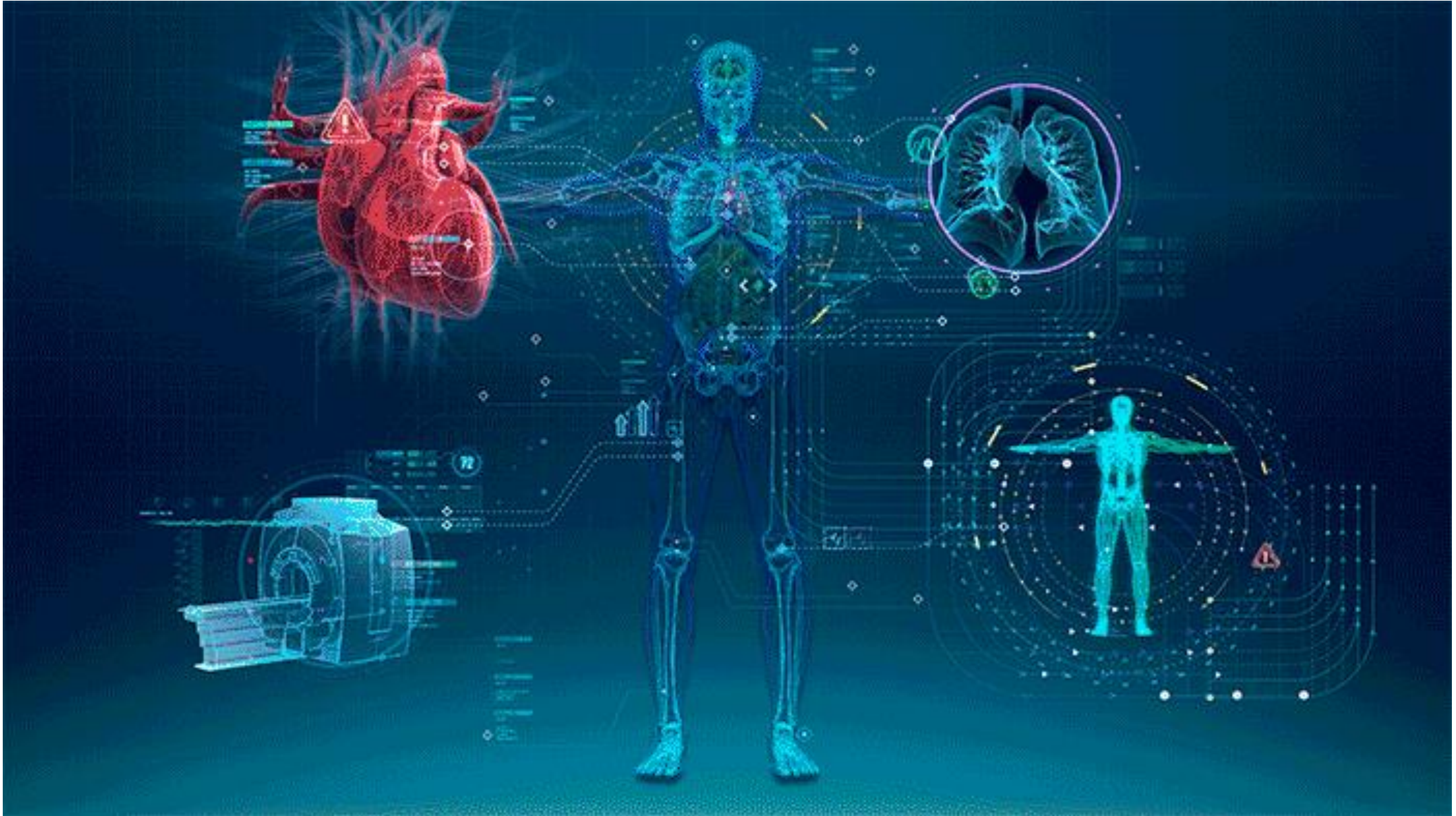


NEW TECHNOLOGIES FOR MEDICAL CARE AND HEALTH

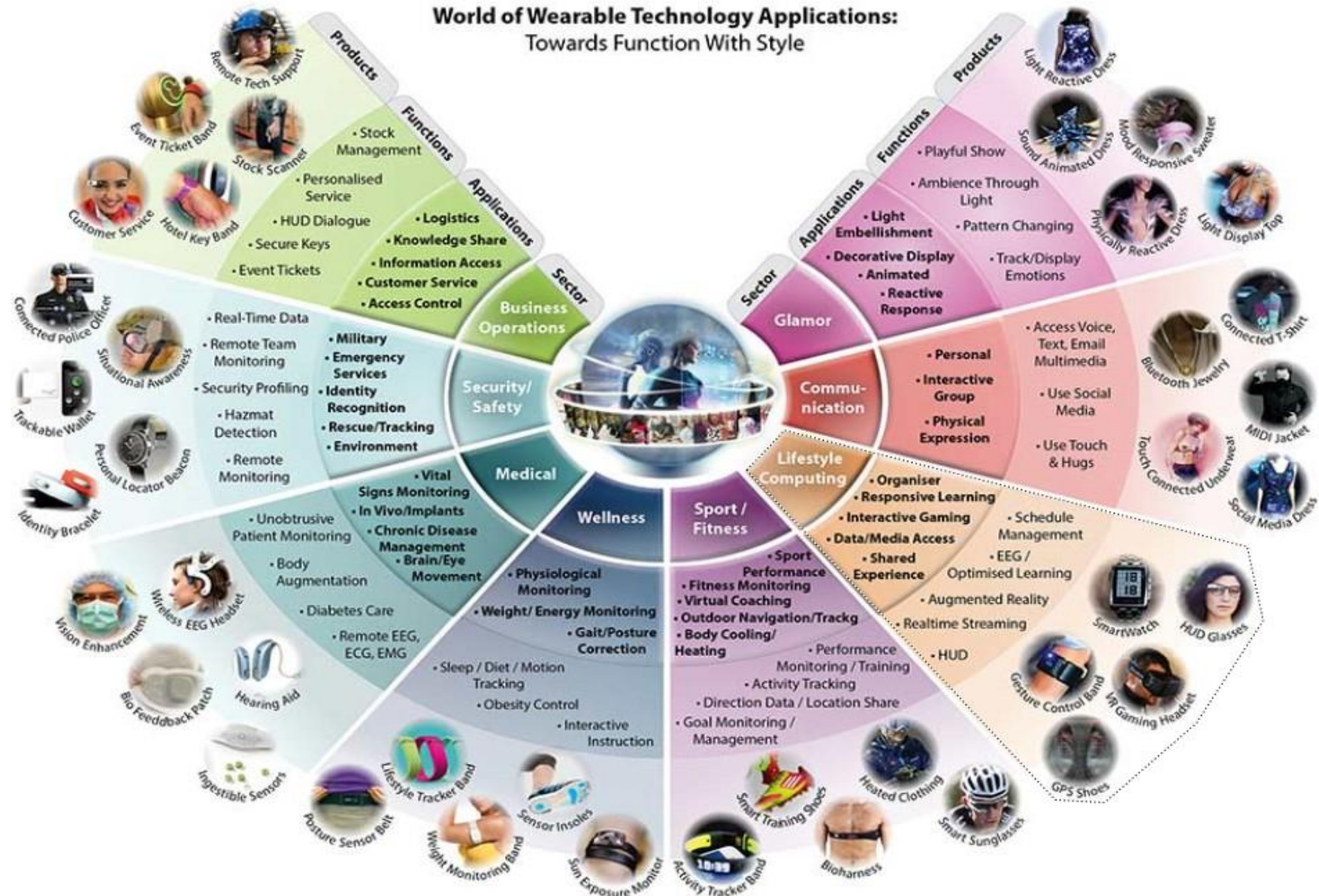


COMPILED BY HOWIE BAUM

SUBJECTS COVERED

- 1) WEARABLE DEVICES FOR MEDICAL AND HEALTHCARE USES**
- 2) DEVICES ATTACHED TO THE SKIN FOR HEALTH MONITORING**
- 3) THE NEW MATERIAL – GRAPHENE FOR MEDICAL APPLICATIONS**
- 4) MOBILE DEVICES AND APPS FOR HEALTHCARE**
- 5) BIOCHIPS FOR QUICK TESTING AND THEIR USES**
- 6) BRAIN-COMPUTER INTERFACE (BCI) DEVICES AND THEIR APPLICATIONS**
- 7) OTHER TECHNOLOGIES**

WEARABLE ELECTRONICS BY SECTOR



FOCUSING ON HEALTH CARE



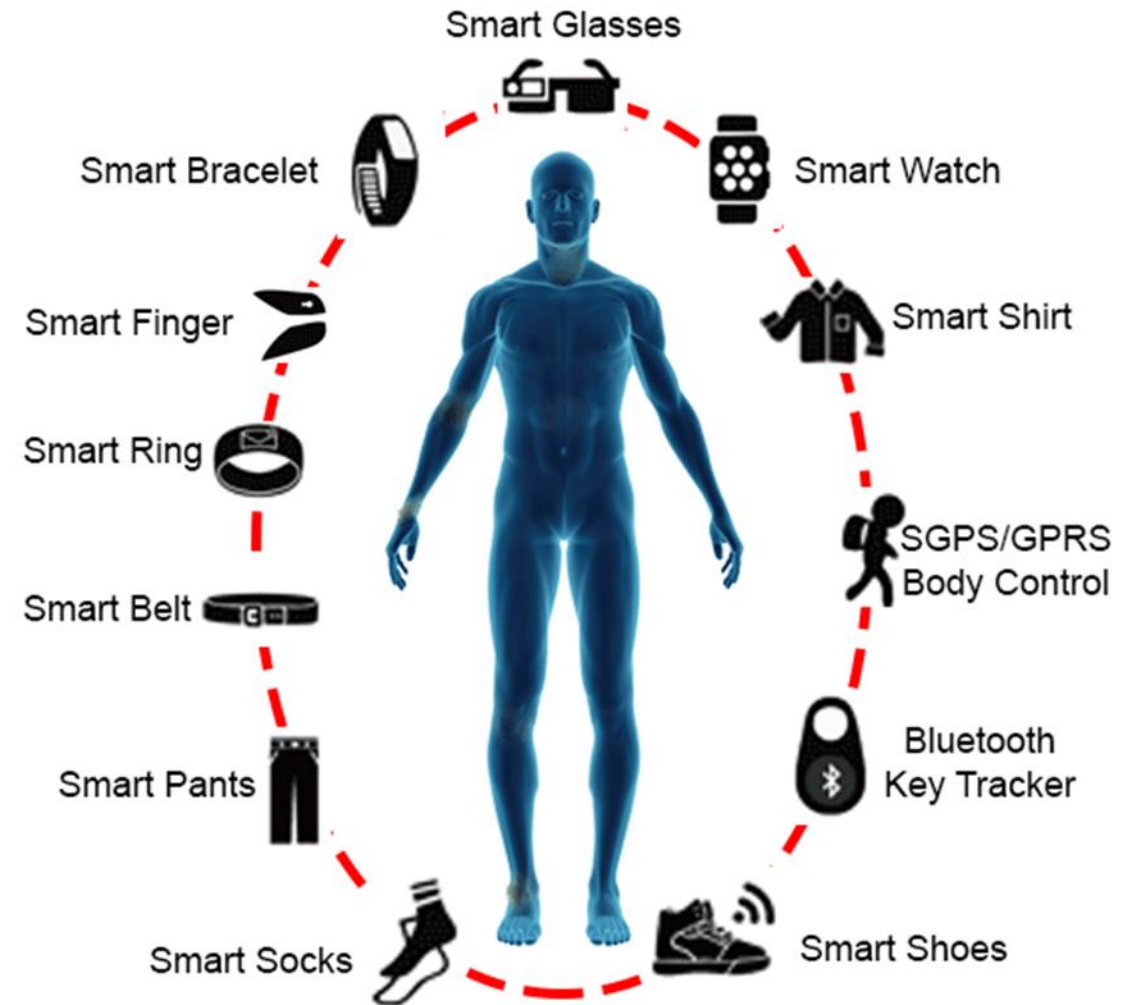
SECTION 1 - THE FUTURE OF WEARABLE ELECTRONIC DEVICES

Preferred Locations for Wearable Technology



EXCELLENT MONITORING USES, OF SPECIAL WEARABLE DEVICES

- **Concentrations of cortisol** for tracking stress (using electronic epidermal tattoos)
- Biomarkers of **inflammation and levels of blood oxygen** (microneedle patches)
- **Skin temperature** (electronic textiles)
- **Blood pressure** (smart rings)
- **Concentration of sweat ions** (wristbands)
- **Eye pressure** (smart contact lenses)
- **Sensing the presence of airborne pathogens and breathing issues** (face masks)
- The **concentration of therapeutic drugs** (on-teeth sensors)



Improved Drug Management



Remote Patient Monitoring



Hand Hygiene Compliance



Telehealth



Chronic Disease Management



Assisted Living



Behavior Modification



Hospital Asset Management



THE DEVICES CAN ALSO BE USED TO REMOTELY MONITOR PATIENTS FOR THE SITUATIONS, SHOWN AT THE LEFT

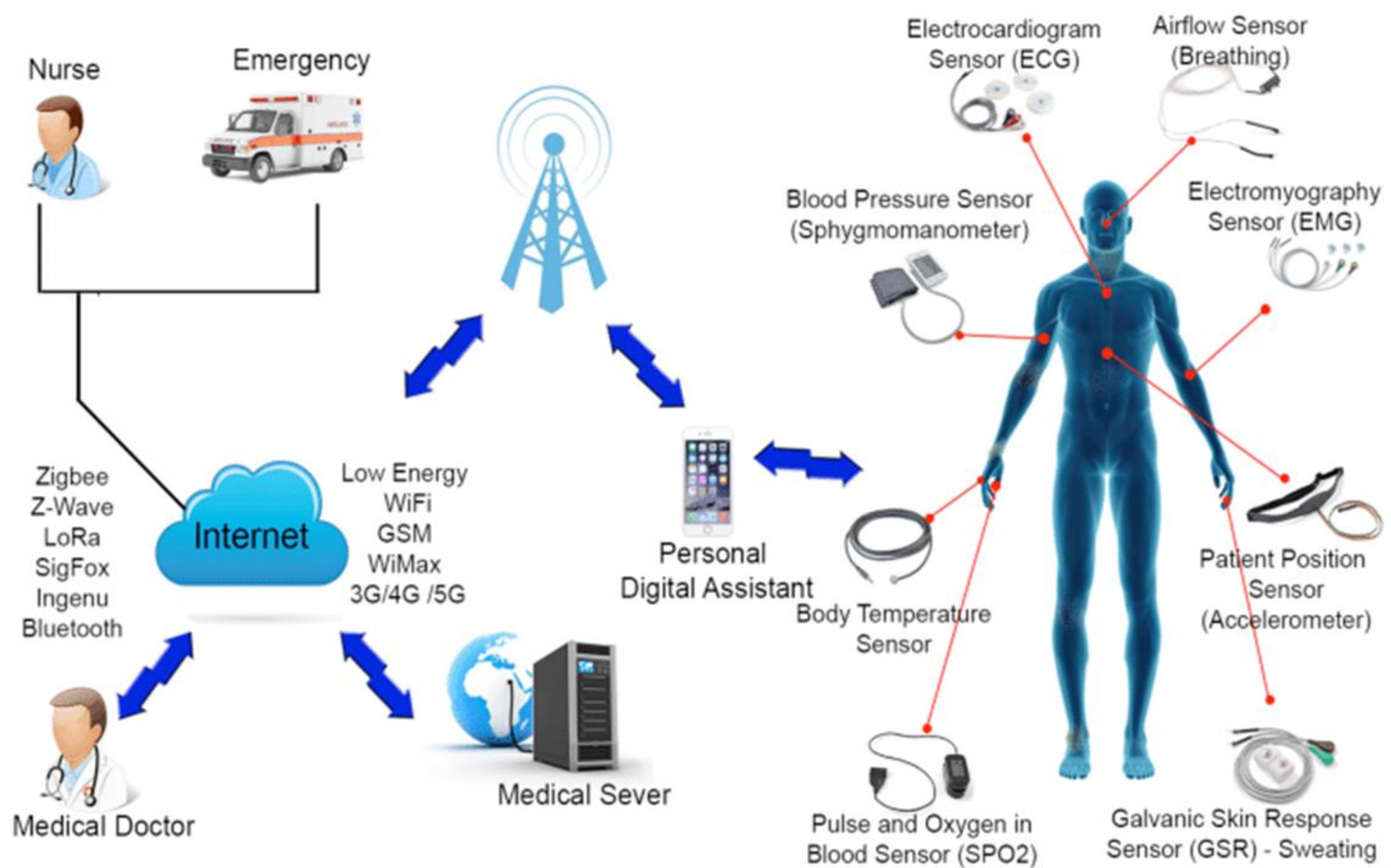


ILLUSTRATION OF AN ARCHITECTURE FOR A REMOTE HEALTHCARE MONITORING SYSTEM



TYPES OF WEARABLE SENSORS AND THEIR APPLICATIONS

Wearable Sensor Types

Bio-potential Sensors:

- Electroencephalography caps
- Electromyography bands
- Electrocardiography chest strap

Optical Sensors:

- Glasses
- Contact lenses
- Cameras

Stretch and Pressure Sensors:

- Textiles
- Belts and bras

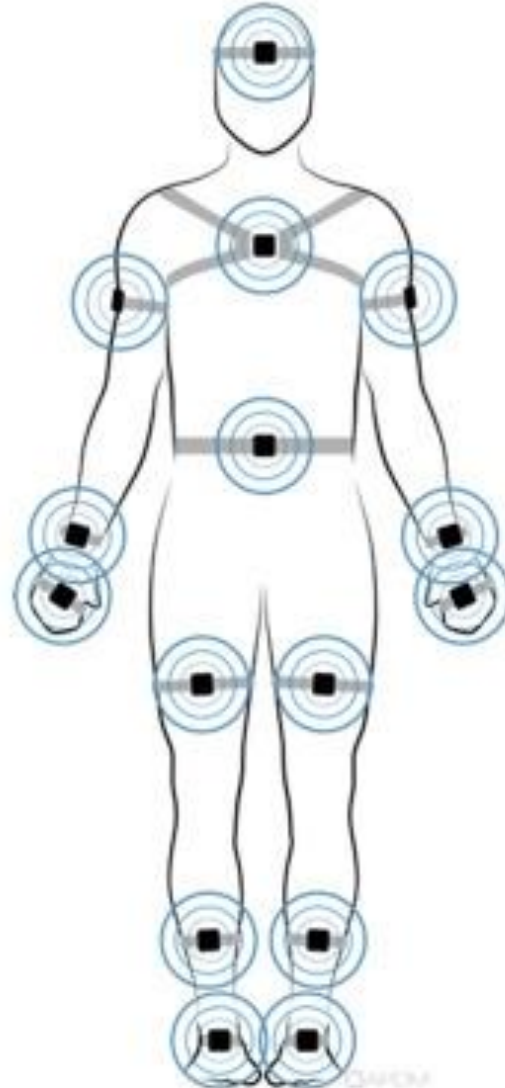
Chemical Sensors:

- Electronic skin
- Textiles

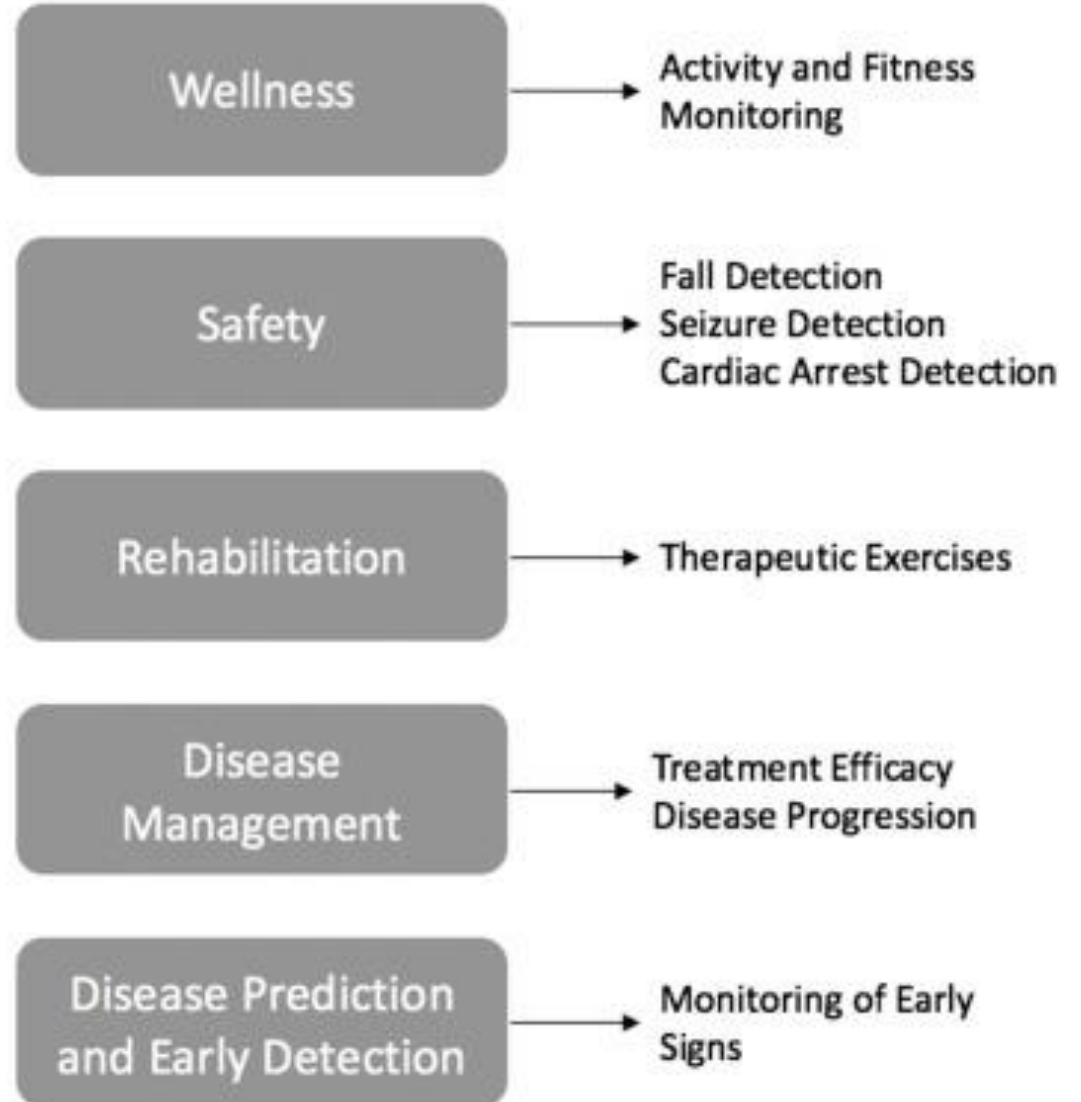
Inertial Measurement Units:

- Wristbands
- Smart watches
- Body fixed sensors

Body Fixed Positions



Health Related Applications

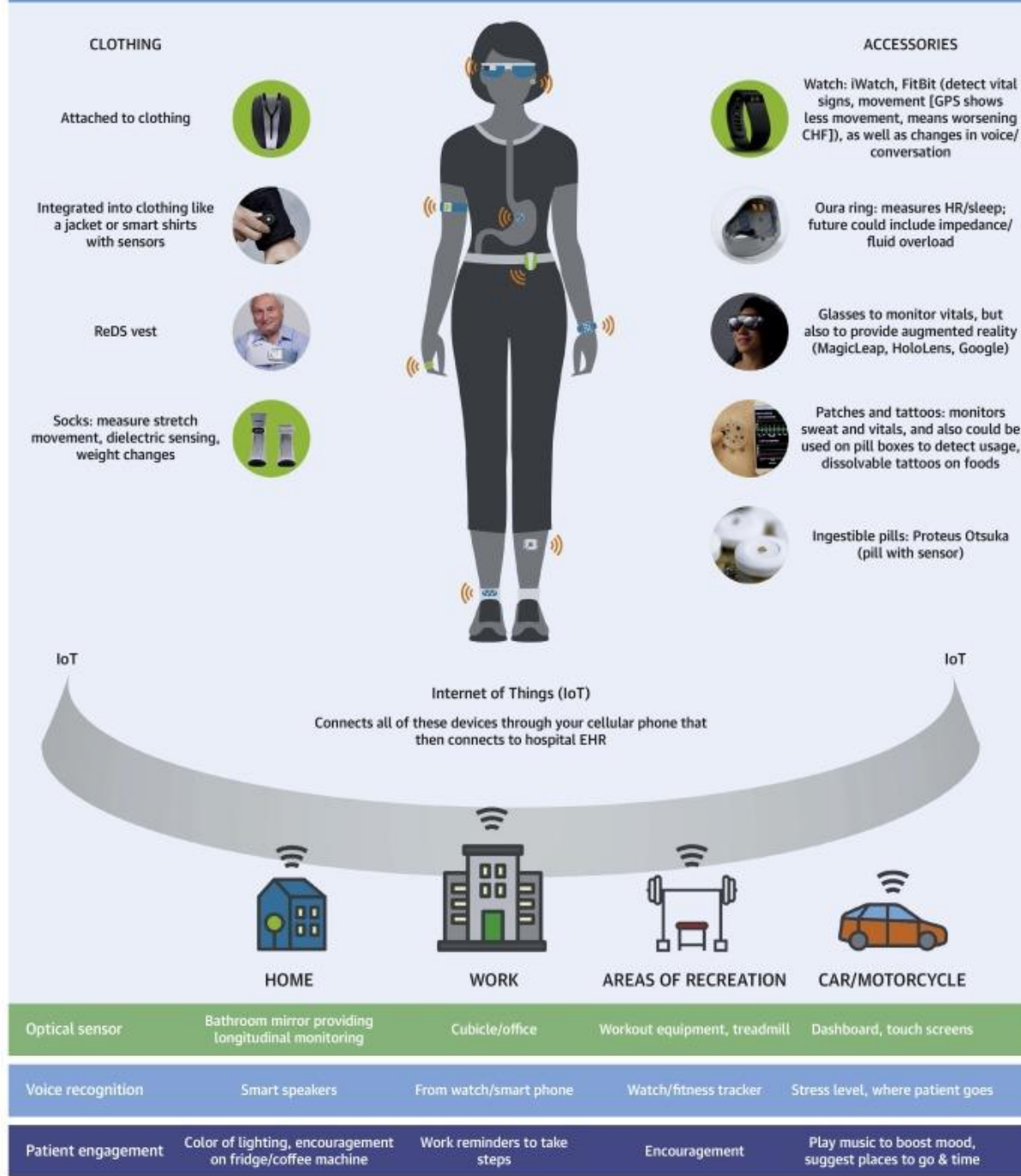


Key attributes of wearable tech products



BIOSENSING WEARABLES

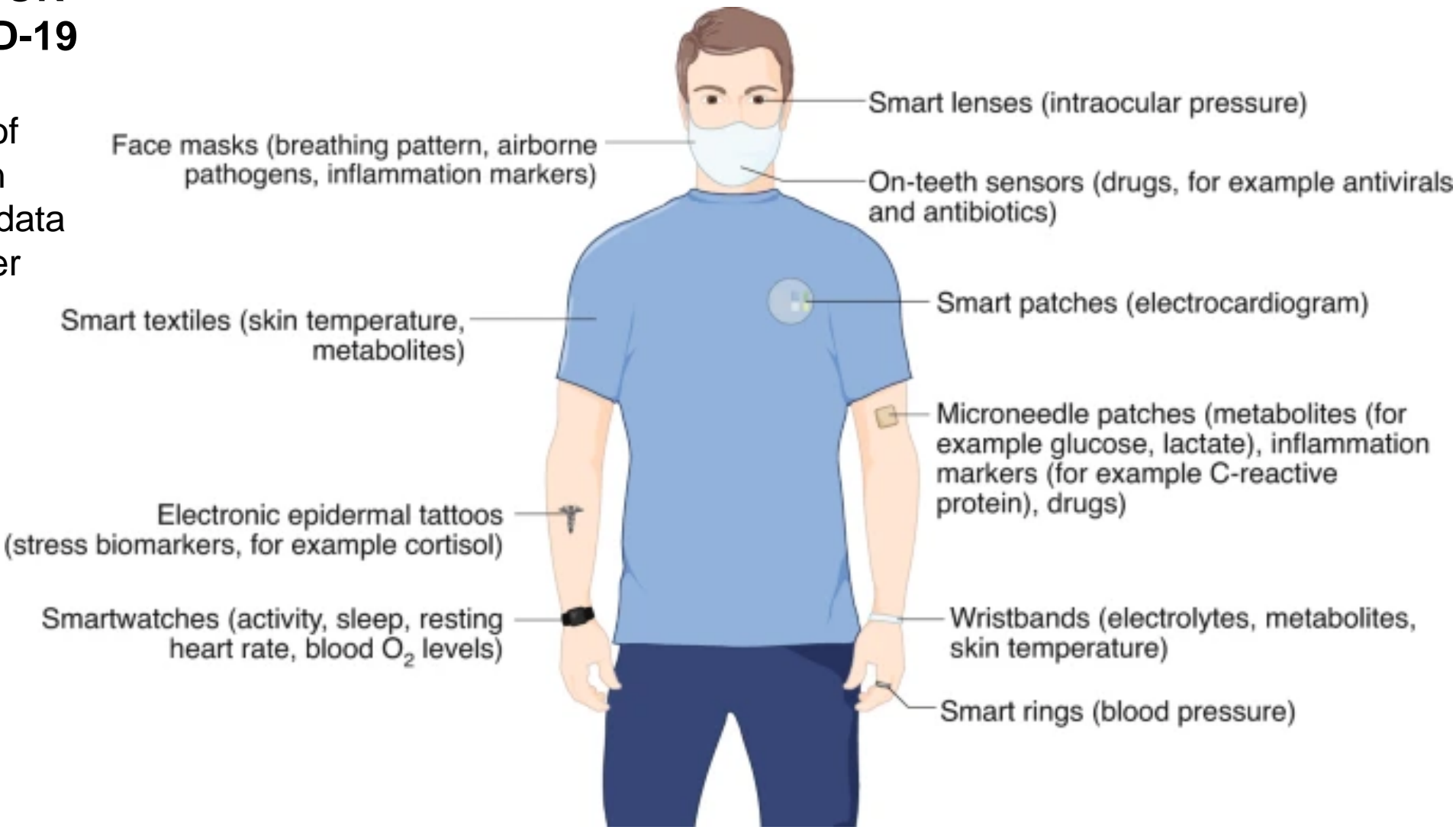
THE FUTURE OF WEARABLES FOR PERSONS WITH HEART FAILURE

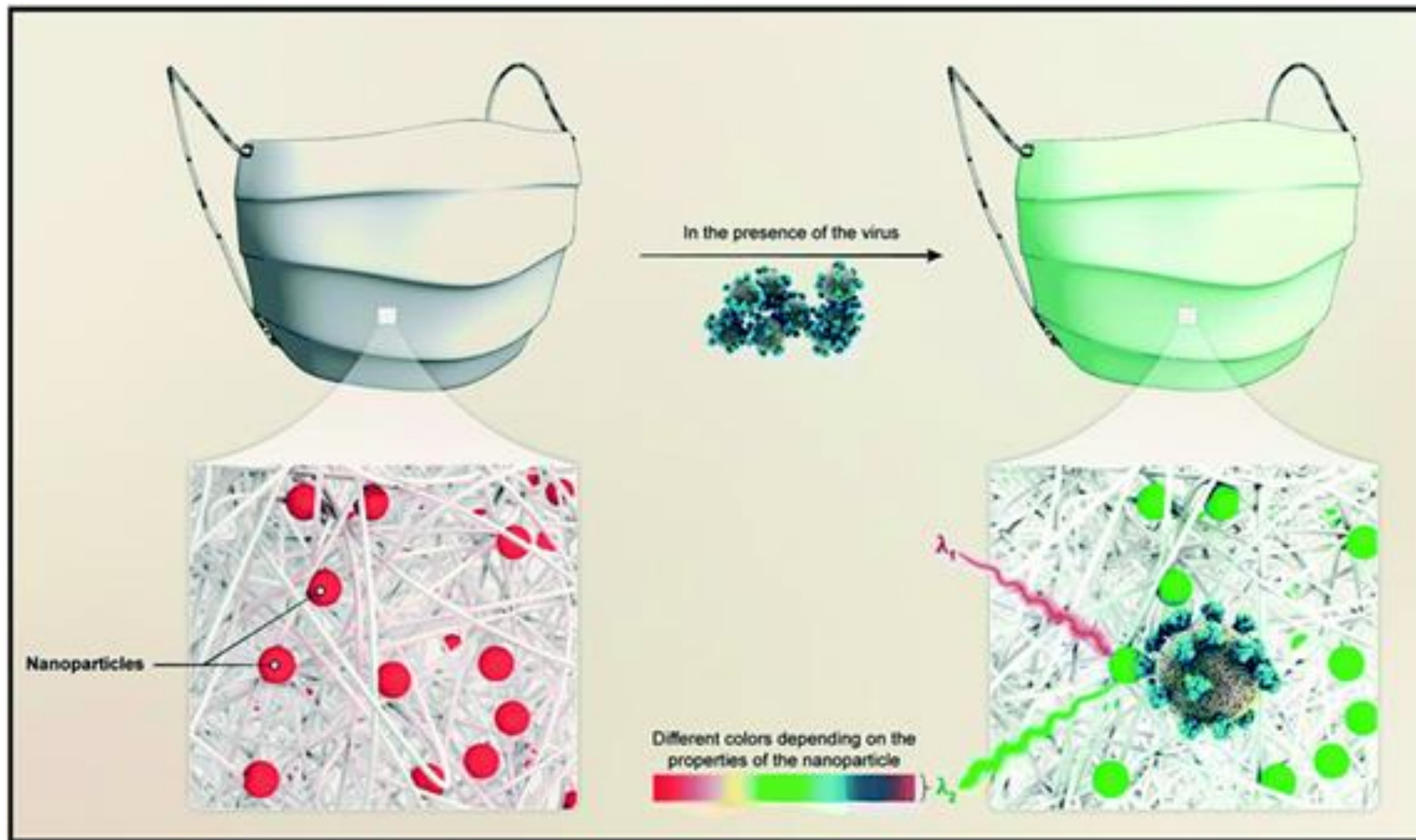


USING WEARABLES FOR CHECKING FOR COVID-19

Stanford University School of Medicine and Case Western University have shown that data from smartwatches and other health wearables, can be monitored to detect pre-symptomatic cases of COVID-19 :

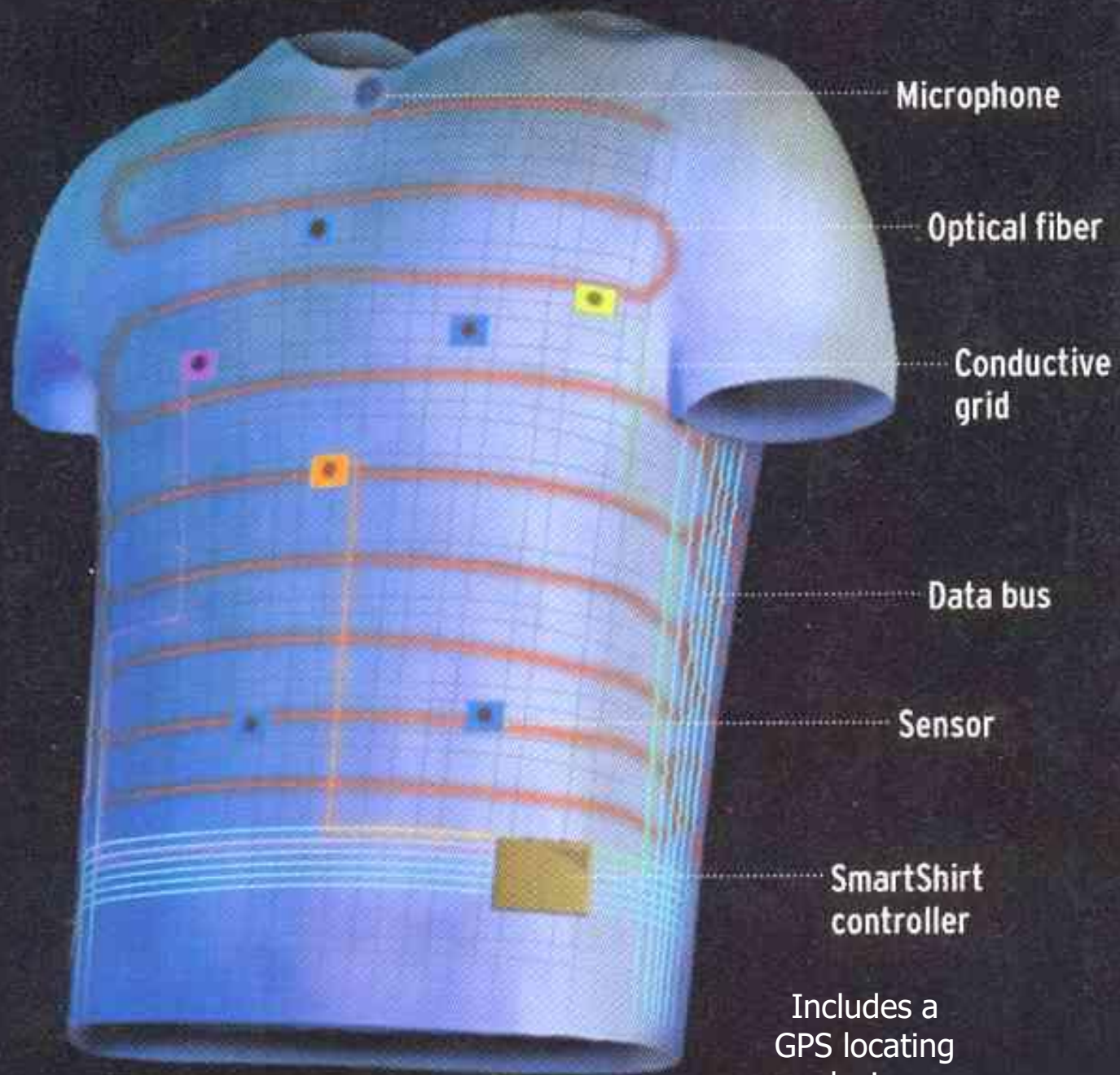
- Heart rate
- Body temperature
- Number of daily steps
- Sleep time





COVID-19 DETECTION USING THE COLOR CHANGE OF NANO PARTICLES IN A WEARABLE MASK.

Credit: creative commons attribution license, copyright @ MDPI (2020).



Microphone

Optical fiber

Conductive
grid

Data bus

Sensor

SmartShirt
controller

Includes a
GPS locating
device

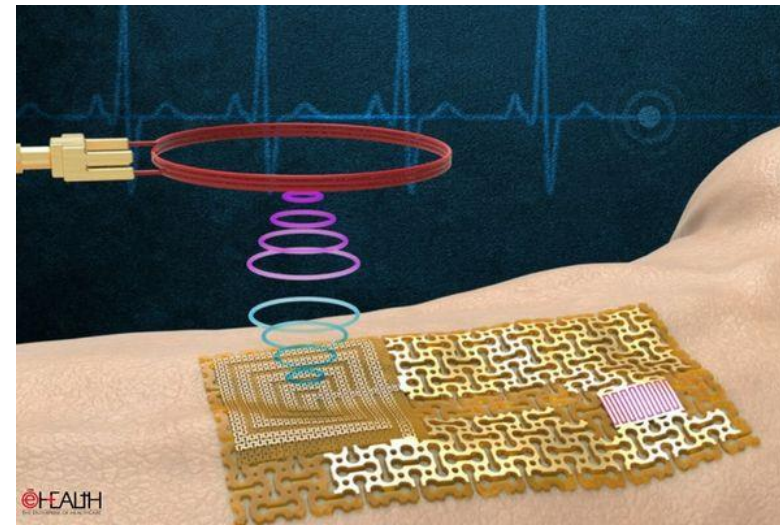
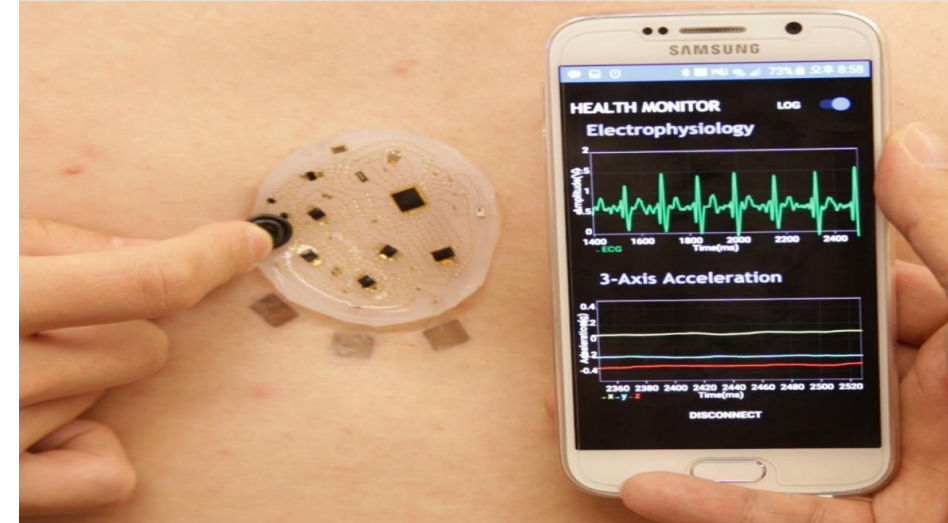
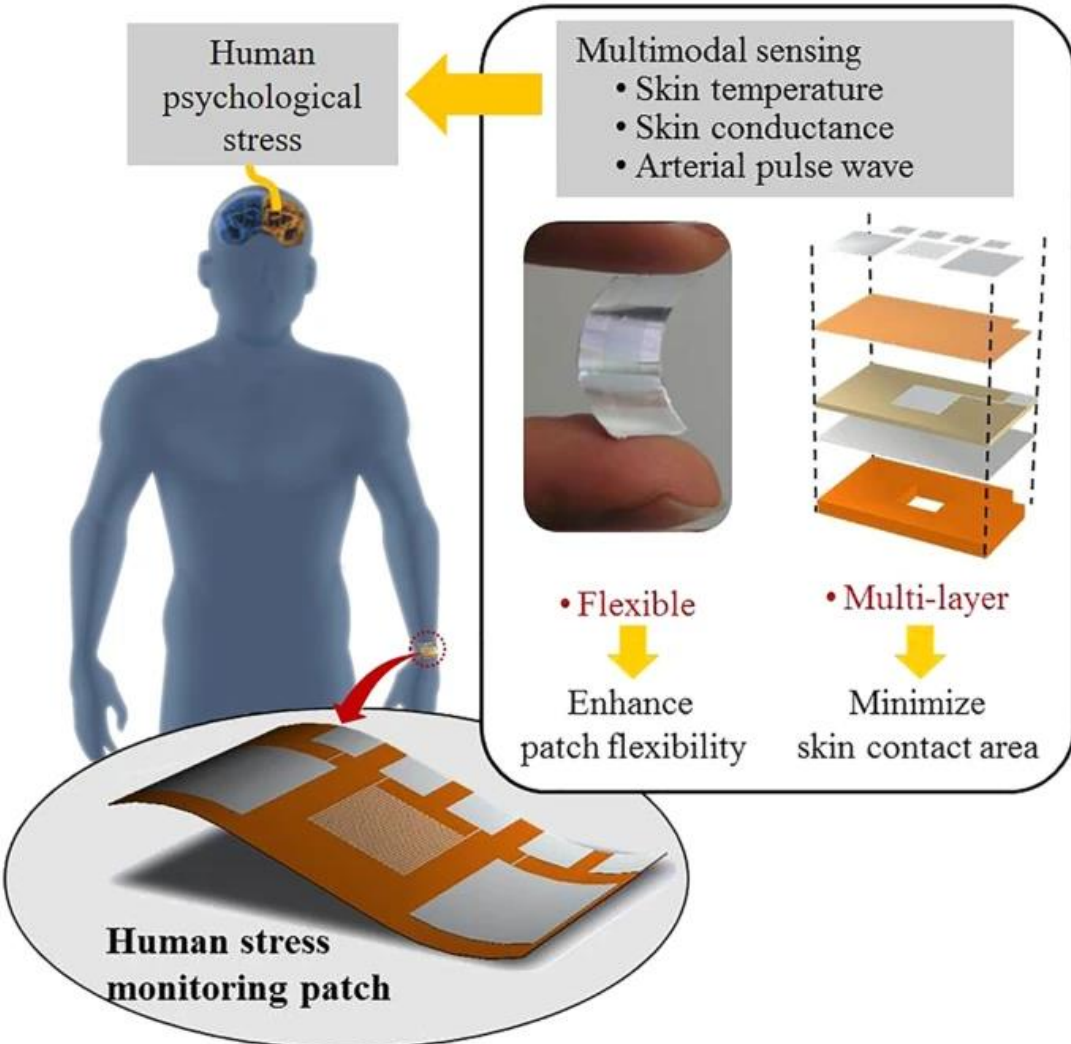
A SINGLE-CHIP ENCRYPTED WIRELESS 12-LEAD ECG SMART SHIRT FOR CONTINUOUS HEALTH MONITORING



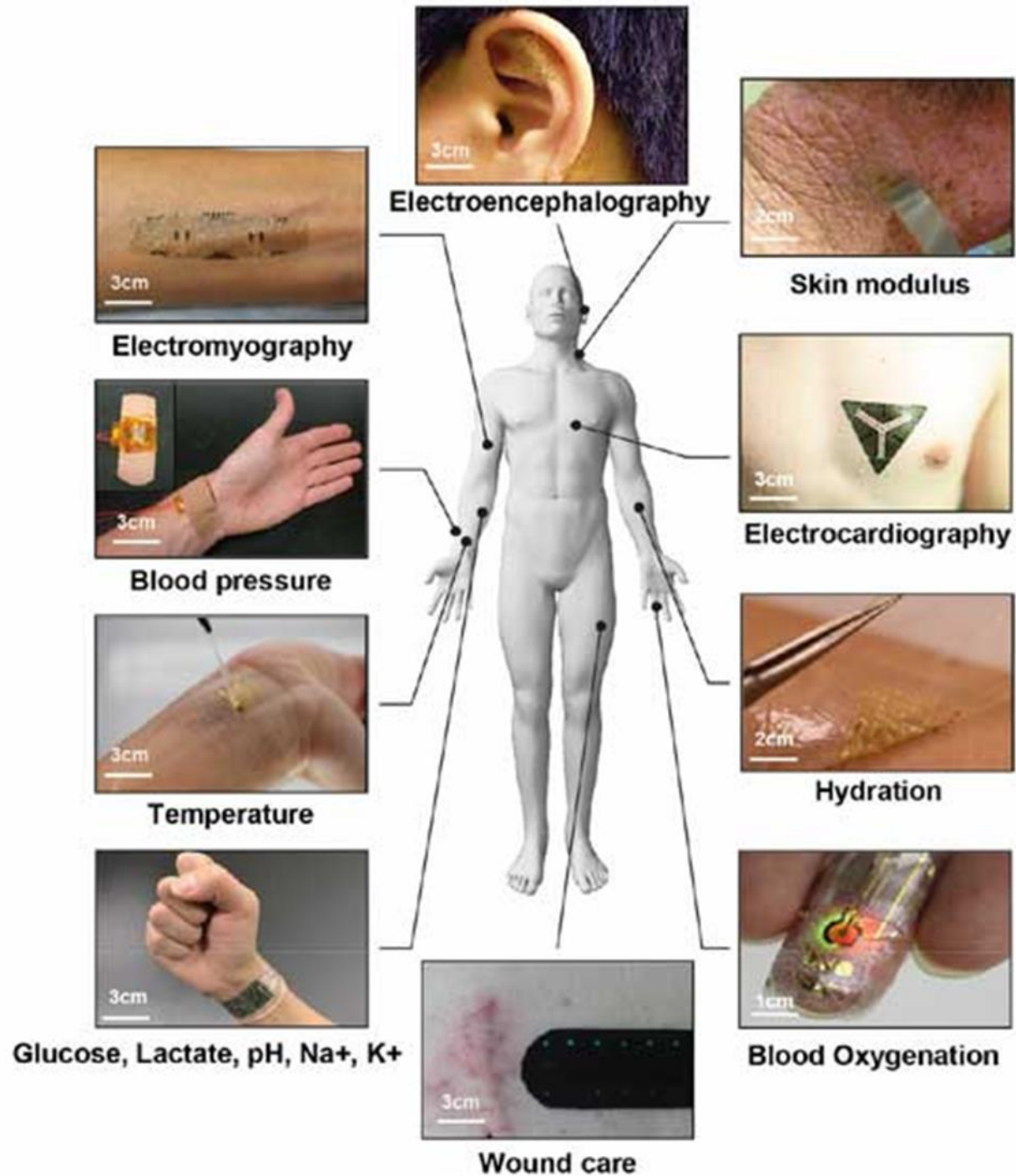
2) DEVICES ATTACHED TO THE SKIN FOR HEALTH MONITORING

Skin, the largest organ in the human body, is sensitive to external stimuli.

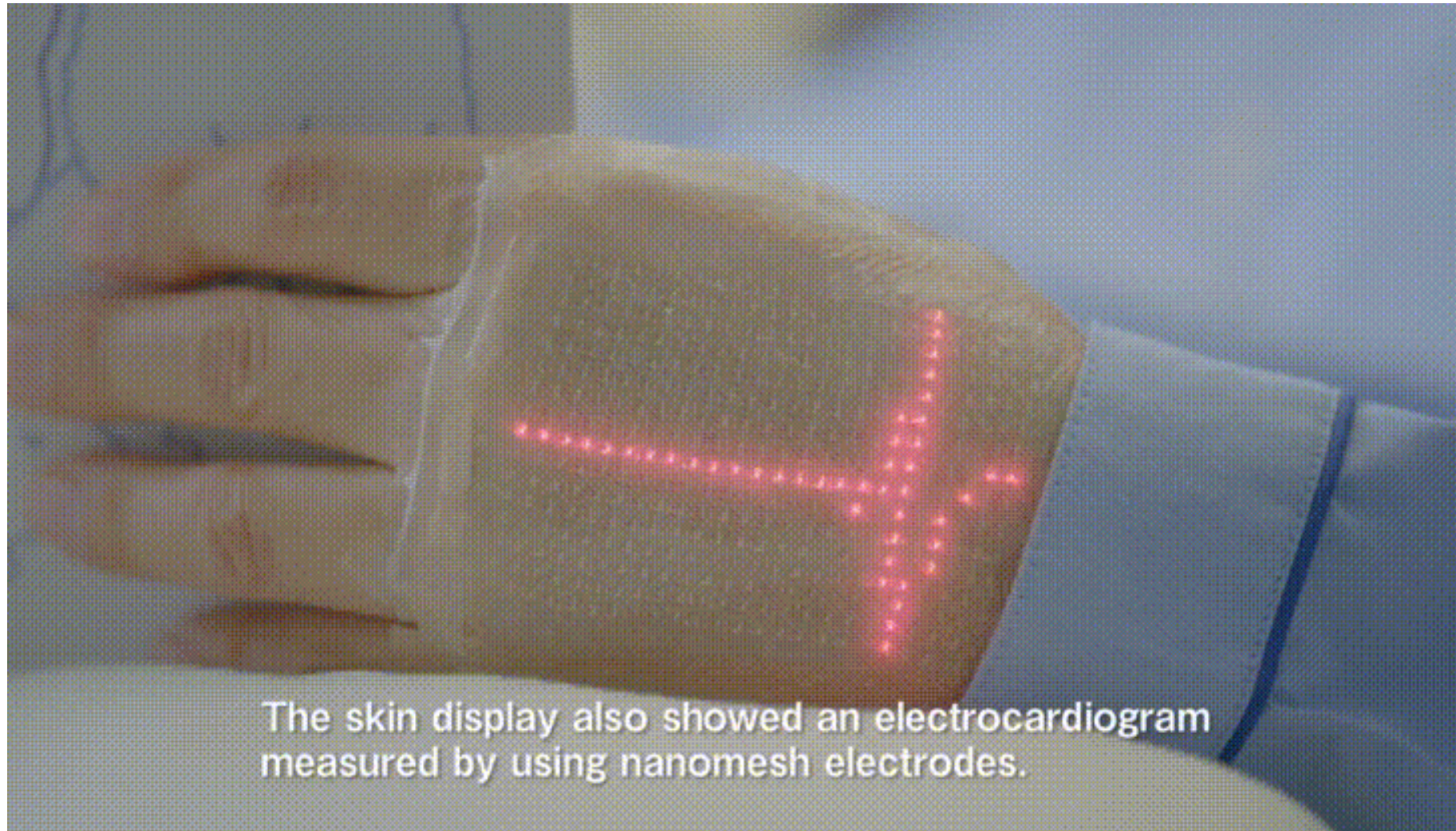
In recent years, an increasing number of skin-inspired electronics, including wearable electronics, implantable electronics, and electronic skin, have been developed because of their broad applications in healthcare and robotics.



**NEW KINDS OF ELECTRONIC
TATOOS AND CIRCUITS
THAT CAN BE PUT ON THE
SKIN WHERE REMOTE
MONITORING IS NEEDED**



Japanese researchers developed an ultrathin, highly elastic skin display. The device displays an electrocardiogram recorded by a skin sensor, which holds promise for home healthcare application.



<https://www.youtube.com/watch?v=zpGujcLRHNw> 1.5 min

FLEXIBLE WIRELESS ELECTRONIC SKIN (E-SKIN) WITH A 3-WAY SENSOR SYSTEM

It contains a multi-functional sensor device that lets a person feel:

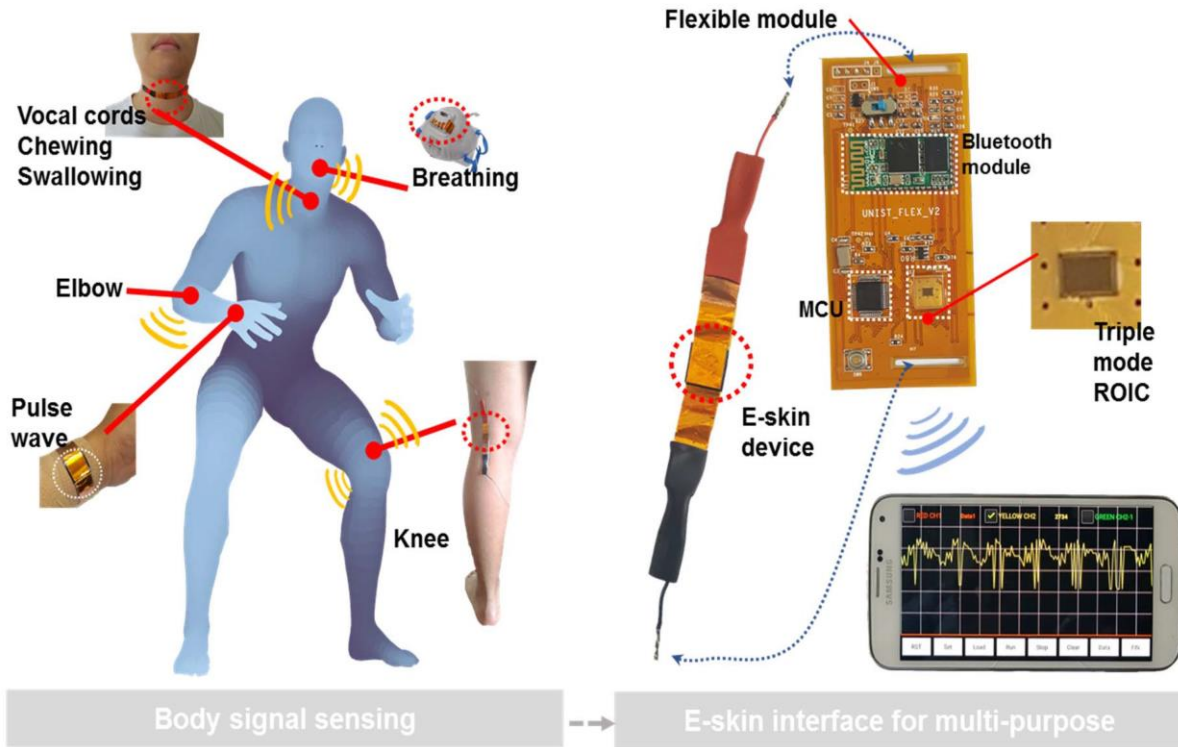
- Skin pressure
- Heat
- Cold

It uses a Piezoelectric circuit **for energy harvesting** from the surroundings, to power the device.

Depending on where it is placed, It can be used to monitor a persons:

Voice
Chewing/swallowing
Breathing
Knee movements
Temperature

The results can be displayed on a smartphone.



A Triple-Mode Flexible E-Skin Sensor Interface for Multi-Purpose Wearable Applications

SKIN PATCHES

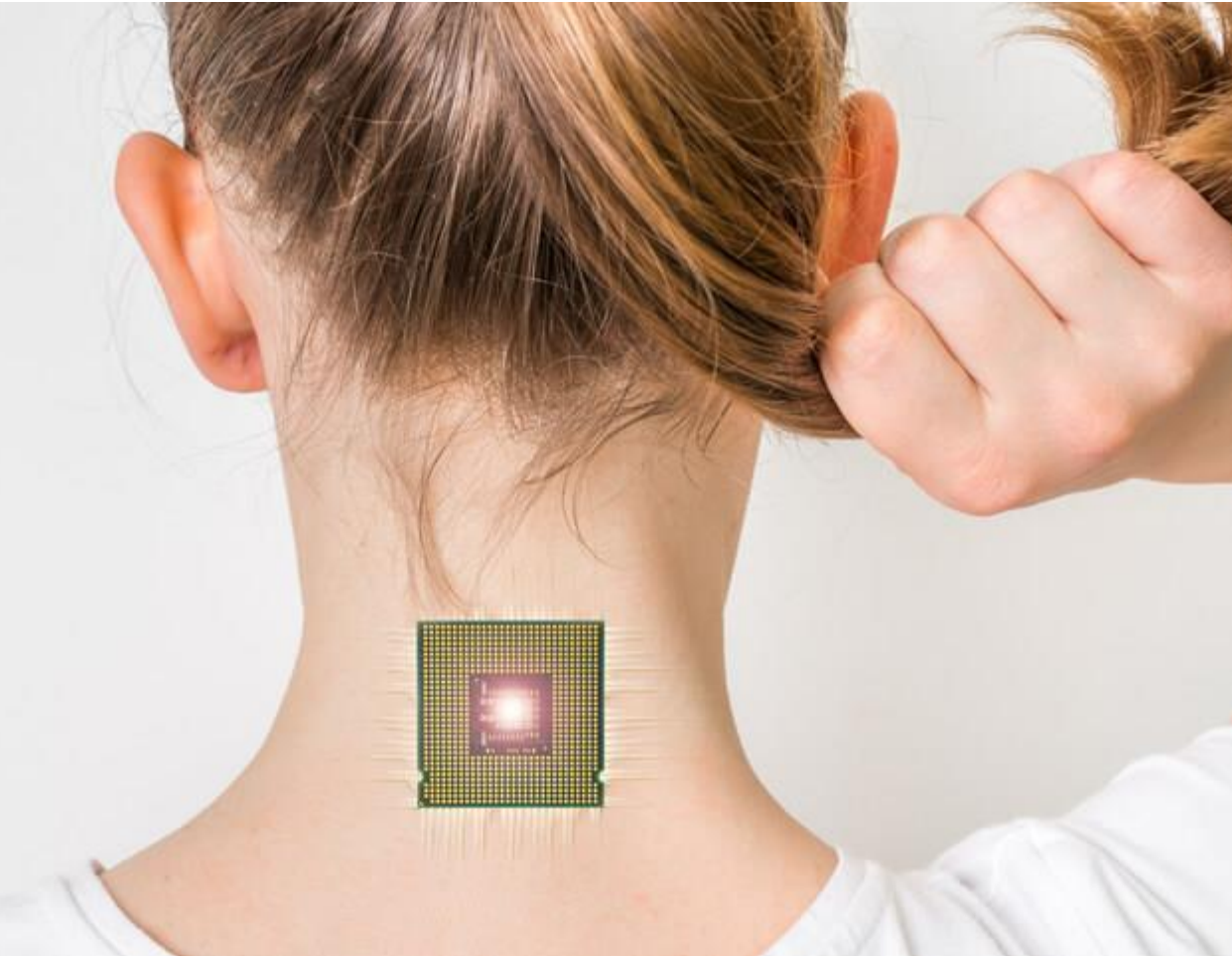
They are wearable technology that adheres to the skin like a self-adhesive bandage.

Smart patches are basically used for athletic performance or healthcare monitoring.

The most common patches for healthcare measure:

- Blood Glucose
- Temperature
- Blood Pressure/Flow
- Heart Rate
- ECG
- Blood Oxygen

The end users for monitoring and diagnosis are mostly focused on cancer, diabetes, cardiac disorders and blood pressure conditions.



ELECTRONIC CIRCUITS CAN BE PAINTED DIRECTLY ON SKIN

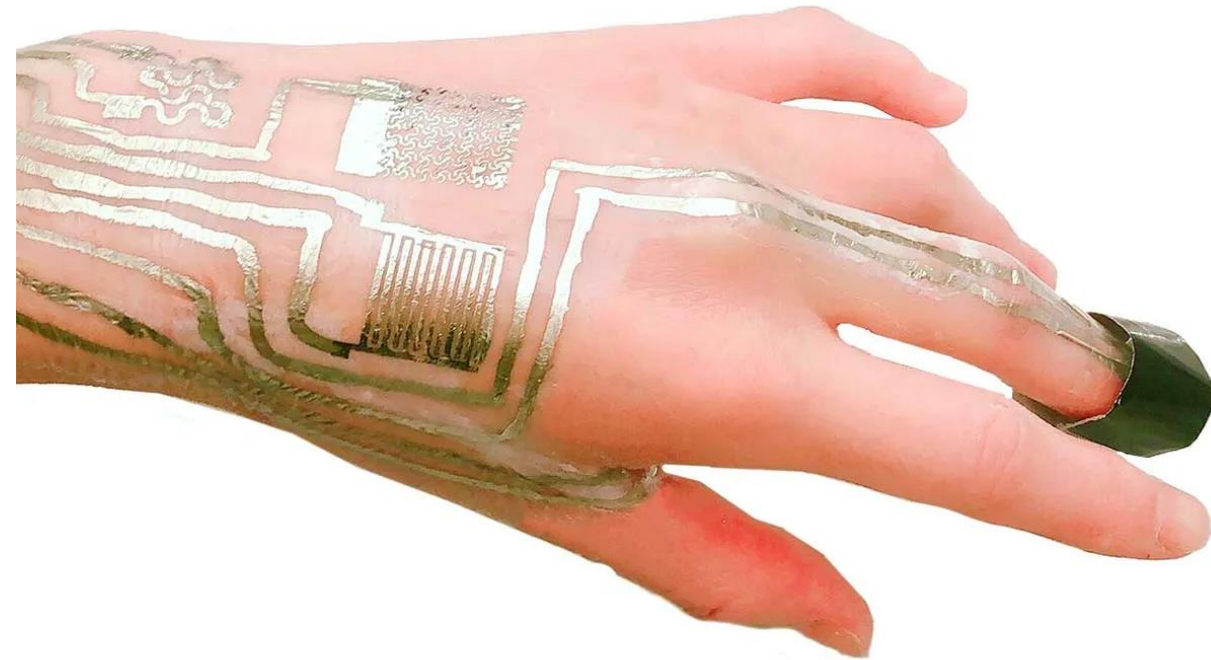
ROOM-TEMPERATURE SINTERING ENABLES SKIN SENSORS TO MEASURE VITAL SIGNS

Scientists wanted a way to sinter—that is, use heat to fuse—metal nanoparticles to fabricate circuits directly on skin but the regular methods usually require heat levels far too high.

Researchers at Pennsylvania State University developed a way to sinter nanoparticles of silver at room temperature which created a smooth base for electrical circuits, printed on top of it.

This in turn improved the performance of these circuits in the face of bending, folding, twisting and wrinkling.

The researchers now plan to apply these sensors for diagnostic and treatment applications for cardiopulmonary diseases, including COVID-19, pneumonia, and fibrotic lung diseases.



CREATING ARTIFICIAL SKIN

Skin – the body’s largest organ – is constantly monitoring for pain.

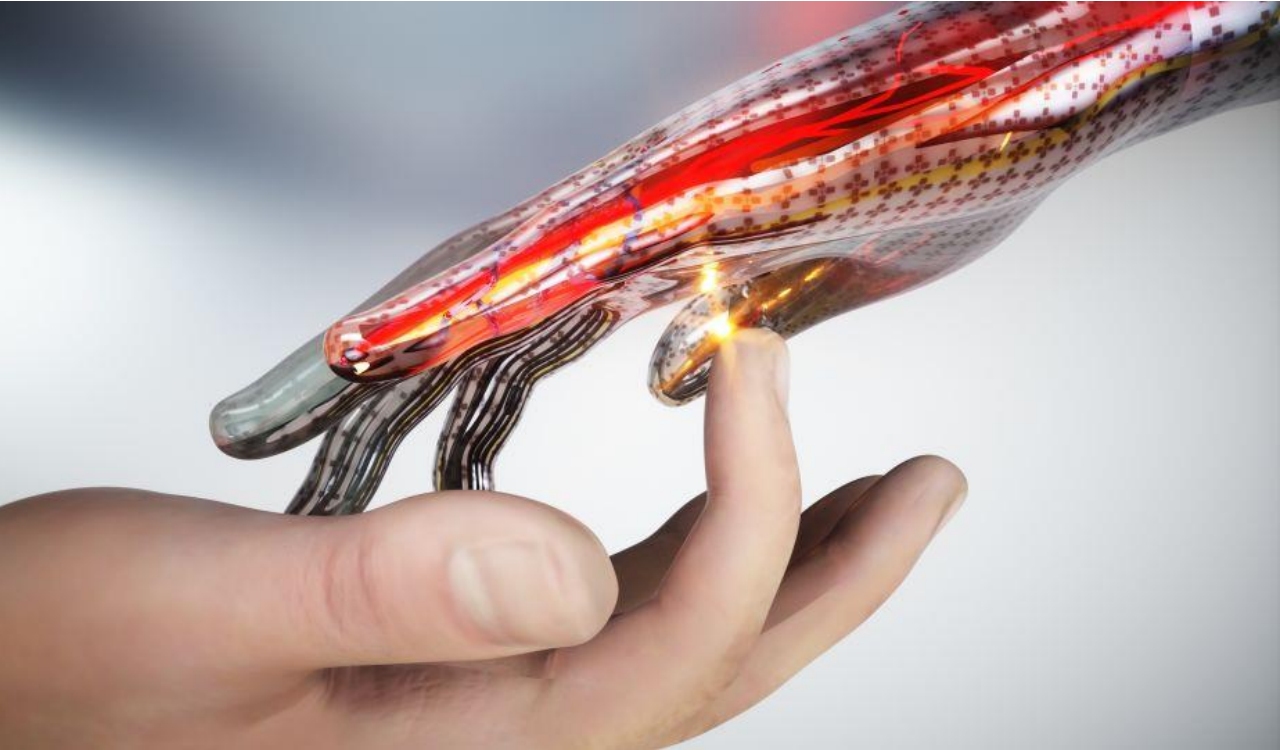
Now, researchers at RMIT University in Melbourne, Australia, have created an artificial skin that mimics this mechanism and reacts to pain stimuli.

Made of silicone rubber, it has the texture of real skin and is also “very similar to skin in its mechanical properties.

It is designed to react when pressure, heat or cold surpass a pain threshold.

Its outer layers sandwich electronic circuits studded with sensors, which respond to stimuli.

The result is artificial skin that can differentiate between the gentle touch of a pin or a painful stab as well as hot and cold temperatures.



EPIDERMAL SKIN PATCH

Engineers at UC San Diego have developed a flexible, all-in-one skin patch.

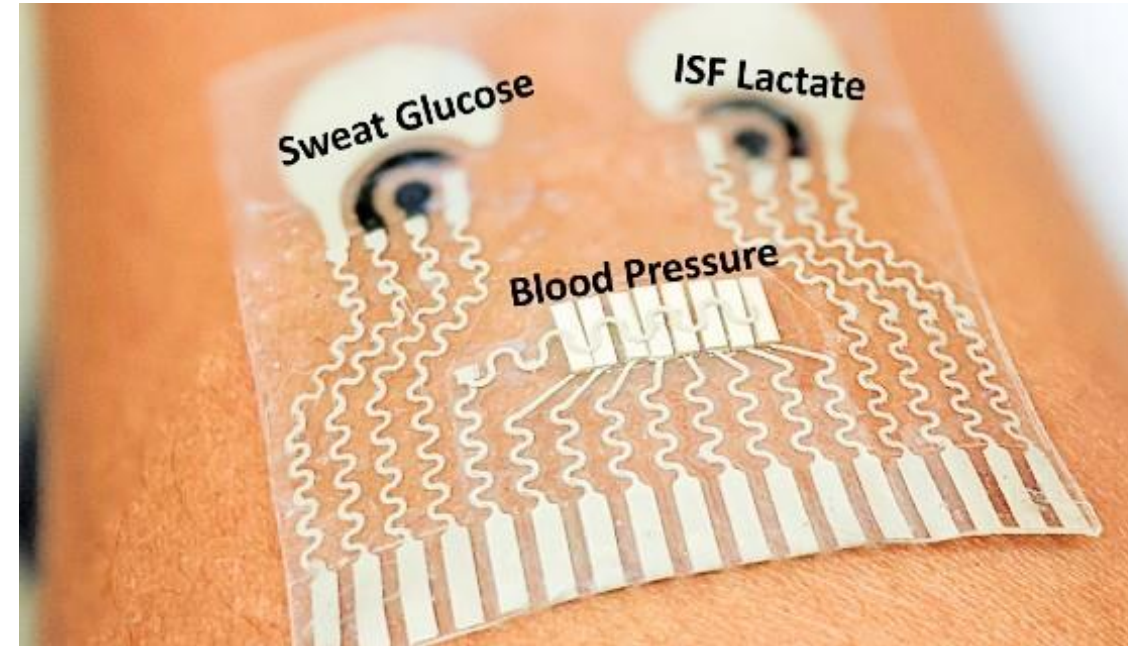
They figured out how to place ultrasound sensors—that monitor heart rate and blood pressure—and chemical sensors—that detect metabolites of glucose and other substances in body fluids—on the same 2 inch by 2 inch square patch.

The top left sensor detects substances in sweat— lactate, which increases during exercise, as well as caffeine and alcohol.

The top right sensor measures substances in the fluid in the space between cells in the body)—in this case, levels of blood glucose.

The bottom, center area is a row of ultrasound transducers that pulse sound waves into blood vessels and pick up the returning sound waves.

Those returning signals measure blood pressure and heart rate.

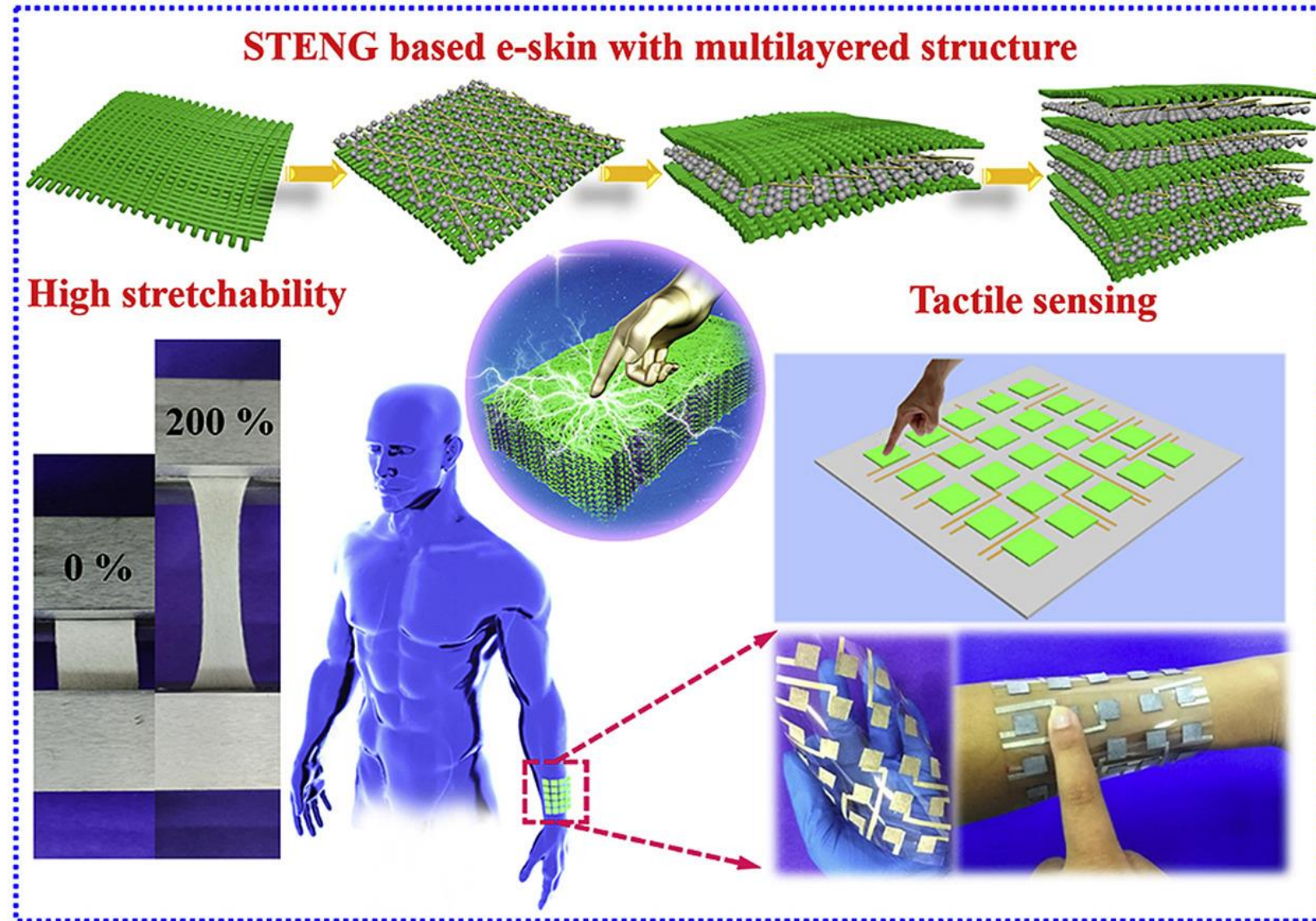


Credit: Joseph Wang and Sheng Xu, UCSD.

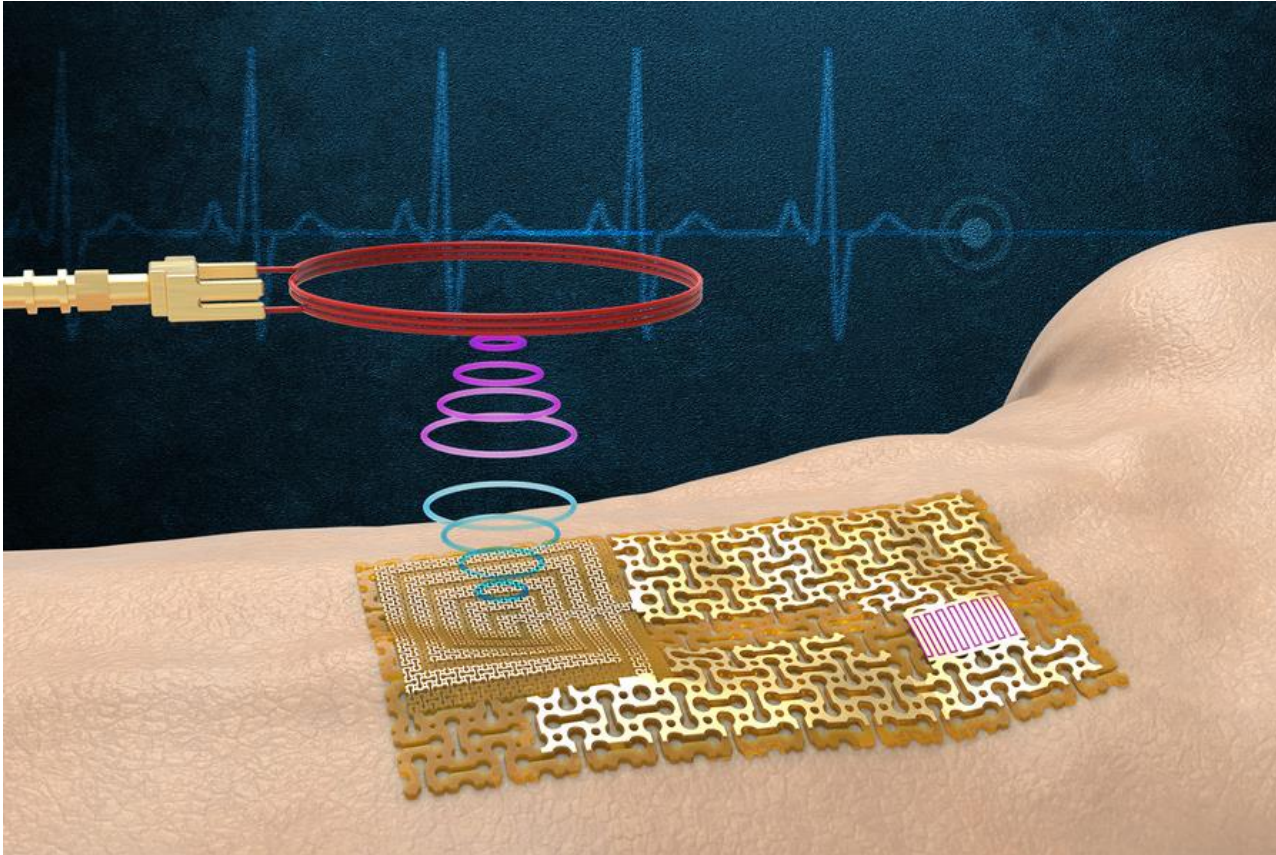
ULTRA-STRETCHABLE, TRIBOELECTRIC NANOGENERATOR AS A HIGH- SENSITIVE AND SELF-POWERED ELECTRONIC SKIN FOR ENERGY HARVESTING AND TACTILE SENSING

A flexible and self-powered electronic skin (e-skin) based on an ultra-Stretchable TriboElectric Nano-Generator (STENG) for powering itself as well as being stretchable.

It can sense strength and direction and strength of motion of a person, robots or other devices.



ENGINEERS FABRICATE A CHIP-FREE, WIRELESS ELECTRONIC “SKIN”



The device senses and wirelessly transmits signals related to pulse, sweat, and ultraviolet exposure, without bulky chips or batteries.

The heart of the sensor is an ultrathin, high-quality film of gallium nitride, a material that is known for its 2 piezoelectric properties:

1. It can both produce an electrical signal in response to mechanical strain
2. It can mechanically vibrate. in response to an electrical impulse.

The researchers found they could harness gallium nitride’s two-way piezoelectric properties and use the material simultaneously for both sensing and wireless communication.

3) THE NEW MATERIAL – GRAPHENE FOR MEDICAL APPLICATIONS

It is an atomic-scale, single layer, hexagonal lattice made of carbon atoms.

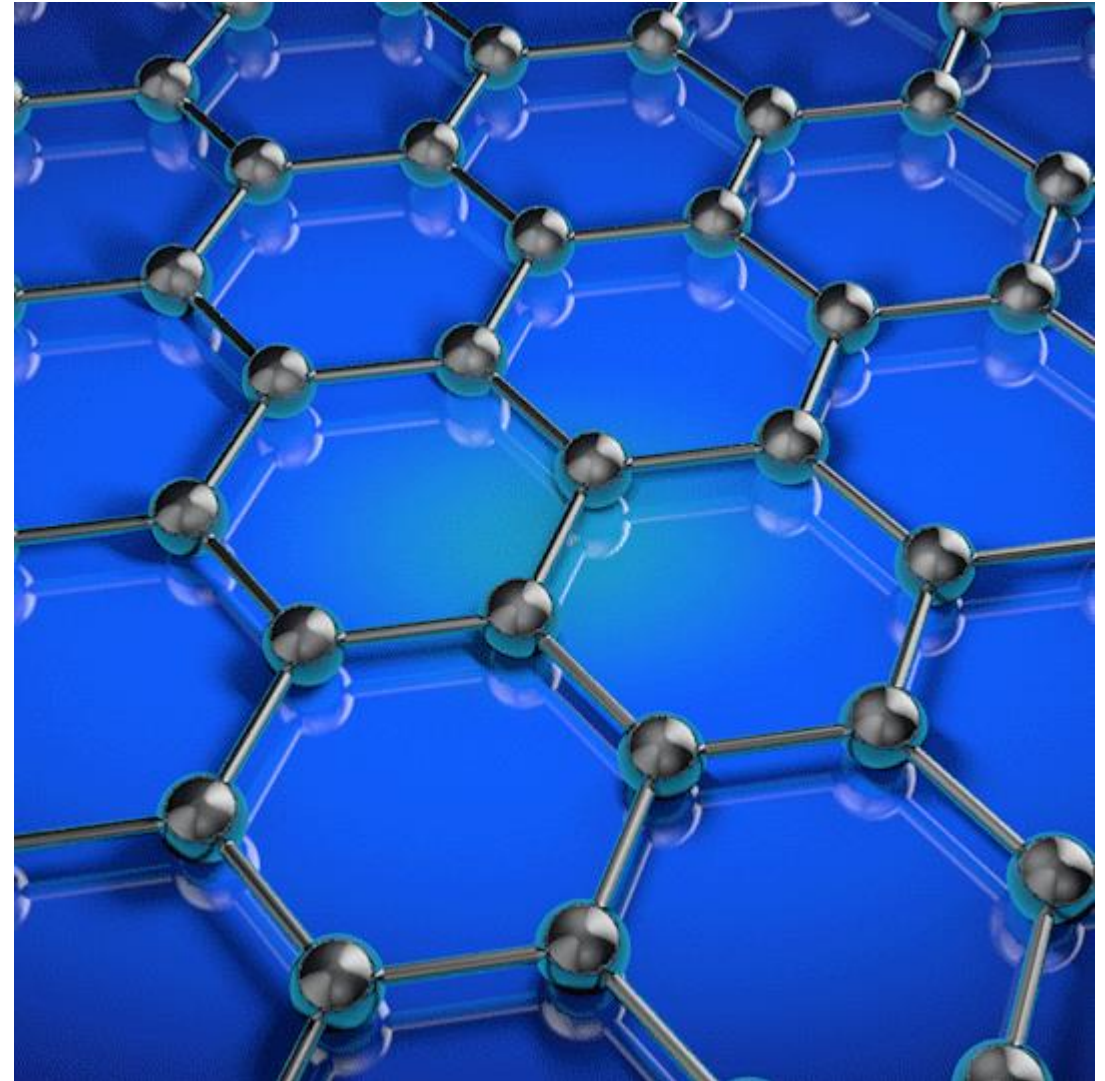
It is the strongest, lightest and most electrically and heat conductive substance on Earth.

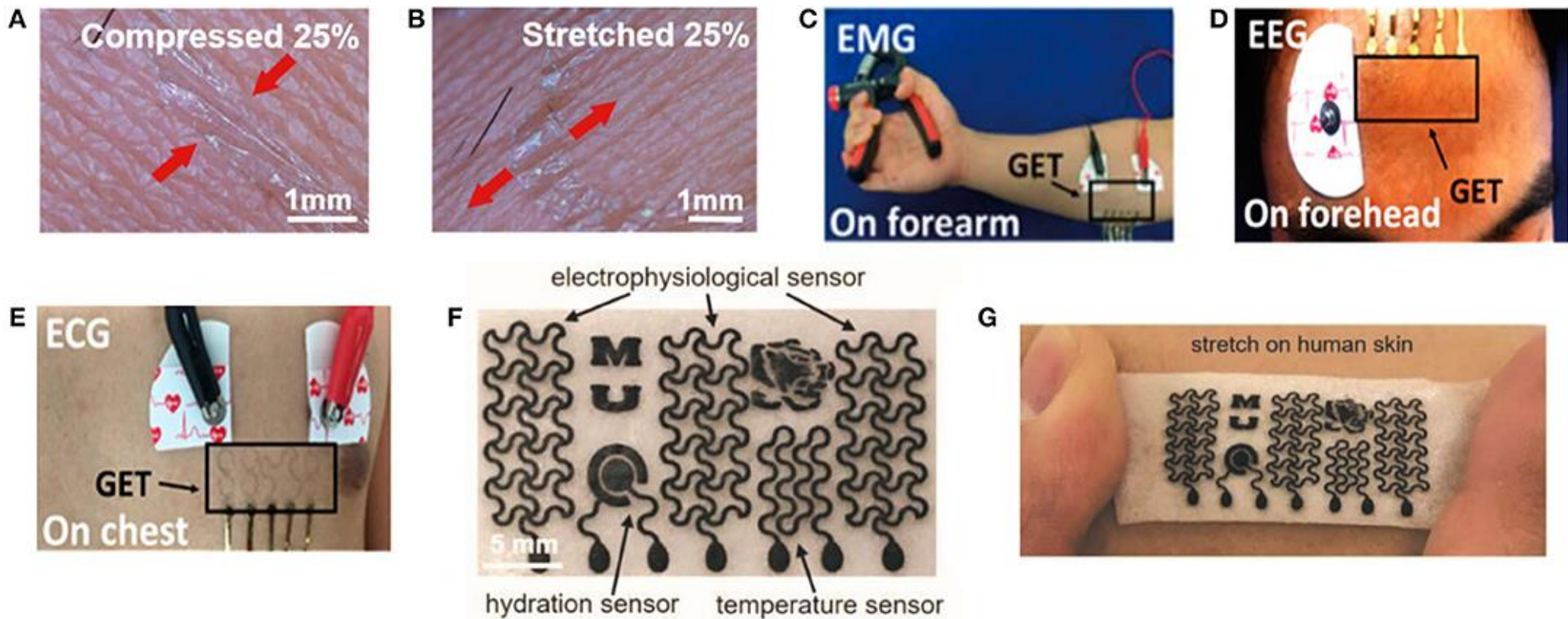
It strongly absorbs light of all visible wavelengths so it is black in color but actually clear because each atomic layer is so thin.

It is the strongest material ever measured - up to 150 times stronger than the equivalent weight of steel.

It is pliable as rubber and has the ability to stretch up to 120% of its length then recover its original shape.

It can be used in biosensors - a graphene-based sensor was used to detect a cancer risk biomarker.





Magnified photographs of a Graphene Electronic Tattoo (GET) on compressed (A) and stretched (B) skin.

(C) Electromyographic (EMG) muscle sensing on the forearm with the GET and gel electrodes.

(D) Electroencephalograph (EEG) sensing on the forehead with both the GET and gel electrodes.

(E) Electrocardiogram (ECG) (heart measured synchronously by the GET and gel electrodes).

(F) Optical images of the as-made on-skin bioelectronics sensing systems

(G) Sensor mounting on skin.

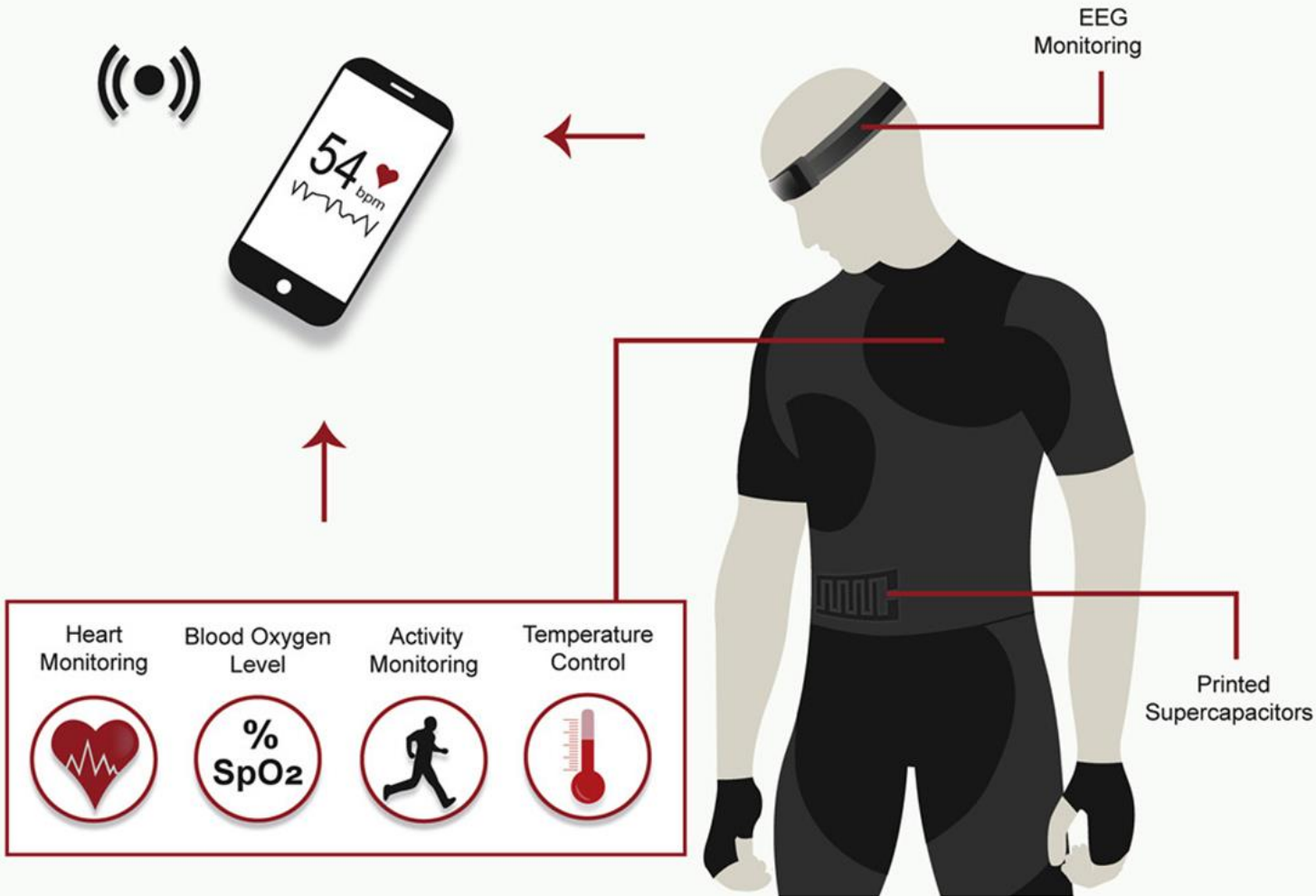
GRAPHENE-BASED SCREEN-PRINTED CONDUCTIVE, FLEXIBLE, AND MACHINE-WASHABLE E-TEXTILES

Researchers invented a flexible sensing device that stores energy and monitor physiological conditions including bio-signals.

The approach includes highly scalable printing of graphene-based inks on a rough and flexible textile substrate, followed by a fine encapsulation to produce a highly conductive machine-washable e-textiles platform.

It can detect activities of various body parts.

It could potentially lead to a multifunctional garment of graphene-based e-textiles that can act as flexible and wearable sensors powered by the energy stored in a graphene-based, textile supercapacitor.



Graphene-based Sensors in Health Monitoring

Invasive Applications

Nervous System

- ECoG
- Neural stimulation

Cardiovascular System

- ECG
- Blood glucose

Digestive System

- Gastrointestinal diagnosis

Locomotor System

- EMG
- Muscle stimulation

ECoG – Eastern Cooperative Oncology Group rating

ECG or EKG – Electrocardiogram (heart rhythm)

EMG – Electromyography (muscles & nerves)

EEG – Electroencephalogram (brain)

EOG – Electrooculography (eyes)

Non-invasive Applications

Biophysical

Electrophysiological

- EEG
- EOG
- ECG
- EMG

Kinematic

- Pulse/heart rates
- Respiration
- Phonation
- Facial expressions
- Blood pressure
- Joints movements
- Gesture
- Muscle movements

Thermometer

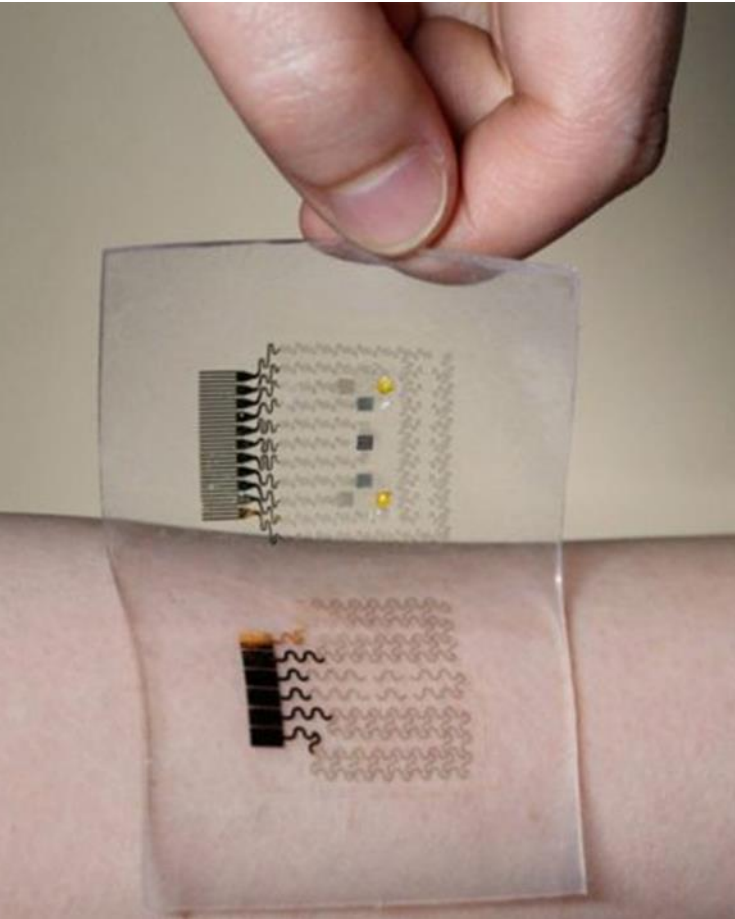
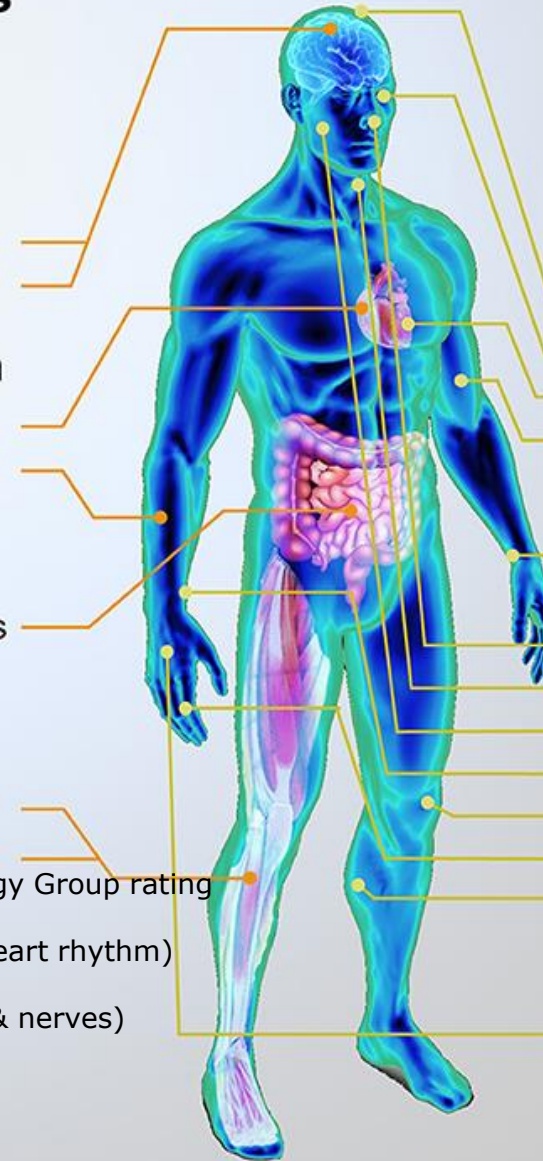
- Body temperature

Environmental

- Light
- Gases
- Heavy Metal

Bio-chemical

- Volatile gases
- Electrolyte
- Metabolite
- Bacteria
- Drug
- Dopamine
- Tumor markers
- Others

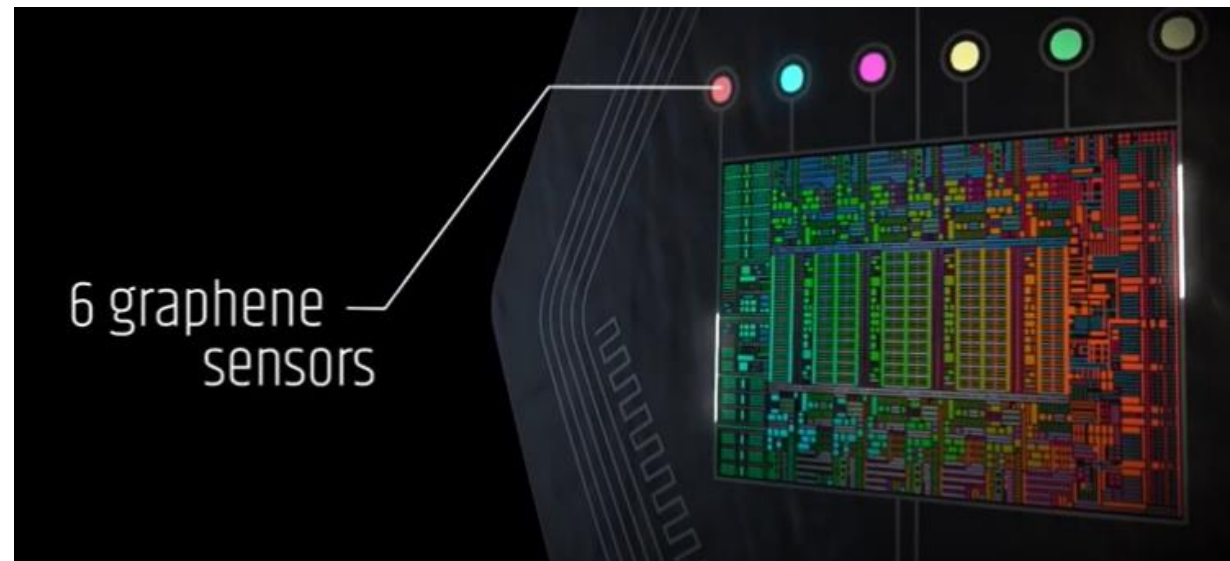


GRAPHENE FITNESS PATCH

Since it is flexible and extremely sensitive to changes in heat and light, graphene has a big future in wearable devices.

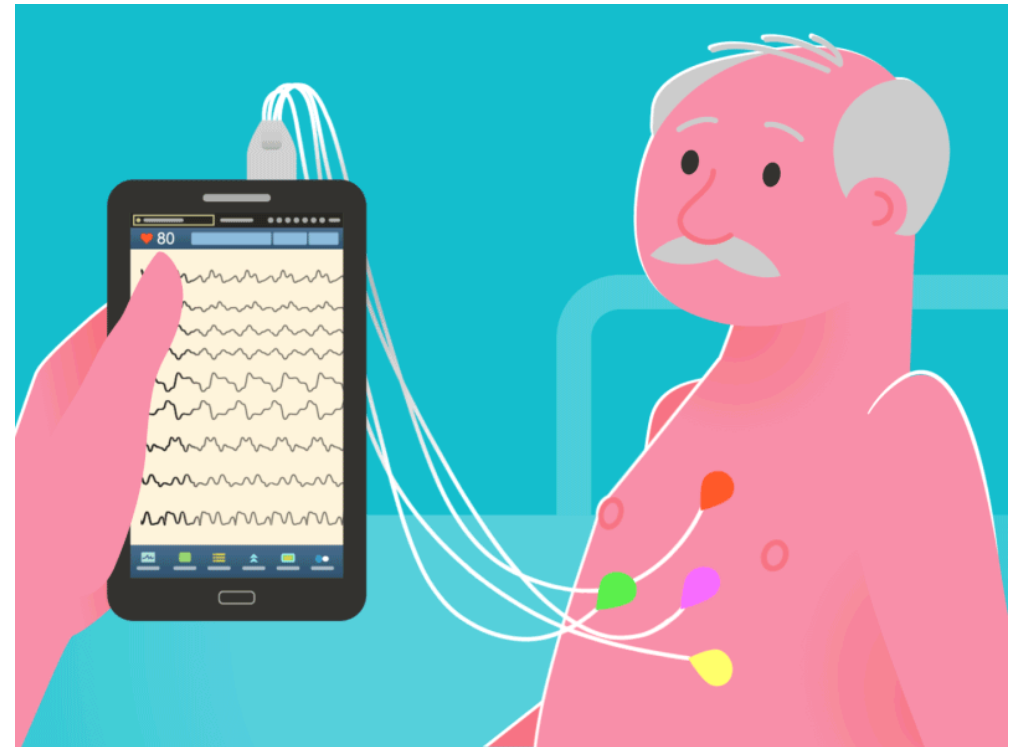
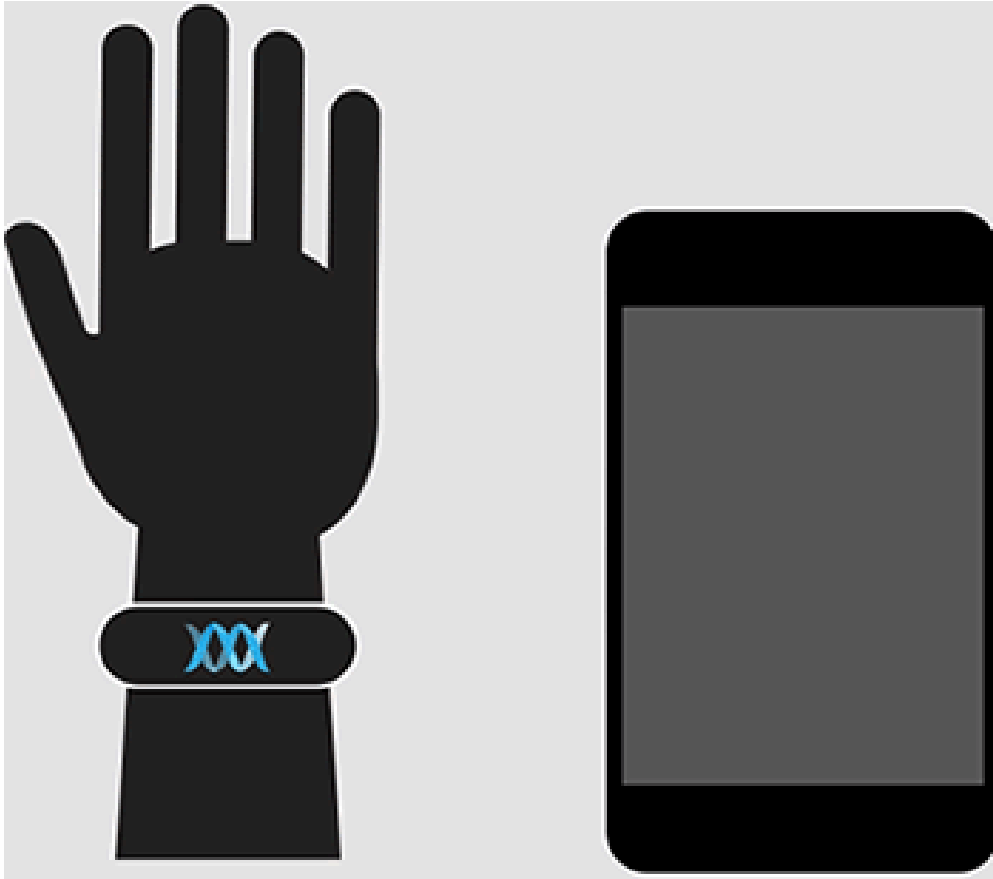
This 'transdermal fitness patch' from the ICFO in Barcelona **does everything your Fitbit can do, and more, but in the form of a stick-on patch.**

It measures heart rate, hydration and breathing rate with improved accuracy and less power consumption than current fitness bands and conforms to any surface.

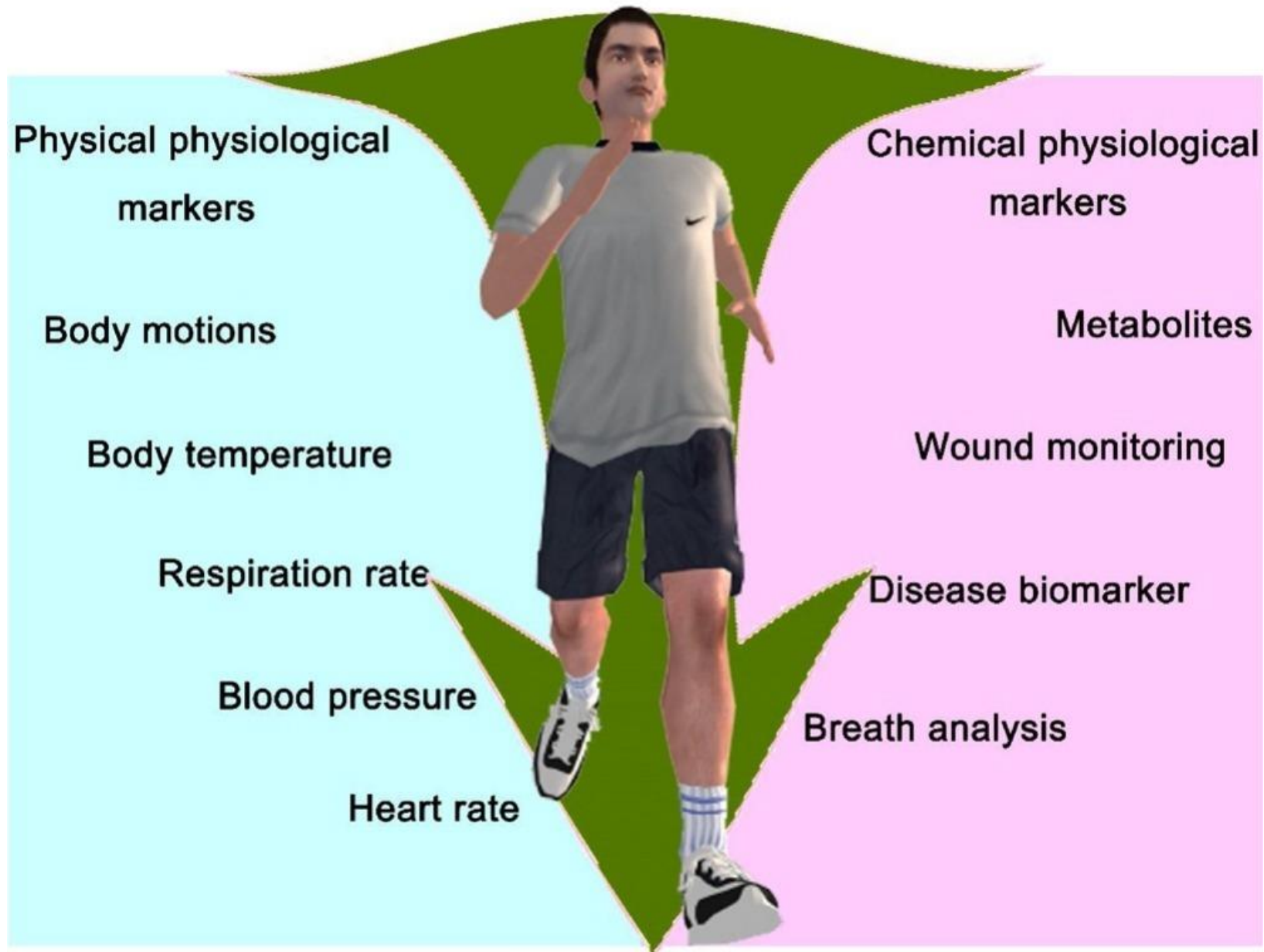


https://www.youtube.com/watch?v=Wb0qCnMObw&feature=emb_logo 1.5 min

4) MOBILE DEVICES AND APPS FOR HEALTHCARE



Wearable Healthcare Devices



Fully Integrated Wearable Healthcare Systems

BENEFITS OF WEARABLE TECHNOLOGY

Educate and empower patients to take control of their health

Help physicians & patients monitor & diagnose disease

Assist in medical procedures



Allow patients to control & manage their pain

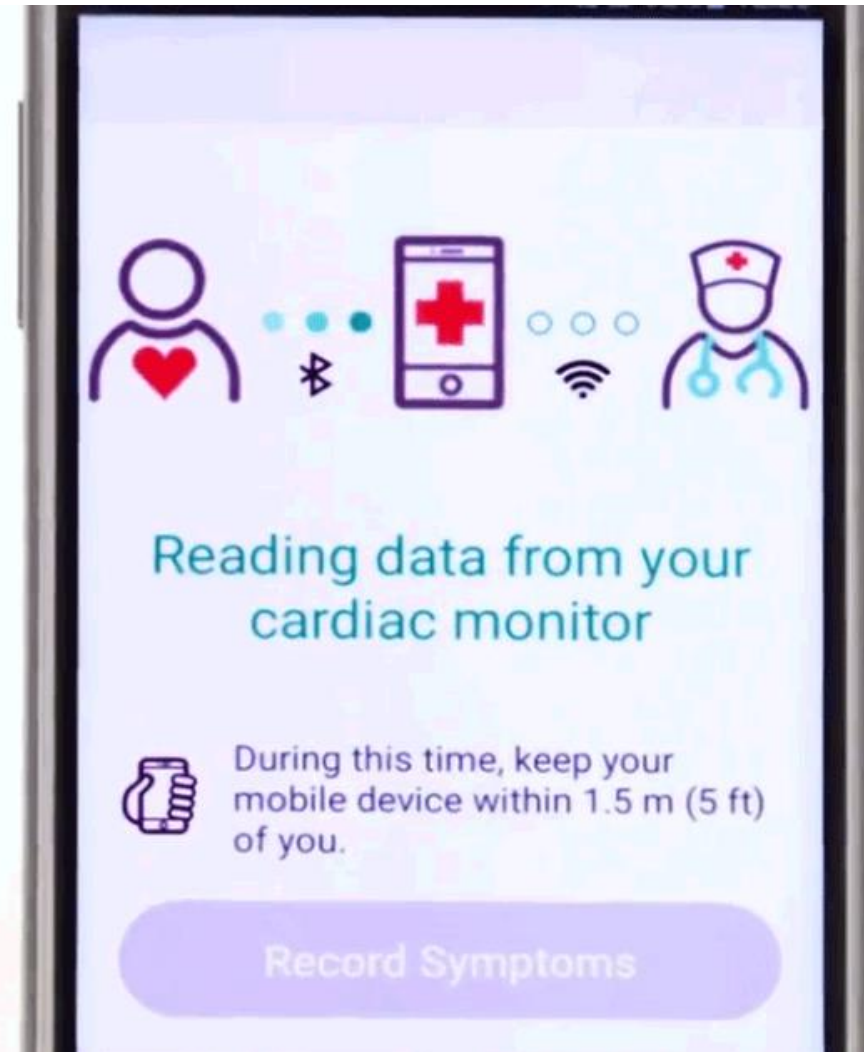
Make personal fitness more fun

THE TERM **APP** STANDS FOR AN APPLICATION

**AN APP IS A COMPUTER SOFTWARE
PACKAGE OR PROGRAM THAT
PERFORMS A SPECIFIC FUNCTION
DIRECTLY FOR AN END USER**

Health and medical apps are application programs that offer health-related services for smartphones, tablet PCs, Wearable watches, etc.

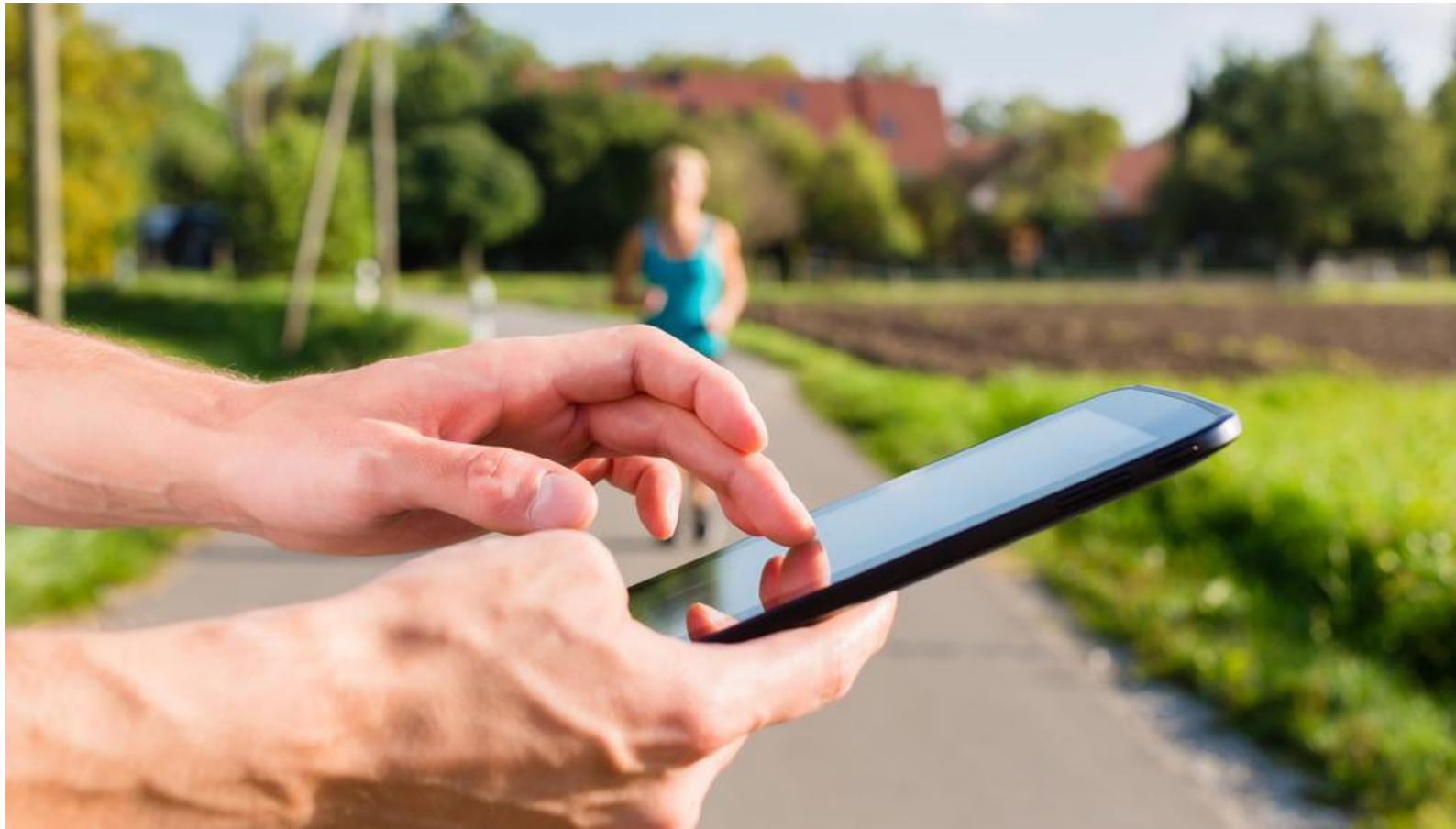
Because they're accessible to patients both at home and on-the-go, health apps are a part of the movement towards **mobile health (mHealth)** programs in health care.



General Health and Fitness Apps:

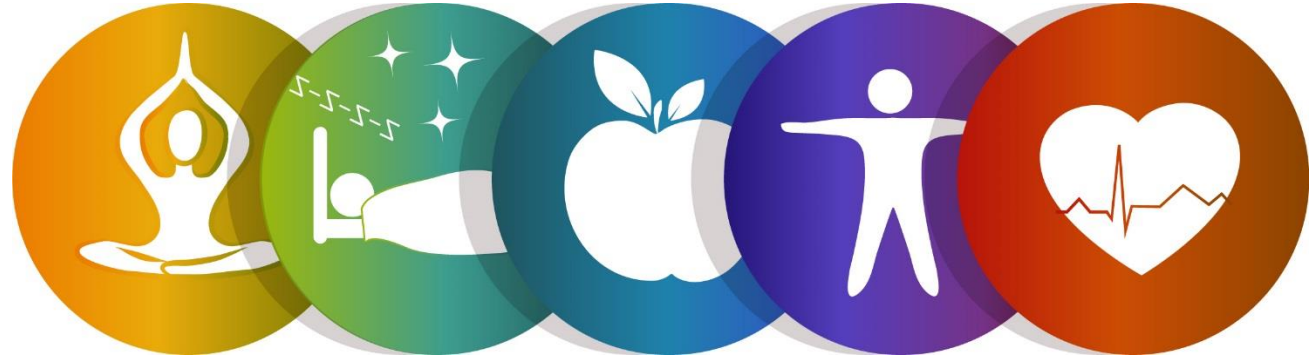
These apps constitute almost 75 percent of MMAs (Managed Medical Assistance) found on app stores.

These are related to nutrition, health tracking, fitness, and weight loss, and work with wearable technology devices such as a "FitBit", Smart Watch, and other types of health monitors.

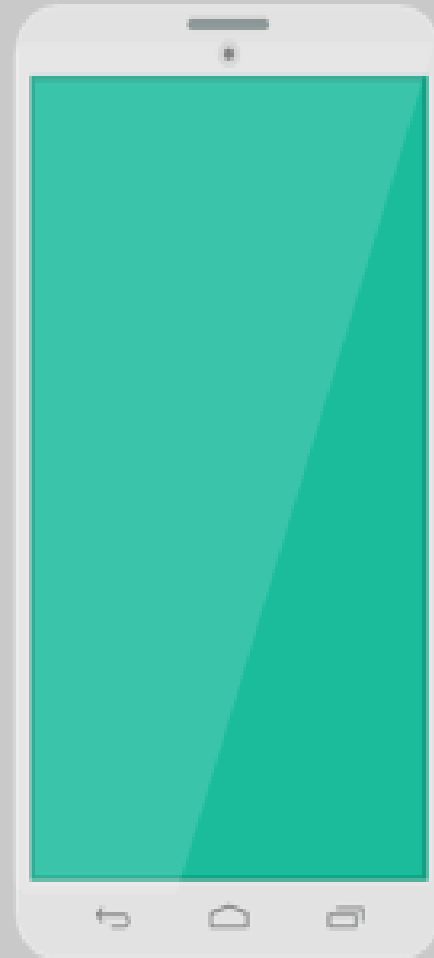


The most popular categories of health and wellness apps include:

- ❖ Sports and fitness activity tracking
- ❖ Diet and nutrition
- ❖ Weight loss coaching
- ❖ Pharmacy
- ❖ Sleep cycle analysis
- ❖ Stress reduction and relaxation
- ❖ Meditation
- ❖ Medical advice and Patient & Caregiver communities
- ❖ Menstrual period tracking
- ❖ Pregnancy
- ❖ Hospital selection and Physician appointment management



Different Kind Of Sensors Available On A Smartphone



Barometer 

Thermometer 

Pedometer 

Heart Rate Monitor 

Fingerprint Sensor 

 Accelerometer

 Gyroscope

 Magnetometer

 Proximity Sensor

 Light Sensor

 Microphone

+ Breath Analyzer for Smartphone

- FDA registered fuel cell sensor
- Plug into to headphone jack
- Learn drinking habits, enhance lifestyle
- \$49.9 to \$99.9



+ Mobile Ultrasound Device

- Until now, 60% of the world did not have access to ultrasound.
- Mobisante- the world's first smartphone-based ultrasound imaging system, the MobiUS™ SP1 ultrasound system.
- This device has been approved by the FDA



+ Urine Test on Smartphone

■ Scanadu Scanaflo

- 99¢ for the apps, \$20 for a packet of strips
- Test for levels of glucose, protein, leukocytes, nitrites, blood, bilirubin, urobilinogen, microalbumin, creatinine, ketone, specific gravity, and pH in urine
- Use color to give feedbacks: Green = normal, red = abnormal
- Urine tract infection, kidney disorders, pregnancy evaluation, etc



Dip

Wait

Scan

Get



Dario™, a cloud-based mobile **Diabetes management platform**, is the next generation in advanced Diabetes self-management.



Dario Smart Diabetes
Management Solution

Diabetes Management Simplified



KINSA SMART THERMOMETER

Just fire up the app, plug the thermometer into your headphone jack, stick it under your kid's tongue (or in their ... you know) and get a reading in less than 10 seconds.

It's virtually unbreakable and compatible with iOs and Android devices.

The app can track, record, and save symptoms and medication information for up to 8 profiles.



CELLSCOPE OTO HOME

Quickly and easily **capture ear images** to determine whether your child has an infection, allergies, or swimmer's ear.

The accompanying app provides guided exams, or you can share the images with a doctor on Cellscope's HIPAA-compliant platform.



SURGICAL DIAGNOSIS APPLICATIONS OF SMARTPHONE CAMERA ADAPTERS.



(A) iPhone-based otoscopy and laptop-based wireless endoscopic otoscopy

(B) A polarized dermoscope enables accurate comedone manipulation

(C) Smartphone-endoscope adapter to capture video

(D) Smartphone attached to a microscope through a 3D printed adapter

(E) Smartphone microscope adapter

(F) Smartphone attached to a microscope through an adapter

HEART HEALTH MONITORING WITH A SMART PHONE

the KardiaMobile 6L is a medical-grade, pocketable heart health device capable of delivering readings of your Electrocardiogram (EKG), advanced artificial intelligence, cloud technology, and resulting state-of-the-art cardiac care.



Apple and other smart watches



SMART WATCHES FOR HEALTH AND MEDICAL MONITORING

Currently, smartwatches provide information such as

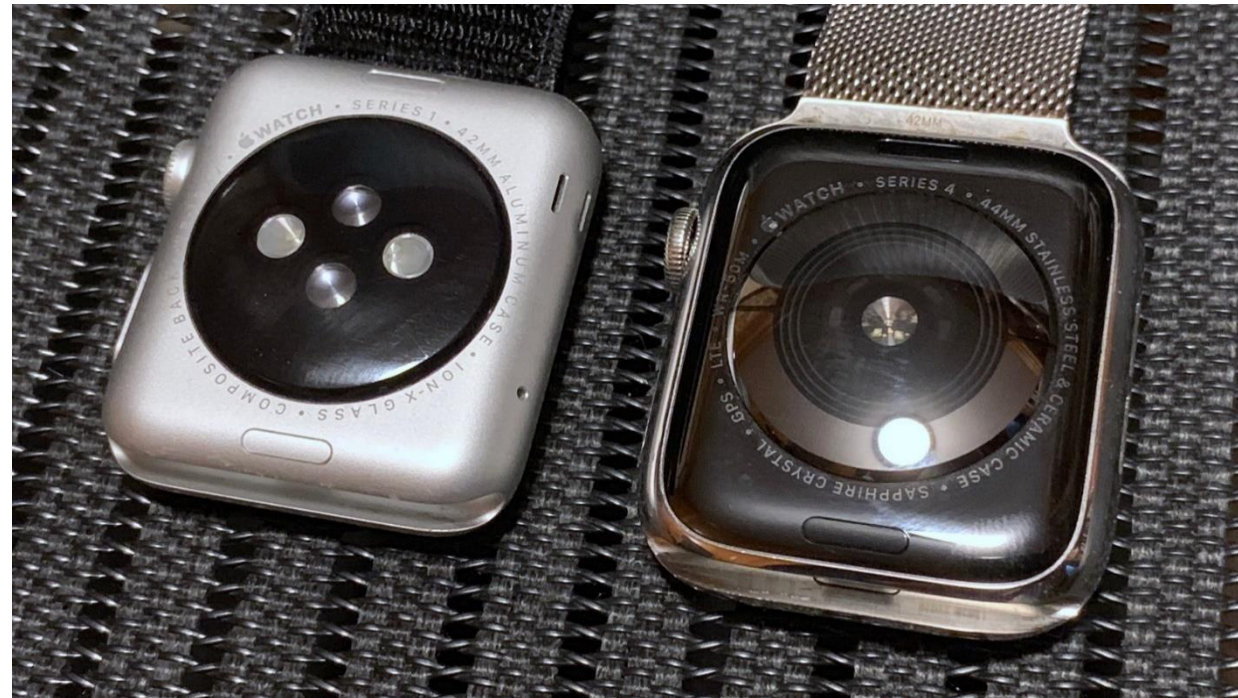
- Heart rate (to detect the possibility of A fibrillation)
- Sleep time
- Glucose from sweat (for persons with Diabetes)
- Activity patterns
- Sensing the amount of impact, if a person fell



THE APPLE SMART WATCH

The Apple Watch Series 4 (right) completely redesigns the health sensor array on the bottom of the watch to incorporate an ECG (Electro-cardio-gram) (or EKG) electrode and new optical heart rate sensor.

By adding this feature, the Apple Watch has gone from a smart [fitness](#) tracker to a potentially life-saving medical device that will be able to warn wearers of abnormal heart rhythms associated with atrial fibrillation (A Fib) and other serious medical conditions.



NEW FEATURE IN THE APPLE 6 WATCH !

BLOOD OXYGEN MEASURING

Your blood oxygen level is a key indicator of your overall wellness.

It can help you understand how well your body is absorbing oxygen, and the amount of oxygen delivered to your body.

The remarkable new sensor and app in Apple Watch Series 6 allow you to take on-demand readings of your blood oxygen as well as background readings, day and night.



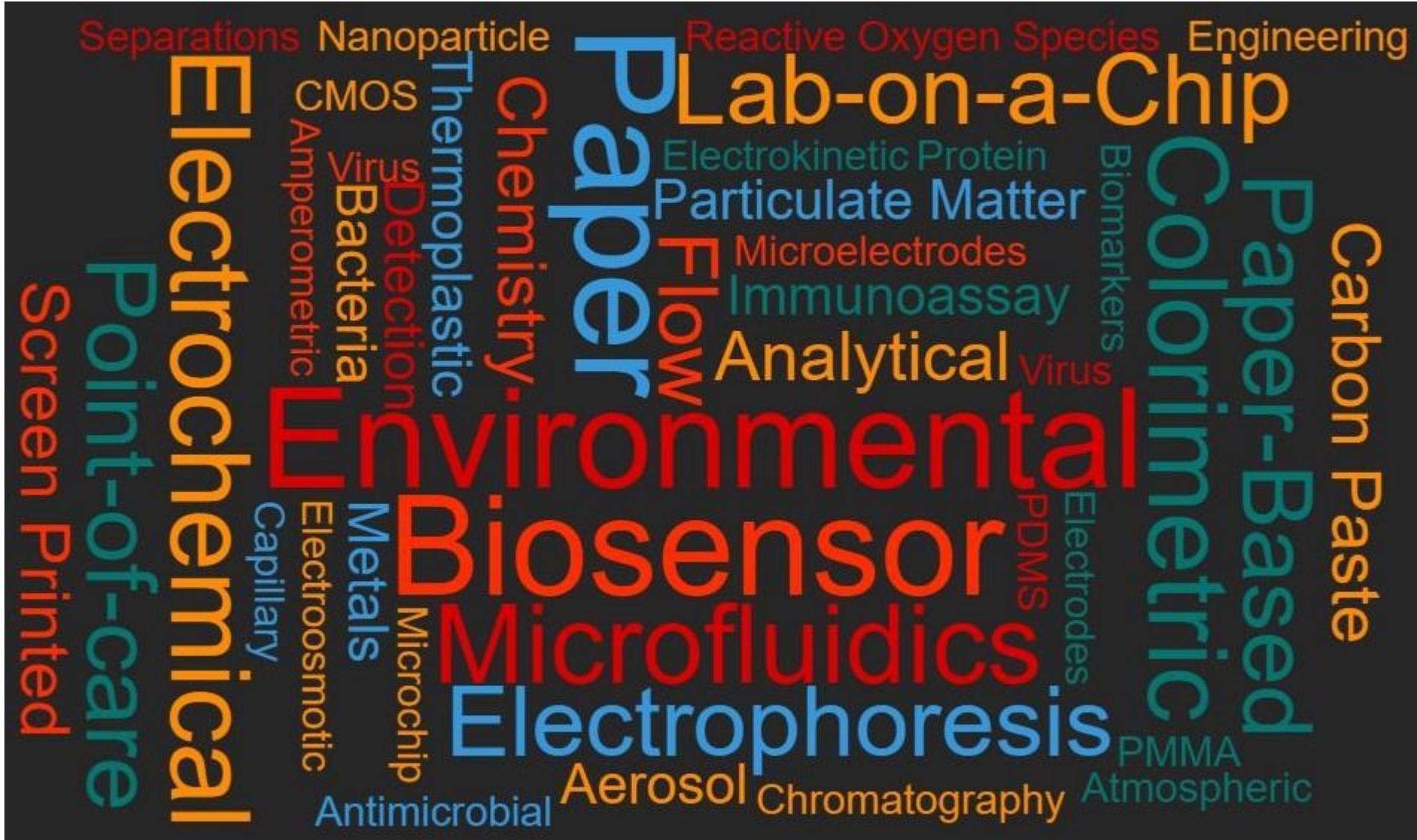
THE NEW APPLE WATCH 8 AND SE MODELS



- Electrocardiogram (ECG) app for high and low heart rate notifications
- Fall detection
- Temperature-sensing
- Crash Detection and Emergency SOS (If needed)
- **International roaming** - make calls, send texts, stream music, and get help in an emergency, in many of the places your travels take you
- Evaluation of Sleep stages
- Enhanced Workout app
- Blood Oxygen level
- Activity tracking
- Apple Pay
- Maps, a fully visible compass, Siri, and more

<https://www.youtube.com/watch?v=UfawgQJICU8> 1.5 min

5) LAB-ON-A CHIP DEVICES FOR QUICK MEDICAL DIAGNOSTICS



WHAT IS A BIOCHIP?

They are also called Lab-on-a chip.

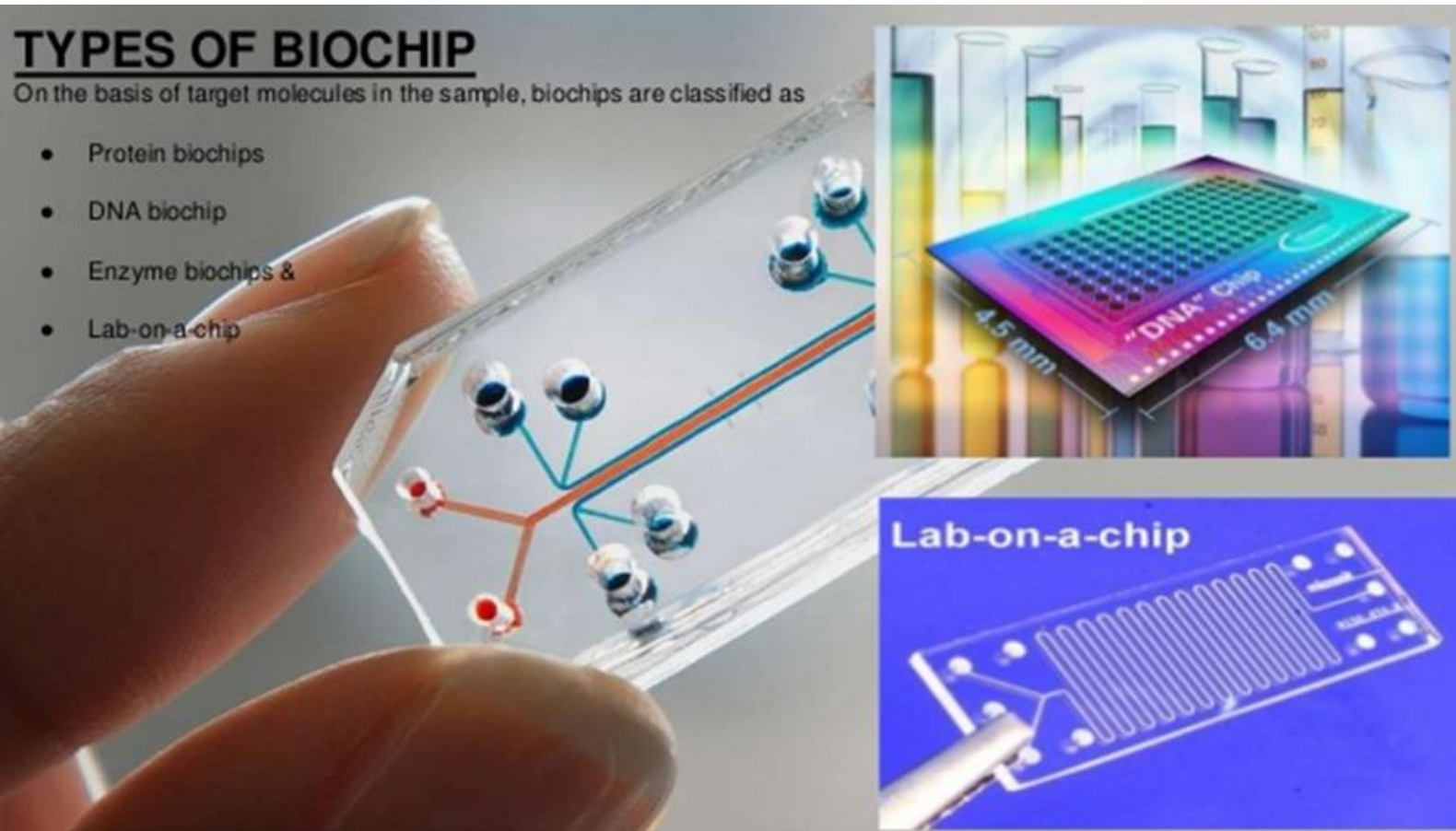
It is a set of very small dots that are placed on a strong surface that allows many experiments to be executed at the same time, to reduce the normal time it takes to do this.

The devices contains millions of sensor elements or biosensors.

These are not electronic devices.

Each and every biochip can be considered as a microreactor that can detect a particular analyte like an enzyme, protein, DNA, biological molecule or antibody.

The main function of them is to perform hundreds of biological reactions in a few seconds like decoding genes (a sequence of DNA).

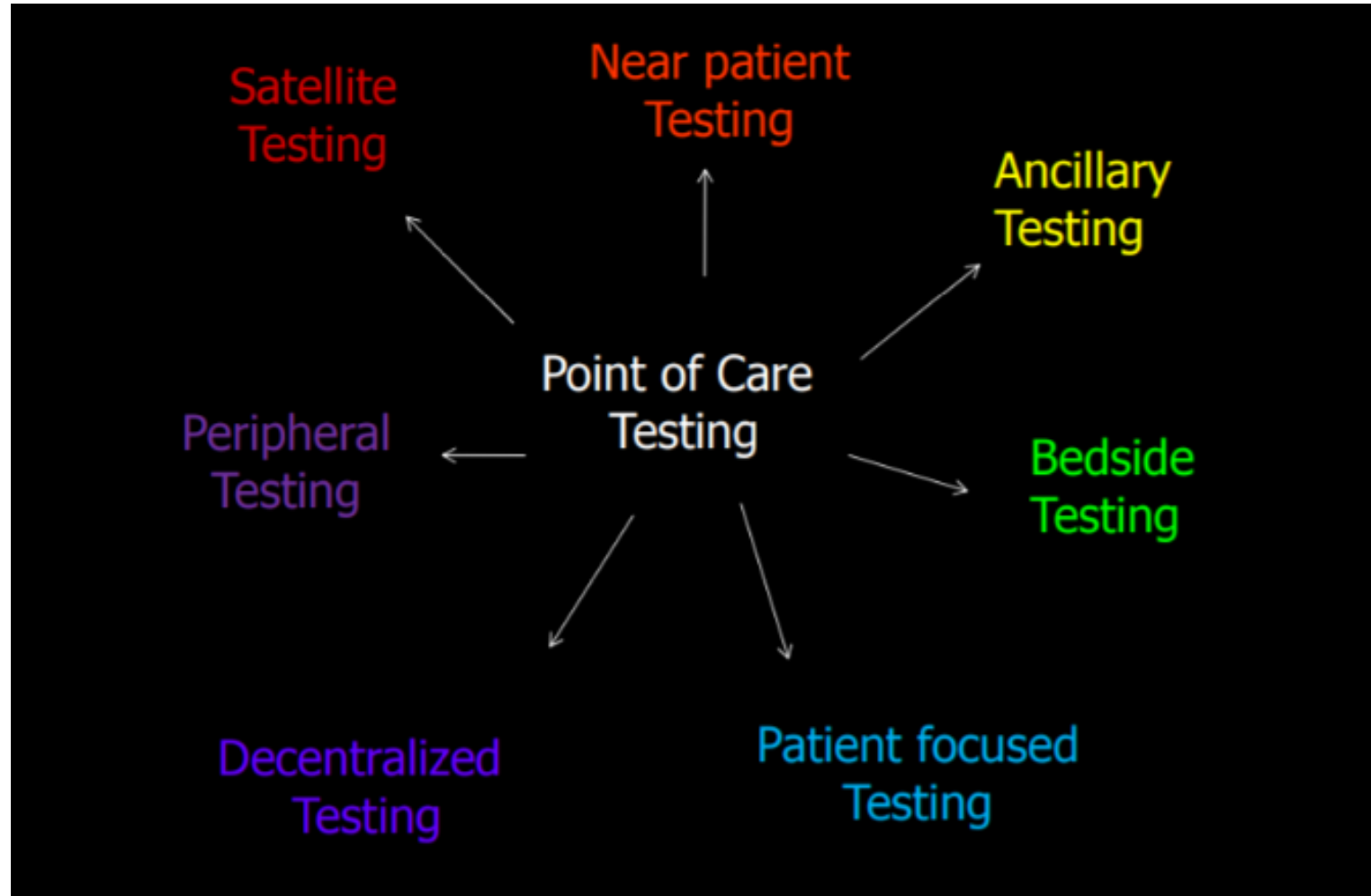


POINT-OF-CARE TESTING (POCT)

It is also known as remote testing, rapid diagnostics, near-patient testing, bedside testing, or satellite testing.

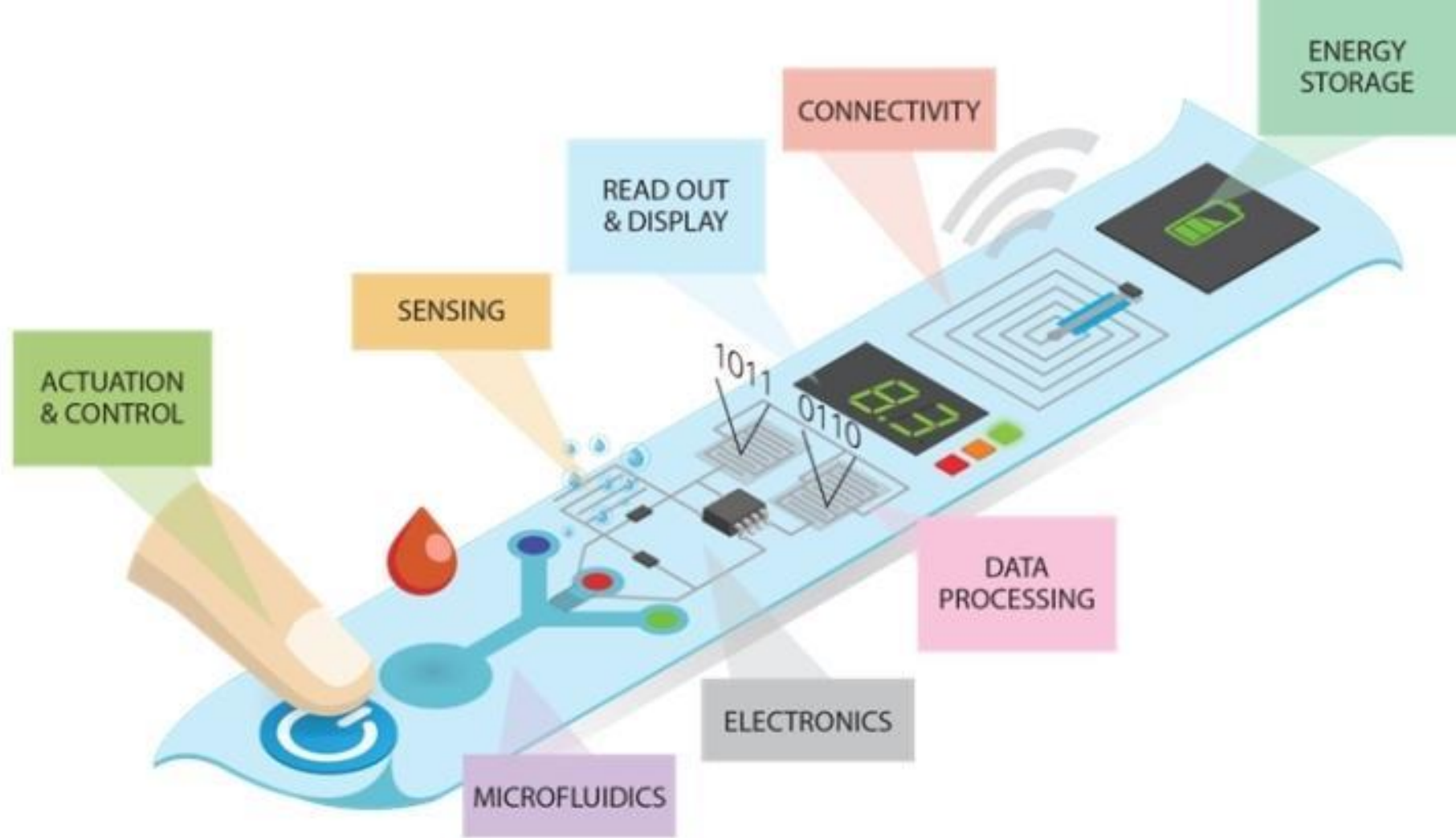
It could be done at a health clinic, at home, in an ER room, in an ambulance, at an accident scene, on an airplane - essentially anywhere.

Many point-of-care tests can give a patient results (and in some cases diagnoses) quickly so that treatment or a consultation with a Doctor can be provided quickly.



WHAT KIND OF MEDICAL CONDITIONS CAN BE CHECKED ?

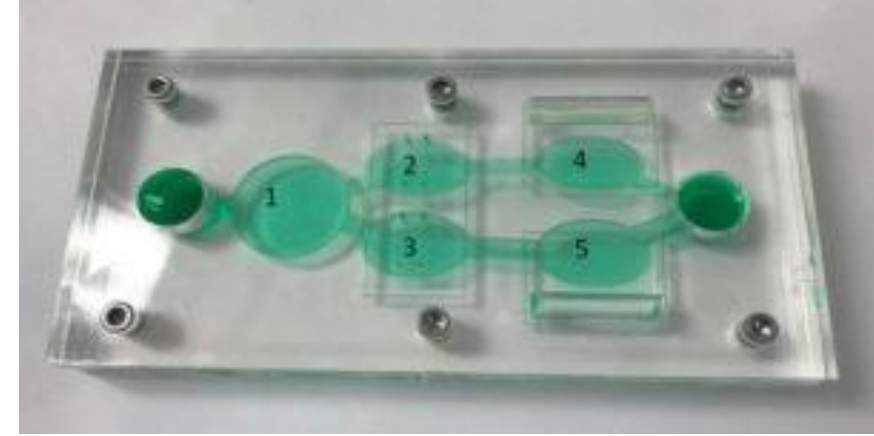
- Infectious diseases
- Blood Glucose (for persons with diabetes)
- Cholesterol
- Cancer (tumor marker testing)
- Pregnancy
- Strep–Group A streptococcus bacteria
- Flu (Influenza) virus
- **Covid-19 virus**
- Urinary Tract Infection (UTI)
- Anemia
- Cardiac marker
- MRSA
- Electrolytes analysis
- Drug abuse
- Malaria
- HIV
- Dengue Fever
- Hepatitis
- DNA analysis
- RNA analysis
- Tumor Marker
- Blood Coagulation
- Animal or person tracking
- Ph of body fluid (acidic or basic)
- Enzyme analysis
- Blood gases
- Food pathogens screening
- Hemoglobin diagnostics



Envisaged integrated point-of-care diagnostic device, published by The Royal Society of Chemistry.

Screen-printed radio frequency identification (RFID) tags on flexible substrates. The purpose of these RFID tags is to enable low-cost and integrated point-of-care diagnostic solutions

**PHYSIOLOGICALLY ACCURATE
MODEL OF THE HUMAN BODY
INCORPORATING 5 AND 10
ORGAN SYSTEMS
INTERCONNECTED USING A
MICROFLUIDIC PLATFORM.**

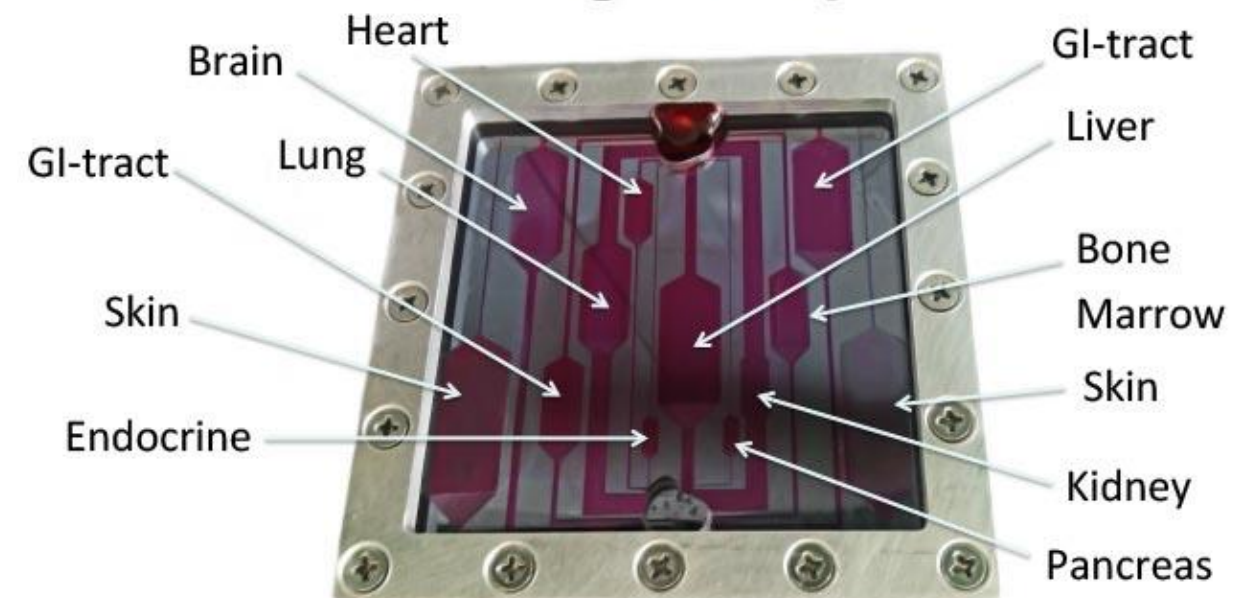


Hesperos, a US Orlando based company, has been able to create a microfluidic lab that can manage up to 5 organs which makes it possible to observe the dynamics in the interaction among the 5 different organs.

It is hoped that this “Body-On-A-Chip” model will provide the means to generate highly predictive and in- depth analyses of novel therapeutic methods.

The successful development of such advanced human models may also pave the way for the reduction and eventual replacement of animals in preclinical drug development which are costly, time-consuming and often poor predictors of human responses to drugs.

10-Organ Chip

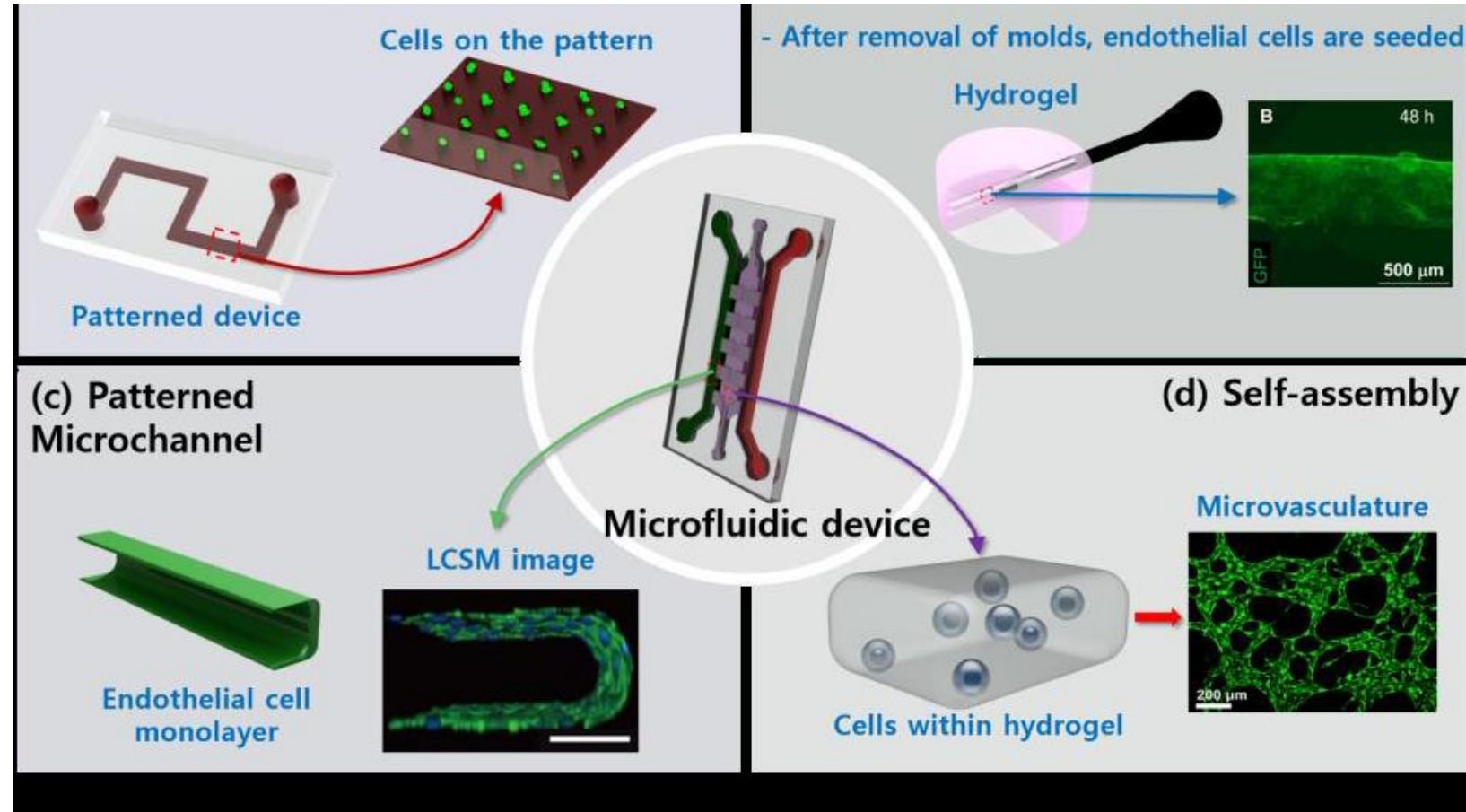


BLOOD VESSEL ON A CHIP

This is a 3D blood vessel-on-a-chip model that can be used to understand what happens to vessels during injury on a molecular scale.

We hope to use these devices to learn more about how to keep vessels healthy, and about what goes awry in disease settings.

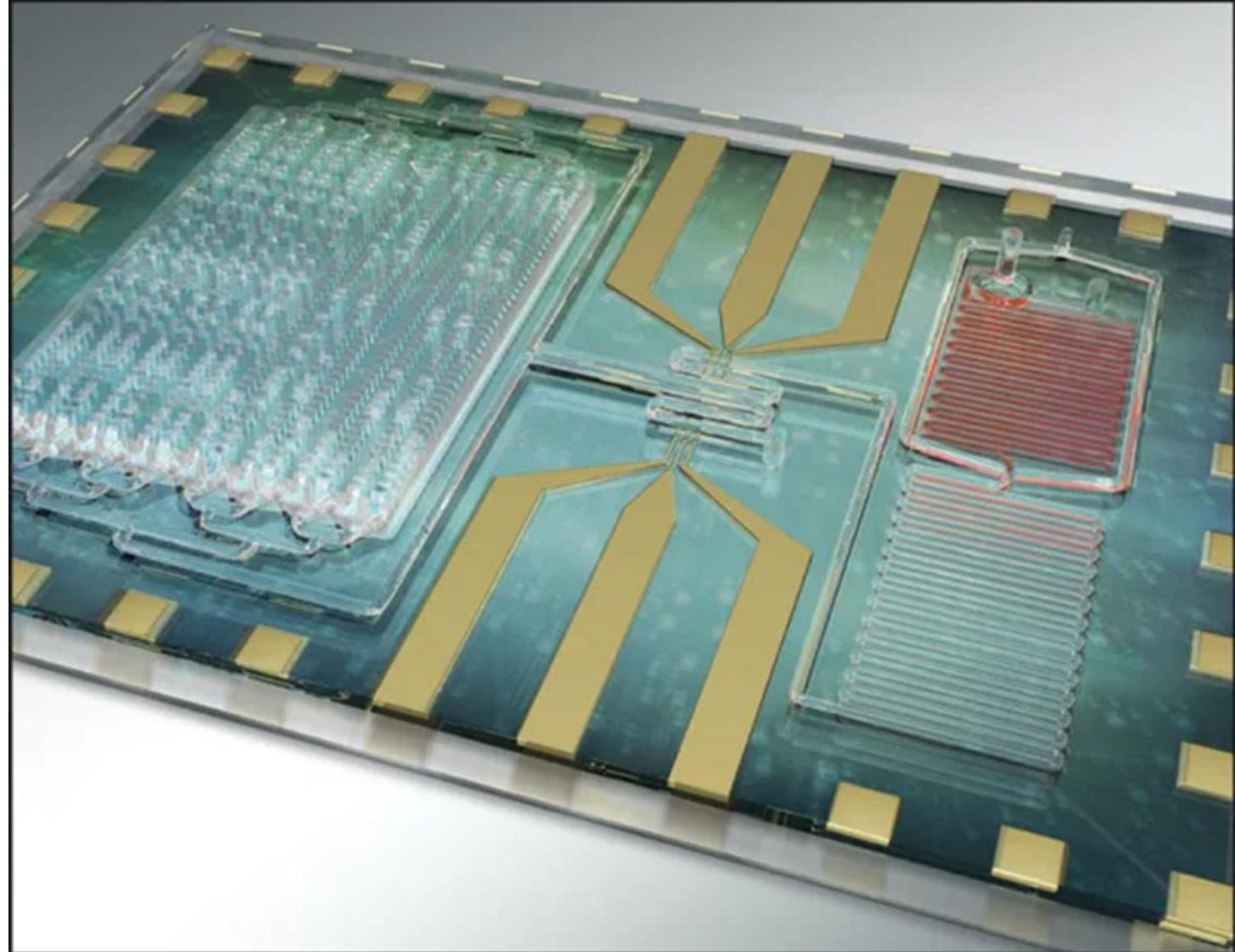
The 3D blood vessel-on-a-chip has allowed a research team to identify specific proteins that regulate vascular barrier function.



This is a rapid test using a single drop of blood for early detection of the deadly blood infection, sepsis.

The microfluidic chip could enable early intervention for this life-threatening complication, which accounts for the most deaths and highest medical expenses in hospitals worldwide.

The Sepsis biochip showing microfluidic channels that remove red blood cells on the right and the larger chamber of microchip posts on the left that capture the CD64 positive immune cells that are markers for sepsis.



MICROFLUIDIC CHIP RAPIDLY IDENTIFIES DEADLY BLOOD INFECTIONS

(Credit: Rashid Bashir, U. Illinois at Urbana-Champaign.)

Microfluidic Paper-based Analytical Devices (μ PAD)

Low Volume

Low Cost

Portable

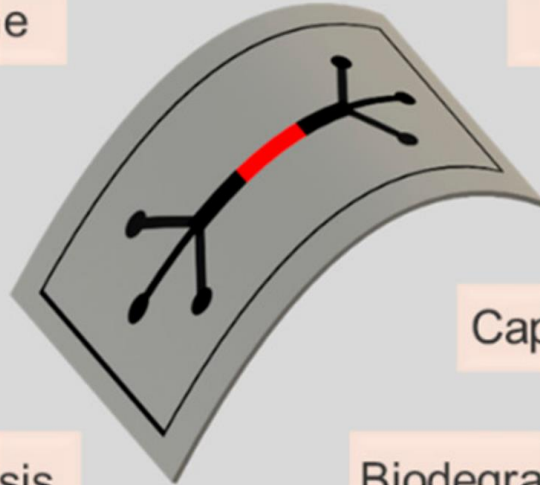
Flexible

Fast Reaction

Capillary Flow

Multianalysis

Biodegradable



2D & 3D
Fabrication
Techniques

Flow Control
Methods

Health Diagnostics

Environmental Monitoring

Food Quality Control

Drug Analysis

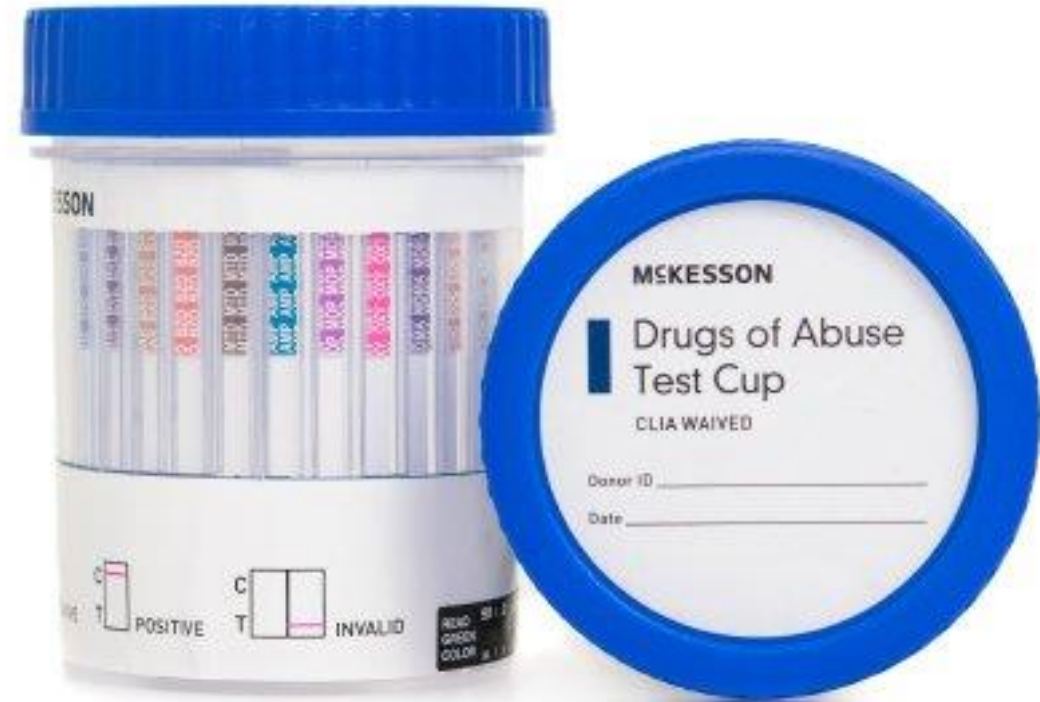
Cell Assays

Drugs of Abuse Test

McKesson 14-Drug Panel with Adulterants - Urine Sample cup

AMP - Amphetamine
BAR - Xanax "Bars"
BUP - Buprenorphine
BZO - Benzodiazepine
COC - Cocaine
mAMP/MET - Methamphetamine
MDMA - 3,4-methylene-dioxy-meth-amphetamine
(Ecstasy/Molly)

MOP300 - an opiate
MTD - Methadone
OXY - Oxycodone
PCP - Phencyclidine
PPX - Propoxyphene
TCA - Tricyclic Antidepressant
THC (OX, pH, SG) - Cannabis - Marijuana



SCIENTISTS EMULATE THE HUMAN BLOOD-RETINAL BARRIER ON A MICRO-FLUIDIC CHIP

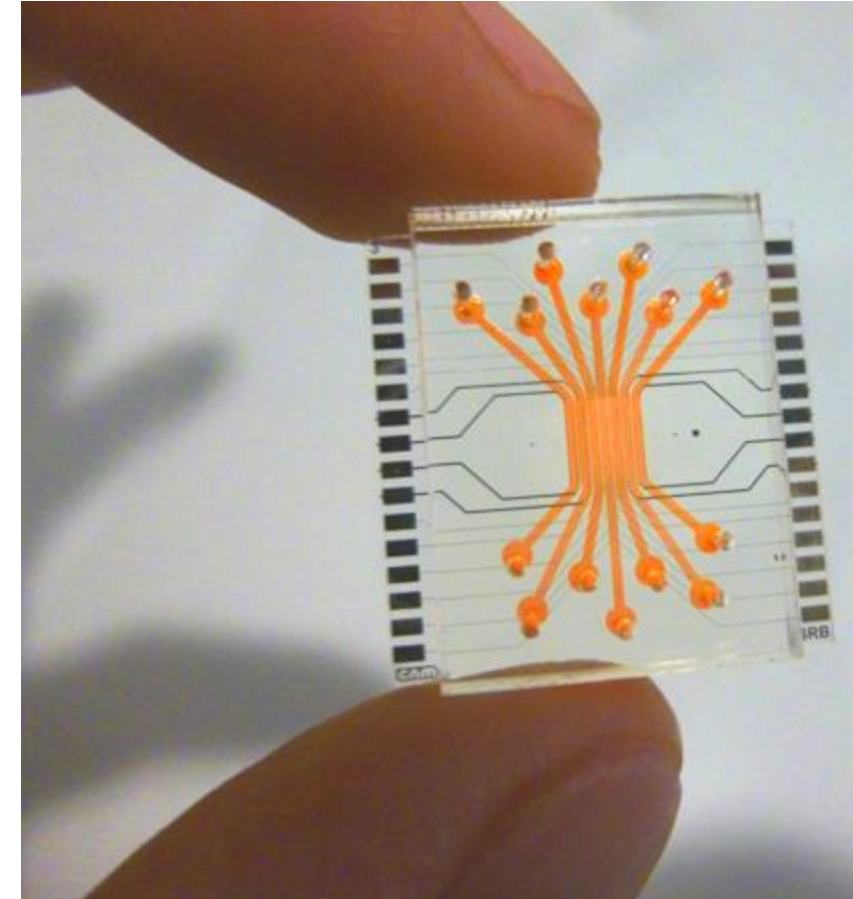
The device contains living cells and mimics the structure and physiological conditions of the blood-retinal barrier. It can be used for testing molecules in a real tissue and studying diseases such as diabetic retinopathy.

The method helps to find ways of reducing animal testing and accelerating clinical trials by mimicking tissues and organ functions, very close to reality.

It is called an "Organ-on-a-chip" and is made of several parallel compartments, arranged to emulate the retinal layer structure.

In every compartment a type of cell has been cultured:

- Endothelial cells (which constitute capillary vessels which carry oxygen and nutrients)
- Neuronal cells (which form the neuroretina)
- Retinal pigmented epithelial cells, which form the outer layer of the blood-retinal barrier.

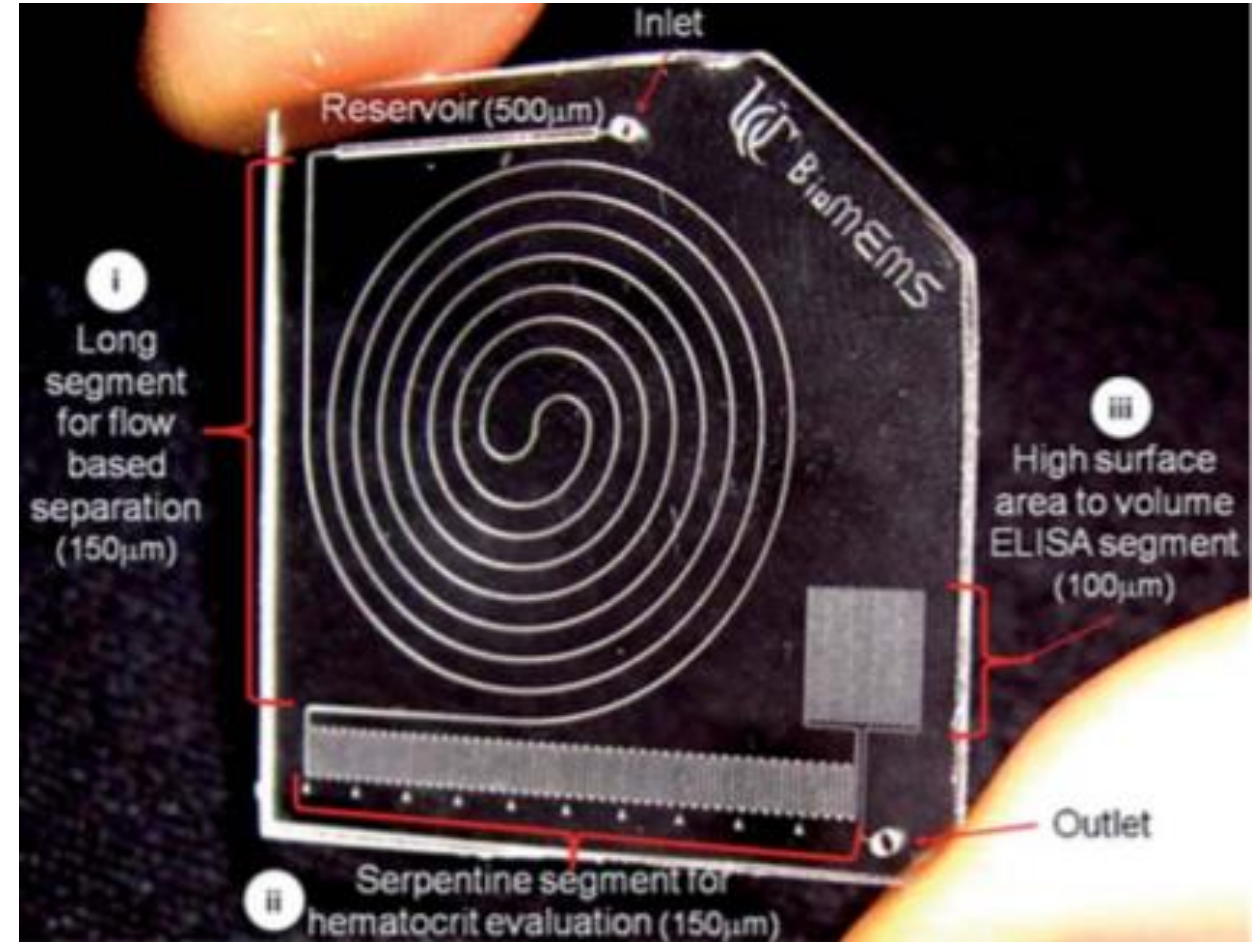


CHIP DESIGN FROM THE UNIVERSITY OF CINCINNATI

This is an integrated blood analysis chip design fabricated in a clear plastic like Polyethylene. It is very small with dimensions of .107 inch X .107 inch.

At the top inlet, a blood sample is injected into to a long spiral flow-based separation channel.

When the blood sample reaches and flows into the long serpentine segment, (ii) the hematocrit (% of red blood cells in the blood sample) is evaluated based on the number of serpentine switchbacks that are filled with packed erythrocytes, which are red blood cells that contain hemoglobin)



University of Cincinnati Smartphone Lab delivers test results in 'split' second

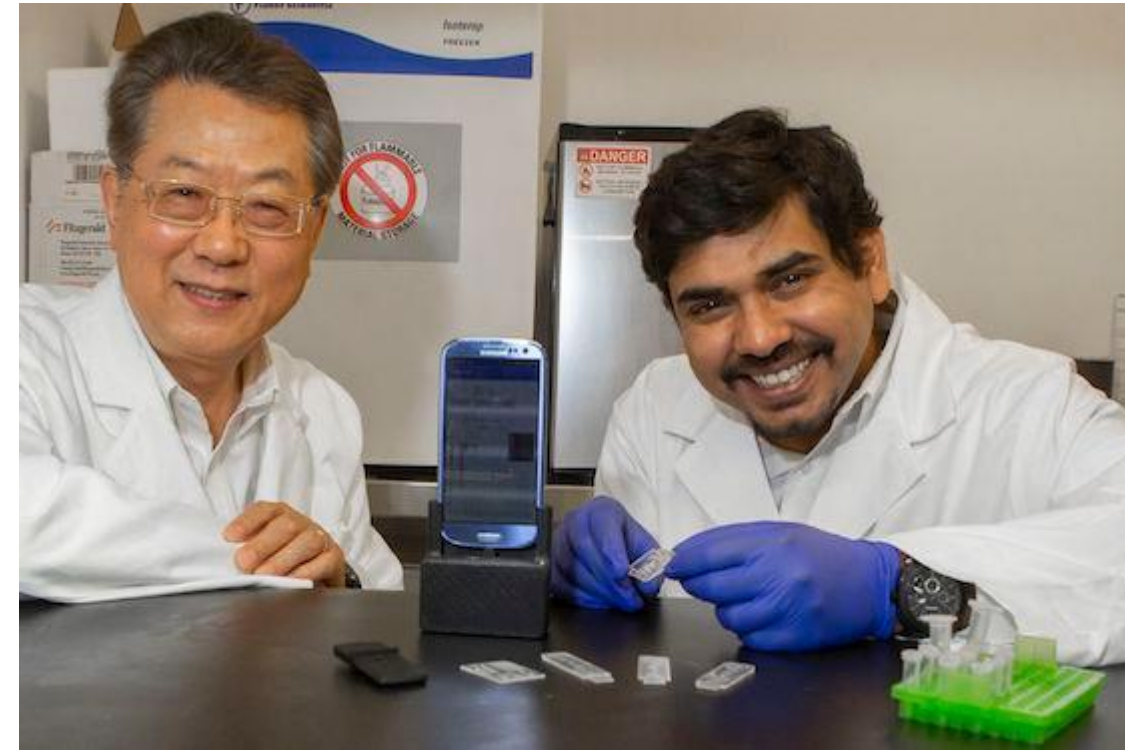
Using your phone to diagnose disease or track your medical condition is the holy grail for remote health monitoring, but so far, it's been impractical to combine the two in a single device.

Tech companies don't want the regulatory headaches that would come from labeling phones medical devices.

University of Cincinnati engineers have come up with the next best thing.

Professor Chong Ahn led a lab team that designed a tiny portable device that plugs into a phone, connecting it automatically to a doctor's office through a custom app UC also developed.

With a single drop of blood or saliva on the UC-designed custom plastic lab chip, the device smaller than a credit card can diagnose infectious diseases such as coronavirus, malaria, HIV or Lyme disease or countless other health conditions like depression and anxiety.

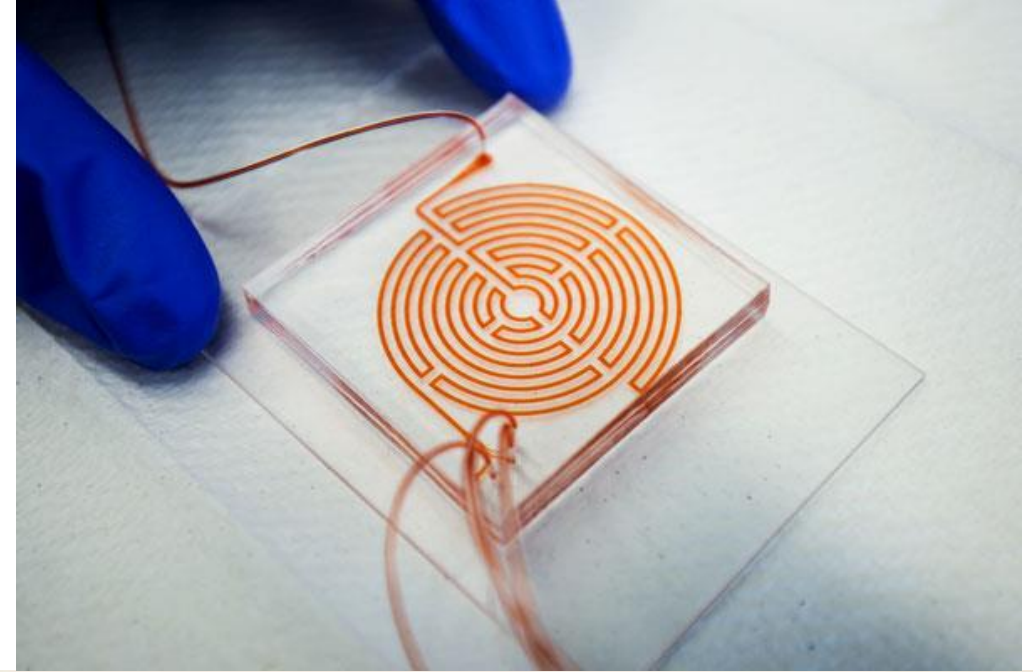


LABYRINTH' CHIP COULD HELP MONITOR AGGRESSIVE CANCER STEM CELLS

Blood runs through the labyrinth chip, quickly separating cancer cells from white and red blood cells.

Inspired by the Labyrinth of Greek mythology, a new chip etched with fluid channels sends blood samples through a hydrodynamic maze to separate out rare circulating cancer cells into a relatively clean stream for analysis. It is already in use in a breast cancer clinical trial.

Credit: Joseph Xu, Michigan Engineering Communications &



"LUNG-ON-A-CHIP" SETS STAGE FOR NEXT WAVE OF RESEARCH TO REPLACE ANIMAL TESTING

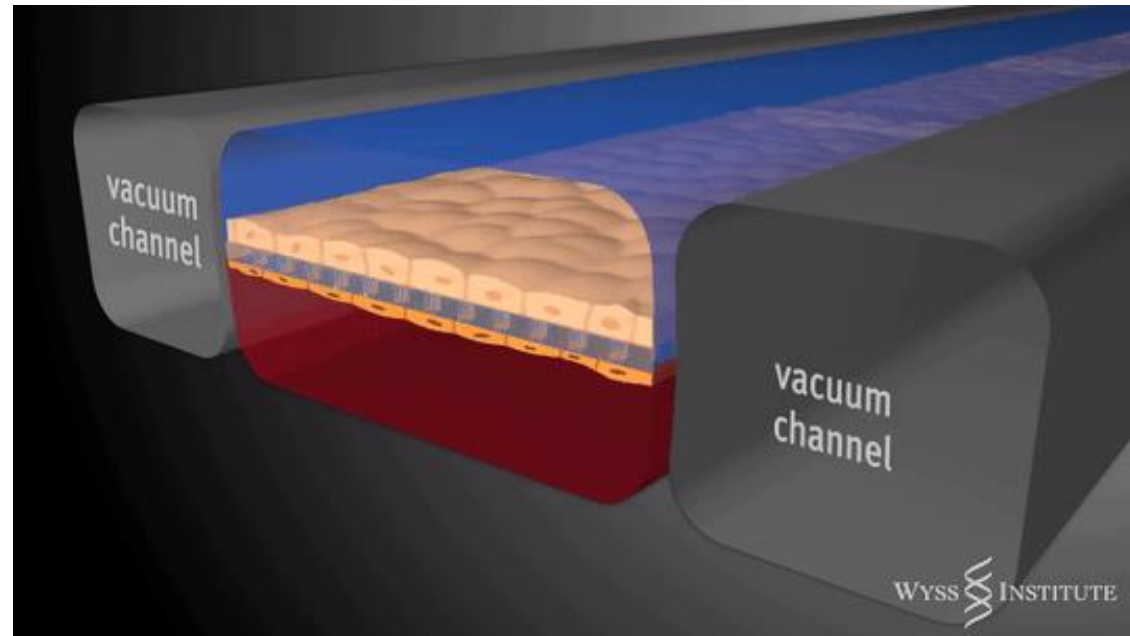
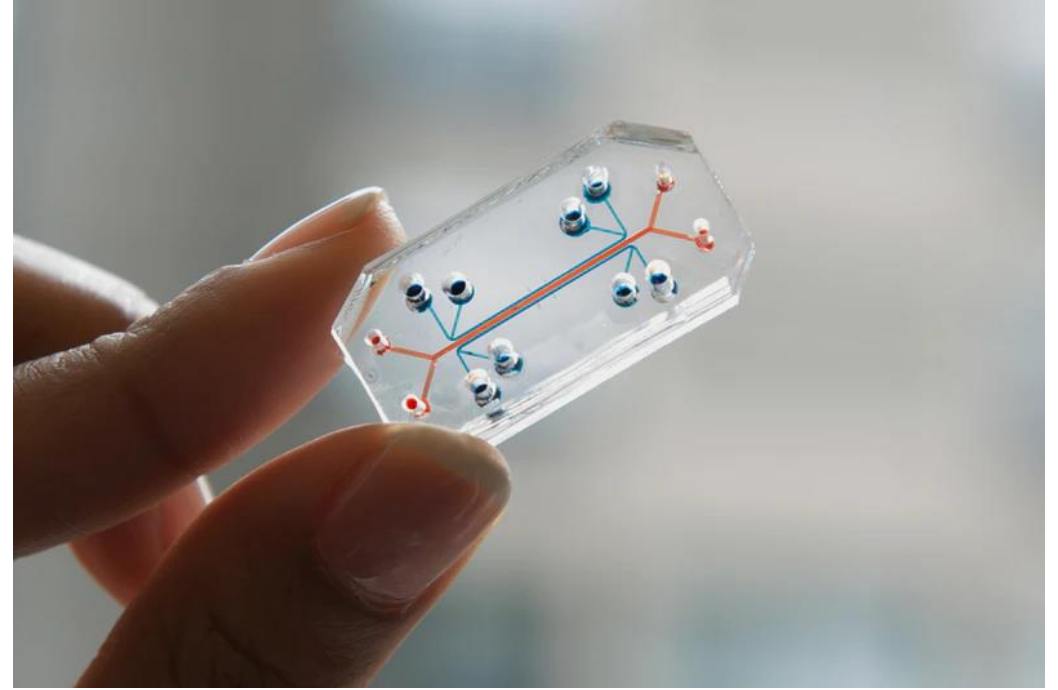
The lung-on-a-chip device is a crystal clear, flexible polymer about the size of a memory stick that contains hollow channels fabricated using computer microchip manufacturing techniques.

Two of the channels are separated by a thin, flexible, porous membrane that on one side is lined with human lung cells from the air sac and exposed to air; human capillary blood cells are placed on the other side with medium flowing over their surface.

A vacuum applied to side channels deforms this tissue-tissue interface to re-create the way human lung tissues physically expand and retract when breathing.

https://www.youtube.com/watch?v=Mg2fJ0UBj_0&t=9s

2.8 min



MICRO-ELECTRO-MECHANICAL SYSTEMS (MEMS)

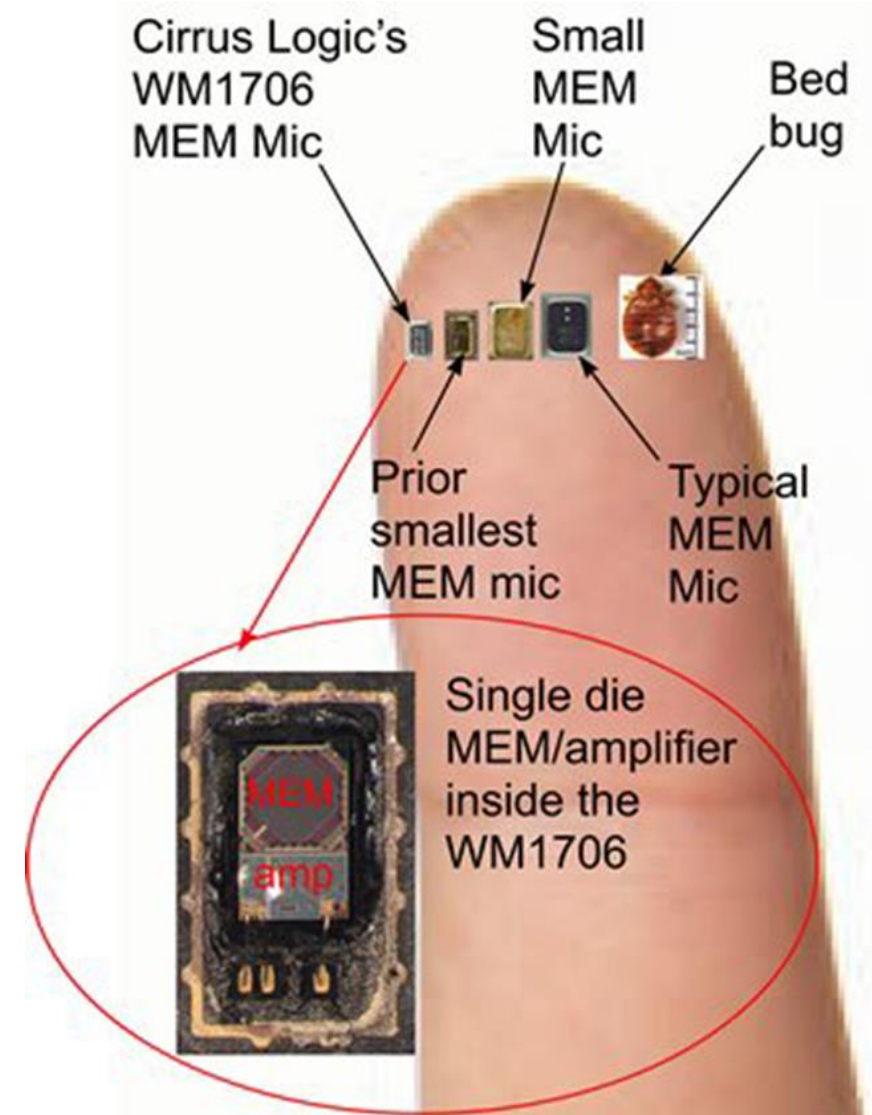
MEMS sensors & actuators: the 5 senses and many more

(Source: Status of the MEMS Industry report, Yole Développement, 2019)



COMMERCIAL APPLICATIONS OF BIO-MEMS INCLUDE:

- **Disposable pressure sensors for use in healthcare.**
- **Pedometer**
- **Blood pressure monitoring**
- **Early diagnosis of Glaucoma**
- **Used in hearing aid microphones**
- **Very small pumps for insulin infusion devices for diabetics**
- **Complex procedures such as DNA analysis**
- **Biomedical transducers medical implants**
- **Microsurgical tools**



Capsule Endoscopy

Devices used to perform endoscopy operations

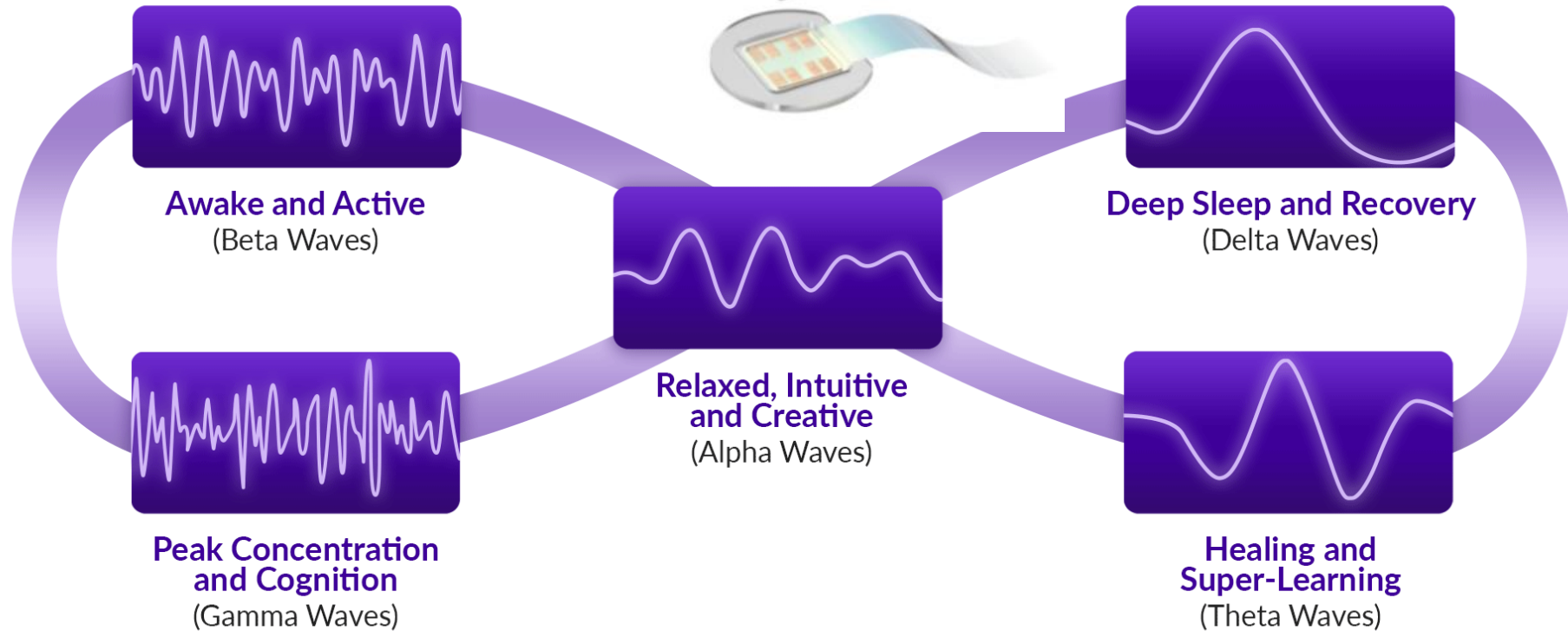


Capsule	PillCam® SB 3 Given Imaging	EndoCapsule® Olympus America	MiroCam® IntroMedic Company	OMOM® Jinshan Science and Technology
Size *	Length: 26.2 mm Diameter: 11.4 mm	Length: 26 mm Diameter: 11mm	Length: 24.5 mm Diameter: 10.8 mm	Length: 27.9 mm Diameter: 13 mm
Weight	3.00g	3.50g	3.25-4.70g	6.00g
Battery life	8 hours or longer	8 hours or longer	11 hours or longer	6-8 hours or longer
Resolution	340x340	512x512	320x320	640x480
Frames per second	2 fps or 2-6 fps	2 fps	3 fps	2 fps
Field of view	156°	145 °	170°	140°
Communication	Radio frequency communication	Radio frequency communication	Human body communication	Radio frequency communication
FDA approval	Yes	Yes	Yes	No
Price per capsule	\$500	\$500	\$500	\$250

* 25 mm (**millimeters**) = 1 inch

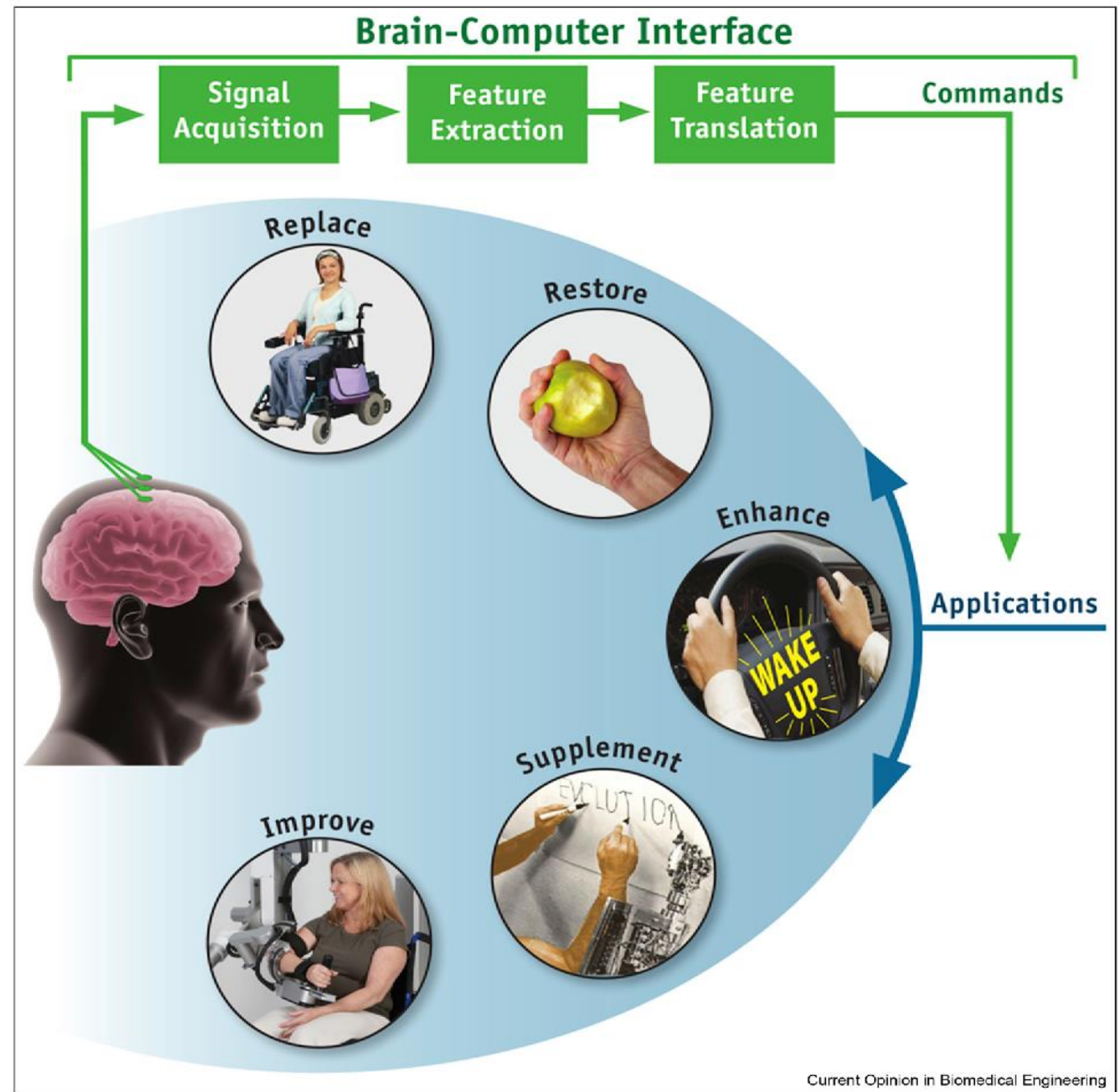
6) AN INTRODUCTION TO THE BRAIN-COMPUTER INTERFACE (BCI)

THE NEURALINK DEVICE



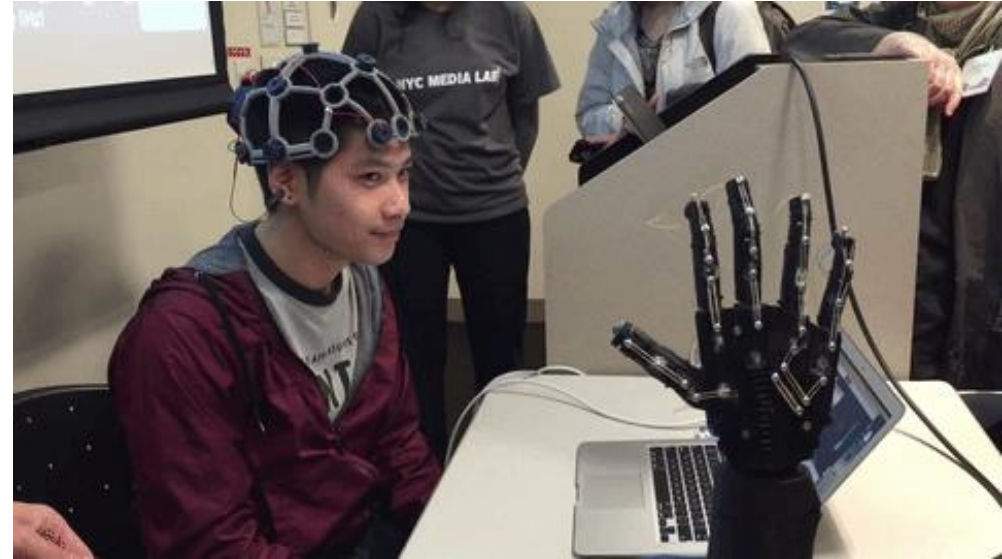
They work in 3 main steps:

1. Collecting brain signals
2. Interpreting them
3. Outputting commands to a connected machine, according to the brain signal received.



BCI CAN BE APPLIED TO A VARIETY OF TASKS:

- Neurofeedback
- Restoring motor function to paralyzed patients
- Allowing communication with locked-in patients
- Improving sensory processing



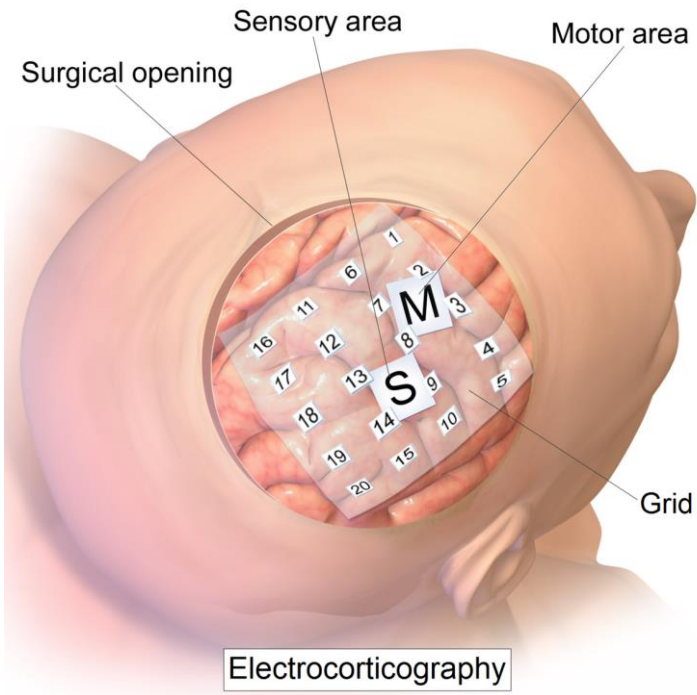
WHAT ARE THE 3 TYPES OF BCI'S ?

- Non-Invasive
- Semi-invasive
- Invasive



NON-INVASIVE

The sensors are placed on the scalp to measure the electrical potentials produced by the brain (EEG) or the magnetic field (MEG).



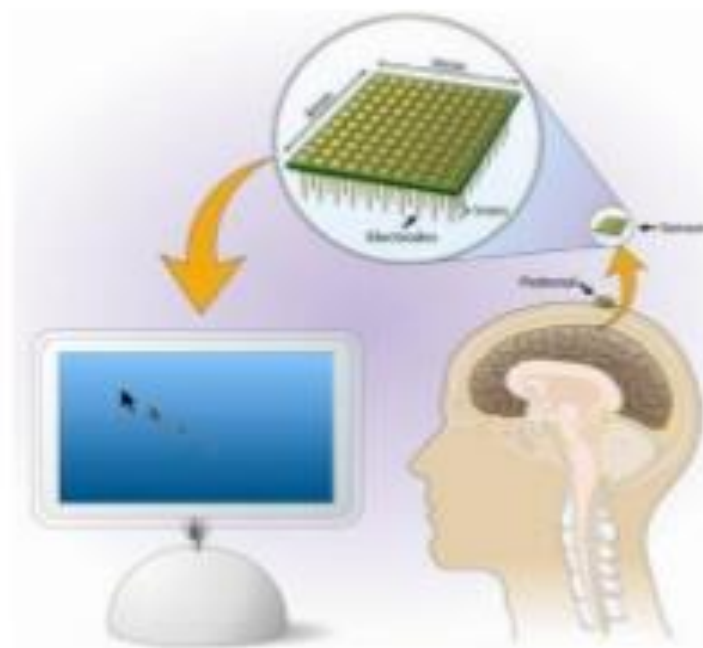
SEMI-INVASIVE

The electrodes are placed on the exposed surface of the brain - electrocorticography. (ECoG).

It is called semi-invasive but it still requires a craniotomy to implant the electrodes. For this reason it is used only when surgery is necessary for medical reasons (epilepsy for example).

Invasive BCIs

- Invasive BCIs are implanted directly into the grey matter of the brain by neurosurgery.
- As they rest in the grey matter, invasive devices produce the highest quality signals of BCI devices.
- But are prone to scar tissue build-up, causing the signal to become weaker or even lost as the body reacts to a foreign object in the brain.



BrainGate Neural Interface System



EMOTIVE EPOC (14 SENSORS)



EPOC +



INSIGHT (7 SENSORS)



FLEX (32 SENSORS)

THE EMOTIV SYSTEMS CO.

In 2009, they released a headset called the EPOC that allows the user to play video games with only their brainwaves.

The device can read 4 mental states, 13 conscious states, facial expressions, and head movements.

The Emotive EPOC system is a wireless neuro-headset.

It uses a set of sensors to tune into electric signals produced by the brain to detect player's thoughts, feelings and expressions and connects wirelessly to most PCs.



Neuralink

Elon Musk started a new company to build brain implants to directly link human minds to computers.

Their goal is to make AI an extension of the human brain, essentially creating a symbiotic human-Artificial Intelligence (AI) relationship.

INVASIVE

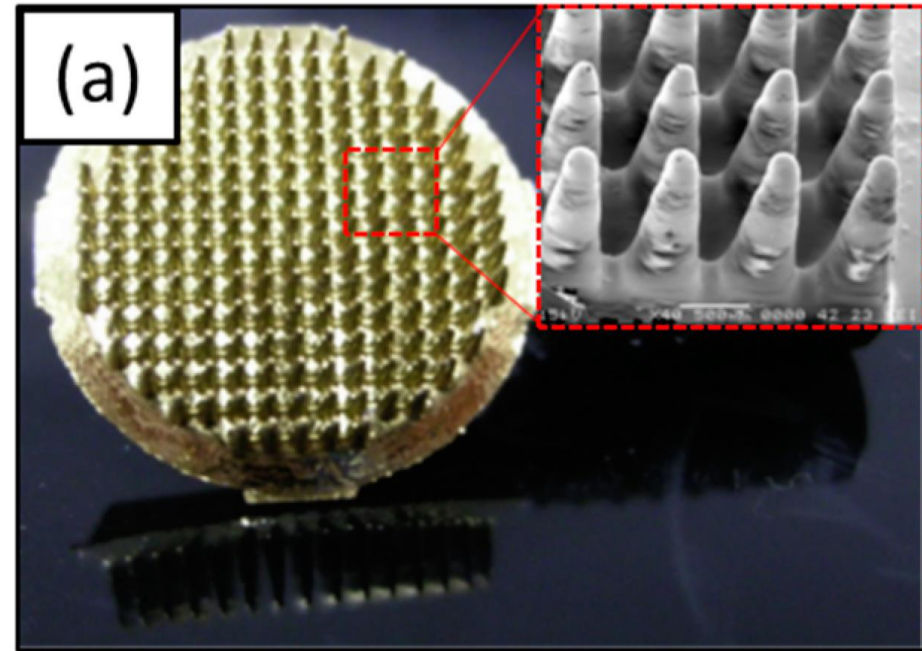
They are implanted directly into the brain during neurosurgery.

The micro-electrodes are placed directly into the cortex, measuring the activity of one or more neurons.

The Neuralink device connects to the brain with very small wires.

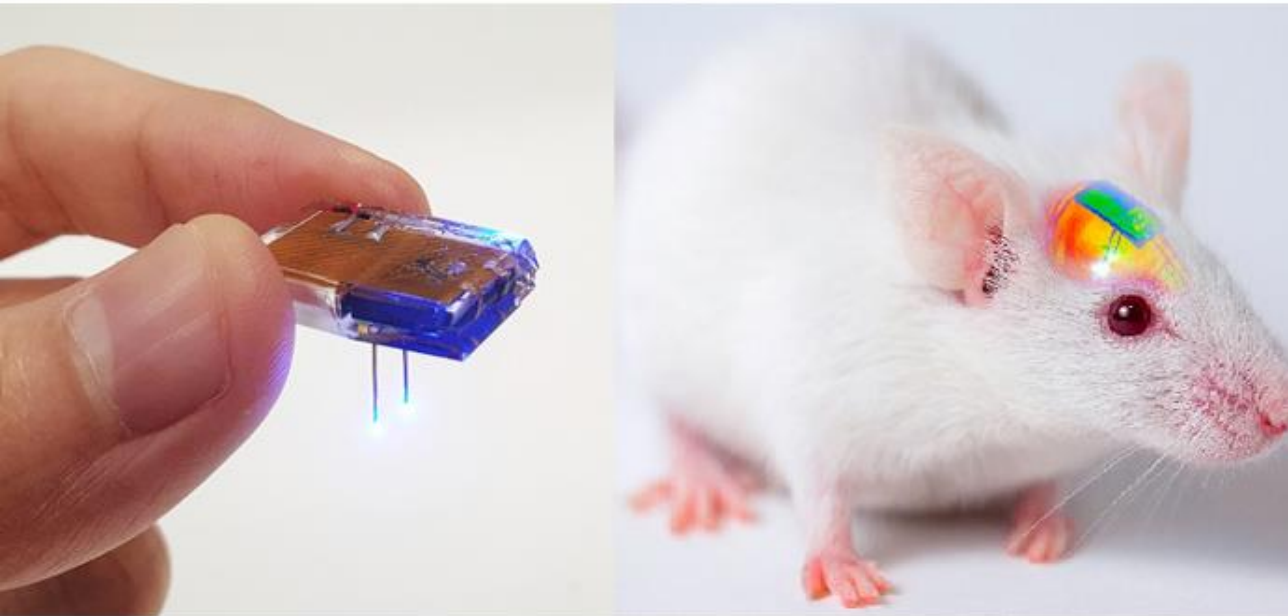


NEURALINK



NEW BRAIN IMPLANT CAN BE CHARGED WIRELESSLY

NO NEED FOR SURGERY TO REPLACE A DRAINED IMPLANT BATTERY



Testing a new brain implant in animals is a race against the clock for scientists – Its limited to the amount of charge in the device's battery.

Once that battery is drained, it must be removed and replaced, which requires the animals to undergo repeated surgeries, which can be painful and disruptive to research.

Now, researchers have developed a new brain implant that can be charged wirelessly using a magnetic field.

They've already used it to control the behavior of rats — and they think it could one day make the leap to humans for treating them for medical issues.

In 2019, a team from the Korea Advanced Institute of Science and Technology (KAIST) unveiled a neural device that sat on a rat's head like a helmet.

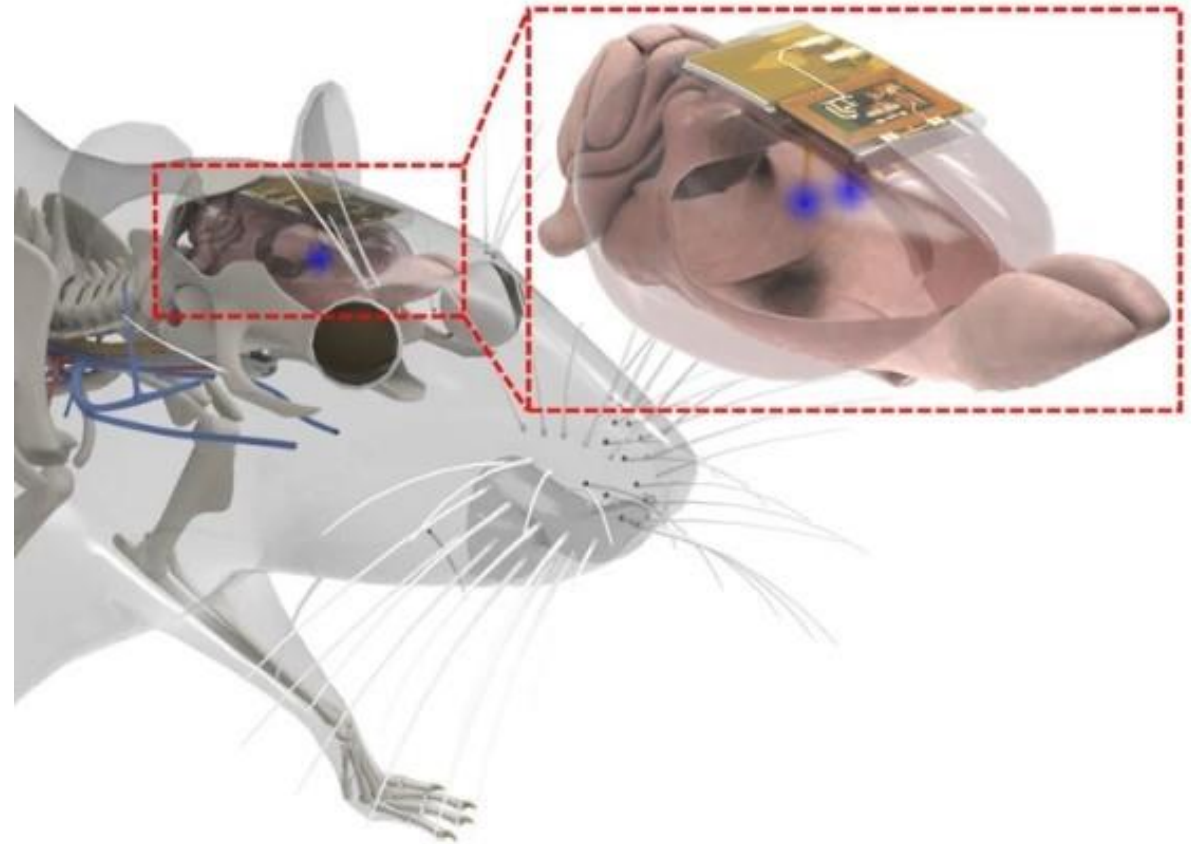
The upgraded design is fully implanted, and contains a coil antenna and Bluetooth chip that can harvest energy from alternating magnetic fields, that are put out by a device around their cages.

To prove the device works, the researchers used it to control cocaine-cravings in rats by triggering specific neurons in their brains with Light Emitting Diodes (LEDs), all from a smartphone.

The new brain implant remains charged while the rodents moved around freely in their cages, during the experiment.

, to reduce the burden on patients and for long-term use within the body, the Korean researchers felt that the same basic technology can be applied to various types of implants such as:

- Deep brain stimulators
- Cardiac pacemakers
- Stomach monitors

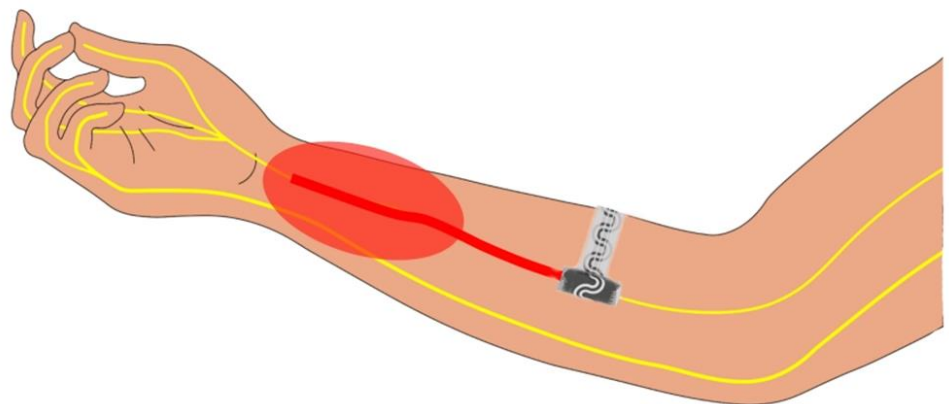


OTHER MEDICAL TECHNOLOGIES





Credit: Northwestern University



An illustration of the device in an arm. The red area represents pain.

THIS IMPLANT COOLS OFF NERVES TO GIVE TARGETED PAIN RELIEF

WE NEED ALTERNATIVES TO OPIOIDS. THIS COULD BE ONE

Northwestern researchers developed a small, soft, flexible implant that relieves pain on demand and without the use of drugs.

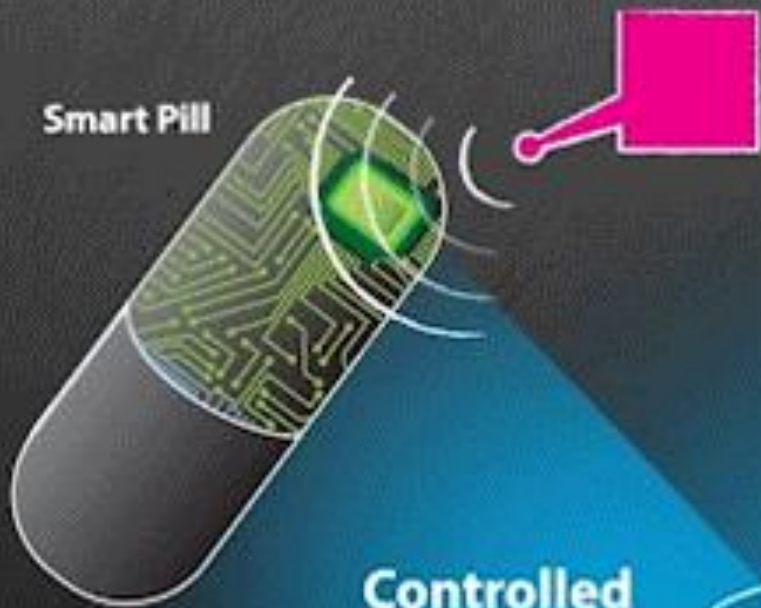
The device works by softly wrapping around nerves to deliver precise, targeted cooling, which numbs nerves and blocks pain signals to the brain.

It provides targeted pain relief, in rats.

After it is no longer needed, it naturally absorbs into the body — bypassing the need for surgical extraction.

If it is as safe and effective in humans, the “nerve cooler” could help people manage pain without addictive opioids.

Smart Pill



Controlled
Release

By placing these
devices inside
smart pills



they could perform
controlled drug delivery
to treat diseases like
Malaria or Alzheimer's

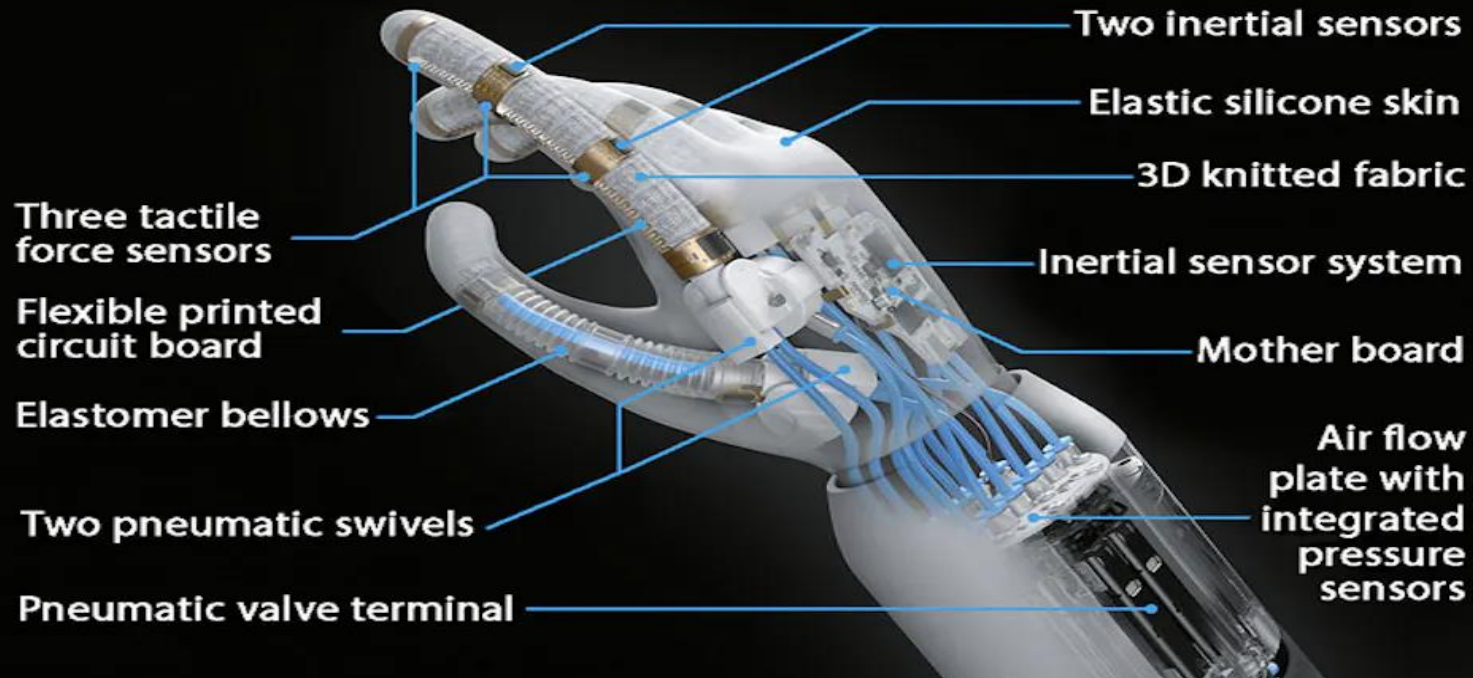
THE BIONIC SOFTHAND

It is air operated, so it can interact safely and directly with people, and it has no bones.

Its fingers consist of flexible bellows structures with air chambers. The bellows are enclosed in the fingers by a special 3D textile covering, knitted from elastic and high-strength fibers.

These features combine to make the actuator light, flexible, adaptable, and sensitive, yet able to exert strong forces.

The proportional piezoelectric valves used in the terminal provide precise control of finger movement and applied force.



THESE COLOR-CHANGING SUTURES CAN CATCH INFECTIONS, PREVENTING MORE SURGERY

Iowa City teenager Dasia Taylor came up with the idea of using beet juice coated sutures to catch surgical infections as quickly as possible.

The idea came when she read about “smart sutures,” which can warn of infection via changes in a wound’s electrical resistance and when the sutures’ conductive surface detects a change, it sends a warning to a smartphone or computer.

That is well and good in the U.S., but it may not be practical for patients in developing countries, where up to 11% of surgical wounds develop infections, according to the WHO, and among women who give birth via c-section in Africa, up to 20% can suffer infections.



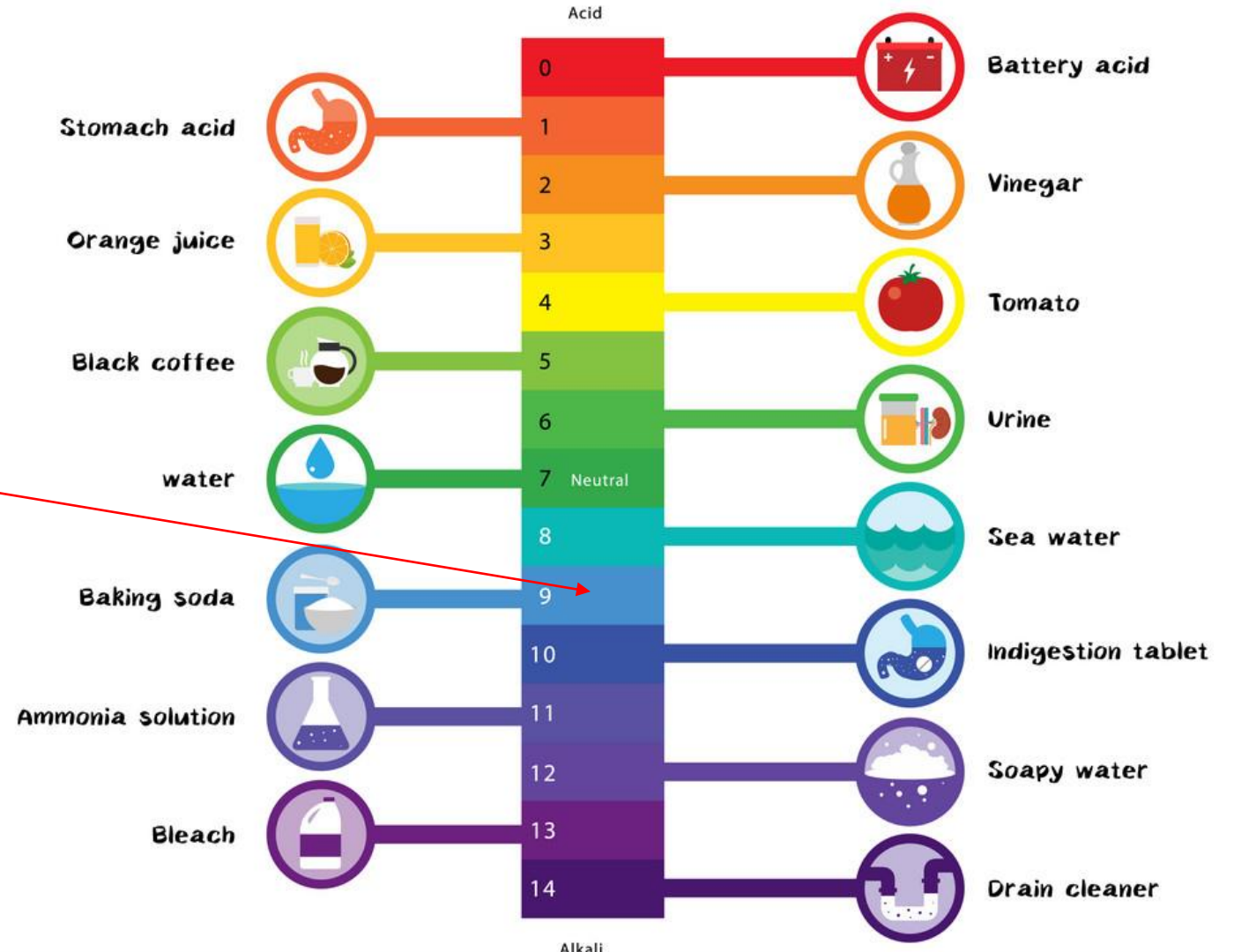
Skin pH (how acid or basic the surface is, with 7 as neutral) levels typically hover around 5, but an infection can cause pH to spike upwards, when the skin surface becomes more basic.

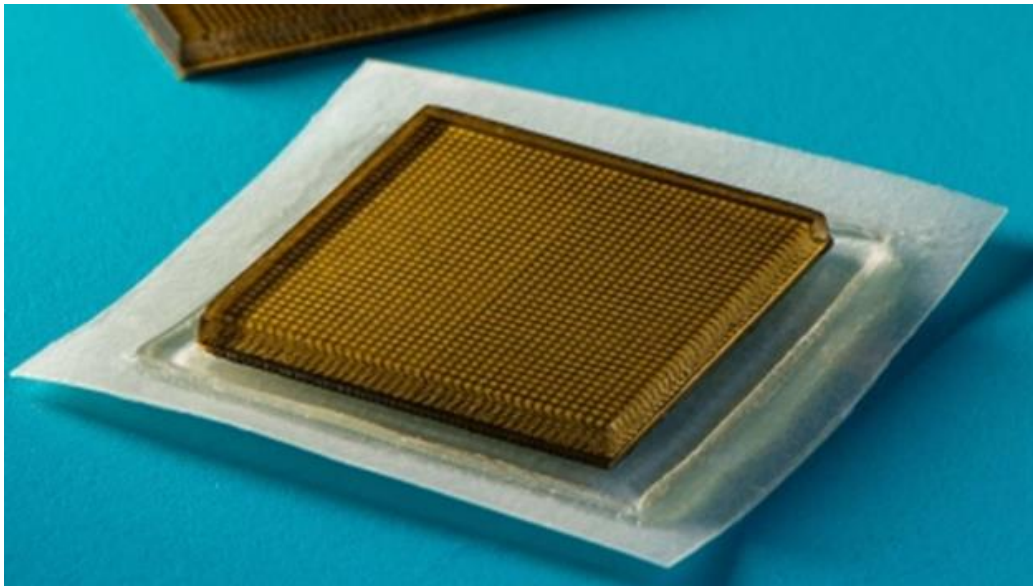
When it does, her color-changing sutures, dyed with beet juice, go from red to purple.

“I found that beet juice changed color at the perfect pH point,” Taylor said, around a pH of 9.

“That’s perfect for an infected wound.”

Because changes in pH happen early in infection, Taylor hopes the color-changing sutures can help spot infections early, when antibiotics can treat them, instead of more invasive measures.





MIT'S NEW ULTRASOUND STICKER LETS YOU SEE INSIDE YOUR BODY

WELCOME TO THE ERA OF 'WEARABLE IMAGING'

MIT researchers have created an ultrasound sticker that can continuously monitor a person's organs and tissues for up to 48 hours — potentially making ultrasound imaging as accessible and easy to use as Band-Aids.

Ultimately, they plan to make the technology available to consumers via a phone app, who could monitor their hearts, muscles, and pregnancies on demand.



THE ELECTRONIC NOSE AND TONGUE

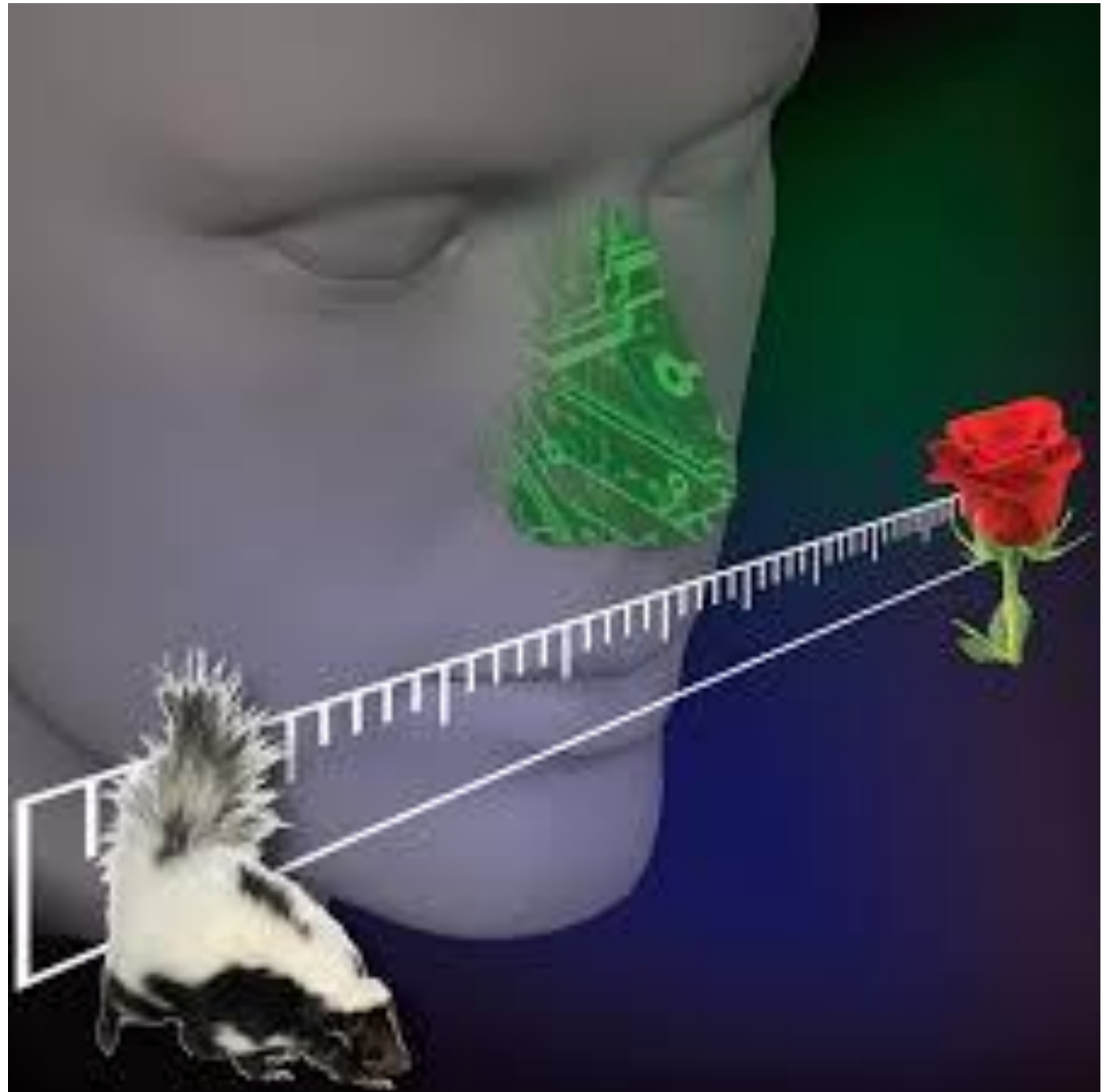


AN ELECTRONIC NOSE IS A DEVICE INTENDED TO DETECT ODORS OR FLAVORS.

Over the last decades, "**electronic sensing**" or "e-sensing" technologies have undergone important developments from a technical and commercial point of view.

The expression "electronic sensing" refers to the capability of reproducing human senses using sensor arrays and pattern recognition systems.

Since 1982, research has been conducted to develop technologies, commonly referred to as **electronic noses**, that could detect and recognize odors and flavors.



CYRANOSE 320 UNIT

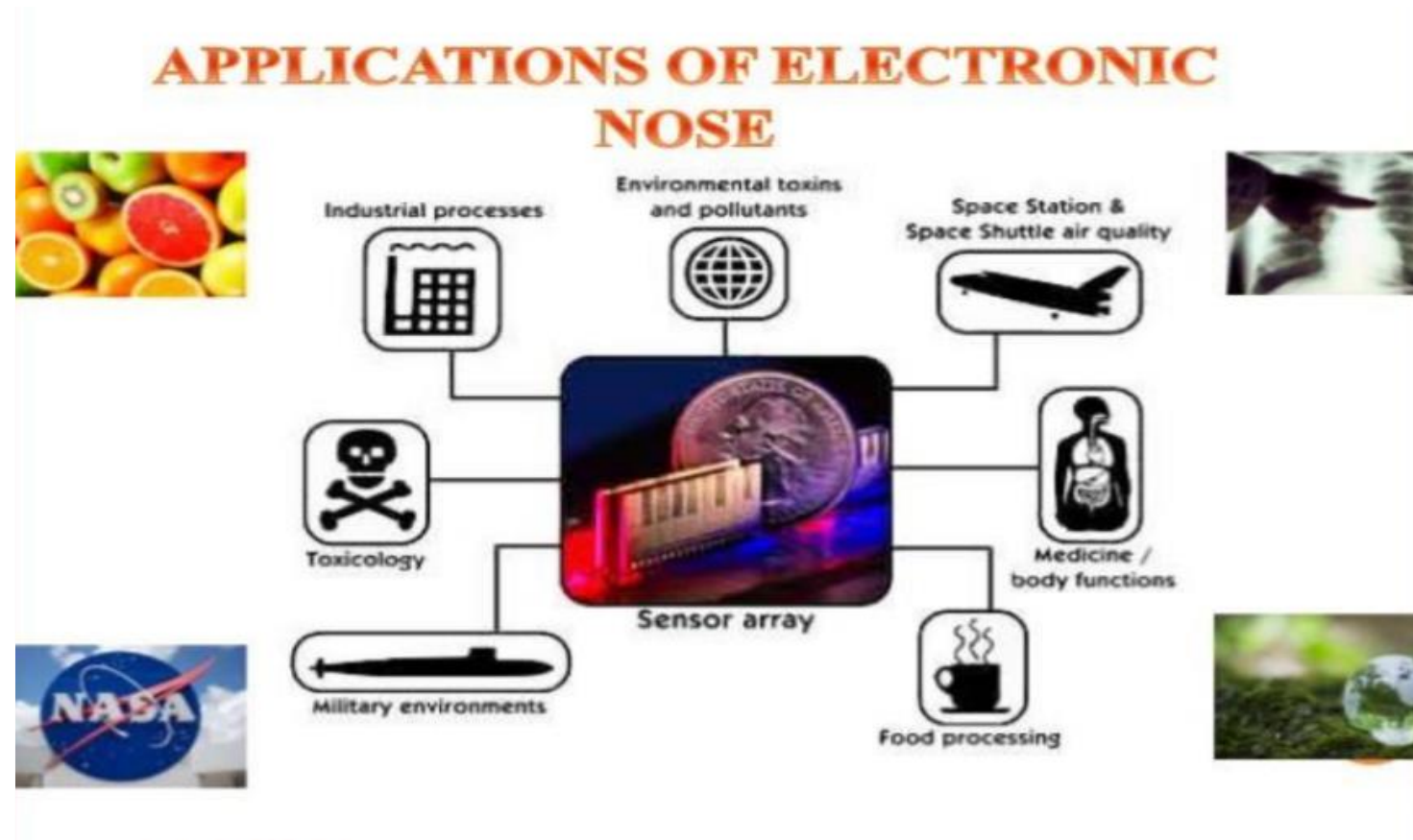
The Cyranose® 320 is a fully-integrated handheld chemical vapor sensing instrument designed specifically to detect and identify complex chemical mixtures that constitute aromas, odors, fragrances, formulations, spills, and leaks.

It uses the NoseChip® array of nano-composite sensors and advanced pattern recognition algorithms to detect and recognize the chemical vapor of interest, via its "smellprint".



CURRENT AND FUTURE APPLICATIONS IN THE FIELDS OF HEALTH AND SECURITY

- ❖ Detection of dangerous and **harmful bacteria**, such as MRSA (Methicillin-resistant Staphylococcus aureus)
- ❖ Detection of **lung cancer** or other medical conditions
- ❖ Detection of viral and bacterial infections in **COPD symptoms**
- ❖ Detect odorless smells to for **bomb odors**
- ❖ **Drug detection method in airports**
- ❖ **Environmental Monitoring**
- ❖ Identification of volatile organic compounds in air, water and soil samples



Using a
Cyrano
unit with a
Nasal
Breathing
Cup, with
the patient
breathing
out of her
nose, into
the unit.

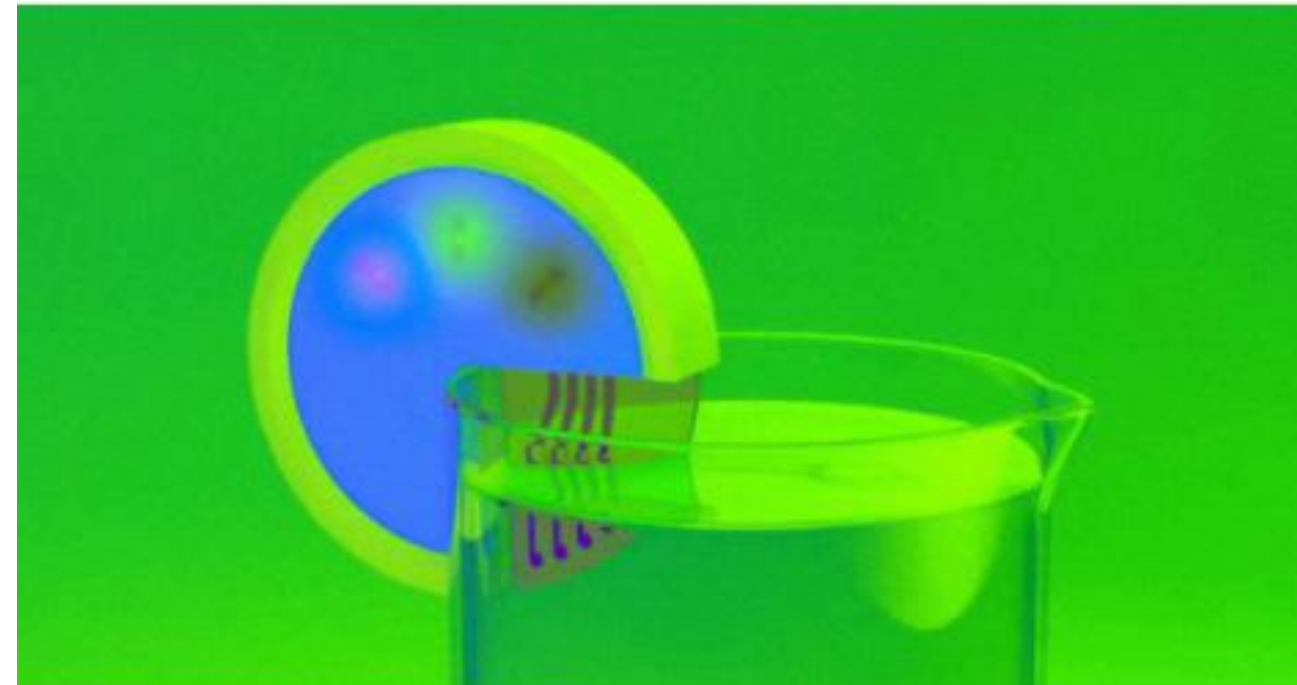
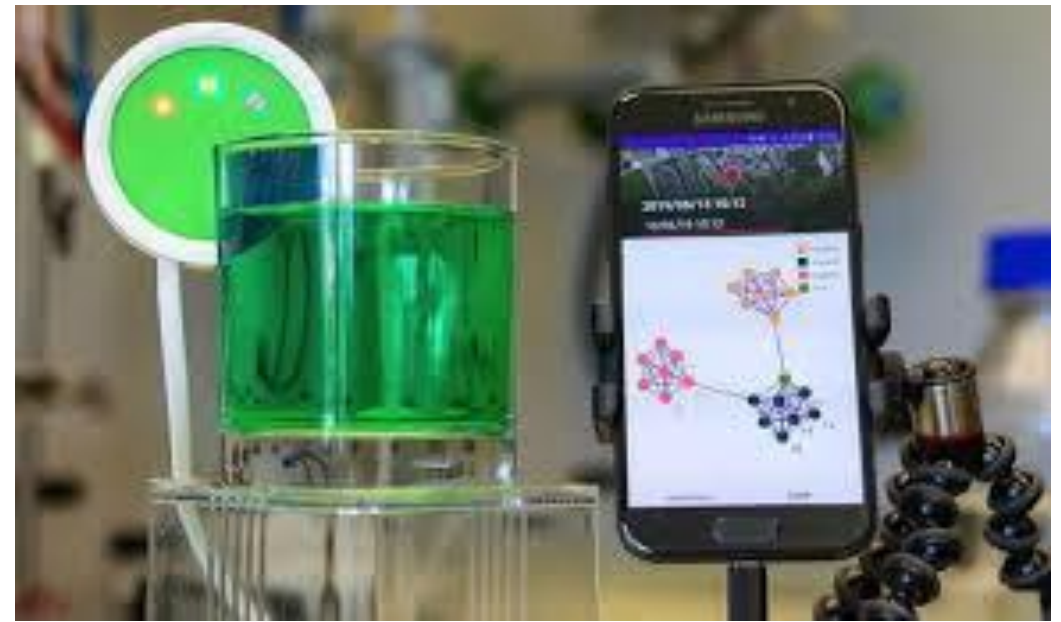


IBM UNVEILS NEW “ELECTRONIC TONGUE” TO TASTE AND IDENTIFY LIQUIDS

The IBM team calls its electronic tongue Hypertaste, and it looks a bit like a drink coaster with a slit in its side that rests on the edge of a glass of liquid.

Once in this position, an array of electrochemical sensors can sense the presence of molecule combinations in the liquid, analyze them and measure it within a minute.

Once Hypertaste has this fingerprint, it transmits it to a mobile device, which in turn, sends it to a cloud server. There, an Artificial Intelligence software compares that fingerprint to the fingerprints of known liquids and sends the closest match back to the mobile device.



A CURE FOR BLINDNESS MAY BE FIRST PRODUCT MADE IN SPACE

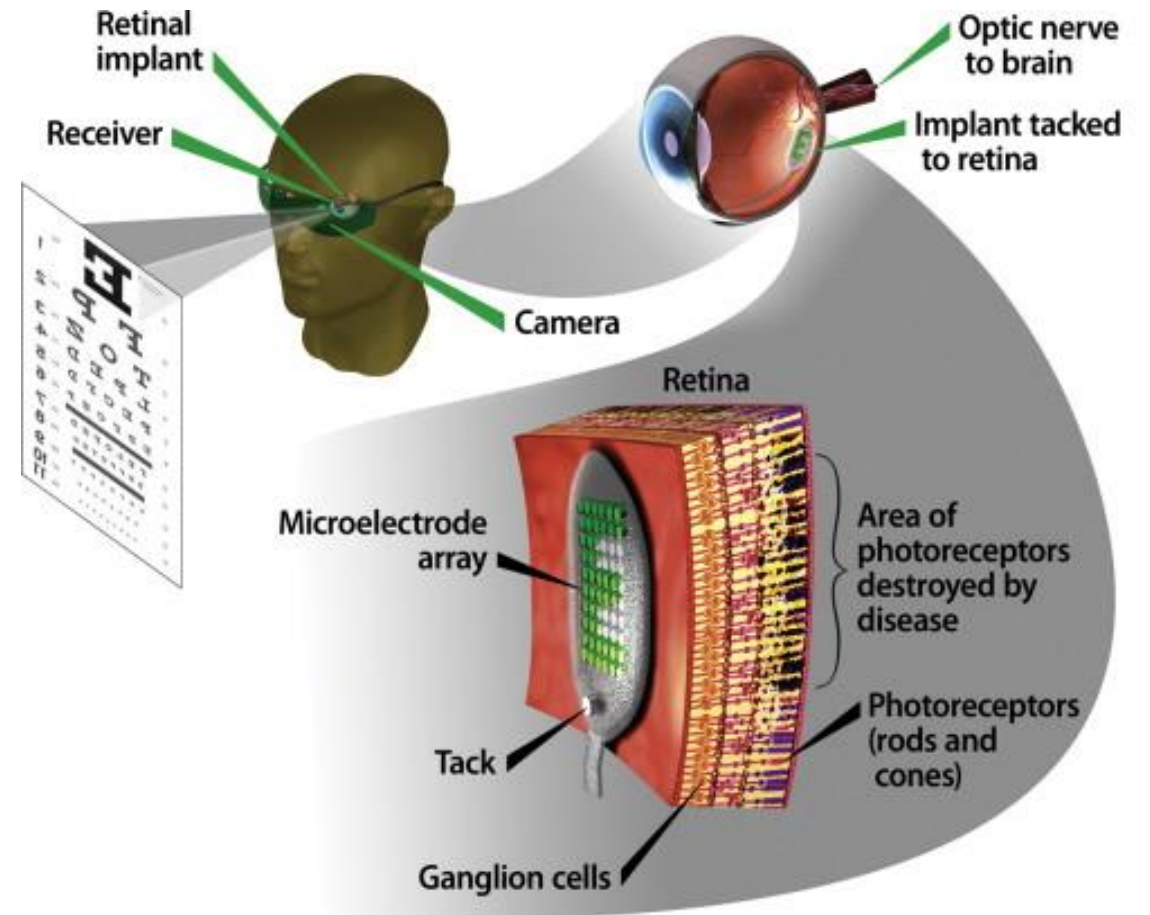
AN ISS EXPERIMENT SUGGESTS THAT ARTIFICIAL RETINAS WILL BE MORE EFFECTIVE IF MANUFACTURED IN MICROGRAVITY

Artificial retinas made in space appear to be better than retinas made on Earth because even a force as light as the pull of gravity during manufacturing, can lead to imperfections.

It suggests that a cure for a leading cause of blindness could be one of the first products manufactured on tomorrow's commercial space stations.

Connecticut startup LambdaVision is using 200 layers of a light-activated protein, called "bacteriorhodopsin," on a mesh membrane.

The hope is that the devices will one day restore vision in people with retinal degeneration, by filling in for their damaged photoreceptors.



Adapted, with permission, from *IEEE Engineering in Medicine and Biology* 24:15 (2005).



LambdaVision's most recent CubeLab prior to flight.
Credit: LambdaVision

The company teamed up with Space Tango, a space-based research firm, to design an experiment using one of its CubeLabs, box containers packed with all the automated systems needed to perform experiments with near-real-time input from Earth.

Backed by a \$5 million commercialization grant from NASA, it sent its first CubeLab to the International Space Station (ISS) in 2018, and 4 others have followed.

The 5th CubeLab has now returned to Earth, and according to LambdaVision's initial analysis, the 200-layer films in it were more uniform than the controls they created on Earth.

They hope to have its artificial retinas ready for trials involving patients with advanced retinitis pigmentosa in 2024.

If those go well, trials to treat age-related macular degeneration would follow

INJECTABLE GEL REPAIRS SEVERE SPINAL CORD INJURIES AND ENABLES MICE TO WALK

THE SCIENTISTS ARE HEADED "STRAIGHT TO THE FDA" TO BEGIN HUMAN TRIALS

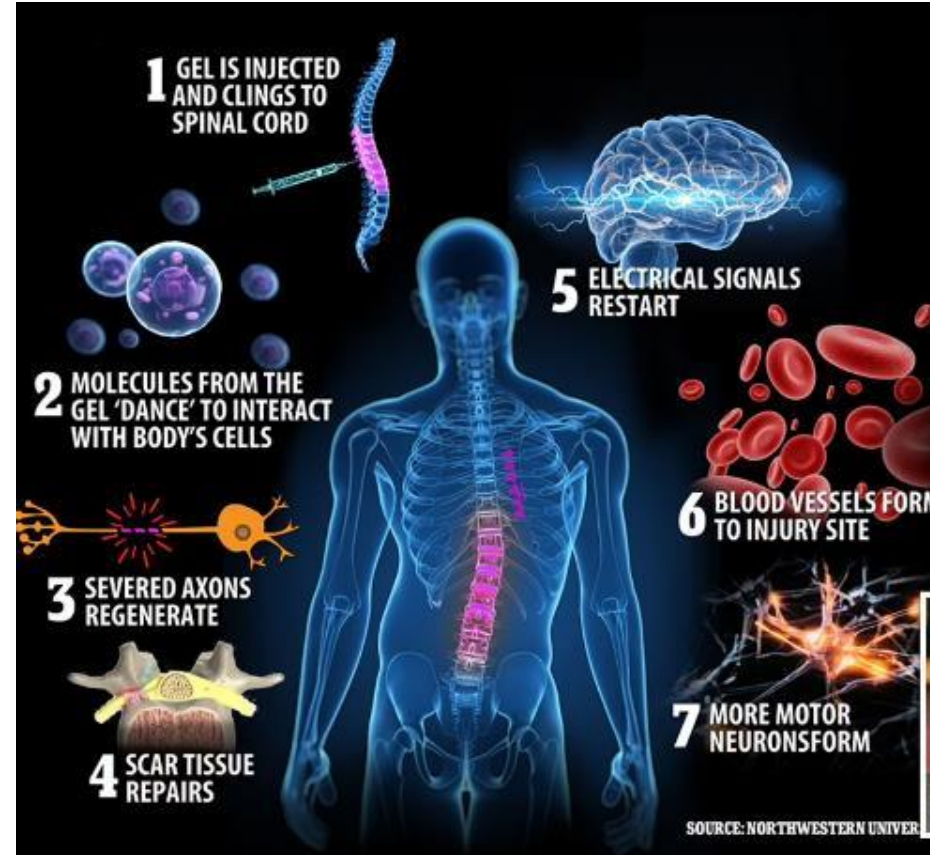
The body is bad at repairing neural damage which is bad news for the nearly one million people who will suffer from a spinal cord injury (SCI) this year.

Surgical interventions and physical therapies improve recovery of motor skills following SCI, but a full recovery is rare.

A group of researchers may have figured out how to insert compounds that stimulate nerve repair.

Mice paralyzed by severe SCI regained the ability to walk three weeks after a single injection of their new therapeutic.

Their secret? Make the drug dance in Jell-O.





“Receptors in neurons and other cells constantly move around,” Samuel Stupp, an expert in regenerative medicine, said.

“The key innovation in our research, which has never been done before, is to control the collective motion of more than 100,000 molecules within our nanofibers.

By making the molecules move, ‘dance’ or even leap temporarily out of these structures, known as supra-molecular polymers, they can connect more effectively with receptors.”

After 3 weeks, mice that received the high-mobility solution, had 50% greater muscle control (i.e., the ability to walk) than those who received the low-mobility solution, and nearly 300% greater control than the mice that received saline (a salt solution).

After 12 weeks, the mice injected with the high-mobility solution exhibited 50 times more axon (nerve cell) regrowth, than the control group.

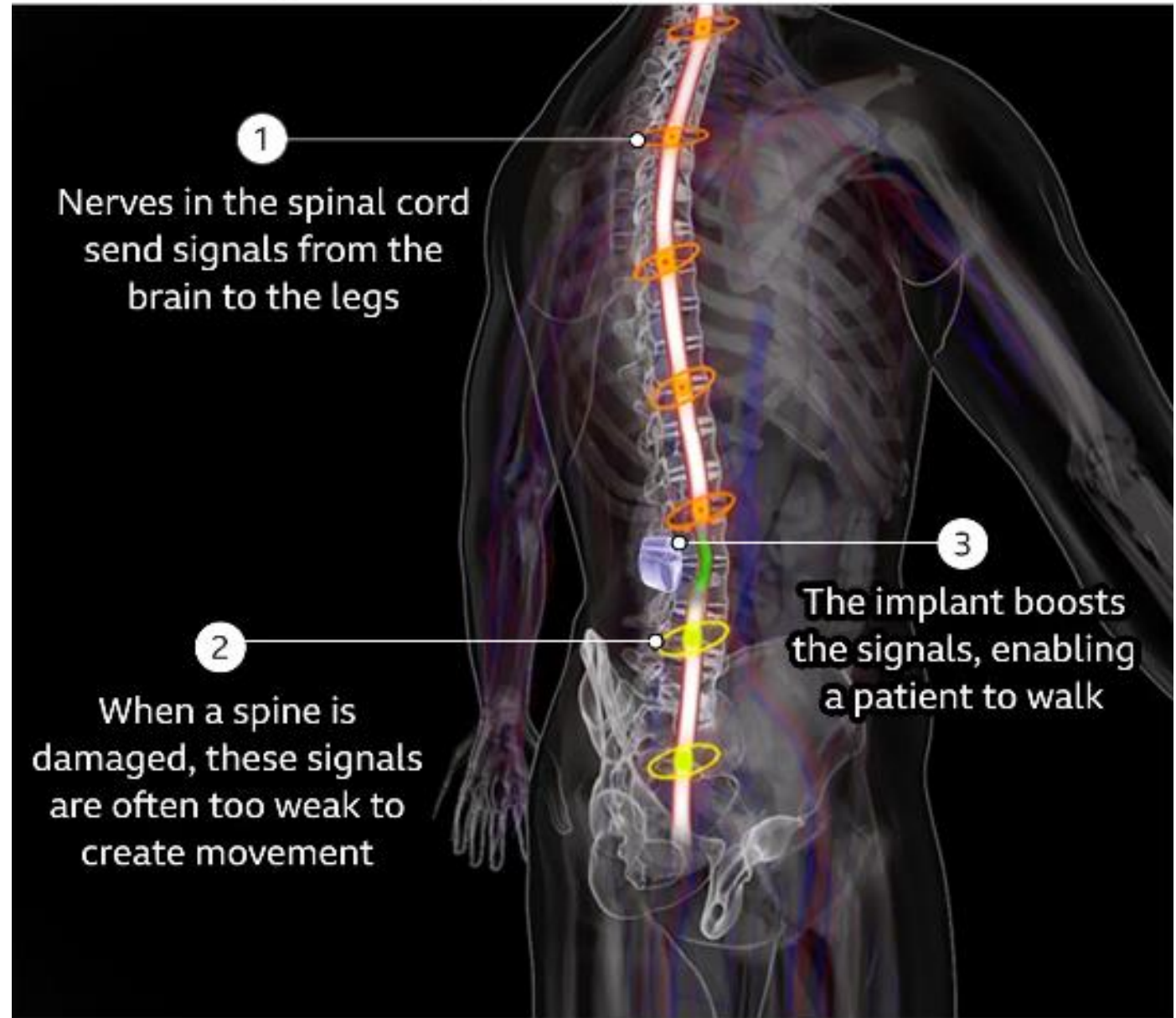
UNTIL RECENTLY, A SEVERE SPINAL CORD INJURY USUALLY MEANT PERMANENT PARALYSIS. BUT A NEWLY DEVELOPED TECHNIQUE OFFERS HOPE

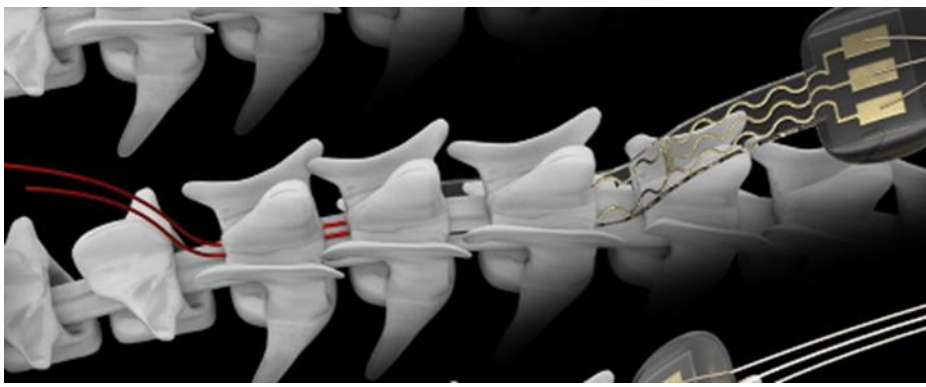
Although still experimental, **epidural electrical stimulation (EES)** has already been used to restore walking in patients with “motor complete spinal cord injury”

Now researchers in Switzerland have used the technique to restore walking in 9 persons with chronic spinal cord injuries.

They have also identified the nerve cells responsible for the recovery, and the unexpected mechanism by which it occurs.

How the spinal implant works





The participants had a **neuro-stimulator** surgically implanted onto the surface of the lumbar spine to activate the motor nerve roots as they exit the cord.

After 5 months of rehabilitation, they could walk outside, using an assistive stabilizing device, and those who had partial spinal cord function before stimulation, could later walk without it.

This led them to hypothesize that EES activates a population of neurons that only becomes essential for walking, after paralysis.

Interneurons are small “local” cells, which in the spinal cord, relay signals between motor neurons and sensory neurons.

They are located within the intermediate layers of the spinal cord and synthesizes the excitatory neurotransmitter glutamate.



A NEW IMPLANT IS ALLOWING MICHEL ROCCATI TO WALK AGAIN DESPITE HAVING A SEVERED SPINAL CORD.

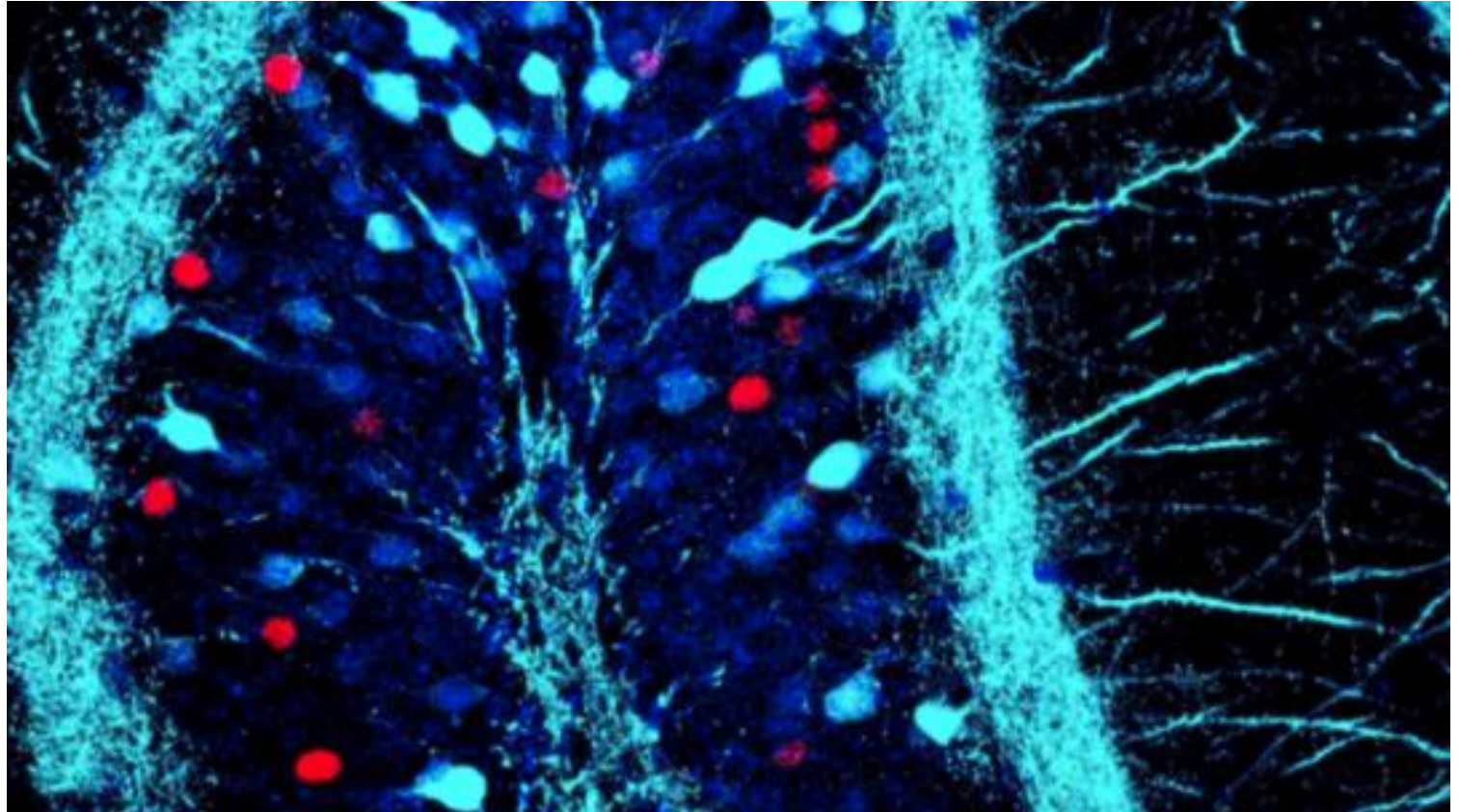
GOOD AND BAD MEMORIES ARE STORED IN DIFFERENT NEURONS, STUDY FINDS

THIS OPENS THE DOOR TO MANIPULATING NETWORKS OF SPECIFIC NEURONS

Memories are stored in all different areas across the brain as networks of neurons called engrams.

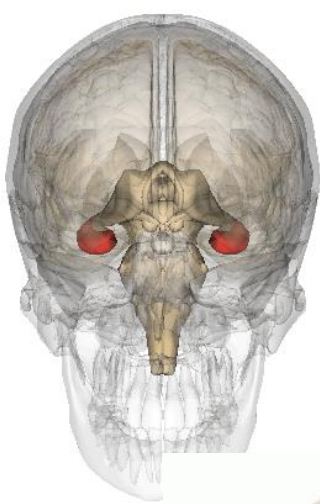
In addition to collecting information about incoming stimuli, these engrams capture emotional information.

In a new study, researchers discovered where the brain stores positive and negative memories and uncovered hundreds of markers, that differentiate positive-memory neurons from negative-memory neurons.



THE RED DOTS ARE NEURONS WITH BAD MEMORIES IN THEM

THE GREEN ONES ARE THOSE WITH GOOD MEMORIES.



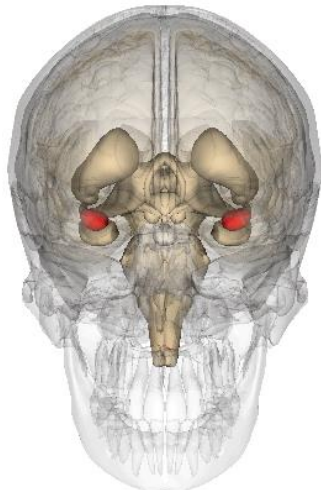
In 2019, they found evidence that good and bad memories are stored in different regions of the **hippocampus**, a cashew-shaped structure that holds sensory and emotional information necessary for forming and retrieving memories.

The top part activated when mice felt enjoyable experiences, but the bottom region activated when they had negative experiences.

They also found 2 other items:

1) Some areas of the brain (notably the **prefrontal cortex**, the region responsible for orchestrating thoughts and actions according to internal goals) hosted positive and negative memory-storing neurons.

2) Other regions primarily hosted only one type.



Some parts of the **amygdala** (which is involved in emotional information processing) primarily hosted neurons that stored positive memories, whereas other areas of the **amygdala** primarily hosted neurons that held negative memories.

STRONG MEMORIES ARE FORMED BY "TEAMS" OF NEURONS FIRING AT THE SAME TIME

Researchers found that that the brain recruits a higher number of neurons which fire impulses in a synchronized manner, to form and store strong memories over long periods.

The key word here is “redundancy”, which means the brain has backup to remember the exact occurrence

The study adds the crucial bit of knowledge that this is achieved by forming stable groups of neurons with synchronous firing to represent an environment, even while individual neurons showed fluctuations from day to day.

This is important in adding to our understanding of how memory works and could help treat memory loss in conditions that affect the brain, like Alzheimer’s disease or strokes.

How Neurons Form and Solidify Memory

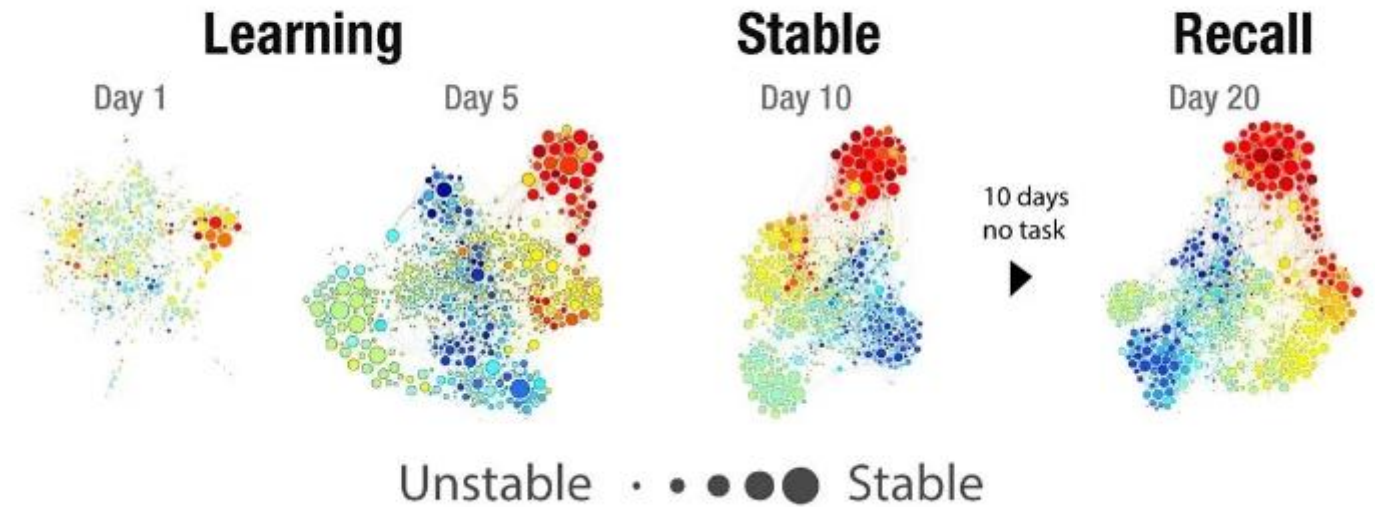


Diagram of neural activity in the hippocampus, recorded from a mouse as it learned about its new surroundings.

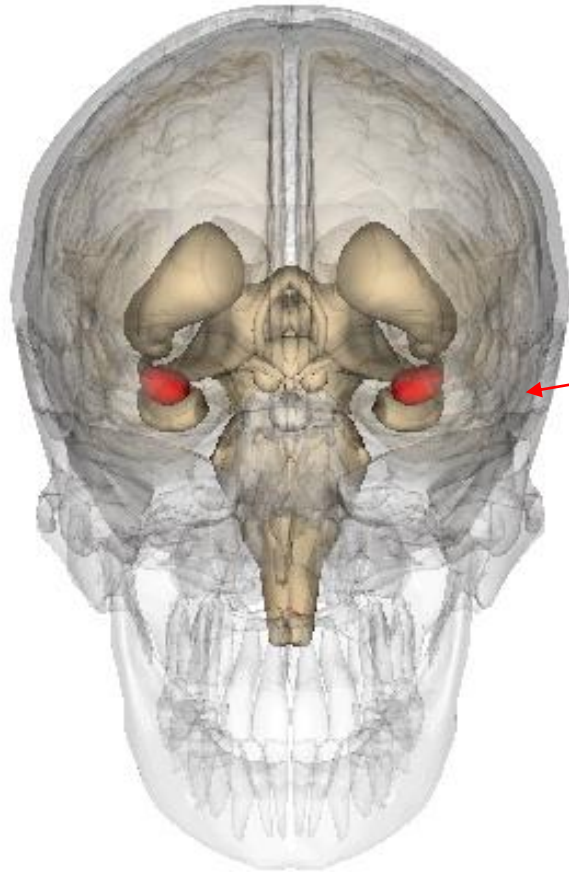
Colors correspond to unique locations within the new place.

Over time and continued exposure to the area, the mouse forms stable memories by recruiting teams of neurons to encode for the location.

Credit: Caltech

HOW THE BRAIN PURGES BAD MEMORIES

A BRAIN CIRCUIT HAS BEEN FOUND THAT ALLOWS US TO FORGET FEAR AND ANXIETY



A new study confirms that a working connection between 2 brain regions – the **Amygdala** and the **prefrontal cortex**, are necessary to do away with fear.

The **amygdala**, two small arcs of brain tissue deep beneath our temples, is involved in emotional reactions, and it flares with activity when we are scared.

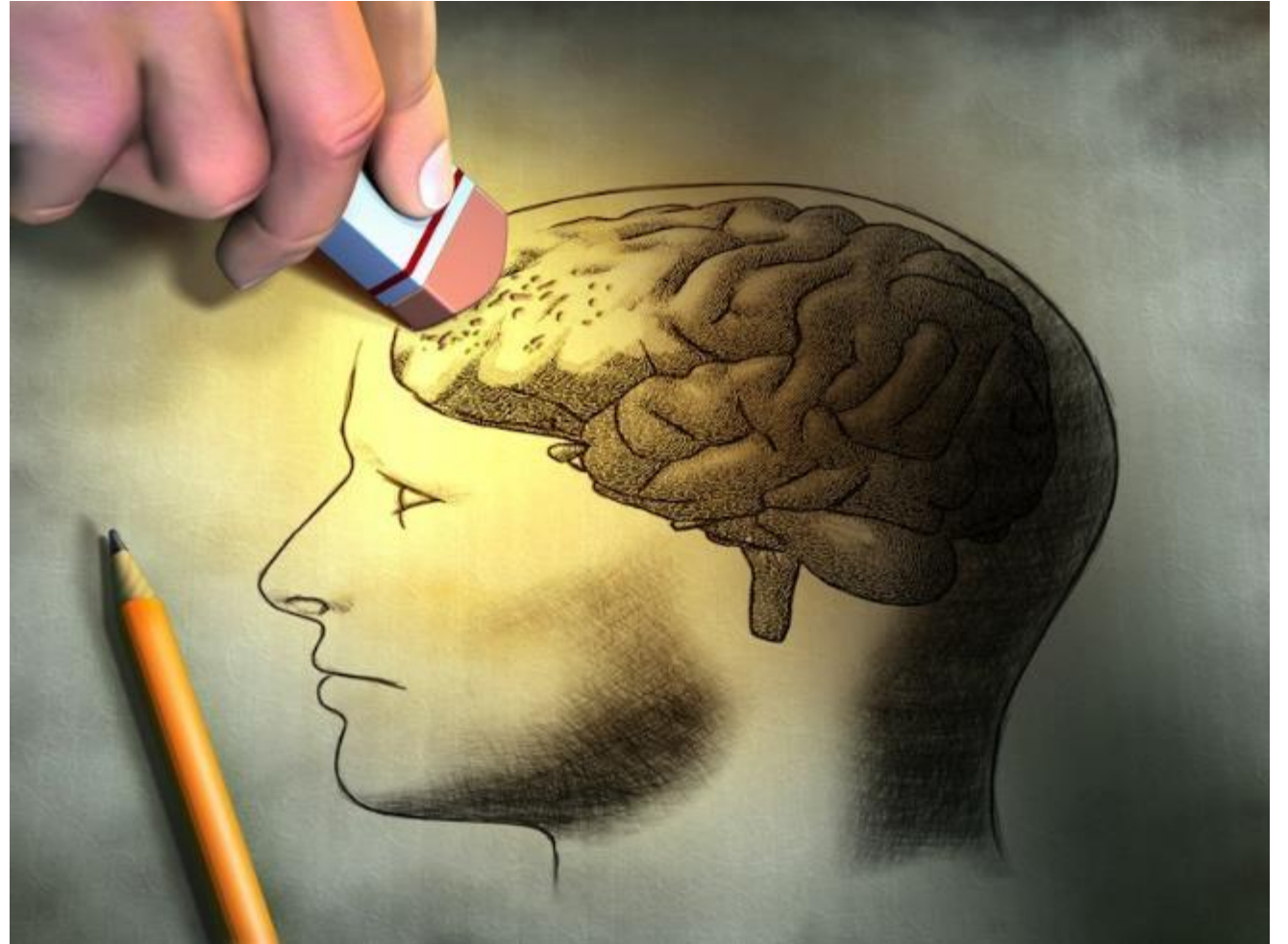
If a particular threat turns out to be harmless, a brain region behind the forehead, called the **prefrontal cortex**, steps in and the fright subsides.

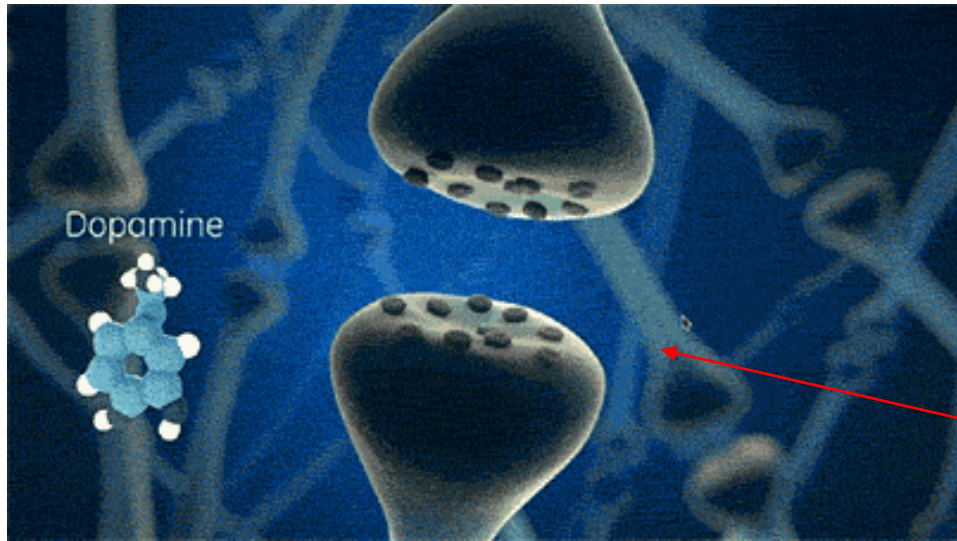
New research has identified a neuronal circuit responsible for the brain's ability to purge bad memories, findings that could have implications for treating PTSD and other anxiety disorders.

Healthy fear extinction relies on “neural plasticity,”

This is the brain’s ability to make new neuronal connections, which is in part influenced by the brain’s own cannabinoids, compounds that regulate neurotransmitters.

Medications that alter the cannabinoid system, could provide a way to modify the fear circuit, thereby—possibly—alleviating anxiety.





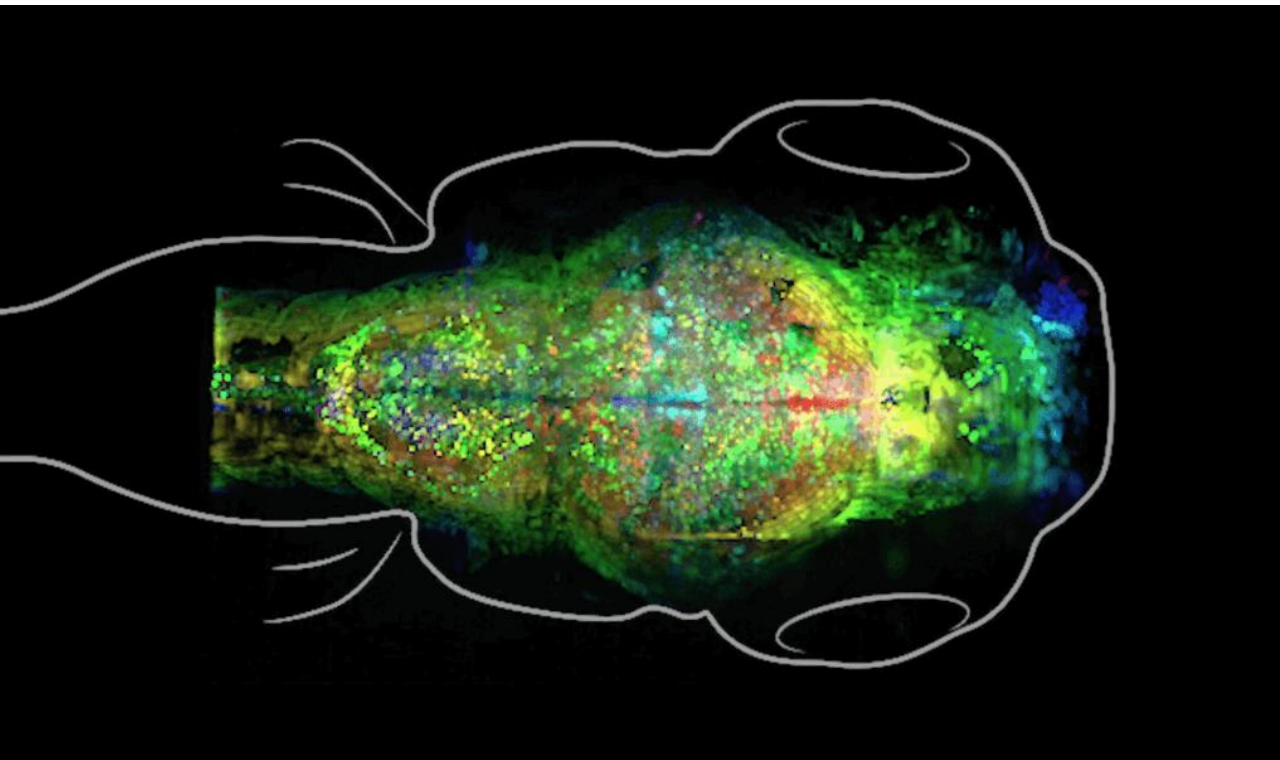
USC TEAM SHOWS HOW MEMORIES ARE STORED IN THE BRAIN, WITH POTENTIAL IMPACT ON CONDITIONS LIKE PTSD

Fish that glow; a tailor-made microscope; and a new way to catalog science.

Researchers were able to record how brain cells of the fish - which are transparent when young - 'lit up like Times Square on New Year's Eve' during the experiment.

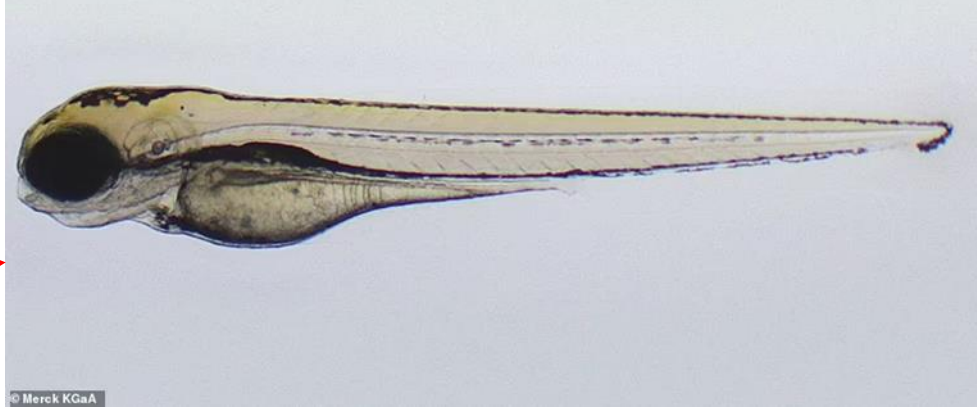
Contrary to expectations, they discovered that when memories are formed, it causes brain synapses, the connections between neurons, to multiply in some areas and also, new ones are created in a different region, rather than merely changing their strength, as commonly thought.

They found that negative memories appear to be formed in a different part of the brain to most other memories - the amygdala, which is responsible for emotional responses, including fight or flight.



What physical changes occur in the brain when a memory is made?

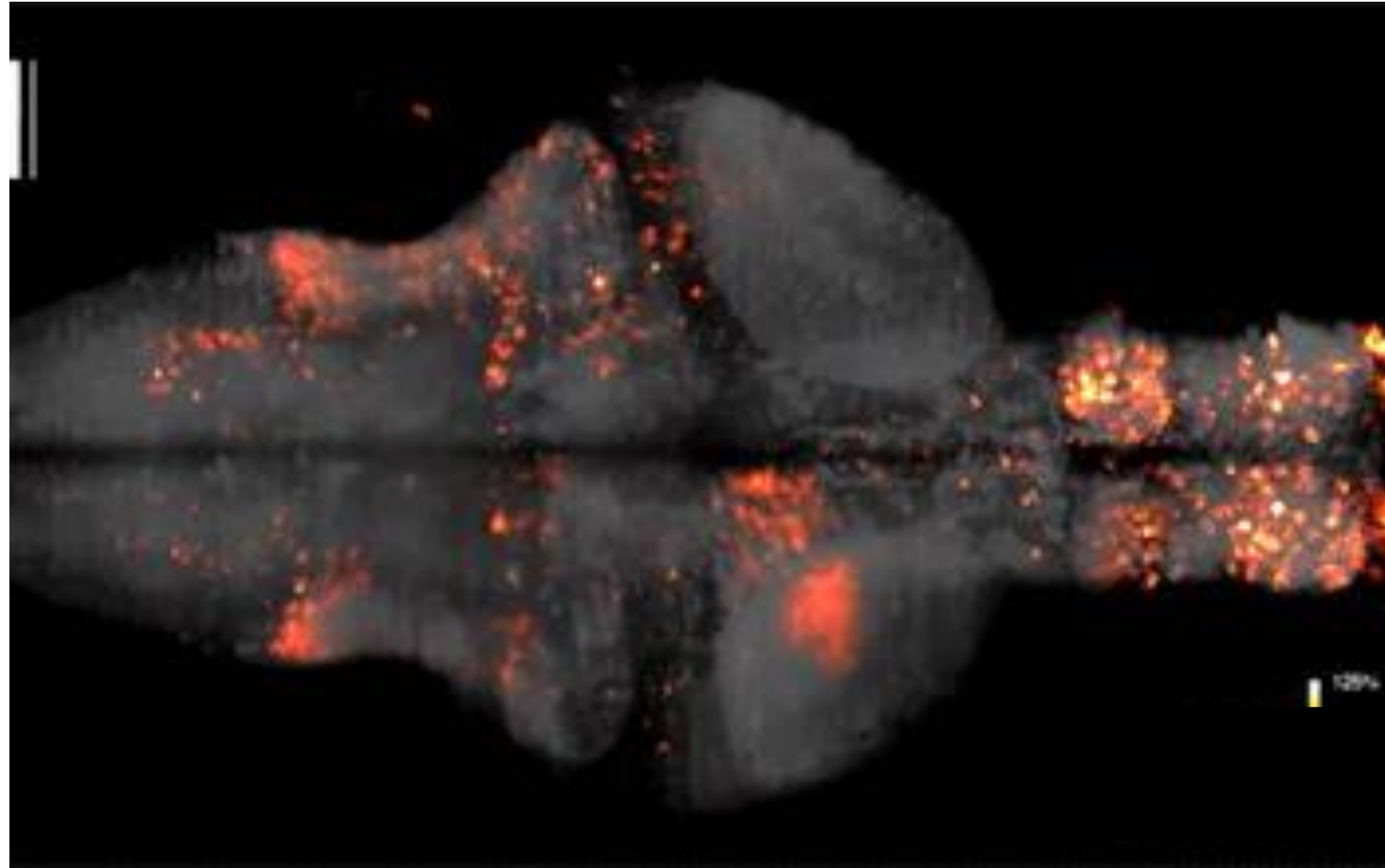
They induced a memory in a larval zebrafish and then mapped changes in their transparent heads.



These changes in synapses may help explain how memories are formed and why certain kinds of memories are stronger than others.

On average, the human brain contains about 100 billion neurons and many more neuro-glia which serve to support and protect the neurons.

Each neuron may be connected to up to 10,000 other neurons, passing signals to each other via as many as 1,000 trillion synapses.



ELECTRONIC DISPLAY SURFACES





CLOWN DOCTORS

The Big Apple Circus Clown Care Unit, which entertains children in New York City hospitals, is compared with non-Western healers, especially shamans.

There is not only superficial resemblance--weird costumes, music, sleight of hand, puppet/spirit helpers, and ventriloquism--but also similarity in the meanings and functions of their performances.

- **Both clown and shaman violate natural and cultural rules in their performances.**
- **Both help patient and family deal with illness.**
- **Both use suggestion and manipulation of medical symbols in attempting to alleviate their patients' distress.**

Clown doctors can provide positive therapy that may enhance medical treatment in developed nations, particularly for children.



A complex, multi-colored mandala pattern with a central white starburst shape. The pattern consists of concentric, overlapping layers of geometric shapes in shades of purple, blue, red, and green, creating a rich, textured effect. The central starburst is a bright white, multi-pointed star that radiates outwards, illuminating the surrounding colors.

THE END

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