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BIOCHIPS

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ABSTRACT

A biochip is a collection of miniaturized test sites (microarrays) arranged on a solid substrate that permits many tests to be performed at the same time in order to achieve higher throughput and speed. 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 helped to dramatically accelerate the identification of the estimated 80,000 genes in human DNA, an ongoing world-wide research collaboration known as the Human genome project. Developing a biochip plat-form incorporates electronics for addressing, reading out,Sensing and controlling temperature and, in addition, a handheld analyzer capable of multipara meter identification. The biochip platform can be plugged in a peripheric standard bus of the analyzer device or communicate through a wireless channel. Biochip technology has emerged from the fusion of biotechnology and micro/nanofabrication technology. Biochips enable us to realize revolutionary new bio analysis systems that can directly manipulate and analyze the micro/nano-scale world of biomolecules, organelles and cells.

I. INTRODUCTION

1.1 What is a biochip?

A biochip is a collection of miniaturized test sites (microarrays) 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.Biochip is a broad term indicating the use of microchip technology in molecular biology and can be defined as arrays of selected biomolecules immobilized on a surface. Biochip will also be used in animal and plant breeding, and in the monitoring of foods and the environment.Biochip is a small-scale device, analogous to an integrated circuit, constructed of or used to analyze organic molecules associated with living organisms. One type of theoretical biochip is a small device constructed of large organic molecules, such as proteins, and capable of performing the functions (data storage, processing) of an electronic computer. The other type of biochip is a small device capable of performing rapid, small-scale biochemical reactions for the purpose of identifying gene sequences, environmental pollutants, airborne toxins, or other biochemical constituents.

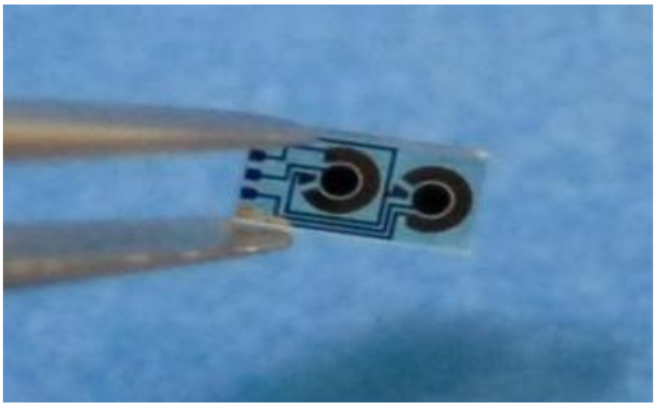

Fig 1.1Biochip

II. HOW DOES A BIOCHIP WORK?

The "chip contains a 10 character alphanumeric identification code that is never duplicated. When a scanner is passed over the chip, the scanner emits a 'beep' and your ... number flashes in the scanner's digital display." Biochips concentrate thousands of different genetic tests on a surface area of just a few square centimetres so that they can be analysed by computer within a very short space of time. On the one hand this makes the individual genetic tests much cheaper and on the other hand, thanks to the capacity, many more tests can be carried out.

Biochips concentrate thousands of different genetic tests on a surface area of just a few square centimetres so that they can be analysed by computer within a very short space of time. On the one hand this makes the individual genetic tests much cheaper and on the other hand, many more tests can be carried out. Affymetrix invented the “high-density microarray” in 1989 and has been selling this assay since 1994 under the name of Gene Chip® (figure 1). In this context, microarray means that the genetic tests are organised (arrayed) inmicrometrespacing (micro).As it was not previously possible to go below the millimetre range, the description “high density” is certainly justified. Experiments (e.g. measurement ofgene activity or sequencing to demonstrate mutations and polymorphisms) that could previously only be done individually, one after the other, can now be carried out in large numbers at the same time and in a highly automated manner.

III. BIOCHIP ARCHITECTURE

The biochip implant system consists of two components; a transponder and a reader or scanner. The transponder is the actual biochip implant. The biochip system is a radio frequency identification (RFID) system, 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.

3.1Size

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

Fig 3.1 Actual Size of Chip

3.2 Components

3.2.1 The Transponder: The transponder is the actual biochip implant. It is a *passive* transponder, meaning it contains no battery or energy of it's own. In comparison, an *active* transponder would provide it's own energy source, normally a small battery. Because the *passive* biochip contains no battery, or nothing to wear out, it has a very long life, up to 99 years, and no maintenance. Being *passive*, it's inactive until the reader activates it by sending it a low-power electrical charge. The reader "reads" or

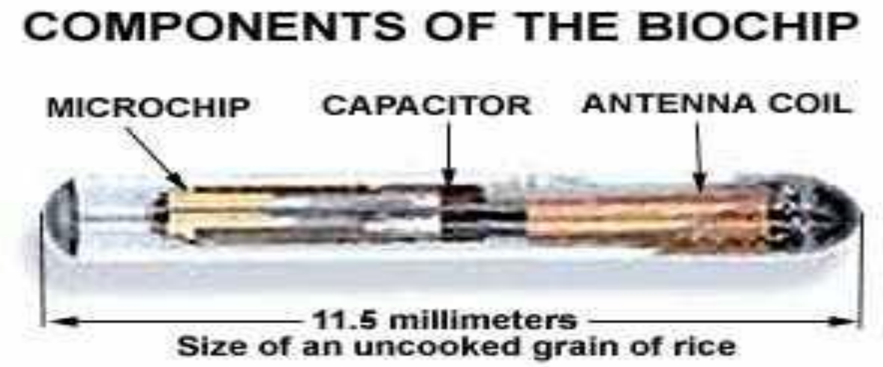

Fig 3.2 Components

"Scans" the implanted biochip and receives back data (in this case an identification number) from the biochip. The communication between biochip and reader is via low-frequency radio waves. The biochip-transponder consists of four parts; computer microchip, antenna coil, capacitor and the glass capsule.

3.2.2 Computer Microchip: 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".

3.2.3 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.

3.2.4 Tuning Capacitor: The capacitor stores the small electrical charge (less than 1/1000 of a watt) sent by the 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.

3.2.5 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.

3.2.6 Cost: Biochips are not cheap, though the price is falling rapidly. A year ago, human biochips cost $2,000 per unit. Currently human biochips cost $1,000, while chips for mice, yeast, and fruit flies cost around $400 to $500. The price for human biochips will probably drop to $500 this year. Once all the human genes are well characterized and all functional human SNPs are known, manufacture of the chips could conceivably be standardized. Then, prices for biochips, like the prices for computer memory chips, would fall through the floor.

IV. APPLICATIONS OF BIOCHIP

4.1Genomics

Genomics is the study of gene sequences in living organisms and being able to read and interpret them. The human genome has been the biggest project undertaken to date but there are many research projects around the world trying to map the gene sequences of other organisms. The use of Biochip facilitate: Automated genomic analysis including genotyping, gene expression DNA isolation from complex matrices with aim to increase recovery efficiency DNA amplification by optimizing the copy numberDNA hybridization assays to improve speed and stringency .5.2Proteomics

Proteome analysis or Proteomics is the investigation of all the proteins present in a cell, tissue or organism. Proteins, which are responsible for all biochemical work within a cell, are often the targets for development of new drugs. The use of Biochip facilitate:

- High throughput proteomic analysis
- Multi-dimensional
  micro separations (pre LC/MS) to achieve high plate number
- Electro kinetic sample injection for fast, reproducible, samples
- Stacking or other preconcentration methods (as a precursor to biosensors) to improve detection limits
- Kinetic analysis of interactions between proteins to enable accurate, transport-free kinetics

4.2 Cellomics

Every living creature is made up of cells, the basic building blocks of life.. Cells are used widely by for several applications including study of drug cell interactions for drug discovery, as well as in bio sensing. The use of Biochip facilitate:

- Design/develop"lab-in-cell" platforms handling single or few cells with nan probes in carefully
- Controlled environments.
- Cell handling, which involve sorting and positioning of the cells optimally using DEP, optical traps etc.
- Field/reagent based cell lysis, where the contents of the cell are expelled out by breaking the membrane, or increase the efficiency of transfection using reagents/field
- Intracellular processes to obtain high quality safety/toxicity ADME/T data

4.3 Biodiagnostics and (Nano) Biosensors

Bio diagnostics or bio sensing is the field of sensing biological molecules based on electrochemical, biochemical, optical, luminometric methods. The use of Biochip facilitate: Genetic/Biomarker Diagnostics, development of Bio warfare sensors which involves optimization of the platform, reduction in detection time and improving the signal-to-noise ratio

- Selection of detection platform where different formats such as lateral flow vs. microfluidics are compared for ease/efficiency Incorporation of suitable sensing modality by evaluating trade-offs and down select detection modes(colour / luminometric, electrochemical, biochemical, optical methods) for specific need.

4.4 Protein Chips for Diagnosis and Analysis of Diseases

The Protein chip is a micro-chip with its surface modified to detect various disease causing proteins simultaneously in order to help find a cure for them. Bio-chemical materials such as antibodies responding to proteins, receptors, and nucleic acids are to be fixed to separate and analyze protein.

V. DEVELOPMENTS & PROJECTS

5.1 View of the Future

The immediate prospects for biochip technology depend on a range of technologic and economic issues. One is the question of chip reusability. Current biochips are of necessity disposable, in part because the current devices are not physically robust. For example, nucleic acid probes tend to break away from a supporting glass plate. A decade from now, this problem may have been better addressed, making the chips more reusable, and perhaps at the same time permitting probes with longer spans of genetic data than are feasible today. In this way, a manufacturing improvement might facilitate more powerful forms of genetic analysis. On the other hand, it may be better to manufacture biochips so inexpensive that they can be used once and then discarded. Another issue is biochip versatility. Current biochips are single-purpose, hardwired devices. Even if future biochips do not become programmable, in the fashion of computer chips, they may become usable for multiple purposes, such as the analysis of a tissue sample for numerous pathogens. An overarching issue is standardization. For diagnostic purposes, any medical test should be administered, and its results interpreted, in a standardized way. Beyond that, it seems desirable for biochips performing different tests to have an output detectable by the same readout device. Hence, a race is underway to create a biochip platform or motherboard capable of handling a wide range of biochips, irrespective of the internal details of a given chip's function. In particular, two companies, Affymetrix and Molecular Dynamics, have formed the Genetic Analysis Technology Consortium, or GATC (a name that also represents the four nucleotides that carry genetic code in DNA). The hope is to establish industry-wide standards for the reading of biochips.

VI. ADVANTAGES & DISADVANTAGES

Advantages

- The ability to detect multiple viral agents in parallel e.g. differential diagnosis of agents from other diseases that cause similar clinical symptoms, or the recognition of complex mixtures of agents. .Clarification of syndromes of unknown aetiology .Increase speed of diagnosis of unknown pathogens ("future proofed" surveillance tools).
- .Viral typing (AIV, FMDV, Rabies)

- .Drive policy for diagnostics and disease control.
- .Epidemiological tracing
- .Interagency collaboration. The consortium consists of National, EU and OIE reference laboratories and has access to real sample material from a wide selection of hosts and viruses.

Disadvantages

- These methods have problems that a DNA chip cannot be fabricated at high density and mass production is limited. Thus, these methods are applicable to fabrication of a DNA chip for study. .Meanwhile, the DNA chip and the DNA microarray have different fabrication methods but are similar in that different oligonucleotides are aligned on a square spot having a certain size in a check pattern.

VII. CONCLUSION

Biochips are fast, accurate, miniaturized, and can be expected to become economically advantageous attributes that make them analogous to a computer chip. One expects to see an accelerated trend of ultra miniaturization, perhaps involving entirely novel media, and an increased ability to analyze not only genetic material but also other types of biologic molecules. One expects, too, an eventual harmonization of technologies, so that dominant fabrication strategies will emerge, at least for certain types of applications, including a favoured format for genetic analysis and another for antibodies and other proteins. Since the potential applications are vast, both for research and for clinical use, the potential markets for biochips will be huge, a powerful driving force for their continued development.

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