Digitised diseases
Creating 3D models of human bones at University of Bradford

“The team challenge and push students helping them achieve to a high standard and give them many opportunities.”

Summary
Digitised diseases (http://digitiseddiseases.org) is a collection of 3D models of human bones created at the University of Bradford in partnership with the Royal College of Surgeons of England and Museum of London Archaeology. The collection provides an open access resource for both students and researchers which supports the study of human osteology and palaeopathology, physical anthropology and related medical disciplines. Students can use this collection in conjunction with hands-on access to real specimens, in an innovative and integrated learning environment.

The project has had a number of impacts:

• Developing high level technical skills among staff and students, enabling University of Bradford to establish an international reputation for 3D imaging and visualisation techniques
• Supporting students in acquiring skills which equip them for employment or further study - evidenced in a high proportion moving on to professional employment or further research
• Enabling worldwide virtual access to fragile human remains while preserving the original specimens, allowing students and researchers to see and virtually manipulate a far wider range of pathological type specimens than would otherwise be possible
• Helping students and researchers to appreciate the access and ethical issues associated with making such materials available online

Creating the resource
The digitised diseases project began as part of the Jisc-funded mass digitisation scheme (content programme 2011-13), under the leadership of Dr Andrew Wilson, Senior Lecturer in forensic and archaeological sciences. Since then the work has continued to be maintained with HEIF funding and as an adjunct to other grant-funded projects.

Bradford was ideally placed to take a lead on creation of the collection, both in working with researchers at the “forefront of the field” and acknowledging the legacy of Professor Keith Manchester, Clinical lead digitised diseases and the late Professor Don Ortner, former
head of the National Museum of Natural History, Smithsonian Institution after whom Bradford's facilities are named.

The resource was established to digitally document examples of chronic diseases of the human skeleton and create accurate 3D models of fragile bone specimens for research and educational purposes, using 3D laser scanning, CT and radiography. In 2018 the collection comprises over 1,620 scanned specimens and over 1,425 descriptions, creating a digital dataset over seven terabytes in size. During the first week following launch, the resource had 1,093,814 hits from 14,191 different visitors from 119 countries.

The team at Bradford developed their own classification system for diseases. This was needed because existing schemes (such as that of the World Health Organisation) were suited to classifying health problems in the living and recent dead, but the Bradford project needed something more appropriate for palaeopathological case examples from archaeology and medical history. They also created a bespoke viewer using WebGL to optimise viewing across different platforms.

The website offers both a "view" and a "download" option, with the latter including detailed information about terms and conditions of re-use. Digitised diseases has its own fair use agreement (see http://digitiseddiseases.org/fairuse.php), and the images are made available under a Creative Commons CC BY-NC-ND public licence. The models are direct facsimiles of the bones of real people and must be treated with respect. There are particular issues with human remains from the collections of the Royal College of Surgeons (a partner in digitised diseases) as they are subject to a Human Tissue Authority licence.

At the time of writing, the "download" option has been suspended to allow the team to review access rights in the light of new platforms such as Sketchfab (https://sketchfab.com) becoming available. There is a concern about digitised diseases images reappearing on the internet in ways that were not foreseen by the original project. The team is considering setting up its own Sketchfab account with Digital Object Identifiers (DOIs) for each model, to ensure that the collection is retained with the envisaged contextual information produced as part of this research.
Innovative integrated learning environment
Human osteology and palaeopathology teaching at Bradford takes place within the life sciences Integrated Learning Centre (brad.ac.uk/life-sciences/lslc). This high quality, modern learning environment has specialist laboratories for anatomy and pathology. Equipment includes the Anatomage table (a touch screen controlled set of digitised images, designed to enable students to investigate the different structures and systems in the human body) and an iGene digital autopsy table, as well as human anatomical specimens and models. Collectively, the centre provides students with hands-on access to real specimens along with cutting edge simulation technology to support their learning. They can access a wide range of resources and information within a single space that integrates traditional and technology-enhanced learning.

The Keith Manchester Laboratory provides a focal point for human osteology teaching and includes a large touchscreen linked to projection which enables students to explore 3D anatomical and skeletal models, including those created as part of the digitised diseases project.

The Biological Anthropology Research Centre offers climate-controlled storage for the largest teaching collection of archaeological human remains in an archaeology department in the UK, comprising over 4,000 individuals curated to museum standards.

Access to the human remains collection is carefully managed, and students learn about the correct way to handle human remains as part of their programmes. With the digitised diseases collection, students are able to view and manipulate 3D models at any time and anywhere, using a wide range of platforms and personal devices. They are also able to borrow a Surface Pro for use in the lab. The risk of damage to the original specimens is limited, and access is available to a wider range of users including students and researchers beyond Bradford and indeed the UK. Statistics show that usage from the USA was equivalent to UK usage in 2017.

Skills and employability
Dr Andrew Wilson and the wider visualising heritage team (visualisingheritage.org) have developed comprehensive skillsets through the original digitised diseases project and later grant-funded activity. Skills include 3D laser scanning, structured light scanning, structure-from-motion photogrammetry, CT, radiography, and 3D printing, together with experience of a wide range of post-processing software. Since 2011 undergraduate placement and dissertation students as well as masters and PhD students have been associated with the team developing key 3D imaging skills, and a new masters programme is planned. The team is developing an international reputation as experts in the field of imaging and visualisation in archaeology, anthropology and wider heritage applications.

Students use the digitised diseases resource in a range of different modules, and it is a particular focus for the MSc in human osteology and palaeopathology. Using this collection helps students gain professional skills in the analysis and interpretation of archaeological human remains. This masters programme is relevant to those seeking vocational training or wishing to develop a research career. First destination figures for postgraduate taught programmes in the school of archaeological and forensic sciences indicate that 71% of graduates achieve work or further studies in the discipline or cognate areas, and of those in employment, 88% are at professional or managerial levels. New modules are in development which will include elements of digital imaging skills, and visualisation techniques are applicable in many other academic areas such as optics and animation.
Impact and future developments
Digitised diseases has been described by Killgrove in Forbes.com as "the first and most extensive digitisation project in bioarchaeology to date". The human remains teaching team won a Vice Chancellor’s Teaching Award in 2014, in part because of the digitised diseases resource and also because of the supportive feedback from students as exemplified in the following quotes from masters students:

The MSc in human osteology and palaeopathology scored 90% for student satisfaction in the 2015 postgraduate taught experience survey.

While seeking to maintain the open access nature of the resource, the team do wish to revisit the question of download and re-use permissions in the light of new developments in web technology and sharing platforms such as Sketchfab.

£20M “Fragile Heritage Hub” bid to the Global Challenges Research Fund.

In the meantime, the collection continues to be a core element in teaching in the school of archaeological and forensic sciences. Students can use this collection in conjunction with hands-on access to original specimens, in an innovative and integrated learning environment, incorporating state of the art learning technology.

Find out more
Contact: Dr Andrew Wilson
Email: a.s.wilson2@bradford.ac.uk
Digitised Diseases: http://digitiseddiseases.org
Life Sciences Integrated Learning Centre: brad.ac.uk/life-sciences/lslc

“[The] reference collection has a wide range of examples. There is almost no need to look anywhere else. Digitised Diseases is a new and useful tool for any students on this module.”

The image files are currently hosted off-campus and backed up by the archaeology data service in York. The university hopes to develop a suitable on-campus research data storage solution for the future.

The digitised diseases collection is used internationally, and the team are gaining an international reputation in imaging and visualisation techniques. There is no permanent funding stream for developing the work, however, the team has continued to grow over the years with further grant funding, and Dr Andrew Wilson has recently submitted a new

Education consultancy Sero HE was commissioned by Jisc to interview Dr Andrew Wilson about developments in learning and teaching in a digital age at the University of Bradford. The studies focus in particular on the impact of such developments on the student experience.