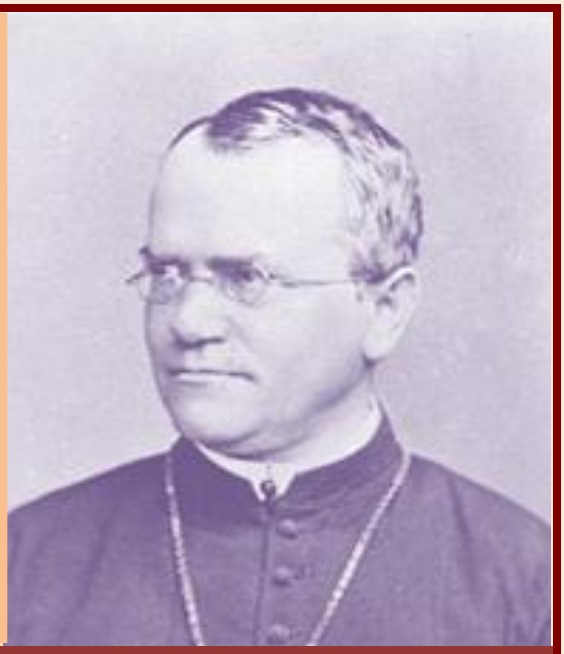
THE MENDEL NEWSLETTER

Archival Resources for the History of Genetics & Allied Sciences



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New Series, No. 21 **September 2017**

IN THIS ISSUE

THE AMERICAN PHILOSOPHICAL SOCIETY LIBRARY
Philadelphia

The Mendel Newsletter

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The Mendel Newsletter, New Series, No. 21 (September 2017)
Issued occasionally by The American Philosophical Society Library. Available only in digital format, readers may print and redistribute copies. The current issue and many back issues may be downloaded from The Mendel Newsletter webpage at www.amphilsoc.org/library/mendel.

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Photograph of Gregor Mendel, *ca.* 1860, from the Curt Stern Papers, American Philosophical Society. APS graphics:2210

From the Librarian

Patrick Spero

AS readers of the *Mendel Newsletter* may know, I recently had the honor of taking up the mantle of Librarian and Director at the APS Library. I came to the APS from Williams College where I served as an assistant professor of History and Leadership studies after receiving my Ph.D. in history from the University of Pennsylvania in 2009. While my area of specialty is early American history, particularly the American Revolution, it has been my goal while at the APS to expand the Library's fellowships and programs in its core collection strengths, including the history of science, medicine, and technology. The past year has been marked by welcoming new fellows to the Library to undertake archival research, including those involved in the study of the history of genetics. One of the most fascinating projects to emerge from a fellowship last year examined how the models used in livestock breeding and genetics came to influence the ways in which scientists thought about human genetics. This researcher spent much of his time working with the Hubert Dana Goodale papers and found evidence of Goodale's work in transplanting the reproductive organs of chickens into the opposite sex. Goodale, a poultry and cattle geneticist, was a student of Charles Davenport and this researcher is exploring how Goodale's work may have influenced human eugenicists. This is only one of many stories revealing the new connections scholars are making with APS materials.

In addition, the Library is planning new programs this year to cultivate a lively intellectual community around its core collecting areas. Each month, the Library brings in a scholar from Philadelphia and beyond to talk about new research in

their field. We've begun hosting writing workshops for fellows to present works-in-progress for critique and discussion by their peers, APS staff, and outside scholars in their fields. Finally, each year the Library will host a scholarly conference to coincide with the Museum's exhibition. In 2016, the APS held a symposium on Native American languages, in 2017 it will be on art and revolutions, and in 2018, to celebrate the 275th anniversary of the Society, the Library will host a conference that explores the role of learned societies and associations in history. I encourage *Mendel* readers who have occasion to be in Philadelphia to attend one of our new programs, whether a lunchtime seminar or fall conference, to learn more about our collections and the new research emerging from their use.

The History of Genomics Program at the National Human Genome Research Institute (NHGRI)

Christopher Donohue

NHGRI and History of Genomics Program donohuecr@nih.gov

THE Human Genome Project officially began in 1990 and concluded by 2003. It was, according to Francis Collins then Director of the NHGRI, "the first major foray of the biological and medical research communities into "big science", leading to the "development of an array of new technologies; the generation of highly useful genetic, physical and transcript maps of the genomes of several organisms" and a "highly polished sequence of the human genome, free and readily accessible to all." (Collins, Morgan, and Patrinos 2003). All of these statements are generally correct, with the disagreements occurring in the specifics. (Eichler, Clark, and She 2004) (Chaisson et al. 2015).

In 2003, there was collective agreement by Francis Collins, the leadership at the NHGRI, and the extramural grantee community for the NHGRI to continue its leadership and advisory role in the funding of genomic science in the United States. Writing that same year, Collins with senior leadership staff, including current Director Eric Green, elucidated an ambitious agenda for the NHGRI to guide the development of genomic science after the Human Genome Project. This included "elucidating the structure and function of genomes" including the "organization of genetic networks and protein pathways and how they contribute to cellular and organismal phenotypes" and producing a "detailed understanding of the heritable variation in the human genome" while also "translating genome-based knowledge to health" with the NHGRI's role being the "large-scale production of genomic data sets" and the facilitation of "quantum leaps" in technology development, such as "allowing a human genome to be sequenced for $1000 or less" (Collins et al. 2003).

The subsequent genomic program development efforts undertaken by the NHGRI generally reflect these emphases, from the NHGRI's stewardship of the International HapMap Project to continuing bioinformatics funding efforts (Gibbs et al. 2003). Such a strategic orientation was also illustrated by the development of the Encyclopedia of DNA Elements (ENCODE) in 2003, an international consortium to identify all of the functional elements in the human genome sequence (Consortium 2004). Collins' dictum to translate genome-based knowledge to health resulted in collaboration with the National Cancer Institute (NCI), with the Cancer Genome Atlas. The TCGA began in 2005 is "a comprehensive and coordinated effort to accelerate our understanding of the molecular basis of cancer through the application of genome analysis technologies, including large-scale genome sequencing." (see https://www.genome.gov/tcga/). Newer programmatic efforts underscore the increasing relevance of genomics to clinical diagnosis and treatment. But the clinical focus and advances in genomic medicine has not lessened the focus on genome

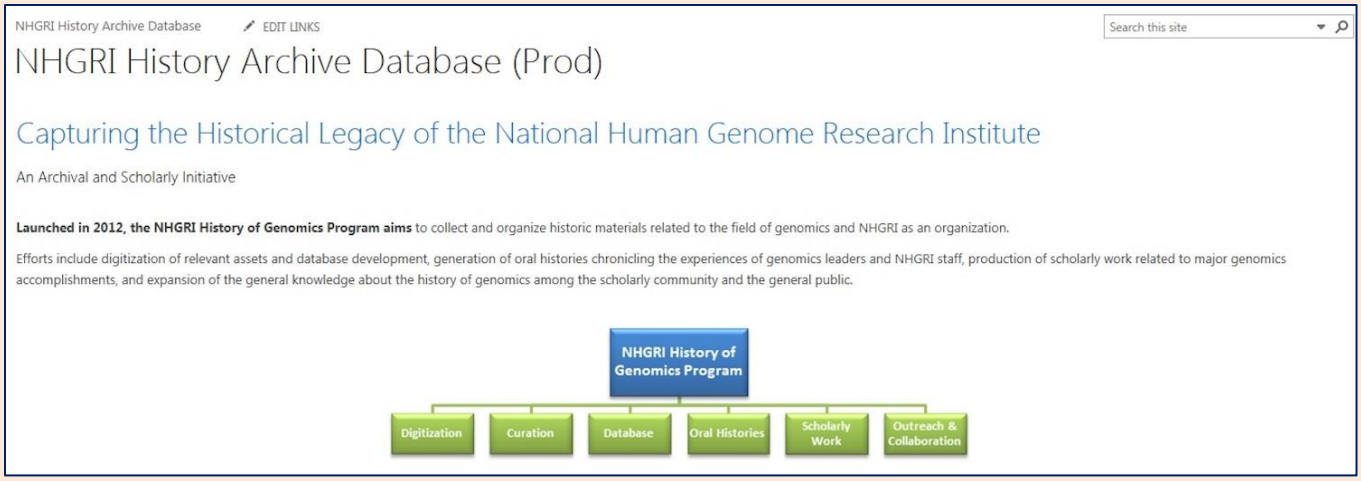

Figure 1. NHGRI History Archive Database homepage.

biology (Manolio et al. 2013) (Green and Guyer 2011).

Eric Green, having been appointed Director of the NHGRI in 2010, began the History of Genomics Program in 2012 to implement various measures, including paper document digitization and born-digital file collection and organization, to capture the rich legacy of the Human Genome Project as well as to ensure that the history of recent genomic science under the stewardship of the NHGRI was not lost. To the ends of that charge, the History of Genomics Program is home to the following efforts: a substantial digitized archive, an oral history effort, efforts for the promotion of scholarly work on molecular biology, genetics and genomics, database development, a visiting scholar lecture series as well as the sponsorship of various annual conferences and academic meetings on topics of interest to historians and philosophers of biology. The History of Genomics Program also has developed a student internship program.

The first and foremost mission of the History of Genomics Program is to make available for scholarly research to as wide a scholarly audience as possible the digitized paper documents and born-digital files contained within the archive for the purposes of the development, dissemination and publishing of more nuanced and archivally-informed articles and monographs on the history of the Human Genome Project and on the continuing development of genomic science.

At present the archive contains about 2.5 million documents, with each file containing a single document. This means that the archive contains around 25 million pages. A select stratum has been made available to scholars through the development of a database resource. More on that below. The archive has a growth rate of about 8% to 10% a year. This includes about 700,000 pages of digitized paper files of Francis Collins' correspondence and files generated in the course of daily business when he was Director of the NHGRI (1993 to 2008) with the remainder consisting of born-digital files.

The born-digital files mostly cover the management of genomics programs. Such files with some exceptions date from after 2005. These digital files are mostly in unremarkable formats (such as Microsoft Word, PDF, and Excel.) Therefore, the archive does not have any of the issues associated with old or incompatible file formats.

In general, the majority of the archive pertains to the history of genomics and of the Human Genome Project from the vantage point of the NHGRI, as the principle funder and steward of these scientific efforts in the United States. There is about equal representation in the areas of the

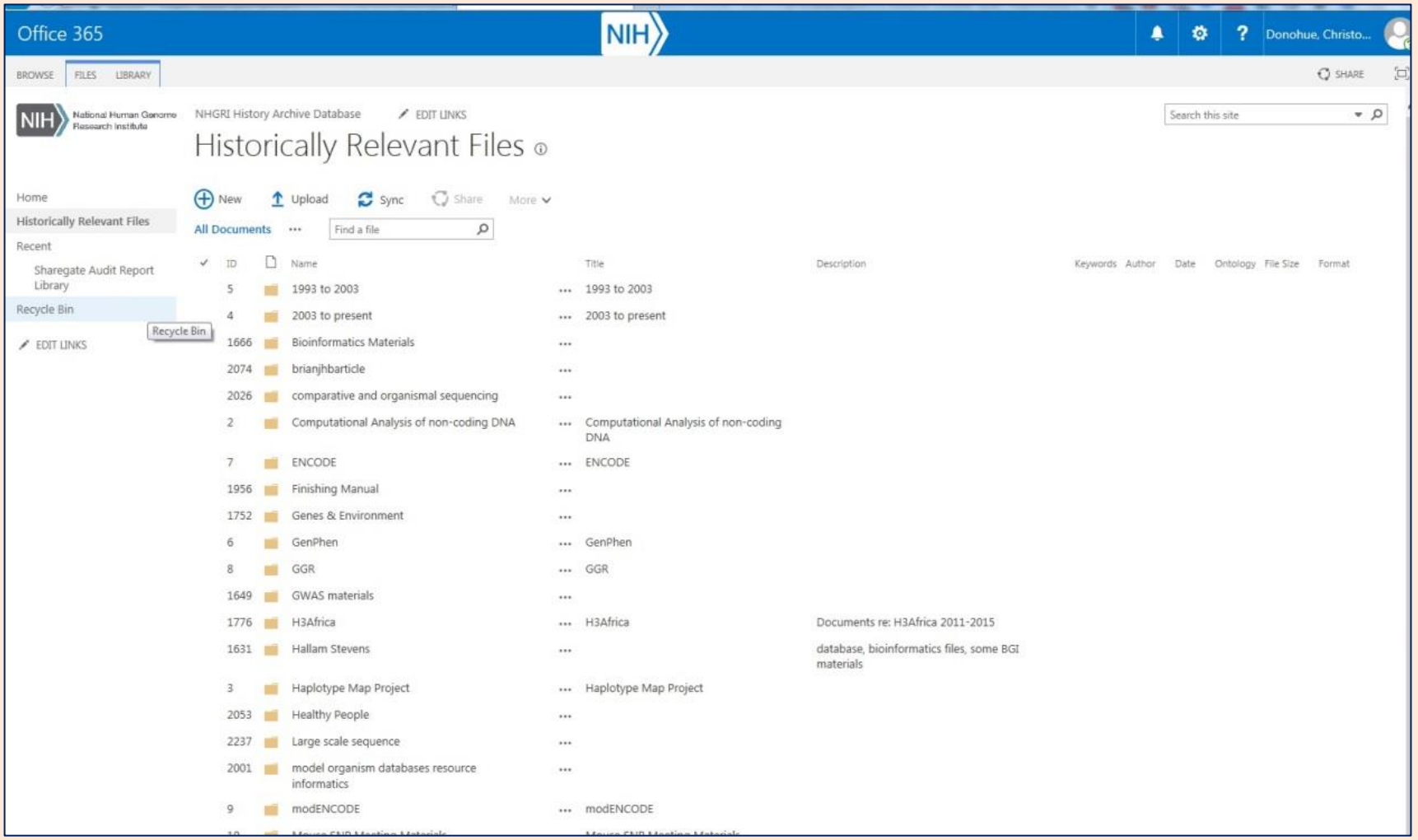

Figure 2. Library organization.

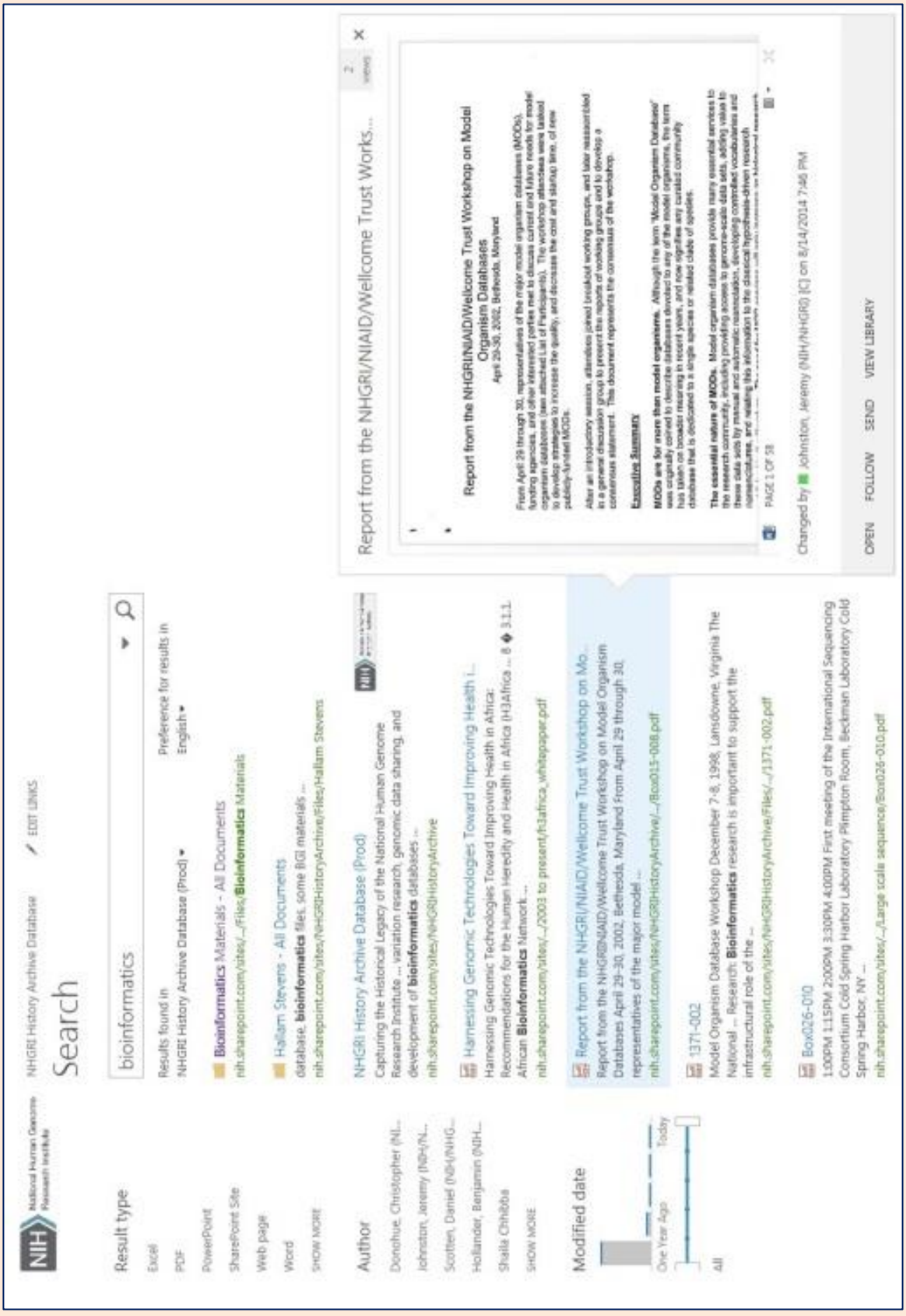

Figure 3. Example of search results.

development of sequencing and mapping technologies, the integration of genomics into various areas of biology, funding of computational biology, bioinformatics, and database development projects, efforts to characterize the nature and significance of human variation, functional studies of genomic sequence, model organism sequencing, and the ethical, legal and social implications of genomic science. The majority of the files pertaining to the Human Genome Project are from the papers of Francis Collins. The History of Genomics Program has also digitized the paper files of retired senior staff. Last, a significant portion of our digitized paper files detail day to day workings of the Ethical, Legal and Social Implications (ELSI) Research Program and should be of great interest to historians of bioethics, discussions of race in scientific research, and historians of policy.

The archive illustrates extramural scientific program conceptualization, development and funding; thus, the archive contains files which describe scientific efforts at funded institutions in the grantee network. From this extramural focus, much of the day to day workings of the major sequencing centers can be inferred from the mid-1990s especially, after the imposition of consistent reporting metrics. It contains much less material pertaining to intramural science or research carried out on campus by tenured investigators and other scientific staff, although this will change once the History of Genomics Program begins collecting intramural paper files and digital documents of historical significance. However, the History of Genomics Program has extensive materials detailing the day-to-day workings of the NIH Intramural Sequencing Center or NISC, which throughout the 2000s was among the world's leaders in comparative sequencing, sequencing finishing and sequence quality standards (Blakesley et al. 2004) (Liu et al. 2003).

Chronologically, the archive contains documents from the early planning stages of the Human Genome Project, and the deep involvement of the Department of Energy (DOE) in the nascent Human Genome Project in the mid to late 1980s. The archives also illustrate the complex process of the National Institutes of Health overtaking the DOE's stewardship. Rather serendipitously, the archives possess digitized paper documents from the "pre-history" of the Human Genome Project on the NIH campus, from the period when the Human Genome Project was actually briefly overseen by the National Institute of General Medical Sciences (NIGMS). There are also numerous digitized documents from the relatively brief tenure of James Watson as first Director of the National Center for Human Genome Research from 1989 to 1992. More extensive are digitized documents from tenure of Michael Gottesman as the Acting Director as the Center for Human Genome Research. Gottesman's tenure is remarkable for the relative stability he provided during a rather tumultuous year for the development of genomic science and for the Human Genome Project, i.e. the Institute for Genome Research (TIGR) and the Sanger Center were both founded in 1992, nearly within the same week. Many of James Watson's paper files remain at the Cold Spring Harbor Laboratory and Archives. There is an enormous uptick of files after the instillation of Francis Collins as the Center's Director in 1993.

This does not merely reflect the increasing coordination of the Human Genome Project in the United States by NIH after 1993 but also closely charts the increased pace of sequence data generation after 1993. In 1992, there were wide-spread fears of the lag in the development of sequencing technology. By 1995 and 1996, large scale sequencing technology had advanced sufficiently to discuss scaling up of sequencing at a number of centers. By 1997, such discussions concerning scale-up and how to manage large quantities of sequence data (including such issues as sequencing data quality and assembly issues) as well as technology and methods develop to ensure that sequence cost continued to decrease while quality remains consistent across platforms and methods as well as consistent with community standards.

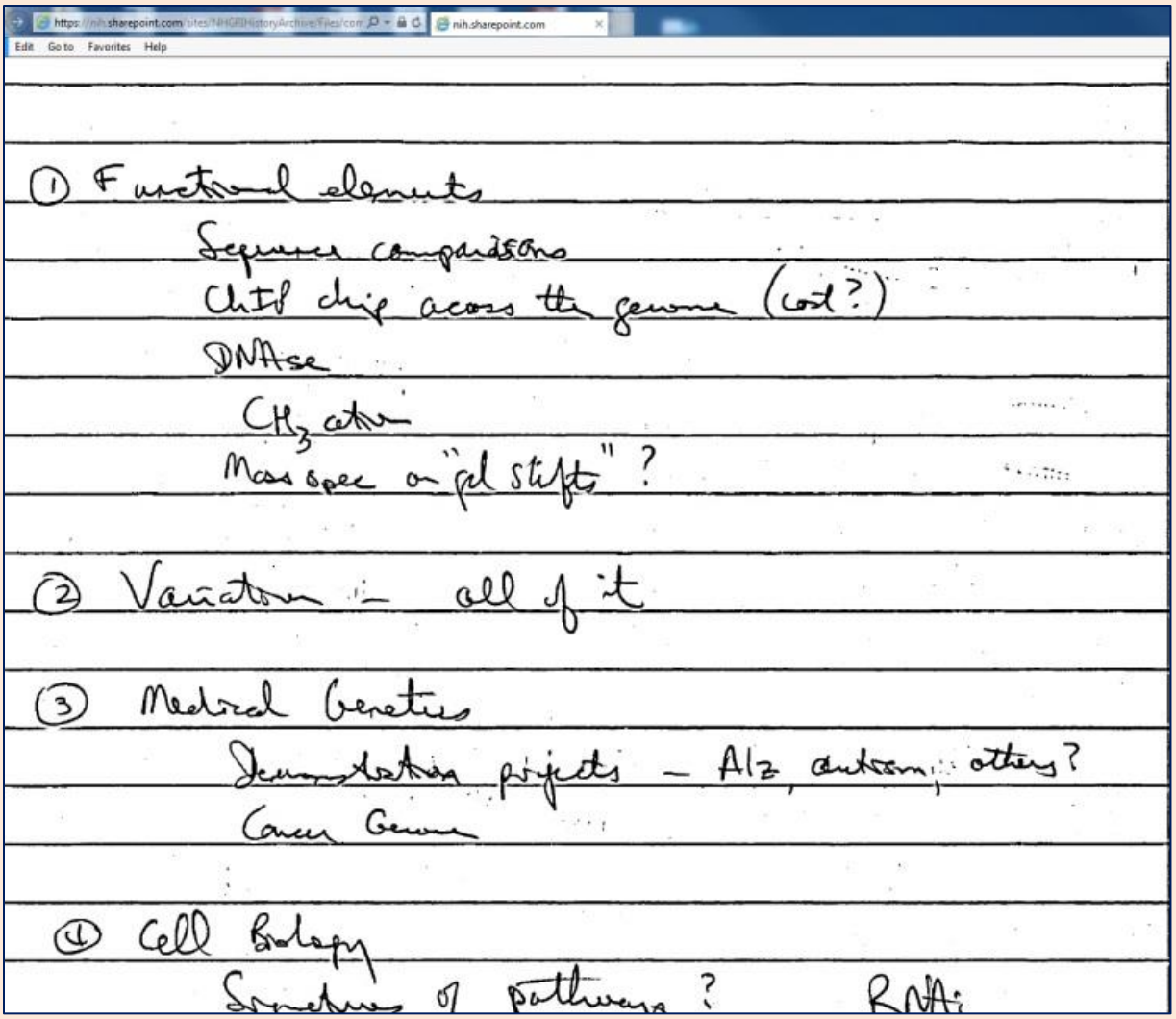

Figure 4. File from archive that can be accessed through database.

As importantly, from even the early nineteenth nineties, the archives also detail how many of the intellectual and scientific leaders of the human sequencing effort, such as Maynard Olson, Barbara Wold, Ron Davis, Aravinda Chakravarti and many others began to define the biological importance of the produced human sequence. This resulted in a forceful orientation of the planning and conceptualization of the latter phase of the Human Genome Project in order to capitalize on the knowledge derived from newly sequenced data of "draft" quality in order to answer basic biological questions.

The archive is particularly rich in digitized documents relating the activities of the large-scale sequencing centers (not only in the United States but at Sanger as well as the Beijing Genome Institute). These documents detail not only the rather frenetic pace of sequencing (particularly in 1999) but also changes in the large scale sequencing program in consequence to the announcement of Craig Venter of a competing privately financed project. It should be noted that there was an incredible amount of collaboration between the two efforts. Much of the perception of a "race" between the two efforts was the consequence of journalistic reporting.

In sum, for each scientific program developed at the NHGRI, whether initial mapping efforts in the very early 1990s to the conceptualization of the $1000 genome as a stated goal in technology development, the archives contain the documents illustrative of the iterative decision-making process from initial conceptualization to the discussion of grantee progress towards agreed upon scientific goals after funds have been awarded. In the case of the International HapMap Project, documents illuminate and detail the pre-history of the program in 1999 and describe the sundry issues encountered in developing an international consortia given the task of defining variation in an ever-increasing number of populations. The archive contains continuous files on the efforts of the NHGRI to study human variation from the late nineties to the Functional Variation Program (or FunVar), which was launched last year.

In order to make these rich digitized documents and born digital files available to scholars, for the past two years the History of Genomics Program has devoted most of its resources to database development. Any researcher aligned with an educational or scientific institution can apply for access to our database for scholarly research on the history of genomics and of the Human Genome Project. Any scholar or scientist requesting access must have their institution assent to a confidential disclosure agreement. This agreement, which is ratified by the technology transfer office (and only in force for three years), places the NHGRI and the scholar requesting access (through his or her institution) in a research collaboration agreement. Once the agreement has been ratified by the NHGRI and the researcher's institution, the researcher is allowed to use the files for publications and public presentations. The NHGRI strongly urges (but does not require) that individuals who are about to publish send us the final corrected proofs in case of accidental transmission of confidential information, such as accidently disclosed unfunded grant or study section material. Researchers can apply for access by sending an email to NHGRIHistory@nih.gov

The database contains a select number of born digital files (such as PowerPoint, Excel documents Microsoft Word) and digitized paper documents, around 2,500 total at present. Each of the files (whether a digitized paper document or a born digital file) in the database is from the archive. Each of these files in the database and in the archive ideally contains one document, although with some older files (typically pdfs) contain multiple documents. Most of the documents are about ten pages long, although this is not universally the case. The History of Genomics Program staff moves each file from the archive, places the file in a specific library or sub-library, and then adds metadata. Metadata allows for more efficient search and retrieval. Searching can be done by keyword, although browsing entire libraries or sub-libraries is also possible.

The History of Genomics Program staff hope to grow the file database by about 5,000 files a year. There are two types of libraries: user requested libraries and general coverage libraries. User requested libraries are for those scholars who have asked for a specific file library or file group. One example of such a library is that being developed for users actively researching porcine sequencing. Another user has asked for files relating to the history of cohort development for a project relating to the history of genomic studies into the genetic underpinnings of complex disease. Any scholar who has access to the database resource can request a custom library. The files should be available within two to three weeks, with full metadata ready within another four to six weeks.

General coverage libraries are those curated and characterized with metadata by History of Genomics Program staff. These files (whether paper files or born digital) and programs were judged to be of general historical interest and significance. Existing general coverage libraries include those on the International HapMap Project, the NIH Common Fund Project Human Heredity and Health in Africa (H3Africa), the ENCODE and modENCODE programs, the genomics of gene regulation (GGR) program, files detailing

human and murine mapping and sequencing, files pertaining to the history of bioinformatics initiatives as well as funding for and conceptualization of various model organism databases (MODs). In the next year, the NHGRI History of Genomics Program hopes to quadruple the number of files detailing human sequencing efforts from the early 1990s to the present and has begun a sustained effort in the curation of files relating to the history of technology development at the Institute.

Last, the History of Genomics Program has developed an oral history effort. At present there are about forty oral histories which have been videotaped and transcribed. These oral histories will be posted on the NHGRI's YouTube page, Genome TV, beginning in March 2016. At present, the rate of the production of oral histories is about one or two per month. The oral history effort experiences numerous upticks, however. Early last year, for example, because of an increase in retirements and because of a serendipitous arrival of outside scientific speakers, the oral history effort recorded four histories in one week.

The focus of the oral history effort for the first three years of its existence has been to capture the experiences of scientific program staff at the NHGRI, many of whom were in the process of retiring when the History of Genomics Program was being developed. The oral history effort has also on an *ad hock* basis interviewed former NHGRI grantees and significant figures in the history of the Human Genome Project, including Maynard Olson, Ari Patrinos (who headed mapping and sequencing efforts at the Department of Energy), Ewan Burney (known for his significant role in the ENCODE consortium), among others. The oral history program has been aggressive in interviewing leading population geneticists such as Lynn Jorde and Sarah Tishkoff (Bamshad et al. 2001) (Hsieh et al. 2016) while also trying to capture the experiences of intramural investigators engaged in intramural laboratory research on campus.

Regarding the focus on intramural research, their experiences are important to capture since these investigators are relatively unknown to historians and sociologists of science. As importantly, the unique nature of intramural scientific funding at the NHGRI poses novel questions about the funding of in many cases high risk research with slightly differing review mechanisms than investigators and centers funded through extramural mechanisms (though nonetheless rigorous). An oral history archive of intramural scientists is all the more important because of the sometimes fraught discussions over the status of intramural science on the NIH campus; namely, that intramural scientists, because they have "dedicated funding" pursue and produce less rigorous science than extramural research grantees. No consistent studies have been attempted to either prove or disprove this assertion. It is hoped that the oral history program, in detailing the experiences and research of intramural scientists at the NHGRI, can serve as a resource for the significance of intramural science to be addressed (Liotta 1992).

Over the next year, the History of Genomics Program plans to interview some of the key conceptual architects of the Human Genome project as well as long-standing leaders in the genomics field, including Debbie Nickerson, David Valle and Michael Bamshad on the Centers for Mendelian Genomics (Bamshad et al. 2012), George Church (on synthetic biology), Eric Lander (on the history of the Human Genome Project and the role of the Broad Institute in the Human Genome Project and most recently in the Common Disease Centers) Carlos Bustamante (on population genetics and the genomics of complex disease), and others.

In sum, the History of Genomics Program, through its gathering of oral histories, making its archival resources available, promoting scholarly work and a hosting visiting lecture series, wishes to turn the NHGRI into a welcoming environment for scholars of contemporary biology. To that end, the History of Genomics Program is moving forward with a major meeting on the history and philosophical implications of the last 15 years of

genomic science, focusing on functional studies of the genome such as the ENCODE and the modENCODE programs.

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Bamshad, Michael, Toomas Kivisild, W Scott Watkins, Mary E Dixon, Chris E Ricker, Baskara B Rao, J Mastan Naidu, BV Ravi Prasad, P Govinda Reddy, and Arani Rasanayagam. 2001. "Genetic evidence on the origins of Indian caste populations." Genome research no. 11 (6):994-1004.

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Manolio, Teri A., Rex L. Chisholm, Brad Ozenberger, Dan M. Roden, Marc S. Williams, Richard Wilson, David Bick, Erwin P. Bottinger, Murray H. Brilliant, Charis Eng, Kelly A. Frazer, Bruce Korf, David H. Ledbetter, James R. Lupski, Clay Marsh, David Mrazek, Michael F. Murray, Peter H. O'Donnell, Daniel J. Rader, Mary V. Relling, Alan R. Shuldiner, David Valle, Richard Weinshilboum, Eric D. Green, and Geoffrey S. Ginsburg. 2013. "Implementing genomic medicine in the clinic: the future is here." Genet Med no. 15 (4):258-267.

The Papers of Conrad Hal Waddington at Edinburgh University Library Special Collections

Clare Button

THE The papers of the biologist and thinker C.H. Waddington (1905-1975), held at Edinburgh University Library Special Collections, occupy nearly 70 boxes. They reveal Waddington's rich diversity of interests and activities as a scientist, writer and public communicator, as well as an exponent of ecological and strategic thinking, art and architecture, and their potential is only just beginning to be unlocked by the research community.

Brief biography

Conrad Hal Waddington was born in Evesham, England, on 8 November 1905. After studying Natural History at Sidney Sussex College, Cambridge and holding a studentship in Philosophy, Waddington was appointed Embryologist and Lecturer in Zoology at Strangeways Research Laboratory, Cambridge in 1934. During the Second World War, Waddington worked in Operations Research on photographic reconnaissance and with anti-shipping strikes.

In 1947, Waddington became chief geneticist of the newly-formed National Animal Breeding and Genetics Research Organisation in Edinburgh, Scotland. This was established by the Agricultural Research Council to boost post-war food production by applying the science of

Figure 1. C. H. Waddington, c. 1940s, with his characteristic pipe. From EUA IN1/ACU/A1/5/7. 0057350d.

All images courtesy of Edinburgh University Library Special Collections.

Figure 2. Portrait of Waddington in the style of artist Marc Chagall, painted by Ruth Clayton. From EUA IN1/ACU/A1/5/7. 0057357d.

genetics to the improvement of livestock. Waddington combined this post with the Buchanan Chair of Animal Genetics at the University of Edinburgh. In 1951, NABGRO split to form the Animal Breeding Research Organisation and the ARC Unit of Animal Genetics. Waddington now headed up the latter organisation, based within the University's Institute of Animal Genetics.

Over the following two decades, the Institute expanded to encompass diverse separately-funded research units. It became the largest genetics department in the UK and one of the largest in the world, and established Edinburgh's reputation as a world-class centre for genetics research. Waddington's laissez-faire style of directorship was found problematic by some, but it arguably also gave scientists a degree of freedom to research in a variety of directions. Waddington's own interests added to this diversity: he established a Film Unit at the Institute, set up an Epigenetics Laboratory and also played a major role in the expansion of the biological faculty of Edinburgh University.

In addition to his research and publications, Waddington was involved in many societies and organisations, including the World Health Organisation, the Club of Rome and UNESCO. Waddington believed in the power of science to educate and inform a better future, and his 'systems thinking' approach led him to use biological and evolutionary reference models as a way of analysing issues con-

cerning human population and settlement, as well as the environment. It was partly this thinking which led him to establish the School of the Man Made Future in 1972 at the University of Edinburgh (now Glasgow's Centre for Human Ecology). He also had a lifelong interest in art and architecture, and in 1969 he published a lavishly illustrated work on art and its relationship with the natural sciences, *Behind Appearance*.

In 1970, he accepted an invitation from the State University of New York to spend two years in Buffalo occupying the Albert Einstein Chair in Science. Shortly before his return to Edinburgh in 1973, Waddington suffered a heart attack. A second attack outside his home two years later proved fatal, and he died on 26 September 1975.

Waddington had been awarded the CBE in 1958, and had been elected a Fellow of the Royal Society of Edinburgh in 1948 and held honorary degrees from Aberdeen, Dublin, Geneva, Montreal and Prague. He had a long record of publication, from 1929 to the 1975, including authorship or editorship of 27 books. He is now chiefly remembered for introducing into biological discourse the concepts of 'canalisation' and 'epigenetics' (now much altered in meaning as a concept). His interdisciplinary and sometimes unorthodox way of approaching science, and the polymathic range of his interests, were once unfashionable but are now beginning to be recognised and appreciated.

Finally, he was always known affectionately as 'Wad', and - seeing as I have spent four years getting to know him through his papers - I will refer to him in the same way.

Acquisition and funding history

Wad's papers arrived at Edinburgh University Library in the late 1970s, following his death. A (very) basic box list of the papers was made, but it was not until 2012 that a full online catalogue was developed, as part of the project 'Towards Dolly: Edinburgh, Roslin and the Birth of Modern Genetics'. This project, and its successor, 'The Making of Dolly: Science, Politics and Ethics', are funded by the Welcome Trust's Research Resources funding stream, which supports the cataloguing and preservation of museums, library and archive collections of value to the medical and scientific humanities.[1] In addition to Wad's papers, rare books, glass slides and objects, as well as the records of various scientific institutions and the personal papers of other scientists, were also catalogued, preserved and conserved.

As I detailed in the *Mendel Newsletter* No. 20 (June 2015), the grant enabled these collections to be rehoused in archival quality folders and boxes, for conservation work to be carried out on particularly fragile items, such as glass slides and early rare books, and for catalogues to be made to international standards and mounted online on a dedicated project website.[2] A project blog was also developed, which aimed to draw out the individual stories behind certain items or individuals within the collections.[3]

The papers

Cataloguing Wad's papers was my first task as Project Archivist on 'Towards Dolly', and, as a non-scientist, it was a daunting one at first, getting to grips not only with the basics of genetics terminology but also with Waddington's polymathic nature. I was also fortunate to be able to speak with many scientists who had known Waddington in their early careers, and a picture emerged of a man often seen as aloof or shy by his staff, a famously absentee Professor and an almost non-existent PhD supervisor. This more awkward, elusive side of Wad is at odds with the figure which emerges from

[1] Wellcome Trust, http://www.wellcome.ac.uk/Funding/Medical-Humanities/funding-schemes/support-for-archives-and-records/index.htm (accessed 6 April 2016)
[2] Edinburgh University Library Special Collections, 'Towards Dolly' project website, http://www.archives.lib.ed.ac.uk/towardsdolly/ (accessed 6 April 2016)
[3] Edinburgh University Library Special Collections, 'Towards Dolly' project blog, http://libraryblogs.is.ed.ac.uk/towardsdolly/ (accessed 6 April 2016)

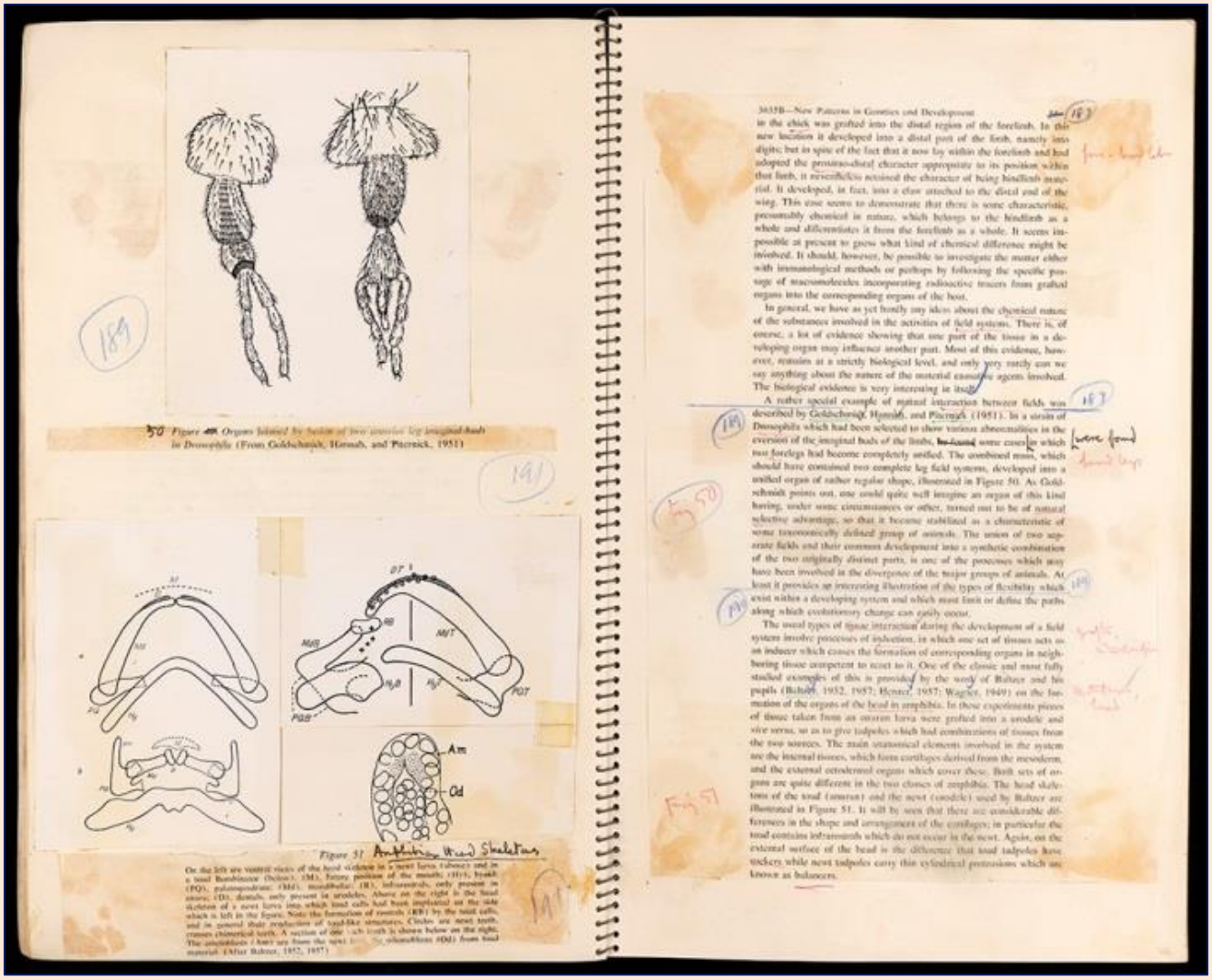

Figure 3. Printer's proofs of *New Patterns in Genetics and Development* (c. 1961). Coll-41/2/1/8. 0057464c.

his papers; a lively and assertive communicator, not afraid to challenge opinions and fight his corner. One letter from Francis Crick about Wad's epigenetic landscape concept advises him to 'Throw it away and start again!' However, Wad stood his ground, and Crick's next letter sees him begging for 'Peace! Peace!'

The archive comprises Wad's laboratory books (for which I gratefully called upon the help of one of our academic advisers on the project to interpret the scribblings about chick embryology and experiments with *Drosophila*), typescripts and manuscripts of books and articles; diagrams and illustrations, and, touchingly, a file of papers discovered on Wadd's desk at the time of his death. There are subject files covering everything from 'Catastrophe Theory' to the 'Egg Marketing Board', and box upon box of correspondence with colleagues, publishers, the media, the public, and various distinguished scientists and thinkers. Papers concerning Wad's scientific research and publications feature largely, of course, but there is also plenty about his work in Operational Research during the Second World War, his influence with organisations such as UNESCO, the World Health Organisation and the Club of Rome, and his establishment of the School of the Man Made Future and Edinburgh's Epigenetics Research Group.

Amidst all of this information can also be found light personal touches and occasional surprises: a schoolboy essay on 'Alchemy' complete with Wad's intricate occult illustrations; a beautiful pencil sketch of a horse statue made for him by Indian craftsmen; and Wad's words for an abstract musical performance (later published in verse form in his book *The Man-Made Future*) which contain the lines: 'The querulous who merely question the qualifications / of the scientific enquiry after quantity and quality / will find that their eternal quest is querying / whether their quasi quietude qualifies them / for equality quashiokor, quod or the quietus, / unless these quandum Quixotes / quite quit their queasy quibbling / and take as quarry their quota of quotidian quiddities'!

But there are omissions and gaps too. There is very little about Wad's early life, his Cambridge University days and the beginning of his career as a developmental biologist at the Strangeways Research Laboratory. While correspondence with colleagues and University authorities is voluminous, there is little to demonstrate the lively – and sometimes tempestuous – social life at Edinburgh's Institute of Animal Genetics, where Wad was director for over twenty years. For an impression of this, we must turn to the archives of his colleagues, which have also been catalogued as part of the 'Towards Dolly' project. The records of the Institute of Animal Genetics, for instance, contain affectionate caricatures of Wad, pipe always in mouth, painted by his colleagues in the style of various artists; a beautiful photograph album, put together for his 50th birthday, which depicts jovial staff drinks parties, boisterous singing and dancing (dressed up as *Drosophila*, no less), and a vinyl LP of Institute staff singing comic genetics-related songs. A significant collection of artwork and correspondence relating to the artist and designer Yolanda Sonnabend sheds light on their working relationship as they collaborated on Waddington's final book, *Tools for Thought*. Life wasn't always so harmonious, however; a 1951 report among the papers of one of Waddington's colleagues, James Sang, reveals details of an official enquiry into the growing discord between Waddington and some of his staff during a period of communal living. This now infamous part of Edinburgh's genetics history became enshrined in fiction in Edith Simon's 1953 novel *Past Masters*. There's no doubt that Waddington continues to surprise to this day: in my 'other life' as a traditional music researcher, I was fascinated to learn of Waddington's involvement with the English folk dance revival in 1920s Cambridge!

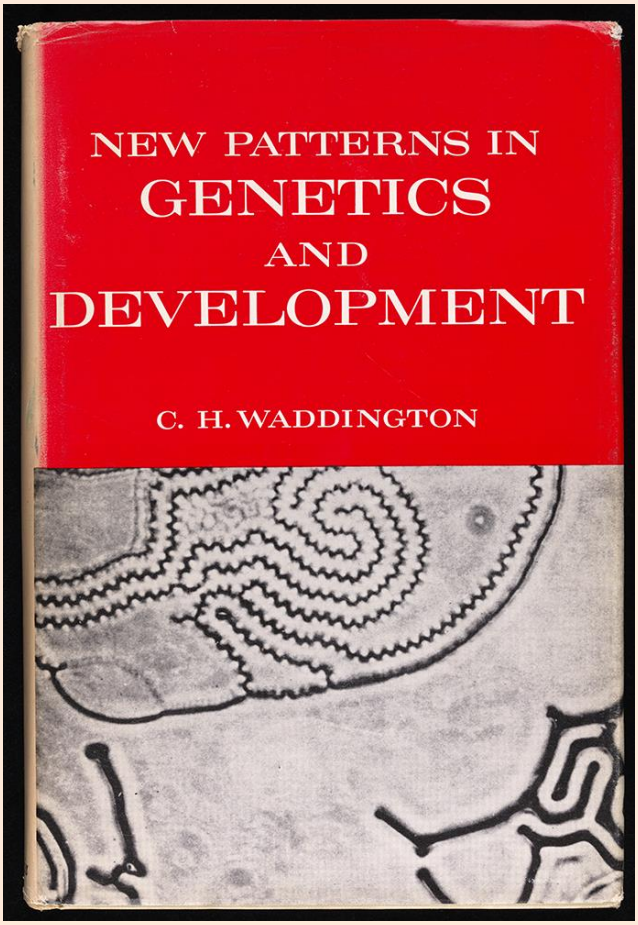

Figure 4. Cover of *New Patterns in Genetics and Development* (1962). 00957478c.

Cataloguing and blogging about the Waddington archive and related collections has led to a surge of interest from researchers from various disciplines, including scientists, historians, and artists. Historians have drawn upon different aspects of the archives to enhance their understanding of, for ex-

ample, women in science, operations research during World War Two and the British art scene of the 1950s. Paul Harrison has drawn from both the Waddington and Yolanda Sonnabend archives for his work as artist in residence with the European network EpiGeneSys[4] while graphic designer Mhairi Towler used some of the scientific illustrations to inspire new 3D animations.[5] It is hoped that these archives will continue to play a key part in Waddington's long overdue critical renaissance.

A note on the arrangement of and access to the papers

The papers have been arranged in the following ways: laboratory notebooks and bundles of research notes; manuscripts, typescripts and related correspondence; material relating to Waddingtons' lectures; illustrative figures and plates for publications; correspondence chiefly concerning Waddington's writing with various publishers; material relating to a variety of societies and organisations; material relating to conferences, meetings and visits; files relating to the University of Edinburgh; personal and departmental papers; subject files in A-Z order.

As well as descriptive and contextual information, the catalogue also contains interlinked authority terms (personal, place and corporate names) and subject index terms, which allow related material across other collections to be cross-referenced.

EUL Special Collections are fortunate to have two academic advisers on the project board; Dr Steve Sturdy, Head of Science, Technology and Innovation Studies at the University of Edinburgh and Professor Grahame Bulfield CBE, former director of the Roslin Institute and Professor Emeritus of Genetics at the University of Edinburgh. They have been able to provide informed perspectives and expert interpretation beyond the remit of a librarian or archivist, and these projects would have been immeasurably poorer without their imput.

Access to the collections is by appointment; details are given below.

Edinburgh University Library Special Collections
Main Library
George Square
Edinburgh
EH8 9LJ
is-crc@ed.ac.uk

Online Resource
The Waddington catalogue
http://archives.collections.ed.ac.uk/repositories/2/resources/85257
The 'Towards Dolly' project blog
http://libraryblogs.is.ed.ac.uk/towardsdolly/
Further information about the Centre for Research Collections
http://www.ed.ac.uk/information-services/library-museum-gallery/crc

[4] EpiGeneSys, http://www.epigenesys.eu/en/ [accessed 12 April 2016].
[5] Vivomotion, http://www.vivomotion.co.uk/ [accessed 12 April 2016].

The Papers of Britton Chance in the American Philosophical Society

Charles Greifenstein *and* Bayard Miller
American Philosophical Society Library

BY any measure, biochemist and biophysicist Britton Chance (1913-2010) had a long career, beginning in the 1930s and remaining productive into the 21st century. He was a conscientious record keeper, too. The bulk of his papers—46 file cabinets' worth—he had sent to a storage compartment on the New Jersey Shore—where he spent much of his time—after he became emeritus. Other material was held in his lab at the University of Pennsylvania, at his home on Pine Street, and in a storage facility in the Germantown section of Philadelphia. Selecting *in situ* records that were potentially important, gathering it all together, took several months, before processing could start, but his huge archive, thanks to a bequest from his estate and a grant from the Arnold Beckman Foundation, has been processed expeditiously and is now open to researchers. At 275.5 linear feet—the largest fully-processed collection in the Library—there is a lot to examine.

If one were to choose a single word to sum up Chance's work in a single word, it would be instrumentation. Born in Wilkes Barre, Pennsylvania, Britton was the son of Edwin M. Chance, an engineer who among other accomplishments invented a device to detect carbon monoxide in coal mines. As a young man Britton showed the technological aptitude that characterized his career. He invented an automatic steering device for ships, which received a patent in 1937 (the first of 44 he was to receive) and was tested on a voyage to Australia on a British-flagged ship, the New Zealand Star.

It was fitting that Chance's first patent was for a nautical instrument. His family had moved to Haverford, Pennsylvania and took vacations on the New Jersey Shore, where the whole family (and, eventually, Britton's large brood) would sail. A notable trip Britton took with his father—well-documented by slides and movies in the collection—was to the Caribbean. Noted naturalist and author William Beebe was with them for part of the voyage, on which they met Ernest Hemingway. To say sailing was a significant part of Chance's life and that he was excellent at it risks understatement. He designed boats (Britton Chance, Jr. was a noted boat designer as well) and won many races, from local events at Barnegat Bay, New Jersey, to an Olympic gold medal in 1952. Given the thorough record keeper that Chance was, it is not surprising that there are 9 linear feet of records (not counting photographs and movies) about this aspect of his life.

Chance received a PhD in physical chemistry from the University of Pennsylvania, the focus of his work being the development of the stopped-flow device, which measures fast chemical reactions, and the study of enzyme kinetics. The opportunity to test his steering device from London to Australia also gave him the opportunity to work at Cambridge University with Hamilton Hartridge, Francis

A small portion of the 275.5 linear feet of the Britton Chance Papers. MSS.MS.COLL. 160.
http://www.amphilsoc.org/collections/view?docId=ead/Mss.Ms.Coll.160-ead.xml

Roughton and Glenn Millikan and their rapid flow device. Chance miniaturized and improved the stopped-flow device and also developed a spectrophotometer. The threat of war kept Chance from returning to England after a visit to the US, but he continued work on his second PhD with Roughton, who had moved to Harvard University.[6] Cambridge granted Chance his second PhD, in physiology, in 1942.

Chance's skill with instrumentation contributed to the war effort during World War Two. At the urging of Louis Ridenour, Chance joined the Radiation Laboratory (Rad Lab) at the Massachusetts Institute of Technology (M.I.T.) in the summer of 1941, where he helped develop radar, navigation systems, and a bombing computer as well as writing and editing Rad Lab reports. While there, Chance worked with the ENIAC computer, the first reprogrammable computer in the US, and would go on to do use ENIAC's successor, EDVAC, to do enzyme research in the 1950s. During this early period, Chance was already collecting his correspondence as well as notes about what he was doing. (There is a specific series about his Rad Lab work.)

After the War, Chance travelled to Stockholm, Sweden on a Guggenheim Fellowship to work with Hugo Theorell at the Nobel Medical Institute. Using the flow apparatus and spectrophotometer to investigate the mode and nature of action enzymes, Chance and Theorell discovered the process by which an enzyme metabolizes alcohol; it is now

[6] The APS has the Roughton Papers as well.

called the Theorell-Chance mechanism. Chance's development of a dual wavelength spectrophotometer made it possible to observe the enzyme-substrate combination and the reaction with alcohol. This successful collaboration led to Theorell's 1955 Nobel Prize. Chance went on to learn crystallography with Nobelist Max Perutz.

There is much correspondence with Theorell in the papers, but also, in keeping with Chance's collaborative nature, there is communication with at least 21 laureates in the papers.

Chance returned to the University of Pennsylvania and became the director of the Eldridge Reeves Johnson Foundation in 1949, with which he was associated for the rest of his career. From there he oversaw the growth of the molecular biochemistry and molecular biology fields as well as the birth of biophysics especially through the many doctoral and post-doctoral students who came through his lab. He had especially strong working relations with Asian students and colleagues.

Chance did pioneering work throughout his long career and, just as important, laid the groundwork for others to develop. For instance, work he did on magnetic resonance spectroscopy led to the development of magnetic resonance imaging for diagnostics. Chance's work is documented in meticulously-kept experimental records, many of which he had bound, and laboratory notebooks. It is possible to cross-references photographs of experiments in the notebooks with published articles.

Chance's Papers are unusually comprehensive with some notable features. Besides the yachting material and the exceptional experimental records, the collection includes records of his patents and equipment catalogs that help to document the evolution of technology. In short, there is a lot to explore in the papers of Britton Chance.

American Philosophical Society Library

Research and Fellowships in Genetics, History of Medicine and Related Disciplines

The American Philosophical Society Library

We are a leading center for historical research with holdings renowned for their depth and interdisciplinary value to scholars. Resources include more than 11 million manuscript items, 350,000 printed volumes, thousands of maps, prints and photographs, and thousands of hours of audio recordings.

Among the Library's most well known collections are the papers of many noted scholars, academics and statesmen particularly of the 18th through 20th centuries. Significant research collections of far-reaching social and political interests embrace topics as diverse as first-person historical accounts and the official records of research organizations. Our holdings have great depth in many fields of history, science, and art, conserving centuries of intellectual pursuits, professional achievements and the personal reflections of men and women worldwide. The Library does not hold collections on philosophy in the modern sense. Interested parties unsure if the Library has materials related to their research are invited to inquire.

Our collection strengths include, but are not limited to:

- Studies in Genetics and Eugenics
- History of Physiology, Biochemistry and Biophysics
- American and European Science and Technology
- Natural History Through the 19th Century

History of Genetics Collections

The American Philosophical Society began specifically collecting manuscripts and books relating to the history of genetics in the early 1960s at the instigation of the mouse geneticist L. C. Dunn, but it was the project conducted by H. Bentley Glass between 1977 and 1985 that led to truly outstanding growth. Funded by the Mellon Foundation, Glass surveyed and indexed the existing collections at the library and prepared a printed guide to them for researchers. This was the original basis for the comprehensive guide to the American Philosophical Society's own collections in genetics, which include the papers of L. C. Dunn and H. Bentley Glass, among numerous others.

The APS continues to seek out new collections in the history of genetics and to make them available to scholars.

INFORMATION ON RESEARCH FELLOWSHIPS THROUGH THE APS LIBRARY

www.amphilsoc.org/library/fellowships

Inquiries relating to the APS's manuscripts, printed-materials, and other collections may be sent to reference@amphilsoc.org