Institution: **10007822**

Unit of Assessment: **12**

Title of case study: **Osteomics: improved biomedical product development**

1. Summary of the impact (indicative maximum 100 words)

Cranfield's research on Osteomics (the science of bones) & Biominerals (O&B) has improved the manufacture and performance of biomedical prostheses. The techniques developed have also resulted in a spin-out company and analytical techniques with broader application in forensic casework. Specifically, our research has resulted in:

(i) Improved biomedical prostheses where new coating techniques and new product quality assurance protocols and standards underpin coating processes in industry; worth several £M/year. These have been developed with, and are currently used by Biomet, an international medical device manufacturer.

(ii) The creation of a spin-out company, HALO X-ray Technologies, to exploit the technologies based on our novel X-ray analytical techniques.

(iii) Several new analytical methods for the discrimination of bone in forensic case work (used by Cellmark Forensic Services (CFS)).

2. Underpinning research (indicative maximum 500 words)

Biomaterial research at Cranfield has a long (>15 years) track record. Biomimetic approaches to producing chemically active coatings have always been an attractive goal for the pharmaceuticals industry. These approaches have the potential for significant energy and materials savings. Further, clinical trials have indicated that enhanced bone ingrowth and biomimetic coatings could reduce health burdens by several £M and improve quality of life.

Our research in this domain is based on:

- analytical characterisation
- development of industrial and analytical processes
- synthesis of apatite based biominerals
- characterisation of natural biomineral materials (e.g. bone) and synthetic analogues.

Cranfield has pursued physicochemical characterisation of biological apatites to address key issues associated with understanding their physical behaviour, disease, and the difference between biological materials [P1] and man-made substitutes. Understanding biological apatites - calcium phosphate materials that are the major constituents of bones – has allowed the use of crystallographic analysis in forensic identification for species recognition [G1, P2]. Cranfield has also developed physico-chemical methods for the industrial scale manufacture and characterisation of biomimetic coatings on endoprosthetics (e.g. hip implants) [G2, G3].

Our research has focussed on new manufacturing techniques for bone-like coatings on these implants and the detailed in-situ characterisation of biomimetic, active coatings. These coatings have a complex chemistry and a number of components with a range of structural orders. Cranfield's research has included quantification of the composition with depth through the coating and the engineering of 'smart' materials. This was supported by research to develop novel quality

assurance protocols for such coatings [P3, P4] and by the development of new approaches to rapid data acquisition [P5].

Key Researchers	Post details and dates involved	Research
Prof K D Rogers	Professor, Tenure throughout	(G2,3)
Dr P Zioupos	Reader, Tenure throughout	(G1,3)
Dr S Beckett	Research Fellow, 2006-2012 , Lecturer, 2012-present	(G2,3)
Dr A Williams	Research Fellow, 2004-2006, Lecturer, 2006-present	(G1)

3. References to the research (indicative maximum of six references)

Evidence of quality – peer-reviewed journal papers

P1 Zioupos P & Rogers K D, *Complementary physical and mechanical techniques to characterise bone-like tissues*. J. Bionic Engineering, **3**(1), pp. 19-31, 2006. DOI: 10.1016/S1672-6529(06)60003-6

P2***** Rogers K D & Daniels P, *An X-ray diffraction study of the effects of heat treatment on bone mineral microstructure*. Biomaterials, **23**, pp. 2577-2585, 2002. DOI: 10.1016/S0142-9612(01)00395-7

P3* Rogers K D, Etok S E, Scott R[a], *Structural characterisation of apatite coatings*. Journal of Materials Science, **39**(18), pp. 5747-54, 2004. DOI: 10.1023/B:JMSC.0000040085.43633.8a

P4 Rogers K D, Etok S E, Broadhurst A, Scott R[a], *Enhanced analysis of biomaterials by synchrotron diffraction*. Nucl. Inst. Meth. A **548**, pp. 123-128, 2005. DOI:10.1016/j.nima.2005.03.078

P5***** Evans P[b,c], Rogers K D[c], Chan J[b], Rogers J, Dicken A[b,c], *High intensity x-ray diffraction in transmission mode employing an analog of Poisson's spot*, Appl. Physics Lett. **97**, p. 204101, 2010. DOI: 10.1063/1.3514235

* Three identified references that best indicate the quality of the research

Key to papers

a: Biomet

b: Nottingham Trent University

c: Halo X-ray Technologies Ltd

Further Evidence of quality – underpinning research grants

G1 EPSRC (GR/S98054), *A laboratory based analytical method to determine 'age at death'*,

£127k; 2004-2006 PI: P Zioupos; CI: S Black (U Dundee), J Clement (U Melbourne)

G2 EPSRC (GR/R19700), *A new method for non-destructive depth profiling in thin film materials*, £175k; 2001-2004 PI: KD Rogers

G3 EPSRC (GR/R23404/01), *A multipurpose X-ray diffraction facility*, £295k; 2001-2004 PI: KD Rogers

4. Details of the impact (indicative maximum 750 words)

Cranfield's research on osteomics and biominerals has enhanced the use of biomaterials in health applications and forensic analysis, and improved industrial standards in the manufacture of medical prosthetics.

- The research has resulted in robust quality assurance protocols for biomimetic coatings that have been adopted across Europe. These protocols are used by Biomet, an international medical device manufacturer, and are essential for the reliable supply of many M€ worth of prosthetic products, [C1].

- A unique approach to structural tomography developed by Cranfield to derive depth resolved physicochemical information is now employed by Biomet, amongst others, as a biomimetic method for chemical modification of endoprosthetic surfaces. This has become a commercial coating, being produced in five factories across Europe, [C1].

- A spinout company from Cranfield, in collaboration with Nottingham Trent University, (Halo X-ray Technologies, registered in 2012) has been formed based on the unique methods developed for data acquisition from our analytical techniques. Rogers is a Director (Chief Scientific Officer) and the company has attracted further funding – from EPSRC and TSB in partnership with other UK companies – to develop novel sensors for XRD-crystallography in-situ and in-vivo. The company was awarded a grant for $3.5M from the US Department of Homeland Security in July 2013 which enabled it to recruit an additional 4 members of staff, [C2].

- New methods based on our work on the characterisation of natural bone have led to the development of species discrimination techniques. These have been applied in the casework of forensic providers where human identification is required (Cellmark Forensic Sciences), [C3].

5. Sources to corroborate the impact (indicative maximum of 10 references)

C1 Contact: Head of Research & Development, BIOMET

C2 Contact: CEO, Halo X-ray Technologies

C3 Contact: Former Specialist Forensic Practitioner, Cellmark Forensic Services