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The Engineering of an Automated and Portable DNA Analysis System

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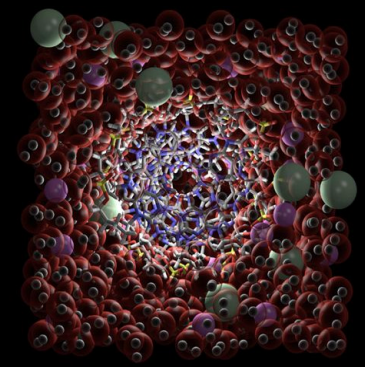
Introduction

The development of improved DNA sequencing technologies over the last 30 years has heralded a new era in biology, in which organisms can be examined in terms of the set of instructions that specify their development, form, function and behaviour. The currently available DNA sequencers are large and designed for high throughput sequencing rather than portability and field use. A DNA sample needs to be sent to a laboratory for it to be sequenced. This is not always feasible and is a hindrance to sequencing research. A DNA analysis system that is compact yet performs all the tasks of the DNA sequencing procedure would find use in a large number of applications.

Research Objective

The DNA sequencers currently available are large and require technical expertise to use. However, with automation, integration and the use of lab-on-a-chip and other micro-technologies, there is a possibility of reducing the size and number of components involved in the process of DNA analysis. The scope of this project is to investigate and if possible, prototype a system design for a portable, integrated and rugged DNA analysis device.



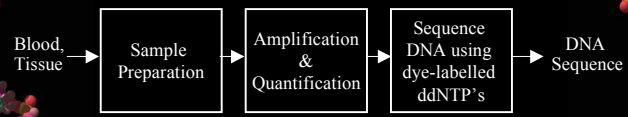
Motivation

There are no portable DNA analysis systems currently available. However, such a system would have innumerable uses. Some of the applications are listed below.

- ***Clinical Diagnostics*** - Analyse unknown virus and bacteria samples away from the laboratory.
- ***Research*** - More flexibility in DNA testing.
- ***Bio-defence*** - Provide automated, field-based testing for pathogenic agents such as Anthrax.
- ***Determination of GE modification*** - Check for the presence of genetic engineering in food.

Process of DNA Analysis

The process of determining the sequence of nucleotides making up the length of DNA is called DNA sequencing or DNA analysis. The procedure of obtaining the DNA sequence starting from a hair, blood or tissue sample is briefly outlined below.



Flowchart: Steps involved in DNA analysis

Sample Preparation

The first step involves extracting the DNA from the hair, tissue or blood sample. This is done by enzymatic degradation of cellular components. The result is purified DNA in a solution.

Automated DNA sample preparation

Thermal Cycler

Amplification & Quantification

After extracting the DNA, specific regions are amplified using the polymerase chain reaction to produce millions of copies. This is done by cycling the DNA between three different temperatures in an instrument known as a thermal cycler.

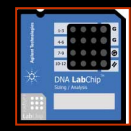
Sequence using dye-labelled ddNTP's

After amplifying specific regions of the DNA, a sequencing reaction is performed in the thermal cycler using fluorescently labelled terminators. The sequences of DNA obtained are then separated by the process of gel or capillary electrophoresis and finally read using a laser.

DNA Detection Machine

Lab-on-a-chip

A small chip (often the size of a credit card) containing microfluidic channels narrower than a human hair. They take advantage of the properties of liquids and gases to separate and better allow microsensors to analyse their constituent elements. Variants of these chips are being used to carry out biological research on a miniature scale.

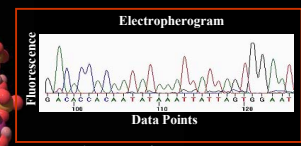


Agilent Technologies Lab-on-a-Chip determines the suitability of a mRNA molecule

Conclusions

The preliminary stages of the project have been spent investigating the current trends and equipment used in the process of DNA sequencing. This also included a study of the micro-technologies used for biological analysis. At this stage, designs for a portable DNA sequencing system are being developed. The next stage involves building a prototype sequencer from these designs.

Expected completion date: July 2003.



Graph: Output from DNA sequencer

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