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DNA – the Key to Unique and Infallible Identification

September 2009 marks the 25th anniversary of the discovery of DNA fingerprinting, when it was realised that the incredibly variable patterns in the structure of DNA could be used to distinguish one individual from another, opened up a new field of scientific investigation that has since helped to solve numerous crimes and answered questions and disputes over personal identity, paternity, immigration, conservation, and cloning. All organic matter has DNA, and a company that is using the principal of DNA identification and applying it to the authentication sector is Applied DNA Sciences, which has recently announced a number of breakthrough applications and clients. To mark the 25th anniversary of the discovery of DNA fingerprinting, and to find out more about how it is applied in our sector, Authentication News spoke to ADNAS CEO James Hayward.

Applied DNA Sciences was founded to market DNA authentication technology. It subsequently acquired the technology and all its related intellectual property, and since then has developed and patented a variety of new technologies. Its patent portfolio now includes 12 issued and 26 pending patents, as well as numerous trademarks.

The company was floated and took its present name in 2002. Originally based in Los Angeles, the corporate headquarters were relocated to the Long Island High Technology Incubator at Stony Brook University, New York (a corridor for DNA technology) in 2005, where it established laboratories for the manufacture of DNA markers and product prototypes, as well as DNA authentication.

At that time, Dr Hayward, a biochemist and entrepreneur with a track record in developing and managing biotech companies, became CEO. Since then, a new management team and Board has been put in place and the company is now beginning to make significant inroads into commercial markets for the technologies it has spent the past decade or so developing.

In April this year, meanwhile, it opened a laboratory in the UK. Operated by its subsidiary Applied DNA Sciences Europe Ltd, the new testing facility is located at the Textile Centre of Excellence in Huddersfield, Yorkshire and will provide forensic authentication services and sales development and support for its clients throughout Europe.

Two Core Platforms

According to Hayward, the company is the only one in the world to make use of the complex codes embedded in botanical DNA as the ultimate solution to counterfeiting. The solution is based on two core platforms. One is *SigNature® DNA*, which uses the DNA from plants to mark and authenticate products in a unique manner that essentially cannot be copied. The other is *BioMaterial Genotyping*™, which offers a means for determining the authenticity of natural materials used in finished products by detecting and identifying their genomic or endogenous DNA.

The process for the first of these platforms, SigNature DNA, comprises three steps. First is the creation and encapsulation of a specific encrypted DNA segment. Second is the application of this to a product or item. And third is the detection of the presence or absence of the specific segment.

Inherently Unique

During the manufacturing process, the naturally-occurring botanical DNA segment or segments are taken and rearranged into unique encrypted segments or *chimers* whose sequences are known only to ADNAS. These sequences are then recorded and stored in a secure database. The DNA is modified, not for its biological relevance, but for its information content and is rendered biologically non-functional during this process. Because DNA is inherently unique and dense with information, only minute amounts of DNA molecules need to be placed on any product to mark and authenticate it.

A proprietary encapsulation system that applies a protective coating to encrypted DNA chimers stabilises these, creating SigNature DNA markers that are resistant to heat, organic solvents, chemicals and UV radiation and so can be identified for hundreds of years after being embedded directly or applied or attached to the item to be marked. According to Hayward, the company is able to extract and detect the DNA at all stages of the process – from initial application through to finished product – and has processes in place to insure that SigNature DNA is present on all items as part of its quality control measures.

Three Detection Methods

Once applied, the presence of the markers can be detected at any point in the supply chain via one of three methods.

First is a simple spot test carried out in the field using a hand held device, the size of a key fob, that instantly detects the presence of rapid reporters layered within the marker.

Second is a more complex field test based on PCR (polymerase chain reaction) with a hand held device that confirms authenticity in around ten minutes.

And third is full forensic DNA sequencing, which is performed in ADNAS' laboratories. This obtains definitive proof of the presence or absence of a specific type of SigNature DNA Marker that can be used as evidence in courts of law.

Because the portion of DNA in a SigNature DNA Marker is so minute, it cannot be detected unless it is replicated billions of times over, or amplified. This amplification can only be achieved by applying matching strands of DNA, or a primer and PCR techniques to the SigNature DNA marker. The sequence of relevant DNA has to be known in order to manufacture the primer for that DNA. As a result, the effort required to find, amplify, select and clone the relevant DNA in a SigNature DNA marker would involve such enormous effort and expense that they are virtually impossible to copy without ADNAS's proprietary systems.

Distinct and Unique

According to Hayward, each SigNature DNA marker is distinct and unique, with the nature

of DNA allowing for customised markers that do not have to be repeated as there is a near-infinite number of codes.

SigNature DNA has now been prototyped and tested in many different types and forms of inks (including intaglio, offset, UV), toners, varnishes, adhesives, paints, polymers, laminates, cyanoacrylates and textile treatments. Furthermore, it is safe to use in ingestible products, making it suitable for sectors such as wines, foods and pharmaceuticals.

BioMaterial GenoTyping
The second platform technology, BioMaterial GenoTyping, uses the DNA of a natural material to authenticate the finished product from which it is made. Applications for this version of the company's technology are broad and include anything that is biological in nature – including, but not limited to, textiles and apparel, consumables, nutraceuticals, and biotherapeutics.

The first of these – textiles and apparel – is a key market. The unique signature that the genomic DNA from mature cotton leaves behind, for example, is ideal to forensically authenticate cotton fiber, yarn, greige, finished fabric and apparel, and can be used to identify not only fibre content but also geographic origin. In conjunction with Supima, the trade group representing US pima cotton growers, ADNAS has developed a commercial test - *FiberTyping* - that can differentiate between pima and upland cotton from fiber to finished fabric and apparel, adding accountability to all stages of the textile manufacturing process. It has also developed *PimaTyping,* which differentiates between the pima cottons grown in different regions of the world by distinguishing specific cotton cultivars.

Prior to these tests, there had never been a successful attempt to extract DNA from mature cotton fibres, as these were believed to be devoid of usable DNA. ADNAS proved otherwise. In addition to American Pima, its tests can be used to test for premium fiber and products such as Egyptian Giza, Peruvian, Sea Island, and Israeli extra long staple cottons.

In addition to textiles, ADNAS has high hopes for BioMaterial GenoTyping in the currency sector, having announced recently the development of a patent-pending method to track the genetic trail of the cotton fibres used in banknote paper. This method, similar to the tests developed for Supima, could be used to validate the authenticity and source of the material in the substrate even after multiple subsequent stages of production, including paper forming and printing.

Major CIT Business
One of the largest verticals to date for the company is in a sector related to currency, namely cash-in-transit, through SigNature DNA and the provision of related authentication services to Loomis, one of the world's largest CIT companies, for its UK operations.

Loomis is using the markers in its cash degradation systems, which are installed in the containers used to transport cash. When the containers are opened without authorisation or moved outside a predetermined location, the systems activate to stain the contents (and the criminals) with the indelible ink, marking the cash as stolen and rendering it worthless. The use of SigNature DNA within the dye provides each cash box with its own unique identity, thereby enabling law enforcement to trace the origin of stolen cash and forensically authenticate it so that recovered cash can be attributed to specific robberies, to individual criminals, and to the original owners.

According to ADNAS, since it started working with Loomis in January last year, its share of the CIT taggant market in the UK has increased to nearly 20%.

Breakthrough in Textiles
Another of the company's breakthrough contracts is also in the UK, this time in the textile sector. SigNature DNA has been selected as the sole security platform for a programme funded by the European Regional Development Agency and the regional development agency Yorkshire Forward to protect UK-manufactured fibres (which are produced principally in the region) from 'fibre-to-fabric', as well as products from other industries.

The contract follows a trial to mark wool and woollen products from the region, also funded by Yorkshire Forward (see AN Vol 15, No 4), the objective of which was to demonstrate that SigNature DNA could withstand the different textile manufacturing processes, including dyeing, scouring, washing and dry cleaning. According to the company, the marker was authenticated unequivocally at every stage.

This second phase contract will bring the level of funding to £5.95m over three years for four chosen technology platforms, and represents ADNAS' largest contract to date. It will support other pilot studies and a commercial scale-up of the SigNature DNA markers. In addition, ADNAS is receiving a capital grant of around £250,000 for the new forensic authentication facility.

Largest Deployment Yet
In another major coup in the textile sector, ADNAS has successfully marked over 500,000 pounds of raw cotton fiber as part of a pilot study conducted in collaboration with one of America's largest cotton growers. The pilot, a complement to the above-mentioned Supima program to track cotton's native DNA through BioMaterial Genotyping, is the largest deployment of a commercial DNA marker to date, says the company.

According to ADNAS, as a result of this and the work with Yorkshire Forward, SigNature DNA is fast becoming recognized by the textile and apparel industry not only for cotton, but a wide range of commercial and industrial textile applications. For an industry plagued by authentication issues, where counterfeiting is rife and where compliance with labelling laws and trade quotas is required, SigNature DNA could be used to give every SKU in the world a unique mark.

Other Sectors
Whereas textiles and CIT are the two sectors that have provided technical and commercial breakthroughs for the company, it is also working to prove its technology in a number of other sectors, with feasibility studies successfully completed in event ticketing, homeland security and document printing. For example, it has worked with Print Color Screen of Switzerland to develop *spectraCRYPT*, a line of tagged security inks for passports, drivers licences and brand protection applications, and with IIMAK on thermal transfer ribbons incorporating SigNature DNA. It has also developed a tagged laminate together with a leader in security laminates for use in credit cards, travel documents and government-issued ID documents.

In the wine sector, it has successfully concluded a pilot study with two 'boutique' wineries on Long Island to incorporate SigNature DNA into the inks used to print the labels, and is now working on a similar project for tamper-evident foil capsules and screw-on bottle tops. It sees the global wine industry as a key sector for the company.

Looking for Partners
It sees the same of pharmaceuticals, due both to its size and because the biological nature of SigNature DNA means that it can be easily incorporated into drug doses, pills and topical skin treatments.

Because, however, FDA approval is required for the use of markers in pharmaceutical products, the company is actively looking for a partner to develop unique dosage markers.

In addition, ADNAS has a number of applications for pharmaceutical packaging under development, and also sees opportunities for its BioMaterial Genotyping platform for identifying DNA content in biological drugs and in natural ingredients used in pharmaceuticals, skin products, cosmetics and nutraceuticals.

Profitability in Sight
The two major new sectors, along with the inroads it is making into the wine sector and the successful conclusion of a number of pilots and feasibility studies, will bring much-needed revenue streams to ADNAS, which has accumulated substantial debts in the course of developing and commercialising its technologies.

Last year it had sales of just over $870,000. According to Hayward, the cross-over to profitability for the company is now in sight. Given that he has abstained from taking a salary until the company becomes profitable he will not, it would appear, have to wait too much longer.