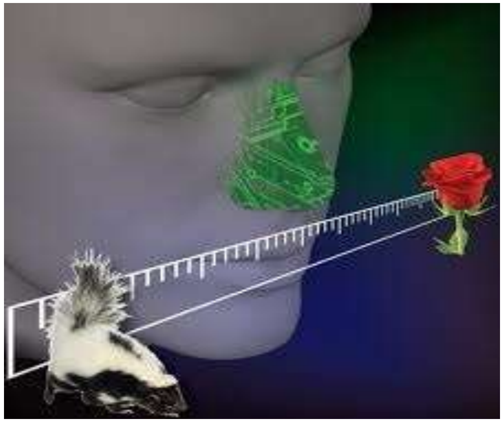
E – NOSE
Bio-olfactory mechanisms



Biological Inspiration

- Animals are capable of impressive performance in classifying, localizing, tracking, and tracing odor trails and plumes.
- Moths can use single-molecule hits of pheromone to locate the female.
- Dogs can track scent trails of a particular person and identify buried land mines.

- Rats build complex mental maps of the odor environment to avoid exposing themselves to danger.
- Simple insects use wind sensors and chemical sensors.
- Mammals use wind, chemical, and vision processing, as well as higher cognitive mapping and behavioral strategies.
- How can we get robots to do this?

History

- E-nose was first suggested by K. Persaud and George Dodd of Warwick University in 1982.

- Then in 1988, another professor of this university named Julian Gardner conducted his research on this.

- Came into popular use after 1989.

- Since then, development of sensor array-based instruments has been actively pursued in Asia, Europe and North America.

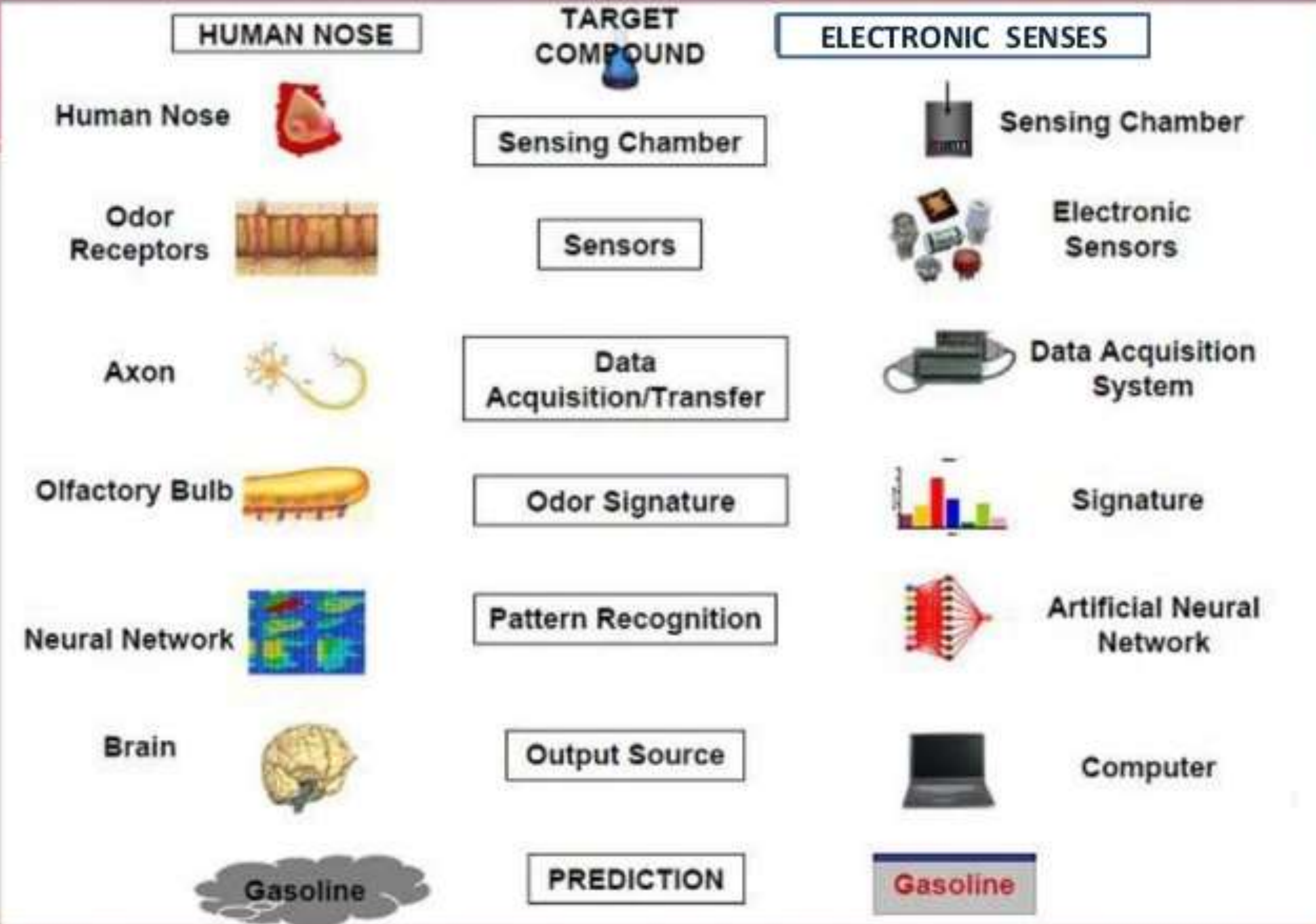
Introduction

- An electronic nose is a device intended to detect odors or flavours.
- It is based on “Electronic sensing” or “e-sensing” technology.
- E-NOSE consists of certain mechanisms such as an array of electronic sensors for chemical detection and artificial neural network for pattern recognition.

Working of Human nose

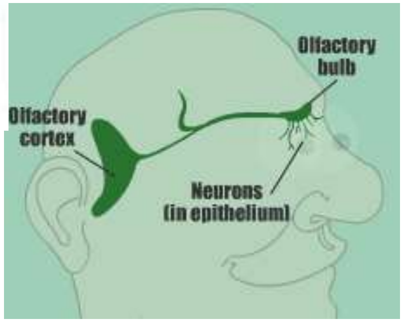
- The smells are composed of molecules, which has a specific size and shape.
- Each of these molecules has a corresponding sized and shaped receptor in the human nose.
- When a specific receptor receives a molecule it sends a signal to the brain and brain identifies the smell associated with the particular molecule.

- The electronic noses work in a similar manner of human.
- The electronic nose uses sensors as the receptor. When a specific sensor receives the molecules, it transmits the signal to a program for processing, rather than to the brain.

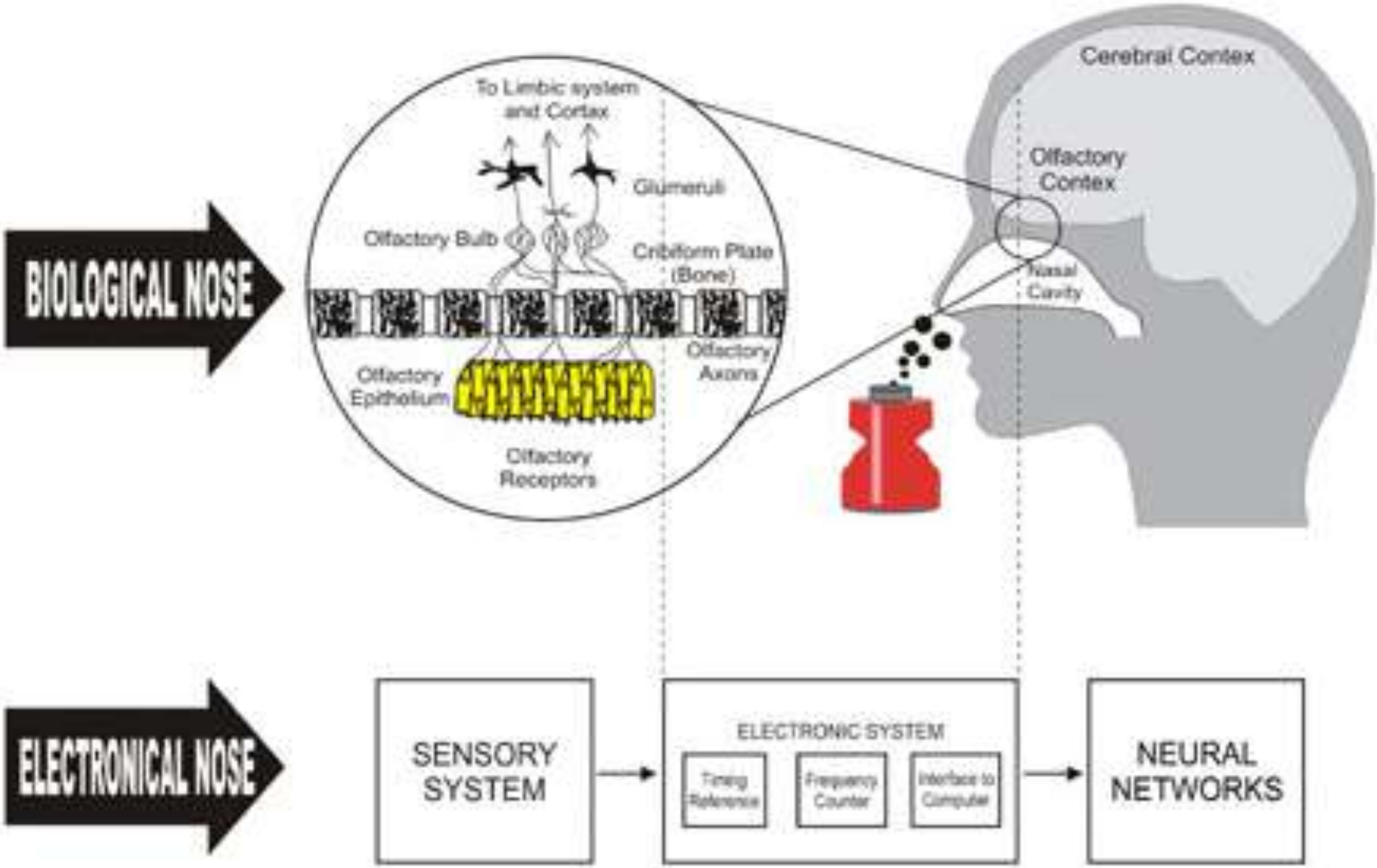

HUMAN NOSE
TARGET COMPOUND
ELECTRONIC SENSES
Human Nose
Sensing Chamber
Sensing Chamber
Odor Receptors
Sensors
Electronic Sensors
Axon
Data Acquisition/Transfer
Data Acquisition System
Olfactory Bulb
Odor Signature
Signature
Neural Network
Pattern Recognition
Artificial Neural Network
Brain
Output Source
Computer
Gasoline
PREDICTION
Gasoline

A Code in the Nose – Mammalian Olfaction

Biological Nose	E-Nose
Inhaling	Pump
Mucus	Filter
Olfactory epithelium	Sensors
Binding with proteins	Interaction
Enzymatic proteins	Reaction
Cell membrane depolarized	Signal
Nerve impulses	Circuitry and neural network



ELECTRONIC NOSE CONCEPT



Electronic Nose Working Principle:

- The electronic nose was developed in order to mimic human olfaction whose functions are non separate mechanism , i.e. the smell or flavor is perceived as a global finger print.

- Essentially the instrument consists of

➢ **sensor array,**

➢ **pattern reorganization modules,** and

➢ **headspace sampling**, to generate signal pattern that are used for characterizing smells.

Major Parts

The electronic nose consists of three major parts

- **sample delivery system**
- **detecting system**
- **computing system**

The sample delivery system:

- The sample delivery system enables the generation of headspace of sample or volatile compounds which is a fraction analyzed.
- The system then sends this head space into the detection system of the electronic nose.

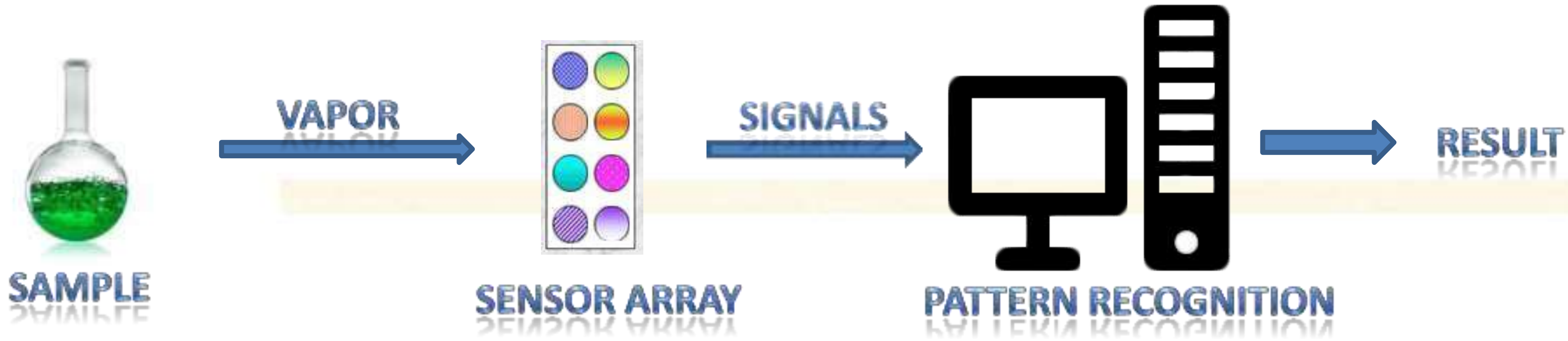
The detection system:

- The detection system which consists of a group of sensors is the reactive part of the instrument.
- When in contact with volatile compounds at that time the sensors reacts causing changes in electrical characteristics.

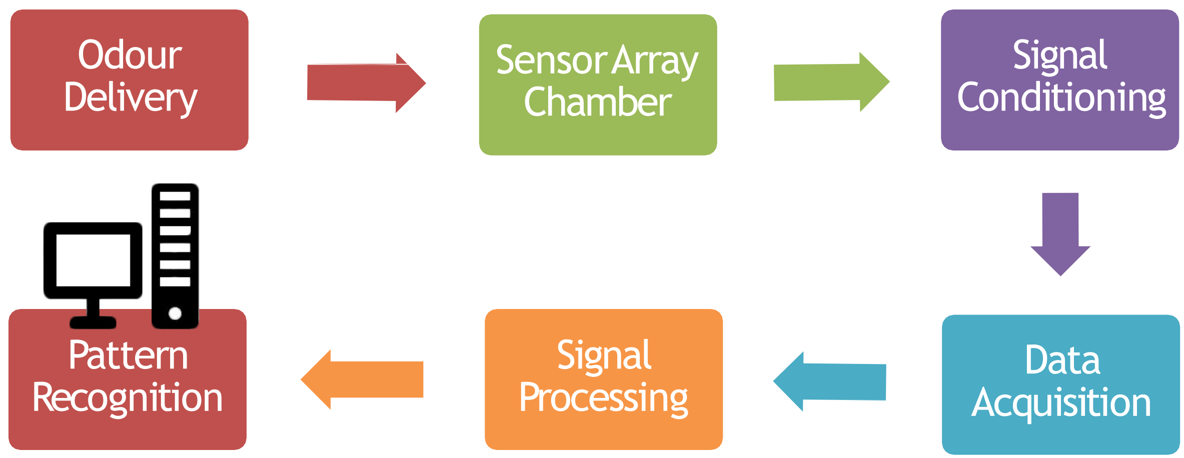
The Computing system:

- In most electronic noses each sensor is sensitive to all molecules in their specific way.
- Most electronic noses use sensor arrays that react to volatile compounds.
- Whenever the sensors sense any smell , a specific response is recorded that signal is transmitted into the digital value.

BASIC DESIGN



BLOCK DIAGRAM



Working of e-nose

1. In a typical e-nose, an air sample is pulled by a vacuum pump through a tube into a small chamber housing the electronic sensor array.

2. A sample-handling unit exposes the sensors to the odorant, producing a response as the VOCs interact with the active material.

3. The sensor response is recorded and delivered to the Signal-processing unit.

4. Then a washing gas such as alcohol is applied to the array for a few seconds or a minute, so as to remove the odorant mixture from the active material.

Commonly used sensors in electronic nose

- Metal oxide semiconductor (MOSFET)
- Conducting polymers
- Quartz crystal microbalance
- Piezoelectric sensors
- Metal Oxide sensors
- FET Gas sensors
- Optical sensors

Metal Oxide semiconductor sensor:

- This is used for switching or amplifying electronic signals
- The Working principle of MOSFET is that molecules entering into the sensor area will be charged positively or negatively which have direct effect on the electric field inside MOSFET.

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Metal Oxide Semiconductor (MOS) Capacitor

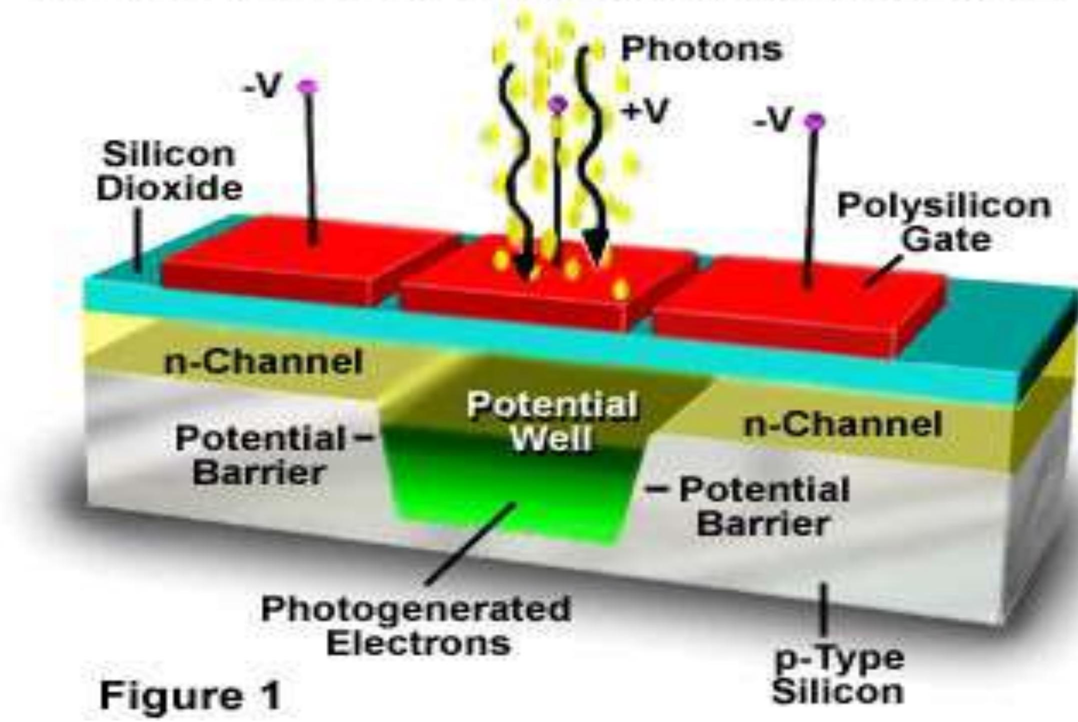


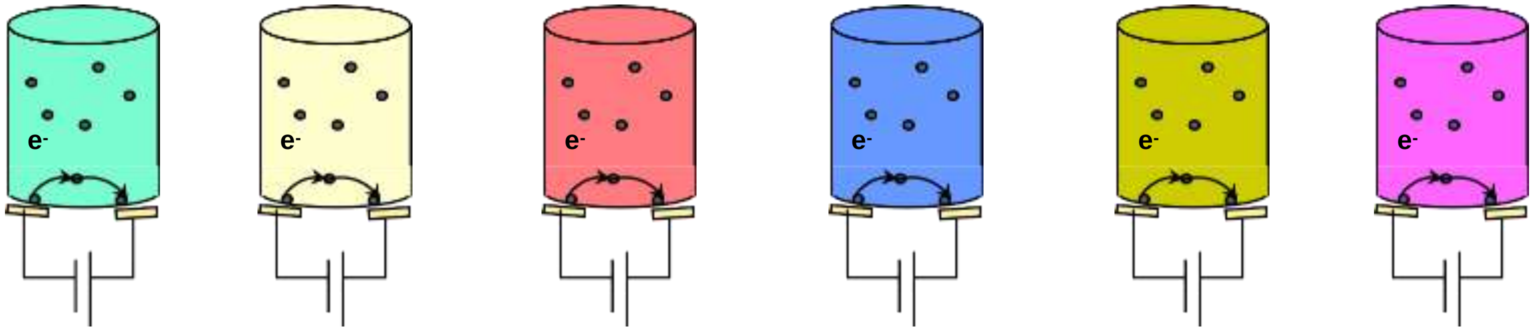
Figure 1

Conducting polymers:

- Conductive polymer gas sensors operate based on changed in electrical resistance caused by adsorption of gases onto the sensor surface.

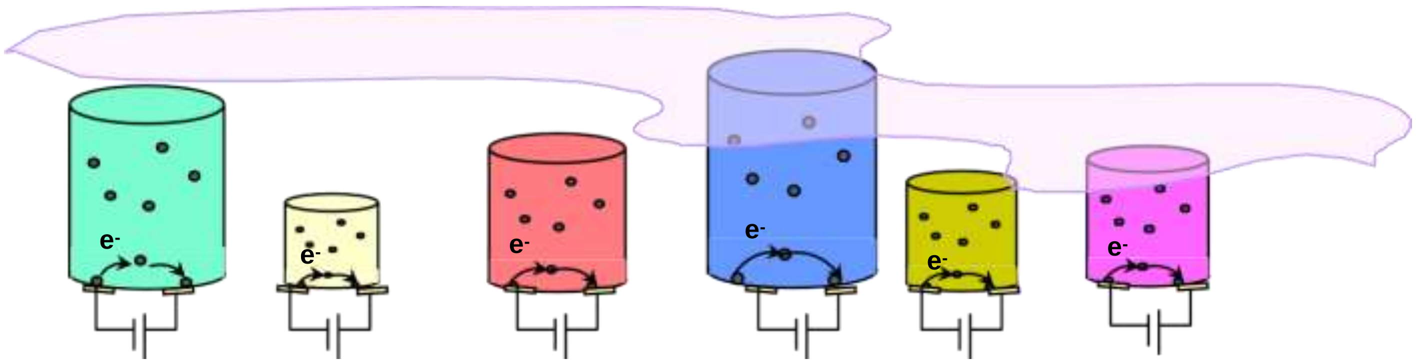
- Here the active material is a conducting polymer from such families as the Polypyrroles, thiophenes, indoles or furans. Changes in the conductivity of these materials occur as they are exposed to various types of chemicals, as certain reactions take place.

CONTD.

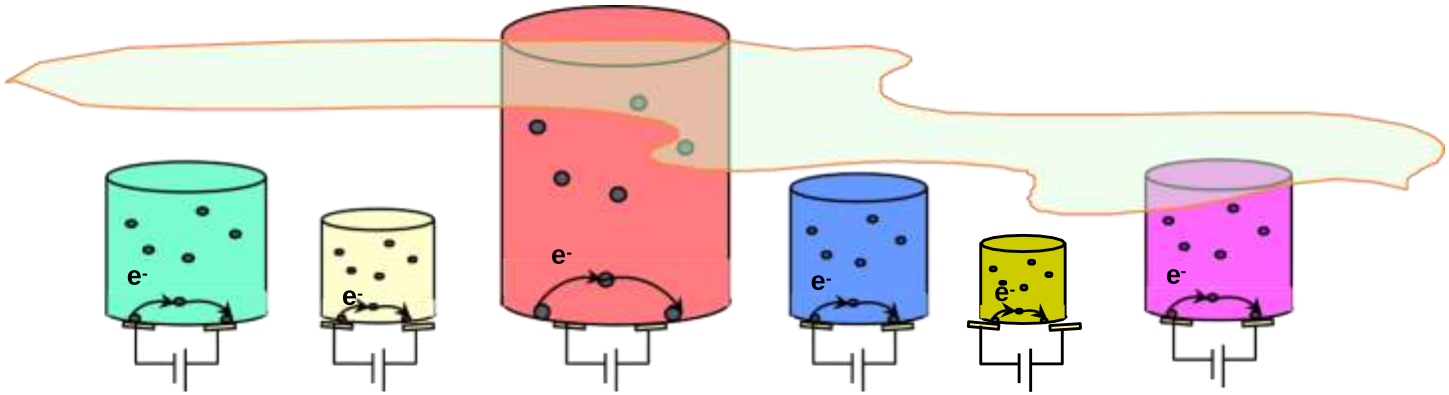


All of the polymer films on a set of electrodes (sensors) start out at a measured resistance, their *baseline resistance*. If there has been no change in the composition of the air, the films stay at the baseline resistance and the percent change is zero.

CONTD.



Each polymer changes its size, and therefore its resistance, by a different amount, making a pattern of the change.



If a different compound had caused the polymer to change, the pattern of the polymer films' change would have been different.

Quartz crystal microbalance:

- This is a way of measuring mass per unit area by measuring the change in frequency of crystal resonator. This can be stored in a data base.

Piezoelectric sensors:

- Uses piezoelectric effect, to measure changes in pressure, acceleration, strain or force by converting them to electrical charge

Metal Oxide sensors: (MOS)

- This sensor is based on adsorption of gas molecules to provoke change in conductivity.
- This conductivity change is the measure of the amount of volatile organic compounds adsorbed.

FET Gas sensors:

- Chemical FET(**Field-effect transistor**) is a type of a field- effect transistor acting as a chemical sensor

- In this, the charge on the gate electrode is applied by a chemical process which may be used to detect atoms, molecules, and ions in liquids and gases

Optical Sensors:

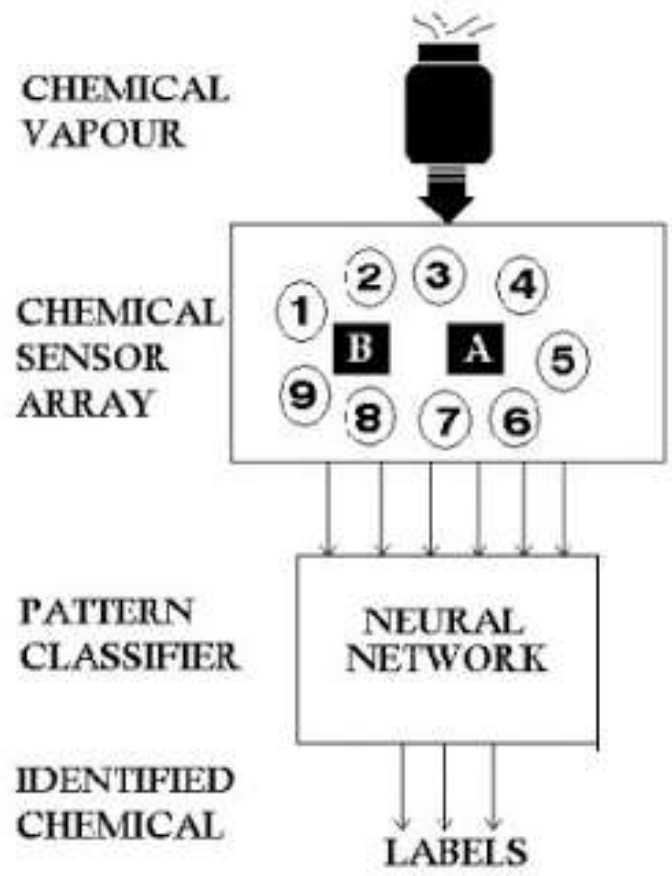
- These utilize glass fibers with a chemically active material coating on their sides or ends.
- A light source is used to interrogate the active material which responds with the change in color to the presence of VOCs.
- The active material contains chemically active fluorescent dyes. As the VOCs interact with it, the color of the fluorescent dye changes, hence lead to detection.

Data Analysis for Electronic Nose:

The digital output generated by electronic nose sensors has to be analyzed and interpreted in order to provide.

There are three main types of commercially techniques.

- **Graphical analysis**
- **Multivariate data analysis**
- **Network analysis**



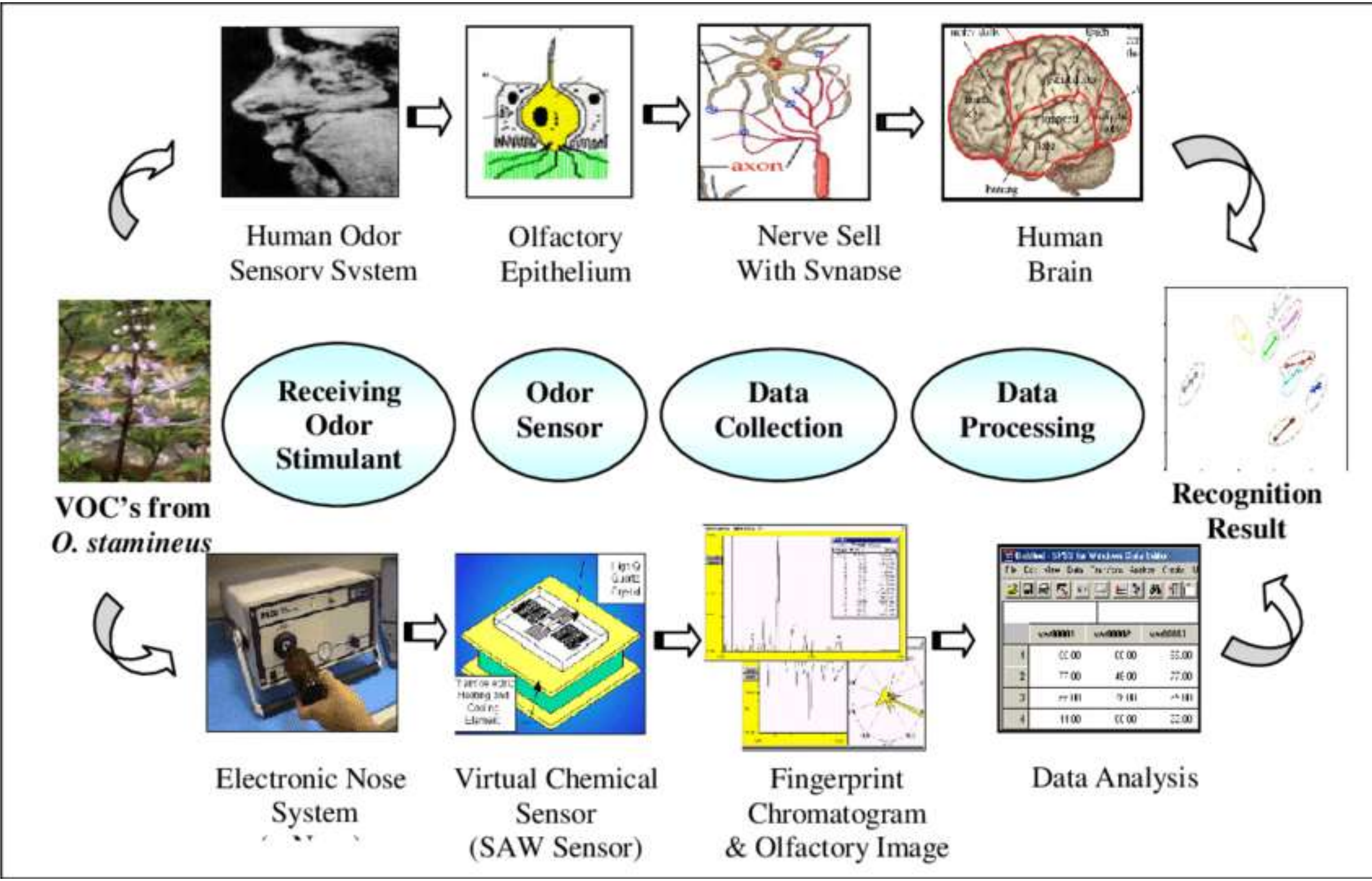
The choice of method utilized depends on available input data from sensors.

- **Graphical Analysis**: The simplest form of a data reduction is a graphical analysis useful for comparing samples or comparing smells identification elements of unknown analysts relative to those of known sources in reference libraries.

- **The multivariate data analysis** generates a set of techniques for the analysis of data that is trained or untrained technique
- The untrained techniques are used when a data base of known samples has not been built previously

- The simplest and most widely used untrained MDA technique is a principle component analysis (PCA).
- The electronic nose data analysis MDA is a very useful when sensors have partially coverage sensitivities to individual compounds present in a sample mixer.
- The PCA is most useful when no known sample is available.

- **The neural network** is the best known and most derived analysis techniques utilized in a statistical software packages for commercially available electronic nose.


Human Odor
Sensory System
Olfactory
Epithelium
axon
Nerve Sell
With Synapse
Human
Brain
VOC's from
O. stamineus
Receiving
Odor
Stimulant
Odor
Sensor
Data
Collection
Data
Processing
Recognition
Result
Electronic Nose
System
Virtual Chemical
Sensor
(SAW Sensor)
Fingerprint
Chromatogram
& Olfactory Image
Data Analysis

BIO- NOSE	E-NOSE
1. It uses the lungs to bring the odor to epithelium layer.	1. It employs a pump to smell the odor.
2. It has mucus, membrane and hair to act as filter.	2. It has an inlet sampling system that provides filtration.
3. The human nose contains the olfactory epithelium, which contains millions of sensing cells that interact with the odorous molecules in unique ways.	3. E-nose has a variety of sensors that interact differently with the samples provided.
4. The human receptors convert the chemical responses to electronic nerve impulses whose unique patterns are propagated by neurons through a complex network before reaching the higher brain for interpretation.	4. Similarly, the chemical sensors in the E-nose react with the sample and produce electrical signals. A computer reads the unique pattern of signals, and interprets them with some form of intelligent pattern classification Algorithm.

CYRANOSE 320

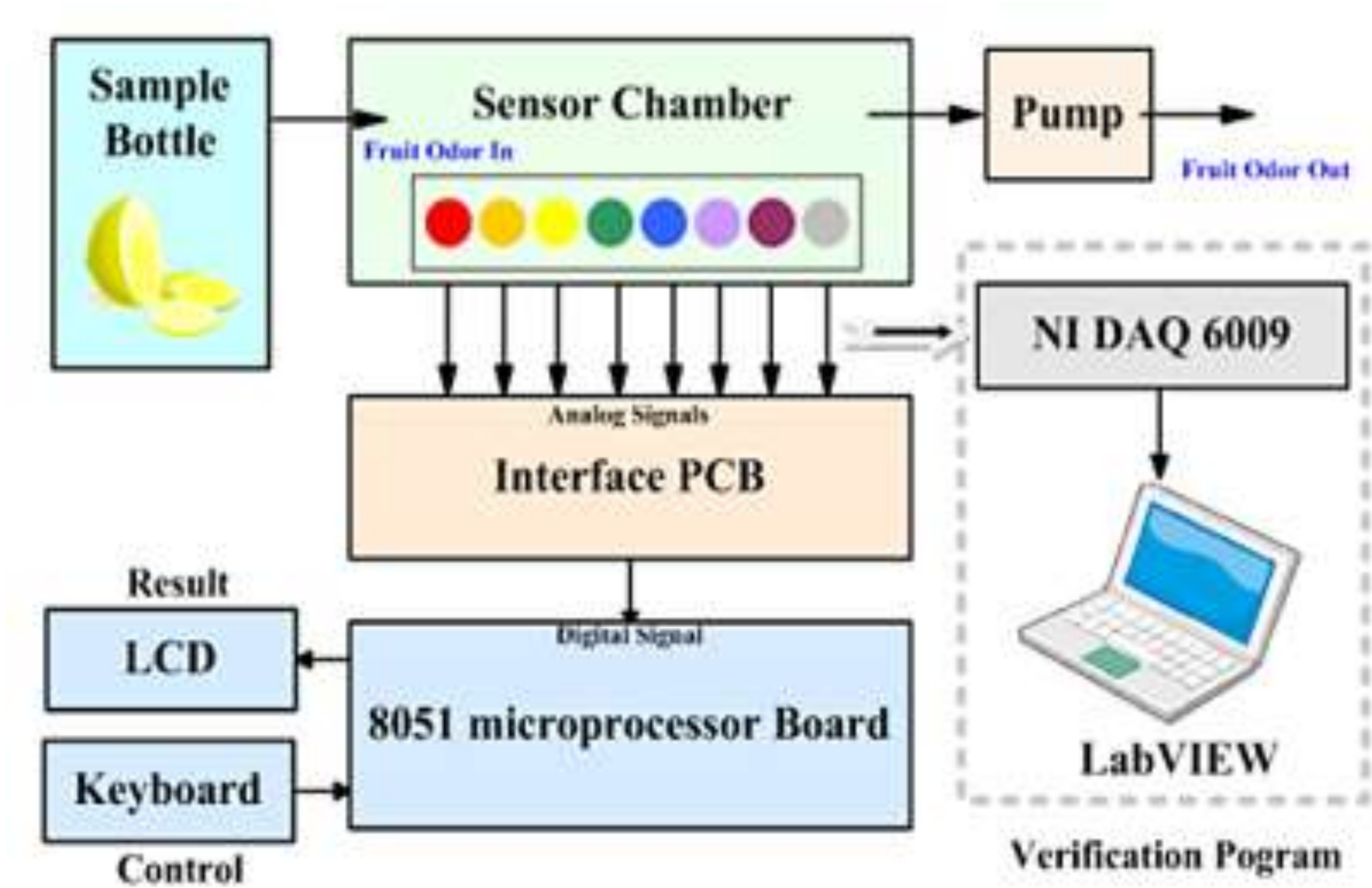
•The Cyranose 320 is a handheld "electronic nose" developed by Cyrano Sciences of Pasadena, California in 2000.

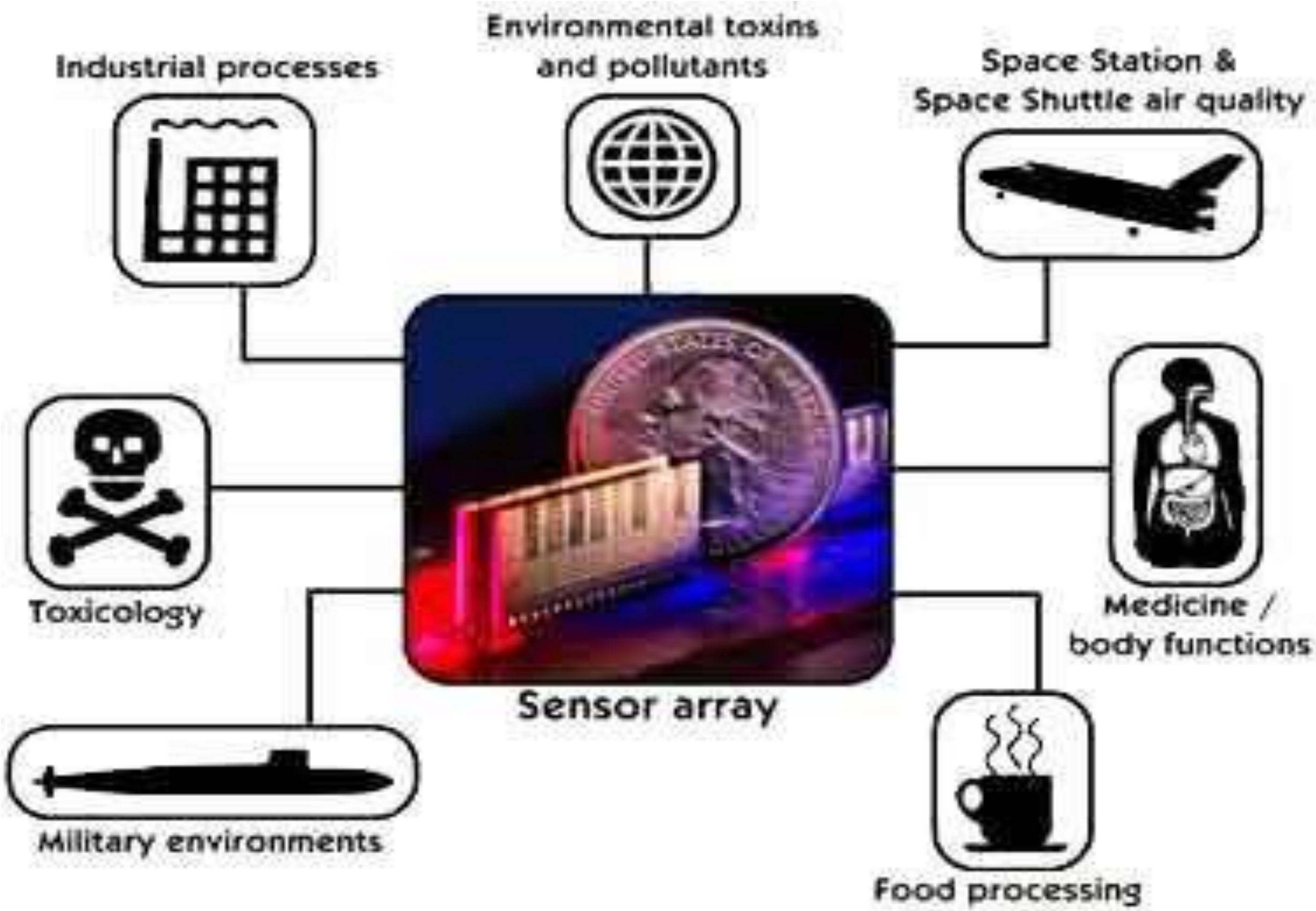
The Cyranose 320 is capable of detecting most Toxic Industrial Chemicals (TICS) and Chemical Warfare Agents (CWA) - such as Sarin, at levels below IDLH (Imminent danger to life and health).

Application of Electronic nose:

- Medical diagnostics and health monitoring
- Environmental monitoring
- Application in food industry
- Detection of explosive
- Space applications (NASA)
- Research and development industries
- Quality control laboratories
- The process and production department
- Detection of drug smells
- Detection of harmful bacteria

- **Fruit smell detection**





FEW APPLICATIONS OF E-NOSE

Human Nose vs. E-Nose

- Human Nose
  - $>10^8$ receptor cells
  - $>10^3$ types
  - Responds in a few seconds
  - Sensitivity in ppb/ppt
  - Massive neural processing in the brain
  - Receptors regenerated every few weeks (~30 days)
- Electronic Nose
  - 5-32 sensors
  - 5-32 types
  - Responds in tens of seconds to a few minutes
  - Sensitivity in ppm/ppb
  - Pattern recognition, AI, artificial neural nets
  - Sensors replaced on a maintenance schedule (depends on application)

Electronic Nose

- Advantages
  - Detection of poisonous gas is possible
  - Can be done in real time for long periods
  - Cheaper than Trained human sniffers
  - Individuals vary, e-nose don't
  - Digital represenation of odour is possible.
- Limitations
  - Time delay between successive tests
  - Insensitivity to some species
  - According to application, e-nose has to be changed