Institution: University of East Anglia

Unit of Assessment: 8 - Chemistry

Title of case study:

***Intelligent Fingerprinting Ltd.* – a spin out company from the School of Chemistry**

1. Summary of the impact

The spin-out company *Intelligent Fingerprinting Ltd*. was founded in 2007, based on Professor David Russell's research. The company develops novel technologies using antibody-nanoparticle reagents to detect drugs and drug metabolites in latent fingerprints whilst simultaneously providing high resolution fingerprint images for identification purposes. Combining these technologies with a fluorescence-based hand-held reader provides a non-invasive diagnostic platform for use in the criminal justice sector, institutional testing and hospital environments.

Total funding to date for the company has been >£3.2M in four investment rounds. The company employs 11 staff, who work in dedicated office and laboratory premises within the Norwich Research Park Innovation Centre.

The company received its first purchase order from the UK Home Office in 2012. A distribution agreement is in place with Dallas-based SmarTox Inc. for North American sales of *Intelligent Fingerprinting* products for 'Drugs of Abuse' testing.

2. Underpinning research

Professor David Russell's research is focused within bioanalytical chemistry, particularly in developing nanoscale-based approaches for novel chemical measurements. As part of this research, gold nanoparticles were synthesised and then stabilised with a monolayer of Protein A. Anti-cotinine antibody was then bound to the Protein A on the nanoparticles to provide a conjugate that was used to detect cotinine, the major metabolite of nicotine, in the fingerprints of smokers. The antibody conjugates bound to the cotinine antigens, while a fluorescently-tagged secondary antibody fragment was used to image the fingerprints. Not only did the reagents detect the drugs and drug metabolites in fingerprints, but they simultaneously provided a high resolution image of the print to establish the identity of the individual.

Initial research was performed by M.Chem. student **Emma Lee-Smith** during her final year research project in 2005 under the supervision of Professor Russell. Her work and subsequent Ph.D. research studies by **Richard Leggett** (Ph.D. awarded in 2007), also from the Russell laboratory, were patented (1) and then published (2). Following publication, there was considerable media attention as this was the first report that drug metabolites, and therefore drug usage, could be determined from the sweat deposited in a fingerprint. These results also provided preliminary data for a collaborative EPSRC research grant (i) with Dr Sue Jickells and Dr Barbara Daniel from the Department of Forensic Science and Drug Monitoring at King's College London.

The EPSRC research grant supported **Dr Pompi Hazarika** (post-doctoral research associate at UEA, 2006-2010) who developed iron oxide based particles which were functionalised with Protein A/G. Protein A/G is a recombinant fusion protein that combines IgG-binding domains of both Protein A and Protein G. This created an exceptionally versatile platform on which numerous classes of antibodies could be bound. The platform technology was used to conjugate various antibodies that specifically bind to their target antigen. These antibody-particle conjugates were used to detect: Δ9- tetrahydrocannabinol (THC), the main psychoactive component of marijuana; methadone, a synthetic opioid generally prescribed as a substitute pharmacotherapy to heroin-dependent patients; 2-ethylidene- 1,5-dimethyl 3,3-diphenylpyrrolidine (EDDP), the major metabolite of methadone; and benzoylecgonine, the major metabolite of cocaine in the fingerprints of volunteers attending a methadone maintenance programme (3). Publication of paper (3) prompted further significant media attention since the paper highlighted the detection of illegal drugs and drug metabolites using the antibody-magnetic particle conjugates.

An EPSRC Follow-on Fund grant (ii) was awarded to Russell in 2009 to further develop the

antibody-particle conjugates for forensic applications. Results from this study reported the multiplexed detection of *two* drug metabolites (from heroin and cocaine) in a single fingerprint (4).

The University of East Anglia patented the technology, focused on the antibody-particle conjugates for the combination of drug detection and personal identity, in 2007 (1). Patents were granted in the European Union (2011), Australia (2012) and United States (2013). Other territories are pending. The University maintained the family of patents until they were assigned to *Intelligent Fingerprinting Ltd* in February 2012.

3. References to the research

(UEA authors in bold)

1. **Patent**: WO 2007/110605: Fluorescence-based detection of substances
   D. A. Russell, **R. Leggett**, **E. E. Lee-Smith**, S. M. Jickells and B. Daniel
2. "Intelligent" fingerprinting: Simultaneous identification of drug metabolites and individuals by using antibody-functionalized nanoparticles
   R. Leggett, **E. E. Lee-Smith**, S. M. Jickells and **D. A. Russell**
   Angewandte Chemie International Edition, **2007**, *46*, 4100-4103.
   doi: 10.1002/anie.200700217
   This paper was highlighted by: Nature (2007, *447*, 119); Nature Nanotechnology (2007, *2*, 388); New Scientist, Chemistry World; Chemistry & Industry; C&E News; Analytical Chemistry; National newspapers - Sunday Telegraph; Daily Mirror; International media - CNN On-line; Interviewed by German and BBC radio.
3. Imaging of latent fingerprints through the detection of drugs and metabolites
   P. Hazarika, S. M. Jickells, K. Wolff and **D. A. Russell**
   Angewandte Chemie International Edition, **2008**, *47*, 10167- 10170 (plus inside cover).
   doi: 10.1002/anie.200804348
   This paper was highlighted by: Angewandte Chemie as a 'Very Important paper'; Nature Materials (2009, 8, 5); Discovery Channel on-line; Chemical and Engineering News (Dec 22, 2008, p34); Interviewed for BBC World Service Radio.
4. Multiplexed detection of metabolites of narcotic drugs from a single latent fingermark
   P. Hazarika, S. M. Jickells, K. Wolff and **D. A. Russell**
   Analytical Chemistry, **2010**, *82*, 9150-9154.
   doi: 10.1021/ac1023205

Grants Awarded:

i. Light it up: A nanotechnology approach for the acquisition of forensic evidence
   D. A. Russell (UEA); S. Jickells and B. Daniel (King's College, London)
   EPSRC, 2006-2009, £426,569 (UEA - £247,956)

ii. Nanoconjugates for the detection of forensic residues
   D. A. Russell
   EPSRC Follow on Fund, 2009-2010, £100,047

4. Details of the impact

Intelligent Fingerprinting Ltd., a spin-out company created from the research of Professor David Russell [corroborating source A], has developed a unique *in vitro* diagnostic technology platform that non-invasively screens for metabolites present in fingerprint sweat while simultaneously enabling determination of personal identity. Using a hand-held device, the test can determine recent drug history within 10 minutes. This technology has substantial potential in rapid point-of-care *in vitro* diagnostic testing. The *Intelligent Fingerprinting* test offers a direct link between individual (biometrics) and result (diagnostics), by clearly identifying drug metabolites found in the sweat deposited in the unique patterns on the ridges of each fingerprint. The test is therefore unequivocally linked to an individual. Results can be rapidly rechecked to confirm any diagnosis. The core competency of the company is the antibody-functionalised nanoparticles and fluorescence imaging detection. A person places a fingerprint on the hand-held device, the device then dispenses the reagents. Following incubation and removal of excess particles, the device

images the fingerprint to determine the presence of drug metabolites. The key industry sectors for the company are Criminal Justice – drug rehabilitation and roadside screening for drug driving; Institutional testing – prisons, military and commercial companies; and Healthcare – patient testing, hospital admissions and drug compliance. Current screening methods using urine, blood or saliva have restricted usefulness linked to invasive collection of hazardous samples, donor dignity, transport and disposal of bio-hazardous waste and, most importantly, problems associated with the ability of tested individuals to cheat the system. The *Intelligent Fingerprinting* test overcomes all of these limitations.

Intelligent Fingerprinting Ltd. was founded in 2007. A Proof of Concept award from the East of England Development Agency (EEDA) [corroborating source B], with a supporting contribution from UEA, (totalling £48K) was used to pay for market research, performed by two independent companies. Having established considerable market potential in several sectors, the ICENI Seedcorn University Challenge Fund invested £221K in 2009 for a share of equity in *Intelligent Fingerprinting Ltd*. based on milestones around the further development of the reagent chemistry and business plans. All milestones were achieved ahead of schedule. In December 2010, Porton Capital Inc., a venture capital investor company, together with their UK company Synergis Technologies Ltd. made a £250K investment in *Intelligent Fingerprinting Ltd*. [corroborating source C]. At the same time, a further £50K was invested by ICENI Seedcorn University Challenge Fund. This second round funding was used to hire a small team of staff and to develop a prototype hand-held instrument that could dispense the reagents onto the fingerprint and then image the resultant prints to establish drug use. In February 2012, a consortium of US-based individuals invested £2M in *Intelligent Fingerprinting Ltd.* for a share of equity [corroborating source D]. The third round funding provided for expansion of the company's staff and research and development activities. Key products are the antibody-particle reagents and the self-contained, hand-held device that applies the reagents to a fingerprint through microfluidics and then fluorescently images the fingerprint. In 2013, US investors provided a fourth funding round of £750K for the manufacture of demonstrator products. To date, total investment in the company has been in excess of £3.2M.

Intelligent Fingerprinting Ltd. has signed a North American distribution agreement with Texas-based SmarTox Inc. with ambitious sales targets of both the hand-held device and antibody-particle based reagent cartridges [corroborating source E]. *Intelligent Fingerprinting Ltd.* received its first purchase order for services from the UK Home Office in 2012 [corroborating source F].

In 2012, as part of on-going product development in conjunction with key end-users, *Intelligent Fingerprinting Ltd.* applied for, and won, two research grants totalling £425K from the MRC/TSB 'Biomedical Catalyst' scheme for pilot studies with the Accident and Emergency Department at the Leicester Royal Infirmary and H. M. Coroner's Office in Sheffield respectively. The first project assessed the feasibility of the technology for fast, non-invasive drug screening of hospital A&E patients on admission. The second project, working with the Sheffield coroner, has been trialling *Intelligent Fingerprinting*'s non-invasive drug testing device to establish cause of death without the need for full, invasive toxicological screens. Additionally, in 2013, *Intelligent Fingerprinting Ltd.* won a €982K EU Eurostars grant with the University of Eastern Finland and Finnish SME Addoz Oy to develop a remote diagnostic monitor for opiate-substitution treatment [corroborating source G].

The fingerprint methods developed by Russell are included in the new *Fingermark Visualisation Manual* (publication and distribution in January 2014) [corroborating source H]. This manual, produced by the Home Office Centre for Applied Science and Technology (CAST), is distributed to all UK police forces. It is *the definitive* source of fingerprinting methods and their application for police and forensic use in the UK. Importantly, as the key fingerprint information source, the Manual is also used by Police Forces across Europe, USA, Australasia and Asia.

Based in dedicated offices and laboratories at the Norwich Research Park Innovation Centre, *Intelligent Fingerprinting Ltd*. now employs 11 staff: Dr Jerry Walker (Chief Executive), Dr Paul Yates (Business Development Manager), Dr Mark Hudson (Development Director), Su Mace (Finance Officer), 6 technical/scientific staff (4 Ph.D.s and 2 graduates) and a PA. In addition, the company has bought out Professor Russell from his University duties (2011-2013 inclusive) for 40% FTE, to enable him to work as the Chief Technical Officer.

Intelligent Fingerprinting Ltd. has already received considerable recognition for its activities,

including [corroborating source I]:

- In four consecutive years, 2010-2013 inclusive, *Intelligent Fingerprinting Ltd.* was highlighted as one of 50 companies with future potential in the East of England through the Eastern Daily Press (EDP) '**Future50**' competition.
- In 2012, *Intelligent Fingerprinting Ltd.* won the 'One to watch' category at the EDP Business Awards.
- *Intelligent Fingerprinting Ltd.* was shortlisted in the 2010 Times Higher Education Awards in the 'Outstanding Contribution to Innovation and Technology' category.

The original science behind the company has also been recognised by EPSRC, with the science of the fingerprinting research developed as part of the original grant (grant (i) above) highlighted in the EPSRC '*Pioneers*' magazine 2009 and within the EPSRC 'Impact Case Studies' (Case study 08) in 2010 [corroborating source J].

5. Sources to corroborate the impact

A Registration of *Intelligent Fingerprinting Ltd*. Company number 06409298 – Companies House. Company website: http://www.intelligentfingerprinting.com/

B Nanotechnology for fingerprint and metabolite detection
East of England Development Agency (EEDA), Proof of Concept Award; 2007-2008; £38.5K together with £10K contribution from UEA.

C Investment agreement with venture capital funder 'Porton Capital Inc.' (copy held on file at UEA).

D Investment agreement and audited accounts filed with Companies House April 2013, showing £2M investment by US investment consortium. (Copies held on file at UEA)

E *Intelligent Fingerprinting Ltd.* 'Distribution agreement' with SmarTox Inc., Dallas, Texas, USA (subsidiary of SmartStart Inc.). (Copy held on file at UEA)

F UK Home Office Purchase Order 2012 (Copy held on file at UEA)

G Research grant awards:
   a. Biomedical Catalyst Feasibility Award: Medical Research Council / Technology Strategy Board; £135,000; 2012-2013; *Intelligent Fingerprinting Ltd.* and A&E Department (Professor Tim Coates) Leicester Royal Infirmary.
   b. Biomedical Catalyst Early Stage Award: Medical Research Council / Technology Strategy Board; £290,000; 2012-2014; *Intelligent Fingerprinting Ltd*. and Sheffield Coroner's Office.
   c. EU Eurostars Award: €982K; 2013-2015; Fingerprint Recording in Opiate Substitution Treatment (FR-OST) – Non-invasive Diagnostic Monitoring' *Intelligent Fingerprinting Ltd.* with the University of Eastern Finland and Addoz Oy.

   (All details held on file at UEA)

H *Fingermark Visualisation Manual*, Home Office Centre for Applied Science and Technology (CAST). Publication and distribution to UK Police Forces, January 2014.
(Notices of publication and inclusion held on file at UEA)

I Awards to *Intelligent Fingerprinting Ltd*.
   a. EDP Future 50; 2010-2013 inclusive (copies of articles held on file at UEA)
   b. EDP 'One to Watch' business awards winner 2012 – Video of Professor Russell collecting the award on behalf of *Intelligent Fingerprinting Ltd.* http://www.intelligentfingerprinting.com/news.html
   c. Shortlisting for 2010 Times Higher Education Award: http://www.timeshighereducation.co.uk/story.asp?storycode=413567

J EPSRC 'Pioneers' magazine (2009) and EPSRC Impact Case Study number 08 (2010). (Copies of both documents held on file at UEA)