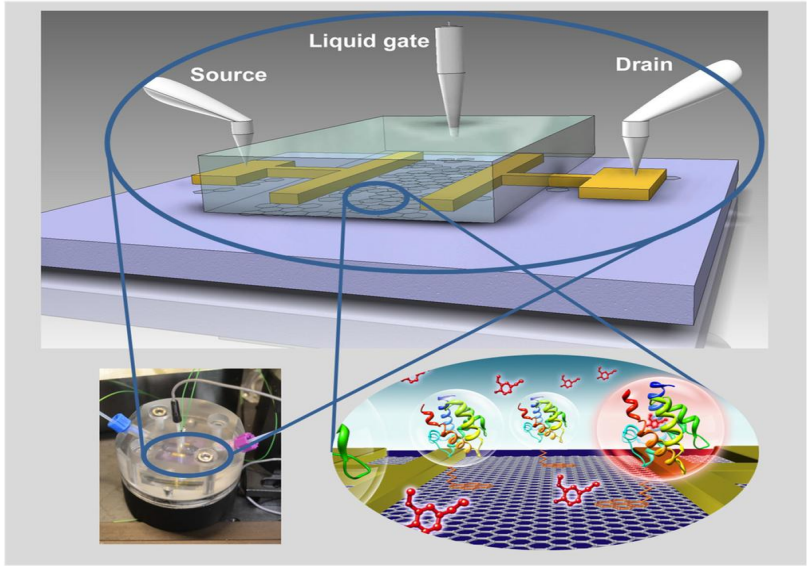
Biomedical Devices, Sensors & Systems

- Biological properties can be measured and altered using electronics, magnetics, photonics, sensors, circuits, and algorithms.

- Applications range from basic biological science to clinical medicine and enable new discoveries, diagnoses, and treatments by creating novel circuits, devices, systems, and analyses.

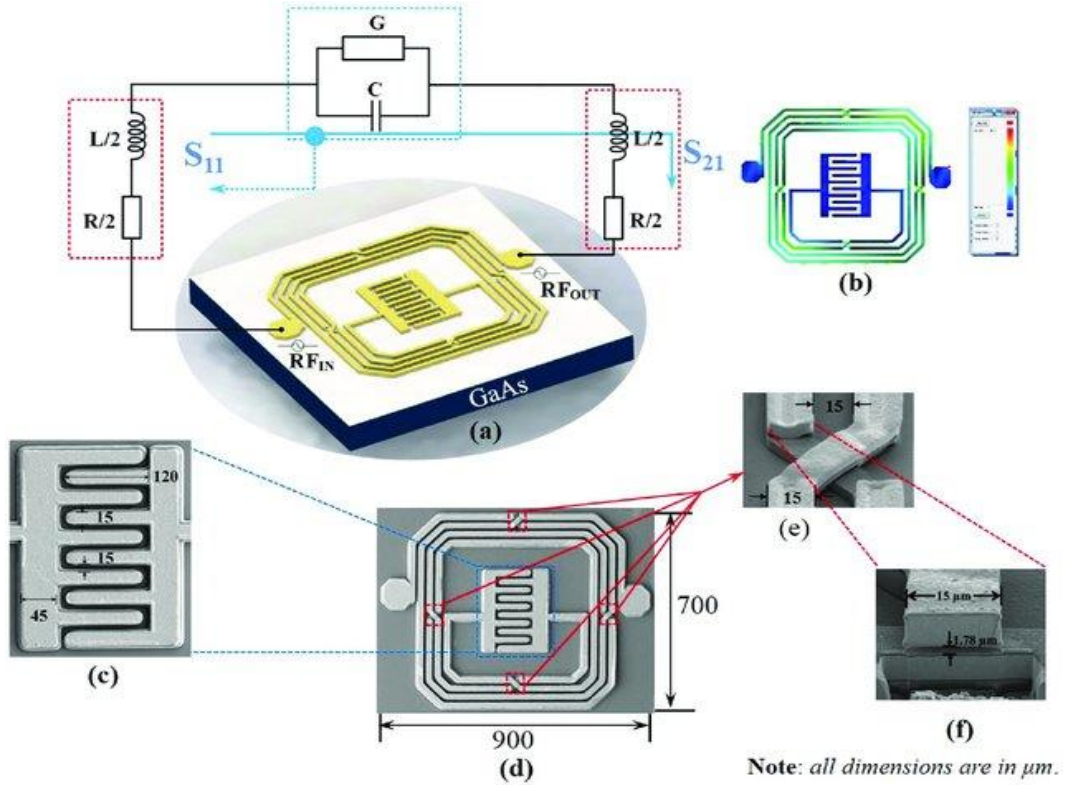
Examples include:

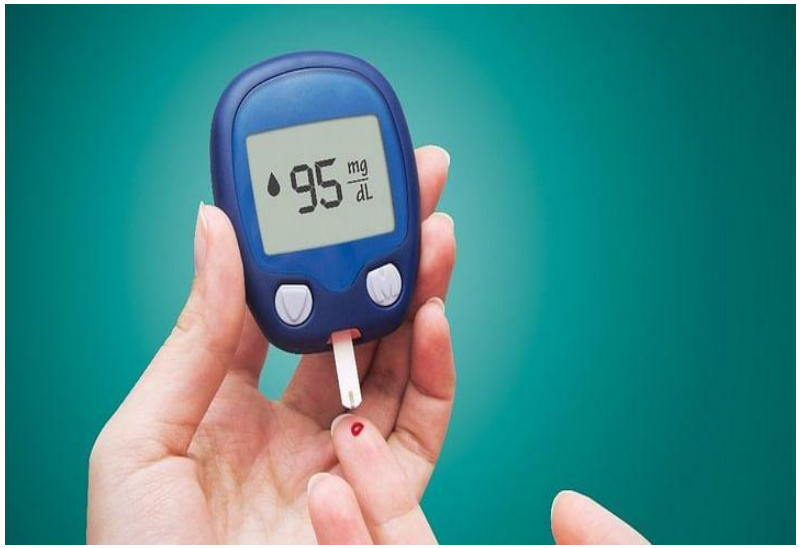
- Measuring molecular concentrations
- Measuring and altering activity of electrically-excitable cells such as neurons
- Building implantable bio-sensors, bio-stimulators, and closed-loop delivery systems



Graphene oxide-based biosensors, which are highly sensitive, label-free, disposable and cheap, with electronic signals that are easy to analyze and interpret

https://www.elprocus.com/what-is-a-biosensor-types-of-biosensors-and-applications/





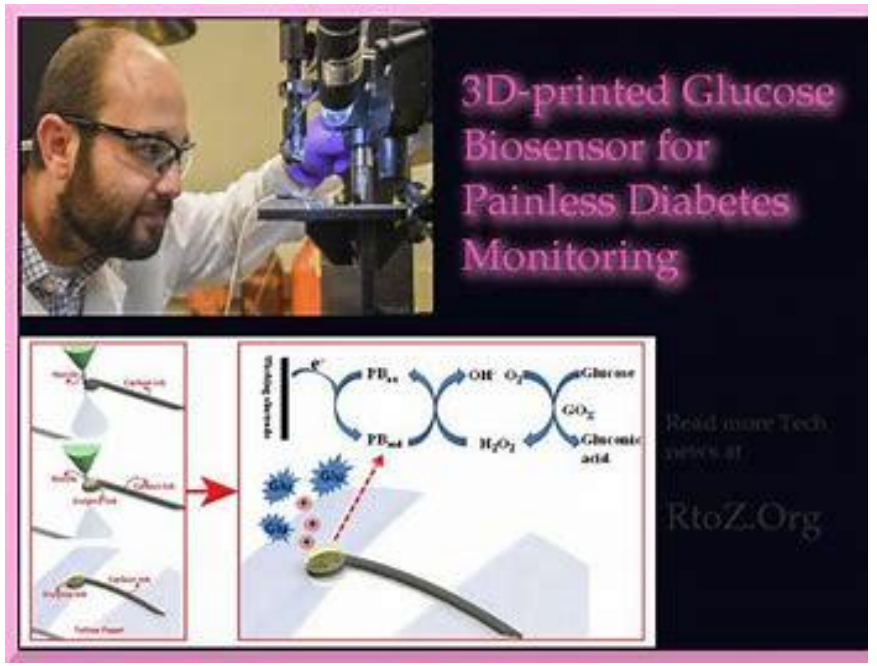


Fig. 3D-Printed Glucose Biosensor

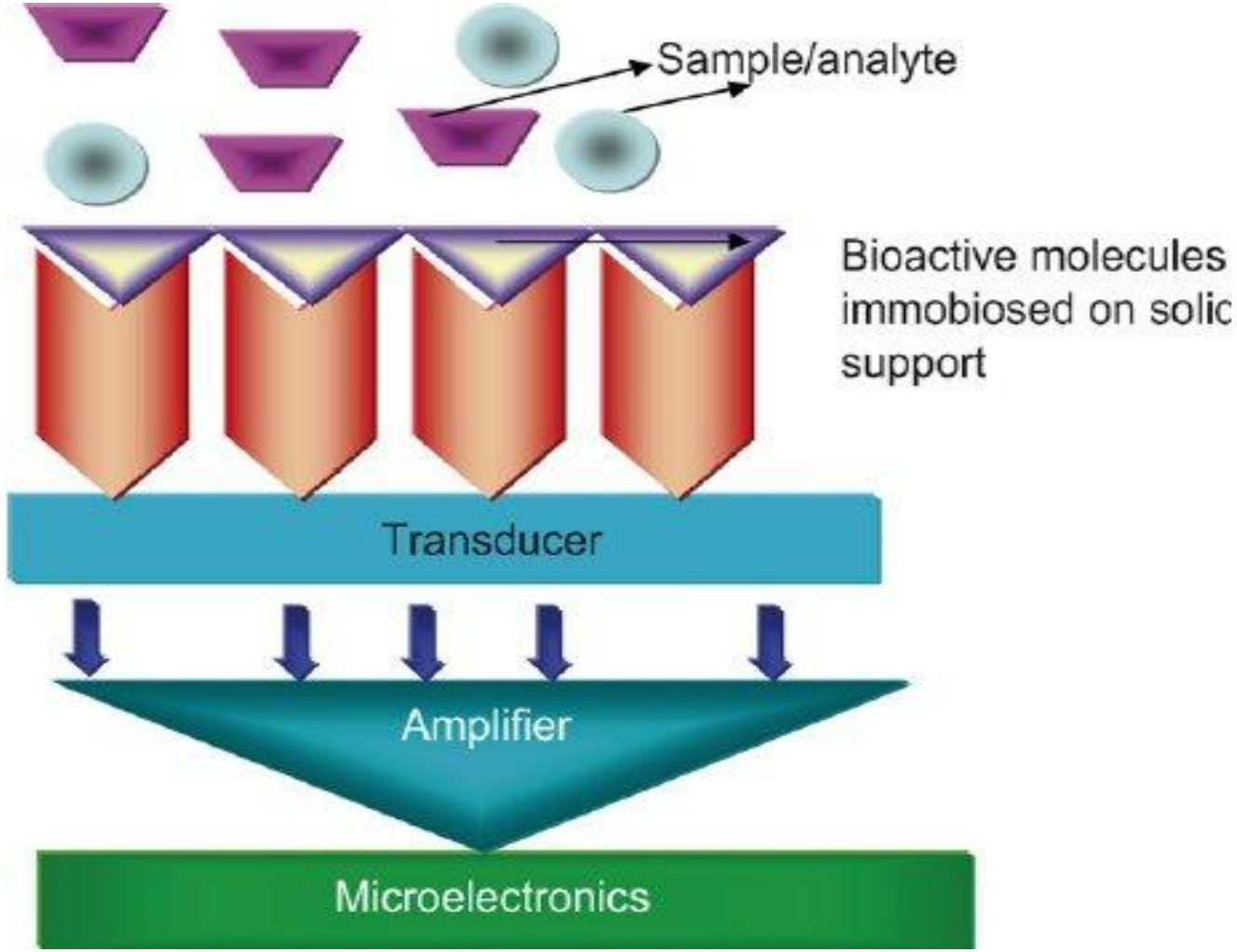
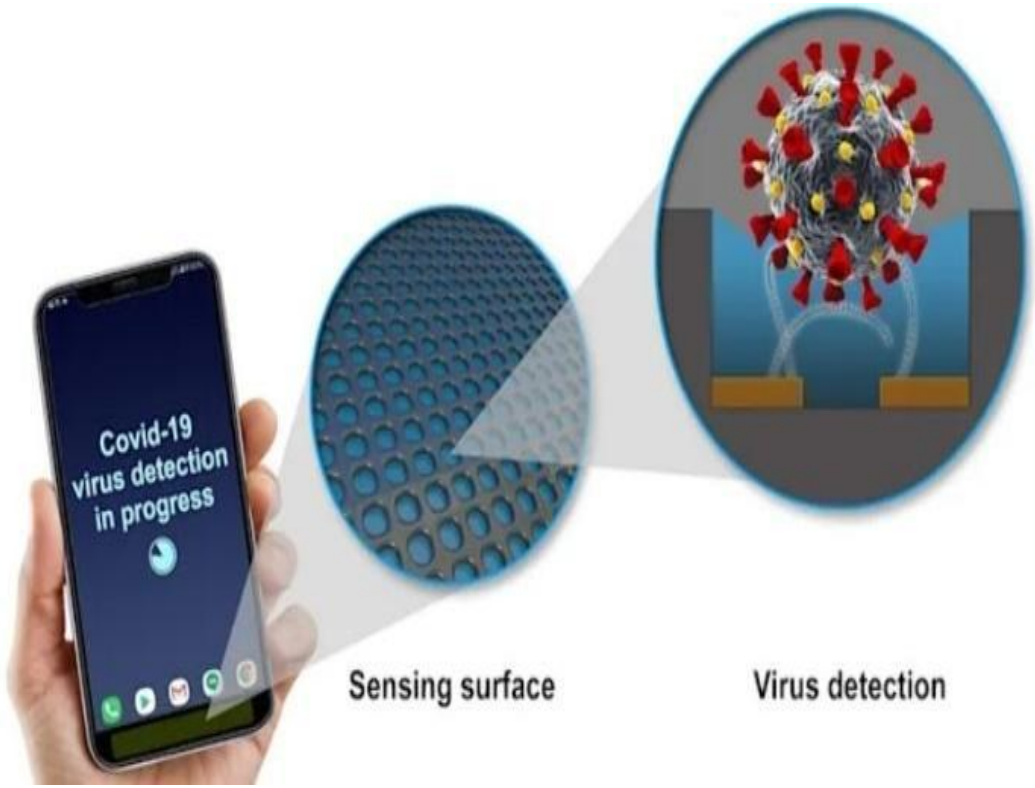


Fig. Schematic of biosensor.

STICK-ON SENSOR CAN DETECT AND TRACK COVID-19 SYMPTOMS

Small device, which sticks to the base of the throat, can detect how long and how often you cough, as well as breathing problems



Smartphone Sensor To Instantly Detect Coronavirus

Biomedical Devices, Sensors & Systems

- Brain-machine interfaces
- On-chip imaging and sensing
- Photonic systems for in vivo imaging
- DNA synthesis and sequencing

- Wireless sensing and powering
- Constructing low-cost devices for point-of-care medical applications

- Designing new algorithms and systems for early cancer screening and detection

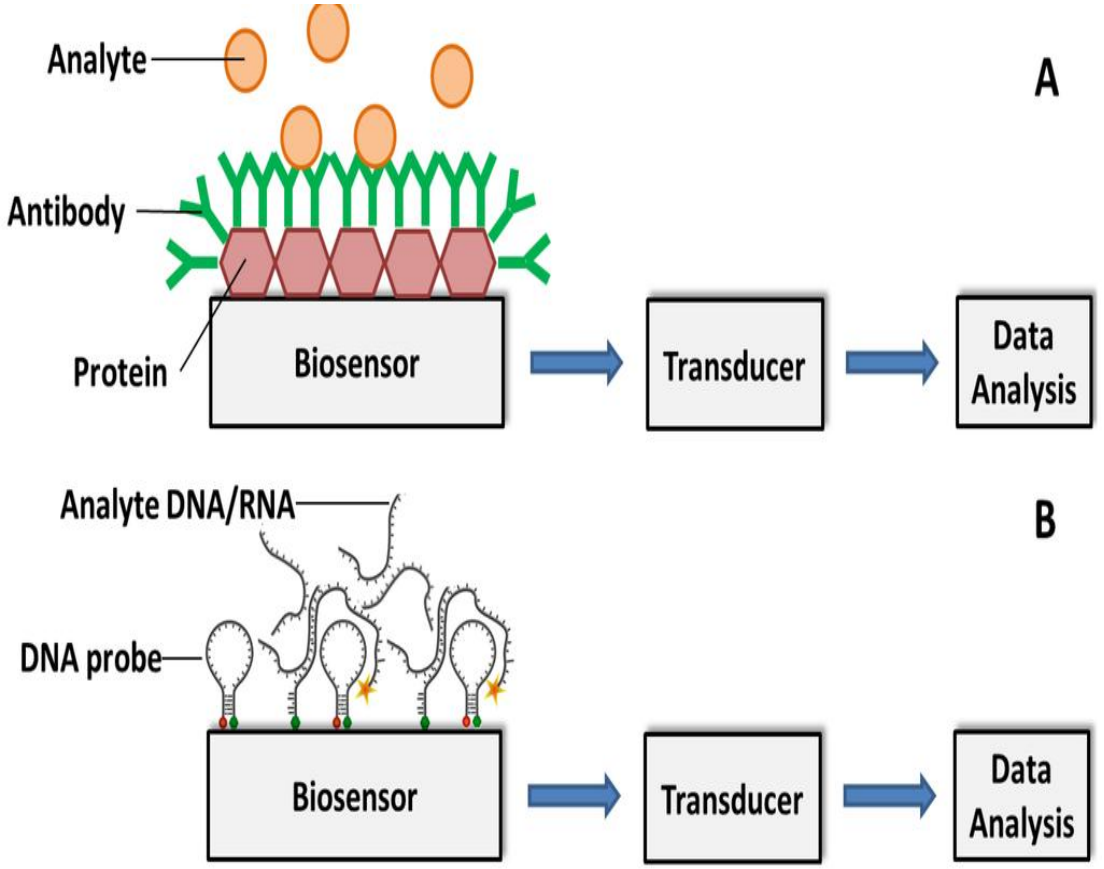


Figure . Schematic illustration of (A) antibody-based and (B) DNA/RNA-based biosensor for analyte detection. The specific combination of analyte and immobilized antibody (A) or DNA/RNA probe (B) produces a physicochemical change, such as mass, temperature, optical property or electrical potential. The change can be translated into a measurable signal for detection.

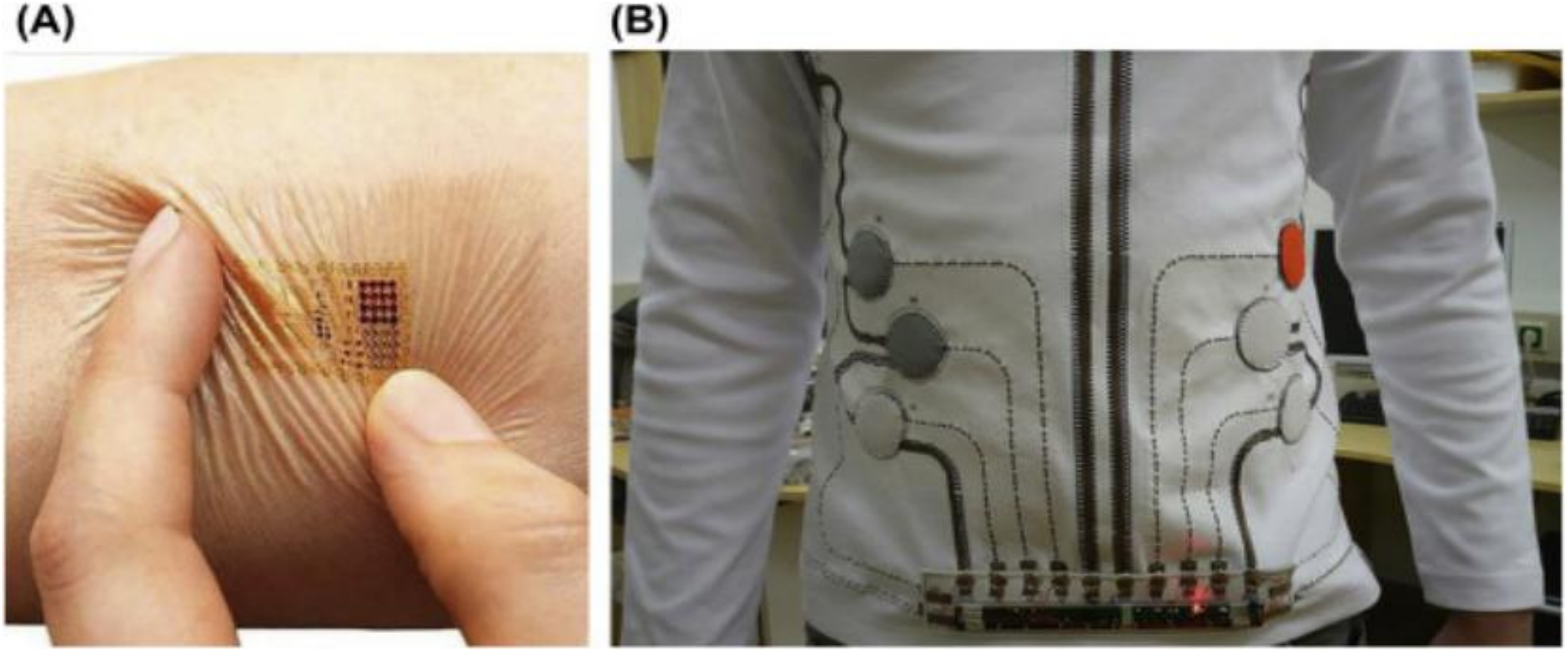
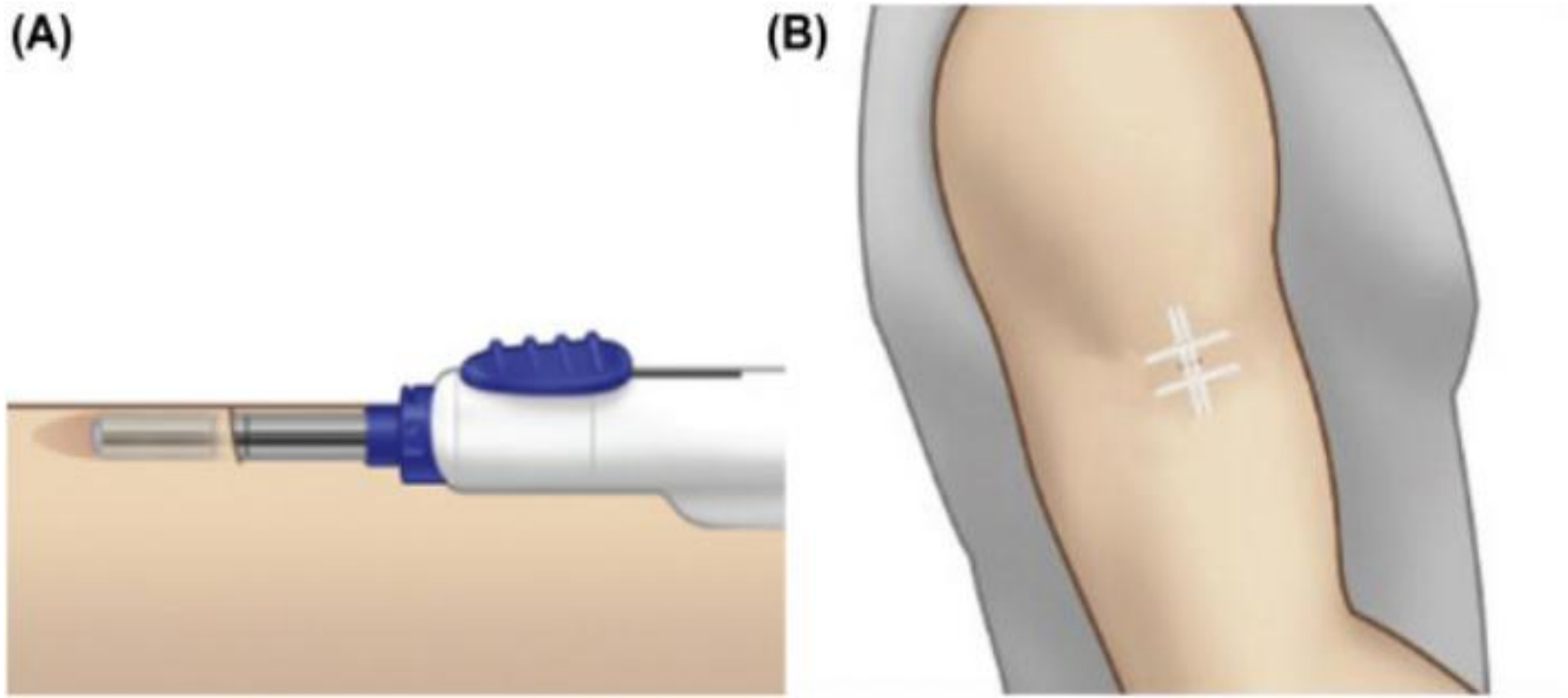


Figure. Wearable sensor: (A) on-body temperature (Wearble sensor, 2019) and (B) stitched in shirt of patient

On-body sensors where different BMSs are placed or stitched on/in the shirt of the body of the patient, as shown in Fig. 4.3A and B.



BMSs used to monitor different vital signs of a patient

The implantation of BMSs is the second method where different BMSs are inserted via surgery or swallowable, as depicted in Fig. 4.4A and B.

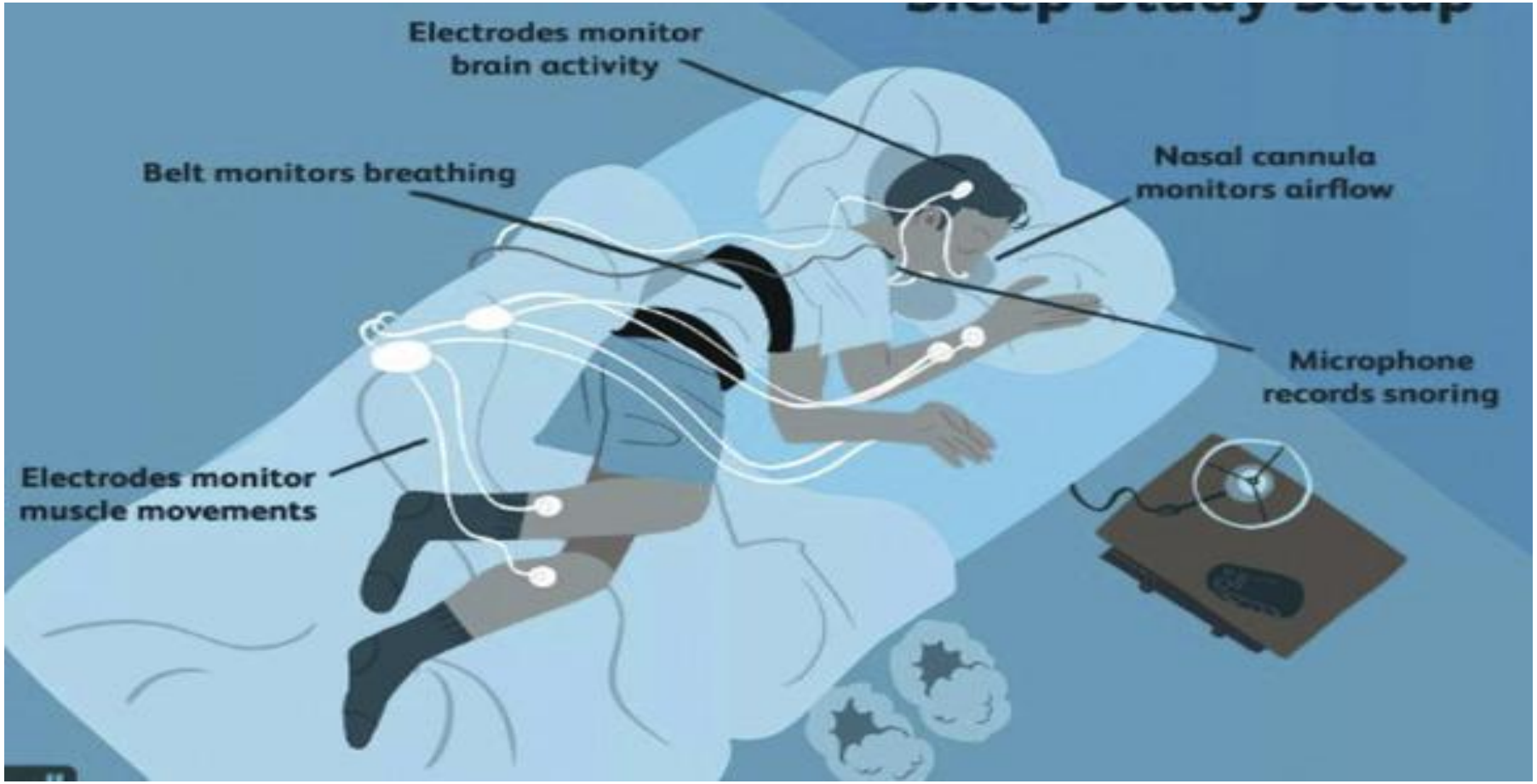


Figure. Deployment of sensors around a patient for monitoring of different physical activities like sleeping time and different positions

The third method sensors are based on the monitoring of different physical activities of a patient like how he is sitting on the bed, sleeping position and duration and also observes the improvement in health, as shown in Fig. 4.5.

- Biomedical sensors are special electronic devices that can transduce biomedical signals into easily measurable electric signals.

- Biomedical sensors are the key component in various medical diagnostic instruments and equipment.

- Measuring a biosignal entails converting it to an electric signal using a device known as a biotransducer.

- Research on biomedical sensing technology is mainly focused on how to improve the understanding of biology processes and technology for medical diagnosis and treatment.

- Numerous discoveries and inventions in biomedical materials have quickly gained importance in applications for biomedical sensors, molecular detection sensors, drug analysis and screening sensors, and micronano implantable probes.

- Biomedical sensors have been widely applied in medical image analysis and diagnostics, portable and clinical diagnostics, and laboratory analytical applications.

Sensor Classifications

- Biomedical sensors are usually classified according to the quantity to be measured and are typically categorized as physical, electrical, or chemical, depending on their specific applications.

- Biosensors, which can be considered a special subclassification of biomedical sensors, are a group of sensors that have two distinct components

- The purpose of the transducer is to convert the biochemical reaction into the form of an optical, electrical, or physical signal that is proportional to the concentration of a specific chemical.

- Thus, a blood pH sensor is not considered a biosensor according to this classification, although it measures a biologically important variable. It is simply a chemical sensor that can be used to measure a biological quantity.

- Biosignals provide communication between biosystems and are our primary source of information on their behavior.

- Interpretation and transformation of signals are major topics of this text. Biosignals, like all signals, must be carried by some form of energy.

- Biosignals can be measured directly from their biological source, but often external energy is used to measure the interaction between the physiological system and external energy.

- The resultant analog signal is often converted to a digital (discrete-time) signal for processing in a computer.

- Biosignals and the systems that produce them have several important properties: they can be stationary or nonstationary, linear or nonlinear, and deterministic or stochastic (i.e., random).

- Biosignals often contain noise, which is an unwanted signal component.

- Biosignal acquisition is the basis for diagnosis systems and understanding of the electrophysiology of the body.

- Bioelectric signals arise from the changes in the potential across the cell membrane of excitable cells. These are of low frequency and very low voltage and are often plagued with external interferences.

- Hence an ideal acquisition system should provide high overall gain, high selectivity for the biosignal and high common mode rejection ratio (CMRR) with ease of use and applicability.

- A biosignal is any signal in living beings that can be continually measured and monitored. The term biosignal is often used to refer to bioelectrical signals, but it may refer to both electrical and non-electrical signals.

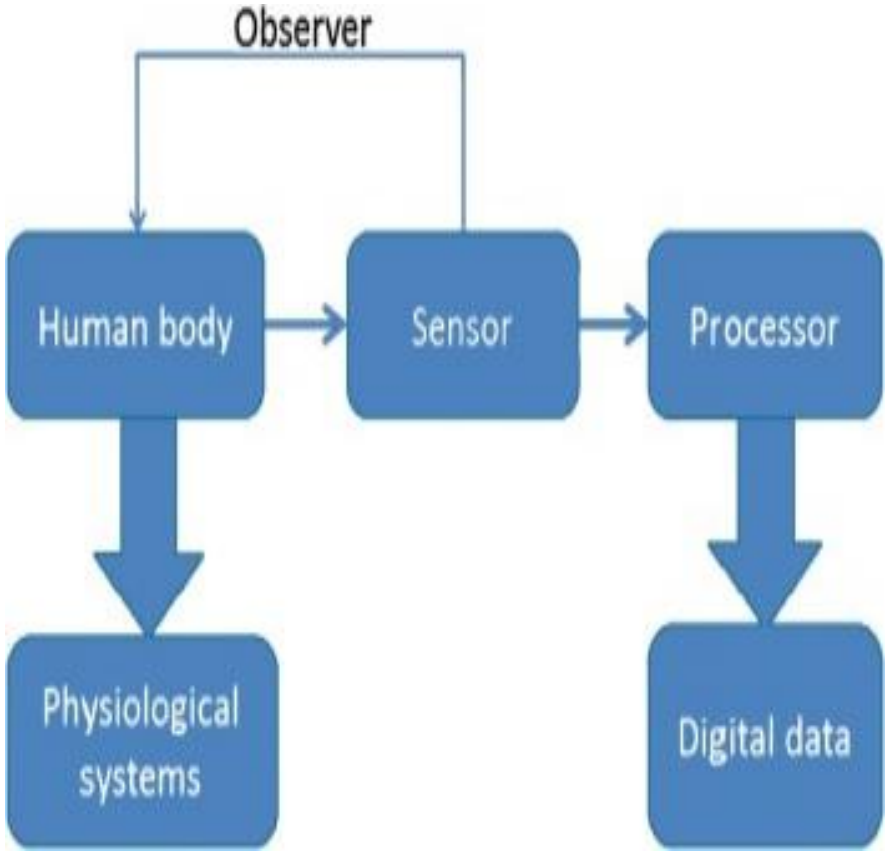
- The usual understanding is to refer only to time-varying signals.

- Bio-signals monitoring is a medical intervention defined as the act for collection and analysis of cardiovascular, respiratory, and body temperature data, in order to determine and prevent complications (businesswire).

- The bio-signals values situated in a range over normal values occur in case of diseases, and an alteration of vital signs is used to evaluate a patient's progress.

- The biomedical signals are measured using invasive and noninvasive sensors.

- Both types of sensors, invasive and noninvasive are wearable devices for health monitoring (Figure).



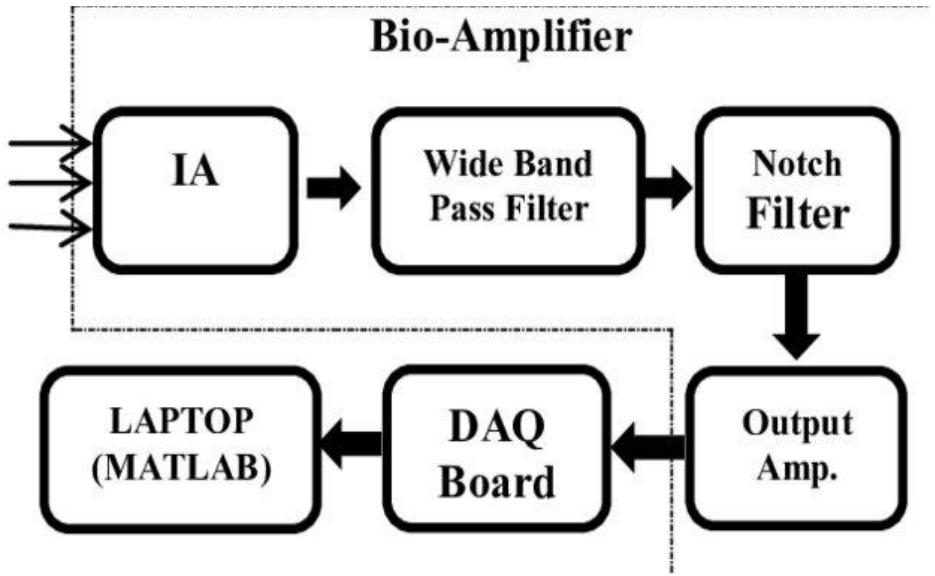


Fig. 1. Structure of Bio-electric signal Acquisition systems

Multipurpose low cost bio-daq system for real time biomedical applications

- Bio electric signals (signals generated by nerve cells/action potentials)

- Bio acoustic signals (example: flow of blood, flow of air)
- Bio mechanical signals (motion/displacement/chest wall/respiratory activity)

- Bio magnetic signals (generated by the magnetic field of heart and brain)
- Bio chemical signals (02, Ph values)
- Bio optical signals (generated by transmission and reflection of light)

These signals represent the normal wellbeing of the system under investigation.

However, any change in the characteristics of these signals represents altered performance or abnormal states of the system. Based on the complexity of the bio signals, they can be classified into

- Less complex bio signal
- Moderate complex bio signal
- More complex bio signal

Further, based on a signal processing point of view, the bio signals are classified into three different types namely:

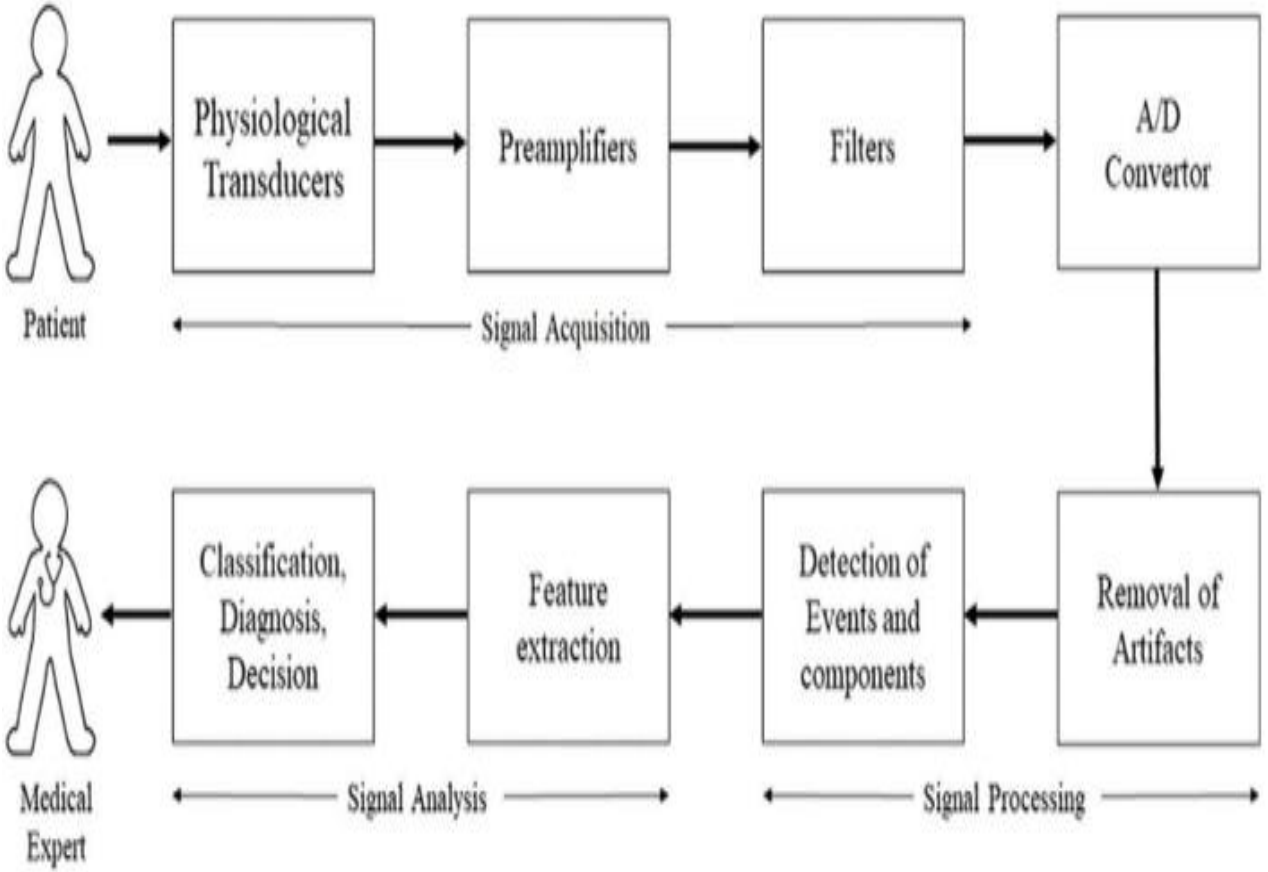
1. The deterministic signals: These signals can be represented as a function and the future values of these signals can be predicted from their post values.
2. The stochastic signals: These signals are random in nature and it is not possible to predict the future values from the past values.
3. Chaotic signals: Theses signals exhibit complex properties such as chaos.

Further, fractal signals exhibit scale invariance in which a similar pattern repeats itself invariant to the scale in which it is studied.

- The acquisition and analysis of biosignals and diagnosis of a particular disease, involves several stages as shown in Figure 2.1.

- The first stage involves the acquisition of the signal from the region of interest of the body. The region of interest can be a particular muscle or tissue or even a single cell.

- This acquisition is made using the placement of a suitable physiological transducer (example: electrodes or microphones) on the location of interest.



- Further, the output of physiological transducer is amplified and filtered using suitable electronic circuits

Bio-potential measurements

- Biopotentials, such as EEG, ECG, and EMG, are generated from volume conduction of currents made by collections of electrogenic cells. EEG, which is measured on the scalp, is the electrical potential induced from collective activities of large number of neurons in the brain.
- Biopotentials measurements are essential for biological research and biomedical monitoring of excitable tissues.
- Signal acquisition, processing, and transmission are fundamental capabilities of biomedical research and medical devices development.
- Important: Integrated, low-power consumption systems for portable, wearable, or implantable monitoring of signals.
- The system level requirements and alternatives for data acquisition, processing, and wireless transmission are main factors

Childwith ASD often have problems with social communication and interaction, and restricted or repetitive behaviors or interests.

Autism spectrum disorder