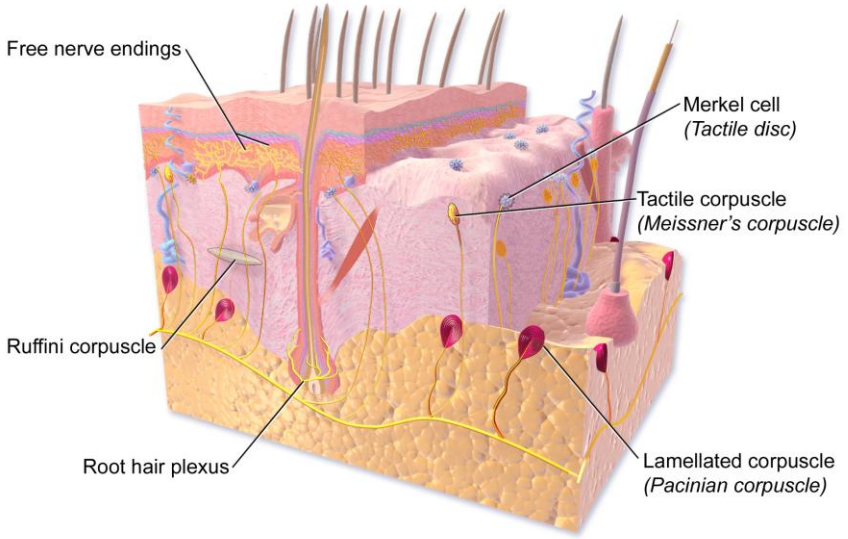
Human Skin as sensor

Dermis is below the epidermis and contains four kinds of mechanoreceptors that respond to stimuli such as pressure, stretching, and vibration.

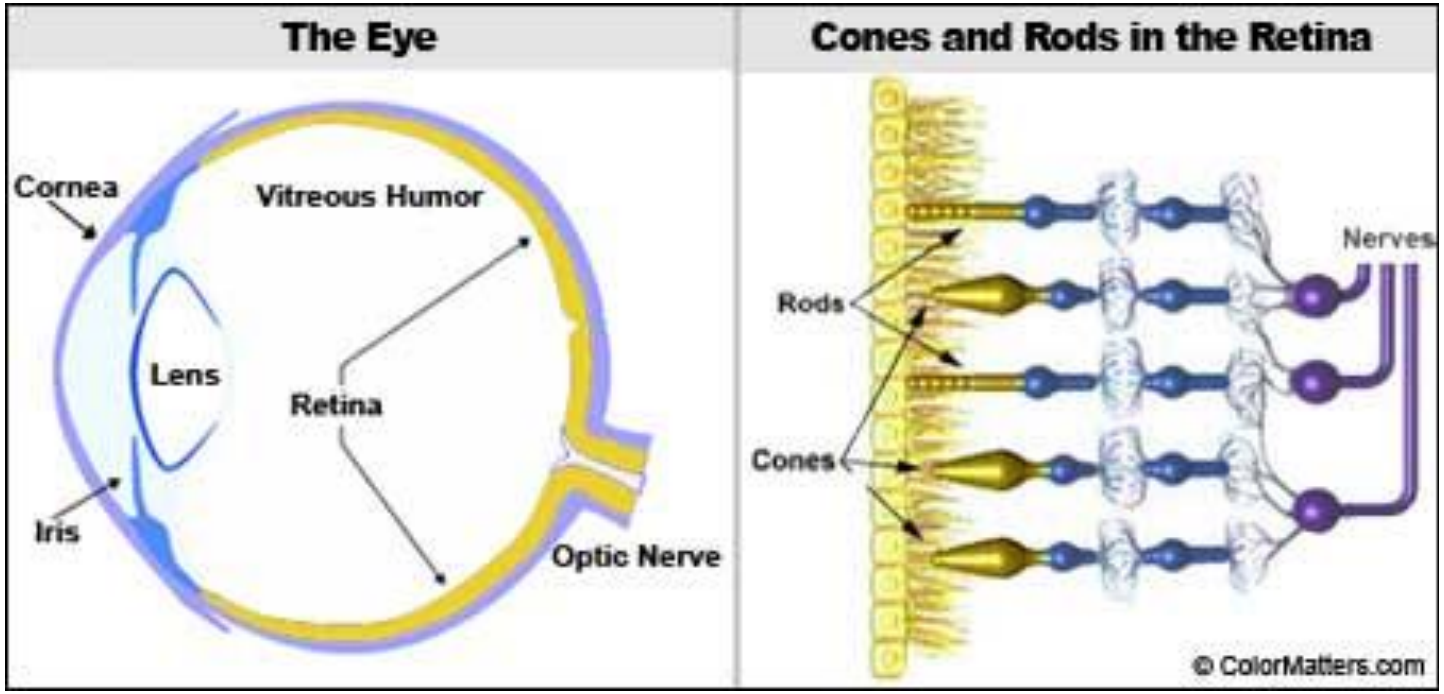
- Meissner corpuscles- respond to light **touch** and adapt rapidly to changes in **texture** (vibrations around 50 Hz).
- The bulbous corpuscles (also known as Ruffini endings) detect **tension** deep in the skin and fascia.
- The Merkel nerve endings (also known as Merkel discs) detect sustained **pressure**.
- The lamellar corpuscles (also known as Pacinian corpuscles) in the skin and fascia detect rapid **vibrations** (of about 200–300 Hz).
- Cutaneous mechanoreceptors respond to mechanical stimuli that result from physical interaction, including **pressure and vibration**.



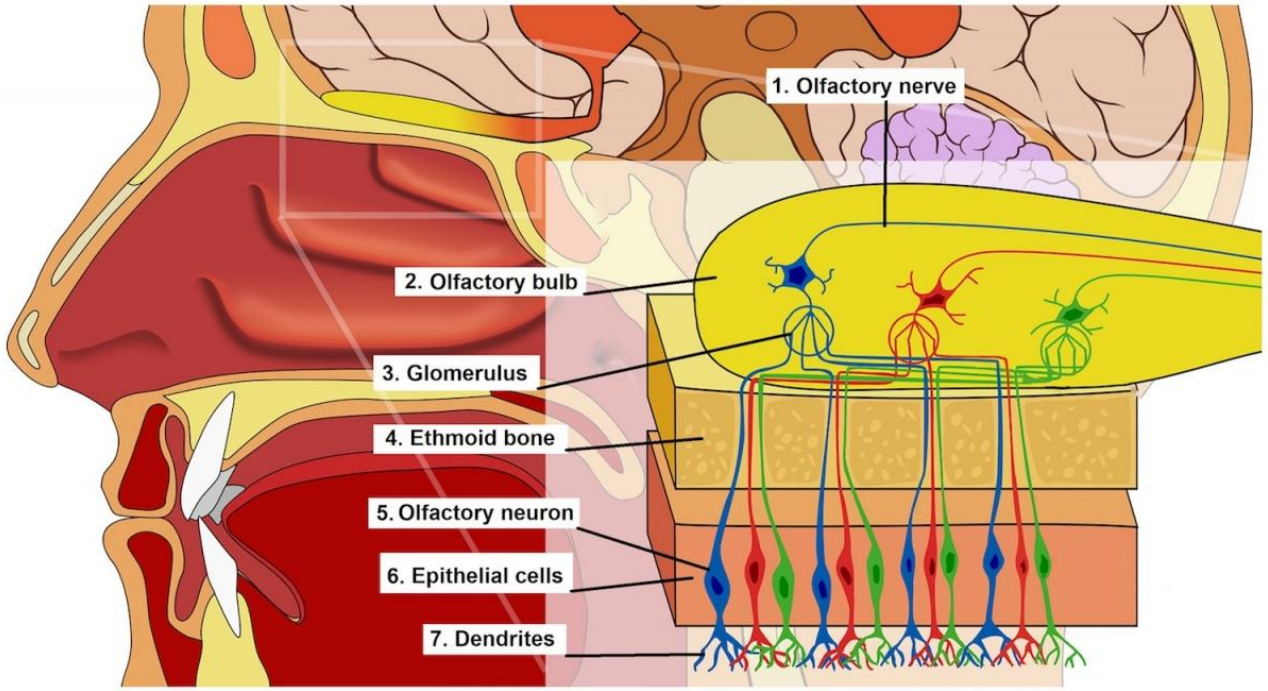
Tactile Receptors in the Skin

[Wikipedia](). L

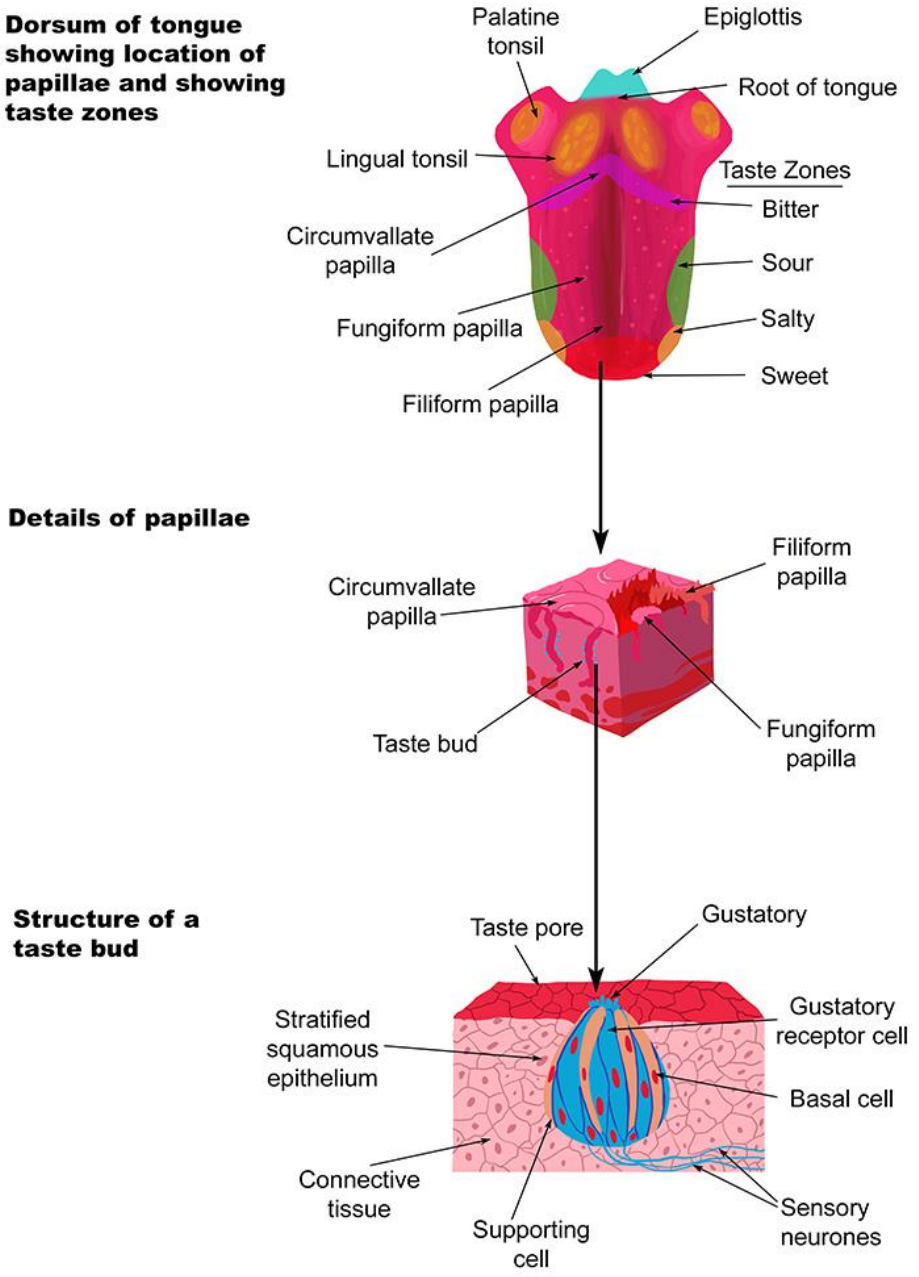
Eye & brain as visual sensor



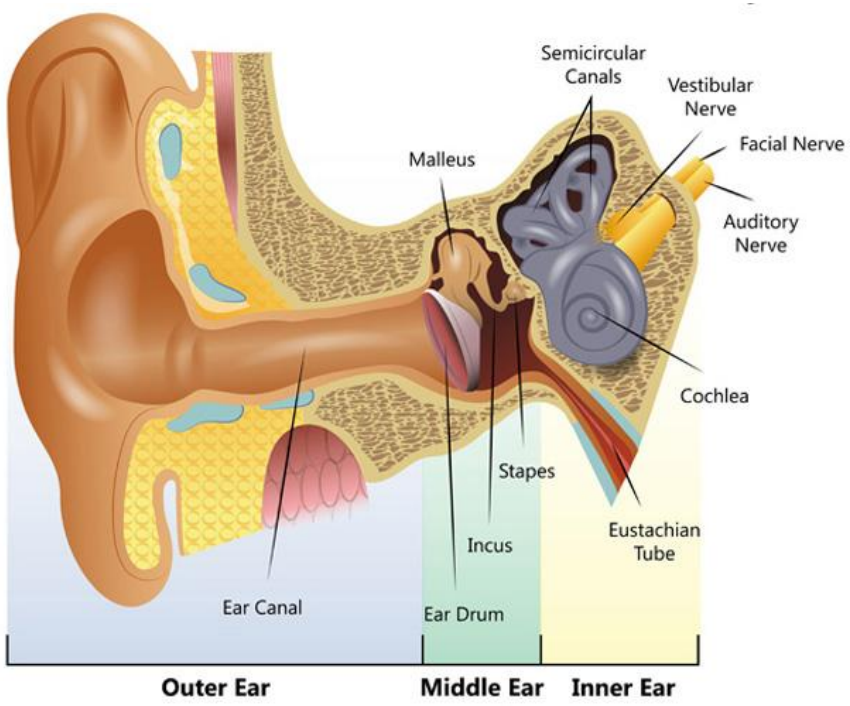
Nose as a sensor



Tongue as a sensor

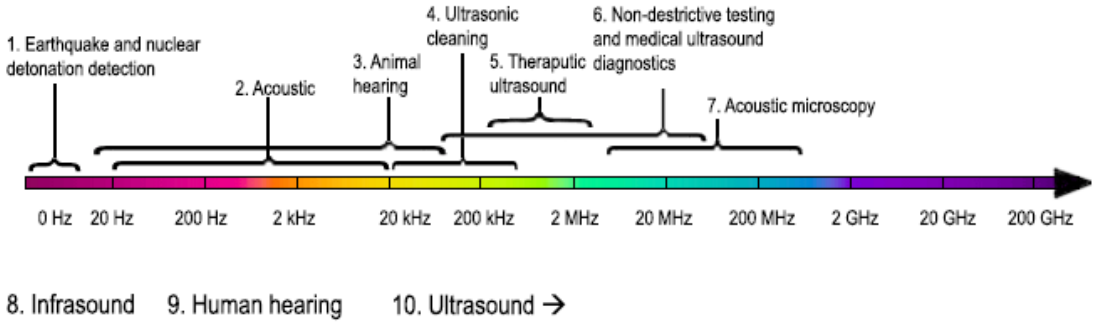


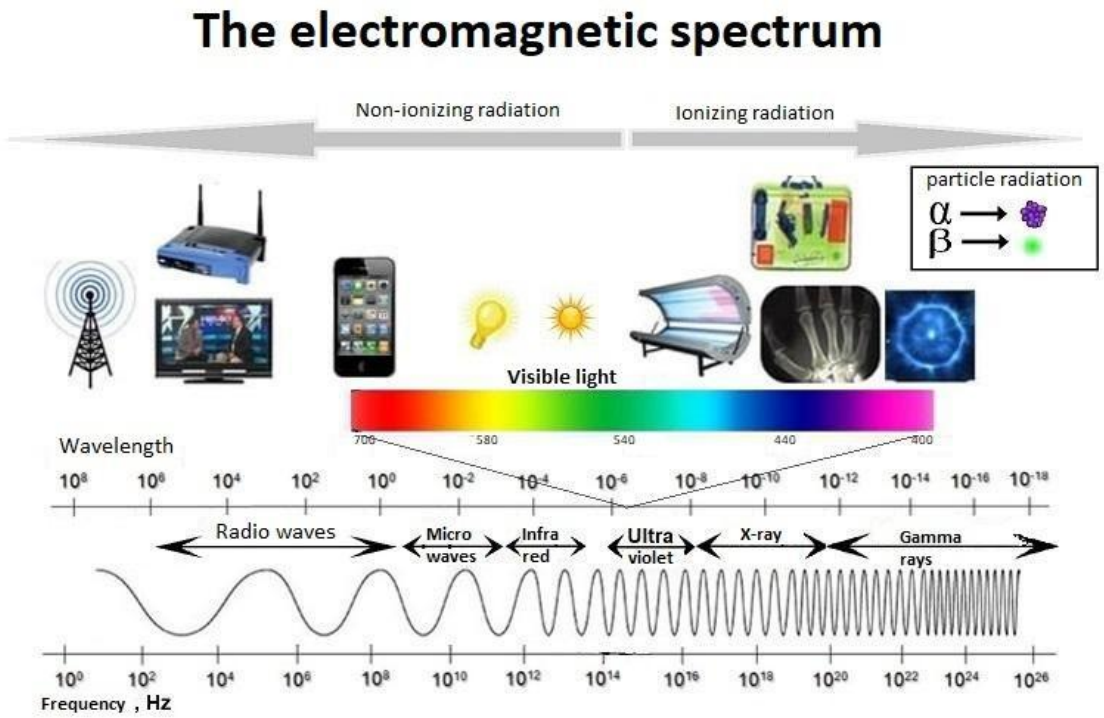
Ear – auditory sensor

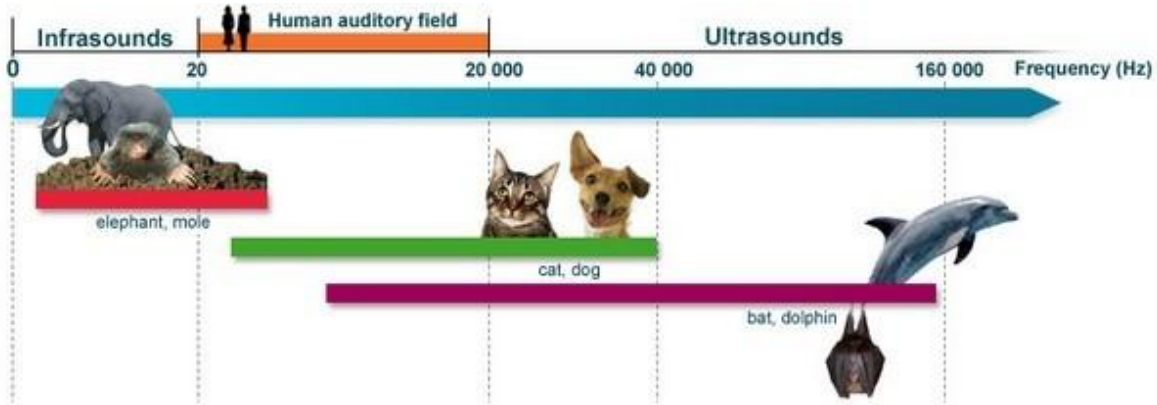


Eardrum – vibration ➔ hammer/anvil/stirrup bones ➔ the structure & conductive motion of middle ear amplifies the sound ➔ vibration of the fluid in the inner ear (hydraulic energy)➔ oscillation of thousands of tiny sensory hair cells in cochlea ➔ chemical/electrical signals to the brain

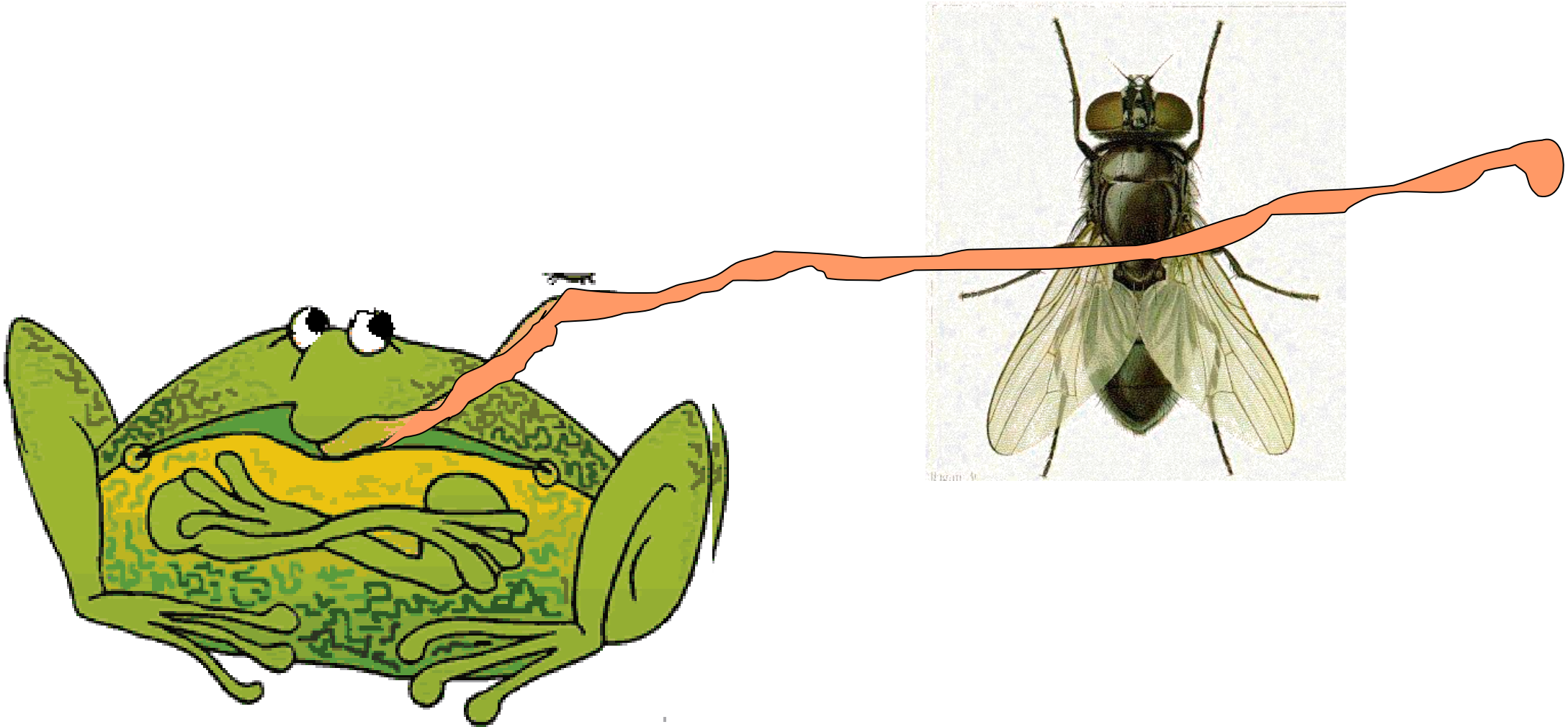
Spectrum for sensing..



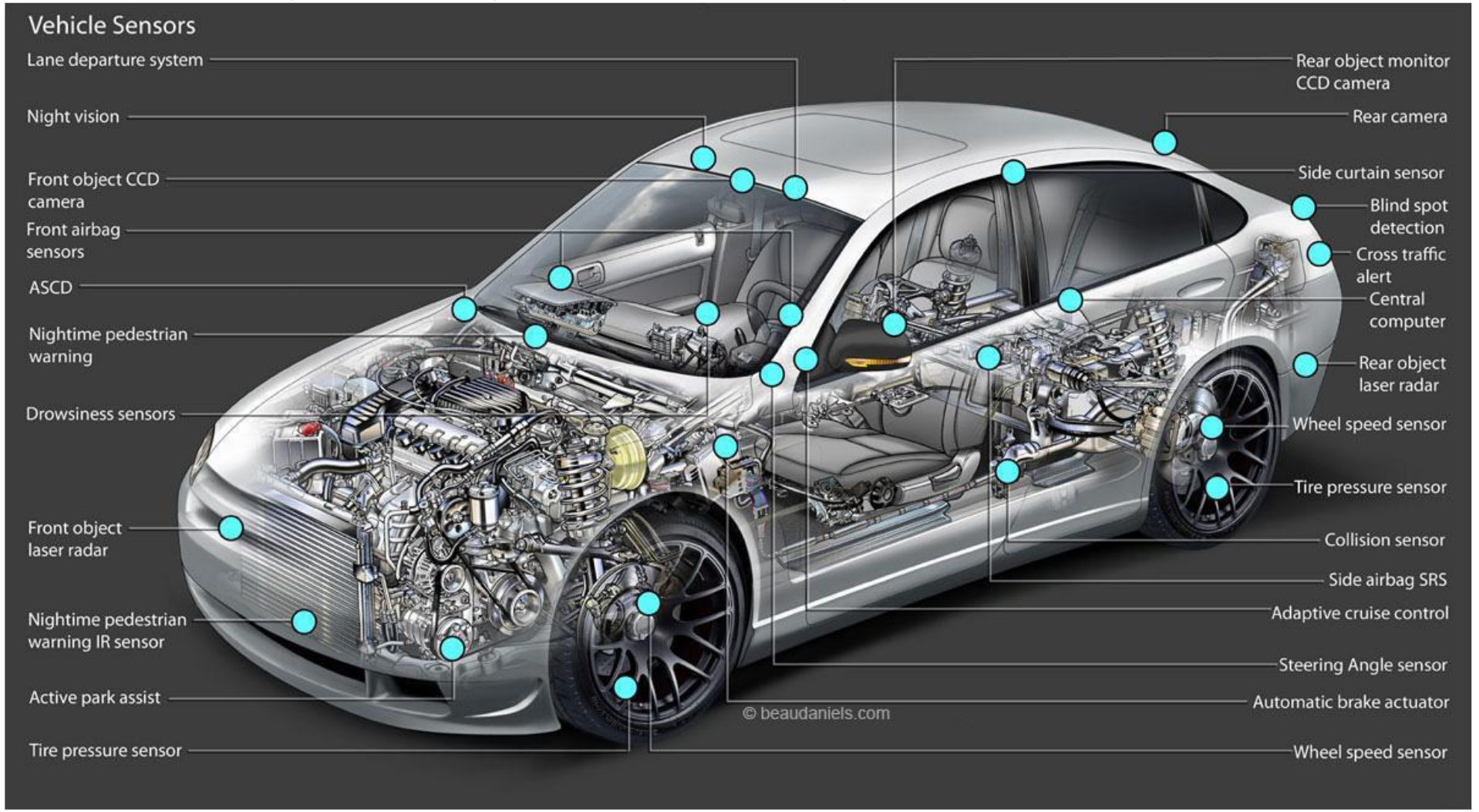




Sensing, recognizing and actuator control!



Complexity – density of sensors



https://blogs.sw.siemens.com/simcenter/the-sense-of-virtual-sensors/