

<b>Institution: University of Leicester</b>		
<b>Unit of Assessment:</b> UoA 5		
<b>Title of case study:</b> Popularising genealogical heritage: from King Richard III to public ancestry		
<b>Period when the underpinning research was undertaken:</b> 2008 - 2015		
<b>Details of staff conducting the underpinning research from the submitting unit:</b> N		
<b>Name(s):</b> Turi King	<b>Role(s) (e.g. job title):</b> Reader in Genetics and Archaeology	<b>Period(s) employed by submitting HEI:</b> 2007 - Present
<b>Period when the claimed impact occurred:</b> August 2013 - 2020		
<b>Is this case study continued from a case study submitted in 2014?</b> N		
<p><b>1. Summary of the impact</b></p> <p>Professor King led genetic and statistical analysis that identified skeletal remains discovered by a University of Leicester research team as those of King Richard III. By 2015, this research had boosted Leicester's economy by GBP79 million, including the construction of the Richard III Visitor Centre, and created 1,012 new jobs. The discovery and identification reached ~one billion people globally by 2017. In 2018 alone, 11.5 million people visited Leicester with an economic impact of GBP650million. The research inspired a wide range of cultural responses, and the team's educational materials have reached ~100,000 worldwide. The research continues to anchor Leicestershire's tourism plans 2019-2025, and Leicester Cathedral's 2020-2023 GBP11.3million restoration project, including the construction of a new Heritage Learning Centre. Furthermore, King's 2009 Y-chromosome findings have provided the sole research for Ancestry.com's exclusive DNA-testing patent (2017), with 21 million tests sold by 2019.</p>		
<p><b>2. Underpinning research</b></p> <p>King combines genetics and archaeological research and has a long-standing interest in the use of sex-specific DNA markers for identification purposes. King undertook the first large-scale study of Y chromosomes and hereditary surnames in Britain, developing the first reliable indicator of the false paternity rate in British populations over the past 700 years [R2]. King demonstrated that rarer surnames were often dominated by a single Y chromosome haplotype, which was likely that of a single male ancestor who bore that name several hundred years ago [R2]. King applied her methodology focused on surnames as a sampling strategy to investigate the genetic legacy of the Vikings [R1]. King also established sampling strategies that, combining forensic DNA typing of living individuals, with historical and archaeological data, led to an understanding of aspects of past population structure and population change in ways that simple analysis of modern and ancient DNA does not [R1, R2, R4].</p> <p>King established that heritable surnames are highly diverse cultural markers of co-ancestry in human populations. A patrilineal surname is inherited in the same way as the non-recombining region of the Y chromosome. Studies of Y haplotypes within surnames, mostly of the British Isles, reveal high levels of co-ancestry among surname cohorts. Combining molecular genetics and surname analysis illuminates population structure and history, with potential 'genetic genealogy' applications – an area of rapidly growing public interest [R7].</p> <p>In 2012, the University of Leicester multidisciplinary research team undertook excavations to locate the remains of King Richard III (R111), d.1485, believed to be interred in the lost church of the Greyfriars in Leicester. Prof Turi King's forensic, population-genetics and genetic-genealogy research [R1-R6] methodologies underpinned both the excavation practices and the identification of his remains primarily by comparing the ancient DNA evidence of the remains</p>		

against the modern DNA of living relatives, incorporating population-based frequencies of genetic data and conducting a Bayesian statistical analysis of the evidence.

Given the constraints of the exhumation licence granted by the Ministry of Justice, only skeletons exhibiting characteristics consistent with what was known about Richard III (location in friary, age at death, possible spinal abnormality, battle injuries) would be exhumed during the excavation for subsequent genetic analysis. One such skeleton was uncovered which matched contemporary accounts of RIII's spinal deformity, burial location and death in battle [R3, R6] marking this skeleton as suitable for exhumation and King's genetic investigation. King's DNA analyses of the skeleton and RIII's living relatives identified a perfect mitochondrial DNA match between the sequence from the remains and one living relative, and a single-base substitution when compared with a second relative. The latter is not unexpected due to chromosomal mutations occurring in the generations separating RIII and the relative. The mitochondrial genome was found not to have any matches in any forensic mitochondrial DNA databases in Europe or in the UK, and therefore has been shown to be a very rare type [R3, R5, R6].

Y-chromosome haplotypes from male-line relatives do not match the remains. This could be attributed to a false-paternity event occurring in any of the intervening generations. DNA-predicted hair and eye colour are consistent with Richard's appearance in an early portrait. King calculated the likelihood ratios for the non-genetic and genetic data separately and combined, concluding that the evidence for the remains being those of Richard III is 99.99999% [R4, R6]. King also carried out sequencing analysis of genes known to determine hair and eye colour to establish probable hair and eye colourings and thereby identify the most closely matching of the early portraits of King Richard III [R4, R5].

### 3. References to the research

- R1.** Bowden, G. R., Balaesque, P., **King, T. E.**, Lee, A. C., Pergl-Wilson, G., Hurley, E., ... & **Jobling, M. A.** (2008). Excavating past population structures by surname-based sampling: the genetic legacy of the Vikings in northwest England. *Molecular Biology and Evolution*, 25(2), 301-309
- R2.** **King, T. E.**, & **Jobling, M. A.** (2009). Founders, drift, and infidelity: the relationship between Y chromosome diversity and patrilineal surnames. *Molecular Biology and Evolution*, 26(5), 1093-1102.
- R3.** Buckley, R., Morris, M., Appleby, J., **King, T.**, O'Sullivan, D., & Foxhall, L. (2013). 'The king in the car park': new light on the death and burial of Richard III in the Grey Friars church, Leicester, in 1485. *Antiquity*, 87(336), 519-538.
- R4.** Fortes, G. G., Speller, C. F., Hofreiter, M., & **King, T. E.** (2013). Phenotypes from ancient DNA: approaches, insights and prospects. *Bioessays*, 35(8), 690-695.
- R5.** **King, T. E.**, Fortes, G. G., Balaesque, P., Thomas, M. G., Balding, D., Delsler, P. M., ... & Schürer, K. (2014). Identification of the remains of King Richard III. *Nature communications*, 5(1), 1-8.
- R6.** Appleby, J., Ruttly, G., Hainsworth, S., Woosnam-Savage, R.C., Morgan, B., Brough, A., Earp, R., Robinson, C., **King, T.E.**, Morris, M. and Buckley, R., 2015. Perimortem trauma in King Richard III: a skeletal analysis. *The Lancet*, 385(9964), pp.253-259.
- R7.** **King, T. E.**, & **Jobling, M. A.** (2009). What's in a name? Y chromosomes, surnames and the genetic genealogy revolution. *Trends in genetics*, 25(8), 351-360.

### 4. Details of the impact

Triangulation of multidisciplinary applications, underpinned by University of Leicester research, has contributed to the expansion of interest in genealogical heritage. The research has enabled the identification of ancient remains via the historical lineage of their descendants, most famously, those of King Richard III (RIII) and opened access to ancestral data for members of the public to explore their own ancestry.

### Heritage, tourism and economic impact

Discovery of RIII's skeleton beneath a Leicester carpark and the identification of his remains significantly contributed to Leicestershire's transformation into a national and global tourism destination. The Tourism Growth Plan (2019) stated: *"The economic potential of Leicester and Leicestershire was significantly enhanced by the discovery of the remains of King Richard III... and his reinterment in Leicester Cathedral in 2015. The value of this remarkable story to the area... provided a spotlight that enabled both the City and the County to showcase the area's rich heritage and tourism potential"* [E1Eii].

A 2015 Leicester City Council (LCiC) report showed that the discovery and identification of RIII drove significant economic impacts. In the period between the discovery and March 2015, 622,562 additional visitors to RIII-related events in Leicester spent GBP54,625,048; an additional 1,012 FTE jobs were created; an estimated GBP79,082,740 gross value added to Leicester's economy; and volunteering valued at GBP118,566 [E1A]. Although impacts and data relating to the discovery began in the REF2014 census period, the Leicester research has delivered significantly greater impacts since August 2013. 2020 LCiC [E1Eii] and 2019 Leicestershire County Council (LCoC) [E1Eiii] reports showed that the RIII discovery and identification, along with other regional attractions, contributed to the region's overall tourism growth. Since 2013, there has been *"an increase of 26.9% in value from the tourism sector, an 18.6% increase in visitors and a 12.6% increase in employment"*. [E1Eii]. In 2018 alone, 34.9 million people visited Leicestershire [E1Eii] and 11.5 million people visited the city of Leicester, valued at GBP651 million—significantly driven by the discovery of RIII [E1Eiii].

LCiC invested GBP4 million in the new **King Richard III Visitor Centre (RIIIVC)** at the Greyfriars site which showcases the team's research, including King's genetic genealogy work [E1A]. The RIIIVC's permanent exhibition is explicitly designed around the team's research on RIII's burial [R1]; his Bosworth battle wounds [R2]; a 3D model of CT scans of his bones to reconstruct his scoliosis [R3]; and the team's identification procedures, including King's DNA testing [R4] [E1B]. Between its opening on 26 July 2014 and 31 December 2020, the RIIIVC had 347,155 visitors from the UK and beyond. Overseas visitors came from as far away as the USA, Australia, and China [E1C]. In 2018, the RIIIVC won the Group Leisure and Travel Awards' 'Best Museum or Gallery' by reader vote, beating the British Museum and Tate Britain [E1C]. *Lonely Planet* added the RIIIVC to their 'Ultimate United Kingdom Travelist' in 2019, stating it *"reveals... one of the world's greatest archaeological detective stories"* [E1Eiii]. The discoveries published in [R1] prompted Historic England to designate the Greyfriars site as a Scheduled Ancient Monument in 2017 [E1D]. In 2014 alone, **Leicester Cathedral** drew 398,500 more visitors than in 2012 (an increase from 29,500 to 428,000 total, a 14-fold increase), and between 2013 and 2018 it attracted 1,223,560 total visitors [E1B]. In March 2015, approximately 43,000 people attended reinterment events at the Cathedral, and the burial service was viewed by more than 600 million worldwide. In the year following the identification, **Bosworth Battlefield Heritage Centre (BBHC)** ticket sales increased by 62% (2013: GBP95,375; 2014: GBP154,425) and retail sales increased by 74% (2013: GBP74,215; 2014: GBP129,440), with smaller rises in visitor numbers in subsequent years [E1F]. .

The *"remarkable King Richard III discovery and [his] connection with Leicester and Leicestershire"* [E1F] continues to drive **regional economic and tourism investment and planning**. The Leicester and Leicestershire Tourism Growth Plan 2019 has designed *"a critical mass"* of RIII experiences through 2024 [E1Eii]. The Leicester Tourism Action Plan 2020-2025 is *"anchored by the King Richard III story"*. This includes relocating the city's tourist information centre to the RIIIVC *"for the 130,000-plus visitors now coming each year, many drawn to see the tomb of RIII"* [E1Eiii]. LCoC created a Conservation Plan for BBHC to foster *"a local economy that supports . . . protection of the archaeological resources"* stating that the Battle of Bosworth *"has accrued even greater significance following the discovery of the remains of Richard III"* (August 2013) [E1Ev]. Leicester Cathedral's 2020-2023 Strategic Plan confirmed that RIII is a core driver for its GBP11.3 million project, funded by the National Lottery Heritage Fund (2016), to restore the Cathedral and build a Heritage Learning Centre, stating: *"The Cathedral changed enormously leading up to, during and in the aftermath of March 2015 when King Richard III was reinterred .... This new situation has become increasingly embedded and we are now into the*

*next major redevelopment phase entitled ‘Leicester Cathedral Revealed’” [E1Ei, iv].*

### Outreach and education impact

A- and AS-level *Wars of the Roses* History curricula incorporated the team’s research (September 2015). The RIIVC also incorporated the research into educational and outreach programmes, which, since opening in July 2014, have reached approximately 12,000 learners. In the 2018/2019 academic year alone, they reached 3,324 (62% KS 1&2; 23% KS 3&4; 15% FE/HE, July 2019) [E2A]. The underpinning research was a key feature of the seven-day RIII exhibit at the Royal Society’s ‘Festival of Science’ (June 2015), with 13,000 visitors, where of those responding to the visitor survey 85% strongly agreed or agreed that the exhibition had increased their interest in ‘science’. The replica skeleton and research displays travelled to Birmingham’s ‘Big Bang Fair’ (2014, c.70,000); Galway Science and Technology Festival (2017, c. 20,000); and Bulgaria’s Sofia Science Festival (2017, c.17,000) [E2B]. The University of Leicester RIII website and educational materials have had 1,782,871 unique page views from the UK (39.5%), the USA (33.1%), Australia (7.1%), and worldwide (August 2013 – December 2020) [E2C]. By December 2020, more than 83,000 people had enrolled in the research team’s six-week MOOC, *England in the Time of King Richard III*. Participants’ satisfaction scores averaged a high 4.7 out of 5, with 278 reviews stating, for example: “[T]his course has reignited my passion for history and archaeology and led me to apply to do a Masters Degree in an archaeology discipline” [E2D]. In 2015, the Scout and Guiding associations produced a RIII challenge badge drawing on the RIII research and story, with approximately 2,000 challenges completed in Leicestershire alone by May 2020 [E3].

### Cultural impact

Press and media coverage in March 2015 relating to the reinterment alone totalled 2,071 stories and reached 358 million people. By 2017, press and media coverage of the discovery and reinterment reached an estimated one billion people around the globe [E4]. In November 2013, the University of Leicester Archaeology Service (ULAS) won the Queen’s Anniversary Prize: “*The University of Leicester is recognised for its long record of exceptional research, commercial archaeology and public engagement in history and heritage, highlighted by the work of the team that discovered the remains of King Richard III beneath a car park*” [E5A]. BBC’s *History Extra* website visitors voted RIII as their number one historical figure of interest in the ‘Top 100’ poll 2015 – 2017, and in July 2020, they voted ‘Did RIII order the murder of the Princes in the Tower?’ as “*history’s greatest mystery*” with 35% of the votes, “*almost three times as many as the building of Stonehenge*” [E5B].

The RIII story and the research underpinning it [R1 – R5] stimulated significant cultural responses. It generated new publications and music, largely aimed at general audiences. Books include Mike Pitts’ *Digging for Richard III: How Archaeology Found the King* and David Horspool’s *Richard III: A Ruler and his Reputation*, as well as literature aimed specifically at children, such as former Children’s Laureate Michael Morpurgo’s *The Fox and the Ghost King* (fiction) and Rosalind Adams’s *Children’s Book of Richard III* [E7]. It inspired three creative responses for RIII’s 2015 reburial service at Leicester Cathedral: *Ghostly Grace*, a choral piece by Judith Bingham; an anthem by Judith Weir; and *Richard*, a eulogy by Poet Laureate Carol Ann Duffy, read by Benedict Cumberbatch, with more than 265,000 views (December 2020). Nico Muhly composed the song, ‘Old Bones’, using the words of ULAS lead Richard Buckley and RIII Society’s Philippa Langley, for countertenor Lestyn Davies [E8].

The project also inspired major dramatic productions and television documentaries [E4 – E8]. *The Hollow Crown* (BBC2, 2016), starring Benedict Cumberbatch, used the team’s analysis of RIII’s skeleton [R2], and opened with a shot of his spinal curvature. The production reached 0.84 million viewers in one week, and 0.94 million in 28 days [E6A]. The Leicester research also inspired Ralph Fiennes’ 2016 portrayal of Shakespeare’s *Richard III* at the Almeida Theatre. Fiennes stated: “*They found the spine and it is very curved, so we tried to base his physicality as close as possible to the evidence that came out of the excavation in Leicester*” [E6B]. The



performance, which featured a reconstruction of the excavation site on stage, sold 21,850 tickets and its live broadcast reached 50,000 additional viewers worldwide [E6B].

Channel 4's *Richard III: The New Evidence* (August 2014), featured University of Leicester research [R1, R3–R5], reaching 1,760,000 viewers in seven days [E6C], while PBS (USA) ran the director's cut, *Secrets of the Dead: Resurrecting Richard III* (September 2014). Both starred actor Dominic Smee as RIII. Smee, who shares the king's condition, stated that the analysis of the king's condition profoundly impacted his confidence and his acceptance of his own body. Removing his shirt during filming "was a defining point in my life. This was the first time that I had been truly honest and open about a part of me that I had kept hidden for so many years" [E6C]. Smee stated the experience made him feel like he was reliving RIII's last moments, and he is now "confident enough to give lectures about his experiences and the research" [E4].

#### Patented Ancestry.com DNA test reaches millions worldwide

King established that combining molecular genetics and surname analysis can help identify population structure and history [R7], which can be applied to 'genetic genealogy' procedures. Because of the growing popularity of individual DNA testing, this research has indirectly reached 14 million people by 2019. The US-based Ancestry.com, the world's largest for-profit genealogical company, used King's [R7] findings as the sole underpinning research for their exclusive DNA-testing patent (2017). The patent applies to the company's AncestryDNA tests, which are sold to the public for GBP79 each. AncestryDNA sold 14 million DNA test kits worldwide in 2019, doubling their 2018 sales of 7 million [E9].

#### 5. Sources to corroborate the impact

**E1. A.** Leicester City Council Economic Impact of RIII Report 2015. **B.** Leicester Cathedral Report 2015. **C.** Collated RIII Visitor Centre materials: RIIIVC Report 2015; BBC News Story about the investment 22 July 2014; Group Leisure and Travel Award 2018. **D.** Historic England Scheduled Ancient Monument 1442955, 13 December 2017. **E.** Tourism plans: Leicester Cathedral Strategic Plan 2018 – 2020; Leicester and Leicestershire Tourism Growth Plan 2019–2023; Leicester Tourism Action Plan 2020–2025; Bosworth Battlefield/LCC/Heritage Country Park strategy August 2013. **F.** LCC Heritage Support Officer emails: Bosworth Battlefield Heritage Park data, April and August 2020; Hinckley and Bosworth Community and Wellbeing Strategy 2016-20.

**E2. A.** Compiled RIIIVC Management Reports, March 2016 – September 2019. **B.** Royal Society's Trustees' report and financial statements, 31 March 2016. **C.** UoL RIII website data, 1 August 2013 – 31 December 2020. **D.** FutureLearn enrolment data and feedback.

**E3.** Scout and Guiding challenge badge news and email from County Office Manager.

**E4.** Representative news features. Collated media data reports: University of Leicester/Precise Media RIII Reinterment report, March 2015; Efficiency Exchange Report by Ather Mirza, 8 June 2017.

**E5. A.** November 2013 Queen's Anniversary Prize. **B.** Collated public interest votes from BBC History Extra 2015 – 2020 and expert nominations June 2020.

**E6. A.** *The Hollow Crown*, BBC2, 21 May 2016. Collated interviews, features, and BARB viewing figures. **B.** *Richard III*, Almeida theatre, 2016. Collated features, reviews, live broadcast, images, and email from Almeida Theatre Marketing Manager, 11 May 2020. **C.** *Richard III: The New Evidence*, Channel 4, 17 August 2014 and *Resurrecting Richard III*, PBS (USA), September 2014. Collated features and interviews.

**E7.** Materials evidencing popular books.

**E8.** Materials evidencing poetry and music: Judith Bingham's *Ghostly Grace* collated feature stories March and August 2015; Kings Place seating plan; Poet Laureate Carol Ann Duffy's eulogy, *Richard*. <https://tinyurl.com/ydenhupu>; Recording of Benedict Cumberbatch reading at reinterment; <https://www.youtube.com/watch?v=38nodTfpro4>

**E9.** US Patent 20170011042 15/203776, *Genetic And Genealogical Analysis For Identification Of Birth Location And Surname Information*, filed 12 January 2017; Ancestry.com website with product and data; *MIT Technology Review* articles 2018, 2019