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How DNA analysis works

By Lloyd Williams: Senior Associate Editor

The following is the second segment of a three-part look at the DNA Unit at the Forensic Science Laboratory. The first part appeared in the Sunday Gleaner:

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MR. COMPTON Beecher, Chief Forensic Officer, Forensic Science Laboratory, and who has a Master's degree in Biotechnology, demystified DNA analysis during a tour of the DNA Unit, going from extraction to amplification to the actual typing or fingerprinting of the samples.

In many murder cases blood from the victim or the assailant is left on clothing, at the crime scene, or on some weapon such as a knife, machete, brick, rock or other object. In the case of rape, semen stains or vaginal swabs are vital to the investigation of the crime.

The process begins, Mr. Beecher says, in the extraction area of the DNA Unit where it is determined, for example, whether a stain is blood or semen. DNA experts do not look at body fluids only, but at hair, fibre, bone, teeth, and saliva, because, as Mr. Beecher puts it, `DNA can be extracted from anything and DNA taken from any part of the body is the same`. However, each sample requires a different type of method to extract the DNA. `What we do here (the Extraction Area) is basically take DNA from the cells and purify it so that we can do further work on it.

`After it is extracted we need to determine how much DNA is in the sample that we have extracted because in some cases we don't get much DNA, especially in cases where the evidence has been exposed to a lot of environmental hazards such as heat and bacteria which would aid in the degradation of the DNA sample`. It is critical to determine how much DNA is in a sample that is extracted because the sample then goes to the amplification stage which requires that a certain amount of DNA be in the sample. A human DNA probe is then used to determine how much human DNA is in the sample.

In the Amplification Area what is called `amplification reaction` is done. `Here, what we look for on the human genome is variation at certain points. What happens during the amplification process is that these variable points are multiplied. So if we start to bond one molecule of the DNA we can end up with one million molecules. So it doesn't matter if the amount of starting DNA is small, which is typical of crime-scene evidence, we can multiply it and it is done using an instrument called a thermal cycler. It has basically a heater and a chiller to provide variation in temperature which incubates the sample for a set time. It is a

three-step process. The first step is denaturation where the DNA sample separates. The next step is the primer annealing process where a piece of DNA is put in the reaction mix which will look for the variable regions and target them. The third step is the chain extension where these variable regions are then multiplied.

All the reactions are set up under a sterile cabinet which pushes out sterile air, so in working under it, the work is being done in a sterile environment. Everything used in each area is dedicated to that area. For example the micro-pipettes which measure very small volumes are not moved from one area to another; neither are the tubes, the lab coats or anything else.

As Mr. Beecher explained it, the most important contamination factor in a DNA lab is DNA that has just been amplified so you don't want to move out anything. So once a DNA has been amplified, we take it directly to the typing room so it doesn't come into contact with our extracted area. A typical amplification process takes between one and one-half to two hours.

In the Typing Area the actual typing of the amplified samples is done. There are two systems both of which use a vertical electrophoresis system. We load the samples into wells into acrinamine gels, apply electric current through it ... and the DNA separates in terms of the size of the fragments, the larger fragments migrating at a slower rate through the gel than the smaller fragments, a process that last for about 2 1/2 hours.

You can't visualise the DNA. It's not something you can see so what we do is mix it with a dye so we can monitor the run. The next step is to put the samples through the Hitachi FMBIO II Fluorescence Imaging System or scanner.

During the amplification process the piece of DNA that is used to detect the variable segments is labelled with fluorescent dyes. Once the samples are run through the gel the fluorescent dye is still there and the fluorescence scanner allows you to visualise the dyes. It is attached to a computer and everything is done by the machine including all the analysis -- typing the actual sample. We have to determine the name of the alleles (fragments) that are present in a sample; it determines that for us. It also dumps it into a database.

As Dr. Cruickshank explained, Once you start talking about database, we are speaking of volume, hence the need to computerise and to automate.

Mr. Beecher: What the United States is running now is a database system called CODIS (Combined DNA Index System) and what they are doing is basically taking samples from scenes of crime and from suspects and dropping them onto the database so they can try and match crimes.

(The FBI in November 1997 announced the selection of the CODIS system to constitute the core of the United States national DNA database. Using these databases will make it possible to tie suspects to crime scenes and crime scenes to another through comparisons of DNA evidence.)

It is this type of system that the DNA Unit has just installed and is now running checks on and validating; it will be using the same software that the US is using. `So eventually the database will have crime-scene samples and samples from suspects, samples from missing persons, and such. So you are looking at different hits that you can get -- scene-to-scene hits. For example a crime committed in say Montego Bay could be matched to one committed in Kingston and a DNA profile obtained`.

DNA is also useful where a wrongdoer uses aliases. For example, a man may have committed a crime in Montego Bay, changed his name and come to Kingston, but left a profile in Montego Bay and also left a profile in Kingston. DNA could determine that that was one and the same person. This could be determined from hair, blood, semen, or fibre taken from the crime scene.

(In Budleigh Salterton, Devon, England in January 1998, a man was convicted of burgling a shop after being identified by a cigarette butt he discarded at the scene of the crime.)

According to Mr. Beecher the forensic community is trying to standardise their systems, using this technology. This is where they are going now. `Essentially what we are moving for is sharing of information across country borders. The International Criminal Police Organisation (Interpol), with headquarters in Paris, is trying to facilitate that. They want to be the centre. So if you want to do a search of a database in the United States for instance you would send the profile to Interpol which would send it on to the United States which would search their database and route their findings back through Interpol.

`We are up-to-date. This new system has really put us there. This should be around for a little while as everybody is standardising on this system.`

In several European countries, the United States and other countries legislation has created centralised databases that will eventually include DNA profiles of millions of individuals, primarily convicted felons.

Next: DNA -- SOME OTHER USES