CONTENTS

TOPIC	PAGE NO.
1. INTRODUCTION	1
2. NEUROPROSTHETICS	3
2.1. WHAT IS NEUROPROSTHETICS	3
2.2. BLOCK DIAGRAM	4
2.3. TYPES OF NEUROPROSTHETICS	5
2.4. ADVANTAGES	7
2.5. CHALLENGES	7
3. BRAIN-COMPUTER INTERFACE	9
3.1.WHAT IS BRAIN-COMPUTER INTERFACE?	9
3.2. HOW A BRAIN COMPUTER-INTERFACE WORK?	10
3.3. BCI ADVANTAGES	12
3.4.BCI DISADVANTAGES	13
3.5.BCI INNOVATORS	13
4. BIONICS-HELP FOR THE DISABLED	15
4.1.EXOSKELETON	17
4.2.BIONIC EYE	17
4.3. ROBOT LIMB	17
4.4. PROSTHETIC LIMB	17
4.5.BIONIC EAR	17
4.6.VESTIBULAR IMPLANTS	17
4.7.DEEP BRAIN STIMULATION TO TREAT BRAIN AILMENRS	18
4.8. BIONIC HEART	18
4.9. ARTIFICIAL KIDNEY	18

4.10. ANKLE AND FOOT 19
4.11. ARM AND HAND 19
4.12. BIONIC FINGER 19
5.BIONIC EYE 20
5.1. THE HUMAN EYE 20
5.2. THE BIONIC EYE 21
5.3.WORKING OF BIONIC IMPLANT 21
5.4.ADVANTAGES 24
5.5. DISADVANTAGES 24
6.BIONIC EAR 25
6.1. HUMAN EAR 25
6.2.WORKING OF BIONIC EAR 26
7.CONCLUSION 29
REFERENCES

LIST OF FIGURES

TITLE	PAGE NO.
2.1. Neuroprosthetic Block Diagram	4
3.1. Brain Computer Interface	11
4.1. Bionic Body Parts	16
5.1. Human Eye	20
5.2. Bionic Eye	21
5.3. Working of Bionic Eye	22
5.4. Retinal Implant	23
6.1. Human Ear	25
6.2. Bionic Ear	28

Chapter 1

INTRODUCTION

The human body is one of the best creations of nature, for it is an amazing combination of muscles, sensory organs, neural networks and all. But, over a period of time and also due to some unforeseen circumstances, some of the natural combinations cease to work to their potential or get damaged altogether. So it is possible to get back the glory bestowed on us by Mother Nature? Is it possible to graft a human organ or restore sensory perceptions to the human body? One major field working towards this is '**bionics**':an approach where different technologies are coming to make this scenario possible.

Etymology: from bi (as in "life") + onics (as in "electronics"); the study of mechanical systems that function like living organisms or parts of living organism.

According to popular definition, bionics or biomimetics is the application of methods and systems found in nature to the study and design of engineering systems and modern technology. In simple terms ,when we think about bionics, it is generally about prosthetic arms or leg enhancements that are worn outside the body and to some extent even implanted sensor devices inside the body which are specifically enhanced to carry out routine tasks .The are essentially life systems that are powered by motors/actuators and sensory arrays. These send neural signals from the affected part of the body to the brain, by which individuals are able to perform some tasks independently.

Bionics (biology plus electronics) is a branch of science that deals with the application of living systems and biological methods, to design and implement engineering systems. Extensive research in this field has led to the development of gadgets that can perform similar to, or even better than normal human functionalities. They are paving way for the world of cyborgs.

Bionics are a set of technology products that are constantly evolving. Bionics are proposed as body add-ons or replacement for many body parts (ears, eyes, knees, neural prostheses, joints, muscles, kidney, liver, cartilage lungs, discs, pancreas, dental pulp, skin, hippocampus, legs and hands), and functions such as speech. Two main applications of bionic products are; one being for the restoration of body abilities to a species-typical norm and the other being the addition of abilities to the body that are not species-typical. Disabled people are one main group perceived to be in need of therapeutic interventions that use various bionic products. So far, therapeutic interventions are about restoration to the species-typical norm. However, therapeutic bionic products increasingly give the wearer beyond normal body abilities (therapeutic enhancements). Many so-called non-disabled people want the same enhanced body-abilities especially through non-invasive bionic products (e.g., non-invasive brain machine interfaces, exoskeletons).

Chapter 2

NEUROPROSTHETICS

2.1What is Neuroprosthetics?

Neuroprosthetics (also called Neural Prosthetics) is a discipline related to neuroscience and biomedical engineering concerned with developing neural prostheses, artificial implantable devices to replace or improve the function of an impaired nervous system. Neuroprosthetics are the set of physical devices that interact with the brain or other neural tissue to augment, restore, or otherwise impact function. Neuroprosthetics are electrical stimulation technologies that replace or assist damaged normal functioning neuromuscular organ systems and attempt to restore normal body processes, create or improve function, and/or reduce pain. These systems are either implanted or worn externally on the body. Such assistive devices range from intramuscular stimulation systems designed to limit limb atrophy in paralysis, to implanted bladder voiding systems and more complex implanted neuromuscular control. The process of transitioning this technology into a clinically useful device will require two parallel paths of research.

In the first path, experimental paradigms involving microelectrode array recordings in behaving animals will be developed in conjunction with signal processing techniques for studying the unknown aspects of neural coding and functional neurophysiology. These signal processing techniques will then be implemented in portable, low-power, wireless hardware. The second path, high-density array ECoG recordings in humans, provides a less invasive technique for neural interfaces however it still remains unknown how to extract BMI control signatures that are sufficiently spatially and temporally resolved.

Neuroprosthetics is an area of intense scientific and clinical interest and rapid progress. The word ‘prosthesis’ is derived from the Greek word for ’ addition’. A breakdown of the word includes ‘pros’ meaning ‘to’, and ‘thesis’, meaning ’a placing'. Neuroprosthetic are in their infancy just now, but they offer two things that are truly wonderful:

- Bypassing the body, and letting the mind interface directly with VR, for the ultimate immersive experience – the virtual body becomes as the normal functioning body
- Augmented body parts will be able to be fitted to the body, and controlled by the brain as if you were born with them – after a little training, without conscious thought.

2.2.Blockdiagram

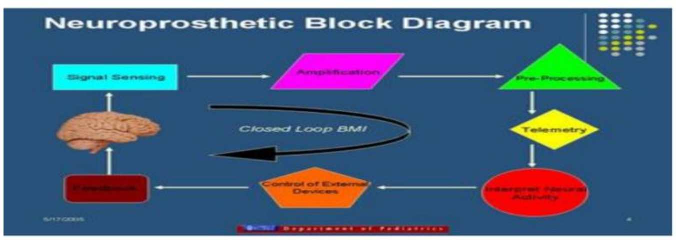

Fig.2.1.Neuroprosthetic Block diagram[1]

BMI is currently growing with exponential speed, with real successes in linking human brains to computers, and the control of virtual, and physical prosthetic limbs via pure thought control as in fig 2.1 . Neuroprosthetics, brain emulation and mind uploading are together perhaps the most extreme end of the trend towards virtual reality. All three are BMI, or Brain-Machine Interface. BMI is an old field, stretching back over six decades, concerned with direct-connecting the human brain to machines, in order to improve the function of both. A BMI uses a computer to implement brain models that translate signals from individual neurons into artificial limb commands. Discovery of the knowledge needed to uncover the unknown aspects of systems-based neural encoding and decoding for complex tasks needs highly demanding computational modeling. The architecture consists of multiple forward-inverse pairs of dynamic models for movement planning and control. The movement commands are the combined outputs of selected pairs of models on the basis of real-time feedback signals The research aims to

- identify the types, numbers and combinations of models for complex movement control and
- deploy the cyber infrastructures for both BMI implementation and research. It uses closed loop experiments where a computer processes brain signals from rats to control robotic movements.

2.3. Types of Neuroprosthetics

There are three main types of neuroprosthetics –

1. Sensory prosthetics.
2. Motor prosthetics.
3. Cognitive prosthetics.

2.3.1.Sensory Prosthetics

Sensory prosthetics get information into sensory areas like hearing and sight.

2.3.1.1. **Visual prosthetics**

A Visual prosthetics or bionic eye is a form of neutral prostheses intended to partially restored lost vision or amplified existing vision. It usually takes the form of an externally worn camera that is attached to a stimulator on the retina, optical nerve, or in the visual cortex, in order to produce perceptions in the visual cortex. Research has produced visual prostheses that give patients fuzzy vision with a pixel resolution of about 20 x 20, but these are just experimental and not ready for mass use.

Other visual prostheses place the implant elsewhere, including the sub-retinal space at the back of the eye, the optic nerve, and the visual cortex. Placed close to its target cells, the sub-retinal implant requires relatively low energy output to stimulate neuronal signaling one drawback is that its necessarily small size limits its capacity to generate power. A solar cell-based prosthetic, stimulated and powered by light, may resolve this concern and is undergoing clinical trials.

2.3.1.2. Auditory prosthetics

Cochlear implant and auditory brainstem implant. Cochlear implant and auditory brainstem implant. A cochlear implant (or 'bionic ear') is a surgically implanted device that can help provide a sense of sound to a person who is profoundly deaf or severely hard of hearing. Unlike hearing aids, the cochlear implant does not amplify sound, but works by directly stimulating any functioning auditory nerves inside the cochlea with electrical impulses. External components of the cochlear implant include a microphone, speech processor and transmitter.

2.3.1.3Prosthetics for pain relief

Biphasic, charge balanced stimulation does not produce tissue damage if each phase is below 0.3 micro Coulombs. The human DBS system is biphasic, charge balanced. The cathodal pulse is short and high amplitude while the anodal pulse is shallow and of longer duration. Rebase current is the smallest current still capable of exciting a neural element regardless of the pulse width.

2.3.2 Motor Neuroprosthetics

A Motor prosthetics device, or brain computer interface, is a machine that can take some type of signal from the brain and convert that information into overt device control such that it reflects the intentions of the user's brain. In essence, these constructs can decode the electrophysiological signals representing motor intent. With the parallel evolution of neuroscience, engineering, and rapid computing, the era of clinical neuroprosthetics is approaching as a practical reality for people with severe motor impairment.

2.3.3 Cognitive Neuroprosthetics

Sensory and motor prostheses deliver input to and output from the nervous system respectively. Theodore Berger at the University of Southern California defines a third class of prostheses aimed at restoring cognitive function by replacing circuits within the brain damaged by stroke, trauma or disease. Work has begun on a proof-of-concept device a hippocampal prosthesis which can mimic the function of a region of the hippocampus a part of the brain responsible for the formation of memories.

2.4. Advantages

- Replacement of the impaired function part of the human body like brain, heart, ears, retinal devices called bionical devices .
- Not only that but also the hand, legs interaction takes place by using softwares and hardwares which is equivalent to the electronic circuit which is easy to implement.
- Not only that but also all parts of the man parts like kidney, teeth also.
- Replacing of lost neural tissue damage
- Electrode systems, from micro wires and platinum disc electrodes to penetrating microarrays, are capable of effectively and chronically interfacing with the human nervous system which increases the capability.
- Neuroprosthetic devices, and have curbed neuroprostheses markets to the point of commercial non-viability. As such, Medicare coverage and reimbursement policies constitute both the most pernicious and most easily changed hurdle faced by neuroprostheses commercialization efforts.

2.5. Challenges

2.5.1.Cranial Nerves

There are twelve cranial nerve pairings (making 24 nerves in total) which split out from the brain, and move to cover the needs of the cranium and face, rather than make their way down through the central spinal cord. These nerves are important to consider, as most are of critical importance to sensory data, yet do not pass through the central cord, and so cannot be intercepted at the same juncture.

2.5.2.IBM's blue brain project

The blue brain project's mission is to recreate a human brain through simulation, replacing neuron by connection. But the project is still in development due to the complex organization of brain ,and yet need to be decoded for any further advancement.

2.5.3.Interrupting the Brainstem

The brainstem is the part of the brain that descends just in front of the cerebellum. It drops down from the brain to meet and meld with the spinal cord rising from the body. The issue is, how do we go about hijacking the brainstem, to splice a virtual body, or artificial body parts onto it .

Chapter 3

BRAIN-COMPUTER INTERFACE

3.1 What is Brain-Computer Interface?

For generations, humans have fantasized about the ability to communicate and interact with machines through thought alone or to create devices that can peer into person's mind and thoughts. These ideas have captured the imagination of humankind in the form of ancient myths and modern science fiction stories. However, it is only recently that advances in cognitive neuroscience and brain imaging technologies have started to provide us with the ability to interface directly with the human brain .This ability is made possible through the use of sensors that can monitor some of the physical processes that occur within the brain that correspond with certain forms of thought.

Brain-computer interface (BCI) is a collaboration between a brain and a device that enables signals from the brain to direct some external activity, such as control of a cursor or a prosthetic limb. The interface enables a direct communications pathway between the brain and the object to be controlled. In the case of cursor control, for example, the signal is transmitted directly from the brain to the mechanism directing the cursor, rather than taking the normal route through the body's neuromuscular system from the brain to the finger on a mouse.

By reading signals from an array of neurons and using computer chips and programs to translate the signals into action, BCI can enable a person suffering from paralysis to write a book or control a motorized wheelchair or prosthetic limb through thought alone. Current brain-interface devices require deliberate conscious thought; some future applications, such as prosthetic control, are likely to work effortlessly. One of the biggest challenges in developing BCI technology has been the development of electrode devices and/or surgical methods that are minimally invasive. In the traditional BCI model, the brain accepts an implanted mechanical device and controls the device as a natural part of its representation of the body. Much current research is focused on the potential on non-invasive BCI.

There are two general classes of brain imaging technologies: invasive technologies,in which sensors are implanted directly on or in the brain, and non-invasive technologies,which measure brain activity using external sensors. Although invasive technologies provide high temporal and spatial resolution, they usually cover only very small regions of the brain. Additionally, these techniques require surgical procedures that often lead to medical complications as the body adapts, or does not adapt, to the implants. Furthermore, once implanted, these technologies cannot be moved to measure different regions of the brain

3.2.How a brain-computer interface work?

As the power of modern computers grows alongside our understanding of the human brain, we move ever closer to making some pretty spectacular science fiction into reality. Imagine transmitting signals directly to someone's brain that would allow them to see, hear or feel specific sensory inputs. Consider the potential to manipulate computers or machinery with nothing more than a thought. It isn't about convenience -- for severely disabled people, development of a **brain-computer interface** (BCI) could be the most important technological breakthrough in decades. Here, we'll learn all about how BCIs work, their limitations and where they could be headed in the future.

3.2.1 The Electric Brain

The reason a BCI works at all is because of the way our brains function. Our brains are filled with **neurons**, individual nerve cells connected to one another by dendrites and axons. Every time we think, move, feel or remember something, our neurons are at work. That work is carried out by small electric signals that zip from neuron to neuron as fast as 250 mph . The signals are generated by differences in electric potential carried by ions on the membrane of each neuron.

Although the paths the signals take are insulated by something called myelin, some of the electric signal escapes. Scientists can detect those signals, interpret what they mean and use them to direct a device of some kind. It can also work the other way around. For example, researchers could figure out what signals are sent to the brain by the optic nerve when someone sees the color red. They could rig a camera that would send those exact signals into someone's brain whenever the camera saw red, allowing a blind person to "see" without eyes.

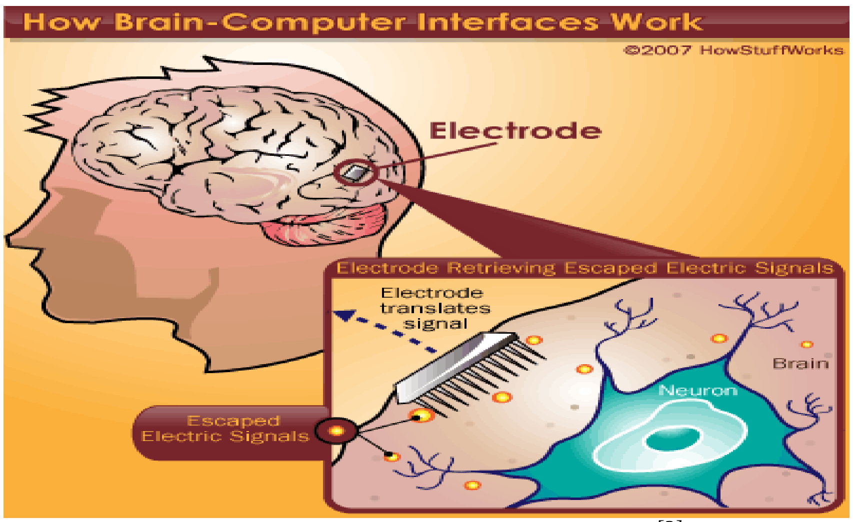

Fig 3.1 brain-computer interface[2]

3.2.2 BCI Input and Output

One of the biggest challenges facing brain-computer interface researchers today is the basic mechanics of the interface itself. The easiest and least invasive method is a set of electrodes -- a device known as an **electroencephalograph** (EEG) -- attached to the scalp. The electrodes can read brain signals. However, the skull blocks a lot of the electrical signal, and it distorts what does get through.

To get a higher-resolution signal, scientists can implant electrodes directly into the gray matter of the brain itself, or on the surface of the brain, beneath the skull. This allows for much more direct reception of electric signals and allows electrode placement in the specific area of the brain where the appropriate signals are generated. This approach has many problems, however. It requires invasive surgery to implant the electrodes, and devices left in the brain long-term tend to cause the formation of scar tissue in the gray matter. This scar tissue ultimately blocks signals.

Regardless of the location of the electrodes, the basic mechanism is the same: The electrodes measure minute differences in the voltage between neurons. The signal is then amplified and filtered. In current BCI systems, it is then interpreted by a computer program, although you might be familiar with older analogue encephalographs, which displayed the signals via pens that automatically wrote out the patterns on a continuous sheet of paper.

In the case of a sensory input BCI, the function happens in reverse. A computer converts a signal, such as one from a video camera, into the voltages necessary to trigger neurons. The signals are sent to an implant in the proper area of the brain, and if everything works correctly, the neurons fire and the subject receives a visual image corresponding to what the camera sees.

Another way to measure brain activity is with a **Magnetic Resonance Image** (MRI). An MRI machine is a massive, complicated device. It produces very high-resolution images of brain activity, but it can't be used as part of a permanent or semipermanent BCI. Researchers use it to get benchmarks for certain brain functions or to map where in the brain electrodes should be placed to measure a specific function. For example, if researchers are attempting to implant electrodes that will allow someone to control a robotic arm with their thoughts, they might first put the subject into an MRI and ask him or her to think about moving their actual arm. The MRI will show which area of the brain is active during arm movement, giving them a clearer target for electrode placement.

3.3. BCI Advantages.

- Allow paralyzed people to control prosthetic limbs with their mind.
- Transmit visual images to the mind of a blind person, allowing them to see.
- Transmit auditory data to the mind of a deaf person, allowing them to hear.
- Allow gamers to control video games with their minds .

- Allow a mute person to have their thoughts displayed and spoken by a computer.

3.4. BCI Disadvantages

Although we already understand the basic principles behind BCIs, they don't work perfectly. There are several reasons for this.

- The brain is incredibly complex. To say that all thoughts or actions are the result of simple electric signals in the brain is a gross understatement. There are about 100 billion neurons in a human brain [source: Greenfield]. Each neuron is constantly sending and receiving signals through a complex web of connections. There are chemical processes involved as well, which EEGs can't pick up on.
- The signal is weak and prone to interference. EEGs measure tiny voltage potentials. Something as simple as the blinking eyelids of the subject can generate much stronger signals. Refinements in EEGs and implants will probably overcome this problem to some extent in the future, but for now, reading brain signals is like listening to a bad phone connection. There's lots of static.
- The equipment is less than portable. It's far better than it used to be -- early systems were hardwired to massive mainframe computers. But some BCIs still require a wired connection to the equipment, and those that are wireless require the subject to carry a computer that can weigh around 10 pounds. Like all technology, this will surely become lighter and more wireless in the future.

3.5. BCI Innovators

A few companies are pioneers in the field of BCI. Most of them are still in the research stages, though a few products are offered commercially.

- Neural Signals is developing technology to restore speech to disabled people. An implant in an area of the brain associated with speech (Broca's area) would transmit signals to a computer and then to a speaker. With training, the subject could learn to think each of the 39 phonemes in the English language and reconstruct speech through the computer and speaker [source: Neural Signals].

- NASA has researched a similar system, although it reads electric signals from the nerves in the mouth and throat area, rather than directly from the brain. They succeeded in performing a Web search by mentally "typing" the term "NASA" into Google [source: New Scientist].
- Cyberkinetics Neurotechnology Systems is marketing the BrainGate, a neural interface system that allows disabled people to control a wheelchair, robotic prosthesis or computer cursor [source: Cyberkinetics].
- Japanese researchers have developed a preliminary BCI that allows the user to control their avatar in the online world Second Life [source: Ars Technica].

Chapter 4

BIONICS-HELP FOR THE DISABLED

Scientific research into bionic human parts has advanced impressively in recent years, driven by improvements in computer science, shrinking electronic components, and a growing understanding of the nervous system. Some of these devices are simply meant to help people regain normal functions — like eye implants that provide sight for the blind. But other researchers, particularly those interested in military technology, are looking for ways to make humans bigger, better, and stronger.

In medicine, there is a quiet revolution going on in which implanted devices are being used to make up for lost function. For about a century it has been known that metal pins (to stabilize broken bones), could be implanted and accepted by the body.

However, it is only since the development of the cardiac pacemaker in the Early 1960s, that complex electronic devices could be implanted and function for a decade or more. New materials, new components and new surgical techniques offer the promise of implanting devices that will provide function that improves the quality of life — and even sustains it. Technological progress is changing the perception of what the disabled body is and can do: not only do the newest prosthetics no longer mimic 'human' bodies, but their capacities put into question the capacities and limits of the nondisabled body. Voluntary cyborg-like enhancements of the human body redefine previous categories of what is and isn't a disabled body; in comparison to the technologically enhanced bionic body, everybody can be thought of as a 'disabled' body.

Some of the bionic body parts that help the disabled are discussed below:

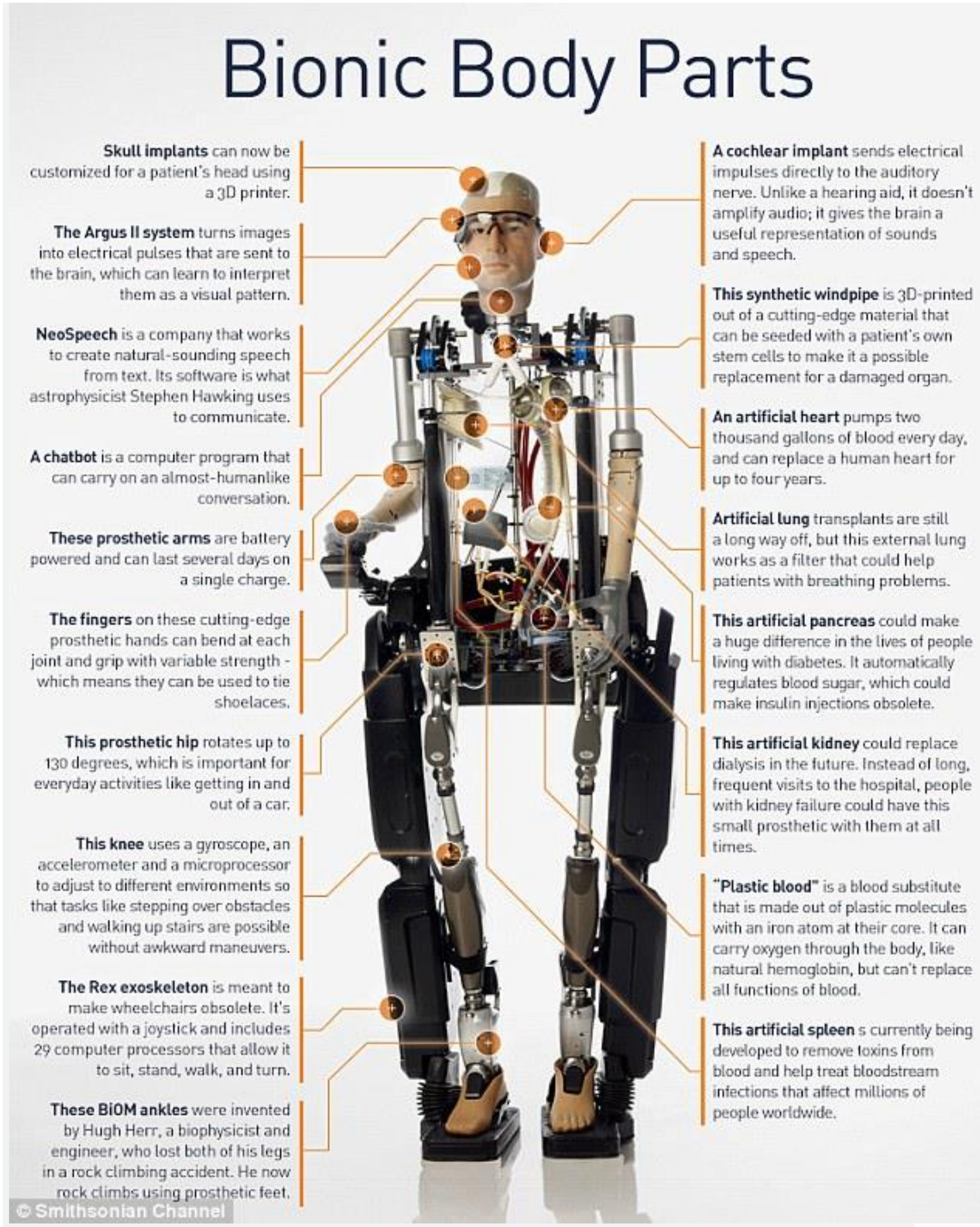

Fig 4.1.Bionic Body Parts[3].

4.1. Exoskeleton

External skeletons are something that crustaceans and insects have naturally. And now researchers are working on exoskeletons for humans, too. Some devices are meant to enhance the strength of people who have been weakened from paralysis or old age. But the military is also looking at exoskeletons to make people stronger.

4.2. Bionic Eye

Bionic eye is an implant that restores the sense of vision in patients suffering from degenerative retinal conditions. It consists of a retinal implant surgically placed at the back of the eye and some external devices

4.3. Robot Limb

It uses brain implants in people with paralysis to allow them to physically interact with the world.

4.4. Prosthetic Limb.

The loss of a limb can have serious negative effects on a patient—both mentally and physically. There was a time when the purpose of limb prosthesis was to conceal disability. But now it helps the subject to restore some of the lost functions too.

4.5. Bionic Ear.

A bionic ear (or cochlear implant) is an artificial hearing device, designed to produce hearing sensations by electrically stimulating nerves inside the inner ear.It consists of an internal implant device, which is placed under the patient's skin behind the ear during an implant operation, and an external sound processor which sits behind the ear and is worn externally, similar to a hearing aid.

4.6. Vestibular Implants.

It is an implant that restores vestibular system function called bionic balance.The vestibular implant is just one of several new, improving and emerging prosthetic organs, limbs and other body parts that are using ever more sensors, processors and motors–they are becoming more bionic. The goal, of course, is to make prosthetics more sophisticated, subtle, and ultimately, more closely interfaced with living human beings and therefore more helpful.

4.7. Deep-Brain Stimulation To Treat Brain-Ailments.

The brain sends signals using both chemicals and electricity. And for decades the main way to intervene and fix brain problems was through the chemical side — through drugs.But recently that has begun to change. Some people now receive implants in their brains that give off electrical currents to simulate their brain cells. Think of it as a pacemaker for the brain.This technique is called deep-brain stimulation. And it's already FDA-approved for treating Parkinson's disease and a movement disorder called dystonia. Medtronic's deep-brain stimulation system, for example, has been implanted in some 110,000 people. The technique has also been tested in people for psychiatric illnesses, including obsessive-compulsive disorder and severe depression.

4.8. Bionic Heart

The bionic heart has a small bladed disk spins in the heart at 2,000 revolutions per minute to pump blood around the body without a pulse, a significant departure from traditional pulse-based designs, which included balloon-like sacs to pump blood Australian researchers have developed the world's first bionic heart that pumps blood without a pulse and it could be ready for human trials within three years. If everything goes according to plan, the device could provide a real alternative to organ donation for the hundreds of people who are diagnosed with heart disease every year.

4.9. Artificial Kidney

Artificial kidney is actually a development that may eliminate the need for dialysis and end up with rows of transplants.The device contains thousands of microscopic filters and a bioreactor that replicates the functions of metabolism and water balance of a real kidney.The treatment has proven to be effective - a larger version of the device and its constituent parts have been successfully tested in animal models and in critically ill patients. The scientists' goal now and miniaturize the equipment, using the chip manufacturing technology to create an artificial kidney "the size of a coffee mug," along with special compartments to insert cultures of living cells of the kidney.

4.10. Ankle and Foot

A bionic ankle– foot prosthesis is designed with both passive and active components that facilitate the generation of net positive work at the prosthetic ankle joint during the stance phase of walking. This powered prosthesis performs negative and positive work by employing a series-elastic actuator, comprising a brushless motor and ball-screw transmission in series with a carbon-composite leaf spring. The motor's rotary motion is converted into linear motion through the ball-screw transmission. The in-series leaf spring improves motor efficiency by storing and returning some of the energy delivered by the motor

4.11. Arm and Hand

Bionic hand and arm technology is possible primarily because of two facts of amputation. First, the motor cortex in the brain (the area that controls voluntary muscle movements)is still sending out control signals even when certain voluntary muscles are no longer available for control and second when doctors ampute a limb, they don't remove all of the nerves that once carried signal to the limbs.

4.12. Bionic Finger

Robotic finger is a wrist-mounted robot equipped with two long digits. A specially designed algorithm controls the digits, enabling them to move in sync with the wearer's real fingers.

Chapter 5

BIONIC EYE

5.1 The Human Eye

We are able to see because light from an object can move through space and reach our eyes. Once light reaches our eyes, signals are sent to our brain, and our brain deciphers the information in order to detect the appearance, location and movement of the objects we are sighting at. The human eye is the organ which gives us the sense of sight, it allows us to learn about the surrounding world than any of the other senses.

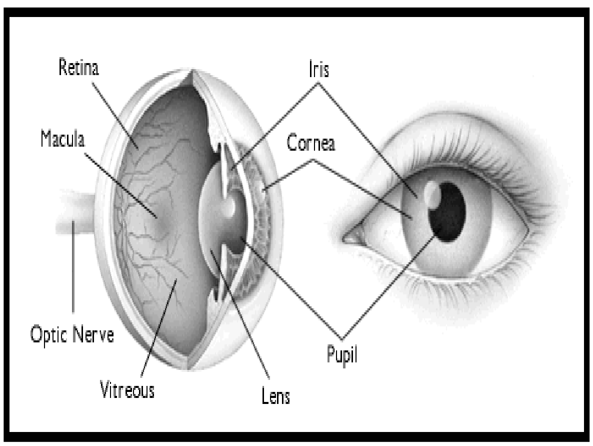

Fig 5.1.Human eye.[4]

The eyeball is present in a protective cone-shaped cavity in the skull called the orbit or socket and measures approximately one inch in diameter. The orbit is covered by layers of soft, fatty tissue which protect the eye and enable it to turn easily. The important part of an eye is retina.

The retina lies at the back of the eye and it acts as though the film in a camera act by receiving and processing everything.

5.2. The Bionic Eye

Bionic Eye is an artificial eye which provokes visual sensations in the brain by directly stimulating different parts of the optic nerve. Bionic eye consist of electronic systems which consist of image sensors, processors, receivers, radio transmitters and retinal chips. There are also other experimental implants that can stimulate the ganglia cells on the retina or the visual cortex of the brain itself.

Technology paved way through a bionic eye to allow blind people to see again.

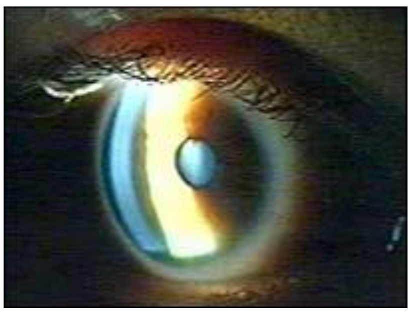

Fig 5.2.Bionic eye[4]

It comprises a computer chip which is kept in the back of the individual's eye, linked up using a mini video camera built into glasses that they wear. Images captured by the camera are beamed to the chip, which translates them into impulses that the brain can interpret.

Although the images produced by the artificial eye were far from perfect, they could be clear enough to allow someone who is otherwise blind to recognise faces. The breakthrough is likely to benefit patients with the most common cause of blindness, macular degeneration, which affects 500,000 people.This occurs when there is damage to the macula, which is in the central part of the retina where light is focused and changed into nerve signals in the middle of the brain. The implant bypasses the diseased cells in the retina and stimulates the remaining viable cells.

5.3 Working of Bionic Implant

A bionic eye implant that could help restore the sight of millions of blind people could be available to patients within two years. This device is 2 millimeters across and contains some 3,500 micro photodiodes which is placed behind the retina, this collection of miniature solar cells is designed to convert normal light to electrical signals, which are then transmitted to the brain by the remaining healthy parts of the retina. A Belgian device has a coil that covers around the optic nerve, with only four points of electrical contact. By shifting the phase and varying the strength of the signals, the coil can stimulate different parts of the optic nerve, rather like the way the electron guns in TVs are aimed at different parts of the screen. The video signal senters from an external camera and are transmitted to the implant through a radio antenna and microchip under the skin just behind the ear. Implants of a microchip, smaller than the head of a pin and about half the thickness of a sheet of paper were used to remove blindness.

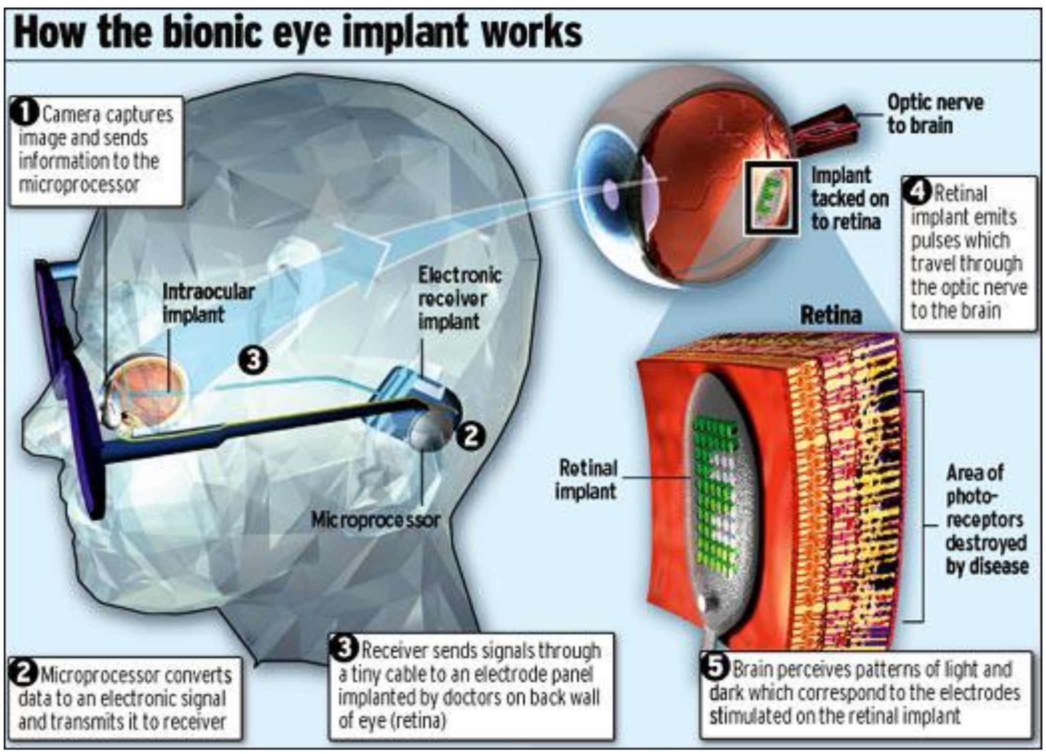

Fig 5.3.Working of bionic eye[7]

The eye-position monitor controls the image camera's orientation. If the image-acquisition camera is not mounted on the head, compensation for head movement will be needed. Finally, if a retinal prosthesis is to receive power and signal input from outside the eye via an IR beam entering the pupil, the transmitter must be aligned with the intraocular chip. The beam has played two roles: one is to sends power, and another is to send pulse - or amplitude - modulated to transmit image data. Using the control of eye movement, the main imaging camera for each eye can swivel in any direction. Each of these cameras--located just outside the users' field of view to avoid blocking whatever peripheral vision they might have captures the image of the outside world and transmits the information through an optical fiber to a signal-processing computer worn on the body.

The Argus II system uses a spectacle-mounted camera which is used to send information to electrodes in the eye. Patients who tested less-advanced versions of the retinal implant were able to see light, shapes and movement.

The function of Bionic eye is to take real-time images from a camera and convert into tiny electrical pulses that help the blind eyes to see.

1: Camera which is implanted on glasses helps to view the image.

2: Signals are sent to hand-held device

3: The information which processed is sent back to glasses and wirelessly transmitted to receiver under surface of eye.

4: Receiver sends information to electrodes in retinal implant.

5: Electrodes stimulate retina to send information to brain.

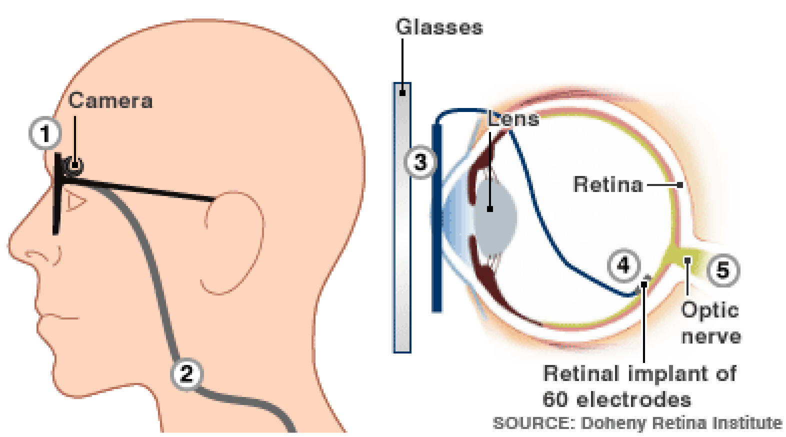

Fig 5.4.Retinal implant[7]

Retinal implants can partially restore the vision of people with particular blindness caused by diseases such as macular degeneration or retinitis pigmentosa. About one and half million people worldwide have retinitis pigmentosa, and one in ten people over the age of fifty five have age-related macular degeneration. Both diseases cause the retinal cells which process light at the back of the eye to gradually diminish. The new device invented work by implanting an array of tiny electrodes into the back of the retina. A camera is used to capture pictures which consist of a processing unit about the size of a small handheld computer and worn on a belt helps to convert the visual information into electrical signals.

These are then sent back to the glasses and wirelessly on to a receiver just under the surface of the front of the eye, which in turn feeds them to the electrodes at the rear.

5.4.Advantages

• It helps to correct the vision.

• There is no necessity to suffer from long and short sights.

• It can be easily implanted .

5.5.Disadvantages

• There are 120 million rods and 6 million cones in the retina of every healthy human eye. Creating an artificial replacement for these is a risky task.

• Si based photo detectors have been tried in earlier attempts. But Si is toxic to the human body and reacts unfavorably with fluids in the eye

• it cost about 30,000$

• It will not be helpful for glaucoma patients.

Chapter 6

BIONIC EAR

6.1Human Ear

Human ear has three parts: External Ear, Middle Ear, Internal Ear as shown in the figure. If we talk in term of electronics language, the middle ear work like amplifier, the internal ear works like a spectrum analyser and transducer. The main function of external ear is just to collect the sound and also to know the direction of sound.

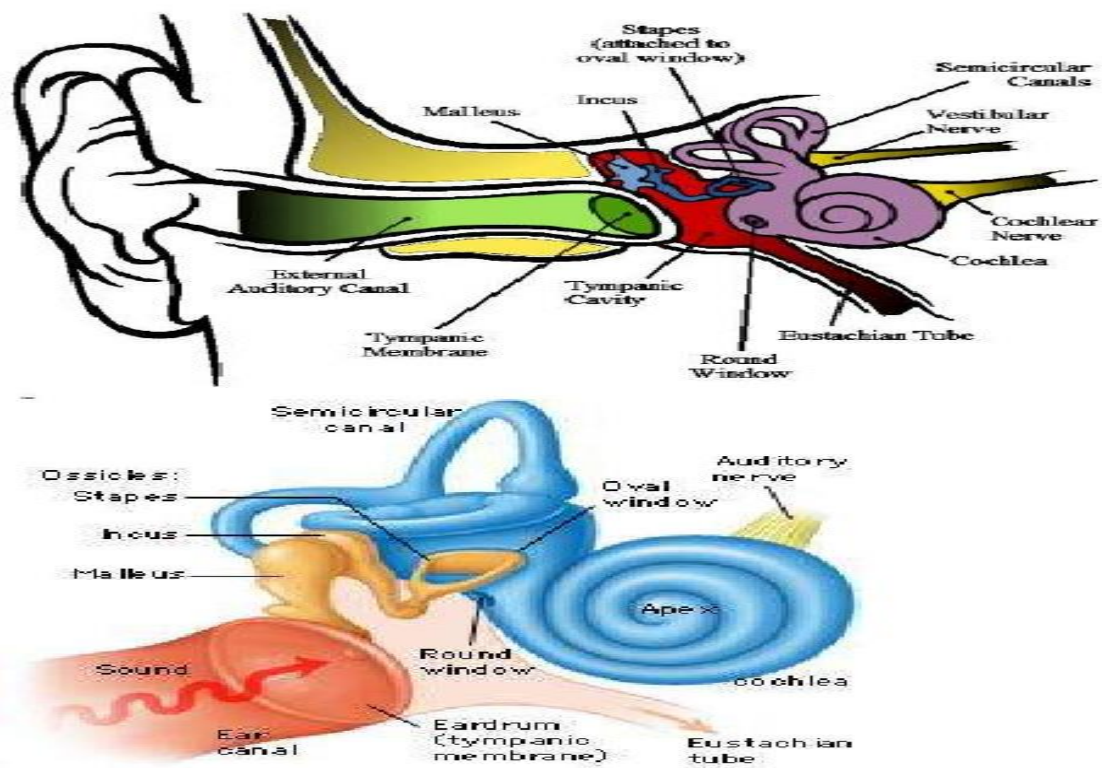

Fig 6.1 Human Ear[4]

As we can see from the figure that in the external ear there is one outside part which we can see from our eye called pinna. The main function of pinna is just to collect sound and also to know the direction of the sound. Then the sound signal enters into external auditory cannel and after that it strikes to the tympanic membrane, which moves according to the pressure applied by the incoming sound signal. It transfer its vibrations to the small bones names malleus, incus and stapes which are connected in chain. These small bones vibrate accordingly and transfer their energy to the oval window and round window. The motions of these windows are opposite to each other in such a way that when one moves down other moves up. The round window transfers its energy to the liquid present in the cochlea and there will be vibrations accordingly. There is basilar membrane in the cochlea which will moves according to the vibrations of the liquid and this membrane is connected to the hair cells. This cochlea actually acts like spectrum analyser. Whatever complex signal having different frequencies comes in it, it will breaks the complex signal into different frequency component and accordingly basilar membrane displaced and it transfer the different frequency signal to the corresponding tuned hair cells. There are different bunches of hair cell which are tuned to different frequencies. These hair cell actually act like transducer which convert mechanical energy into electrical energy. These hair cell are connected to the auditory nerve which carry the electrical signal to the brain.

6.2. Working of Bionic Ear

The implant works by using the tonotopic organization of the basilar membrane of the inner ear. "Tonotopic organization", also referred to as a "frequency-to-place" mapping, is the way the ear sorts out different frequencies so that our brain can process that information. In a normal ear, sound vibrations in the air lead to resonant vibrations of the basilar membrane inside the cochlea. High-frequency sounds (i.e. high pitched sounds) do not pass very far along the membrane, but low frequency sounds pass farther in. The movement of hair cells, located all along the basilar membrane, creates an electrical disturbance that can be picked up by the surrounding nerve cells. The brain is able to interpret the nerve activity to determine which area of the basilar membrane is resonating, and therefore what sound frequency is being heard. In individuals with sensorineural hearing loss, hair cells are often fewer in number and damaged. Hair cell loss or absence may be caused by a genetic mutation or an illness such as meningitis. Hair cells may also be destroyed chemically by an ototoxic medication, or simply damaged over time by excessively loud noises. The cochlear implant bypasses the hair cells and stimulates the cochlear nerves directly using electrical impulses. This allows the brain to interpret the frequency of sound as it would if the hair cells of the basilar membrane were functioning properly.

The implant is surgically placed under the skin behind the ear. The basic parts of the device include:

External:

- one or more microphones which picks up sound from the environment
- a speech processor which selectively filters sound to prioritize audible speech splits the sound into channels and sends the electrical sound signals through a thin cable to the transmitter,
- a transmitter, which is a coil held in position by a magnet placed behind the external ear, and transmits power and the processed sound signals to the internal device by electromagnetic induction.

Internal:

- a receiver and stimulator secured in bone beneath the skin, which converts the signals into electric impulses and sends them through an internal cable to electrodes.
- an array of up to 24 electrodes wound through the cochlea, which send the impulses to the auditory nerves.

The step-wise brief working of coclear impant is as below:

1. Sounds and speech are detected by the microphone.
2. The information from the microphone is sent to the speech processor.
3. The speech processor analyses the information and converts it into an electrical code.
4. The coded signal travels via a cable to the transmitting coil in the headset.
5. Radio waves from the transmitter coil carry the coded signal through the skin to the implant inside.
6. The implant package decodes the signal. The signal contains information that determines how much electrical current will be sent to the different electrodes.

7. The appropriate amount of electrical current passes down the appropriate lead wires to the selected electrodes. The position of the stimulating electrodes within the cochlea will determine the frequency or pitch of the sounds. The amount of electrical current will determine the loudness of the sounds.
8. Once the nerve endings in the cochlea are stimulated, the message is sent up to the brain along the auditory nerve. The brain can then try to interpret the stimulation as a meaningful sound.

Fig6.2.Bionic ear[5]

Chapter 7

CONCLUSION

Bionics are a set of technology products that are constantly evolving. Bionics are proposed as body add-ons or replacement for many body parts (ears, eyes, knees, neural prostheses, joints, muscles, kidney, liver, cartilage lungs, discs, pancreas, dental pulp, skin, hippocampus, legs and hands), and functions such as speech.

Disabled people are one main group perceived to be in need of therapeutic interventions that use various bionic products. So far, therapeutic interventions are about restoration to the species-typical norm. However, therapeutic bionic products increasingly give the wearer beyond normal body abilities (therapeutic enhancements). Many so-called non-disabled people want the same enhanced body-abilities especially through non-invasive bionic products (e.g., non-invasive brain machine interfaces, exoskeletons).