Institution: University of Bradford

Unit of Assessment: A3 Allied Health Professions, Dentistry, Nursing and Pharmacy

Title of case study: Impact in the marketplace: translating research to brands for business growth and consumer communication.

Period when the underpinning research was undertaken: 2015 - 2020

Details of staff conducting the underpinning research from the submitting unit:

Name(s):	Role(s) (e.g. job title):	Period(s) employed by submitting HEI:
Julie Thornton (JT)	Professor of Cutaneous Biology & Director of CSS	1990-present
Rachael Williams (RW)	Research Assistant	2014-present
Stephen Sikkink (SS)	Senior Scientist	2009-present
Desmond Tobin (DT)	Professor of Cell Biology	1989-2019
Vladimir Botchkarev (VB)	Professor in Cutaneous Biology	2006-2019
Natalia Botchkareva (NB)	Reader in Cutaneous Biology	2006-2018
Michael Fessing (MF)	Associate Prof. Molecular and Cell Biology	2006–present
Andrei Mardaryev (AM)	Associate Prof. Stem Cell Biology & Regenerative Medicine	2007-present
Krzysztof Poterlowicz (KP)	Associate Prof. Bioinformatics & Biostatistics	2013-present

Period when the claimed impact occurred: 2015 - 2020

Is this case study continued from a case study submitted in 2014? N

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

The Centre for Skin Sciences (CSS) has, over the last decade, collaborated with 35+ companies on 60 projects in the cosmetics, personal and health care sectors in the UK, USA, Asia and Europe. We have successfully translated our fundamental research into impact in international markets, including launch by BASF Beauty Care Solutions of DN-Age™ for hair greying; relaunch of Aveda hair care brand Invati 3.0 in China; launch of the Aveda scalp care brand Pramasana in the USA; contributed to UKRI policy to launch of a data-management-tools training programme in UK HEI's and bespoke development for J&J (USA) of a software platform for reproducible biomedical and healthcare data analysis.

2. Underpinning research (indicative maximum 500 words)

Products for life-long skin and hair health need to contain active ingredients which are effective when used by consumers. There is an increasing expectation from consumers that the development of products that yield perceptible benefits is driven by strong science in support of compelling claims and brand credibility. Therefore, development of beneficial skin and hair products needs to be directed by a fundamental understanding of skin and hair biology as delivered to BASF and Aveda (1,2). The impact of ageing on cells and tissues at the molecular level has been recognised as a particular academic strength of CSS by industry, evidenced by significant recurring funding (1-2). Our ground-breaking research and extensive knowledge dissemination through conferences, publications and reports to industry partners, has firmly embedded the study of cutaneous aging (1,2) and skin epigenetics (3-6) as fundamental areas of research in modern dermatology across academia, industry and clinical medicine, both in the UK and internationally.

The key research insights that underpin our impact in the cosmetics and personal care market are as follows:

- Discovery by Tobin (PI, 2013-2019) and Sikkink (PDRA, 2013-2019) of the exclusive expression of nuclear Ataxia Telangiectasia (ATM, an ageing biomarker) within hair bulb melanocytes, demonstrating that ATM contributes a distinct role in protecting human hair follicle melanocytes from oxidative stress/damage within the hair bulb (1). This enabled us to provide direct evidence for benefit of BASF product DN-Age for hair ageing, marketed internationally since 2018 and exploited in new hair care brands in 2020.
- Thornton (PI) and Williams (RA) (2015-2020) provided proof of the collapse of the architecture of scalp skin dermis with increasing age in females and discovered changes in previously unknown molecular factors important for healthy/young scalp and hair growth (2). In a collaboration with AVEDA, Thornton and Williams (2015-2020) identified over 60 biomarkers relevant to age-related changes in scalp and hair follicles.
- Significant contributions from Botchkarev (PI, 2014-2019), Fessing (PI, 2014-2018), Mardaryev (PI, 2016-2019), Botchkareva (PI, 2017-2018) and Poterlowicz (PI, 2016-2019) to the field of understanding epigenetics in skin/hair biology (3-5) at both the fundamental and applied level – attracting industry funding (Unilever (MF), Amway (NB), J&J (KP)and Follicum (KP). VB and MF were first to identify that the spatial contact network inside the nucleus between gene 'promoters' and 'enhancers' is crucial for coordinated control of gene expression through p63 (4) and NB was first to discover a role for miR-21 expression in skin ageing (5).
- Poterlowicz's research (2016-current) led to the development of new computer methods to analyse spatial chromatin organisation and location of gene enhancer sites for understanding epigenetics of skin development (4-6). The methods involved developing new 'R' software packages and applying to 5C, CHiP-Seq and RNA-Seq data (4). We also applied these methods to integrate different types of data (CHiP-Seq, RNA-Seq) and discovered the mechanisms on how p63 regulates nuclear envelope associated genes (5). We also developed and made publicly available, a user-friendly software toolkit (Ewastools) to integrate population epigenetics data into healthcare data analysis (6).

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

1. Sikkink, S.K. et al. (2020) Stress-sensing in the human greying hair follicle: Ataxia Telangiectasia Mutated (ATM) depletion in hair bulb melanocytes in canities-prone scalp. Sci Rep. 2020 Oct 30;10(1):18711. https://doi.org/10.1038/s41598-020-75334-9
2. Williams, R. et al. (2020) Age-related changes in female scalp dermal sheath and dermal fibroblasts: how the hair follicle environment impacts hair aging. J Investigative Dermatology. 18711. https://doi.org/10.1038/s41598-020-75334-9
3. Mohammed, I. et al. (2019). Interplay of MicroRNA-21 and SATB1 in Epidermal Keratinocytes during Skin Aging, J Investigative Dermatology. 139: 2538-2542. https://doi.org/10.1016/j.jid.2019.04.022
4. Poterlowicz, K. et al. (2017). 5C analysis of the Epidermal Differentiation Complex locus reveals distinct chromatin interaction networks between gene-rich and gene-poor TADs in skin epithelial cells. PLoS Genetics, Sep 1; 13(9):e1006966. https://doi.org/10.1371/journal.pgen.1006966
5. Rapisarda, V. et al. (2017) p63 transcription factor regulates nuclear shape and expression of nuclear envelope-associated genes in epidermal keratinocytes. J Investigative Dermatology, 137: 2157-2167. https://doi.org/10.1016/j.jid.2017.05.013
6. Murat, K. et al. (2020) Ewastools: Infinium Human Methylation BeadChip pipeline for population epigenetics integrated into Galaxy, *GigaScience*, 9(5): giaa049, https://doi.org/10.1093/gigascience/giaa049

Grants

1. BASF Beauty Care Solutions (France) to D Tobin: Melanocyte aging in the human scalp hair follicle pigmentary unit. 2013-2014; GBP59,140
2. AVEDA (USA) to J Thornton: The effect of an aging stromal environment on the pilosebaceous unit: 2015-2020; GBP843,873

3. Johnson &Johnson (USA) to K Poterlowicz: Predictive epigenetics of epidermal differentiation in health and disease using Bioinformatics and machine learning and transfer of Galaxy platform to J&J and validation: 2016-2019; GBP76,950
4. Follicum AB (Sweden) to K Poterlowicz: In Silico informatics search for roles of osteopontin in skin/hair. What is the role of Osteopontin in hair growth? 2018-2019; £20,400
5. Amway Inc (USA) grant to N Botchkareva. Regulation of skin ageing by targeting non-coding RNA activity. 2017-2018; GBP107,893
6. Elixir (EU) First human copy number variation community implementation study (EU) to Krzysztof Poterlowicz 2019-2021, GBP21,687
7. BBSRC Case award with Unilever Research UK to M. Fessing: Exploration of chromatin remodelling processes in human hair growth cycle and impact of chronological ageing on chromatin remodelling in hair regeneration. 2014-2018; GBP162,000
8. MRC/Newton Fund to V. Botchkarev: DNA hydroxymetylation, Tet enzymes and regulation of stem cell activity during skin regeneration and wound healing: 2015-2018; GBP494,000
9. MRC New Investigator Award grant to A. Mardaryev: Role of the Polycomb group protein Cbx4 in the control of skin regeneration and wound healing. 2016-2019; GBP545,000
10. MRC Confidence in Concept grant to A. Mardaryev: Lineage-specific targeting of epigenetic drugs for modulation of skin regeneration. 2018-2019; GBP56,000

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

Our underpinning research has directly supported our international industry partners' brand activity (Invati 3.0 (A,C) Pramasana (B), DN-Age™ (D,E)); with important and acknowledged contribution to company consumer education and sales (A-E) in USA, EU and China. Our expertise in molecular skin epigenetics analysis and software tools development and training for Life Science data analysis is recognised in the UK (UKRI), in Europe (Elixir) and USA (J&J) (F-L).

BASF is a global bioactive-ingredients supplier to manufacturers in the cosmetics and personal care sector. The quality and credibility of their ingredient portfolios is essential for sales of their products. BASF's product DN-Age™ has, as a result of the work carried out in Bradford, have been introduced into two European Brands for hair care (E). BASF have marketed a DN-Age™ package (D) to global manufacturers of hair care products since 2018 as a complete hair anti-aging rejuvenation product that slows down scalp skin and hair aging from the inside. In this package (D), the results from the University on the role of ATM in hair greying are described and acknowledged and the benefit of DN-Age™ was later shown in clinical studies to slow down hair greying. In a testimonial letter from BASF, the R&D Scouting & Communication Manager (E) commented that "the knowledge that the University Bradford has equipped us with has influenced our technical strategy enabling us to achieve an enlarged DN-Age™ market positioning in Europe directed to the hair care segment and meant we went to market with robust communications in product related information and with support at international conferences and events".

The Estee Lauder Company/AVEDA are a leader in sustainable agriculture, supporting the natural products industry, with plant-derived materials forming the core of their products and ethos. There is a growing interest in environmentally conscious everyday cosmetic products among consumers world-wide, as seen in the strong marketability of products branded 'green', 'natural', and 'local'. However, the basic research needed to justify the use of new bioactive ingredients and demonstrate functionality and benefits to the care of ageing hair and scalp, is incomplete. Our research on age-related changes in the scalp skin and the hair follicle in female scalp is now embedded, via new consumer communication (A-C), into AVEDA's hair care brand Invati 3.0, launched in China in 2020 and our research findings were delivered to AVEDA brand teams through many educational and training events. The Executive Director Hair Innovation and Analytical (Estee Lauder), said "Aveda is continually developing education for the professional salons, as well as directly to the consumer. We have leveraged the insights and understanding that we have gained from the University of Bradford's collaboration, for salon network education. There are 63 education centers in North America and in these, we can go a

bit deeper and educate on scalp aging. From our collaboration, we have been able to speak with authority on various aspects of scalp and hair aging, with years of data to reference" (C).

On describing the impact of the partnership's research findings, Aveda's Executive Director for Hair Care Innovation said "In the Asia Pacific region, the consumer wants a higher level of understanding of what is happening from a scientific point of view, both biological and also how the products are working. We have been leveraging the scientific insights from our collaboration, as well as the work that has been published, to help build creditability in this region. The research has been received very positively with our teams in the Asia Pacific region, with the first communication strategy leveraging our scientific creditability in this space happening this year [2020]", (C).

As a result of UoB's research and reputation in epigenetics, bioinformatics and data analysis-tools-development, Bradford now has strong leadership role (F-I) in the Elixir (European Life Science Infrastructure for Biological Information) community which contributed to a UKRI policy decision in 2020 to integrate research data management practise into all UK Universities and research institutions via an invited training programme grant, Launched Sept 2020 (since awarded to KP(H)). KP is a member of the European Galaxy Community (I) with Galaxy being one of the major global software platforms for reproducible biomedical data analysis (more than 10,000 publications referencing Galaxy up to date) (J,K). Based on this research strength and reputation, we have worked with two companies (J&J and Follicum AB) to develop computational methods to identify new targets for skin health. We developed and integrated a bespoke version of Galaxy™ on a different computing system (Redhat) to enable J&J to study skin epigenetics for consumer healthcare in-house and the data generated was shown to have wider significance in the business (L).

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

A. Research Drives Estée Lauder Invati brand launches mentions Bradford in Happi, a leading personal Care magazine.
B. Testimonial letter from Executive Director, Hair Innovation & Analytical at Estee Lauder. **Partnership contribution to education and training of Aveda Staff and associate personnel 2017-2020:**Bradford mentioned in direct to consumer communication: The launch of Pramasana demonstrates how UoB used its science to bring authority to a new brand launch from Estee Lauder.
C. Testimonial letter from Executive Director, Hair Innovation & Analytical at Estee Lauder: **University of Bradford research project with the Estée Lauder Companies/Aveda: 'molecular mechanisms in scalp and hair aging:** "The knowledge that the University Bradford has equipped us with has influenced our technical strategy greatly. If we did not have the partnership, our understanding would not be as deep and would have limited our technical approach to products as well as our communication strategy for the brands as well. The development times for our products would also be longer and have more risk associated to them as we would not have the basic research done that University of Bradford has assisted with. This means more resources from personnel and budget would be utilized. The confidence in which we address this area publicly would be diminished as well. We have been able to speak with authority to the public, in trade journals, and through public and product education efforts, which we otherwise would not have been able to do without this research".
D. Research underpins BASF product re-launch of DNAge for hair ageing/graying as described in a commercial product re-launch dossier for DN-Age LS9547. The Launch of DN-Age LS9547 by BASF required UoB research data for claim substantiation. The research findings of the University of Bradford on the process of hair greying is cited as making a "crucial contribution to the evidence base to support sales of this material into to the cosmetics industry". Pages 14 & 26
E. Testimonial letter from R&D Scouting & Communications Manager - BASF Beauty Care Solutions: "BASF BCS value the insights the research by the University of Bradford has provided, which has enabled us to refine our technical strategy, make sound investment

decisions and relaunch a successful product into new sectors in new and established market"

F. As the ELIXIR-UK Training Co-ordinator KP oversaw delivery of training events under ELXIR banner in the UK. Since January 2020, there were 34 such events delivered and registered in the ELXIR database
G. University of Bradford Staff member (KP) listed on ELIXIR-UK Key Roles website
H. University of Bradford Staff member (KP) successfully part of National UKRI grant application launched Sept 2020) https://www.ukri.org/news/initiatives-boost-health-and-bioscience-skills-and-industry/. Award letter to KP UoB. https://elixiruknode.org/uncategorized/elixir-uk-announces-new-fair-data-stewards-training-project/
I. The ELIXIR Human Copy Number Variations Community: building bioinformatics infrastructure for research
J. Jalili et al. 2020. The Galaxy platform for accessible, reproducible and collaborative biomedical analyses: 2020 update. *Nucleic Acids Research*. 48 (W1): W395–W402 https://doi.org/10.1093/nar/gkaa434
K. https://www.slideshare.net/carolegoble/elixir-uk-node-presentation-to-the-elixir-board (Slide 16, Galaxy mentioned slides 31, 32).
L. Quotation from J&J Project Manager,(10-05-19) to KP by email after the project concluded. "As part of a J&J consumer and Janssen collaboration we currently have a broader aging study ongoing to pull all data available from literature (not necessarily related to epigenetics) and analyze using AI. In recent discussions we realized that it may be really useful to pull in the datasets we created here as part of this project. This way we would be able to leverage your expertise along with the broader data to pull out biologically relevant data and may provide even broader exposure to prove business value".