International Journal of Advances in Engineering and Management (IJAEM)
Volume 7, Issue 02 Feb. 2025, pp: 673-680 www.ijaem.net ISSN: 2395-5252

# Recent Insight on Biochip and Its Applications

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Date of Submission: 15-02-2025 Date of Acceptance: 25-02-2025

**ABSTRACT**
Biochips represent one of the most groundbreaking technological advancements emerging from the convergence of biotechnology, electronics, and computer science in recent years. These miniaturized devices, often no larger than a fingernail, integrate thousands to millions of biosensors on a solid substrate, enabling high-throughput and rapid analysis of complex biological processes. Originally developed for monitoring fisheries, biochips have since found applications in diverse fields, including genomics, proteomics, pharmaceuticals, medical diagnostics, environmental monitoring, and even animal and human identification.The core components of a biochip system include a transponder (implantable microchip) and a reader, which communicate via low-frequency radio waves. The transponder, typically passive and battery-free, contains a microchip, antenna coil, capacitor, and glass capsule, and can store unique identification data. Biochips are capable of performing thousands of biological reactions, such as gene decoding, in seconds, making them invaluable tools in research and diagnostics.This review explores the recent advancements in biochip technology, its diverse applications, and future prospects. Key applications include molecular analysis, disease diagnosis, environmental monitoring, and non-biological uses such as organic semiconductors. Emerging developments, such as glucose level detectors and oxygen sensors, highlight the potential of biochips to revolutionize healthcare by enabling continuous monitoring of vital parameters. However, the technology also raises significant ethical and privacy concerns, particularly regarding human implantation and data security.Despite challenges, biochips hold immense promise for the future, with ongoing research focused on enhancing their functionality, such as integrating RAM for dynamic data storage and improving their use in personalized medicine. As biochip technology continues to evolve, it is poised to transform industries, improve healthcare outcomes, and redefine the boundaries of biotechnology and electronics. This review underscores the need for balanced innovation, addressing both the potential benefits and ethical implications of this transformative technology.

**Keywords:** Biochip, biosensors, genomics, proteomics, RFID, medical diagnostics, ethical implications, future prospects.

## I. INTRODUCTION

Biochips form the most exciting technology to emerge from the fields of Biotechnology, Electronics and computers in recent years. Advances in the areas of proteomics, genomics and pharmaceuticals are empowering scientist with new methods for unravelling the complex biochemical processes occurring within cells with the larger goal of understanding and treating human diseases. Almost simultaneously, the semiconductor industry has been steadily perfecting the science of micro-miniaturization. The merging of these two fields led to the development of Biochip that enabled Biotechnologists to begin packing their traditionally bulky sensing tools into smaller and slighter spaces. (Lexinnova., 2013).

A Biochip is the device that can contain anywhere from tens to tens of millions of individual sensor elements (or biosensors). The packaging of these sensor elements on a solid substrate over a microscopic slide helps in performing lengthy tasks in a short time with high throughput and pace. Unlike microchips, biochips are generally not electronic. Each biochip can be thought of as a ''micro-reactor' that can sense a specific analyte. The analyte can be a DNA, Protein, enzyme, antibody or any biological molecule. A biochip can perform thousands of Biological reactions, such as decoding genes, in a few seconds. (Tuan, V., 2003)

Biochip implant systems basically comprise of two components; a transponder and a reader or scanner. The Biochip system is radio frequency identification (RFID) based, using low frequency radio signals to communicate between the biochip and reader. The reading range or activation range, between the reader and biochip is small, normally between 2 and 12 inches. (www.studymafia.org)

### 1.1 AIM

The goal of this review is to discuss on the recent insight on Biochips and its Applications.

### 1.2 SPECIFIC OBJECTIVES

1. To determine and discuss the applications of Biochips.
2. Highlight the future of Biochips

## II. LITERATURE REVIEW

A biochip is a collection of miniaturized test sites (micro arrays) arranged on a solid substrate that permits many tests to be performed at the same time in order to achieve higher throughput and speed. Typically, a biochip's surface area is no larger than a fingernail. Like a computer

chip that can perform millions of mathematical operations in one second, a biochip can perform thousands of biological reactions, such as decoding genes, in a few seconds. Biochips are any microprocessor chips that can be used in Biology. The biochip technology was originally developed in 1983 for monitoring fisheries, it's use now includes, over 300 zoos, over 80 government agencies in at least 20 countries, pets (everything from lizards to dogs), electronic "branding" of horses, monitoring lab animals, fisheries, endangered wildlife, automobiles, garment tracking, hazardous waste, and humans. Biochips are "silently" inching into humans. For instance, at least six million medical devices, such as artificial body parts (prosthetic devices), breast implants, chin implants, etc., and are implanted in people each year. And most of these medical devices are carrying a "surprise" guest — a biochip. In 1993, the Food and Drug Administration passed the Safe Medical Devices Registration Act of 1993, requiring all artificial body implants to have "implanted" identification — the biochip. So, the yearly, 6 million recipients of prosthetic devices and breast implants are "bio chipped". To date, over seven million animals have been "chipped". The major biochip companies are A.V.I.D. (American

Veterinary Identification Devices), Trovan Identification Systems, and Destron-Fearing Corporation.(Chaitanya, K., et, al2011).

Most of us won't like the idea of implanting a biochip in our body that identifies us uniquely and can be used to track our location. That would be a major loss of privacy. But there is a flip side to this! Such biochips could help agencies to locate lost children, downed soldiers and wandering Alzheimer's patients.

The human body is the next big target of chipmakers. It won't be long before biochip implants will come to the rescue of sick, or those who are handicapped in some way. Large amount of money and research has already gone into this area of technology.

Anyway, such implants have already experimented with. A few US companies are selling both chips and their detectors. The chips are of size of an uncooked grain of rice, small enough to be injected under the skin using a syringe needle. They respond to a signal from the detector, held just a few feet away, by transmitting an identification number. This number is then compared with the database listings of register pets. (Studymafia.org).

A genetic biochip is designed to "freeze" into place the structures of many short strands of DNA (deoxyribonucleic acid), the basic chemical instruction that determines the characteristics of an organism. Effectively, it is used as a kind of "test tube" for real chemical samples.

A specifically designed microscope can determine where the sample hybridized with DNA strands in the biochip. Biochips helped to dramatically increase the speed of the identification of the estimated 80,000 genes in human DNA, in the world wide research collaboration known as the Human Genome Project. The microchip is described as a sort of "word search" function that can quickly sequence DNA.

In addition to genetic applications, the biochip is being used in toxicological, protein, and biochemical research. Biochips can also be used to rapidly detect chemical agents used in biological warfare so that defensive measures can be taken.

Motorola, Hitachi, IBM, Texas Instruments have entered into the biochip business. (Tuan, V., et, al. 2003).

### 2.1 THE BIOCHIP TECHNOLOGY

The current, in use biochip implant system is actually a fairly simple device. Today's biochip implant is basically a small (micro) computer chip, inserted under the skin for identification purposes.

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(Chaitanya, K., et, al 2011). The biochip system is radio frequency identification (RFID) system (Terry, W.,) using low frequency radio signals to communicate between the biochip and reader. The reading range or activation range, between reader and biochip is small, normally between 2 and 12 inches.

**SIZE**

The size of a Biochip is of a size of an uncooked ricegrain size. It ranges from 2inches to 12inches.


Fig 1

**2.1.1 COMPONENTS OF THE BIOCHIP**

The biochip implant system consists of mainly two components the transponder and reader.

**2.1.2 THE TRANSPONDER**

The transponder is the actual biochip implant. It is a passive transponder, meaning it contains no battery or energy of its own. In comparison, an active transponder would provide its own energy source, normally a small battery. Because the passive contains no battery, or nothing to wear out, it has a very long life up to 99 years, and no maintenance. Being passive, it is inactive until the reader activates it by sending it a low-power electrical charge. The reader reads or scans the implanted biochip and receives back data (in this case an identification number) from the biochips. The communication between biochip and reader is via low-frequency radio waves. Since the communication is via very low frequency radio waves it is not at all harmful to the human body. (Studymafia.org).

The biochip-transponder consists of four parts;

I. Computer microchip
II. Antenna coil
III. Capacitor
IV. Glass capsule

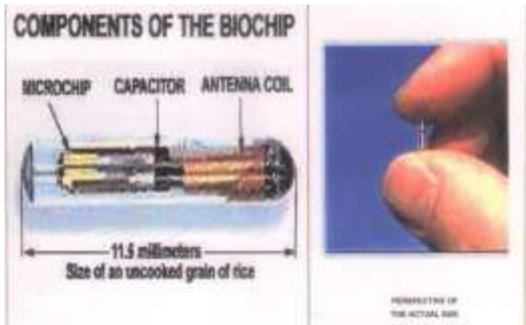


Fig 2

Source: www.(studymafia.org)

**2.1.3 COMPUTER MICROCHIPS**

The microchip stores a unique identification number from 10 to 15 digits long. The storage capacity of the current microchips is limited, capable of storing only a single ID number. AVID (American Veterinary Identification Devices), claims their chips, using a nnn-nnn-nnn format, has the capability of over 70 trillion unique numbers. The unique ID number is "etched" or encoded via a laser onto the surface of the microchip before assembly. Once the number is encoded it is impossible to alter. The microchip also contains the electronic circuitry necessary to transmit the ID number to the "reader". (www.wikipedia.com)

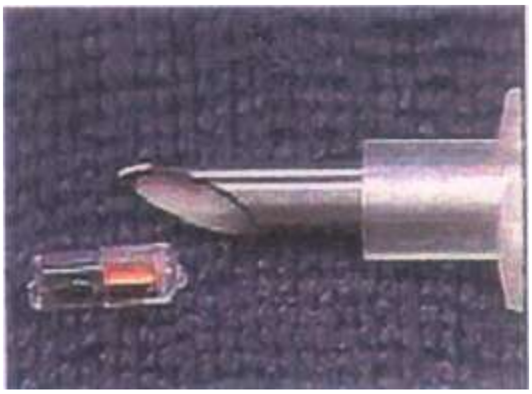

Fig 3

BIOCHIP & SYRINGE: Source; (www.Studymafia.org)

**2.1.4 ANTENNA COIL**

This is normally a simple, coil of copper wire around a ferrite or iron core. This tiny, primitive, radio antenna receives and sends signals from the reader or scanner.

**2.1.5 TUNING CAPACITOR**

The capacitor stores the small electrical charge (less than 1/1000 of a watt) sent by the

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reader or scanner, which activates the transponder. This "activation" allows the transponder to send back the ID number encoded in the computer chip. Because "radio waves" are utilized to communicate between the transponder and reader, the capacitor is tuned to the same frequency as the reader. (www.studymafia.org)

### 2.1.6 GLASS CAPSULE

The glass capsule "houses" the microchip, antenna coil and capacitor. It is a small capsule, the smallest measuring 11 mm in length and 2 mm in diameter, about the size of an uncooked grain of rice. The capsule is made of biocompatible material such as soda lime glass.

After assembly, the capsule is hermetically (air-tight) sealed, so no bodily fluids can touch the electronics inside. Because the glass is very smooth and susceptible to movement, a material such as a polypropylene polymer sheath is attached to one end of the capsule. This sheath provides a compatible surface, which the bodily tissue fibers bond or interconnect, resulting in a permanent placement of the biochip. The biochip is inserted into the subject with a hypodermic syringe. Injection is safe and simple, comparable to common vaccines. Anesthesia is not required nor recommended. In dogs and cats, the biochip is usually injected behind the neck between the shoulder blades. Trovan, Ltd., markets an implant, featuring a patented "zip quill", which you simply press in, no syringe is needed. According to AVID "Once implanted, the identity tag is virtually impossible to retrieve. The number can never be altered." (Chaitanya, K., et, al 2011).

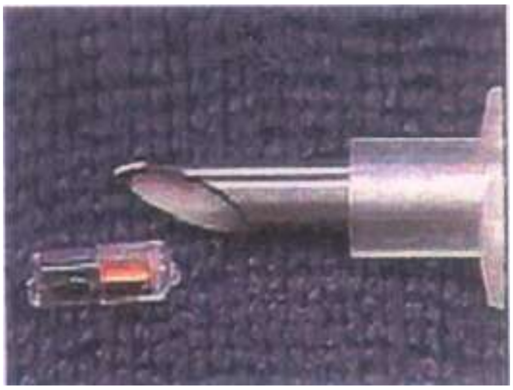

Fig 4
Source: (www.google.com)

### 2.1.8 Mechanism of Action of Biochip

The mechanism of action of a biochip depends on its specific application, but in general, biochips function as miniaturized laboratories that integrate biological molecules with electronic or optical components for rapid analysis. The main principles of their action include:

1. Detection and Binding
- Biochips contain biological recognition elements (such as DNA, RNA, antibodies, or enzymes) immobilized on a microarray or sensor surface.
- When a target molecule (such as DNA, proteins, or pathogens) is present in a sample, it binds to its complementary or specific probe on the chip.

2. Signal Generation and Transduction
- The binding event generates a biochemical or physical signal, such as fluorescence, electrical current, or changes in mass.
- Different types of transducers (optical, electrochemical, or mechanical) convert this biological interaction into a measurable signal.

3. Signal Processing and Analysis
- The detected signal is amplified and processed using microelectronics or computer algorithms to quantify and interpret the results.
- In DNA biochips, for example, fluorescence intensity can indicate the presence or absence of specific gene sequences.

Types of Biochips and Their Mechanisms
- DNA Microarrays: Detect genetic sequences through hybridization of complementary DNA strands.
- Protein Chips: Identify proteins using antibody-antigen interactions.
- Lab-on-a-Chip (LOC): Integrates multiple biochemical reactions, such as PCR, electrophoresis, and immunoassays, into a miniaturized system.
- Biosensor Chips: Use electrochemical or optical sensors to detect biological molecules like glucose or toxins.

Biochips are widely used in medical diagnostics, drug discovery, environmental monitoring, and forensic analysis due to their high sensitivity, specificity, and rapid processing capabilities.

### 2.2 THE READER

The reader consists of an "exciter coil" which creates an electromagnetic field that, via radio signals, provides the necessary energy (less than 1/1000 of a watt) to "excite" or "activate" the implanted biochip. (Lexinnova., 2013). The reader also carries a receiving coil that receives the transmitted code or ID number sent back from the "activated" implanted biochip. This all takes place very fast, in milliseconds. The reader also contains the software and components to decode the

International Journal of Advances in Engineering and Management (IJAEM)
Volume 7, Issue 02 Feb. 2025, pp: 673-680 www.ijaem.net ISSN: 2395-5252

received code and display the result in an LCD display. The reader can include a RS-232 port to attach a computer. (Tuan, V., et, al. 2003).

### 2.2.1 How it works

The reader generates a low-power, electromagnetic field, in this case via radio signals, which “activates” the implanted biochip. This “activation” enables the biochip to send the ID code back to the reader via radio signals. The reader amplifies the received code, converts it to digital format, decodes and displays the ID number on the reader’s LCD display. The reader must normally be between 2 and 12 inches near the biochip to communicate. The reader and biochip can communicate through most materials, except metal. (Chaitanya, K., et, al 2011).

### 2.3 TYPES OF BIOCHIP

On the basis of the target molecules in the sample, biochips are classified as DNA chips, protein chips, enzyme chips and Lab-on-a-chip (LOC) is a device that integrates one several laboratory functions of a single chip of only millimeters to a few square centimeters in size. LOCs deal with the handling of extremely small fluid volumes down to less than Pico liters. This kind of a multipurpose device is the future of biochips.

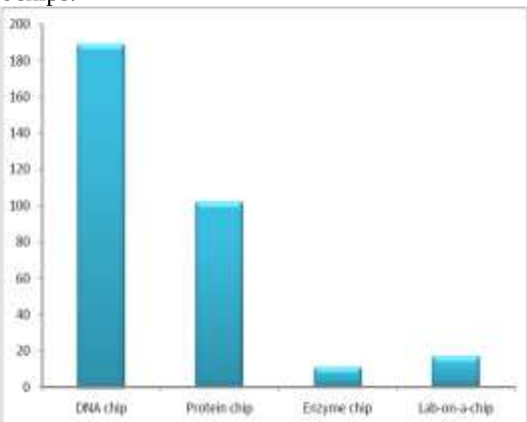


Fig 5

The above figure represents patent distribution trends with the types of biochips. DNA chip is most commonly used among all. This can be attributed to its ability to detect genetic mutations and related diseases henceforth. (Lexiinova.,2013)

## III. APPLICATIONS OF BIOCHIP

Biochips can be categorized into three broad categories based on applications, namely Molecular Analysis, Diagnostic and Non Biological usage.

Molecular Analysis includes detailed study of different types of molecules such as proteins, DNAs, RNAs, antibodies, antigens, enzymes and pathogens such as bacteria, fungi and viruses. It also includes hybridization of nucleic acids.

Diagnosis basically include the use of biochips in medical purposes such as prognosis, treatment and diagnosis of wounds, blood clots and diseases (mainly cancer).

Non Biological usage includes the use of biochips in non-medical fields as organic semiconductors and temperature controllers. (Lexinnova., 2013).

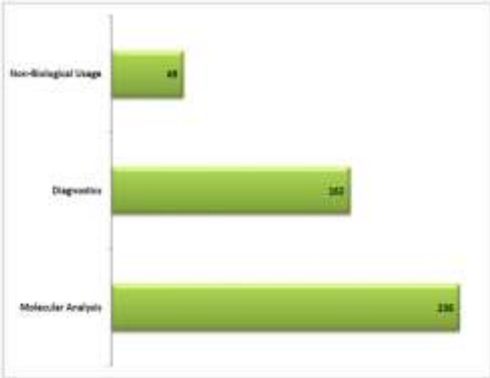


Fig 6

### 3.1 SUB-CATEGORIES OF APPLICATION AND GEOGRAPHICAL DISTRIBUTION

Table 1

The above table is a tool to identify gaps or areas of application least exploited and most exploited in different jurisdiction. The number corresponding to every jurisdiction represents the count of patents in that particular jurisdiction conjugated with a particular application. Therefore, the areas in table with color code Red or value 0 represents possible gaps or white spaces and provide a possible chance to explore the

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corresponding application in that particular country.

### 3.2 APPLICATIONS

I. With a biochip tracing of a person/animal, anywhere in the world is possible; Once the reader is connected to the Internet, satellite and a centralized database is maintained about the bio chipped creatures, it is always possible to trace out the personality intended (www.wikipedia.com).

II. A biochip can store and update financial, medical, demographic data, basically everything about a person: An implanted biochip can be scanned to pay for groceries, obtain medical procedures, and conduct financial transactions. Currently, the in use, implanted biochips only store one 10 to 15 digits. If biochips aredesigned to accommodate with more ROM &RAM,there is definitely an opportunity (www.wikipedia.com).

III. A biochip leads to a secured E-Commerce system: It's a fact; the world is very quickly going to a digital or E-economy, through the Internet. It is expected that by 2012, 60% of the Business transactions will be performed through the Internet. The E-money future, however, isn't necessarily secure. The Internet wasn'tbuilt to be Fort Knox. In the wrong hands, this powerfultool can turn dangerous. Hackers have already brokeninto bank files that were 100% secure. A biochip is thepossible solution to the "identification and security"dilemma faced by the digital economy. This type ofnew bio-security device is capable of accuratelytracking information regarding what users are doing,and who are to accurately track information regardingwhat users are doing, and who is actually doing it.

### 3.3 BIOCHIP AS OXYGEN SENSOR

The biochip can also be integrated with an oxygensensor. The oxygen sensor will be useful not only tomonitor breathing in intensive care units, but also to checkthat packages of food, or containers of semiconductorsstored under nitrogen gas, remain airtight.

The oxygen-sensing chip sends light pulses out into thebody. The light is absorbed to varying extents, depending onhow much oxygen is being carried in the blood, and the chip detects the light that is left. The rushes of blood pumped bythe heart are also detected, so the same chip is a pulsemonitor. (Askari, M.,2005)

### 3.4 BIOCHIP AS A BLOOD PRESSURE SENSOR

In normal situations, The Blood Pressure of a healthyHuman being is 120/80 mm of Hg.

APressure ratio lowerthan this is said to be "Low BP "condition & A Pressure ratio more than this is "High BP" condition. Serious Effectswill be reflected in humans during Low & High BPconditions; it may sometimes cause the death of a Person.Blood Pressure is checked with BP Apparatus in Hospitalsand this is done only when the patient is abnormal.
However, a continuous monitoring of BP is required in theaged people & Patients.

A huge variety of hardware circuitry (sensors) isavailable in electronics to detect the flow of fluid. It'salways possible to embed this type of sensors into a biochip.An integration of Pressure (Blood Flow) detecting circuitswith the Biochip can make the chip to continuously monitor the blood flow rate and when the pressure is in its low or highextremes it can be immediately informed through the readerhence to take up remedial measures. (Chakrabarty, K.,2005).

### 3.5 BIOCHIPS CURRENTLY UNDER DEVELOPMENT

1. Chips that follow footsteps
2. Glucose level detectors.

#### 3.5.1 CHIPS THAT FOLLOW FOOTSTEPS

The civil liberties debate over biochips has obscured their more ethically benign and medically useful applications. Medical researchers have been working to integrate chips and people for many years, often plucking devices from well-known electronic appliances. Jeffry Hausdorff of the Beth Israel Deaconess Medical Center in Boston has used the type of pressure sensitive resistors found in the buttons of a microwave oven as stride timers. He places one sensor in the heel of a shoe, and one in the toe, adds a computer to the ankle to calculate the duration of each stride.

"Young, healthy subjects can regulate the duration of each step very accurately," he says. But elderly patients prone to frequent falls have extremely variable stride times, a flag that could indicate the need for more strengthening exercises or a change in medication. Hausdorff is also using the system to determine the success of a treatment for congestive heart failure. By monitoring the number of strides that a person takes, can directly

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Volume 7, Issue 02 Feb. 2025, pp: 673-680 www.ijaem.net ISSN: 2395-5252

measure the patient's activity level, bypassing the often-flowed estimate made by the patient.

### 3.5.2 GLUCOSE LEVEL DETECTORS

Diabetics currently use a skin prick and a handheld blood test, and then medicate themselves with the required amount of insulin. The system is simple and works well, but the need.(www.studymafia.org). To draw blood means that most diabetics do not test themselves as often as they should. The new S4MS chip will simply sit under the skin, sense the glucose level, and send the result back out by radio frequency communication.

A light emitting diode starts off the detection process. The light that it produces hits a fluorescent chemical: one that absorbs the incoming light and re-emits it at a longer wavelength. The longer wavelength of light is detected, and the result is send to a control panel outside the body. Glucose is detected because the sugar reduces the amount of light that a fluorescent chemical re-emits. The more glucose is there the less light that is detected.

S4MS is still developing the perfect fluorescent chemical, but the key design innovation of the S4MS chip has been fully worked out. The idea is simple: the LED is sitting in a sea of fluorescent molecules. In most detectors the light source is far away from the fluorescent molecules, and the inefficiencies that come with that mean more power and larger devices. The prototype S4MS chip uses a 22 microwatt LED, almost forty times less powerful than a tiny power-on buttons on a computer keyboard. The low power requirements mean that energy can be supplied from outside, by a process called induction. The fluorescent detection itself does not consume any chemicals or proteins, so the device is self-sustaining. (Singh, V.,2006).

## IV. FUTURE SCOPE OF BIOCHIPS

The biochip is continuing to evolve as a collection of assays that provide a technology platform. One interesting development in this regard is the recent effort to couple so called representational difference analysis (RDA) with high throughput DNA array analysis. The RDA technology allows the comparison of cDNA from two separate tissue samples simultaneously. One application is to compare tissue samples obtained from a metastatic form or cancer versus a non-metastatic one in successive rounds. A subtracted cDNA library is produced from this comparison which consists of the cDNA from one tissue minus that from the other.

### 4.1 TYPICAL PROBLEM OF BIOCHIPS

- A chip implant would contain a person's financial world, medical history health care — it would contain his electronic life.
- If cash no longer existed and if the world's economy was totally chip oriented; — there would be a huge "black-market" for chips! Since there is no cash criminals would cut off hands and heads, stealing "rich-folks" chips.
- It is very dangerous because once kidnappers get to know about these chips, they will skin people to find them.

### 4.2 PROPOSED SOLUTION

A generic and existing model of Biochips consists of only ROM component in it and is capable ofaccommodating the data such as social security number, Passport number, bankcard number etc., which are normally permanent in nature. The induction of RAM component in addition to ROM & storing the Bankcard, Financial details which causes the problem is a mere solution. As RAM needs to be continuously charged inorder to retain the data, Current can be supplied to the chip either from the electrical energy produced in the cells or by converting the heat energy in our body to electrical energy.

Once if the chip is taken out from the human body RAM immediately loses the Power supply from the human body; thus information in the RAM is lost and therefore is useless for the kidnappers.

### 4.3 ADVANTAGES

1. To rescue the sick
2. To find lost people.
3. To locate downed children and wandering Alzheimer's Patients.
4. To identify person uniquely.
5. They can perform thousands of biological reactions and operations in few seconds.
6. In monitoring health condition of individuals in which they are specifically employed.
7. They can perform thousands of biochemical reactions.

### 4.4 DISADVANTAGES

1. They raise critical issues of personal privacy.
2. They mark the end of human freedom and dignity.
3.They may not be supported by large percentage of people.
4. There is a danger of turning every man, women, and
Child into a controlled slave.

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**Volume 7, Issue 02 Feb. 2025, pp: 673-680 www.ijaem.net ISSN: 2395-5252**

5. Through cybernetic, biochip implant people will think and act as exactly pre-programmed.
6. They can be implanted into one's body without their knowledge.

## V. CONCLUSSION

A chip implanted somewhere in human bodies mightserve as a combination of credit card, passport, driver'slicense, personal diary. No longer would it be needed toworry about losing the credit cards while traveling. A chipinserted into human bodies might also give us extra mentalpower.The really fascinating idea is under fast track research"but we're close." The day in which we have chipsembedded in our skins is not too far from now. "This isscience fiction stuff."," This is a true example to provescience really starts with fiction".

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