The Venereal Poison: A Historic and Genetic Analysis of Categories of Sexually Transmitted Diseases, 1718-1850

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Submitted in fulfilment of the requirements for the Degree of Doctor of Philosophy

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Abstract

During the first half of the eighteenth century, the monolithic term 'venereal disease' or *lues venerea* covered all signs and symptoms of diseases transmitted through sex. In 1766, Francis Balfour – a medical student at the University of Edinburgh – suggested that *lues venerea* could actually be divided into two separate diseases, each caused by a unique contagion: syphilis and gonorrhoea. This opened a debate that continued for decades, between the monists, who believed that syphilis and gonorrhoea were merely symptoms of the same disease, and the dualists, who believed that the two should be separated.

In this thesis, I investigate how the dualist theory was introduced, debated and finally accepted in Britain, particularly London and Edinburgh. Thomas Kuhn's paradigm shift framework is loosely used as a lens to investigate this process. In the decades prior to 1766, changes in how doctors approached venereal disease lay the necessary foundation for the dualist doctrine. This period also saw a set of crises, both scientific and social; the persistent inability to successfully treat venereal disease, the increase in demand for treatment as patient numbers rose, and an increased perception as syphilis of a moral issue via the Reformation Societies. Immediately after the introduction of the dualist doctrine, those who accepted the new doctrine were all found within the social circle of Balfour. Doctors outside this network did not begin to accept the new theory until the dualists began to produce experimental evidence in their favour, showing the shift in priorities between early and late adopters of a theory from a matter of faith and social trust, to one of hard evidence.

The ability to separate gonorrhoea and syphilis, however, was confounded by the inability to define venereal disease. This difficulty is reflected in how *lues venerea* was represented with anatomical specimens. A comparison of six medical museums in London and Edinburgh shows that specimens emphasised the lesions of disease. This encouraged a flexible approach which prioritised signs and symptoms, rather than through disease categorisation. The difficulty in diagnosing venereal disease is further highlighted by genetic analysis of one of these anatomical specimens, which finds a possible underlying case of nasal infection and food poisoning rather than syphilis. This work demonstrates the importance of shared language and agreed definitions when introducing new scientific theories.

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> I now publicly declare, I am very indifferent as to what Cavils are made against this useful Essay, it not being wrote with a View of Interest respecting the Sale, therefore its Enemies will be greatly disappointed, if they endeavour to depriciate it on that Account, but if through worse Motives, they will not make me angry, as I have the Happiness to be out of Reach of such kind of Envy, consequently they will gain no more Victory, than if they were fighting with the Air, or their own Shadows. (Becket 1765: preface)

Thank you to my supervisors Sam Cohn, Pawel Herzyk and Maggie Reilly for their help with this project. I am especially grateful for Maggie's support, who has been there for me through the many ups and downs of life while writing a thesis.

Thank you to my partner Sam, who has tolerated me and my STD-related sense of humour throughout the last four years. My deepest apologies to Penny, who has missed out on many dog walks and plays in the garden while I spend my time writing instead. She has nonetheless made a perfect working companion. Thank you to my family for dealing with more sex-related conversation than you probably ever hope to hear from your child, particularly my Dad who has attended my lectures, accompanied me to museum openings and given me the endearing nickname of 'dick detective'. My extra thanks to my Mum for proofreading my work, including a section on teeth that I am told gave her bad dreams.

Thank you to colleagues at the University of Glasgow and The Hunterian who have supported me throughout. Many people at The Hunterian have supported me throughout the years, including on the route to my PhD and in my many side projects: thanks in particular to Ruth Fletcher, without whom I would never have discovered my passion for museums, and Nicky Reeves, whose open and frank discussions of academia have been more helpful than he maybe realises. I would have been lost in the lab without assistance from Dave McGuinness and Julie Galbraith, who patiently and consistently made me feel welcomed despite my natural tendency towards clumsiness. In the library, Bob McLean has helped me provided invaluable support. The entire Leverhulme Trust cohort have also been a pleasure to work with. Outside of Glasgow, special thanks to Richard Bellis and Dominik Huenniger for their helpful conversations and consistent interest in the project.

Many special thanks to the hundreds of unsung heroes who made this project possible: the archivists and digitising staff at the institutions that have generously made their work available for free through the internet. This thesis would not exist without them.

Finally, I would like to acknowledge the contributions of the eighteenth-century patients who were experimented on, written about, dissected and preserved. Often this work was done without their consent, and as I discuss within my thesis, exploited marginalised people. In light of this, I have donated the equivalent cost of printing this thesis to POhWER, a UK-based charity that provides advocacy for people using healthcare services.

This work was supported by funding from the Leverhulme Trust.

Author's Declaration

I declare that, except where explicit reference is made to the contribution of others, this dissertation is the result of my own work and has not been submitted for any other degree at the University of Glasgow or any other institution.

Francis Osis

Chapter 1 - Introduction

At the opening of the eighteenth century, doctors and surgeons wrote about a single venereal disease. This disease, typically called the great pox or *lues venerea*, often started with either an ulcer on the genitals known as a chancre, or with discharge running from the penis or vagina, before turning into a systemic disease that could end in death. The early discharge was commonly known as gonorrhoea and considered to be one of the telling signs of *lues venerea*. By 1850, writers no longer discussed a single venereal disease, but multiple. Gonorrhoea was now considered to be its own disease, in a separate nosological category. Practitioners at this stage understood the disease to be caused by a distinct contagion from the *lues*, which was now more often referred to as syphilis. The separation has remained to this day, after it was confirmed by identification of the underlying pathogens; *Neisseria gonorrhoeae*, which causes gonorrhoea and was discovered by Albert Neisser in 1879, and *Treponema pallidum*, which causes syphilis and was discovered by Fritz Schaudinn and Erich Hoffman in 1905.

In this thesis, I investigate the intervening years and the processes which led to the separation of gonorrhoea and syphilis as distinct diseases. This focuses on the debate between the monists – who considered syphilis and gonorrhoea as a single, united disease - and the dualists – who proposed that the two were caused by unique contagions. Previous histories have focused on defining a timeline and primary characters in the debate. I look to expand on this by analysing the types of evidence that were used and rejected by each group, as well as the social connections that fostered the initial debate. Through this analysis, I demonstrate the increasing importance of observation and experimental evidence throughout the eighteenth century. This included the use of anatomical specimens; body parts preserved after dissection in order to retain them as evidence of pathological lesions. I examine the presence of venereal disease in various collections of anatomical specimens and how they were used in the debate. I also undertake genetic sampling of some of these specimens to attempt to determine the underlying pathogens in various lesions, in order to further clarify what signs and symptoms practitioners were including under the umbrella of venereal disease.

Terminology

Since at least the end of the fifteenth century, a large variation of words and phrases have been employed to describe venereal disease. In modern language, the term 'venereal disease' itself is used interchangeably with 'sexually transmitted infection' (STI) or 'sexually transmitted disease' (STD) to designate any of the known diseases that are transmitted through sexual intercourse. However, at the start of the eighteenth century venereal disease was used to refer to a single, specific disease. Throughout the separation of this into syphilis and gonorrhoea (and other diseases), the use of the term venereal disease was often confused; sometimes it referred to the traditional singular disease, sometimes it was used as an umbrella term by dualists for syphilis and gonorrhoea, and sometimes it was exclusively used to describe the symptoms of syphilis and not gonorrhoea. Where I use the term venereal disease throughout this thesis, I am always using it as an umbrella term to describe all sexually transmitted diseases, unless specified otherwise.

The term *lues venerea* is similarly tricky to pin down. While sometimes this was used interchangeably with venereal disease, it more often referred instead to the later 'constitutional' (now designated secondary and tertiary) stages of syphilis. This was also sometimes described as a 'confirmed pox'.[1] When I use either of these terms, I am referring to the later stages of syphilis. As described in more detail below, syphilis is divided in modern terminology into three stages: primary, secondary, and tertiary. In eighteenth-century terminology, these were commonly collapsed into 'local' and 'constitutional' stages of syphilis, as shown more fully in the following chapter. The primary stage, known as the local stage in the eighteenth century, describes the initial ulcer at the point of infection. This ulcer was almost always referred to as a 'chancre' (also sometimes spelled 'chancer'); although sometimes the word ulcer was used, the term ulcer did not exclusively refer to a chancre. For monists, gonorrhoea was also a symptom of local venereal disease. The secondary and tertiary stages of syphilis include symptoms such as skin lesions and bone lesions, and were referred to as the constitutional symptoms

[1] Use of the terms 'pox' or 'great pox' to describe venereal disease was more uncommon in the eighteenth century, despite its regular earlier use.

of venereal disease. The external contagion that caused venereal disease was typically referred to as either the ‘venereal virus’ or the ‘venereal poison’.

The word ‘gonorrhoea’ generally described a discharge from the genitals, although as shown in chapter two it often had a broader definition and included its own constellation of symptoms. The terms ‘clap’, ‘running’ and ‘blennorrhagia’ could be used interchangeably; in this thesis, I only use the term gonorrhoea for consistency. A ‘gleet’ refers to a long-running, persistent discharge and was considered a complication of gonorrhoea.

Syphilis and Gonorrhoea

Although this thesis focuses on historic definitions and diagnoses of venereal disease, it is useful to understand the variety of signs and symptoms that we now know can occur with syphilis and gonorrhoea. Syphilis is commonly referred to today as a ‘protean disease’ or the ‘great imitator’ for the many different ways it can present; this demonstrates the complexity of the disease that practitioners were dealing with.

Pathology and clinical presentation of syphilis.

Venereal syphilis is a sexually transmitted disease caused by the bacteria *Treponema pallidum* subsp. *pallidum* (referred to hereafter as *T. pallidum*). This pathogenic organism is part of the spirochete group, which also includes the bacteria that causes Lyme disease. The spirochetes as a group are long, thin and tightly coiled bacteria. They possess a unique method of motility; axially oriented flagella cause the spirochete to rotate, which in turn drives motion (Charon et al 2012). This makes *T. pallidum* especially motile and able to easily disseminate to tissues throughout the body, where it then causes systemic effects. Syphilis is a complex, multi-stage infection which can cause a dizzying array of signs and symptoms. Fully defining the clinical presentations can therefore be difficult. However, the usual course of the disease can be broken down into primary, secondary and tertiary stages, which are each briefly described here.

The primary stage presents as a chancre at the site of infection. This typically appears 21 days (within a range of 10 to 90 days) after communication of the pathogen (LaFond and Lukehart 2006). This appears as a painless, indurated, non-purulent ulcer, which may range in size from 0.3 - 3cm. However, it is thought that chancres may appear in atypical ways in up to 60% of patients (Kent and Romanelli 2008). Chancres may also easily go unnoticed if they are located in the cervix, urethra and rectum. When left untreated, chancres will heal within 3-6 weeks (Zeltser and Kurban 2004). The primary chancre may be accompanied with regional lymphadenopathy (swelling of lymphatic glands, historically called bubo) in around 80% of cases (Mindel et al 1989). As this is usually associated with genital chancres, it typically appears as swelling of the inguinal lymph glands in the groin.

Secondary syphilis usually occurs within 3 months of infection. The initial symptom of this stage is often a rash. This can vary hugely in appearance, and some patients may not even be aware of changes. The most common manifestation is a disseminated macular rash; pale pink, flat spots of 4-8mm in diameter (Baughn and Musher 2005). Other symptoms of the secondary stage are variable, but can include: sore throat, muscle ache, headache, generalised lymphadenopathy and alopecia (hair loss resulting in a patchy, moth-eaten appearance) (Centers for Disease Control and Prevention 2017). *T. pallidum* may also rarely invade the nervous system during the primary and secondary stages, resulting in aseptic meningitis (early neurosyphilis) (Kent and Romanelli 2008). Most symptoms of secondary stage usually spontaneously resolve. Following this, patients enter a latent stage, where they present with no signs or symptoms although the bacteria is still present in their body.

Current understanding of the progression from latent to tertiary stage syphilis is mostly informed by the retrospective Oslo study of the 1950s (Gjestland 1955). This showed that only approximately a third of patients will progress into the tertiary stage, typically 20-40 years after initial infection. Gummatous syphilis – the formation of granulomatous lesions which may affect any organ of the body – is found in 15% of untreated cases. Cardiovascular syphilis is found in 10% of patients, and late neurosyphilis in 6.5%. Gumma can occur throughout the system and cause a wide variety of syndromes. These lesions are accumulations of lymphatic cells in response to the presence of *T. pallidum*. When they occur around blood vessels, the inflammatory process causes an increase in the number of lining cells, typically constricting the lumen of the vessel (endarteritis obliterans). The obstruction causes local necrosis, which later partially heals (King and Catterall 1959). This cycle of tissue damage and healing is what ultimately causes the symptoms of gummatous syphilis. Exact symptoms depend on which tissue is involved. In bone, gumma cause thickening of the long bones, destruction of thinner bones, and pain (typically at night). The classic pock-marked appearance of bone gumma are the primary indication of syphilis in osteoarchaeology.

Even in this highly condensed review of some of the more common symptoms of syphilis, it is clear that this is a complex and varied disease. It continues to be difficult to clinically diagnose even today, and can only be confirmed by serological tests. Factors contributing to the potential confusion of diagnosis are the wide range of potential symptoms and their differential diagnoses, the variation of incubation times in different stages, the prolonged latent stage and the fact that some major signs are easily overlooked.

Other diseases in the *Treponema* family.

The causative bacteria for syphilis, *Treponema pallidum* subsp. *pallidum*, is one of three currently known subspecies of *Treponema pallidum*. The other two are *Treponema pallidum* subsp. *pertenue*, which causes yaws, and *Treponema pallidum* subsp. *endemicum*, which causes endemic syphilis (also known as bejel). The three diseases share many features. Yaws and bejel, however, are not spread sexually but through skin-to-skin contact. Yaws is a disease of tropical and humid countries (World Health Organization 2012). Primary lesions most commonly affect the lower limb and have a raised and red appearance that resemble raspberries. Secondary lesions most commonly affect the skin and bones. Bejel, on the other hand, is found in dry and arid regions. Its primary lesions are found in the oral mucosa, where they are easily missed. Secondary lesions affect the same region, where they may cause destruction of the palate, as well as skin and bone (Giacani and Lukehart 2014). Another possible subspecies of *Treponema* was Scottish sibbens, a syphilis-like disease that was present in the eighteenth and nineteenth centuries. It is unsure whether Scottish sibbens was the same as yaws or bejel, or even its own distinct treponemal disease (Morton 1967). The importance of sibbens in defining syphilis is examined in chapter four.

Pathology and clinical presentation of gonorrhoea.

Gonorrhoea is also transmitted through sexual activity and is caused by the bacteria *Neisseria gonorrhoeae*. *N*. gonorrhoeae is a Gram-negative, diplococci (round-shaped) bacterium. Unlike syphilis, gonorrhoeal infections are typically limited to the local area of infection. When passed via sexual contact, this is usually lower anogenital tract, where *N. gonorrhoeae* uses surface proteins to embed itself within the sub-epithelial space (Ison 2011). The bacteria can also be spread to other areas by physical contact, for example as with ophthalmic gonorrhoea. Gonorrhoea is, typically, a much simpler infection than syphilis. The primary symptom in men is a clear urethral discharge. In women, gonorrhoea may often be asymptomatic (up to 50% of cases), with the primary symptom being vaginal discharge. Symptoms appear 3-7 days after exposure (Ison 2011).

It is possible for *N. gonorrhoeae* to disseminate to other tissues, causing complications. This may be limited to the rest of the genital tract, possibly leading to epididymitis and testicular swelling in men and pelvic inflammatory disease (PID) in women. In rare cases *N. gonorrhoeae* may invade blood vessels and cause systemic effects. This usually manifests as septic arthritis which may be accompanied by a rash (Ison 2011). Recurrent or chronic (>20 years) gonorrhoeal infections are also strongly associated with urethral strictures (Mundy and Andrich 2011).

Origins of syphilis and gonorrhoea in Europe.

Theories surrounding the origins of syphilis and gonorrhoea in Europe are still under debate, and it is beyond the scope of this thesis to enter this debate. However, their origins were also being debated in the eighteenth century and informed the argument over classifying the two diseases. It is therefore worth outlining them here.

There are several theories which address the introduction of syphilis into Europe. The Columbian Exchange theory posits that venereal syphilis was brought back from the New World by Christopher Columbus. This theory appears to be supported by contemporary accounts, which generally agree that the disease appeared in 1493, as well as accounts of Native Americans who seemed to be well-acquainted with it (Crosby 1973). The direct opposition to this – the Pre-Columbian hypothesis – counters that venereal syphilis had always been present in the Old World but had been misdiagnosed and confused with other diseases (Cook and Powell 2016). However, there is a distinct lack of paleopathological evidence for this. Although pre-Columbian skeletal evidence has been found in the New World, there is no reliable evidence that it can be found before 1493 in the Old World (Harper et al 2011; Armelagos et al 2012).

The Unitarian hypothesis states that the treponemal diseases are, in fact, the same; but behave differently in different environments (Hudson 1965). This theory is typically now discounted due to genetic evidence that shows that although the treponematoses are closely related, they are nonetheless distinct. Finally, an evolutionary theory developed by Hackett (1963) and extended by Brothwell (1981) suggests that venereal syphilis evolved in Europe as a response to cultural changes in hygiene, clothing and sex. Some genomic work with *T. pallidum* has begun to clarify the evolution of the different subspecies, which is fully described in chapter six. However, without sampling more genetic strains of syphilis and the treponematoses, it is difficult to verify or deny this theory (Cook and Powell 2016).

Less work has been devoted to the origins of gonorrhoea. As gonorrhoea does not leave skeletal lesions, its history must be traced using documentary evidence, which appears to be shaky at best. Oriel's (1994) account finds that although the word itself can be found in medical texts as early as Galen, these descriptions do not match the condition we know today as gonorrhoea. Oriel concluded that the first matching descriptions appear in Arabic literature in the tenth and eleventh centuries, followed by Italian accounts in the twelfth century. Fabricius (1994: 122-23) believes that an English Parliamentary Act introduced in 1162, which regulated the activities of prostitutes in order to control venereal disease, was probably targeted at gonorrhoea. Regardless, gonorrhoea seems to have been present in the European population before syphilis appeared. Nevertheless, gonorrhoea swiftly became regarded as a manifestation of syphilis rather than being recognised as a separate disease, leading to the confusion which is addressed in this thesis (Flegel 1974).

Historiography

A general timeline of the monist-dualist debate is now well established. Typically, historians begin with the work of Francis Balfour (1744-1818), a Scottish surgeon who spent most of his life working for the East India Company. As a medical student at the University of Edinburgh in 1767, Balfour wrote his dissertation on the subject of venereal disease; this included the proposition that gonorrhoea and syphilis were caused by distinct contagions (Balfour 1767). Balfour's work was supported by two local Scottish medical practitioners, Andrew Duncan the Elder (1744-1828) and Benjamin Bell (1749-1806). Balfour was opposed, however, by the famous anatomist and surgeon John Hunter (1728-1793). Hunter notoriously undertook an experiment - published in 1786 - to prove the monist side: he collected the discharge from a person suffering gonorrhoea, and inoculated the matter into another person (J. Hunter 1786: 324–27).[2] The subject went on to develop both gonorrhoea and syphilis, supposedly proving that the two were the same and confusing the topic for decades to come. Finally, the French physician Philippe Ricord (1800-1889) settled the matter with a significant series of more than 2,000 inoculation experiments published in 1838 that showed gonorrhoea would not produce syphilis (Ricord 1838).

Most historians writing on the topic offer variations on this basic narrative. For example, Claude Quétel's seminal *History of Syphilis* simply gives a brief account of Balfour, Duncan, Bell and Hunter. Notably, he adds that the dualist doctrine is established in what he describes as the 'Edinburgh school' (Quétel 1990: 82–83). The first attempt to truly untangle the intricacies of the debate came from Kenneth Flegel in 1974, who expanded the usual narrative to also include the position of a number of other physicians such as the Austrian physician François Swediaur (1748-1824), German physician Johan Clemens Tode (1736-1806) and English apothecary William Ellis (fl. 1771). Flegel adds useful detail to timeline of the debate; however, he does not provide significant analysis of the process. He briefly highlights the importance of the evolving understanding of contagion, 'social factors' of venereal disease, and improving technical ability in inoculations. Flegel also suggests an earlier origin for the dualist doctrine, placing it not with Balfour but rather Herman Boerhaave (1668-1738), the Dutch chemist and physician. Some historians have followed this suggestion (Oriel 1994: 27; Spongberg 1998: 23). However, I disagree that Boerhaave can be considered a dualist; this position is discussed in chapter two.

J.D. Oriel's 1994 history of sexually transmitted diseases, *Scars of Venus*, is the next major publication that pays significant attention to the monist-dualist debate. He argues that Bell was 'one of the greatest figures in the history of venereology', although concedes that 'we

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[2] Although he was not explicit about it, it is likely that Hunter himself was the subject of this inoculation. This is described in much greater detail in chapter three.

do not know how his *Treatise* was received' (Oriel 1994: 30–32). This thesis addresses the gap by carefully examining not just the well-known writers on venereal disease but also works by lesser-known practitioners and students, to trace how evidence was discussed, accepted and rejected. Oriel also suggests that medical opinion on venereal disease became increasingly fragmented through the late-eighteenth and early-nineteenth centuries. I expand on the unstable definition of venereal disease throughout this thesis, and also argue that the lack of agreement significantly prolonged the debate between monists and dualists as there was fundamental disagreement over what venereal disease was.

A master's thesis written by Teneille Humphris (2013) appears to offer the only attempt to analyse the intellectual process of the separation. Humphris uses Ludwik Fleck's concept of a proto-idea; that is, prescientific ideas that form the basis for scientific facts. Humphris argues that Bell's development of syphilis and gonorrhoea as separate diseases serves as a proto-idea for Ricord's. However, as I show in chapter four, Bell contributed very little to the development of ideas for the dualist doctrine. The ideas he used were already developed by Balfour and Duncan before him, and although he added new theoretical evidence this went largely ignored by those following him. It is also difficult to argue Bell's contribution was not based on scientific evidence, as he included a set of inoculation experiments similar to that of John Hunter. As described in chapter three, the monist-dualist debate was already well underway before Bell published his *Treatise*.

Mary Spongberg's analysis of the debate takes a different approach and forms part of her broader feminist analysis of venereal disease in nineteenth-century medicine. Spongberg emphasises the social context of the debate, particularly perceptions surrounding women and sexual activity, arguing that medical practitioners created a belief that women were the primary source of venereal disease, which skewed their scientific understanding of syphilis and gonorrhoea. For example, she highlights that women are more often asymptomatic when infected with gonorrhoea, which resulted in confused ideas about transmission (Spongberg 1998: 26–27). I agree with this position, and show in chapter three that the misconception was key to some of the monist's defence. Spongberg also argues that Ricord's work was accepted at least in part as he described gonorrhoea as a non-specific disease that arose spontaneously in women. Ricord's theory appealed to those who wished to impose regulations on prostitution as it framed women as dangerous sources of disease (Spongberg 1998: 38–41).

Overall, histories of the monist-dualist debate are relatively sparse. These have mostly focused so far on establishing a timeline of precedence and famous names. Humphris and Spongberg have provided more valuable analysis on the development of ideas and social influences. I address a gap in the historiography by going beyond how the monist-dualist debate unfolded in order to investigate why certain ideas were accepted or rejected. I also expand focus beyond the usual suspects - Balfour, Duncan, Hunter, Bell and Ricord - by examining how the debate was approached from a much wider angle. Finally, I introduce a social aspect to the development of these scientific ideas by exploring how Quetel's 'Edinburgh school' was more vital to the initial debate than either he or anyone else had noted.

Methodology

Theory.

In this thesis, I loosely use an adaptation of Kuhn's 'paradigm shifts' as a lens to structure the intellectual process that led to the separation of syphilis and gonorrhoea. Kuhn's 1962 work *The Structure of Scientific Revolutions* centres changes of paradigm in science, defined by Kuhn as 'universally recognised scientific achievements that for a time provide model problems and solutions to a community of practitioners' (Kuhn 1996: xlii). A new paradigm will introduce new theories and laws, but most importantly apply those new theories to solving important problems and provide new problems (Kuhn 1996: 6-7). Kuhn argued that science goes through cycles of 'normal science' and revolutions, which introduce paradigms and provide a new basis for the practice of science. For example, in medicine, the acceptance of germ theory over humoral and miasma explanations for disease would be considered a scientific revolution.

Kuhn suggested that most of scientific practice takes place during period of normal science, which involves fact-gathering within the predictions of the current paradigm (Kuhn 1996: 24–25). Eventually, anomalies will arise that cannot be solved by the paradigm. At first, scientists will attempt to solve anomalies within the assumptions of normal science, steadily causing model 'drift' as the paradigm is increasingly unable to answer these problems. Although this stage uses the current paradigm, it is nonetheless vital for a revolution; as Kuhn argued in one case, ‘The progress of normal science … prepared the way to a breakthrough quite thoroughly’. When enough anomalies accumulate this results in a crisis of confidence in the current science. At this stage, competing paradigms arise that offer solutions to the anomalies; these become incompatible with the prevailing paradigm and are unable to exist side-by-side, meaning that one must be accepted over the others. This new paradigm must fulfil two conditions, according to Kuhn:

> First, the new candidate must seem to resolve some outstanding and generally recognized problem that can be met in no other way. Second, the new paradigm must promise to preserve a relatively large part of the concrete problem solving activity that has accrued to science through its predecessors. (Kuhn 1996: 168)

The final acceptance of a new paradigm is a slow progress, as the scientific community who adhere to it builds and creates more persuasive arguments which eventually win over other scientists (Kuhn 1996: 157–58).

Critics of Kuhn argue that the concept of paradigms is too vague, and that ‘revolutions’ are likely to happen constantly and on a much smaller basis (Toulmin 1970). Kuhn described a scientific community which only experiences rare and significant episodes of revolution; Toulmin argues that a more realistic view would find regular, revisionary changes to science. It could be argued that these changes are non-paradigmatic solutions provided by normal science (Bird 2018). However, this highlights the difficulty separating normal and revolutionary science. Watkins argues that Kuhn dismissed normal science as a period of ‘theoretical stagnation’, when in fact many important solutions occur within this period (Watkins 1970). I agree with Toulmin’s view that paradigmatic shifts occur often and in small ways. Indeed, as described below, my own use of the framework assumes a much less dramatic shift than is typically described through the use of paradigms. However, Kuhn’s work is still applicable on this smaller scale, as I show throughout this thesis.

I use the language of paradigm shifts to investigate the separation of venereal disease into syphilis and gonorrhoea, although it should be noted that the changing of doctrines in this case should not be defined as a paradigm shift. However, as Kuhn himself states, the characteristics of a paradigm shift can still be seen in ‘the study of many other episodes that were not so obviously revolutionary’(Kuhn 1996: 7). Other frameworks found in the field of controversy studies could also potentially fit this episode. For example, Ludwik

Fleck's concept of thought collectives was originally described in the context of syphilis - specifically the development of the Wassermann reaction, a test used to diagnose the disease (Fleck 1979). The monist and dualist doctrines could be conceptualised as opposing 'thought styles': ways in which scientific professionals see and think about the world. Fleck's thought styles share some similarities with Kuhn's paradigms, and indeed Kuhn has acknowledged that he was influenced by Fleck's work (Kuhn 1996: xli). Another potential lens is Harry Collins's Empirical Programme of Relativism (EPOR), which examines scientific processes through three stages of investigation (Collins 1981):

1. Demonstrating the interpretative flexibility of experimental data.
2. Showing the social mechanisms through which debate is closed.
3. Investigating the connections between those mechanisms and social processes external to the community of scientists.

These three principles could certainly be applied to the switch from monism to dualism, which – as shown in chapter four – relied heavily on the flexible interpretation of experimental inoculations. There is scope in the future to re-investigate this topic as a case study for the EPOR framework. I have, however, favoured Kuhn's theory in this thesis as a heuristic interpretation of the stages of a paradigm shift was particularly helpful in structuring the historical processes of the adoption of the dualist theory.

While Kuhn does acknowledge the importance of social interactions and communities in accepting a new paradigm, this has been significantly developed by others since his work (Kuhn 1996: 151–52). The sociology of scientific knowledge (SSK) studies the construction of knowledge as a social process. This approach is probably best summarised by the title of Steven Shapin's 2010 book, *Historical Studies of Science as If It Was Produced by People with Bodies, Situated in Time, Space, Culture, and Society, and Struggling for Credibility and Authority*. SSK highlights the various social phenomena that allow scientists to resolve controversies, such as language, reputation and exposure to skills and techniques (Shapin 1982; Michael 2016: 15). I use this social approach throughout, by highlighting the networks, communities and scientific capital of various figures in the monist-dualist debate. I demonstrate that social influences are particularly key in the early stages of the adoption of a new theory, where significant evidence has not yet been accumulated and instead scientists must rely on trust.

However, SSK does not sufficiently account for non-human factors that are also vital in creating new scientific knowledge (Michael 2016: 16–17). Scientific activities also depend on equipment and data that helps to interpret the world around us. In chapters four and five, I show the importance of experimental data and anatomical preparations. Bruno Latour argues that objects[3] have agency in the social networks that form in scientific communities, and that to separate objects from these social chains is to falsely assert them as 'objective' (Latour 2005: 63–86). Instead of being separated, objects and people exist together in shifting networks of relationships. Actor-network theory describes sociomateriality, the concept that relationships can be mapped between concepts and materials. Madeleine Akrich and Latour define the process of building meaning as 'the study of order building or path building [that] may be applied to settings, machines, bodies and programming languages as well as texts' (Akrich and Latour 1992: 259). The anatomical preparations that I investigate in this thesis are shown to be important actors in their own rights; although they may have been created with certain intentions, they could be read in many ways and carried different meanings that evolved over time. The preparations formed collections with complex relationships between themselves, with other collections, with texts and with people.

Curation of printed sources.

Venereal disease was a popular topic to write about during the eighteenth and early nineteenth centuries. In 1825, one anonymous author estimated 1,731 treatises had been written on the subject in the previous century alone (*A Century of Surgeons on Gonorrhoea, and on Strictures of the Urethra* 1825). As such, there is a wealth of potential textual evidence available. This thesis begins in 1718, with the publication of William Cockburn's (1669-1739) *The symptoms, nature, cause, and cure of a gonorrhoea*, and ends in 1850, twelve years after the publication of Philippe Ricord's *Traité pratique des maladies vénériennes*. This body of work, covering 132 years, is narrowed down by language constraints, as I have only worked with texts written in or translated to English. Thus, the monist-dualist debate is therefore only examined here in a British context,

[3] Latour describes objects as 'nonhuman' actors; however, as many of the objects investigated in this thesis are composed of human remains, it would be inappropriate and disrespectful to describe them as such.

although of course many practitioners spoke multiple languages and would therefore have access to sources not described here.

Initially, the list of printed sources used was defined by the University of Glasgow's Wellcome Trust-funded catalogue of pre-nineteenth century holdings on the topic of venereal disease. This collection contained 63 unique English-language works written in the defined time period. However, the selection was eventually expanded to include digitised texts. These were curated through two sources which both have expansive collections of digitised texts contributed by various libraries worldwide: Hathi Trust and Internet Archive. Using search terms combining various keywords, after removing duplicates and irrelevant sources I expanded my corpus to 113 texts. Although not all of these works are directly cited in this thesis, the entire collection was used for data analysis. A full list of all works consulted and used for analysis is therefore included in Appendix A.

Thesis Outline

In this thesis, I demonstrate how venereal disease was separated into syphilis and gonorrhoea and show how different stages of the change in theory relied on different types of evidence and support. Pioneers of the dualist doctrine were largely socially connected through the University of Edinburgh; this network allowed them to build the trust required to make the leap to the new science. However, those outside that network were not immediately convinced by the dualist doctrine. As the revolution went on, experimental evidence accumulated through the use of inoculation and acquisition of anatomical preparations. This mounting evidence slowly began drawing others to adopt the new doctrine.

In chapter two, I outline the state of venereology before the new doctrine was introduced. In the 50 years before Balfour's dissertation in 1767, medical practitioner's definitions of venereal disease were becoming increasingly unstable as they attempted to understand the puzzles of the stages of syphilis and pathology of gonorrhoea. At the same time, they were receiving ever increasing numbers of patients with these diseases, increasing the market pressure to find appropriate treatments. There was little agreement on how to treat venereal disease; while the use of mercury was standard, there were many ways of applying it, and other treatments were also in contention such as vegetable juice and sarsaparilla. This gap in treatment saw a rise in quacks, who competed with 'regular' practitioners for patients. Altogether, these factors led to early theoretical shifts that later fed into the dualist doctrine and created a crisis in the field.

Chapter three examines the introduction of the new doctrine created by the Edinburgh school and its early reception. Although the contributions of Francis Balfour and Andrew Duncan have been described before, I go into depth to elaborate on the arguments they used and how others responded to these. By including texts from lesser-known sources and student essays from the Edinburgh Medical Society, I show that others who were not within Balfour's social circle were not convinced by the largely theoretical position of the dualist doctrine. In response to the new theory, John Hunter wrote about his now infamous experiment. His experimental evidence was accepted by others as proof of monism.

Chapter four examines Benjamin Bell's contribution to the monist-dualist debate. As he is typically positioned as the figure-head of the dualist group, I have undertaken a close reading of his treatise and his contemporaries' responses. Despite the emphasis placed on his work, I show that while many of his theoretical arguments were novel, none appeared to convince the writers who followed. Instead, readers were swayed by the inoculation experiments he described. After Bell, the number of dualists outside Edinburgh rapidly increased. However, many practitioners needed to observe the experimental results with their own eyes, and over the following decades the inoculations were repeated many times on a small scale. This culminated in the work of Philippe Ricord; at this stage, the evidence had accumulated so significantly that most medical practitioners were won over to the new doctrine.

Anatomical preparations were also a vital type of evidence for understanding pathology in this period. Chapter five explores the contents of six museum catalogues collated from 1785-1866 in Edinburgh and London. These specimens offered a different way to examine disease. While in texts, pathologies were separated into specific diseases (often categorised through the use of nosology), museums instead separated pathologies into systems and symptoms. This complimented the unstable definitions of venereal disease, as they offered a more flexible approach to understanding sickness. Finally, in chapter six, I take samples from some of these specimens in order to examine genetically if any pathological bacteria or viruses are present. Although no DNA from *T. pallidum* or *N. gonorrhoeae* was successfully recovered, one specimen allegedly showing syphilitic nasal septal erosion yielded potential genetic evidence of *Staphylococcus aureus*, *Haemophilus influenzae* and *Yersinia enterocolitica*. *S. aureus* and *H. influenzae* could potentially account for the erosion in the specimen, while *Y. enterocolitica* is a pathogen typically spread through food poisoning. The possibility of a patient with these underlying illnesses being considered syphilitic reflects the diagnostic issues that eighteenth-century surgeons and physicians had in trying to define venereal disease. It is also a reminder that historical medical records may not reflect our modern categories of disease.

Overall, this thesis presents a rigorous examination of the processes that saw syphilis and gonorrhoea separated into unique diseases. Through this examination, I show how the conditions for acceptance of a new doctrine dynamically change between social influences and physical evidence during the process of debate. I approach this in a multidisciplinary way, introducing evidence from texts, material culture and scientific analysis, thus highlighting the way these disciplines can work together to answer historical questions.

Chapter 2 - The Protean Disease: Defining *Lues Venerea* 1718-1767

Introduction

This chapter examines the period from 1718 - the year that William Cockburn's *The symptoms, nature, cause, and cure of a gonorrhoea* was published - up to 1767 - the year of Francis Balfour's dissertation in which he suggested gonorrhoea and syphilis may be separate diseases (the dualist model). This establishes context for the monist and dualist debate, most significantly by showing how the monist model was becoming insufficient to describe medical practitioners' experiences with venereal disease. These issues will be examined from the perspective of Kuhn's paradigm shift model – discussed in detail in the introductory chapter - which structures the evolution of scientific 'revolutions' into various stages: drift, crisis, revolution, change. Although the medical community's change from a monist to dualist model of venereal disease may not be revolutionary, loosely using this structure still allows us to better understand how that change came about. The history in this chapter covers two parts of Kuhn's paradigm shift, as described in the introduction: crisis and drift.

Eighteenth-century diagnosis and treatment of venereal disease was under a combination of social and medical pressures that created a 'crisis'. Although practitioners often claimed their treatments were nigh-on infallible, this was contradicted by the many cases of patients returning to seek repeated cures. The frenzy of competing treatments appeared to do little to slow down the number of patients with venereal disease, who still filled every available hospital bed in the Lock Wards of London (Siena 2004: 10). At the same time, these problems were magnified by movements like the Society for the Reformation of Manners which aimed to reduce supposedly immoral behaviour such as prostitution – a line of work closely associated with syphilis. Medical theory was also undergoing its own paradigm shift, moving from a Galenic model of humours to one that framed diseases as caused by contagions, encouraging medical practitioners to think of diseases in new ways.

At the same time, there was a shift in categorisation of venereal disease that was already well underway before the dualist theory was suggested. Gonorrhoea had been described as a symptom of the pox since approximately 50 years after the first pox outbreaks (Astruc 1737a: 44). However, in the first half of the eighteenth century the supposed symptom began to cause new questions to arise. Authors asked whether mercury – necessary to eradicate a full, confirmed pox – was needed or even useful when treating gonorrhoea. Practitioners began to attempt to break the *lues* down into various stages and species in an attempt to fit their observations of prognosis and treatment outcomes within the monist model. The underlying anatomy and pathology of gonorrhoea was also under debate, as writers attempted to find a theory that explained how the venereal 'poison' could be the cause of all aspects of the pox.

These aspects together demonstrate that when Balfour proposed the new dualist theory in 1767, the definition of venereal disease had already been brought into question. This chapter establishes these circumstances, allowing the next phases of the paradigm shift – revolution and change – to be understood more fully.

Crisis

Kuhn defines the 'crisis' period of a paradigm shift in terms of the model itself, emphasising how problem-solving no longer works by assuming the field's status quo. Here I also consider the rising external pressures that physicians and surgeons faced in finding a cure for venereal disease, creating 'crisis' of a different kind. There were two major social factors pushing practitioners to find better solutions for treating venereal diseases: first, the movements for moral reform, and second, the astonishingly high number of patients suffering from VD. It should be noted that these pressures did not exist only in this early period but continued to be influential through the rest of the century as the dualists did their work.

In more traditional terms, the field of venereal disease was also experiencing a crisis in its the inability to effectively treat the disease under the increasing social pressures. Patients were increasingly turning to 'quack' doctors to seek treatment as formal medicine failed them (McAllister 1996). As patients had significant control over the eighteenth-century medical marketplace, this put doctors in direct competition with their less traditional counterparts (Jewson 1974). This overall situation forced practitioners to innovate in order to keep their practices.

The shift in thinking around venereal disease was also occurring at the same time as a much broader paradigm change. During the eighteenth century, there was a shift in understanding of the roots of disease, as doctors moved from traditional Galenic thought based on the humours towards ascribing disease to infectious particles (DeLacy 2017: 5). Advances in the taxonomy of plants by Linnaeus influenced doctors to do the same with diseases, classifying them into systematic nosologies (Fischer-Homberger 1970). Anatomists dug deeper into pathology, developing new ways of looking at the physical lesions of disease through organ systems and tissue types (Bertoloni Meli 2018: 6–8). These all influenced the framework in which venereal disease was embedded, allowing changes in definition that led to the separation of syphilis and gonorrhoea. The effects of these wider changes are shown throughout this thesis.

Moral Pressures and the Societies for the Reformation of Manners

In 1688, a major movement for moral reformation began in England. Although the concept of publicly punishing 'immoral' behaviour was not new, this was the first truly organised campaign (Dabhoiwala 2007). The movement – particularly embodied by the Society for the Reformation of Manners – aimed to suppress the vices of swearing, drinking and whoring through legal means, a Protestant response to a perceived post-Revolution moral crisis (Hayton 1990). The Society was made up of three tiers; the second tier, made up of mostly tradesmen, was especially focused on the 'suppression of lewdness' (Craig 1980: 63). Although the second tier comprised only approximately 50 men, they worked efficiently, resulting in the convictions of almost 4000 women for allegedly whoring in London in the period between 1699 and 1707 (Craig 1980: 68). Attitudes towards prostitutes varied, but Henderson has shown that a not-insignificant portion of society throughout the century perceived them as 'agents of destruction' whose behaviours were a threat to civilisation (Henderson 2014: 167–77). While the first Society for the Reformation of Manners declined in the late 1730s, it was revived in 1757 and succeeded later by William Wilberforce's (1759-1833) Proclamation Society in 1787 and the Society for the Suppression of Vice in 1802 (Dabhoiwala 2007).

Although prostitution was the central target for the reformers, venereal disease was of course closely linked with sex work and so was relevant to the ongoing moral panic. This carried on a long tradition of placing the blame for the spread of syphilis on women and prostitutes (Cohn Jr 2018: 117–22). The connection was expressed by an early association of reforming citizens of Tower Hamlets in 1690 who decried brothels for, among other things, spreading the pox, stating that: 'Here it is that bodies are poxed … Here it is that many a housekeeper is infected with a venomous plague which he communicates to his honest and innocent wife' (as quoted in Craig 1980). The satirical pamphlet *A Modest Defence of Public Stews*, written by Bernard Mandeville (1670-1733) in 1724 and intended to mock the reformation movement, emphasised this link by using disease as a reason to legalise and regulate brothels. Venereal disease was 'the great Evil that attends this Vice', with prostitutes a particularly risky source since 'if but a few of these Women are unsound, they can infect a great many Men; whereas these Men have neither Power nor Inclination to infect the like Number of Women' (Ogle 1740: 2, 21). Satirical or not, this view was shared by some in the medical community. For example, Harris stated in his work on syphilis in infants that 'in my Opinion, this Disease is as certainly and naturally produced in the impure Wombs of common Prostitutes, who mix their Embraces with many different Men, as Lice and Fleas are produced from Filth and Uncleanliness' (Harris 1742: 200). In wider society, Hogarth's 1731 series *A Harlot's Progress* reflected these worries, vividly depicting venereal disease as a consequence of immoral sexual behaviour, both deplorable and pitiable (Lowe 1996).

It would be naïve to assume that doctors were outside the influence of such attitudes and beliefs. While there is no clear evidence of medical practitioners' involvement in the reformation movements of the first half of the eighteenth century, the role of morals and sexuality make the occasional appearance in printed medical works. Daniel Turner (1667-1740), a surgeon known today for his work in dermatology, wrote in his *Siphylis* that morals were so intertwined with venereal disease that they became part of its very definition: 'A venomous or contagious Distemper, for the most part contracted by impure Coition, at least some Contact of the Genitals of both Sexes, or some other *lewd and filthy*

Dalliance between each other that way tending' (emphasis mine) (Turner 1737: 25–26). His case studies continued with these judgements, particularly targeted towards the women involved. One patient was infected while intoxicated enough 'to pick up any Foul Slut in his Way'; another, a married man, was described as having fallen 'Prey to one of the Night-Walkers' who 'not only emptied his Pocket of his Money, but clap'd him also' (Turner 1737: 248, 255). The physician Walter Harris (1647-1732) stated that in the early stages of infection, the disease is 'made a Jest of by our Beaux and Rakes' (Harris 1742: 198). However, he added, the poison would eventually spread through the rest of their body, and 'they will abundantly suffer the Punishment due to their Follies' (Harris 1742: 198).

Although such direct judgements were relatively rare, printed medical treatises are not necessarily the best place to find the opinions of their writers. The works were written as a way of improving one's professional or economic status, and as they were written in English their audience often included the patients themselves. Venereal disease already carried a large amount of stigma and shame in the early eighteenth century; practitioners were aware of this and responded appropriately by tailoring their services to be more private (Siena 2004: 31–41). It seems unlikely that they would want to put off their potential patients by expounding moral judgements in works they might read. As Siena has shown, despite the early reformation movements, doctors directly attempting to influence the moral improvement of their patients was not a major part of treatment until the establishment of the women's Lock Asylum in 1787 (Siena 2004: 181-218). However, this lack of direct intervention does not mean that doctors were unaware of the moral pressures of the reform movements, which made treating venereal disease more urgent.

The influence of morality on doctors regarding venereal disease is often clearer when examining its origin stories. The source of syphilis in Europe is notoriously unclear, with scientists and historians today still debating over whether it was brought from the Americas by Columbus or mutated from another *Treponema* species more locally (Cook and Powell 2016: 479–80). Throughout the eighteenth century, most treatises presented the debate and took a side over whether the disease was ancient or modern, often using these stories as a way to express prejudices (McAllister 2000). One theme that emerged was sexual behaviour as a source for syphilis appearing *de novo*. Jean Astruc (1684-1766), professor of medicine at Montpellier, described the supposed promiscuity of the indigenous people of Hispaniola, stating that even during women's menstruation 'the Men thro' the violence of their lust lay like beasts with the first Woman they met with, and as the Women thro' an excess of incontinence promiscuously admitted all that offer'd' (Astruc 1737a: 102). As a result, semen would be mixed in the wombs of the women and become 'corrupted', producing the venereal poison (Astruc 1737a: 103). Marie McAllister's work shows how this theory of 'heterogenous semen' being the source for syphilis, particularly in prostitutes, persisted throughout the century, demonstrating the close interconnection between sexual behaviour and venereal disease (McAllister 2000).

However, it is important to note that these movements were countered by what Faramerz Dabhoiwala has described as 'the first sexual revolution', encouraged by Enlightenment thinking that sex was a personal and private matter rather than something to be regulated by the state. This line of thought promoted sexual freedom and increased permissiveness around premarital sex. Illegitimate births outside of marriage rose from around 1% of births in England in the 1650s, to 25% by the 1800s (Dabhoiwala 2017). Again, doctors were certainly not immune to movements like these, giving them a more personal stake in treatments. For example, Andrew Duncan Senior – a key proponent of the dualist doctrine – was a member of the pro-sexuality club Beggars Benison later in the century (Duncan 1818: 15). As described next, this increased freedom also resulted in higher numbers of venereal patients.

Syphilis as a Market Force

Despite the Reformation movements' attempts to reduce vice – or perhaps sometimes driven by them – numbers of venereal patients remained high enough in London to be considered a serious issue. Incomplete records mean it is difficult to accurately estimate infection rates. Simon Szreter's study of urban Chester in 1774 estimates that 7.655% of the population had been treated for syphilis by the age of 35 (Szreter 2017). This number is likely a significant underestimation of actual infection rates for all sexually transmitted diseases, however, as it is specifically based on hospital admissions for salivation. Patients could often be treated at home rather than in hospitals. For example, Turner described a case of a young man kept in his chambers during salivation while his mother acted as his nurse, and another patient who requested his own lodging and nurse for the process (Turner 1737: 229, 267). These patients would not be included in hospital records. Those with milder cases would also attempt other remedies, such as buying medicines from apothecaries and quacks, or even ignoring their symptoms for many years rather than going through the unpleasant process of salivation (treatment with large quantities of mercury that caused, among other things, excessive salivating). The rate of venereal disease for London would also likely be higher than that of Chester; Szreter's study finds a significant increase in rates of infection between rural and urban areas as the population density increased, a trend which likely would have continued upwards in a larger city. Certainly the number of poxed patients outnumbered the facilities for treatment in London. Siena shows that the reserved wards had lengthy waiting lists and parish workhouses were overwhelmed by applications for help (Siena 2004: 10, 139–40). Siena's investigation of London hospital admission records shows that throughout the seventeenth and eighteenth centuries, venereal patients accounted for up to 30% of patients (Siena 2001). The patient records for the Royal Infirmary in Edinburgh show similarly high numbers, with venereal patients accounting for 19% of the total admissions between 1770 and 1774 (Royal Infirmary of Edinburgh [n.d.]).

The number of patients treated by some individuals helps to demonstrate the sheer volume that doctors were dealing with. Charles Hales (fl. 1765), a military surgeon serving at the Savoy Hospital, claimed to have treated 670 soldiers with venereal disease between 1758-1760 (Hales 1765: xiii). J. Becket (fl. 1765), a surgeon who had studied in St. Bartholemew's Hospital under Percival Potts, outdid even this, claiming in 1765 to have treated over twelve hundred patients in the same span of time (Becket 1765: 59). Although both claims should of course be taken with a pinch of salt as they appear in works to promote their authors' cures, Hales's claim to have seen that number of soldiers, even if all of them had not been cured, appears to be plausibly true. The military failed in paying him for the work and he was able to successfully sue for his fees, where it was 'proved on the part of the plaintiff, and even admitted by the defendant, that 670 were actually cured' (*Dublin Courier* 1760). Even the early eighteenth-century nickname for pox – the alamode or *á la mode* disease – is suggestive of its proliferation in the population (Lowe 1996: 172). Medical practice in the eighteenth century was strongly influenced by the demands of patients, and the effect of this high number of poxed patients on the medical market is clear

(Jewson 1974). By 1825, one anonymous author estimated that 1,731 treatises had been printed on the topic of syphilis and gonorrhoea over the previous century (*A Century of Surgeons on Gonorrhoea, and on Strictures of the Urethra* 1825: 2). Over half of the early modern medical handbills (dated approx. 1660-1715) preserved in the British Library refer to venereal disease, reflecting the high demand from patients (Siena 2001). Altogether, these numbers show that venereal disease was widespread in eighteenth-century London, representing a significant problem that required medical practitioners' attention.

This was even more so the case for gonorrhoea. Despite being considered just one symptom of the venereal disease, it was the most common complaint and often the first or even only symptom patients were diagnosed with. Boerhaave estimated that of every 100 cases of venereal disease, at least 96 began with a gonorrhoea (Boerhaave 1763: 88). Astruc believed that most infected patients would just experience gonorrhoea, and a full pox would follow only if the gonorrhoea was badly managed (Astruc 1737a: 113). Of the 18 cases in Turner's *Siphylis* that described the earliest symptoms experienced by patients, 11 included gonorrhoea, clap, discharge or running as a first symptom (Turner 1737: 228–380). Even this relatively high number may be under-representative of Turner's full practice, as the printed cases were sometimes selected for being unusual or difficult to diagnose. Siena's examination of case books from the Lock Hospital later in the century finds a higher proportion, with 69 of 73 fully described cases citing gonorrhoea as one of the first symptoms noted (Siena 2004: 17). As well as doctors and patients often diagnosing venereal disease from gonorrhoea, this was also the case for midwives. Evidence for this can mostly be found in the record of trials for sexual offences against children, where midwives were commonly the first person called on to inspect injured children. For example, Elizabeth Palmer, a midwife called to examine a child of 11 in 1735, judged that the child had been clapped after finding discharge on her linen (Old Bailey Proceedings Online 1735). Similarly the midwife Mary Maclemara diagnosed a young girl after finding her shift 'as stiff as buckram with corrupted matter', and Elizabeth Peters testified to another girl having the foul disease as 'her linnen was in a most miserable condition' (Old Bailey Proceedings Online 1748, 1749). This prevalence and diagnostic importance of gonorrhoea made it even more necessary to understand its nature.

Drift

Defining Venereal Disease

Daniel Turner described a typical pox case of a young man, one of many he treated, in his treatise on syphilis (Turner 1737: 262–70). In the days after a sexual encounter with a woman, the patient began to experience trouble with urination and a discharge of matter that stained his shirt. This soon developed further into small ulcerations around his genitals, and priapism (painful, persistent erections) at night. After consultation with Turner, he began treatment; not long after, chancres developed on his penis. Turner supplied him with mercury rubs for the chancre and a balsamic lotion for the running and sent him away. Three months later, however, the patient returned, this time with yellow, crusty lesions over his skin, particularly on the forehead. This time he was given a full mercury salivation and declared cured of pox. This progression of symptoms was classic of how venereal disease was understood at the time: local symptoms such as clap and chancre appeared first, eventually progressing into systemic infection of the skin. Venereal disease was understood as a staged infection that began at the site of infection and could eventually corrupt the whole body. However, the definition of these stages, and what exactly each was comprised of, was less clear.

The vocabulary of venereal disease was large and sometimes ambiguous. The basic definition of gonorrhoea, in the words of one medical student, was ‘a flux of matter from the genitals’ (Gossip 1751). In practice, though, the term – often used interchangeably with the more informal term clap - covered much more, including a range of symptoms such as heat during urination, swelling of the testicles and chordee (Turner 1737: 52–53; Astruc 1737a: 247–48; Stuart 1738: 31; Rock 1745: 5–7; Becket 1765: 16). Although the defining feature of gonorrhoea was supposedly a running or discharge, some practitioners described a form of dry gonorrhoea (Astruc 1737a: 303). Even more confusingly, gonorrhoea was sometimes used as an umbrella term to describe the ‘first infection’ – that is, all the initial and local effects of the pox. However, what was actually included in the first infection changed depending on which practitioner you consulted. Many treatises described both chancre and bubo as part of the first infection (Astruc 1737a: 357–418; Rock 1745: 18–22). However, while Turner placed bubo within the first infection, he noted that it was common practice to consider a bubo as the start of a confirmed pox and a sign that the second infection was beginning (Turner 1737: 53). The English surgeon Thomas Gataker (d.1768) separated bubo by describing it as 'owing to the more malignant species of the venereal disease than to a gonorrhoea', and Becket described both chancres and bubos as 'sure Marks of a confirmed Pox' (Gataker 1755: 16; Becket 1765: 27). M. Mooney (fl. 1756), a surgeon practising in London, dismissed such stages at all, describing them as 'imaginary' (Mooney 1756: 41). As the English surgeon John Douglas, rival of Daniel Turner, summarised with evident frustration, all authors:

> divided [venereal disease] into two classes, viz. the first or second degree of Infection. Yet none of them have ever undertaken to tell us the critical time, where or when the first degree ends, and the second begins; but sometimes call Chancres, Bubo's, Excrescences, &c. a sign of the first, sometimes of the second degree. So it lies in the Breast of every A la Mode Dr. (how little soever dignified or distinguished) to christen these Symptoms, &c. of the first or second degree, as they shall think fit. (Douglas 1737: 6)

Although it was clear to practitioners that venereal infections progressed in stages, it was evidently not clear what those stages were – leaving their definition open for the dualists to come.

Syphilis is well known today for its wide range of symptoms that make it difficult to diagnose, which has earned the disease the nickname of 'the great imitator'. Medical practitioners in the eighteenth century were also keenly aware of this. Astruc described the *lues* as 'changeable as Proteus and puts on the shape of every Disease' (Astruc 1737a: 9). Becket despaired that 'no Mimic has more Power over the Features of his Phiz, or can throw himself into a greater Variety of Attitudes, than the Pox has of Appearing in the Form of other Maladies, and assuming the Shapes of different Ailments' (Becket 1765: 72). Descriptions of the second infection, or the confirmed pox, referred to dozens of seemingly unconnected symptoms: a variety of skin lesions, hair loss, tumours and nocturnal pain in the bones, deafness or tinnitus, blindness or conjunctivitis, ulcers in the mouth, nose and throat, fevers, and so on. Complicating matters, patients would present with different selections of these symptoms; two poxed people might have no symptoms in common, a phenomenon explained by their differing humours, habits and constitutions

(Astruc 1737a: 163; Mooney 1756: 45). Given this, it is perhaps unsurprising that definitions of venereal disease were slippery and vague.

Due to its protean nature, a diagnosis of syphilis was fraught with the risk of misdiagnosis. Stakes were high, both for the surgeon and his patient. A patient mistakenly diagnosed with a pox could find him or herself undergoing an unnecessary mercury treatment, with all the side effects that entailed. One man with pain in his jaw and throat, convinced it was a confirmed pox, attempted a cure by salivation; two guineas later, still in pain, he visited the surgeon Becket who confirmed that he was simply suffering from a decayed tooth (Becket 1765: 76–77). For surgeons attempting to prove their favoured treatments worked, it was vital that their patients were actually poxed in the first place. Daniel Turner responded to the translation of a French treatise that advocated not using mercury in treatments for syphilis by sarcastically attacking the status of the patients, declaring how one was diagnosed only from a fistula, 'which you know is always pathognomonical of the Pox', and another only from pains in his feet, 'strange Diagnostics surely of this Disease' (Turner 1737: 399,401). He ultimately decided that of the forty patients used to provide evidence for the new method, he was only certain of the diagnosis of twenty (Turner 1737: 404). One defender of the French method of treatment was John Douglas (d. 1743), a Scottish lithotomist and brother to William Hunter's mentor James Douglas. He responded directly to Turner's accusations in his treatise while detailing patients' case histories, scathingly asking: 'What say you to this, Mr. Daniel Turner, Mr. Patron Palmer, &c. was this man poxed or not?' (Douglas 1737: 14). It was central to a surgeon's reputation as a practitioner that diagnosis was correct; a theme that would go on to be central in the dualist debate.

Diagnosis of venereal disease was a delicate art depending on physical symptoms, sexual history, and the doctor's own experience. Of course, as already explained, physical symptoms could easily be confused with other diseases. Some surgeons suggested certain symptoms were pathognomic to the pox. For Turner, crusty yellow pustules on the scalp and forehead were a certain sign that the disease was venereal (Turner 1737: 143–44). Syphilis was often defined in terms of its effects on the skin; this dermatological connection was why it was in the surgeon's domain rather than the physician's. The presence of certain ulcers on the skin, especially any kind on the genitals, could be all the symptoms seemingly needed to make a diagnosis. Douglas declared one woman poxed based on the primary symptom of ulcers over her whole body, and another man whose only symptom was verrucae on his glans and prepuce (Douglas 1737: 16, 18). Astruc gave detailed instructions on how venereal spots of the skin were to be distinguished from pimples, freckles or scurvy (Astruc 1737b: 58). He also listed a number of other signs he thought to be pathognomic, including frequent abortions, warts or ulcers on the genitals, ulcers of the fauces and palate and pains or certain disorders of the bone (Astruc 1737b: 55–61). Of the 81 cases that Charles Hales published in detail, 66 included venereal eruptions of the skin, ulcers in the nose, mouth and throat, warts or ulcers on the genitals, or nocturnal bone pains as a symptom; the remaining cases were all limited to gonorrhoea, clap or gleet (Hales 1765: 44–67). Despite the huge variety of possible symptoms, these were the primary defining features of venereal disease at the time.

Given that venereal disease was most commonly sexually transmitted, one of the most important diagnostic tools was the patient's sexual history.[4] Gaining this truthfully, however, appeared to often represent a battle between doctor and patient, with doctors mistrustful of their charges and patients keen to hide a disease perceived as shameful. Determining the truth appeared to especially be a problem when trying to differentiate gonorrhoea in women from fluor albus, a non-virulent running. Astruc warned that 'Women frequently lead us into this error, either thro' real or pretended ignorance of the cause of their disorder' and that the true diagnosis 'must still remain in doubt till by the open confession of the Patient herself, her Husband, or the Man she has had to do with, the truth appears' (Astruc 1737a: 266). Jacques Daran (1701-1784), French surgeon to the King, claimed that men may not realise they have a venereal disease as the women they caught it from would hide it, as 'Women are but too well skilled in deceit' (Daran 1766: 10). Despite this, cases where unsuspecting wives caught the disease from their husbands appeared more regularly. Both Douglas and Mooney described cases of women infected in such a way, the latter one fatal (Douglas 1737: 29; Mooney 1756: 90–92). Doctors could even become complicit in this in order to gain their patient's trust. After Turner treated a man for his clap, he discovered his wife had also been infected. However, in order to

[4] Venereal disease was also thought to be transmitted through nursing, cuts, or sometimes through sharing beds and utensils.

protect the husband Turner hid the truth from the woman, telling her that her symptoms were due to her recently giving birth instead (Turner 1737: 230–31). Turner gave advice for surgeons on how to enquire with their patients about the delicate subject, recommending that they approach gently and gain their patient's confidence, and keep the secret as though 'under the Seal of Confession' (Turner 1737: 145). Indeed, in many of Turner's cases the diagnosis of venereal disease was only confirmed after he successfully wrangled an admission of guilt from his patient (Turner 1737: 230, 246, 256–58, 285, 308, 361). Venereal disease, then, was not always necessarily defined by its symptoms or disorders, but rather through its mode of transmission.

A Purulent Catarrh

The dualist theory has occasionally been credited to Herman Boerhaave, the Dutch botanist, chemist and physician, most notably in Oriel's overview of the history of STDs where he states that Boerhaave 'differentiated the two diseases, stating that gonorrhoea was no more than a purulent catarrh' (Oriel 1994: 27). Flegel's comprehensive essay on the separation of gonorrhoea and syphilis also claims that Boerhaave described the two as 'separate affections', although he acknowledges that it was more 'incidental than emphatic' and not a significant influence in this regard (Flegel 1974). Although this is a relatively uncommon claim – with figures such as Francis Balfour, Andrew Duncan Sr. and Benjamin Bell being more commonly cited as early dualists – these are major works in the subject and therefore deserve attention. Examining Boerhaave's work on the *lues* shows that part of this claim is certainly true, as he considered gonorrhoea to be a catarrh (a build-up and running of mucous, like in the nose during a cold) that helped the body in removing the venereal virus:

> It is a preservative against the *lues*. It was observed by those who wrote at the first eruption of this symptom, that the *lues venerea* was greatly mitigated, and even cured, by this discharge. Many, I know, are of a different opinion: but for my part, I have never seen an instance, where the body was first affected with a true gonorrhoea, in which one symptom of the *lues venerea* arose afterwards, if the former was well cured. (Boerhaave 1763: 89)

However, to accept this as a dualist position would require a different definition of dualism. The dualist doctrine was founded on the belief that syphilis and gonorrhoea were not caused by the same venereal virus or poison, and that one was not merely a symptom of the other. Boerhaave still accepted that gonorrhoea was a consequence of infection from the venereal virus, describing it as ‘the first symptom of the *lues venerea*; for in a hundred cases, ninety-six at least are thus originally infected’ (Boerhaave 1763: 87–88). A full case of pox was regarded as the consequence of a poorly managed gonorrhoea, induced by the virus finding ‘access into the vital humours’ (Boerhaave 1763: 284). Although this tentative separation of gonorrhoea from syphilis was important in developing the dualist theory, Boerhaave cannot be considered as a dualist himself.

Boerhaave was also not the only practitioner who defined gonorrhoea as a natural response to infection rather than strictly a symptom. Astruc explained in his influential treatise that the discharge was caused by irritation from the infectious particles, ‘in the same manner as smoke draws tears from the eyes, or pepper brings down the saliva from the glands of the mouth’ (Astruc 1737a: 258). Gataker compared it to running noses and eyes (Gataker 1755: 4–5). Becket described in 1765 that the venereal particles irritated the nervous fibres in the urethra, and the resulting discharge as that ‘which Nature raises in our Constitutions to expel and drive out of our Bodies whatever should be offensive and troublesome’ (Becket 1765: 16). Rather than being an early unsung dualist position, this was the foundation for a considerable amount of debate.

If gonorrhoea was, as Becket described it, a ‘critical discharge’, this meant that it was important to allow it to continue running as it would carry off the virus (Becket 1765). The risks of putting a sudden stop to gonorrhoea could be drastic. It was a widely held idea that this would cause the body to retain the venereal poison and almost certainly result in a confirmed pox (Astruc 1737a: 272; Rock 1745: 17; Jourdan de Pellerin and Arnaud 1750: 191; Fordyce 1767: 31). This made the goal of treatment less clear. While the ultimate aim was to cure gonorrhoea and therefore stop discharge, it was also important not to stop it too quickly – although it was not always clearly defined what a ‘sudden’ stop was. As William Fordyce (1724-1792), a Scottish physician based in London, put it, ‘our art cannot cure it speedily, and effectually, at the same time’, estimating that it would take anywhere from two to six months to properly cure a gonorrhoea (Fordyce 1767: 28). This restriction on treatment was the reason some practitioners disregarded the use of injections as a cure for gonorrhoea, which supposedly stopped up the urethra and caused swelling in the testicles (Gataker 1755: 13; Fordyce 1767: 78).

The framing of gonorrhoea as a physiological response rather than a symptom also fuelled the movement away from treating it with mercury. Mercury was a controversial treatment for syphilis at the start of the century, as practitioners argued over the best method of application or whether it was even a useful treatment at all, with some offering a whole host of alternative medicines including vegetable juice to desperate patients (Wilson 1996: 80; McAllister 1996). However, even some practitioners who advocated for the use of mercury in general believed it was not an appropriate cure for gonorrhoea. This was, again, due to worries of stopping the discharge too quickly, as a strong purge would mean it was 'too hastily forced' (Gataker 1755: 11). Astruc considered that the severe effects of mercury meant it should be avoided in the milder stages of gonorrhoea, and when it was used recommended external applications rather than full salivation (Astruc 1737a: 274–79). Boerhaave was more restrictive, concluding that 'Mercury should not be prescribed in a gonorrhoea; although it is of considerable importance, and to be commended in other stages of the *lues*' (Boerhaave 1763: 147). Becket also took the stance that 'whatever is the Use of it in a confirmed Pox, it certainly ought never to be given in a Clap; and this is acknowledged by all Physicians and Surgeons that have taken Pains to be thoroughly acquainted with this Disorder' (Becket 1765: 34). One army surgeon, Abraham Gordon, claimed that none of the other regimental surgeons used mercury in cases of gonorrhoea, reserving it only for a full pox (Becket 1765: 39).

Of course, not all surgeons agreed that mercury should be abandoned. Turner believed that mercury was necessary as a specific in gonorrhoea to break down the virus before it could be evacuated in a purge (Turner 1737: 153–54). Fordyce insisted on its use to prevent gonorrhoea becoming a pox, and blamed the trend of abstaining from mercury on the timidness of medical practitioners (Fordyce 1767: 29). Regardless, the approach continued to become popular through the rest of the century. John Hunter was one of those who agreed with it, noting that 'so little effect indeed has this medicine upon a gonorrhoea, that I have known a gonorrhoea take place while under a course of mercury sufficient for the cure of a chancre' (J. Hunter 1786: 74). As practitioners increasingly agreed that mercury should only be used to treat a confirmed pox and not gonorrhoea, this discrepancy in treatment became a fundamental argument in dualist theory; Balfour, Duncan and Bell all cited the use of different cures as part of their reasoning for separating syphilis and gonorrhoea (Balfour 1767: 17; Duncan 1778: 225; Bell 1793: 41). By providing evidence for the future dualists, the intertwined debates over the nature and cure of gonorrhoea also acted in part as a precursor to the dualist doctrine.

Dissection and the Pathology of Gonorrhoea

Investigation of the seat of gonorrhoea was made possible by the rise of dissection and pathological anatomy. Although earlier historiography emphasised the role of Parisian hospitals after the French revolution in moving doctors towards the use of tissue pathology, it has increasingly been accepted that its use rose slowly throughout the early modern period (Foucault 1975; Bertoloni Meli 2018; Bellis 2019). The aim of describing pathological lesions also changed over the course of the century. Initially, the priority of the anatomist was to describe how lesions were precisely situated within whole organ systems. This slowly changed as the priority became understanding what tissues were affected by lesions and disease was related to disfunction of those tissues, culminating in the French pathologist Xavier Bichat's (1771-1802) influential work at the turn of the century (Keel 1998). As the seat of disease in gonorrhoea was considered to be part of the reproductive tract – beyond easy visual inspection during life - dissections were vital to go beyond speculation and enable access to the lesions. Anatomical investigations of gonorrhoea appear to question both of these aspects of pathology; the precise seat, and the nature of the underlying lesion.

The seat of gonorrhoea was important to some practitioners when making a prognosis for venereal disease. One approach held that the seat could be in a variety of locations, which were connected to the severity and progression of the clap. Astruc was the most rigorous in this regard, dividing gonorrhoea into a large number of species depending on both the seat and type of inflammation, the latter of which could be diagnosed by the colour of discharge (Astruc 1737a: 268–70). For example, the mildest gonorrhoeas were seated in the Cowper's glands and the most severe in the prostate; those seated in the urethra would result in a dry gonorrhoea (Astruc 1737a: 270–71). However, despite these differences Astruc also noted that diagnosing the seat of gonorrhoea is 'of no great consequence to the cure', as regardless of prognostic the cure will remain similar (Astruc 1737a: 267). William Fordyce placed more importance in dividing gonorrhoea into species by its seat, stating that 'if it is not known how far the disease has got into the genitals in the gonorrhoea … I see not how the indications of cure can be so clearly discovered' (Fordyce 1767: 23). Fordyce described five species of gonorrhoea in this way, noting that the most severe two could be considered as a confirmed pox and should be treated as such (Fordyce 1767: 27). This type of approach was not for everyone; Gataker criticised Astruc's methods for being overly systematic, and the dependence on the colour of discharge too simplistic (Gataker 1755: 50–52). Similarly, Mooney complained that Astruc had 'subdivided the Pathological History of this Disease, and so confounded its Symptoms with those of other Diseases' (Mooney 1756: 2–3).

It is also worth noting that this division may not have been always driven simply by medical theory, but sometimes for monetary purposes. For example, Richard Rock (1690-1777) – the quack doctor depicted in the fifth engraving of Hogarth's *Harlot's Progress* arguing over treating Moll's syphilis - divided gonorrhoea into several stages in his 1745 treatise that was aimed directly at patients. The first degree – the mildest – was while the poison is restricted to the external parts and very end of the urethra, with the second and third corrupting the humours in increasing mass (Rock 1745: 8–17). Of course, each degree required a different cure, all to be bought from Rock himself; a pot of his 'incomparable lotion' for the first degree at 4s. 6d., a 'balsamic restrictive elixir' for 6s. for the second degree, and an 'electuary' for the third degree priced at 6s. (Rock 1745: 11, 41, 17). The more species of gonorrhoea there were, the more medicines it was possible to sell.

The other anatomical aspect of gonorrhoea in contention was the presence of ulcers in the urethra and, as a consequence, the nature of the discharge itself. Practitioners were divided into three camps: that the discharge of gonorrhoea was pus arising from ulcers, that ulcers were not responsible for gonorrhoea but often accompanied it, or that ulcers were never seen in a gonorrhoea at all. Those supporting the latter two theories suggested that the discharged matter in gonorrhoea was either mucous or seminal fluid from the prostate. Evidence supporting the presence or lack of ulcers in the urethra came primarily from dissections, which opened up the part to investigate whether ulcers or the scars they left behind (known as cicatrices) were present. In 1718, William Cockburn became the first to

Figure 2-1: Figure of a penis dissected by William Cockburn and Nathaniel St-André, demonstrating openings in the urethra that are thought to be the seat of gonorrhoea. Engraving by M.V. Gucht (Cockburn 1718: 18-19).

cite such dissections as evidence in his claim that the discharge of gonorrhoea was not pus from an ulcer. Cockburn justified this by observing that ‘the Vestige of a Sore is never obliterated by death; yet if we look for the Seat of a Gonorrhoea on a dead Person, it is no where to be found’ (Cockburn 1718: 51). Cockburn also used dissection to provide his own alternative theory. With assistance from the Swiss-born surgeon Nathaniel St-André (1680-1776), Cockburn experimented with injections of the urethral canal, revealing what he believed to be a set of new openings (figure 2-1, Cockburn 1718: 18–19). Describing the liquid these produced as ‘white and viscid’, he theorised that these openings were the seat of the gonorrhoea and the liquid was modified during a gonorrhoea to become discharge (Cockburn 1718: 52).

Cockburne’s polemic statement that it was ‘absurd to suspect a Gonorrhoea to have any thing of an Ulcer in its nature’ eventually drew the ire of Daniel Turner, who argued in his influential publication *Siphylis* that discharge shared ‘all the Conditions of true Pus’, particularly with regards to its colour and consistency (Cockburn 1718: 51; Turner 1737: 40). Turner condemned Cockburn’s theory that the discharge in gonorrhoea did not come from ulcers with his usual scathing style, claiming that practitioners would get more benefit from reading the history of Tom Thumb (Turner 1737: 44). Strangely, however, Turner did not address Cockburn's use of evidence from dissections. Indeed, Turner did not appear to reference dissection a single time throughout his treatise, relying instead on the more traditional case study for evidence.

Other writers besides Cockburn also prioritised tangible and visual evidence, increasingly relying on their senses over abstract theory. Both Jean Astruc and Giovanni Morgagni (1682-1771) referred to the dissections of Alexis Littré (1654-1726), the French anatomist who first described Littré's glands in the urethra, when discussing the possible seats of gonorrhoea (Astruc 1737a: 252; Morgagni 1769a: 593, 607). Morgagni, an Italian anatomist known today as the father of pathological anatomy, also referred to his own dissections throughout, placing priority on what he had seen himself. He was particularly emphatic about this when discussing the possibility of marks left behind by ulceration during gonorrhoea:

> Although there are, perhaps, few anatomists by whom so many male urethrae have been dissected, and accurately examin'd, as by me; yet it is either much more seldom than is commonly suppos'd, that very evident marks appear, in that canal, of diseases having accompanied the contagious gonorrhoea; or it has happen'd, by I know not what fatality, that notwithstanding so great a number of men is infected with this gonorrhoea, I never, or scarcely ever, saw those evident marks of disease. (Morgagni 1769b: 591)

English surgeons also continued to use evidence from dissection when arguing for their favourite theory of urethral ulceration. The London-based surgeon Alexander Stuart (1673-1742) disagreed with Cockburn's position based on dissections by the Parisian anatomist Joseph-Guichard Duverney (1648-1730), who had shown ulceration in the prostate gland in a man who died with gonorrhoea (Stuart 1738: 29–33). M. Mooney, who served on the admissions committee of the London Lock Hospital where he presumably also had access to patient post-mortems, said he had 'frequently' seen ulcers and cicatrices inside urethras on dissection (Mooney 1756: 28).

In 1755, Thomas Gataker made the somewhat vague statement that 'A great number of bodies have been opened who were affected with this disease when they died. The state of the parts, thus diseased, has been carefully examined by our most celebrated anatomists;

and the result of such enquiries has, as far as I can learn, always contradicted the received opinion of ulcers' (Gataker 1755: 9–10). The celebrated anatomists were no other than John and William Hunter, whose anatomy classes Gataker had been taking. William Hunter (1718-1783), Scottish-born anatomist and man-midwife, had shown through the dissection of a child in 1749 that it was possible for pus to form from inflammation without the presence of an ulcer, setting precedent for the same to be found in gonorrhoea (J. Hunter 1786: 29–30). In 1753 John Hunter continued this by opening the urethras of several executed men who had died with gonorrhoea, finding no ulceration but only increased redness, similar to Morgagni's findings (J. Hunter 1786: 30). It has previously been suggested that Hunter's findings, which were taught in his lectures and eventually published in his 1786 treatise, put an end to the urethral ulcer theory (Oriel 1994: 116). Of course, acceptance was actually much slower, with anatomists and surgeons using their own dissections to argue over what degree ulcers were present in gonorrhoea until at least the end of the century (Simmons 1780: 5; Andree 1781: 17–18; Howard 1794: 146; Bell 1793: 59). Indeed, the presence of ulcers in gonorrhoea became relevant to the monist-dualist debate, as shall be shown.

As dissections became more important, so too did anatomical collections. Preserving specimens for the long term allowed them to be used as tangible evidence in arguments. Methods of preservation had been refined in the seventeenth century, as the discovery of fluid preservation allowed soft tissues to be kept and new wax injection techniques gave creative ways to display them (Simmons 2014: 10; Hendriksen 2014: 42). The strong link between understanding pathology and collecting it was immediately apparent, with Fabricius Hildanus beginning to collect for a surgical museum as early as 1600 (Bertoloni Meli 2017). This connection is also evident in works regarding syphilis and gonorrhoea. While describing a case of *lues venerea* wherein the patient developed soft bones, Morgagni bemoaned the fact that the preserved examples had lost their quality over time 'because they could not be clean'd internally, giving an unctuosity to the fingers in handling them' (Morgagni 1769a: 345). The reference to handling demonstrates the importance of using anatomical specimens to verify pathology with one's own senses – further, Morgagni appeared distrustful of one author's work on *lues venerea* 'because I do not know how far his eyes, and his diligence, are to be depended upon' (Morgagni 1769a: 357). Thomas Gataker took a similar position when criticising Jacques Daran's theories on the development of caruncles during gonorrhoea, pointing out that Daran had sufficient opportunities for dissection and preservation, adding: 'Such a collection, as it would have been very satisfactory to the curious, would have been likewise a strong enforcement and confirmation of his own doctrine' (Gataker 1755: 29). Clearly, pathology collections were useful methods for a surgeon to validate his theories. Analysis of these collections would therefore provide further evidence for what those theories were, and how they developed.

Unfortunately, little evidence remains of anatomical collections from the first half of the century. The best documented is that of Frederik Ruysch (1638-1731), the Dutch anatomist whose methods were a strong influence on anatomists throughout the rest of the century. His inclusion of venereal disease in specimens, however, tends towards the allegorical rather than pathological. For example, Hendriksen has described a specimen which shows an infant's foot placed on fragments of a syphilitic prostitute's skull, demonstrating the victory of innocence over vice (Hendriksen 2014: 19). Nonetheless, it is useful to note the influence of collections at this stage, as their analysis will become important when examining the later part of the century in the following chapters.

Conclusion

Although the suggestion that gonorrhoea and syphilis were caused by different contagious particles was not introduced until 1767, the 50 years preceding this show that the definition of venereal disease was already in contention. Although most practitioners understood that the symptoms of venereal disease occurred in stages, there was considerable disagreement over how to delineate those stages and at which point a local disease turned into a systemic one. The increasing separation of pox into its stages meant that gonorrhoea and confirmed pox became separate entities of venereal disease, distinguishing them in a way that dualists could exploit in the future. Gonorrhoea in particular came under scrutiny during this period, likely because it was the most common symptom of pox. Practitioners debated over how and where the venereal poison affected the genitals and resulted in discharge. Anatomists used dissections of those who had died with the disease to find evidence for their favourite theories, demonstrating which lesions were or weren't present. Their findings fed into developing the diagnosis and prognosis of pox. At the same time, the complicated nature of syphilis made it important to understand so it could be differentiated from the many diseases it imitated. This ultimately meant that diagnosis was typically limited to a subset of pox symptoms and depended heavily on the patient's own assessment of their disease. Although there were many more symptoms that featured in patient cases, these were how venereal disease was defined in everyday practice.

Meanwhile, there was pressure and concern over venereal disease as a moral and public health problem. Doctors were not unaware of the moral implications of venereal disease and could incorporate such beliefs into their scientific work. This showed explicitly through the shame and judgement of their patients' sexual behaviour, and through blame when discussing the origins of syphilis. Due to recurring reformation movements reinforcing long held ideas about blame and syphilis, these moral pressures increased at the start of the century, increasing the threat of venereal disease in the public eye. There were also drastic numbers of infected people, particularly in urban city centres and within the military. A large portion of surgeons' patients were suffering from venereal disease, and this was reflected in the large printed response both in the form of medical treatises and advertisements. A surgeon's reputation depended on his ability to cure his patients; there was intense competition over treatments for pox, and as doctors searched for new remedies it became important for them to understand the underlying nature of the disease.

Altogether, these developments show a period of shift in how venereal disease was understood. Increasing external pressures acted as a catalyst for this. Although many of them were small changes, these all accumulated towards the ultimate separation of syphilis and gonorrhoea as distinct diseases caused by different infectious agents. As Kuhn describes, elements of such paradigm shifts can often be non-linear and almost invisible, with early solutions contributing to future problems before they are even defined (Kuhn 1996: 137–38). The increasing confusion and disagreement over how to define syphilis was emblematic of the old paradigm collapsing. New theories of pox sought to address how to make gonorrhoea and syphilis a cohesive disease by defining them as narrative stages; as this model became insufficient, the dualist doctrine was introduced.

Chapter 3 – The Venereal Poison: Separating Gonorrhoea and Syphilis, 1767-1792

Introduction

The breakdown of stable definitions of syphilis and gonorrhoea paved the way for the introduction of the dualist theory. This proposed that gonorrhoea and syphilis were separate, independent diseases caused by unique contagions. Following Kuhn's drift and crisis of the old paradigm, this was the start of a period of transition where new models emerged to address the deficits of the previous model of venereal disease. In this chapter, I investigate the importance of social networks and prioritisation of different types of evidence in accepting or rejecting the new doctrine.

The dualist theory was first proposed by Francis Balfour, a medical student at the University of Edinburgh. He suggested it originally in a paper delivered to his peers in the Edinburgh Medical Society in 1766, and then in his doctoral dissertation in 1767. The dissertation was read and heard by Balfour's contemporaries in the union, resulting in the local formation of the first group of dualists, Andrew Duncan Senior and Benjamin Bell among them. The local networks built in Edinburgh and the Medical Society were key to this initial development of dualism. The importance of networks is demonstrated by the reception of William Ellis's 1771 treatise. Another early adopter of the dualist doctrine who presented novel evidence for the theory, Ellis was an unknown apothecarist without a large academic network and his work was largely ignored.

Andrew Duncan went on to publish his own arguments for the dualist theory in his 1778 book of medical cases. Duncan's social influence and established publishing relationships meant that his work had a significant impact on the medical community; it appeared rapidly to generate interest, even if it did not convince all readers. A flurry of counter arguments appeared throughout the 1780s. The most important of these was provided by John Hunter, which developed an experimental approach to provide evidence for the monist doctrine. The monists typically outlined their reasoning, making it possible to investigate which evidence they prioritised, which evidence they rejected, and the models they proposed instead. The dualist argument was not defended again until the publication of Benjamin Bell's *A Treatise on Gonorrhoea, and Lues Venerea* (1793); this chapter investigates the debate until just before Bell's work, ending the period at 1792.

1766-1778: Balfour, Duncan, and the Edinburgh School

The University of Edinburgh and the Edinburgh Medical Society

Edinburgh in the year 1766 was formative for the first group of dualists and their supporters. The contributions of some of this group is described here and in the following chapter: Francis Balfour, Andrew Duncan Sr, Benjamin Bell, James Blair and William Anderson.[5] All of these men were matriculated in the Medical School at the University of Edinburgh. Some were also members of the Edinburgh Medical Society, which became the Royal Medical Society in 1778 (henceforth referred to as the Medical Society).

Other influential physicians enrolled as students at the time included Benjamin Rush (1746-1813) and Johan Clemens Tode, who went on to become vocal dualists in their respective home countries, America and Denmark. Johan Clemens Tode was a visiting student in 1766 and became an honorary member of the society in 1778, having maintained correspondence with Andrew Duncan (Royal Medical Society of Edinburgh 1906: 17; Rosner [n.d.]). Duncan had a reciprocal honorary membership in Copenhagen's *Societatis Medicae Havnienis*, which Tode was secretary of (Duncan 1776: 413). Tode promoted the doctrine in his treatise on gonorrhoea, which allegedly caused a backlash from German universities; he was regularly cited in German-language summaries of the debate (Tode 1774; Callisen 1822: 876; Handschuch 1831: 49; Gaillard and McChesney 1867: 238; Gotfredson 1953). Although Benjamin Rush does not appear to have published on the subject, his lectures taught that syphilis and gonorrhoea were unique diseases (Hawke 1971: 253). One of Rush's students in Philadelphia, James Tongue (fl. 1801), produced a series of experiments to demonstrate dualism in 1801 (Tongue 1801).

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[5] Student matriculation information all from Roser ([n.d.]). Information about members of the Medical Society from Royal Medical Society of Edinburgh (1906).

At the time of Balfour's dissertation, the University of Edinburgh was a metropolitan hub with an international reputation for medical learning (Morrell 1971). Teaching was dispersed across a number of classes with John Rutherford (Chair of Practice of Medicine), Robert Whytt (Chair of Institutes of Medicine), Alexander Monro *secundus* (Chair of Anatomy) and William Cullen (Chair of Medicine and Chemistry). John Rutherford (1695-1779) had established formal clinical lectures which allowed students to learn and make notes about diseases at the bedside; for many students this was the most valuable part of their education (Risse 1986: 242–44). Cullen (1710-1790) taught his students about nosology, the systematic classifying of diseases. This encouraged practitioners not just to consider symptoms of diseases, but how those symptoms could be clustered together into distinct disease entities – a vital shift of perspective for redefining syphilis and gonorrhoea. As Margaret DeLacy has argued, nosology was also important in establishing a shared vocabulary where 'terms for diseases can reach across time and space without changing, allowing information about different instances of the same diseases to be compared and combined' (DeLacy 2017: 137). Although Cullen was a monist, he classified syphilis and gonorrhoea entirely separately in his nosology: syphilis is classed under the order *impetigines* (skin disorders), while gonorrhoea is classified as a genus under *apocenoses* (evacuations) that includes both venereal and non-venereal species – a practice which may have encouraged students to consider their differences as well as similarities (Cullen 1792: 54,73). Monro *secundus* (1733-1817) used a large stock of preparations to demonstrate anatomical pathology, and was particularly interested in the actions of the lymphatics and inflammation (Lawrence 1984: 179–80). All these teaching practices would turn out to be vital in the formation of dualist (and countering monist) theories, as shown through the rest of this chapter.

An important part of medical student life in Edinburgh was the Medical Society, which had been established in 1734 by a group of medical students (Lawrence 1984: 201). The group met to share scholarship and clinical cases, initially in a tavern before receiving space in the Royal Infirmary and finally their own buildings in 1776 (Risse 2005: 68). Risse argues that the society was driven by an 'ethos of sincerity, motivation, and the search for knowledge, based on Baconian and Newtonian principles' (Risse 2005: 70). Members used the club as a space to develop their debating abilities by presenting and discussing clinical cases, responses to scientific questions and commentaries on medical aphorisms. The society also encouraged experimentation among its members, who considered it a necessary part of the construction of new knowledge – an attitude which will be clearly shown later in this chapter. However, as Lisa Rosner points out, the dissertations were primarily student exercises and not necessarily intended to contain new discoveries (Rosner 1991: 125). The society was perhaps most important to students as a place to make social connections and was central in establishing the first group of dualists.

Francis Balfour and William Ellis

In 1766, the student members of the Edinburgh Medical Society met in the Royal Infirmary to hear and discuss a paper read by Francis Balfour which would become the foundation for the new dualist doctrine. Members at the time – who probably attended this meeting, since absences incurred a fine - included Andrew Duncan Sr. and Benjamin Rush, who would go on to support dualism. Other future dualists, listed above, were enrolled at the medical school but were not yet members of the society. Copies of the paper were distributed among the society's members and Balfour's friends, making it very likely that the group of dualists had all read it even if they had not attended the meeting (Balfour 1815: 20). Although a copy was submitted to the society's library, it no longer survives, meaning we can never know what exactly Balfour argued during the meeting.

A year later, Balfour obtained his MD by defending a thesis on the topic of venereal diseases. This paper, read in Latin, still exists in the dissertation archives. A short passage of it describes Balfour's position on dualism:

> As far as the true character of the contagion is concerned, it appears that it has scarcely ever been properly known to physicians. They divide venereal disease into topical and general types, and classify gonorrhoea as topical, but they think that the poison in both is of the same character; they argue that in the case of gonorrhoea it is at once conveyed to the location of the disease without coming into contact with the blood. In fact I have grave doubts as to whether this is so. Are there not stronger grounds for suspecting that the matter which gives rise to syphilis is very different from that which causes gonorrhoea? It seems to me that nobody could be accused of drawing this conclusion in an ill-considered manner,

> once he has reflected on the facts that no-one suffering only from gonorrhoea can [transmit] a confirmed case of syphilis; that gonorrhoea is not cured by mercury, and very rarely develops into syphilis; whilst syphilis on the other hand does not turn into gonorrhoea; and finally that the existence of gonorrhoea was only observed in Europe thirty or forty years after the appearance of syphilis, and only very recently among the Chinese. (Balfour 1767: 17–18)[6]

It is likely that his paper to the Medical Society proposed the theory on a similar basis. However, it would not be wise to assume that it was identical. Mary Spongberg has previously suggested that Balfour's defence of dualism was made 'rather timidly' (Spongberg 1998: 23). It is worth remembering the context for this passage. Although Balfour would go on to embrace a reputation for controversy, he was at this stage attempting to obtain his MD: rocking the boat too much might have jeopardized his chances. On the other hand, the Medical Society was founded on the basis of questioning established medicine and challenging students to think in new ways; it is therefore possible he was more outspoken with his suggestions in the society paper (Duncan 1819: 16–17). The society also provided a forum for debate and feedback, meaning some ideas may have been refined in the year between the two papers.

Regardless, the dissertation paper is the only remaining evidence of Balfour's radical proposal. He based his position on four arguments that would remain central in the future debate:

1. Patients suffering from gonorrhoea alone did not spread syphilis.
2. Gonorrhoea is not cured by the use of mercury.

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[6] Translation supplied by Quintus, www.thelatintranslator.com. Adjustments from the original translation are indicated with square brackets. Original passage reads:

> Quod ad veram contagii indolem spectat, vix videtur eam unquam rite medicis innotuisse. Morbum quidem venereum in topicum et generalem dividunt, et gonorrhoeam ad topicum referunt; sed virus in utroque ejusdem esse indolis putant; idque in gonorrhoea statim ad morbi sedem, intacto sanguine, deferri contendunt. An vero res ita sese habeat, multum dubito. Nonne potius suspicandum est, longe diversam esse materiam quae luem parit ab ea ex qua gonorrhoea efficitur? Nec quidem temere in eam sententiam abiisse is mihi videbitur, qui secum reputaverit neminem gonorrhoea tantummodo laborantem confirmatam luem propagare posse; gonorrhoeam non a mercurio tolli, et rarissime in luem commutari; luem contra non in gonorrhoeam verti; et denique gonorrhoeam non nisi triginta vel quadraginta annos post luem in Europa fuisse observatam, et nuperrime tantum apud Sinenses.

3. Gonorrhoea rarely turns into syphilis, and vice versa.
4. Gonorrhoea appeared in the population historically at different times from syphilis.

On their own, these statements were not new; in fact, Balfour cited Astruc and Boerhaave in his footnotes as evidence for them. It was also not new to suggest that gonorrhoea and a confirmed pox were separate and often independent disease entities, as shown in the previous chapter. As Kuhn notes, the transition of a paradigm typically involves the reconstruction of the same data and information into a new framework (Kuhn 1996: 85). The radical break was Balfour's suggestion that each disease arose from a unique, distinct poison.

With this assertion, Balfour became part of a much larger movement – the trend towards contagionism, defined by Margaret DeLacy as ‘the idea that a material substance transmits disease from patient to patient’ (DeLacy 2017: 1). This was a true paradigm shift: the rejection of old theories about humoral and environmental balance in favour of the notion of external matter that caused physiological responses. Contagion theory was especially supported by Scottish-educated physicians and surgeons, such as James Lind, John Fothergill and John Pringle, who had all attended the University of Edinburgh in the 1730s and 1740s (DeLacy 2017: 11).

Venereal disease was an obvious candidate for contagion theory, as it was widely acknowledged that its transmission was via contact. It was established by medical authorities that some kind of poison – commonly referred to as the ‘venereal virus’ - was responsible for this, although the mechanisms and nature of the poison was debated. Astruc believed that the poison could be generated *de novo* in the right circumstances, then increased in the body by fermentation. He described the matter itself as ‘an acid or salso-acid, corrosive and fix’d nature’ (Astruc 1737a: 147). Boerhaave described it as a ‘fine and volatile’ matter, which was able to penetrate through the pores of the skin and had an ‘innate power of propagation’. Some had suggested that animalcula – microscopic organisms – which were found on microscopic examination of venereal discharge were the underlying cause. Both Astruc and Boerhaave sternly rejected this idea, with Astruc going so far as to say that if it were true ‘the whole Theory of Medicine would fall to the ground’ (Astruc 1737: 1:150; Boerhaave 1763: 31). Turner wryly declared the whole debate as something he could not solve, being of ‘too subtil a nature for me’. He appeared to despair of the whole argument, and proclaimed that 'some will have it to consist in an Acid, others in an Alkaline; others in a neutral Salt; others in a Pyrosaline, Cinnabrious, and Armoniacal', dismissing these as the claims of 'spagyrists', or alchemists (Turner 1737: 27–28). All this set precedent for the underlying theory that venereal disease was caused by a contagion.

Balfour appears, then, to have been at the confluence of the right time and place to propose the dualist doctrine. He was able to propose dualism by referring to established - if sometimes controversial – theory, from accepted authorities. The Medical Society provided a safe testing ground among peers. Edinburgh was already an intellectual home for contagionists, whose work was foundational to understanding the concept of specific contagions causing diseases and therefore to the dualist doctrine. Finally, Balfour himself proved to be a person who would happily challenge the status quo, declaring in his final treatise that he was 'bidding adieu to every controversy on the subject of medicine' (Balfour 1815: 19). He spent most of his life vocally promoting his theory on the role of the sun and moon in fevers, with his name still being cited into the 1830s by Anglo-Indian medical practitioners discussing sol-lunar influences (Harrison 2000). Even the course of his career was controversial; his promotion to Full Surgeon of the Indian Medical Service in 1777 was opposed by a number of junior surgeons (Crawford 1906). Although he disappeared from the printed debate over gonorrhoea and syphilis after his dissertation, he claimed to have continued promoting the dualist doctrine in India throughout the rest of his career (Balfour 1815: 20).

Balfour's doctrine retained influence in Edinburgh and the Medical Society for some time. The next time the theory appeared was in another paper presented by an unnamed student to the Medical Society in 1774, eight years after Balfour's ('The History, Causes, Prognosis and Method of Cure of the Syphilis Venerea' 1774). After describing the stages of a pox, the author referred to Balfour's published dissertation as having provided facts that prove gonorrhoea and syphilis are produced independently. The author then added more evidence from an anonymous person of 'undoubted veracity' with 'extensive' practice in treating venereal disease, consisting of five cases in which patients with gonorrhoea are successfully treated without mercury and without the disease progressing into syphilis. The author concluded that these cases added to the evidence that gonorrhoea does not produce a confirmed pox, and that they were 'two different diseases proceeding from different causes'.

Early proposals for the dualist doctrine were not, however, confined to Edinburgh. In 1771, a treatise published by William Ellis presented new evidence for the theory. Very little is known about Ellis. He was an apothecary in London with a shop on Fenchurch Street, which appeared yearly in the Kent Directory from 1771 onwards (Kent 1771: 62). It is uncertain whether he had any connection with Edinburgh; although a William Ellis was registered as a medical student in 1765, there is no certainty that this was the same person. Ellis attempted to explain how the underlying viruses for gonorrhoea and syphilis differed. He observed in his own practice that the exposure of denuded skin to the matter of gonorrhoea would heal if it was washed away and dressed, and not form a chancre. It was known from 'common practice', meanwhile, that contact with the matter from a pox would immediately form a chancre (Ellis 1771: 6). Ellis suggested that this was due to chemical differences in the two viruses. The pocky virus was 'more subtile', meaning it could be taken up by the absorbents to result in a confirmed pox. The virus of gonorrhoea, Ellis proposed, was not so easily absorbed, and instead lay in the urethra where it irritated the membrane and caused the production of purulent matter.

Ellis has been acknowledged by some historians as an early dualist (Bloch 1908: 31; Flegel 1974; Oriel 1994: 27; Forrai 2011). However, his work was mostly ignored in printed treatises until the following century. George Rees (1776-1846), while reviewing writers on venereal disease from 1737-1785 in 1802, noted that Ellis was of the opinion that gonorrhoea and syphilis were caused by distinct poisons, and described his remarks as 'valuable and judicious' (Rees 1802: 157). The most attention Ellis received from his contemporaries was from an anonymous author who wrote a polemic pamphlet directed at Ellis and his treatise (*A Flagellation for a Certain Apothecary* 1773). The author accused Ellis of being the 'lowest instrument' of science, only in the business for money and dismissed the theory that clap and pox were distinct diseases as a 'fashionable opinion' (*A Flagellation for a Certain Apothecary* 1773: 19). Ellis's theory was described as wild conjecture, without even a single experiment to support it. The accusation of lack of experimental evidence would continue to follow the dualists in the decades to come.

The difference between the reception of Balfour and Ellis highlights how vital social trust is in the emergence of new scientific theories. Balfour was part of a supportive peer network in the Medical Society, which offered him a formative space to develop his theories. The social connections he made at the University of Edinburgh resulted in the spread of the dualist doctrine. Ellis, on the other hand, only appeared to attract the attention of an angry rival, with no network of peers to defend him. Balfour also had the advantage of being a fully qualified (or close enough) M.D., giving him the privilege of professionalism. Ellis was a mere apothecary – a profession which was, in the eighteenth century, trying to disentangle itself from quackery and gain trust (Corfield 2009). Although the type of evidence and the scientific arguments themselves were, of course, important in the acceptance or rejection of the dualist doctrine, social standing and trust was also key.

Andrew Duncan

The dualist doctrine received very little attention in published English-language works for over a decade after Balfour's original suggestion. The theory finally broke into the mainstream after Andrew Duncan Senior argued for it in his compilation of medical cases published in 1778 (Duncan 1778: 205–31).

Andrew Duncan Sr was an Edinburgh-based physician; at the time of publishing the medical cases, he had founded Edinburgh's Public Dispensary for the Sick Poor and was teaching a course of extramural lectures on the theory and practice of medicine.[7] After receiving a first degree in Arts at St Andrew's in 1762, he went on to study medicine at University of Edinburgh in 1764-68 before graduating MD by examination at St Andrew's in 1769. In the intervening year, he served as a surgeon on HMS *Asia* with the East India Company. His service with the Company does not appear to have crossed paths with that of Balfour's – Duncan left for his trip to China in April 1768, while Balfour joined the Indian Medical Service in November 1768 (Hardy 1820: 33; Crawford 1906). During his time at University of Edinburgh, he became heavily involved with the Edinburgh Medical

[7] Biographical details about Andrew Duncan from Chalmers (2010).

Society, serving as president in 1767 and again after he returned to Edinburgh from 1769-1774.

Duncan was the embodiment of Scottish Enlightenment ideals: a socialite and member of many clubs, a scientific thinker who was equally passionate about the arts, a keen poet, and an advocate for humanitarian initiatives (Broadie 2007: 3–6). He was a member of at least 17 clubs in Edinburgh; these ranged from scientific societies like the Royal Society of Edinburgh, of which he was a founding member, to learned societies celebrating humanities like the written arts (Speculative Society) or Scottish history (Society of Antiquaries), physical interests such as the Honourable Company of Edinburgh Golfers or the Royal Company of Archers, and more eclectic clubs such as the Royal Caledonian Horticultural Society or the Six Foot Club (whose members had to be at least 6 feet tall) (Chalmers 2010: 115, 169). His membership to this number of clubs demonstrates how wide his network in Edinburgh was; with this, he had a considerable amount of social capital and intellectual influence with the literati of the city.

Duncan extended this influence by publishing a series of *Medical and Philosophical Commentaries*, printed in Edinburgh by Charles Elliot, but also in London by John Murray, ensuring his work reached those in the southern capital (Chalmers et al 2019). Beginning in 1773, the *Commentaries* were intended to report interesting cases, summarise the latest medical findings and provide abstracts of newly published medical books. They evidently had a large readership, with over 1000 copies printed for each quarterly edition (Chalmers et al 2019). By the time *Medical Cases* was published in 1778, Duncan already had an established network and readership among medical men in both England and Scotland.

Duncan's interest in venereal disease was established by his first publication, *Observations on the Operation and Use of Mercury in the Venereal Disease* (1772) in which he outlined what he considered to be the most effective use of mercury. Although he did not mention the dualist doctrine, he noted that the systematic introduction of mercury is completely unnecessary in a case of gonorrhoea, which was a local disease (Duncan 1772: 148–49). Duncan's introduction shows that he was clearly motivated to treat venereal disease by the Enlightenment concept of public health:

> The chief purpose of the study of medicine is to acquire the knowledge of safe and effectual method of curing diseases. The attainment of this end is intimately connected with the public good. (Duncan 1778: i)

Duncan appears to have been committed to this concept throughout his career, establishing a free Public Dispensary in 1776 and a humane asylum in the 1790s, influenced by the deplorable conditions his friend the poet Robert Fergusson (1750-1774) had experienced in Edinburgh Bedlam (Chalmers 2010: 73–74). Venereal disease was clearly a priority for public health, as Duncan comments that ‘few diseases are at present more common than *lues venerea*’ (Duncan 1772: i).

Duncan may have also had other motives for studying venereal disease. He was a member of the Beggar’s Benison, a gentlemen’s club dedicated to the ‘convivial and obscene celebration of the idea of free sex’ (Stevenson 2013: 1). In his book of poetry published in 1818, he noted that the Beggar’s Benison was ‘an order of which I am proud to say have had the honour of being one of the Knights Companions for many years’ (Duncan 1818: 15). The publisher Robert Chambers (1802-1871) wrote in 1829 that the club was dedicated to ‘wit and double entendre’, portraying it simply as a gentleman’s club for sharing sexual humour (Chambers 1829: lii). Evidence shows, however, that the club involved more than just obscene jokes and poetry. Remaining records show that club activities included reading erotica together, paying prostitutes to display themselves, group masturbation, comparing penises, and an initiation ritual that involved masturbating onto a ceremonial platter (Harvey 2004: 64–66; Stevenson 2013: 37–38). The connection between sex and medicine was also explicit in the club activities. Members were given lectures on sex, apparently aimed at sharing up-to-date medical knowledge. Texts of two of these talks still exist; one in 1753, given by James Lumsdaine on the topic of ‘The Act of Generation’, the other by an anonymous MD in 1813 concerning ‘The Male Organs of Generation’ (Stevenson 2013: 35–36). It is easy to imagine that Duncan himself may have given a talk during his time as a member.

Duncan’s open association with the Beggar’s Benison appears to indicate a liberal attitude towards sex. Importantly, this may have influenced his perspective on syphilis and gonorrhoea. Venereal disease had been viewed by many medical practitioners as an act of punishment from God for sexual excess and deviancy (Allen 2002: 41–43; Cohn Jr 2018:

113). If this was true, it did not make sense for there to be two separate diseases. Venereal disease was simply one punishment that varied in severity, which could be explained by the patient's habit in body – which in turn was influenced by their sexual activity or even 'violent passions of the mind' (Astruc 1737a: 163). Viewing sex as something to be celebrated shifted the blame for venereal disease from a person's behaviour to the underlying contagion instead. Framing disease this way made it easier to understand gonorrhoea and syphilis as independent entities. Of course, his own sexuality may have inspired him to study venereal disease in another way. As Franz Swediaur, a physician living near Edinburgh, put it: 'No branch of the medical art has, as far as my knowledge extends, received so many valuable improvements from modern practice as the treatment of the different venereal complaints. These improvements, I venture to say, were principally made because medical men themselves were as much subject to these complaints as any other person' (Swediaur 1787: 16–17).

In *Medical Cases*, Duncan described the case of a 43-year-old man, admitted in March 1777 'with a discharge of whitish viscid matter from the urethra' that the patient believed to be a venereal infection. The symptoms also included a burning sensation during urination (ardour urinae), tightening of the foreskin (phymosis), and a painful urge to urinate (strangury). Duncan treated each symptom individually and avoided using mercury entirely. The patient was relieved of symptoms in a fortnight. After outlining the case, Duncan commented that he had 'no hesitation' in thinking that the patient was affected with a gonorrhoea virulenta, and that the treatment regime followed was very different from what he would have prescribed in a case of syphilis. This finally brought him to the question: 'How far Gonorrhoea and Syphilis are, as has generally supposed, to be considered as different modifications of the same disease?' (Duncan 1778: 208).

Despite the paucity of published works arguing for or against dualism, the debate had evidently continued in-person, as part of societies, or via correspondence. Duncan indicated this, stating that the question of dualism had 'lately been the subject of debate' with 'many arguments' advanced in the monists' favour (Duncan 1778: 208–9). Duncan focused first on the monist side, highlighting four arguments 'on which the principle stress has been laid' which he then countered:

1. Both syphilis and gonorrhoea arose from the same cause (i.e. sexual transmission).

2. A patient could get both diseases from a single exposure.
3. The same woman could infect one man with gonorrhoea and another with syphilis
4. Improper treatment of gonorrhoea caused it to be converted into syphilis.

Duncan believed that the first argument was flawed, as sexual transmission was not the only way to spread venereal disease. Syphilis was known to be spread through nursing and cuts. Although cases of gonorrhoea spreading in these ways were less common, Duncan described an inoculation experiment by a student 'about twelve years ago' at the university which had shown that the same was true for gonorrhoea. The student had given himself gonorrhoea by applying the matter with a probe to his urethra. Duncan's dating of the experiment indicates that it occurred around 1766, the same time as Balfour's thesis. It could be tempting to assume from this timing that Balfour himself had experimented with inoculation. However, a set of student notes from Duncan's lectures on the theory and practice of medicine include a more detailed description of what may be the same experiment:

> The application of the matter in syphilis has produced the same Disease in every Person it acts upon, on the contrary the matter of gonorrhoea produces gonorrhoea, this has been tried by inoculation with the matter particularly by Dr Blair who studied a few years ago at this university. He observed that the 2 diseases run thro' their course without connection, in gonorrhoea no sympt[om] of syphilis make appearance and in syphilis no sympt[om] of gonorrhoea, and syphilis is never removed by a nat[ura]l termination, but by med[icine]. (Gale [n.d.]: 279)

The Dr Blair in question most likely refers to James Blair (fl. 1766), who was enrolled as a medical student in the university from 1761-66 and elected as president of the Edinburgh Medical Society in 1761. However, Duncan gave very little emphasis to this experimental evidence, and specifically used it to support the method of transmission in gonorrhoea rather than as direct proof of dualism. Inoculations would become considerably more important after John Hunter's treatise.

Duncan next tackled the argument that a single exposure to an infected woman could give a patient both syphilis and gonorrhoea, and that an infected woman could spread gonorrhoea to one man and syphilis to another. The common framing of venereal disease as being specifically transferred from infected women to men is important to note here.

While gonorrhoeal infections are asymptomatic in less than 10% of men with urethral infections, they are asymptomatic in up to 50% of women (Bignell et al 2011). This asymmetric appearance combined with the emphasis on blaming women as being responsible for infections confounded observations, as it meant that a woman who only appeared to have the symptoms of syphilis could in fact be infected with both diseases and therefore able to transmit both. Duncan acknowledged that these different patterns of transmission occurred but believed that they could be explained by women who were infected with both diseases.

The final argument Duncan had to counter was that a mismanaged gonorrhoea could develop into syphilis. While Duncan agreed that complications could occur in gonorrhoea – most frequently, swelling of the testicle - he argued that none of these complications 'are to be considered as syphilitic symptoms, but as merely the effect of inflammation' (Duncan 1778: 216). He also suggested that patients who had caught both diseases could appear to have gonorrhoea developing into syphilis, when in reality the two infections were simply running concurrently. This case demonstrates how important it was to have clear and precise definitions when discussing medical theory – specifically, what symptoms were actually considered to be part of a confirmed pox or syphilis. I have outlined in chapter two how the staging of venereal disease was under considerable debate, and Duncan's arguments show the significance of this in the debate over syphilis and gonorrhoea. If practitioners could not agree on how to cluster symptoms to different disease entities, they would not have the shared language needed to then define whether those disease entities had unique causes.

Duncan next supplied evidence in favour of the dualist doctrine, which had been highly developed since Balfour's dissertation in 1767. He focused on three lines of reasoning:

1. Gonorrhoea appeared in populations at distinct times from syphilis.
2. The course of disease was distinct for gonorrhoea and syphilis.
3. The method of cure was distinct for gonorrhoea and syphilis.

The first argument was similar to Balfour's; however, Duncan expanded it and added his own evidence. Like Balfour, he cited Astruc's work showing that gonorrhoea arrived much later than syphilis in Europe and China. He also introduced a new case study: the appearance of venereal diseases in the South Seas, particularly Otaheite, a large island in Polynesia now known as Tahiti. The arrival of venereal diseases in the South Sea islands was a point of contention at the time. Samuel Wallis (1728-1795) of the HMS *Dolphin* was the first European to have visited Tahiti 1767, after a storm blew him off course (Williams 2008). The following year, the two French ships *La Boudeuse* and *L'Etoile*, commanded by Louis-Antoine de Bougainville (1729-1811) also visited the island (Smith 1975). By the time Cook arrived at Tahiti for the first time in 1769, it appeared that the islanders had caught the pox; Wallis and Bougainville both blamed the other for having spread it to the island on their first visit (Samwell 1786: 30). The question of who was responsible for bringing syphilis to the island – or if it was even already endemic – is unimportant in understanding the dualist argument. However, Duncan claimed that he was informed 'by a gentleman whose accuracy may be relied upon, and who visited that island along with Captain Cook [on his second voyage] that, at the time, the gonorrhoea was still unknown to them', implying that syphilis had been transmitted to the island without gonorrhoea (Duncan 1778: 220). If true, this was stronger evidence for the argument than Astruc's, as it did not need to rely on the interpretation of historical documents but was unfolding at the time.

Duncan never specified who his Cook contact was, although a strong possibility was William Anderson (1750-1778). Anderson studied medicine at Edinburgh in 1766-69, before joining Cook on his second voyage (1771-75) as a surgeon's mate (Beasley 2012). Anderson also served as a naturalist and linguist. During Cook's 1773 stop at Tahiti, he worked to build the principal vocabulary of Tahitian words; the first mate David Samwell claimed that he spoke and understood Tahitian better than anyone else on the trip (Schütz 1994: 41). Identification of some items in Alexander Monro *secundus*' collection (now in the National Museum of Scotland) shows they may have originated from Anderson, indicating that he stayed in touch with his university colleagues in Edinburgh (Beasley 2012). His combination of medical and linguistic expertise puts him in an excellent position to have understood the islander's grievances about the spread of venereal disease. When considered alongside his Edinburgh pedigree, this makes Anderson an appealing candidate for Duncan's contact.

Duncan's second argument was based on the 'phaenomena' of the disease, referring to the symptoms, transmission and prognosis. There were several differences that he drew on between syphilis and gonorrhoea. While syphilis could kill a patient if left untended, gonorrhoea 'has a natural tendency cure' (Duncan 1778: 220). Duncan also believed that cases of gonorrhoea never became syphilis, as had previously been suggested. Instead, he thought that practitioners were mistakenly diagnosing the physiological consequences of gonorrhoea – such as a swelled testicle – as symptoms of syphilis. He emphasised the importance of making 'a proper distinction between real syphilitic symptoms and those … which are the mere consequences of an obstructed discharge' (Duncan 1778: 223–24). He also added that if gonorrhoea could cause syphilis, this would occur commonly as the infectious matter of gonorrhoea is applied to the lymphatic absorbents on the glans penis during sexual contact. Instead, ninety-nine out of a hundred cases of gonorrhoea showed no signs of syphilis. This argument was similar to Ellis' assertion that the matter of gonorrhoea is less 'subtile' than pocky matter, and therefore not taken up by the lymphatics.

This line of reasoning depends on a variety of major changes in medical theory that were taking place over the eighteenth century. First, as described above, it is dependent on contagion theory. Second, the rise of the anatomical pathology was important. Third, the recent proposal by William Hunter and Alexander Monro *secundus* that the lymphatics were responsible for draining tissues of the body allowed Duncan and Ellis to make new connections (Ambrose 2007). In the previous chapter, I showed how practitioners had begun to understand pathological lesions as the basis for disease, and subsequently debated where the seat of gonorrhoea was, as well as what type of lesion it was caused by. By beginning with the assumption that the urethra was the seat for an external contagion, Ellis and Duncan were able to identify physiological reasons that matched with their observations that gonorrhoea was more common than syphilis.

Duncan's final argument was that the method of cure is different in gonorrhoea and syphilis. Again, this depended on the shifts in understanding venereal disease that had been occurring over the previous decades; in this case, the movement away from using mercury to treat gonorrhoea. In Duncan's previous publication *Observations on the operation and use of mercury in the venereal disease*, he had argued that mercury worked on the venereal disease by acting as a specific to the contagion and destroying the infectious particles (Duncan 1772: 57–85). His evidence for this had included that mercury could be used topically to cure chancres. If, as he had previously argued, mercury was a specific for the virus that could be used both systemically and locally, it should also therefore cure gonorrhoea if the monist doctrine was true. However, it was now generally agreed that mercury was not an appropriate cure for gonorrhoea, lending weight to his argument.

As well as depending on recent changes in medical theory, Duncan appeared to prioritise evidence that has come from within his social circle; both the experiment and the news from Otaheite are important in his argument. Further, if the identification for the sources as, respectively, James Blair and William Anderson is correct, both were medical students enrolled in the University of Edinburgh at the same time as Duncan. Duncan also first heard the doctrine while studying at the university, from Balfour's paper addressed to the Medical Society – Balfour confirms that he and Duncan were friends and that Duncan knew of his work in a later publication (Balfour 1815: 20). Considered together, the influence of social networks when evaluating scientific evidence is clear. Similarly, the role of the university – and in particular the Medical Society – emerges as the site in which the doctrine was developed. As Steven Shapin argues, trustworthy agents are necessary in the social interactions that allow the construction of scientific knowledge; these men's shared background in an institutional setting allowed them to build that trust (Shapin 1994: xxvi).

1778-1792: Hunter, the Monist Wave, and Alternative Theories

The publication of Duncan's *Medical Cases* was followed by a wave of physicians and surgeons responding to the new doctrine. In the five years following, five treatises on venereal disease were published that included some reference to the dualist doctrine, nearly all published by physicians and surgeons with their practice in London. Of these, four were supporters of the monist doctrine, and one was undecided.

The first two works were published in 1780; in April, by William Thomas (fl. 1780), and in September, by Samuel Foart Simmons (1750-1813). Simmons studied at the University of Edinburgh from 1775 to 1777 and graduated MD at Leiden in 1778 (Brock 2015). He was made honorary member of the Edinburgh Medical Society in 1778 – undoubtably he had heard about the dualist doctrine through these connections. Thomas was also a newly qualified surgeon; however, he had no apparent connection to Edinburgh. Despite this, he stated that the dualist doctrine 'prevails among many', indicating that it had begun to spread outside the confines of Edinburgh (Thomas 1780: 3). Both Simmons and Thomas rejected the dualist doctrine for the same main reason. Their own practical experiences had shown them cases of gonorrhoea converting into syphilis. Duncan's reasoning that a person could be infected with both was clearly not strong enough for either to overcome their own experience, even for newly qualified practitioners. It was difficult to counter what they saw in their 'every day's experience', as Simmons put it (Simmons 1780: 1).

John Andree (1749/50-1833), a London-based surgeon, published his essay on venereal gonorrhoea the following year. Unlike Thomas and Simmons, Andree was not at the beginning of his career and had been practicing surgery since at least 1766 (Payne 2004). Andree also described how his own experience matched more closely with the monist doctrine, and was also able to describe specific examples. He provided cases of men infected with gonorrhoea who had developed syphilis (Andree 1781: 11–12). He also presented cases to show that a person infected with one disease could also transmit the other (Andree 1781: 24–26). The first of these was a case of a man who 'contracted a Gonorrhoea from a common prostitute' before having sex with another woman, who in turn developed chancres. Andree turned this case into an experiment, testing the hypothesis that gonorrhoea could not communicate syphilis. He first treated the man's gonorrhoea successfully without the use of mercury, then attempted to also treat the woman's chancres without mercury. If people infected with gonorrhoea could not transmit syphilis, he theorised, the woman also suffered only from gonorrhoea and therefore would not need mercury to be cured. This 'most fair trial' lasted four weeks before he decided to administer mercury, which resulted in the chancres being cured.[8] Once again, personal experience – and in this case, experiment – trumped the theoretical lines of reasoning proposed by Duncan.

[8] Incidentally, modern understanding of syphilis shows that chancres last for 3 to 6 weeks before resolving on their own (Centers for Disease Control and Prevention 2017).

The next two works were published by George Renny (1757-1848) in 1782, and James Dunbar Innes (fl. 1783) in 1783. Both had studied at the University of Edinburgh; Renny in 1774, and Innes 1778-79. Innes also became a member of the Medical Society in 1779. Innes made little comment on the debate, simply stating that in his opinion they were the same. However, he claimed in a footnote that he has recently made several experiments to prove this, 'which I soon intend to make public' (Innes 1783: 8). Unfortunately, this follow-up never appeared, or at least is untraceable now. Renny was uncertain over whether the dualist or monist doctrine was correct. He agreed that mercury was unnecessary in the cure of gonorrhoea, and that the vast majority of cases of gonorrhoea did not develop into lues (Renny 1782: 2). His conclusion, however, was one that may have been in common with the many practitioners who declined to comment on the debate: that it simply didn't matter. Instead, 'the grand object to be attained' was what treatment worked – and if that was decided, it was unimportant to know more about the underlying contagion (Renny 1782: 3).

There are two clear patterns in this brief surge of writers. First, three of the five studied medicine at the University of Edinburgh, indicating that it was still an important site in acquainting practitioners with the debate. Second, all dismissed the dualist arguments on the basis of their own senses, whether this was cases from their practice or experiments conducted that show the contrary. Empirical evidence took strong priority over Duncan's reasoning. It is also important to note Renny's simple disinterest in the matter, which may help explain why the dualist doctrine took many decades to take hold.

In 1786, John Hunter published his *A Treatise on the Venereal Disease*. Hunter was a Scottish-born anatomist and surgeon, and brother to the famous anatomist and man-midwife William Hunter. Unable to find work in Scotland, he was sent to London by his parents in 1748 to be educated by his brother, who was already an established medical practitioner (Gruber 2004). John quickly took to dissection and began to study surgery under William Cheselden and Percival Pott. In order to qualify for a license under the College of Surgeons, he served as an army surgeon from 1760-62. After returning, he established his own surgical practice and anatomical school in London. Hunter was known for his experimental approach; his quote to 'don't think, try the experiment' is still often repeated today. His reputation means that today he is referred to as the ‘father of scientific surgery’ and has essentially been canonised into the history of medicine by some.

Hunter was also highly respected by his peers and was an established figure in the intellectual society of London. Like Duncan, he was a member of many small societies and groups, although his interests were narrower than Duncan’s. For example, he was a founding member of both the Society for the Improvement of Medical and Chirurgical Knowledge in 1783 and Lyceum Medicum Londinenses in 1785. He was also elected fellow of the prestigious Royal Society in 1767, where he was awarded the Copley Medal in 1787. Informally, he was part of an exclusive group of men who met to discuss scientific advancement in the coffee shops of London, attending meetings with well-known names such as Joseph Banks and Captain James Cook (Edgeworth and Edgeworth 1844: 118). Although Hunter limited his own social circles to his interest in science, his wife Anne was a well-known poet who regularly hosted salons for the literati of London, including the Bluestockings (Oppenheimer 1946). A well-connected man, Hunter’s influence was significant and far-reaching.

John Hunter was firmly on the monist side of the debate. Most of his arguments were not that different from those that preceded him. In response to the idea that gonorrhoea never converted into a confirmed lues, he provided his own cases, as with Simmons, Thomas and Andree. He also disagreed with Duncan’s assessment of Otaheite. He reasoned from the known descriptions of venereal disease on the island that the Tahitians appeared to be suffering from both gonorrhoea and syphilis. The difficulty in agreeing on diagnoses of venereal disease, even from the same descriptions, left Duncan’s evidence open for debate.

Of course, John Hunter is best known for his inoculation experiment. Hunter took gonorrhoeal matter from a patient and inoculated it onto the glans penis, resulting first in a chancre and then over the course of several years other symptoms of syphilis. This led him to conclude that gonorrhoea could indeed convert into syphilis and therefore that the two diseases were the same. Historians have long debated whether Hunter used himself or an unnamed patient for this experiment (Qvist 1977; Herman 1978; Gladstein 2005; Moore 2005: 249–50). Much of this debate seems to stem from a modern disgust at the idea that a beloved and highly-reputed surgeon would perform such an experiment on himself –

which Wendy Moore describes as ‘bizarre’ - and an urge to defend this almost mythical figure. For example, George Qvist explicitly states that he desires ‘the complete eradication of the stigma of syphilis from the image of John Hunter’. Jay Gladstein was so keen to prevent this ‘irresponsible misinterpretation’ that he wrote an article in response to the off-hand mention of Hunter’s experiment in a piece that was actually about Shakespeare. However, this modern-day attitude towards self-experimentation did not appear to be shared by eighteenth-century scientists. For example, Franz Swediaur – who, like Hunter, enjoyed a reputation as a well-respected surgeon – wrote about a lengthy experiment in which he injected his own penis with a caustic mixture in order to show that gonorrhoea could have non-venereal causes (Swediaur 1787: 36–40). Swediaur certainly showed no sign that self-inoculation was unusual, going into great detail about the ‘excruciating; pain and symptoms that followed. Many such inoculation experiments are described in the remaining parts of this thesis, performed by both medical students and established practitioners. Seen in this light, it is perfectly unremarkable that Hunter would inoculate himself with gonorrhoeal matter.

Hunter’s experiment began in May 1767, which could indicate that he was aware of the dualist doctrine significantly earlier than expected. However, the inoculation was not performed with the intention of providing evidence for monism, but rather to ‘ascertain the progress and effects of the venereal poison’ (J.Hunter 1786: 324). Hunter was quite detailed about the course of disease, which is unsurprising given this aim. The experiment began with the inoculation on a Friday, and by the Sunday following the penis was beginning to itch. By Tuesday the point of injection had thickened and become red; the sore – which Hunter designated as a chancre - then sloughed off (i.e. shed the top layer) multiple times and persisted for four months. A bubo also developed in this time, followed by the appearance of a venereal sore on the tonsils, which returned repeatedly over the course of the disease. Copper blotches also appeared on the skin. Hunter finally cured the disease by administering mercury a full three years after the initial inoculation. He believed that the experiment ‘proves many things, and opens the field for further conjections’, including ‘that matter from a gonorrhoea will produce chancres’ (J. Hunter 1786: 327). This detailed experiment provided direct and empirical evidence from a trusted source for the monists; the dualists had no such evidence to counter with.

Hunter's *Treatise* and inoculation experiment is often highlighted as the main reason the dualist doctrine was not accepted sooner (i.e. Oriel 1994: 27–30; Merians 1996: 5–6). However, it is clear from the works that preceded Hunter's publication that practitioners were already doubtful of the theory. Although Hunter's reputation and evidence gave weight to the monist doctrine, it seems unlikely that dualism would have been easily accepted had he not intervened. Regardless, his contribution became an important touchstone for monists, and his arguments and experiment became the standard that dualists needed to refute.

Yet despite Hunter's intellectual reputation, his work was not simply accepted as fact by all readers, but sparked a series of direct retorts and responses. In part this was due to his attitude towards masturbation, which he argued did not cause disease. Duncan Gordon wrote *A letter to John Hunter* the same year, in which he claimed that 'should your doctrine be adopted, the whole human race would be annihilated' as everyone would choose to masturbate rather than procreate (Gordon 1786: 16). Jesse Foot (1744-1826), Hunter's rival and eventually biographer, went so far as to write a lengthy three-part response, peppered with insults to Hunter's character and writing (Foot 1786). This in turn prompted no less than three responses to defend Hunter (Brand 1787; Tyre 1787; Peake 1788). Franz Swediaur added *A Short Review of a Late Treatise on the Venereal Disease by John Hunter* to the end of his own treatise, in which he added to the 'masterly' criticism already written by Foot, describing Hunter's treatise as full of 'whimsical ideas and monstrous excrescences of his brain' (Swediaur 1787: 294). A final pamphlet denouncing Hunter's treatise was published anonymously in 1788, although annotations to the book indicate it was written by John Roberts (d. 1788), a Welsh surgeon based in London (Roberts 1788). The feud was wittily summarised by an anonymous poem written in the front cover of Peake's pamphlet:

> When Hunter first his Book produced,
> His readers were his minions,
> Each glaring Error they excused,
> Nor canvassed his Opinions.
> But Foot with critic skill perused,
> And warn'd the rising youth,
> He saw great Authors much abus'd,

And more of whim than truth.
Then Hunter let his puppets fly
A motley, mongrel band.
Peake Druggist to her Majesty,
And bandage making Brand.
Such weak opponents Foot disdains
And owns them very small
For Peake he knows has little Brains
And Brand has none at all,
And Brand has none at all.

Despite the many pages dedicated to rebutting Hunter's treatise, there was one thing all authors agreed on – the monist theory. This was not due to Hunter's reasoning or experimental evidence, but simply because they had been given no reason to doubt the status quo. Both Foot and Roberts questioned who was denying that gonorrhoea and syphilis were caused by the same poison in the first place (Foot 1786: 10; Roberts 1788: 16). It is unclear whether they were simply out of touch, considering the number of works that discussed the topic by 1786, or whether the dualist doctrine had remained confined so far to a niche number of practitioners. If the latter, then Hunter's major contribution to the debate was to give it a large platform - although everyone may not have agreed with his theories on venereal disease, they were certainly widely read. As with Duncan's *Medical Cases*, a short flurry of activity appeared after Hunter's treatise; by 1790, at least four more publications were written that discussed the dualist doctrine. In fact, one later monist commentator even complained that Hunter had made the matter worse, blaming the opposition to monism on Hunter's attempt to account for the confusion surrounding syphilis (Wallace 1833: 39).

Although Hunter was confident in his rejection of the dualist theory, the flaws in the old model that had been revealed by the dualists needed to be addressed. All practitioners agreed that some people only received chancres from an infection et al gonorrhoea, regardless of the nature of the contagion. The monists needed to account for why this happened if the two were caused by the same venereal virus. Hunter attempted to explain this based on the classification of tissues; he suggested that gonorrhoea occurred when the virus was applied to a secreting surface, such as the membrane of the urethra, and that chancres occurred when the virus was applied to a non-secreting surface, such as the skin of the penis (J. Hunter 1786: 16).

Other authors also made attempts to account for issues in the monist model of venereal disease. Another approach to understanding the difference in presentations and the mechanism of conversion between gonorrhoea and syphilis focused on the presence of ulcers in gonorrhoea – a point of contention, as discussed in the previous chapter. Although by the 1780s few practitioners still claimed that ulcers were the source of gonorrhoeal discharge, a significant number agreed that ulcers could occur in the urethra during a gonorrhoea. This theory offered a solution for the monists to explain how gonorrhoea and lues venerea were connected; gonorrhoea was the result of the venereal poison being confined locally, and it was only able to spread into the constitution and convert to syphilis when ulceration took place and breached the membrane. This ulcerating surface theory became popular among practitioners and was shared by a number of monist writers including William Thomas, Samuel Foart Simmons and John Andree of those already discussed.

It was, however, necessary to explain how this supposed ulceration occurred, and why gonorrhoea only rarely developed into syphilis. Franz Swediaur, a French physician writing the year following Hunter's treatise, suggested that the virus in gonorrhoeal discharge was normally too diluted by the mucous of the urethra to cause chancres (Swediaur 1787: 28–29). He believed that ulceration only happened rarely as the urethra was protected by the stimulation of mucous that occurred during a gonorrhoea; this theory was also shared by William Thomas and Alexander Monro *secundus*, who taught it in his lectures at the University of Edinburgh (Thomas 1780: 6; Swediaur 1787: 27; Monro 1840: xvi). The theory served a double purpose, as it also provided a logical reason for the use of astringent injections in treating gonorrhoea. These washed away the mucous in the urethra, which also contained the virus, meaning that it was removed at the same time (Thomas 1780: 10). This was a useful bonus for the theory; as Dracobly has suggested, medical theories that have useful and practical impacts on treatments are more likely to be accepted (Dracobly 2004). Notably, Swediaur's theory that the venereal virus is lodged in urethral mucous also helped him to counter the dualist argument that mercury did not act as a specific for gonorrhoea. Although he agreed that mercury was no use in these cases, it was not because the contagion was different, but rather because mercury was unable to penetrate through the urethral mucous (Swediaur 1787: 32).

As well as providing reasonable explanation for why a confirmed pox was much rarer than gonorrhoea, the ulcerating surface theory held appeal as it was backed up by tangible evidence. Most of the supporting authors had seen or heard trusted accounts of ulceration in the urethra, through patient cases or dissection. Andree was 'in possession of two Urethrae, in each of which there are ulcers' from men who had been 'afflicted with a Gleet and obstruction of the Urethra' (Andree 1781: 14). He also cited the dissections of Morgagni, who gave 'several histories of dissections of Urethrae so diseased' (Andree 1781: 14). Simmons was convinced that ulcers could arise in gonorrhoea as he had 'met with several instances myself, and have seen others in the collections of different anatomists, of urethras that afforded evident marks of cicatrices from ulcers formerly existing in that canal' (Simmons 1780: 6). However, both Andree and Swediaur also discussed dissections that did not show ulceration in gonorrhoea, in order to demonstrate that this was a rare result – and hence why gonorrhoea did not always convert into syphilis. Andree described his own dissection of a man who had died in London Hospital with gonorrhoea:

> I opened the Urethra, and found its membrane at two inches distance from its outer orifice, and for an inch and a half lower down much inflamed, of a pale red colour, and all this part covered with yellow mucus: after wiping off the diseased fluid, I attentively inspected the diseased part with a magnifying glass, and found the Urethra, where the inflammation was seated, had its vessels much distended with blood; but there was not even the smallest degree of ulceration to be seen, nor was there any appearance of cicatrices, which it is reasonable to imagine would have been perceptible. (Andree 1781: 17–18)

Although this evidence appears on the surface to be contradictory – as it provides proof of both the lack and presence of ulcers in gonorrhoea – practitioners were able to selectively choose evidence to fit their model; that ulceration happened but only rarely, explaining why not all cases of gonorrhoea resulted in confirmed pox.

Although the ulcerating surface theory was popular, it was not the only one put forward. For example, William Nisbet (1759-1822), a Scottish physician, provided an explanation for the chancre/gonorrhoea dilemma where the stage of coition at which the virus was transmitted accounted for the difference. The 'turgescence of the parts' at the start of sex, combined with friction, favoured a chancre forming if the contagion was spread at this stage. On the other hand, uptake of the virus 'during the state of collapse' would result in gonorrhoea (Nisbet 1787: 207). Jesse Foot, Hunter's rival, developed a theory that the virus would only cause infection when it was lodged in 'foreign fluid'; this, he believed, accounted for the fact that chancres did not develop from gonorrhoea (Foot 1790: 18). He also suggested that this meant inoculating a patient with their own venereal fluids was doomed to fail – presumably this was intended to be a jab at Hunter's experiments inoculating patients with secondary syphilis with matter from their own sores (J. Hunter 1786: 294).

Foot was not the only writer to question the validity of Hunter's experiment. John Howard was the only practitioner in this group of publications who did not completely support a monist doctrine, as he believed there was no direct proof for either theory (Howard 1787: 233). Howard did not appear to be interested in reasoning and theoretical arguments, instead insisting that the question must be 'fairly brought to the test of experiment' (Howard 1787: 233). He referred to Hunter's inoculations, but did not consider these to be sufficient as they still left some room for doubt (Howard 1787: 189). His demands were for a much more rigorous set of experiments:

> I may be permitted, I hope, to wish that the experiments, to which I have so often alluded, may be conducted upon a large scale, and performed first with chancrous matter, fairly applied to a mucus surface; and then, that the mucus of a gonorrhoea, when inoculated, may be taken from the different species of this complaint, in different stages of the disease. (Howard 1787: 190)

Howard did not, however, elect to pursue these more rigorous experiments himself, prompting one reviewer to ask: 'if he is dissatisfied with the too small numbers of experiments, why did he not enlarge it with an additional number of his own?' (*The English Review, Or, An Abstract of English and Foreign Literature* 1787: 119).

There were other obstacles to accepting the dualist theory. William Nisbet repeated Renny's earlier views on the whole debate; that treatment was what mattered, and the dualist doctrine did not add anything new on this subject. Nisbet already considered syphilis and gonorrhoea as distinct entities in this area: 'In these different states, the several venereal affections are always to be considered in some degree as independent of each other, and as in no way connected in their cure. Thus gonorrhoea may be removed without affecting chancre, lues without gonnorhea, etc.; and hence the necessity for regarding them as separate diseases' (Nisbet 1787: 33–34). Yet despite this stance, he was a firm monist and concluded after his discussion of dualism 'that the virus producing gonorrhoea and lues are exactly the same' (Nisbet 1787: 69). This presented somewhat of a paradox to the dualists. The distinct treatments for gonorrhoea and syphilis was one of the primary arguments for their separation. However, if a practitioner already agreed that the two required different treatments, there was no practical urgency in separating the two, and hence no compelling reason to support dualism.

As the dualist debate began to enter the mainstream, monism remained the dominant doctrine. Part of the debate took place in printed treatises, but these indicate that more was taking place off-stage, where the dualists developed new arguments. By 1792, Duncan and Ellis were still the only published authors to support dualism, although some authors were still undecided. The main stumbling block was the theoretical nature of Duncan's arguments, which appeared to be contradicted by the monists' own experience in their every-day practice. Although he provided a summary of the experiment by Blair that appeared to support dualism, this did not appear to convince debaters. Instead, the monists began to perform their own experiments, such as the inoculations by Hunter, the mercury trial by Andree, and the never-published experiments by Innes. At the same time, monists were paradoxically held back by agreeing with one of the central arguments to dualism; since gonorrhoea and syphilis were already effectively treated as distinct diseases, there was no motivation to separate them further. Practitioners offered alternate models to connect gonorrhoea and syphilis that enabled them to address the crisis and model shift addressed in the previous chapter without any radical shift of framing disease. These relied on well-known phenomena such as inflammation and the formation of ulcers. Importantly, they relied on principles shared with the old and familiar humoral theory: that differences in disease were due to internal states of the body, rather than external causes.

Pushback in the Edinburgh Medical Society

Although the University of Edinburgh produced a significant number of dualists, there was not a homogenous local culture on the topic. Duncan continued to lecture in his extramural course about the new doctrine, and also stayed involved with the Medical Society for the remainder of his life – he was sufficiently influential in the Society that his portrait remains there to this day. However, teaching staff within the university itself preferred the status quo. William Cullen, who first held the Chair of Institutes of Medicine from 1766 and then of Practice of Medicine from 1773-1790, believed that gonorrhoea would give rise to syphilis given enough inflammation, although he agreed that mercury was not necessary for its treatment (Cullen 1829: 277–78). Alexander Monro *secundus*, who held the Chair of Anatomy from 1758-1798, taught in his lectures that a patient with chancre could transmit gonorrhoea and vice versa (Black 1780). Students at the university would therefore be exposed to both the dualist and monist doctrines in their education, and needed to weigh the evidence and make the decision for themselves which they sided on. In 1781, the student William Harrison chose to experimentally test the doctrines for his dissertation. Three essays on the topic were written by members of the Medical Society between 1778 and 1793 (the publication date for Benjamin Bell's treatise). As these students were encouraged to carefully outline their thinking, the essays offer an excellent insight into local dynamics and the ways different types of evidence were prioritised.

William Harrison (fl. 1781) was a medical student at the University of Edinburgh, attending sporadically for six years between 1776 and 1785, although he did not join the Medical Society in this period. He produced his dissertation on lues venerea in 1781, in which he recounted a series of inoculation experiments he had performed (Harrison 1781)[9]. Harrison may have been inspired by John Hunter's experiment to make his own attempt; although the dissertation came before the publication of Hunter's treatise, word of Hunter's inoculations had already spread to Edinburgh, as seen in Henry Black and Hugh Owen's student essays below. In the first experiment Harrison took matter from a chancre which he

[9] As I have not had the opportunity to have this dissertation translated, information on the experiments comes from the second-hand accounts cited.

inoculated into the urethra; this resulted in a gonorrhoea (Simmons 1783: 214). In the second experiment, he took discharge from gonorrhoea and inoculated it into the prepuce. This time, there was no effect, and no chancre was produced. It is impossible to know Harrison's conclusions from the experiments without access to his dissertation. While they produced mixed results, the conversion of chancre into gonorrhoea would appear to support the dualist doctrine. However, this is not clear cut, as suggested by John Howard when describing Harrison's experiments, as a 'variety of irritants will cause a running' that could mimic gonorrhoea without necessarily being a venereal gonorrhoea (Howard 1787: 186).

The first of the Medical Society essays was written by Henry Black (fl. 1835) in 1780. Black was a student at the university and also enrolled in Duncan's extramural lectures, although he seems to have had some personal conflict with his teacher. Duncan accused him of working in 'sloth and ignorance' after not applying himself properly to his studies, an occasion which seemed to rankle with Black even 50 years later (Chambers and Chambers 1835: 121). Although Black outlined the history of venereal disease – including Duncan's information about Otaheite – he concluded that this was insufficient evidence to say either way. The rest of Duncan's arguments for dualism were dismissed as not meriting 'ample discussion'. For Black, the most important fact to establish was whether a gonorrhoea could be converted into syphilis. He cited Jean Astruc, Gerard van Swieten, and 'all the former writers on the venereal disease' as asserting that this can indeed occur. However, he put the most emphasis on information gained directly from his university teacher Monro, 'whose authority is so deservedly esteemed in medical matters, alledges, that a person having Chancres, communicates Gonorrhoea, or perhaps communicates both the Chancres, and Gonorrhoea'. Monro, Black described, was a supporter of the ulcerating-surface theory; he suggested that if a gonorrhoea was severe enough to form ulcers, this would allow the venereal poison to enter the constitution and turn into syphilis. For Black, experimental evidence 'of the most decisive nature' was needed before he was willing to question authority and 'refute the observations of so many eminent men'. The only such evidence Black was aware of was Hunter's inoculations, which he had heard about through a classmate who had attended Hunter's lectures. Lacking significant experimental evidence and his own personal experience, Black appeared to be most influenced by his preferred teacher. However, he avoided concluding explicitly that he supported monist doctrine.

The next Medical Society student to write on the topic was Hugh Owen (fl. 1783) in 1782-3. Owen immediately attacked Duncan's arguments – although Duncan wasn't named, the Otaheite theory was described – saying that it would 'be no hard task to point out many causes of the fallacy' of the dualist doctrine. The historical arguments were dismissed as too uncertain, as they depended on speculation from outdated diagnostic descriptions. The different symptoms of gonorrhoea and syphilis were, according to Owen, to be expected given the different structures being affected by the poison. As for the matter of mercury treatments, he believed that mercury was also not necessary in every case of syphilis. Dr Hope (presumably referring to John Hope, 1725-1786, the professor of botany at the university) had taught that indigenous American women were able to use the canunculus plant to cure syphilis, and Cullen had similarly described Spanish and Italian physicians curing cases with a restricted diet. The monist doctrine was also reinforced by Owen's personal experience attending wards at the Royal Infirmary with Dr Hamilton (likely Alexander Hamilton, 1739-1802, who was also Professor of Midwifery). There he had seen 'at one & the same time, three syphilitic patients … each of whom had chancres which supervened on a gonorrhoea'. The final and 'decisive proof' came from the experiments of Hunter and Harrison. Like Black, Owen placed emphasis on the need for experimental evidence, and was clearly strongly influenced by the local teaching.

The final Medical Society essay was written by Henry Stanistreet, c1786-7. Stanistreet immediately and confidently declared himself a monist, based on three arguments. First, a person with gonorrhoea could transmit both diseases. Second, neglected gonorrhoea could result in chancres forming. And third, a person with gonorrhoea could develop syphilis if the urethra was accidentally wounded, such as in using a syringe. Stanistreet did not cite sources for these arguments, clearly believing them to simply be common knowledge, apart from noting that a case showing his third argument appeared in Swediaur's treatise. As with the others, Stanistreet's emphasis lay on an experiment that he related after his three main points; he believed that this provided sufficient evidence that 'no doubt can remain that the same virus produces both diseases'. The experiment took the form of two self-inoculations. First, gonorrhoeal matter was applied to the glans penis, and 'in a short time a chancre was produced'. Next, the experiment was reversed, and a gonorrhoea was brought on. Unfortunately, Stanistreet did not say where this experiment originated, only that it was performed by a friend of a late writer. The description appears to match an experiment described in John Andree's *An Essay on the Theory and Cure of the Gonorrhoea* (1781):

> An ingenious Surgeon has proved, that the discharge from a Gonorrhoea will produce a true venereal Chancre, by inoculating himself with a lancet moistened with such discharge: he has likewise inoculated himself with matter taken from a Chancre, and finds that the Chancre caused by the discharge from a Gonorrhoea, is as truly venereal, and as virulent, as that caused by inoculation from the Chancre. (Andree 1781: 25–26)

However, Andree also does not name the experimenter; even if he is the 'late writer' Stanistreet refers to, the identity of the surgeon responsible remains a mystery.

For this new generation of medical practitioners being educated in Edinburgh, the results of experiments clearly took precedence over other types of evidence, to the point of one student (Harrison) even producing his own. While social networks had been vital in forming the first group of dualists, the influence of Duncan's teaching – even though he was well respected in the Medical Society – was not sufficient to counter tangible evidence. Of course, this may have been influenced by a different local movement: David Hume and his empirical philosophies. This priority for evidence that can be confirmed by the senses is also seen in other parts of the students' work. For example, Stanistreet described preparations and dissections shown by Monro to support his belief that ulceration in the urethra can spread to other organs. Similarly, seeing what they interpreted as clinical evidence for monism with their own eyes – as with Owen in the Royal Infirmary Wards – was difficult to counter. This type of evidence was central to the Edinburgh educational system, with its unique opportunities for clinical teaching on the wards, as well as to the purpose of the Medical Society. Collectively, these essays demonstrate that while Duncan was able to get the members of the Medical Society to consider and debate over dualism – something which they may not have done if they were educated elsewhere – the doctrine still fell short when it came to actual evidence.

Conclusion

This chapter has outlined the emergence of the dualist doctrine and the initial response and debate that followed. This began with two early works; Francis Balfour's dissertation in 1766/7, and William Ellis's essay in 1771. Balfour's arguments rested primarily on the established authority of Herman Boerhaave and Jean Astruc. Andrew Duncan Sr, who was present when Balfour presented his dissertation at the Edinburgh Medical Society, developed these arguments further and was able to bring the dualist doctrine into the medical community's mainstream with his established publishing networks. Balfour and Duncan's influence on the local networks at Edinburgh were clear, as the first group of dualists was formed from this group; Johan Clemens Tode, Benjamin Rush and Benjamin Bell. Duncan also relied on evidence from this same group, given by James Blair and William Anderson. These connections demonstrate the importance of establishing trust within social networks when constructing scientific knowledge. Edinburgh remained a dominant force in the following debate, even when it came to monists. Students of the Medical Society produced a series of dissertations responding to the theory, often depending on information from their local teachers. Out of the ten treatises that addressed the theory discussed in this chapter period, six of the writers had a connection to Edinburgh, being either graduates of the medical school or practitioners based in the area.

Rejection of the dualist doctrine was based on the empirical evidence that was available to practitioners. Most often this was in the form of cases that contradicted the underlying arguments for dualism; many physicians and surgeons believed they had seen patients with gonorrhoea go on to develop a confirmed pox. The historical argument was seen as too speculative, not something that could be confirmed with the senses. The monists provided more experimental evidence than the dualists; while Duncan had one inoculation experiment that he described (anonymously in his *Medical Cases*, although described elsewhere as being performed by Dr Blair), the monists had an array of experiments to draw on, including from the highly reputed surgeon John Hunter. The monists also had very little motivation to challenge the status quo; it was already widely accepted that gonorrhoea should be treated differently than chancre or pox, meaning there was little reason to adopt the dualist doctrine. Similarly, when providing alternate models for the problems that dualists had highlighted, practitioners turned to tangible evidence. The importance of an anatomical understanding of disease is especially clear in this case, as writers highlight the dissections and anatomical specimens seen that support their arguments. Overall, it is clear that writers prioritised evidence that they could see and touch over abstract reasoning. The anatomical specimens which provided the tangible evidence practitioners relied on were key to knowledge production; these will be fully explored in chapter five.

The wave of monist writing following Duncan's writing was finally ended by the publication of Benjamin Bell's treatise in 1793, at which point opinion steadily began to ebb towards dualism. This process is followed in the next chapter.

Chapter 4 – Pluralities, Inoculations and Venereal Disease(s), 1793-1850

Introduction

After fifteen years of publications mostly rejecting the dualist doctrine, Benjamin Bell published his *A treatise on gonorrhoea virulenta, and lues venerea*. His treatise marked the start of a change in tide of opinion. Before 1793, the dualists were a minority, with Andrew Duncan's *Medical Cases* and William Ellis' *Essay on the Cure of the Venereal Gonorrhœa* being the only published works that argued in their favour. After John Hunter brought the debate into the mainstream, monists remained the majority with eight further authors defending the status quo. However, the next generation of medical practitioners began to doubt this perceived wisdom, and over the four decades spanning Bell's treatise and Philippe Ricord's (published in 1838) those who picked a clear side in the debate were evenly divided between monists and dualists. The period also saw a willingness to divide diseases into smaller nosological categories, with pluralism beginning to rise: a theory that promoted the idea of multiple contagions causing syphiloid diseases. On the other extreme, a group of French practitioners denied the idea that there was a contagious venereal disease at all, and suggested that syphilis was instead generated spontaneously by inflammation. The debate over the source of gonorrhoea took place alongside this blossoming of nosological theories.

Although Bell is typically noted by historians as the primary proponent of the monist argument, his actual influence on the debate has not been seriously analysed. In this chapter, I investigate what was new about his arguments and how his work was received by those following him. One of his significant introductions was a detailed description of an inoculation experiment with the matter of gonorrhoea and syphilis, which directly countered that of John Hunter, as described in chapter three. The use of inoculation increased in the following period, with many more similar experiments undertaken and written about, providing evidence for both sides. However, as the very definition of syphilis was under attack by both pluralists and denialists, it proved easy for others to pick and choose which inoculations showed 'true' syphilis and which were errors on the part of the experimenters. This type of experiment peaked with the publication of Philippe Ricord's experiments in 1837, which recorded hundreds of inoculations that appeared to definitively prove that gonorrhoea and syphilis were truly separate diseases. These experiments provided sufficient evidence for acceptance of the dualist doctrine, which became the status quo over the following decades.

Benjamin Bell: Paradigm Change

Benjamin Bell (1749-1806) was born into the landed gentry in Dumfriesshire, and after an education at Dumfries Grammar School was first apprenticed to learn surgery from James Hill (1703-1776) in Dumfries in 1764.[10] Hill was a surgeon known best for his approach to cancers. In 1772, Hill published *Cases in Surgery, Particularly, of Cancers, and Disorders of the Head,* which also included an account of sibbens he had written in 1768. Sibbens was a contagious treponemal disease, similar to syphilis and yaws, documented primarily in Scotland. Under Hill's guidance, Bell no doubt saw or heard about cases of sibbens which – as will be described later - would go on to influence his position on the identity of syphilis and gonorrhoea. After this apprenticeship, he begun studying at the Edinburgh Medical School in 1766, where he was in contact with Andrew Duncan and Francis Balfour. He was present at the university when Balfour planted the seeds for dualism, as shown in chapter three. In 1772 Bell extended his education by travelling to London, where he was introduced to John Hunter and able to observe Percival Pott, and to Paris, where he boarded with his fellow Edinburgh surgeon and future brother-in-law James Hamilton (Macintyre 2011). After returning to Edinburgh, in 1776 he was injured in a horse fall, at which point he gave up practice for two years in order to recuperate his health on his farm. This period gave him time to read widely, develop his interest in agriculture, and write his *Treatise on the Theory and Management of Ulcers* which was published in 1778. When he returned to medicine, he acted as a surgeon for the Royal Infirmary as well as setting up his own private practice.

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[10] Biographical details of Bell from Kirkup and Bevan (2004).

Between 1783-1788, Bell published the six volumes of his *System of Surgery*, the work which cemented his professional reputation. As with Duncan, the reach of his influence was increased through his publications, in this case to a much greater degree. Like Duncan, his publisher in Edinburgh was Charles Elliot, a vital figure in the Scottish Enlightenment. Elliot had bookseller contacts throughout Britain and Europe, which he used to increase the reach of the books he published. Elliot's most commercially successful work - of what was an overall already successful career - was Bell's *System of Surgery*, which went through at least eleven editions, as well as Italian, French, German, Spanish, and three American editions (McDougall 2002; Macintyre 2011). The work did receive some criticism, and was particularly condemned in a pamphlet written under the pseudonym 'Jonathan Dawplucker'; this was likely written by John Bell (no relation), who had been in conflict with Bell over how surgeons were appointed to the Royal Infirmary (Kaufman 2005). Despite this, the publication gained Bell a reputation that has earned him the descriptor 'Edinburgh's first scientific surgeon' from some historians (Comrie 1927: 213; Guthrie 1945: 230; Dingwall 2003: 118).

This reputation extended to his practice. He was a popular surgeon and travelled widely to see patients in the rural areas surrounding Edinburgh, which would become the foundation for his epidemiological views on syphilis and gonorrhoea. One of his practice partners, James Wardrop (1782-1869), nephew of Bell's practice partner Andrew Wardrop (1740-1789), later described that:

> Not only was Mr. Bell greatly employed in Edinburgh, but he was sent for to many distant parts of Scotland and the north of England in cases of urgency … Mr Bell's fame may be said to have arisen chiefly from the professional works he had published. (Bell 1868: 111)

Bell's extensive practice was confirmed in a 1794 letter from his publisher, Elliot, to the London bookseller George Robinson, in which Elliot complained that: 'We are detained much by the author's extensive practice. We were within a sheet [of finishing volume two] 10 days ago – he was called 70 miles out of town – there kept 6 days – loss of arm – dangerous operations. This detains me for the moment, but it adds to his reputation' (as quoted in McDougall 2002: 219).

Bell was well connected with the intellectual groups in Edinburgh. He was a member of the tightly-knit Philosophical Society of Edinburgh until its dissolution in 1783, and one of the founding fellows for the Royal Society of Edinburgh which replaced it (Emerson 1985). In 1772, he was elected an honorary member of the Royal Medical Society of the University of Edinburgh (Royal Medical Society of Edinburgh 1906: 104). Bell also married into another academic family: his wife was Grizel Hamilton, daughter of the Professor of Theology in the University of Edinburgh and brother of James Hamilton, a fellow surgeon. He appeared to have connections in Ireland, as he was elected an honorary member of the Royal College of Surgeons in Ireland (Royal College of Surgeons in Ireland 1785).

Bell's *A treatise on gonorrhoea virulenta, and lues venerea* (1793) was the first pro-dualist work on syphilis and gonorrhoea to be published since Duncan's *Medical Cases* in 1778. While Duncan's placed the argument as just one within a number of medical questions, Bell made the doctrine a key part of his treatise. In the preface, he highlighted the treatise's three central points: exact instructions on treating gonorrhoea with injections, quantities of mercury to be used for syphilis, and 'the difference between the matter of Gonorrhoea, and that of Lues Venerea' (Bell 1793: 1:vii-x). He clearly expected this last to be an unpopular opinion that would 'no doubt be censured by many'. Bell's arguments for dualism can be summarised as follows:

1. The symptoms of gonorrhoea and syphilis are fundamentally different.
2. Gonorrhoea does not terminate in syphilis.
3. Syphilis does not produce gonorrhoea.
4. The ratio of cases of gonorrhoea and syphilis can only be accounted for by dualism. *
5. Systemic gonorrhoea is distinct from the systemic symptoms of syphilis. *
6. Gonorrhoea and syphilis have appeared at different times through history.
7. In rurally isolated areas, cases of sibbens – a syphilis-like disease – are not accompanied with gonorrhoea. *
8. That inoculation experiments conducted thus far support dualism. *

Some of these arguments were, of course, built on those already proposed by Duncan, Ellis and Balfour. Those marked with an asterisk were novel ideas presented by Bell. Although Bell is historically considered vital in the dualist argument, no work has examined exactly how he steered the debate. Therefore, these new ideas and their impact will be examined in the following pages in order to determine what Bell's true contribution was and why he became so influential.

In rurally isolated areas, cases of sibbens are not accompanied with gonorrhoea.

Sibbens (sometimes also spelled sibbins or sivvens) was a contagious, syphilis-like disease that was present in Scotland between the seventeenth and nineteenth centuries. It was thought to have either been introduced to Scotland by William Cromwell's soldiers during his 1650 invasion of Scotland or by the introduction of yaws[11] from the West Indies by Scottish sailors (Hill 1772: 225; Hibbert 1826: 308). The disease was known as yaws in southern Scotland and sibbens in the Highlands and Islands – a name likely derived from *sùbh-lìn*, the Gaelic word for raspberry, as the pathognomic skin growth presented as the same size and colour as the fruit. It is unknown, however, if sibbens was caused the same pathogen as yaws. Sibbens was said to be confined to poor, rural communities, as it was associated with uncleanliness and closely shared living spaces. The last known case was recorded in the 1851 minutes of the Town Council of Banff, where a letter was read from Dr Whyte requesting action to quarantine a case that had appeared in Gallowhill (McKenzie Pollock 1953).

The symptoms of sibbens were close to those of both yaws and syphilis, and there was considerable disagreement over how the three were related; a comparison of their similarities was drawn up by the surgeon and venereologist Jonathan Hutchinson at the end of the nineteenth century (table 4-1). From a modern perspective, it is difficult to say what treponemal disease – if any – sibbens was, although it has been judged to sit most closely to yaws (McKenzie Pollock 1953). Although DNA analysis could help improve our understanding of the disease, there appear to be no preserved cases in the pathological collections of the eighteenth century that could be sampled. While archaeological surveys have been able to connect with historical evidence to find cases of endemic syphilis in

[11] Yaws is one of the treponemal diseases, and has some symptoms shared with syphilis. For a description of the known treponemal diseases see chapter one.

human remains in Norway, this has not yet been managed for finding cases of sibbens (Anderson et al 1986; Cook and Powell 2016: 483). We can therefore currently do no more than speculate what the bacterial cause of sibbens truly was.

Bell likely first saw the disease during his apprenticeship to James Hill – who, as described below, wrote about the disease in 1772. According to Bell, sibbens typically began with primary ulcers in the mouth and throat. This was due to it being spread primarily through shared eating and drinking utensils as well as smoking pipes. This was followed by a variety of skin eruptions. As described above, the most characteristic of these was the frambrosian lesion, a 'soft spongy excrescence, in size and colour resembling a common rasp' (Bell 1793: 2:448). This could be accompanied with a variety of symptoms which were also found in syphilis, with Bell commenting 'I have seen it indeed in every part of the body, and in every form under which Lues Venerea usually appears, except in chancres upon the genitals' (Bell 1793: 2:450).

Bell considered there to be two major obstacles in dealing effectively with the spread of sibbens. Firstly, as it so closely resembled venereal disease, he suspected that many people

Sibbens	Yaws	Syphilis
No primary lesion*	Primary lesion	Primary lesion
No buboes*	No buboes	Buboes common
Affects children	Affects children	Affects adults
Throat lesions appear early	Throat lesions appear late	Throat lesions appear late
Frambosian skin lesions	Frambosian skin lesions	Frambosion skin lesions rarely appear
Highly contagious	Mildly contagious	Mildly contagious
Smells	No smell	No smell
Bones rarely affected, if they are it is the nasal bones*	Long bones commonly affected, nasal and palatal occasionally	Long bones commonly affected, nasal and palatal occasionally
One attack usual	One attack usual	Several attacks not unusual

*points not in full agreement with symptoms as described by Bell

Table 4-1: Comparison of symptoms between sibbens, yaws and syphilis as considered by Jonathan Hutchinson. Table adapted from Morton (1967).

did their best to conceal their infection for as long as possible. Secondly, the lack of cleanliness of the 'common people', as he suggested that this made spread of the disease worse. He believed that sibbens could be eradicated by enlisting the local clergymen to address these problems. He described one parish which had been successful with such a scheme:

> The disease had spread to such an alarming height that more than three-fourths of the inhabitants were infected, and many of the more delicate, particularly young children and females, dies under it. This had gone on for a great number of years, when by the exertions of the clergyman of the parish it was entirely removed in the course of a short time. He went personally to every individual of his parish and convinced them of the propriety of applying for medical assistance immediately on the disease breaking out, which they agreed to the more readily from their being sensible that all of them had got the disease in the most innocent manner. In this way it was soon carried off, and by due attention to cleanliness, and avoiding all kind of intercourse with those who they suspected to labour under it, the disease has no for a considerable time been entirely subdued. (Bell 1793: 2:456)

Clearly, behaviour was a significant component of transmission of the disease for Bell. As shown in chapter two, there was an established connection between personal behaviour and spread of disease, and mode of transmission was an important way to define venereal disease. He considered those infected with sibbens to be 'innocent', in contrast to those who spread venereal disease. This contrasting attitude can be seen in one of his cases, where he explained that 'much depends upon the habit of body of the patient, and upon his manner of living' (Bell 1793: 1:57). The case described four men who all had sex with the same woman: three 'who were accustomed to live freely' received a 'very severe clap', while one who 'usually lived with much sobriety' received a milder gonorrhoea (Bell 1793: 1:58). The division of infected patients into innocent and guilty was vital for his dualist argument. Sibbens was found 'almost entirely among poor country people, whose manners do not expose them to the hazard of being infected with Gonorrhoea': the more innocent form of transmission meant, to Bell, that sibbens had 'retained its original, unmixed form' as a variation of syphilis (Bell 1793: 1:36). It is likely that there were indeed fewer cases of venereal disease in the remote, rural areas where Bell treated cases of sibbens. As mentioned in chapter two, a population study of syphilis in the 1770s found that residents in the city of Chester were more than eight times likelier to be treated for syphilis by the age of 35 than those in the 10 mile radius surrounding the city, indicating a lower concentration of the disease in more rural areas (Szreter 2017). Sibbens, then, was regarded as an untainted variant; an experimental control against which syphilis could be tested. If gonorrhoea and syphilis arose from the same contagion, it would be expected that gonorrhoea would appear in sibbens too. On the contrary, Bell claimed that he had never seen a case where gonorrhoea took place.

Unfortunately, Bell was not more detailed about his cases, only saying that he had seen 'many hundred people labouring under it' (Bell 1793: 1:38). It is therefore difficult to offer a closer analysis of the types of cases he saw, and whether he saw gonorrhoea-like symptoms which he dismissed as spurious gonorrhoea, or if he met with a complete absence. His experiences with gonorrhoea and sibbens certainly differed from his teacher, Hill, who closely associated the two. According to Hill, 'a common clap, when long neglected or wrong treated, daily produces the same effects as sibbens' (Hill 1772: 239). In 1755, Hill was able to trace an outbreak of nine cases of sibbens in his own family back to a case of clap and chancres; similarly in 1768 he determined the source of another family outbreak to be a woman infected with gonorrhoea (Hill 1772: 239–40). Joseph Adams (1756-1818), a London-based surgeon who visited Scotland to investigate sibbens, described increased secretion due to ulcers in the throat that he considered analogous to venereal gonorrhoea (Adams 1807: 177). Adams also attacked the lack of detailed reporting in Bell's treatment of sibbens, remarking that 'his incorrect manner of describing a disease, well known in the Southern metropolis, makes one doubt his accuracy in this' (Adams 1795: 60).

It was difficult to use sibbens to make a convincing case for dualism when sibbens itself was not well-known and poorly understood. There was considerable disagreement over what sibbens actually was, and case reports were relatively sparse in the literature. The first detailed report appeared to be from Ebenezer Gilchrist (1707-1774), a physician practicing in Dumfries, who described the disease in some detail, first in a paper read in 1765 and then in a published report in 1770 (Adams 1807: 165; Gilchrist 1770). Like Bell, he blamed a lack of cleanliness among the 'lower ranks'; unlike Bell he did not seem to consider this an innocent form of transmission. He worried that, if not kept under control, the disease was likely to spread to families of 'good condition', going as far as to say that: 'Any servant that comes into, or remains in a family, having the distemper and knowing it, must be deemed guilty of a crime, as the consequence may be highly injurious, and even fatal to others' (Gilchrist 1770: 13,16). While Gilchrist agreed that sibbens should be 'classed with' syphilis, he nonetheless described it as 'improper to call it venereal' (Gilchrist 1770: 5). In 1767, a dissertation on sibbens was written by Adam Freer (1747-1811), another Edinburgh Medical School graduate. Freer's dissertation proposed a rather unusual theory for the origins of sibbens. Citing various authors suggesting that both the itch and syphilis were caused by insects, he suggested that the two had crossbred to produce a new, hybrid insect that was the root cause of sibbens (Freer 1767; as described in Adams 1807: 179). Similarly, Franz Swediaur believed that sibbens was a compound of the itch and venereal disease, although he did not ascribe this to insects (Swediaur 1787: 12). Hill's account on sibbens, published as a response to Freer, accused Freer of making so many errors that he must have never even seen a case of sibbens (Hill 1772: 223). Unlike Gilchrist, who viewed sibbens as a non-venereal disease, or Freer and Swediaur, who regarded it as a compound between itch and syphilis, Hill described sibbens and syphilis as 'precisely the same disease'. He took examples of lues venerea from numerous established authors such as Van Swieten and Boerhaave, which he believed described cases of sibbens, concluding that 'from the above authorities it appears, that the distemper called the *venereal syphilis*, or *French pox*, in France, Germany, Holland, England, and Ireland, is the very same disease which our country-people call the *sibbens*' (Hill 1772: 249). Although Hill and Gilchrist disagreed on the relationship between sibbens and syphilis, both emphasised that sibbens was a 'very different' disease from yaws (Gilchrist 1770: 5; Hill 1772: 226).

The confusion and contradiction between these various accounts appeared to frustrate Joseph Adams while writing the first edition of his *Observations on morbid poisons* (1795). Attempting to understand what the true course of the disease was, he highlighted differences in described symptoms between authors. Gilchrist had claimed that sibbens never attacked the long bones; Bell, on the other hand, claimed to have seen 'several instances', although again he did not provide further details (Bell 1793: 2:449). Adams ascribed this to Bell's inability to diagnose the disease correctly, saying that: 'as he conceives sivvens to be syphilis, he may mistake syphilis for sivvens' (Adams 1795: 59).

Adams's distrust of Bell's medical abilities – perhaps fuelled by Adams's friendship with his teacher, John Hunter – also carried over to his descriptions of syphilis, as shall be shown. The lack of precise information available on sibbens prompted Adams to undertake a trip to Dumfries and Galloway between 1804-5, followed up with a report in the second edition of *Observations on morbid poisons* (1807). After relating details of the cases he was able to observe, Adams concluded that although sibbens had a similar appearance to the venereal disease, they were not the same (Adams 1807: 186).

Although southern Scots often called sibbens 'yaws', Adams, Gilchrist, Hill and Bell all agreed that it was a separate disease, but this agreement was not universal. In 1812, Mason Good described sibbens as 'syphilis being rendered hybrid by passing through a constitution already contaminated with genuine yaws' (as quoted in McKenzie Pollock 1953). In 1826, Samuel Hibbert (1782-1848) published an article in the *Edinburgh Journal of Medical Science* to attempt to show that the two were actually the same disease (Hibbert 1826). Hibbert was primarily a geologist and an antiquarian; although he obtained an M.D. from the University of Edinburgh in 1817, he never practiced medicine (Sutton and Baigent 2004). Immediately after graduating, Hibbert travelled to the Shetland Islands to undertake a geological survey. During this visit, he saw cases of sibbens (Hibbert 1822: 542). Drawing on these observations and his historical knowledge, he concluded that sibbens was identical to yaws, and also that *morbus gallicus* as described in the fifteenth and sixteenth centuries was not actually syphilis, but sibbens (Hibbert 1826). The situation was further confused by the introduction of another dermatological disease known as venereal condyloma, described in 1834 by Henry James Johnson (fl. 1834), a house-surgeon for the London Lock Hospital (Johnson 1834). D. Wills (fl. 1844), a surgeon based in Ayrshire, thought this description matched exactly that of sibbens (Wills 1844). David Skae (1814-1873), another Lock Hospital surgeon, also concluded that sibbens and condyloma were identical while experimenting with inoculation in condyloma (Skae 1844).

Clearly, the definition of sibbens was even more controversial than that of syphilis and gonorrhoea, making its nomenclature difficult to use. Without an agreed definition or the provision of clear and detailed case reports, those who did support the use of sibbens as part of Bell's argument for dualism had to simply take him at his word. As such, very few writers even mentioned sibbens while discussing the debate. The only evident case of a dualist using the sibbens argument in writing is from Cosmo Gordon Stevenson (1785-1825), who cited Bell's observations on sibbens as evidence that gonorrhoea and lues venerea did not produce each other, before concluding that the two were distinct diseases (Stevenson 1803: 11). Even monists appeared wary of mentioning sibbens at all, perhaps due to their unfamiliarity with the disease. Thomas Whately (fl. 1801), a surgeon in Derby, briefly argued that sibbens was not analogous at all to gonorrhoea and syphilis (Whately 1801: 3). Largely, however, Bell's novel argument went ignored.

The ratio of cases of gonorrhoea and syphilis can only be accounted for by dualism.

Bell's next argument was in direct response to John Hunter's attempt to explain why infection with the venereal virus sometimes resulted in gonorrhoeae and sometimes in chancres. Hunter had suggested that gonorrhoea was a result of the virus being applied to secreting surfaces – for example, inside the urethra – and chancre was a result of the virus being applied to non-secreting surfaces – such as the skin of the penis (see chapter three). Bell, however, considered this logic to be 'more ingenious than solid' (Bell 1793: 1:19). During sexual intercourse, the external parts of the penis would be more exposed to the virus than the urethra; indeed, Bell found it 'difficult to conceive how the matter by which the disease is communicated should find access to the urethra; while, on the contrary, all the external parts of the penis, particularly the glans, must be easily and universally exposed to it' (Bell 1793: 20). Bell claimed that he saw three cases of gonorrhoea for every case of chancre – a number which he would have expected to be reversed, given the anatomy of the surfaces (Bell 1793: 20–21). He pointed to Hunter's own work as further evidence; Hunter had estimated that he saw at least four or five cases of gonorrhoea for every one of chancre (J. Hunter 1786: 217).

It is worth noting that Bell framed his argument here in terms of the penis, and it is unclear how the vagina fit into his scheme. Hunter considered the inside of the vagina to be a secreting surface, and it was commonly thought to be one of the potential seats of gonorrhoea in women (Astruc 1737a: 146; Swediaur 1787: 22–23; Hunter 1786: 82–83; Bell 1793: 1:53-4). By Bell's logic, this should have meant a predicted difference between the sexes. While men would have had external skin of the penis exposed most to the virus and therefore be expected to develop chancres, women would have the secreting surface of the vagina exposed through intercourse and would be expected to mostly develop gonorrhoea. As was the case with asymptomatic gonorrhoea (chapter three), the framing of venereal disease as the result of a man's exposure to an infected woman was fundamental to how practitioners understood its pathology.

There was minimal response to Bell's argument regarding the frequency of gonorrhoea. As discussed in chapter two, it was widely agreed that gonorrhoea was the most common form of venereal disease. Although Bell did not provide detailed statistics for his cases to confirm the different rates of disease, his observations were not new and those reading would likely not need convincing of the ratio between the two. However, while monists appeared to agree that gonorrhoea was more frequent than chancres, there was little attempt to address Bell's logic. Solomon Sawrey (1765-1825), a surgeon and anatomist in London, while writing a commentary on Hunter and Bell's venereal works, pointed out that if the urethra was difficult to access then the expected frequency of gonorrhoea would be lower even if the two were caused by distinct poisons (Sawrey 1802: 38). A handful of dualists continued to use the argument to support their theory. Cosmo Gordon Stevenson asked why gonorrhoea and chancre were not 'constant companions' if they were caused by the same poison, noting the ratio of three to one (Stevenson 1803: 12). George Borlase Childs (1816-1888), a dualist who acted as Surgeon-in-Chief for both the City of London police and the Great Northern Railway, placed Hunter and Bell's arguments side-by-side. He added his own explanation for the high frequency of gonorrhoea despite difficult access to the urethra, suggesting that nine out of ten cases developed from irritation at the meatus (Childs 1843: 33–35). Otherwise, once again, little attention was paid to Bell's evidence. As with sibbens, the evidence itself was contentious, and – as Sawrey had noted – only weakly supported dualism.

Systemic gonorrhoea is distinct from the systemic symptoms of syphilis.

The monist doctrine of venereal disease held that gonorrhoea and chancre were local forms of the disease, and lues venerea was the result of the systemic absorption of the venereal virus. Gonorrhoeal matter being absorbed into the system was one way to get a confirmed pox; some theories suggested that this happened only when gonorrhoea resulted in ulceration of the urethra, and that this only rarely occurred due to dilution by urethral mucus (see chapter three). However, Bell pointed to cases where gonorrhoeal matter had clearly been transmitted through the system and resulted in wider effects without ever turning into lues venerea. The first of these cases was in gonorrhoeal ophthalmia; he described a patient he had seen in 1786 whose symptoms had begun with urethral discharge and then developed into discharge from the eyes (Bell 1793: 1:27-9). This symptom went on for the full course of a year without ever developing the secondary symptoms of syphilis. Similarly, he detailed two cases of discharge from the nose after gonorrhoea, one of which continued for three years without other systemic symptoms appearing (Bell 1793: 1:30-2). These cases clearly demonstrated that even in situations where ‘a translation of the matter of Gonorrhoea to other parts of the body, and which we suppose to happen through the medium of the circulation’ constitutional syphilis still did not occur (Bell 1793: 26). However, gonorrhoeal ophthalmia was yet another disputed topic. Practitioners had long agreed that ophthalmia was a potential symptom of syphilis, but they had only recently begun to distinguish between a venereal ophthalmia and a gonorrhoeal ophthalmia (Howard 1787: 83). This was not clarified until at least the mid-nineteenth century, after a series of inoculation experiments (Oriel 1994: 127). Dualists did not use this evidence in the following decades.

Inoculation experiments conducted thus far support dualism.

As described in chapter three, a large barrier for the dualists was a lack of experimental evidence in comparison to those performed by monists. Although Andrew Duncan had briefly described one inoculation experiment – likely performed by Dr Blair while a medical student – Hunter had contested this with his own experiment. Although Hunter’s work was heavily criticised, he possessed considerably greater scientific credibility than Duncan. Hunter also provided significantly more detail, offering two dense pages of description in comparison to Duncan who described the experiment in a single sentence. Finally, while Duncan described an experiment performed by an anonymous ‘student at this university’, Hunter explicitly performed his inoculations himself. All these factors made Hunter’s evidence more legitimate; as Shapin describes, credibility and detail were needed to substitute actual observation to help reassure the scientific community that the experiment was trustworthy (Shapin 1984). Additional experiments supposedly demonstrating monism had also been described by Harrison – although his were not conclusive – and Andree (Andree 1781: 25–26; Harrison 1781). To counter monist arguments, then, Bell's work had to provide credible experimental evidence.

Bell, however, did not believe that inoculation experiments were the best way to support the argument, and appeared to be more interested in undermining their validity. He considered the process of inoculation to be too 'productive of such anxiety and distress' to ever be repeated frequently and reliably (Bell 1793: 1:33). In response to the experiments conducted so far, he added that 'in order to avoid fallacy, and to give support to the opinion, these experiments would not only require to be conducted with accuracy, but to be numerous, and to be repeated on a variety of patients under every possible variety of circumstances; whereas we have heard of only a single experiment or two being made by any individual; and even these seem to have been made under the management of such as were strongly and obviously biassed [sic] in favour of one side of the question' (Bell 1793: 1:33-4).

Despite his misgivings, Bell included experimental evidence that countered the monists' experiments. In the first edition of Bell's *Treatise*, he included experiments made 'by two young gentlemen of this place' – most likely more students of medicine at the University of Edinburgh (Bell 1793: 34). The first experiments involved introducing the matter from chancres and buboes into the urethra; these caused pain and irritation, but not gonorrhoea. The second part involved 'fretting' (corroding) the skin of the prepuce and glans with a lancet, before 'rubbing the parts with the matter of Gonorrhoea'; this resulted in 'slight sores' that 'never assumed the appearance of chancres', which healed without the need for mercury. Once again, however, Bell did not give further details, neglecting to describe the length of time the experiment went on for, the source of the venereal matter, detailed symptoms and progression, or if the experiments were repeated at all.

Bell added a new section to the second edition of his *Treatise*, offering 'further proofs of the difference between gonorrhoea virulenta and lues venerea' (Bell 1797: 1:437), which offered another two sets of experiments. One was undertaken by a young man which was 'made a good many years ago, and meant to form the subject of a paper for a medical society of which I am a member', likely referring to the Royal Medical Society; the other came from two medical students. Although Bell left the three men anonymous, he lent them his own credibility by explaining he was 'personally acquainted by all of them', and that Duncan 'saw the progress of some of them' (Bell 1797: 1:438). Indeed, despite Bell having no hand in conducting the experiments, they were regularly referred to under his ownership in future references. Bell also described these experiments in considerably more detail than the one in his first edition, with seven total pages dedicated to them.

The first set of experiments had two parts. First, the matter from a chancre was introduced into the experimenter's urethra and left for eight days, at which point the urethra was dilated to show a chancre inside, followed by the appearance of buboes a few days later. However, 'no discharge took place from the urethra, during the whole course of the disease' (Bell 1797: 1:439). In the second part, gonorrhoeal matter was left between the prepuce and the glans and 'allowed to remain there without being disturbed' (Bell 1797: 1:440). After two days, inflammation and discharge ensued – which cleared after two or three days – but no chancre was ever produced, even after repeating the experiment twice more.

The second set of experiments provided more detail; neither of the experimenters had suffered venereal disease before, and the matter of infection was taken from patients who had never used mercury. First, lint soaked in gonorrhoeal matter was left between the prepuce and glans for twenty-four hours, resulting in severe inflammation and gonorrhoea in the two men. For one, the symptoms were so drastic that he decided to not undergo any further experiments. The second student went on to introduce gonorrhoeal matter with a lancet into his skin three times: none of these experiments resulted in the appearance of chancres. Finally, the student inserted the matter from a chancre into his urethra with a probe. No gonorrhoea followed, but after six days a chancre appeared, followed by buboes and secondary symptoms. From these experiments, Bell concluded:

> I have thus been enabled to adduce the most decisive proof that can be wished for, of the difference between the matter of Gonorrhoea and Syphilis, and to shew that while the matter of Syphilis excites chancres, even when applied to the secreting surface of the urethra, and that these again contaminate the constitution, yet that the

> matter of Gonorrhoea cannot be made to produce chancres, or any symptom of disease in the system. (Bell 1797: 1:444)

The appearance of a chancre following application to a secreting surface was a direct contradiction of Hunter's theory, which stated that gonorrhoea was the result of venereal matter infecting the secreting surfaces and chancres the result of infection through the skin.

However, even when describing experiments that supported the dualist doctrine, Bell continued to use language that demonstrated his distaste for them. He added to the first experiment he described that 'we cannot place much dependence upon these or any other experiments that have yet been made upon this subject' (Bell 1793: 1:35). When introducing the further experiments, he declared that he thought the subject sufficiently proved without additional evidence, and was presenting it only for 'others who may not be so fully convinced' (Bell 1797: 1:437). When one of the students attempting an experiment was too distressed by the symptoms he induced to continue, there was a note of satisfaction in Bell's declaration that 'he was convinced of the imprudence and hazard of all such experiments' (Bell 1797: 1:442). Bell was also not the only writer who was unconvinced by the need for or rigor of such inoculation experiments. Solomon Sawrey, for example, wrote that 'to make experiments upon our fellow creatures, must be highly distressing, if we could obtain permission … To the individual we can never be justified! Besides, experiments of this nature are not altogether free from error' (Sawrey 1802: vi).

The potential room for error in inoculation experiments influenced the reception of Bell's experiments. John Alexander Schetky (1785-1824), a military surgeon and monist, wrote that 'experiments instituted with a view to the direct solution of this question by inoculation, are open to a fertile source of fallacy', primarily as it was impossible to distinguish a venereal gonorrhoea from discharge caused by irritation from probes being introduced (Schetky 1818: 5–6). John Bacot (1781-1879), another surgeon and monist, suggested that the matter used for Bell's experiments may have been from a spurious rather than venereal gonorrhoea (Bacot 1829: 88). Similarly, Joseph Adams, the surgeon who had made an investigation of sibbens, stated there was 'no satisfactory test of the difference between virulent and simple gonorrhoea', rendering Bell's experiment unreliable (Adams 1795: 280–81). This rhetoric technique of questioning the validity of diagnosis that inoculations rested on continued to be used in the many inoculation experiments that followed, described later in this chapter.

Nevertheless, the experiments that Bell described continued to be an important piece of evidence in the dualists' armoury and were the foundation for experiments that proceeded. Writing in response to the Medical Society of Beçanon's prize question on the identity of syphilis and gonorrhoea, J. F. Hernandez (fl. 1812) described the inoculation experiments 'far more decisive' than those described by Andreé and Hunter (Hernandez 1812; as translated in Ricord 1842: 56). Richard Carmichael (1779-1849), the Irish surgeon, described how the 'decisive' experiments Bell described directly contradicted those of Hunter, and that 'if these experiments will not enable us to decide on the fact, arguments can make but little impression' (Carmichael 1814: 75). Both Hernandez and Carmichael were important influences in adoption of the dualist doctrine, as shown later in this chapter. The inoculations even filtered through to books intended for the public. David Cardwell's *The book of private knowledge and advice* – one of many pamphlets describing venereal disease and its cures that were aimed at a layperson audience rather than other medical practitioners – described Bell's experiments as 'most conclusive' (Cardwell 1833: 9–10). The inclusion of multiple, detailed inoculations meant that dualists finally had experimental evidence to counter that of the monists. Bell's experiments turned out to be the first of many over the following decades.

Bell's influence.

Although Bell's arguments received a mixed reception, his *Treatise* nonetheless appeared to be a catalyst for acceptance of the dualist doctrine. Of the 110 published texts examined between 1737 and 1850, 56 included mention of the debate over the identity of syphilis and gonorrhoea. By the end of the 1840s, there was a fairly even divide with 24 total monists and 25 total dualists. However, the distribution of these over time shows that many of the monists appeared in the earlier decades to defend the status quo, prompted by the publication of Hunter's work (figure 4-1). On the other hand, only 2 published dualist works appear in the two decades before Bell's *Treatise*, with the vast majority published afterwards. Seven out of nineteen authors published after Bell - just over a third - directly cited his work while establishing their position, indicating the significant influence he had.

The majority of these citations refer to the experiments described by Bell, demonstrating how key experimental evidence was to convincing medical practitioners in the eighteenth and nineteenth centuries (i.e. Carmichael 1814: 75; Thornton 1816: 56; Boyle 1824: 10; Cardwell 1833: 7–8; Acton 1841: 22; Ricord 1842: 64–65). The importance of this is reflected in the many inoculation experiments that followed.

From examination of the impact of Bell's novel arguments, it seems that his influence on the dualist debate did not come from his own research. Dualists writing over the following decades continued to use the same theoretical arguments that had been used since Duncan's time. The evidence Bell considered the weakest was prioritised by others, while the arguments he considered strongest – for example, the epidemiology of sibbens in rural areas – did not seem to take hold. However, Bell had taken the important leap of faith that Kuhn describes as essential to a paradigm shift (Kuhn 1996: 156–58). At this early stage, while the new model was still widely rejected, having an influential supporter was more important in some ways than the evidence itself. He also provided a highly developed version of the dualist doctrine in comparison to the early arguments provided by Balfour, Duncan and Ellis. While ultimately much of Bell's new material was not incorporated into the debate, his treatise acted as the tipping point needed for others to begin the shift.

As shown in chapter three, the monist theory was begun and initially spread in Edinburgh, Bell's primary city of practice. Considering this, it may be that Bell had more early

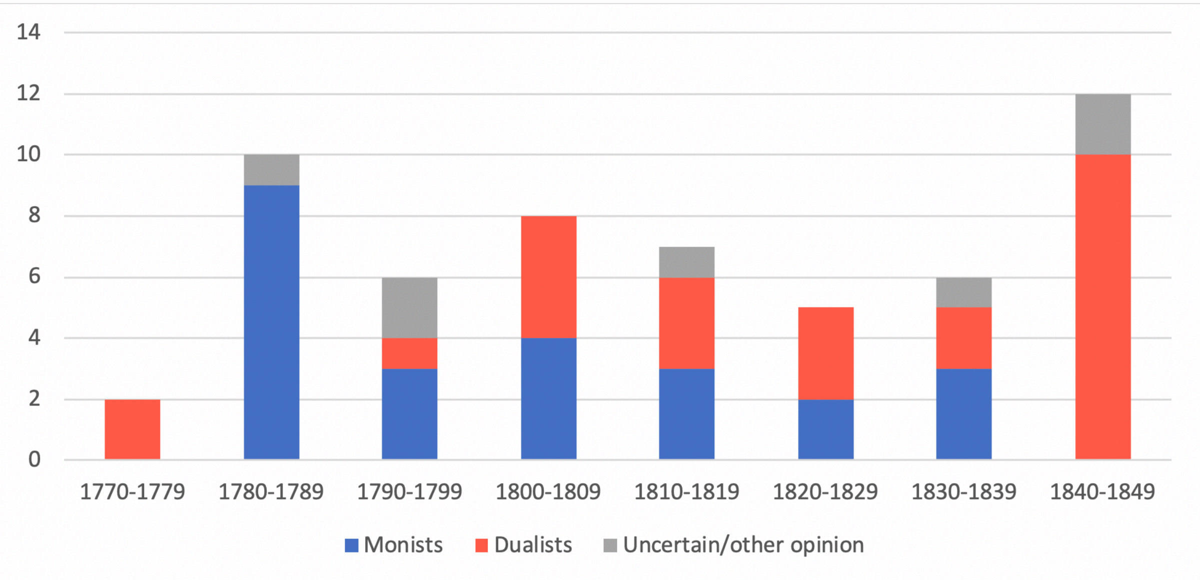

Figure 4-1: Chart showing the division of monists and dualists from 1770-1849 in printed works. The list of works included in this figure is included in Appendix A.

influence in his home city than across the rest of the Britain. The University was fertile ground for the debate and was particularly important as it would influence the next generation of medical practitioners. Duncan, who had been teaching extramurally and in 1790 was finally appointed Chair of Institutes of Medicine in the University of Edinburgh, had continued to push the dualist theory in his lectures. At the same time, however, Monro *secundus* promoted the monist view, resulting in a clash of doctrines presented to students studying at the University.

Bell's treatise appeared to have weighed the balance into the favour of the dualists, as reflected in a series of student essays written for the Royal Medical Society between 1792 and 1796. In the 1792-3 session – just before publication of Bell's work - two students wrote on the topic of venereal disease, including an outline of the debate over gonorrhoea and syphilis, concluding that the two shared a contagion. Both students – Andrew Knox and William Bourke - appeared to be highly influenced by Monro's lectures. Knox, writing on a case of gonorrhoea, described that 'Doctor Monro, in the course of his lectures, shews many preparations from persons formerly labouring under Gonorrhoea, which have, evidently, marks of ulcerations in the urethra' (Knox 1792). Knox followed Monro's logic that lues will follow gonorrhoea if there is a breach that allows for absorption of the poison – in other words, an ulcer in the urethra. The presence of ulcers in gonorrhoea had been in question since the first half of the century (see chapter two); this demonstrates how tightly the dualist and monist debate was connected with other contested theories. Similarly, Bourke – while writing about a case of syphilis – stated that there was no difference in the poisons of gonorrhoea and syphilis (Bourke 1792).

After Bell's treatise was published two further essays followed, both specifically dedicated to the topic of whether gonorrhoea and syphilis are caused by the same contagion. Now, both supported the dualist side. The first of these was written by Alexander MacLarty in the 1793-4 session, the second by Richard Heelis in 1794-5. The two followed the structure of Duncan's lectures. First, the monist arguments were laid out: that a man can receive gonorrhoea, syphilis or both infections from a woman, no matter which symptoms she has; and that gonorrhoea can terminate in confirmed lues. Both countered the first by pointing out that a woman can suffer from multiple diseases at the same time, with Heelis going as far as to say that this is not surprising for women 'who are in the daily habit of prostitution'. Both MacLarty and Heelis argued that gonorrhoea and syphilis appeared historically at different times, and cited Duncan's evidence of their appearance in Otaheite (described in chapter three). Both also argued that as mercury was not a specific treatment for gonorrhoea, it must be caused by a different contagion. Most importantly, both essays cited the experiments described by Bell and Hunter, with Bell's being prioritised. MacLarty attacked Hunter's experiments by claiming that inoculations 'conducted with accuracy' supporting monism were still lacking; on the other hand, 'when Experiments of this nature are conducted with accuracy, that the matter of Syphilis produces Syphilis only, and that of Gonorrhoea, Gonorrhoea alone'. Heelis questioned the honesty of the subject who had been inoculated by Hunter, suggesting that in the four months between inoculation and the first appearance of a chancre, it was probable 'that the person, upon whom the experiment was tried had not been so chaste all that time, as he had led Mr. Hunter to imagine' (ignoring the possibility of self-inoculation). While Heelis concluded that Bell's inoculation experiment was still 'far from conclusive', he did not question its validity in the same way. This selective questioning of evidence would become a trend in how authors dealt with conflicting inoculation results over the following decades.

Outside of the university, records of the Edinburgh Royal Infirmary (RI) may give some indication as to whether the dualist doctrine became more accepted. Risse has previously suggested that there was an increased tendency over the course of the eighteenth century to record gonorrhoea and syphilis as distinct diseases, which could indicate that a dualist doctrine had been adopted in that institute (Risse 1986: 128). As Bell was surgeon to the Infirmary for 18 years, it would not be surprising if he had influenced practice there. Risse's investigation of the RI took a 'randomised' subset of 3,000 patients from the ward entries between 1770-1800; He concluded that 'the gradual diagnostic distinction between gonorrhoea and lues venerea in the General Register suggests that a number of medical clerks subscribed to Bell's theory'. To investigate whether there was truly any trend in the labelling of gonorrhoea and syphilis, I took a fuller account of the register, noting every patient with a venereal diagnosis from 1770 (the beginning of the register records) to 1829, allowing for any changes in a three decade period after Bell's work was published. This

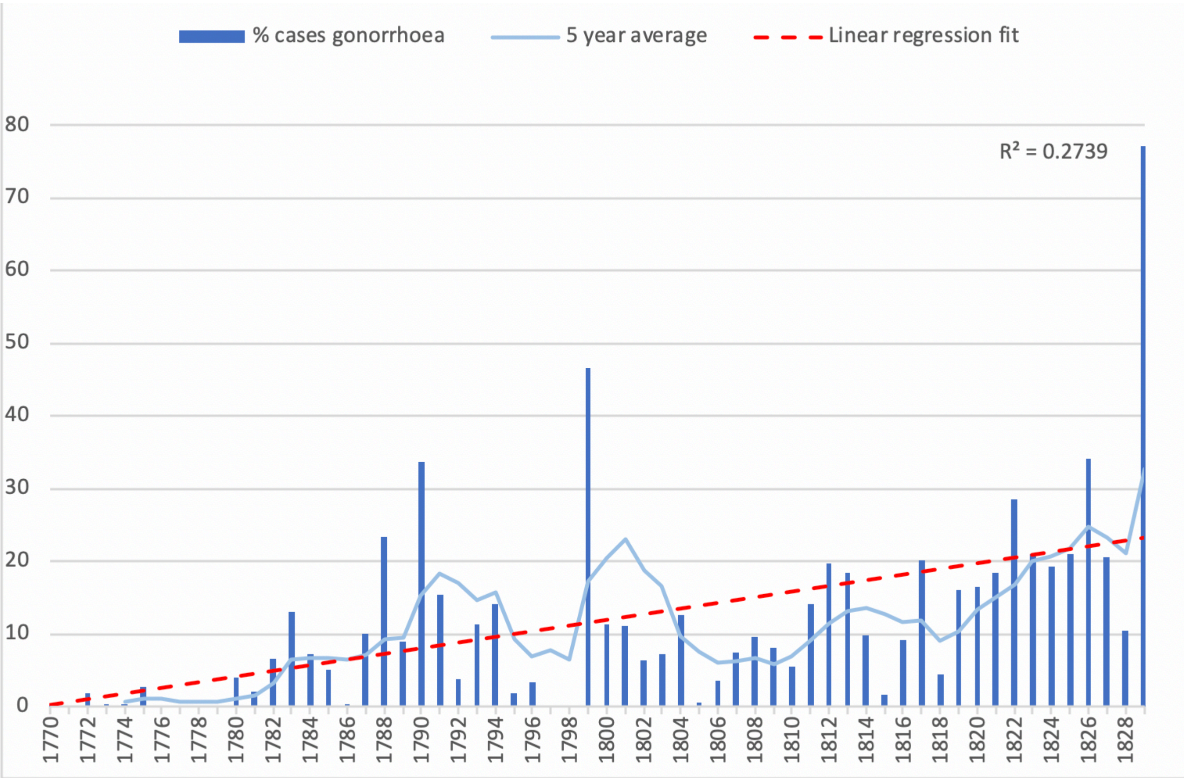

Figure 4-2: Graph showing the percentage of STD cases recorded in the Royal Infirmary that were specifically reported as gonorrhoea or clap. Other cases were reported as lues venerea, venereal disease, or syphilis.

resulted in a significantly larger set of data than Risse's: 12,783 patients who had been recorded in some way as venereal over a 60-year period.

This data only showed a weak increase in the percentage of cases specified as gonorrhoea rather than syphilis, chancres, venereal disease or lues venerea (figure 4-2). A linear time series analysis of cases over time showed only a very weak trend ($R^2 = 0.27$), meaning that in the model, 27% of the change in number of cases is attributable to change in time.[12] This relationship is statistically significant ($p = 0.000014$).[13] Although the linear model is highly statistically significant, the R^2 value of 0.27 is not especially strong. It should also be noted that there is an unusually high number of cases designated gonorrhoea in 1829, which slightly skews the data. Removal of this datapoint changes the R^2 value to 0.2714. There is no obvious reason for the sudden spike in diagnoses in 1829, and further investigation of

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[12] Statistical analyses undertaken using Excel. The R^2 value estimates goodness-of-fit for a linear regression model. A value of 0 indicates that the model does not explain the data, while a value of 1 indicates that the linear model fully explains the data.

[13] The p-value estimates whether the model found is statistically significant. It tests whether the null hypothesis (i.e. that there is no regression effect) is true. Significance is usually set at a value of <0.05.

the following years would be useful in determining whether this was a trend or an anomaly.

The linear regression analysis suggests that while there may have been a rise in cases designated gonorrhoea, this was not substantial enough to be considered evidence of widespread adoption of the dualist doctrine. Risse's suggestion that there was a gradual diagnostic distinction may be correct, with perhaps some of those making entries adopting the new doctrine while others still rejected it. Considering the number of different surgeons involved at the Royal Infirmary, this is unsurprising. Fluctuating periods of increased separate labelling of gonorrhoea and syphilis could perhaps be attributed to dualists present on the rota for a short time, or even simply due to surgeons who recorded symptoms with more precision. Rather than confirming the acceptance of Duncan and Bell's dualist position, the records seem to reflect that even in Edinburgh, opinion was divided.

Overall, it appears that Bell's most important contribution was widening discussion, as witnessed by more dualists emerging after the publication of his work. Although he had introduced novel arguments from those already presented by Francis Balfour, William Ellis, and Andrew Duncan, these were mostly not developed by those who followed him. On the other hand, the experiments he described were seen as useful evidence, despite his reluctance about the rigor of inoculations. Over the following decades, the medical community appeared to be evenly divided between monists and dualists. The dualists were not especially interested in introducing new theoretical evidence; instead, there was a flurry of inoculation experiments, which will be explored in the third part of this chapter.

A Plurality of Poisons: Pseudo-Syphilis, Chancres, and Spontaneous Disease

The conflict between monism and dualism was not the only nosological debate surrounding venereal disease in the early nineteenth century. Two other theories were also being circulated in medical works. The 'physiological' theory of venereal disease, which denied the existence of a venereal virus at all; and on the other end of the scale, the pluralist position, which claimed that there were multiple syphilis-like diseases. These were often considered independently from monist or dualist theories. For example, both John Alexander Schetky and Richard Carmichael were pluralists who believed that several diseases had been confounded with syphilis; however, as described above, Schetky was a monist and Carmichael a dualist. However, this expansion of theories did introduce further disagreement into the diagnosis of venereal disease, which affected the reception of various inoculation experiments.

The physiological doctrine of venereal disease was largely a French movement which stated that venereal disease was not caused by any contagion, but rather generated through physiological imbalances. Influenced by the irritation and inflammation theories of François Broussais, the doctrine was part of the larger anticontagionist movement that was pushing back against contagion theory (Heaman 1995; Dracobly 2004). The doctrine's proponents were mostly students of the Broussain school, but denial of a syphilitic virus was considered radical even among the larger anticontagionist movement (Ackerknecht 1948). Devergie claimed that the 'dangerous doctrine' of belief in a virus had only four false beliefs left: variola, the vaccive virus, hydrophobia, and syphilis (Devergie 1837: 19). The anticontagionism movement was also present in Britain, where it contributed to Victorian narratives about filth and cleanliness (Ackerknecht 1948; Brown 2008). Although syphilis contagion denialists were less common, there was nonetheless sufficient interest in the theory in Britain for English translations to be produced of some of their work (Jourdan 1823; Desruelles 1830; Devergie 1837). Denialism did not gain a significant following, however. The mainstream response is probably best summarised by G.J. Guthrie, who joked in his writing on non-mercurial syphilitic treatments that if he adopted the doctrine it would probably make his work much simpler (Guthrie 1817: 551).

While the complete denial of a syphilitic virus did not appear to catch on in English-language works, the broader concept of physiologically generated syphilis did receive attention. This was framed as a parallel possibility to contagion by writers; while they accepted that syphilis was contagious, they suggested that in some cases it could be caused by irritation and inflammation. For example, the military surgeon William Henry Judd (1795-1868) argued that syphilis could be spontaneously generated, providing a thought-experiment of an insulated colony 'peopled by clean, healthy and undefiled persons' who would regardless develop venereal disease through natural processes (Judd 1836: 138–39). However, he also argued that this resulted in the creation of contagious poisons, and claimed that syphilis was 'in reality a mixture of poisons, or a compound amalgam of modified ones' (Judd 1836: 149). This theory was strongly reminiscent of the humoral theories a century earlier; Judd gave an example of the venereal compound forming from poisonous fluids collecting in the vagina of prostitutes, a description very close to Astruc's suggestion that venereal disease had originated through 'the different, acrid and heterogenous seed of several Men blended together, and mix'd with a sharp and virulent menstrual Blood, and contain'd in the over-heated Wombs of very filthy Women' (Astruc 1737a: 102–3).

Meanwhile, British physicians were also arguing for the opposite doctrine from the physiological theory; that, in fact, there was many distinct poisons that caused diseases which resembled syphilis. Like monism and dualism, the pluralist theory had its roots in the second half of the eighteenth century. John Hunter's *Treatise* included descriptions of 'diseases resembling the lues venerea, which have been mistaken for it'; while these cases shared symptoms with syphilis, they did not heal with courses of mercury (J. Hunter 1786: 379–91). This appeared to be primarily as a defence to his experimental practice of transplanting teeth from live subjects, which had apparently resulted in cases of venereal disease. Hunter insisted that the tooth transplantations had not caused venereal disease, but a form of pseudo-syphilis (J. Hunter 1786: 391–98). The increasing number of descriptions of sibbens and yaws, as described previously in this chapter, added to this picture as examples of diseases that resembled syphilis but were unique.

In the 1810s and 1820s, the concept of there being multiple syphilis-like diseases became more popular, driven particularly by the two Irish surgeons Richard Carmichael and John Abernethy (1764-1831). Through categorising chancres and ulcers, Carmichael defined no less than six species of disease that resembled primary syphilis (Carmichael 1814). It is thought that some of the ulcers he described may have been caused by chancroid, another bacterial infection that causes sores on the genitals (Oriel 1994: 103–13). The pluralist theory of syphilis gained more traction than the French physiological doctrine, and Carmichael's work was regularly referred to by others (i.e. Guthrie 1817: 555; Schetky 1818: 3; Hamilton 1820: 3–5; Wallace 1833: 37–38; Skey 1840: 14). Syphilis was steadily expanded into a veritable plethora of diseases; for example, Schetky's essay on syphilis mentions Bateman's Ezema Mercuriale, Pearson's Cachexia Syphiloidea, Abernethy's pseudo-syphilis and Mathias's mercurial disease (Schetky 1818: 22).

Overall, this variety of doctrines and theories complicated the field of venereal disease and reduced the shared language available between medical practitioners. Syphilis was a nosological category in flux; symptoms described as syphilitic by one writer could be considered as a completely different disease by another writer. This period of confusion is predicted by Kuhn's understanding of a paradigm shift: the single-disease model of venereal disease was becoming insufficient, and dualists were not the only respondents to provide alternate models. The physiological school rejected the contagious theory of syphilis completely, and pluralists began frantically dividing syphilis into further and further categories. Importantly, the variety of diagnostic models allowed medical practitioners to criticise experimental evidence, as seen in the next part of this chapter.

Inoculations and Philippe Ricord

The rise of inoculation experiments.

After Bell's *Treatise*, there was a rise in the number of inoculation experiments performed to investigate the nosological categories of syphilis and gonorrhoea, particularly those made in support of the dualist doctrine (table 4-2). Many of these experiments were simple repetitions of inoculations, seemingly done so that investigators could rely on their own diagnosis and observations. From the language used, it appears that these experiments were performed even more widely than those described in print. One anonymous treatise, for example, claimed that 'similar tests have been made at almost all the hospitals in town' and that 'the experiment has been made so many times … that not the least doubt exists at the present time of the difference between the two diseases' (*A Treatise on Gonorrhoea and Syphilis* 1821: 136–37). Another treatise by Robert Barker (1778-1808) casually referred to 'decisive experiments made public by some eminent professional characters, and from others' (Barker 1801: 3). It seems likely, therefore, that these observations were often made individually and shared in spaces outside of print.

Reference	**Experimenter/date if different from reference**	**Description**	**Theoretical conclusion**
Duncan 1778	Blair 1766 (probable)	Inoculation of gonorrhoeal matter to urethra produces only gonorrhoea.	Monism
Hunter 1786	1767	Inoculation with gonorrhoeal matter caused a chancre and syphilis.	Dualism
Stanistreet 1786, Andree 1781	Unknown, likely referring to same experiment	Inoculation with syphilitic matter caused gonorrhoea. Inoculation with gonorrhoeal matter caused chancre.	Monism
Harrison 1781		Inoculation with syphilitic matter caused gonorrhoea. Inoculation with gonorrhoeal matter did not cause chancre or syphilis.	Mixed
Bell 1793	Unknown	Matter introduced from chancres into the urethra does not cause gonorrhoea. Inoculation with the matter of gonorrhoea does not cause chancres.	Dualism
Bell 1797	Unknown	Inoculation with the matter of chancres caused only chancre. Introduction of gonorrhoeal matter between the prepuce	Dualism

Reference	**Experimenter/date if different from reference**	**Description**	**Theoretical conclusion**
Tongue 1801		(Multiple) inoculations with gonorrhoeal matter in the arm caused no inflammation. Inoculation with syphilitic matter mixed with a variety of substances: mixed results including chancre (quality of matter questioned in some).	Dualism
Barker 1801		Inoculation of gonorrhoea under the skin never produces chancre.	Dualism
Hernandez 1812		Inoculation of convicts with gonorrhoea in glans and prepuce unable to produce chancres.	Dualism
Thornton 1815		Six trials of inoculation with the matter of chancre never produced gonorrhoea.	Dualism
Evans 1819		Inoculation with matter from sores causes similar sores.	Supports contagious nature
Syder and Jones 1821	Cooper 1817	Inoculation with gonorrhoeal matter into the prepuce. Healed and no secondary syphilis observed.	Dualism

Reference	**Experimenter/date if different from reference**	**Description**	**Theoretical conclusion**
Wallace 1833		Inoculation with matter from bubo resulted in syphilitic response in only 3/100 cases.	N/A
Ricord 1842	Percy 1807	Inoculation with matter from bubo and urethra. Results ‘nothing satisfactory’.	N/A
Ricord 1842	Dubled 1824	Inoculated in the arm for self and patients with syphilis. No result.	Denial of contagion
Ricord 1842	Desruelles, date unknown	Inoculation with matter from syphilitic lesions fails to produce further lesions.	Denial of contagion
Ricord 1842		Many inoculations with syphilitic and gonorrhoeal matter.	Dualism
Skae 1844		Inoculations of condyloma matter into thigh: 4/36 successful.	Pluralism: condyloma is specific from syphilis.

Table 4-2: List of inoculation experiments undertaken to determine the nature of the syphilitic poison.

Many of the writers described how hearing about another experiment prompted them to make their own; Barker, for example, followed up his comment with a brief description of inoculation experiments that he had made himself (Barker 1801: 3). Hernandez, whose experiments were later cited by Ricord, described being sent Bell's treatise after it was 'found on board a prize'; Bell's then inspired him to research the topic himself (as translated in Ricord 1842: 57). Robert John Thornton (1768-1837), a physician and botanist, copied heavily from Bell's *Treatise* in his own work, before stating that:

> For the above arguments for *distinct* diseases, we rest chiefly upon the authority of Bell; and thinking the subject of that importance, I procured some young men, induced by money, and under the promise of cure, to submit to some experiments made upon them. (Thornton 1816: 66)

It was only after his own experiments that he felt confident enough to conclude that syphilis and gonorrhoea were distinct diseases. Clearly, Bell's evidence and authority – while enough for people to take dualism seriously - was not sufficient for practitioners to decide against the monist status quo. Instead, they needed to truly see the results for themselves to be certain. While the social networks in Edinburgh had been sufficient for the first group of dualists to take a leap of faith, those outside that community needed further evidence.

Much of the distrust of experimental evidence was likely due to the increasing lack of shared agreement on what constituted a 'true' syphilis or gonorrhoea. Inoculation results were frequently attacked for being founded on incorrect diagnoses. Hernandez threw doubt on results obtained by John Hunter and John Andree, described in the previous chapter. In both cases, he questioned whether the chancre that was allegedly produced was truly a chancre, or a different kind of ulcer with syphilis 'presumed merely from its appearance' (quoted in Ricord 1842: 54–56). Hunter's diagnosis of resulting syphilis was also questioned by Carmichael – one of the lead pluralists - who believed that the symptoms described fell under his own categorisation of systemic gonorrhoea (Carmichael 1842: 35–36). Spurious gonorrhoea (discharge which did not have a venereal source but closely resembled virulent gonorrhoea) was also a cause for diagnostic confusion on both sides. John Bacot accused Bell's experiments of only using matter from a spurious gonorrhoea, which could not cause syphilis (Bacot 1829: 88). The surgeon and dualist Astley Cooper (1768-1841), on the other hand, suggested that inoculation with chancres resulting in discharge proved nothing as it was 'the effect of any irritating body on a secreting surface' (Syder and Jones 1821: 324).

Philippe Ricord was particularly savage in accusing his opponents of misdiagnosis. One such surgeon, Camille-Melchior Gibert, failed to produce syphilitic symptoms from inoculation using the matter from a woman with vaginal discharge and ulcerations of the neck of the uterus; he suggested that therefore the results of such inoculations could not be relied on. Ricord used the old disagreement over whether gonorrhoea was associated with ulceration (see chapter two) and countered that Gibert's source had been affected with ulcerated gonorrhoea rather than chancres (Ricord 1842: 62). On the other hand, when describing experiments that had supposedly produced syphilitic symptoms from gonorrhoea alone, Ricord suggested that chancres hidden in the urethra had been missed and so yielded false positive results (Ricord 1849: 27). Given the room for error and distrust of such evidence, it is not surprising that many medical practitioners chose to perform their own experiments, or that these individual experiments appeared to have little influence on the acceptance of the dualist doctrine. Although practitioners were demanding observational evidence for dualism, there was insufficient trust in these experiments to tip the balance.

Monism and dualism after Philippe Ricord.

The increase in inoculation experiments culminated in the work of Philippe Ricord. Born in 1800 in Baltimore to French parents, he moved to France in 1820 where he pursued a career in medicine. He was eventually offered an appointment in 1831 to l'Hôpital du Midi, a hospital which specialised in venereal diseases. His work there convinced him that diagnostic processes for venereal disease were inadequate, especially in women, and between 1831-1837 he began testing the use of inoculation as a diagnostic method with over 2,500 experiments, taking matter from buboes, ulcers or discharge and inoculating it into the thigh (Oriel 1989). Ricord believed that inoculating a patient with their own syphilitic matter would produce a chancre, and therefore provide confirmation of the patient's diagnosis. This was a significant step towards prioritising laboratory medicine over a patient's history in the diagnostic process. Venereal disease was an ideal test subject for this shift, given the difficulty medical practitioners described in relying on patient narratives during syphilis diagnoses (see chapter two). Ricord published his results in his

1838 treatise *Traité pratique des maladies vénériennes*[14], stating his experimental aims: (Ricord 1842: v–vi):

1. Prove the existence of a venereal virus.
2. Distinguish between diseases that resembled each other.
3. Fix the differences between primary and general infection.
4. Prove the efficacy of prophylactic agents.
5. Examine the 'hygenic and medico-legal' view of syphilis.

Ricord was clearly not responding primarily to the monist and dualist debate, but to the other models of venereal disease that had been formed over the last two decades. His first aim was to prove the physiological school wrong by demonstrating that a specific contagion was able to cause chancre through inoculation, in response to the inoculation experiments of Dubel and Desruelles described in table 4-2 (Ricord 1842: 20–24). His second priority was more closely aligned with Carmichael and the other pluralists, as he wanted to use inoculation to provide a standardised way of differentiating syphilitic chancres from other, syphilis-like ulcers and sores. Although the separation of syphilis and gonorrhoea is often framed as Ricord's experiments 'disproving' Hunter's (see for example Magner 1992: 181; Bynum and Porter 2004: 567; Carpenter 2010: 81), neither Ricord nor Hunter were actually performing their experiments with the sole intent of taking a stance on monism or dualism.

Of course, Ricord was nonetheless aware of the difficulties in separating syphilis and gonorrhoea. He described the primary symptoms of syphilis as so ill-defined that diagnosis was 'not only difficult … but impossible', and counted gonorrhoea as part of the cause of this confusion (Ricord 1842: 53). Responding to the dualist doctrine, he highlighted the experimental evidence which had been produced so far, focusing largely on the work of fellow French surgeon Hernandez, Bell, and James Tongue, who had produced a dissertation outlining dozens of inoculation experiments under the tutelage of Benjamin Smith Barton in Philadelphia (who was in turn another Edinburgh Medical School graduate). He also emphasised how the debate thus far had been hampered by diagnostic

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[14] Due to my own language limitations and availability of copies I refer to the 1842 American edition (unknown translator) throughout this thesis.

issues. In cases where constitutional syphilis supposedly followed gonorrhoea, he believed it was most probably that a hidden chancre was the root cause and that the patient had simply not been examined properly (Ricord 1842: 68). His repeated attacks on the diagnoses of others supported the primary thesis of his treatise; that primary syphilis could *only* be diagnosed through inoculation.

However, while Ricord did not consider gonorrhoea to be one of the primary symptoms of syphilis, he was also not of the dualist doctrine of thought as he did not think that gonorrhoea was caused by a specific contagion. His thoughts on gonorrhoea were closer to the physiological school, as shown in his lectures on the subject:

> … it is connected with no absolute specific origin; it arises under the influence of the usual causes of spontaneous inflammation in man, resulting from the shock of the passions; it is contagious, but not necessarily so; it produces no specific results by inoculation on the skin; it does not contaminate the system. (Ricord 1849: 18)

Ricord thought that separating specific from the non-specific diseases – i.e. syphilis from gonorrhoea – was the key to uniting the French physiological school and the contagionists. His view of gonorrhoea was corroborated by his experimental results. He described that the inoculation of contagious syphilitic matter always resulted in a characteristic ulcer with raised, red edges; anything that did cause the same ulcer was then, by definition, not syphilis (Ricord 1842: 48). Of the more than two thousand experiments he performed, 667 inoculations were made using matter from gonorrhoeal discharge (table 4-3). According to Ricord, none of these resulted in the diagnostic chancre of syphilis. However, as he saw no

Inoculation from gonorrhoea seated in…	**Number of inoculations**
Glans and prepuce	82
Urethra	291
Vulva	31
Vagina	82
Uterus	27
Anus	36
Eyes (ophthalmia)	6
Multiple seats	112
Total	667

Table 4-3: Summary of inoculations performed by Ricord, replicated from Ricord 1842, p.211-212.

pathological results of any kind following these inoculations, he also considered gonorrhoea as inoculable and therefore not relying on a specific contagion.

Ricord's inoculations differed from the previous scattered attempts through sheer scale, enabled by the post-Revolutionary modernisation of hospital medicine that gave him experimental access to large numbers of patients. Most previous experiments had been limited to a handful of participants, and often those were medical students keen to make an early career discovery. This is seen in the consistent output from the Edinburgh Medical School – including the experiments described in Bell's work - and also in Tongue's Philadelphia dissertation, where he was only able to perform a number of experiments by recruiting friends and fellow students. Ricord's approach, on the other hand, was systematic and rigorous. Of the 667 inoculations using gonorrhoeal matter included in his summary tables, Ricord wrote out 55 individual cases in detail. These included full descriptions of patient symptoms, in order to avoid accusations of misdiagnosis. His diagnostic caution is evident in the detailed cases, for example of this female patient in 1835:

> For seven years this patient had been affected with a discharge which had several times relapsed into the acute stage; she had often communicated blenorrhorea[15], but never chancres; moreover she stated she had never perceived any such ulcers on herself. She had never had any symptoms which could be attributed to a secondary syphilitic affection. Now, the blenorrhoeal discharge was very abundant and of a greenish color; on examining the sexual organs with the speculum, a purulent secretion was seen to proceed from the orifice of the cervix, whose posterior lip presented an ulceration in the form of a blister, and the left commissure an ulcerated fissure; the vagina was red, and the mucous membrane granulated by the inflammatory tumefaction of the follicles. Some pus was taken from the ulceration of the commissure and inoculated on the right thigh by two punctures; then the pus collected from the surface of the vagina was inoculated on the left thigh in like manner. (Ricord 1842: 139)

[15] Blenorrhoea was an alternate word to gonorrhoea used by some in order to avoid the implication that the discharge was seminal in nature, as gonorrhoea is formed from the Greek words 'gonos' (semen) and 'rhoia' (flux).

Here, Ricord protected himself against a number of diagnostic mishaps. He specified which diseases the patient had been known to spread, described examination by the speculum to locate any potentially hidden chancres, and described the gonorrhoeal discharge to differentiate it from fluor albus. This level of detail far exceeded that of Bell and the other experiments produced thus far and was presented in a manner that would still hold up in the face of the unstable nosology of venereal disease.

Most importantly, perhaps, Ricord's experiments offered diagnostic stability for syphilis and gonorrhoea. As described, the purpose of these experiments was not to separate the two diseases, but to find a better way to diagnose syphilis. He proposed that this could be done through inoculation: if a person developed a chancre after being inoculated with matter from their sores, they had syphilis. Throughout the previous chapters, I have shown how the debate between the monist and dualist doctrines was driven by an inability to agree on how to define venereal disease. Most of the arguments put forth by dualists previously had been based on symptoms and treatment. Ricord cut the Gordian knot by choosing to redefine syphilis on his own diagnostic terms. This also reflected a broader transition towards use of the clinical laboratory in medicine that was occurring simultaneously. Richard Bright had introduced testing for albumin in urine for diagnostic use in 1827, and in 1843 Gabriel Andral published his *Essai d'Hematologie Pathologique*, which was a turning point for the use of chemical investigation of bodily fluids in diagnosis (Moore 2005). This new way of diagnosing disease cut away the uncertainty surrounding syphilis and gonorrhoea.

Although Ricord was not technically a dualist himself – as he did not consider gonorrhoea to be caused by a specific contagion – his experiments were nonetheless significant for the debate. Dualism rapidly appeared to become the more accepted doctrine; of the books examined from 1840-1849, those that discuss the topic almost all fell on the side of dualism. The only exceptions were Frederic Carpenter Skey (1798-1872) and William Acton (1813-1875) – a pupil of Ricord's – who both agreed that gonorrhoea was non-specific. Ricord's work quickly became the key reference for dualists. Perhaps as they sensed agreement nearing, authors also no longer wrote long pages on the subject, summarising it in language that indicated the matter was settled. Langston Parker (1803-1871), a student of Abernethy's who became a well-known venereologist, referred to

Ricord's evidence as having 'universally prov[en]' that gonorrhoea and syphilis were independent diseases (Parker 1845: 41). George Hume Weatherhead (1790-1853) relegated the topic to a footnote, where he added that Ricord's experiments had 'satisfactorily determined the distinct natures of the matter of gonorrhoea and the venereal virus' (Weatherhead 1841: 220). Similarly, Homer Bostwick (1806-1883) described the contagiousness of gonorrhoea as 'apparently settled' by Ricord, and George Borlase Childs believed that Ricord had 'brought this long-disputed subject to a close' (Bostwick 1848: 131; Childs 1843: 30). Evidently, they believed that Ricord's experiments were sufficient enough to close the case.

Conclusion

By providing a solid foundation for the experimental evidence that was to come and lending his intellectual authority to the doctrine, Benjamin Bell opened the door for the dualists. At the same time, a new generation of doctors were growing up with the dualist doctrine as part of their education. This new generation would also have seen how the nosological categories of venereal disease became increasingly unstable. A number of overlapping and opposing theories were produced about the number of contagions involved, ranging from complete denial of the 'venereal virus' to the suggestion that dozens of poisons were involved. This was a two-edged sword for the dualists. While the separation of gonorrhoea and syphilis as distinct diseases became a less radical proposition against this backdrop, the disagreement over fundamental diagnosis provided ammunition to throw doubt on the inoculation experiments that repeatedly appeared to verify the dualist doctrine. The dualists efforts were scattered and uncollaborated, as each attempted to experimentally demonstrate the separation for themselves. Ricord's rigorous and systematic inoculation experiments in the venereal wards of Paris provided the tangible evidence that the dualists needed to finally become the majority.

By the 1860s, dualism appeared to be the status quo. Authors still describing the debate did so in clear cut language, explaining how 'gonorrhoea was thus set aside from syphilis'; that the distinct contagion of gonorrhoea was 'now a fact'; or describing how progress how been made 'since the grand division of venereal disease' (Barton 1868: 6; Lancereaux 1868: 92; Gardner 1864: 1). Ricord's experiments were typically described as being the deciding factor. This textual shift to presenting dualism as simple fact shows how it was accepted; as Kuhn says, textbooks – in this case, medical treatises – ‘are the bases for a new tradition of normal science’ (Kuhn 1996: 143). Arguments continued over the remaining categorisation of venereal diseases – for example, in 1852 Léon Bassereau suggested the separation of hard and soft chancres, a distinction which is now known to be a differential symptom of chancroid and syphilis, causing a fresh debate to begin (Oriel 1994: 105–8). The separation of gonorrhoea and syphilis, however, appeared to be complete.

Experiments were not the only form of observable and tangible evidence that was available to medical practitioners. Anatomical specimens offered permanent evidence for the results of dissection, which was vital in untangling some of the theories surrounding venereal disease. In the following chapter, the role of medical museums and the anatomical specimens within them in defining venereal disease is explored.

Chapter 5 – Collecting Venereal Disease: Evidence in Medical Museums, 1785-1866

Introduction

In the preceding three chapters, I have examined the experimental and observational evidence that writers used to redefine venereal disease from 1737-1850. In this chapter, I more closely examine another type of evidence that was increasingly relevant throughout this period: morbid anatomy and its presentation within medical museums. Throughout the late-eighteenth and nineteenth centuries, museums became central to medical education, with this period referred to as 'the age of museum medicine' (Reinarz 2005). Museums were filled with preserved human remains taken during dissection and post-mortems, known as anatomical preparations[16]. This chapter will situate the preparations in their historical context, providing background for their genetic analysis which is found in the final chapter. The contents of seven medical museums, based in London and Edinburgh, are used to investigate how venereal disease was represented across both space and time; these collections are introduced with brief biographies in the first part of this chapter.

Medical museums were not simply neutral repositories for anatomy. The production of each anatomical preparation – including selection, dissection, preservation, and cataloguing – was an intentional curatorial decision, made because the specimen was deemed valuable enough to keep. As a product of many such decisions, museums reflect the priorities and beliefs of the medical world at the time; catalogues can provide a snapshot of this. Museums were important sites for both learning and scientific investigation. Young student physicians and surgeons' early perceptions of pathology were shaped by the preparations they saw. Specimens were also kept as tangible evidence of interesting cases and discoveries, often referred to in journal articles. The second part of this chapter investigates how the use of museums gave preparations an active role in

[16] These are also referred to as anatomical specimens from the nineteenth century onwards. Both terms are used interchangeably here.

defining disease: something that for syphilis and gonorrhoea was, as shown so far in this thesis, under question throughout this period.

Curation and development of collections

William Hunter, 1785

William Hunter was a Scottish-born man-midwife, teacher and anatomist who lived in London, where he gave private lectures on anatomy.[17] He attended the lectures of Monro *primus* in Edinburgh in 1739, and learned midwifery under the guidance of William Smellie, another Scot based in London, in 1740. He lived there in the household of James Douglas (1645-1742) - a physician, man-midwife and anatomist - from 1740-1749. Douglas had a collection of anatomical preparations which was passed on after his death to Hunter, along with his papers. Hunter began teaching anatomy in 1746, and in 1749 he moved his teaching to Covent Garden with his brother, John Hunter.

In 1767 Hunter had his school built on Great Windmill Street, which included a museum for the display of his collections. He continued to build on this collection avidly throughout his life, acquiring preparations through a range of methods including post-mortems, dissections performed in his school on Great Windmill Street, auctions and as gifts from friends (McDonald and Faithfull 2015). The museum was open to his students and friends, and Hunter used the preparations to supplement his teaching, as described later. Hunter taught anatomy and dissection until his death in 1783. He bequeathed his collections to the University of Glasgow, on the condition that they stayed with his nephew, Matthew Baillie (1761-1823), for up to 30 years (Campbell 2015: 5–6). A catalogue of the 4,650 preparations was created for the university in 1785 by his Trustees, using a catalogue Hunter had previously overseen and annotated as a basis to ensure accuracy (Fordyce et al 1785).

[17] Biographical details for William Hunter from Brock (2004).

Alexander Monro *primus* and *secundus*, 1798

Alexander Monro *primus* (1697-1767) was an Edinburgh-based surgeon, anatomist, and teacher. He trained in the University of Leiden under Herman Boerhaave (1668-1738), the famed Dutch physician, where he also learned how to make anatomical preparations under Frederik Ruysch (1638-1731).[18] Ruysch's anatomical preparations were well known for their beauty, moral messages and elegance. In 1720, Monro became the Professor for Anatomy at the University of Edinburgh. During this time he collected human and comparative anatomical preparations, which he kept in the university from 1725. Monro's method of teaching anatomy focused more on preparations than on dissections, and he left precise notes about which specimens to use during his lectures (Lawrence 1988).

His son, Alexander Monro *secundus* (1733-1817), followed in the family tradition by assisting teaching of anatomy at the university in 1753, while still studying towards his medical degree. He left Edinburgh from 1755-1758 to study anatomy with William Hunter in London, Johann Friedrick Meckel (1724-1774) in Berlin, and Bernhard Siegfried Albinus (1697-1770) in Leiden. He returned to Edinburgh and took over teaching anatomy at the University of Edinburgh from his father in 1758. Monro *secundus* continued adding preparations to the collection and also used them for his classes, following the notes his father had written. In 1764, he asked the university for more teaching space. In return, he offered to donate the family's personal anatomy collection to the university. The collection was formally donated in 1797, with a catalogue produced in 1798 listing around 3,000 preparations ('Monro Catalogue' 1798). The catalogue has been signed by Dr Fyfe, whose handwriting appears throughout. This was likely Andrew Fyfe (1752-1824), the appointed dissector to Monro *secundus* and, later, Monro *tertius*, showing that he at least gave oversight to the process to ensure that the specimens were described correctly.

Guy's Hospital, 1829

[18] Biographical details for Alexander Monro *primus* and *secundus* from Guerrini (2004), Rosner (2004a) and Alberti (2016).

Guy’s Hospital and St. Thomas’s Hospital had been sharing the teaching of medical students as the ‘United Hospitals of the Borough’ since 1768, including sharing a museum.[19] However, in 1825, a dispute over the appointment for Astley Cooper’s successor led to their union being dissolved and separate medical schools being established. A new school was built, including an associated anatomical theatre and museum. The majority of the shared museum preparations were kept by St. Thomas’s, with just 500 specimens left at Guy’s. The post for curator at the new museum was taken up in 1826 by Thomas Hodgkin (1798-1866). Hodgkin is now known as a pioneering pathologist, who gave the first systematic lectures on morbid anatomy and first identified Hodgkin’s lymphoma. He was also the hospital’s Inspector of the Dead and was able to rapidly expand the collection through the post-mortems he performed in this role. In 1829 - just three years after he took the post - Hodgkin published the first printed catalogue for the museum, which now held around 3,200 preparations (Hodgkin 1829).

Royal College of Surgeons, 1830

Towards the end of the eighteenth century, the Company of Surgeons (as it was called at the time) had an increasingly poor reputation as an institute; the Company was described in parliament by Lord Thurlow as ‘one of the most extraordinary, useless set of learned men that were ever hung around the neck of learning’ (quoted in Chaplin 2016: 96). Few surgeons attended the Company’s dissections, which were even characterised by the Company’s own Master ‘totally inadequate and ineffectual’ (Chaplin 2012: 226). In a bid to improve their reputation, the Company applied for a Royal Charter. Their application was boosted by the recent acquisition of John Hunter’s collection of over 13,000 preparations, which had been purchased by the government and given to the Company on the condition that they open the museum to students and medical practitioners (Royal College of Surgeons of England [n.d.]). The Company was granted their Charter and became the Royal College of Surgeons in London (RCS).

[19] Details for the history of Guy’s Hospital and museum from Daws (1999).

John Hunter's collection was vast, and described by William Seward in 1795 as 'the completest collection in comparative anatomy that was ever assembled together' (Seward 1795). Seward was biased on the matter, as he was friends with John's widow, Anne Hunter, who was at the time trying to sell the collection to escape debt after Hunter's death (Chaplin 2009: 153–54). His statement nonetheless rings true, especially when comparing the number of preparations to the other anatomical collections examined in this chapter. Hunter's school was built as part of his household, with the back half of his property containing a lecture theatre, dissection rooms and the museum. In 1792, Hunter took on William Clift (1775-1849) as his apprentice, to make drawings of the collection and assist in caring for the museum. Hunter died the following year, and when the collection was given to the Company of Surgeons, Clift was taken on as conservator of the Hunterian Museum (Sloan 2004). Together with his assistant, Richard Owen (1804-1892), he wrote the first print catalogue for the collection which was published in six volumes between 1830-1831 (Royal College of Surgeons in London 1830).

Royal College of Surgeons of Edinburgh, 1836

Alexander Monro *tertius* (1773-1859), son of Monro *secundus*, began assisting his father with teaching at the University of Edinburgh in 1800; however, he was an infamously unpopular lecturer and criticised for his lack of surgical experience (Rosner 2004b). Many of these attacks came from the surgeon John Thomson (1765-1846), an extramural lecturer who wanted the University to create a new professorship of surgery for him (Brown et al 2015: 108–9). He was supported by lobbying from the Royal College of Surgeons of Edinburgh (RCSE), and eventually in 1804 a new post for Professor of Surgery was created within the College itself rather than the University. Part of the responsibilities set out for the new role included forming a new museum in order to facilitate teaching the subject ('History of the Museums' [n.d.]). Five curators were also appointed to assist in managing the collection. In 1814, the College began appointing a Keeper or Conservator to care for the museum, rather than the Professor of Surgery. Unlike the other collections described thus far, the College's museum was not primarily formed of one personal collection but from various donations and acquisitions. Initially, preparations were donated by Edinburgh practitioners John Thomson, James Wardrop and Robert Erskine. Over the following two decades, the collections of John Barclay (an extramural lecturer in

Edinburgh), the Meckel family (a German physician whose collection had been gathered over three generations) and Charles Bell (the Scottish surgeon who first described Bell's palsy) were acquired for the museum. Other preparations were donated by members of the College. The first print catalogue was produced in 1836 by William MacGillivray (1796-1852), who was conservator from 1831-1841, and included just under 3,100 preparations (MacGillivray 1836).

St. Bartholomew's Hospital, 1846

St. Bartholomew's is thought to have been the first London hospital to establish a museum for its students in 1726 (Evans 2016). The collection was initially small, mostly comprised of calculi with some donations from hospital post-mortems and the surgeon Percival Potts. The collection received major development under the guidance of John Abernethy, lecturer in anatomy and surgery at St. Bart's over 1788-1829, who donated his personal collection of preparations in 1828. Care of the museum was the duty of the appointed teacher of anatomy, who was not allowed to make their own personal collections but rather required to add any preparations they made to the hospital museum. Another significant donation came from James Paget, who is today considered one of the founders of medical pathology. The first print catalogue was published in 1831 by Edward Stanley (1793-1862), who was curator of the museum from 1826-1831 (Stanley 1831). The second print catalogue, which is used in this chapter, was written in 1846 by Paget while he worked as the museum curator (Paget 1846). The catalogue included around 2250 preparations.

St. George's Hospital, 1866

Although St. George's Hospital had taught medical students for many years, the medical school was only formally established in 1834. This occurred after Samuel Lane (1802-1892), who was a house surgeon at St. George's, established his own private school next to the hospital known as 'The School of Anatomy and Medicine adjoining St. George's Hospital' (Gould and Uttley 2000: 8–10). Benjamin Brodie (1783-1862), a senior surgeon at the hospital, disliked Lane and responded to the opening of school by buying property on Kinnerton Street, which he leased back to St. George's to be used as an official school; this included space for an anatomy theatre and museum. Brodie donated his own collection of preparations to the Kinnerton Street school in 1843. The museum was at one point curated by Henry Grey, of *Grey's Anatomy* fame. A print catalogue was produced in 1866, edited by two of the museum's curators, John William Ogle (1824-1905) and Timothy Holmes (1825-1907). It is unclear whether any other major donations were received before this point, although from the catalogue itself it is evident that a large number of the specimens were taken from post-mortems performed in the hospital. The catalogue listed just over 3,000 preparations, as well as 197 drawings and 127 casts (Ogle and Holmes 1866).

Use of medical collections

Teaching

As seen in the biographies of the various collections above, medical museums were typically established as part of a medical school. The primary purpose of such collections was for education. Anatomical specimens were seen as essential tools for teaching. William Hunter declared in his introductory lessons that it was necessary 'to have a competent stock of *anatomical preparations*' to teach the subject (W. Hunter 1784: 87). Chaplin has found that of the 69 anatomists offering extramural lectures in London between 1756-1800, 66 were known to possess a collection of preparations (Chaplin 2009: 37). There was fierce competition between the many private schools in London, and having a significant medical museum was important in attracting students; collections had a strong presence in advertisements for private courses, and many of the courses included lessons on making preparations (Chaplin 2009: 105).

In eighteenth-century Edinburgh, anatomical education was less competitive as it was dominated by Alexander Monro *primus* and *secundus* at the University of Edinburgh. As described above, competition primarily came from the Royal College of Surgeons of Edinburgh in the early nineteenth century, when they offered an alternative to Monro *tertius*'s lectures. There were, however, some extramural offerings, and it appears that anatomical preparations were still considered a key part of any offering. The surgeon John Aitken offered his courses on anatomy, surgery and midwifery from at least 1779 until his death in 1790 (Kaufman 2003). An advertisement for his course in the Caledonian

Mercury claimed that he was ‘constantly increasing his collection of Preparations’, although nothing is known today of the extent of his collection (*Caledonian Mercury* 1786). John Barclay (1758-1826) also taught private courses of anatomy, physiology and surgery in Edinburgh, from 1797-1825 (Kaufman 2006). He owned a collection of preparations that was focused largely on comparative anatomy, which were used in his teaching (Barclay 1827, v–xvi). These were preserved for him by assistants and students, with dissection of animals being an important part of his courses (Macdonald and Warwick 2014). The exception to this pattern is John Bell (1763-1820), who offered a private course of anatomy, with a strong emphasis on surgery, from 1786-1799 (Walls 1964). Bell emphasised the use of fresh dissection over preparations, and was disdainful of the Monros’ reliance on specimens:

> In Dr. Monro's class, unless there be a fortunate succession of bloody murders, not three subjects are dissected in the year.[20] On the remains of a subject fished up from the bottom of a tub of spirits are demonstrated those delicate nerves which are to be avoided or divided in our operations; and these are demonstrated once at the distance of 100 feet!-nerves and arteries which the surgeon has to dissect, at the peril of his patient's life. (Bell 1810, 579)

For Monro *primus* and *secundus*, the anatomical collection was key to their style of education, which has been described as the ‘Edinburgh manner’ of teaching (Lawrence 1988). Where other anatomy lecturers used dissection as well as preparations, resulting in the resurrectionist trade flourishing throughout the UK, the Monros were more cautious over the use of cadavers. Although cadaveric dissection was included as part of the course, this was much more limited in nature and depended on the availability of recently executed bodies. This may be due to violent riots that broke out in 1725, after rumours spread that Monro *primus* was demonstrating anatomy using live bodies (Guerrini 2007). During the eighteenth century, anatomists found themselves struggling to reconcile an image of being a ‘gentleman’ performing a public service with the generally unpopular act of dissection (Lawrence 1995). Although there were disturbances in the early 1700s around gathering bodies for dissection in London, the anger of these first instances appears to have been

[20] Note that the ‘bloody murders’ here refers to the fact that hanged murderers were used for dissection and is not implying that the dissected cadavers were murdered bodies.

aimed at institutions - i.e. the College of Barber-Surgeons - rather than individual anatomists (Cregan 2008). Perhaps, then, it is not surprising that the Monro family preferred to rely on their collection in teaching rather than risking public ire through dissection.

Although students were usually welcome to simply browse the anatomical museums associated with their place of learning, cadaveric dissection and specimens were also actively used to supplement lectures on the subject of anatomy. There is ample evidence that preparations were regularly presented or at least referred to within lessons. As described, the Monros consistently used preparation in lectures; Monro *primus*'s notes carefully outlined which preparations he referred to at which point during the lecture (Lawrence 1988). William Hunter passed preparations around the class during his lectures and included careful instructions to not injure or destroy the objects by pressing, bending or trying their strength, adding that 'despite all possible care they are constantly wearing out' (W. Hunter 1784: 112). Surviving student notes for both William and John Hunter's lectures include list of preparations that were referred to throughout the courses (Chaplin 2009: 357–65). Hodgkin's preface to the Guy's Hospital catalogue emphasised how the collection's 'first and most important use [is] in assisting the Lecturer to convey and the Pupils to receive and understand the descriptions of disease' (Hodgkin 1829: ix–x). Museum collections also continued to be used in lectures throughout the nineteenth century. For example, Henry Lee (1817-1898), who was curator of the Hunterian Museum at the Royal College of Surgeons, gave a series of lectures on syphilis in 1875 in which he regularly referred students to preparations in the collection (Lee 1875).

The use of preparations in these lectures was summarised by William Hunter as having 'two purposes chiefly, to wit, the preservation of uncommon things, and the preservation of such things as required considerable labour to anatomize them, so as to shew their structure distinctly' (W. Hunter 1784: 89). 'Uncommon things' referred to, in this context, a variety of things: anatomical variations and rarities, 'monstrosities', and morbid anatomy or pathology. Preparations could be used to demonstrate things that were difficult to describe, or where scientific language was not yet available (Lawrence 1993). Specimens and dissection engaged students in multisensory learning, allowing them to develop the tactile knowledge and dexterity that was necessary to become a surgeon. Use of all the senses was important in eighteenth century anatomy. William Hunter described how a student could only become an anatomist ‘by the labour of their own hands [and] by an examination with their own senses’ (W. Hunter 1784: 108). John Hunter was known to taste cadaveric fluids, advising his students on the flavour of gastric juice, urethral mucous and semen (Moore 2005: 118–19). Hodgkin described the preparations as ‘visible and tangible representations of the subjects they are designed the illustrate’ (Hodgkin 1829: x). Tactile information about the preparations was vital in interacting with them, and was even embedded into their descriptions and labels (Bellis 2019: 102-7).

As preparations were so integral to teaching, they inevitably shaped student’s perceptions of healthy and diseased anatomy. Medical museums helped train the eye in pathological investigation, by demonstrating the signs and lesions that a physician or surgeon would need to look for in their patients (Alberti 2011: 177). As Carin Berkowitz has argued, these displays were vital for training both vision and touch by imposing a type of order on nature (Berkowitz 2013). William Hunter, for example, believed that understanding the structures of the body was an essential part of medicine, stating in his introductory lectures that understanding anatomy was a great step ‘towards the knowledge and cure of diseases’ (W. Hunter 1784: p. 1). Medical practitioners were also expected to continue to reference pathological specimens throughout their career, meaning the preparations became a diagnostic tool. Hunter described how during ‘any uncommon case, I frequently go to my preparations, and receive much information and satisfaction, by comparing the diseased parts with the sound’ (W. Hunter 1784: 110). Similarly, Hodgkin emphasised the importance of ‘frequently reviewing’ preparations as a ‘practical assistance to diagnosis’ and to reinforce lessons (Hodgkin 1829: x). Care was taken in preserving and selecting preparations to ensure they would make a reliable diagnostic tool; Stanley’s 1831 preface for the St. Bartholomew’s Hospital collection explained that some pathologies were missing as ‘only those Morbid Specimens have been preserved which might be expected to retain their original characters in a sufficient degree to render them useful as objects of future reference’ (Stanley 1831: i).

As pathological anatomy became more central to medical education throughout the nineteenth century, the medical museum became increasingly important (Alberti 2011: 165). Students took recommendations to use the collections seriously, and evidence shows that they actively engaged with collections and continued to do so as professionals. Museums were busy and noisy places, often full with medical students et al (Alberti 2011: 178). Professionals would also continue to use collections for reference later in their careers. For example, Charles Bell's museum on Great Windmill Street was open twice a week 'to those members of the profession who reside in town' (Bell 1816b: 15). Members of various professional societies would meet to discuss interesting cases using preparations, such as the societies based at Guy's Hospital (Lawrence 1985). Specimens in museums formed the basis for pathology, and therefore would affect diagnosis and definition of disease – a key skill underlying the separation of syphilis and gonorrhoea - by influencing students during their education, and by acting as tangible references later in their career.

Scientific investigation

Making anatomical preparations was important for scientific investigation in the eighteenth and nineteenth centuries both as producing tangible evidence of observations, and as part of the process of discovery. This became increasingly so with the rise of pathological anatomy, as anatomists investigating the body through dissection began to associate tissue lesions with causing changes in health and disease. The practice was epitomised by Morgagni's *Seats and causes of disease* (1769), which comprehensively listed post-mortem cases and connected them with the medical history of the patients. Although practitioners still referred to the humours and often used therapies aimed at bringing these back into balance, new concepts of pathology began to take hold. While pathological anatomy is often attributed to post-revolutionary Paris, other work has demonstrated how development began earlier in London – particularly with the Hunter brothers - and elsewhere in Europe (Keel 1998).

Preparations were useful to act as evidence in these investigations of disease. Over the course of the century, the role of observing in science was slowly transforming; observations became important tools in making and disproving conjecture and hypothesis (Daston 2011). Bruno Latour describes how texts alone are rarely sufficient for describing these observations. Instead, mobile, visible and readable resources are required to allow what he describes as 'optical consistency' – visual information that can be interpreted and applied to other situations (Latour 1986: 13). In the more concise words of Julie Hansen: 'Representation, and demonstration—the witnessing of a phenomenon with replicable results—is essential to its acceptance into the larger cultural body of knowledge.' (Hansen 1996: 671). As with the inoculation experiments described in the previous chapter, anatomical specimens provided observable evidence so practitioners did not simply have to rely on trust.

It has already been shown that preparations helped provide a visual and tangible reference for pathology to both students and medical practitioners. This role extended to include demonstrating new discoveries and interesting cases. Specimens were regularly referred to as evidence in medical case reports submitted to periodicals. This included instructions on how to see the objects in question, which would either be kept in a personal collection or deposited with a larger collection to ease access; accessibility was particularly important for anatomists who were located in more rural areas (Chaplin 2009: 113–14). The use of preparations to illustrate interesting cases increased as collections moved from personal to institutional ownership. Hospital museums were often curated by the same person who performed post-mortems, which opened up opportunities to find body parts with pathologies deemed valuable enough to preserve. As more bodies became available, the connection between pathological anatomy or lesions and nosology also became stronger (Bertoloni Meli 2018: 7–12). Pre-existing preparations could also be reinterpreted through the lens of new theories, such as with Matthew Baillie's use of Hunter's collection (Bertoloni Meli 2018: 3; Bellis 2019: 116–17).

Medical museums, then, became sites for both learning about and challenging definitions of disease. First, preparations were used extensively in teaching anatomy, particularly to aspiring medical practitioners. The use of specimens allowed students to train their senses in order to observe like an anatomist. Preparations were also used in self-education, as a reference library which could be consulted in difficult cases. Second, they were able to act as evidence in scientific inquiry, by making observations replicable and mobile. Collections can show how students were being trained, and aspects of disease they would have observed in this time. Investigating medical collections can help to trace the process of scientific inquiry over the course of time, by examining how priorities and interpretations of pathologies change. This approach will ultimately provide an insight into how the collector perceived the disease that is represented, what curatorial choices anatomists made in selecting and preserving specimens, and how doctors were exploring ideas about disease with dissection.

Venereal disease in collections

Factors in collecting venereal disease

Although specimens were intended to provide a visual atlas for diseases, there were other factors that limited what might be included in a collection. As mentioned above, some parts were more amenable for preservation than others. The act of preserving body parts could change their character, making them unsuitable for use as a reference. Hunter complained that specimens preserved in spirits lost their colour and texture, while dried specimens lost their consistency, size and shape (W. Hunter 1784: 90). Certain pathologies may therefore be missing simply because they were not suitable for preservation; these are likely to be less robust lesions, such as the blotchy skin lesions of secondary syphilis. However, there were methods to get around this limitation; skin lesions could still be represented by taking plaster casts of a specimen, as referenced in Henry Lee's Hunterian lectures on syphilis (Lee 1875: 130–35). These alternate representations are investigated here alongside traditional preparations when they are described in a collection.

It is difficult to know how much a collection reflected the simple chance of what diseases an anatomist came across during dissection, and how much it was driven by a desire to collect particular lesions or pathologies. Venereal disease was certainly common enough in London that an anatomist was likely to come across it on the dissecting table, as described in chapter two. It is important to note that the number of specimens showing certain pathologies may not reflect their perceived importance, but rather how common they were. On the other hand, anatomists also sought out interesting specimens to add to their collections. John Hunter, for instance, famously stole the cadaver of Charles Byrne, the 'Irish Giant', in order to add the skeleton to his museum (Doyal and Muinzer 2011). Similarly, Astley Cooper paid resurrectionists to recover the body of a patient whose knee he had operated on twenty years ago in order to add the case to his collection (Mitchell and

Chauhan 2013: 143). Any analysis of venereal disease in museums must take this balance between availability and desirability into account.

From a modern-day perspective, we would expect the tertiary lesions of syphilis to be more common in cadavers than the primary symptoms. While syphilis can be fatal, this is typically only in later stages of the disease, meaning primary symptoms like chancre would no longer be present as they tend to self-resolve in a matter of weeks. Finding such ulcers on a cadaver would be down to chance, and whether someone died for other reasons while suffering primary syphilis. Museum collections can therefore be expected to offer a good representation of lesions that the collector considered late symptoms of the disease, as these would be more available to preserve. The situation with gonorrhoea is more complicated, as fewer anatomical lesions are left behind. Normal courses of gonorrhoea are limited locally to i.e. the urethra or cervix, where they cause mucous membrane inflammation. Gonorrhoea may leave behind more anatomical evidence when it progresses to disseminated gonococcal infection (DGI), which is thought to occur in modern-day patients in 1-3% of cases (Levens 2003). The main symptoms of DGI, which can be fatal, are arthritis and skin lesions; both of these would be visible to a dissector. The link between arthritis – or rheumatism – and gonorrhoea began to be established in nineteenth century, so there is a possibility the connection may be made in dissection (i.e. *A Treatise on Gonorrhoea and Syphilis* 1821: 69; Titley 1831: 210; Culverwell 1841: 55).

Another important factor associated with preparations of venereal disease is the connection with complex social issues surrounding sex and sexuality. Anatomists were not just informed by their knowledge of disease when making decisions about preparations, but their underlying conceptions of sex. Eighteenth-century explorations of generation and the physiology of nerves were entwined with contemporary philosophical ideas about sensibility; dissection of genitalia provided a medical context for this interplay (Wagner 2013: 92–97). There was certainly variation in how different demonstrators approached the display of genitalia. Monro *primus* would modestly cut the abdomen of cadavers in a way that covered the genitals (Guerrini 2007: 10). John Hunter, on the other hand, proudly displayed a mercury injection of a set of boar's testicles in his own dining room (Wagner 2012). Nonetheless, genitals regularly featured prominently in anatomical collections, as the moral imperative to understand their physiology was seen as greater than the dubious morals of displaying them (Wagner 2013: 97). At the same time, there were the moral implications of venereal disease itself. At the start of the eighteenth century, writers often emphasised that pox was a consequence of immoral behaviour, and even a punishment from God (see chapter two). Displays of anatomy reflected this, such as Frederick Ruysch's allegorical preparation of a prostitute's syphilitic skull with an infant's foot placed on top, representing innocence and debauchery (Hendriksen 2014: 19). Although the connection between venereal disease and (im)moral behaviour lessened slightly over the course of the century, dissection was still an arena for philosophical discussion. For example, Monro *primus*'s dissections have been described as 'moral theatres' that played on viewer's sensibility to encourage compassion (Guerrini 2007). Although messages may not be as strikingly clear as found in Ruych's work, anatomists did not work in a social vacuum and it is likely that their views on sex informed the work they produced.

As well as the broad factors for collecting specimens explored previously, then, venereal disease further influenced what could be collected and why. Syphilis was a common disease in London, and the probable availability of some lesions – particularly from what is currently defined as the tertiary stage - may mean they are represented more within collections. Similarly, some pathologies may be missing simply because they were too difficult to preserve while maintaining the integrity of the preparation as a diagnostic tool and reference. Finally, the complexity of social perceptions of sex and sexuality may influence how venereal disease was displayed in collections. The next section of this chapter analyses the contents of seven different medical museums to find how these factors influenced collections, and how they in turn influenced perceptions of disease.

Venereal disease in collections

Each of the seven catalogues were searched for entries that made explicit reference to venereal disease, or that were indexed as such. A full list of included entries is included in Appendix B.

It is important to note that many other specimens may have been useful references for anatomists when investigating individual symptoms of syphilis and gonorrhoea. Stricture (the abnormal narrowing of a passage in the body, such as the urethra), for example, was often thought to be a consequence of gonorrhoea. John Hunter believed that stricture was not a direct consequence of the venereal poison, but rather a secondary symptom caused by inflammation from the disease (J. Hunter 1786: 109). Hunter included several plates in his *Treatise* that showed urethral stricture in specimens from his collection.[21] However, in the collection itself, although gonorrhoea is included in the series title, none of the specimens themselves were referred to as a consequence of gonorrhoea. Similarly, when the Edinburgh-based surgeon Robert Allan made the connection between inflammation of the urethral membrane and stricture in venereal disease, he described two specimens from Charles Bell's museum on Great Windmill Street that showed stricture of the oesophagus with non-venereal causes (Allan 1819: 167). Clearly stricture was considered to be related to venereal disease, and these specimens would inform medical practitioners who were treating the symptom. However, they were not strictly venereal specimens themselves. Unfortunately, it is impossible to know which specimens may have been used in this way beyond speculation; therefore this chapter is limited to explicitly venereal specimens.

[21] Some of these specimens are still held by the Royal College of Surgeons: RCSHC/P 308, RCSHC/P 1324, and RCSHC/P 1370.

	W. Hunter 1785	**Monro 1798**	**Guy's 1829**	**RCS 1830**	**RCSE 1836**	**St. Bart's 1846**	**St. George's 1866**
Number of venereal specimens	19	20	27	39	72	33	55
Percentage of total collection	0.4%	0.7%	0.8%	0.3%	2.4%	1.5%	1.8%
Bone lesions (exc palate/nose)	13	10	4	18	62	21	22
Lesions of the skin and reproductive organs	2	5	18	17	2	3	19
Upper respiratory lesions (inc palate/nose)	2	4	3	3	4	6	8
Urethra/kidneys/ bladder	1	1	1	1	3	1	4
Other	1	0	1	0	1	2	2

Table 5-1: Overview of the number of venereal specimens listed in each catalogue, percentage of the total collection, and number of the most common types of specimens. The upper respiratory system is defined as the nose and nasal cavities, the interior of the mouth, the larynx, and the pharynx (throat superior to the larynx and oesophagus).

Catalogue	**Specimen number**	**Description**
Hunter 1785	EE.28	Inflammation & Suppuration with ulcer in the posterior part of the posterior lob cerebri the Dura Mater near the lateral Sinus was corroded & the Sinus neatly dissected round (Mrs. Bell's Case) died suddenly there were rather tumours internally on the [blank] suspected venereal disease (case wrote)
Guy's 1829	1376	Tendon, sloughing from Hospital Gangrene, attacking a Venereal Sore of the Leg. Belongs to 1217.
RCSE 1836	862	Portion of a dura mater from a child who had syphilitic caries of the skull opposite this part.
St. Bart's 1846	Series VI, 22	Portion of Cerebrum, exhibiting an abscess in its anterior lobe, which was communicated with the lateral ventricle of the same side. The patient was a man forty years old, who appeared to die exhausted by syphilis and the effects of mercury. The only cerebral symptoms were extreme restlessness and delirium at night. The case is related by Mr. Earle, in the Medical and Physical Journal, Vo. xxiii, p.89, London, 1810.
St. Bart's 1846	Series XII, 58	A Heart, with a Sac attached to the left side of its left ventricle. The sac is spheroidal in form, and upwards of three inches in its greater diameter. Its walls are composed of the exterior of the ventricle, the pericardium, and a dense tissue by which the opposite surfaces of the pericardium were adherent. It is lined by irregularly laminated coagula: the phrenic nerve runs over its anterior part; it communicates with the cavity of the ventricle by an oval aperture, about a quarter of an

		inch in diameter, the margins of which are smooth and round. A portion of white glass is passed through this aperture. The muscular substance of the ventricle immediately around the aperture has disappeared, and is replaced by a dense white tissue. The rest of the heart is healthy: but its exterior is covered by false membrane by which it adhered to the pericardium. It may be presumed, that there was in this case a rupture, or an ulceration, through the wall of the left ventricle; that the blood was prevented from being effused into the cavity of the pericardium, by adhesions previously formed between its two surfaces; and that these adhesions, and the pericardium for a considerable distance around the aperture, were stretched by the force of the blood, so as to form a sac, in nearly the same manner as a false aneurism is formed after the destruction of the coats of an artery by the distension of its sheath. From a woman thirty-seven years old, who had had syphilis for many years in its worst form. She had long been under observation at the Penitentiary; but had presented no distinct sign of disease of the heart. She died with dysentery and slight bronchitis. Presented by Dr. Baly.
St. George's 1866	Series VI, 83	Specimen of aneurysm of the ascending aorta bulging into the right ventricle of the heart, and considerably obstructing the orifice of the pulmonary artery, associated with an aneurysmal pouch of the septum of the ventricles. The sac of the aneurysm so involved the commencement of the pulmonary artery that one of the valve-flaps, and portions of the two others, were quite destroyed, and the only passage left for the flow of blood, was an oval chink capable of being

		distended so as to admit the tip of the finger. This passage corresponded to the portions of the two valve-flaps left uninjured. Into the right ventricle, the aneurysmal pouch in thee septum, situated about half-way up the septum, also bulged. This was about equal in size to a pigeon's egg, and its walls and summit were formed by the mere apposition of the lining membrane of the two ventricles, which appeared to have no muscular fibre between them. Examination of the aorta shewed that the orifice of the large aneurysm was situated in the sinus behind the posterior flap of the aortic valve. This orifice was rounded, with even margins, and surrounded by slight atheromatous deposit in the walls of the aorta. It also partly involved the commencement of the left or posterior coronary artery. The aneurysm was full of firm light-coloured clot, and at one part of the aneurysmal pouch within the right ventricle, owing to ulceration of a portion of the walls, the clot was freely exposed to the current of venous blood within the ventricle. The lungs and kidneys were found much congested, and the liver large and granular. The specimen was removed from the body of a man aged 42, who was a patient in the Hospital, owing to bronchitis, general anasarca and albuminous urine. Having left the Hospital much relieved, he returned with ascites, in addition to his other symptoms. A distinct systolic bruit existed most audible t the apex of the heart, and a double bruit also, mostly audible at the base of the heart, but not traceable along the course of the large vessels. The pulse was regular, small, and about 99 per minute. The

		patient had been very intemperate, and the subject of syphilis. Post Mortem and Case Book 1855 p.146 Path Soc Trans vol vii p.104
St. George's 1866	Series VIII, 176	Specimen showing syphilitic disease of the dura mater, with meningeal apoplexy. There is a membrane loosely attached to the inner surface of the dura mater, covering the right hemisphere, which is nearly decolorized; and in the midst of this and attached to it is a hard thick mass of yellow and opaque organized lymph. On Microscopical Examination, it was found to be indistinctly fibrous, with a few fibrillating cells intermixed. It is about half an inch in thickness, and had produced evident compression of the convolutions on which it lay. Outside the membrane was a smaller patch of lymph, in an exactly corresponding situation, which appeared to be continuous through the dura mater. Opposite to the part of the membrane thus affected, was a node in the parietal bone, which was chiefly indicated by a circle of new rough bone. (For preparation of the skull, see No.101A Series II). The preparation was removed from a man, aged 35, of very dissolute habits, who had, at a former period, lost bone from the nose. He was admitted into the Hospital February, 1852. In November, 1861, while in tolerably good health, he was attached with convulsions, which chiefly affected the left side, and which were followed by a state of unconsciousness which lasted three days. He subsequently had three similar attacks, unattended however by any loss of consciousness. When admitted into the Hospital, he was in the fifth convulsive seizure. Most of the voluntary muscles of the left side twitched violently; the

		muscles on the right side being slightly affected. His intelligence was unimpaired, and there was no loss of sensibility of the skin. He was covered with perspiration. Next day when the seizure had almost passed off, it was the found that the left limbs were rather weaker than the right, and were somewhat wanting in sensibility. It was afterwards observed, that when awake he was scarcely ever quiet, more or less of the convulsive movements being always present. Finally, an abscess was formed near the left elbow, and he sank and died about two weeks after admission. Before his death, the movements ceased, and he became quite deaf. For further particulars, see Path. Soc. Trans. vol xiii. p.8; also Post Mortem and Case Book. 1862. p.48

Table 5-2: Specimens included in the 'other' category.

For all the museums, venereal specimens comprised only a small part of the collection, with none exceeding 2.5% of holdings (table 5-1). The earliest four had less than 1% of their collection dedicated to venereal disease; this number appeared to rise after 1830. The increase in venereal specimens could be either due to better availability or a desire to display the disease more. Mitchell and Chauhan (2013) have noted that there was a similar rise in acquisitions of syphilitic specimens for the Westminster Hospital Pathology Museum from the 1880s to the 1900s, which rose from 4% of the denuded bone collection to 14%. Together, this indicates there was a broader rising trend in collecting venereal disease from the mid-nineteenth century.

It is worth noting that all of the museums with higher numbers of venereal specimens – Royal College of Surgeons of Edinburgh (2.4%), St. Bart's (1.5%) and St. George's (1.8%) – were institutional collections, rather than personal ones. RCSE was amalgamated from a variety of different collections, while St. George's and St. Bart's were both hospital collections that were contributed to significantly by post-mortems. In comparison, the earlier collections were primarily formed by one person (or family); William Hunter, Alexander Monro, *primus* and *secundus*, John Hunter at RCS and Thomas Hodgkin at Guy's, although of course Hodgkin had access to institutional resources. Although St. George's did not have a dedicated venereal ward, both St. George's and St. Bart's had a significant number of venereal patients. A survey in 1867 by William Wagstaffe (1843-1910) reported that 8.14% of outpatients at St. Bart's were venereal, and 7.22% at St. George's (Wyke 1973). This high number would likely have been reflected in the cadavers that passed through the dissecting room. In the RCSE catalogue, three entries referred to the Lock Hospital in the patient history, implying that this was a source for bodies for the museum; this would help explain the particularly high number of specimens in the collection (MacGillivray 1836: 158, 160, 270). The RCSE also doubtless had connections with the Royal Infirmary in Edinburgh, where venereal disease accounted for 19% of total admissions between 1770 and 1774 (Royal Infirmary of Edinburgh [n.d.]). It seems possible, then, that the rising number of venereal preparations was not necessarily due to changing priorities, but due to the changing nature of the collections (and collectors) themselves.

Figure 5-1: Figure of a preparation showing an abscess formed from the anterior ventricle of the brain. Specimen in St. Bart's catalogue: series VI, 22 (see table 2). Engraving by Cooper (Earle 1810).

The mix of symptoms represented in specimens remained remarkably stable over this period (table 5-1). At least 85% of every collection was made up of four core pathologies: lesions of the bones (i.e. nodes in the long bones or carious skulls, not including the nose and palate), lesions of the skin and reproductive organs, lesions of the upper airways (i.e. ulceration of the nose, throat and palate), or lesions of the urinary system (i.e. the urethra). Lesions of the bones and airways are to be expected, as detailed above, because they are symptoms of the later stages of syphilis. These would be among the most common lesions of syphilis that would be found during post-mortem, so it is unsurprising that they dominated medical collections.

The gaps in the collection, however, can help us understand the limits of knowledge regarding tertiary syphilis at that time. As described in the introduction, late-stage syphilis can affect nearly any system in the body, not just the bones and upper respiratory system. Most of the specimens that did not fall into the main four categories were tentative inclusions of other tertiary symptoms (table 5-2). Three preparations showed ulcerations of the dura mater; however, these were considered a consequence of lesions of the overlying bone. Another specimen showed an abscess in the cerebrum of a man who 'appeared to die exhausted by syphilis and the effects of mercury' (figure 5-1). An associated case report concluded, however, that this was not a result of venereal disease, but ‘seemed rather to depend on a peculiar state of the constitution, (perhaps dependant on his disturbed state of mind,) which state was much aggravated by the improper use of mercury’ (Earle 1810). Two specimens show lesions of the heart: one a sac on the left ventricle, the other an aneurysm of the ascending aorta. The latter symptom is now known to be strongly associated with syphilis (Paulo et al 2012). However, despite Morgagni’s suggestion decades earlier that syphilis could have effects on the heart, the connection to venereal disease was very cautious. Both cases merely listed syphilis as part of the patient’s history and did not make an explicit suggestion that this was related. Evidentially, understanding of the full extent of tertiary syphilis was still to come.

Lesions of the skin and reproductive organs were also strongly represented in collections. These types of pathology are found in the primary and secondary stages of syphilis, which meant they would be less common to find in post-mortems as a patient would have to die from another cause while also suffering from venereal disease, as syphilis is rarely fatal in its early stages. Their consistent presence despite their rarity on the dissection table would therefore indicate that they were purposefully sought out and included. This importance is demonstrated particularly by their presence in the collections at Guy’s and St. George’s, where they are represented in higher numbers by wax models and plaster casts. Models and casts would have been possible to create from patients who were still alive, negating the need to wait for the right post-mortem. Neither plaster casts nor wax models were simple to make; both required time, skill and a level of artistry (Hendriksen 2017; Dacome 2017). At Guy’s, part of the curator’s responsibility was ‘the care of making Casts of such interesting Cases as occurred in the Hospital’ (Hodgkin 1829: v). Thomas Addison (1793-1860), who is now known for his pioneering work in dermatology, was a physician with Guy’s since 1820: so it is perhaps no surprise that cutaneous diseases were a priority in the museum (‘Thomas Addison’ [n.d.]). Considering the preservation of skin lesions through models required these considerable resources to make, indicating that their inclusion was important for the collection. This seems sensible given that dermatological symptoms were considered pathognomic for syphilis (see chapter two).

However, the use of models in Guy’s and St. George’s clearly reflected different approaches to venereal disease. Both these collections were built in a later period, with

Guy's museum only starting in 1826 (with the catalogue written in 1829) and St. George's in 1834 (catalogue written in 1866). This means the collections were produced after the pluralists entered the field of venereology and introduced a variety of syphilis-like diseases (see chapter four). The catalogue at Guy's was written at the peak of this debate, and the models were clearly influenced by the pluralists, as shown from the language used in descriptions. 'Venereal ecthyma', one of the pseudo-syphilises, was used to describe five of the wax models. Two casts of the penis were described as showing 'phadagenic ulceration', which was one of Richard Carmichael's categories of chancre. It is difficult to know with certainty if this was also the case at St. George's, as the entry only described 'A collection of sixteen models illustrating syphilitic affections of the male and female generative organs', presented by H. Lee. The models are no longer in the collection and there appears to be no further information about them. However, Henry Lee – who donated the models - did reference a number of plaster casts while lecturing at the RCS in 1875. It seems probable that these were of a similar nature to the ones he presented to St. George's. In his lectures, the casts were used (alongside drawings and watercolours) to attempt to show the 'infinite variety' of skin eruptions in syphilis, and not to distinguish between syphilis-like diseases as appeared to be the case with the collection at Guy's (Lee 1875: 125,130-134). Students learning at the two hospitals would therefore be presented with very different categorisations of venereal disease.

While Guy's and St. George's held a significant collection of models and casts, the RCS collection was notable for its comparatively large number of cadaveric specimens in the skin lesion category. The catalogue contained a series of specimens dedicated to syphilis, no doubt reflecting John Hunter's own interest in venereal disease. The majority of these specimens were various types of ulcerations, and examples of phimosis and paraphimosis. Ulcerations of the penis were not uncommon generally in the seven catalogues. However, these were only rarely attributed to syphilis. Most were simply described as an ulcer or ulceration, and had no associated underlying disease. It is possible that the difference seen here is a priority of cataloguing and categorisation rather than the collection itself: as Hunter had a particular interest in venereal disease, he may have been more likely to note the connection.

Figure 5-2: Specimen RCSHC/P 30 from the RCS museum, showing inflammation and the lacunae in gonorrhoea. The specimen was from a convict dissected by John Hunter in 1753. Photo (C) Royal College of Surgeons.

The last common thread was the inclusion of lesions of the urethra. This was firmly the realm of gonorrhoea rather than syphilis, as dissection was key in establishing the role of ulceration in urethral discharge. As described in chapter two, there was considerable debate over the cause and seat of gonorrhoea. The discharge was initially thought to be pus, caused by ulcerations within the urethra. This was brought into doubt after William Cockburn's dissections of the penis suggested that the discharge was mucous instead, caused by inflammation of the glands within the urethral membrane (Cockburn 1718: 18–19). Over time, the debate evolved from questioning whether ulceration was the underlying cause of discharge in gonorrhoea, to whether ulceration of the urethra ever occurred during gonorrhoea. In his 1786 *Treatise*, John Hunter published the results of his dissection of two executed convicts who had died with gonorrhoea:

> In the spring of 1753 there was an execution of eight men, two of whom I knew had at that time very severe gonorrhoea. Their bodies being procured for this particular purpose, we were very accurate in our examination, but found no ulceration, the two urethras appeared merely a little blood-shot, especially near the glans. (J. Hunter 1786: 30)

Museums played a vital role in this debate, as the product of such dissections could be preserved to act as permanent evidence. Hunter kept a preparation of at least one of the urethras (figure 5-2 and table 5-3). Similarly, Morgagni had described dissecting the urethras of people who had died with gonorrhoea without finding ulceration, but simply inflammation and redness of the membrane (Morgagni 1769b: 591). Hunter's contemporary Alexander Monro[22], however, believed that ulceration took place in the urethra in patches where the venereal poison was applied (Carmichael 1814: 75). Monro also had a preparation in his museum that supported his theory (table 5-3). Hunter and Monro's museums, then, appeared to have tangible evidence of contradicting arguments. The presence of specimens as evidence of ulceration (or lack thereof) in later museum catalogues also demonstrates that the issue was not settled for many years. Two of the collections, Guy's and RCSE, included preparations that specifically showed the urethra was inflamed during gonorrhoea (table 5-3). The specimen at RCSE was donated by Charles Bell, who had agreed that Hunter had 'proved' there was no ulceration in gonorrhoea (Bell 1816a: 6). As late as 1866 however, St. George's Hospital had a preparation that showed ulceration of the mucous portion of the urethral membrane (that is, the portion furthest from the meatus) from a patient with gonorrhoea.

Dissections and preparation were a convincing argument for many practitioners. For example, John Andree, a student of John Hunter, described attending the dissection of a man who had died with gonorrhoea: after Andree 'attentively inspected the part with magnifying glass', he found inflammation but no ulceration, which was enough to persuade him that ulcers did not occur during gonorrhoea (Andree 1781: 17–18). It is likely that Andree had also seen Hunter's dissection while he was a student. Another of Hunter's students, Joseph Adams, also referred to the 1753 dissections (Adams 1795: 202), as did Thomas Brand in his pamphlet defending Hunter against his rival, Jesse Foot (Brand 1787: 27–37). Monro's preparations also seemed to make an impression on his students: Andrew Knox recalled in his essay on gonorrhoea and syphilis that 'Doctor Monro, in the course of his lectures, shews many preparations from persons formerly labouring under Gonorrhoea, which have, evidently, marks of ulcerations in the urethra' (Knox 1792). The

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[22] This is presumably Alexander Monro *secundus* from the dates cited, but in this case it is difficult to separate references between *primus* and *secundus*.

Catalogue	**Specimen number**	**Description**	**Donated by (if known)**
Monro 1798	509	The Bladder, Prostate Gland & Penis. The Urethra cut open the whole length to shew Ulcurations from a Gonorrhoea of 3 months continuance.	Alexander Monro
Guy's Hospital 1829	2401	Urethra, inflamed, from Gonorrhoea.	Unknown, but likely predates Hodgkin
Royal College of Surgeons 1830	81 (in current collection as RCSHC/P 30)	The anterior part of the penis of a person who had a gonorrhoea at the time of his death. The urethra is laid open, and bristles are put into the enlarged lacunae.	John Hunter
Royal College of Surgeons of Edinburgh 1836	2128	Urethra very much contracted nearly through its whole ectent [sic]. This state of the passage is produced by the inflammation of gonorrhoea, or by the improper use of irritating injections. In such a case the urethra feels tense and hard along all the lower part of the penis.	Charles Bell
St. George's Hospital 1866	Series XII, 61	The urethra and bladder taken from a patient labouring under gonorrhoea. Phimosis exists, and some ulceration of the mucous membrane is seen at the membranous portion of the urethra.	Benjamin Brodie

Table 5-3: Specimens showing ulceration or inflammation in gonorrhoea.

shaping influence of the museum can be clearly seen here, as each student had seen seemingly irrefutable evidence in the form the preparations

Not all the specimens were so directly involved in defining venereal disease. As some specimens that were not described as syphilitic were still considered relevant to venereal disease, the reverse was also true: some specimens that were taken from syphilitic patients were of interest for other reasons. For example, in the RCSE catalogue, one entry read: 'Epiglottis wasted and the membrane of the larynx thickened by chronic inflammation. The disease supposed to be venereal. The patient died suddenly after being admitted into the Lock Hospital'. The entry also included a reference to a case in Charles Bell's *Surgical Observations*. The reference was not an observation on venereal disease, however, but a report on diseases and wounds of the larynx in general (Bell 1816b: 14–22). The specimen was one of many listed in the report and grouped in with other examples of 'chronic inflammation of the epiglottis'. Venereal disease was not mentioned; instead the specimen was seen as a useful illustration of one of the types of *cynanche laryngea* (inflammation of the larynx). Similarly, a necrosed larynx in St. Bart's was connected with an article in the *Medico-Chirurgical Transactions* that dealt more generally with lesions of the larynx that required a bronchotomy (Lawrence 1815; Stanley 1831: 368). This approach to categorising preparations reflects the approach to stricture described above. Specimens were important as representations of individual symptoms, which could then be used in reference to any disease which included that symptom, regardless of what the lesion was caused by in that particular case. This demonstrates how the relationship between lesions and disease was not always straightforward, or causal. This is seen in the way practitioners described their treatment regimes for venereal disease, which often targeted individual symptoms rather than syphilis or gonorrhoea itself. The systems of categorising medical museums reinforced this emphasis on individual lesions over a disease as a whole.

Despite the apparent focus on symptoms, museums were also used in the debate over treatment. Some practitioners had suggested that the consequences of using mercurial treatments had been confused for the symptoms of syphilis (i.e. Mathias 1816; Schetky 1818: 22). Some of the preparations reinforced this by explicitly associating lesions with mercury. Two cases of pharyngeal ulceration in St. Bart's museum were attributed to the 'effect of mercury' in patients with syphilis, as was the preparation of a cerebral abscess described previously (Stanley 1831: 197, 358,362). One of the wax models at Guy's Hospital showed 'a large and foul Ulcer, the result of Syphilis and Mercury' (specimen 2739). In St. George's museum, the association was less obvious but still present. One specimen was catalogued as exfoliated bone 'removed from a patient who had been for a long time suffering from syphilis, for which he had been repeatedly mercurialised' (Ogle and Holmes 1866: 95). An associated journal article cited in the catalogue entry described the case as 'mercurial disease' (Keate 1835). Most damning were the specimens donated to RCSE by John Thomson, a surgeon who strongly advocated for the use of sarsaparilla over mercury (Thomson 1817). These were not even described as syphilitic, but 'mercurial caries' and 'mercurial exfoliation' (specimens 291, 317, 318, 480 and 481).[23] Museums provided a venue for intellectual output and debate that was just as important as the medical journals and treatises; a skilled researcher would use both text and specimens to support their theories.

[23] Note that these specimens are not included in the breakdown in table 5-1 as they were not explicitly described as syphilitic.

1785 catalogue number	**The Hunterian accession number**	**Description**
X.89	N/A	The kidnies of a young Surgeon who died Frantic had a Suppression of urine from Stricture in consequence of Gonorrhoea there was a Supperation in the apex(?) of the Prostate Gland which extended to the bulb of the urethra - the kidnies are taking on the tuberculated appearance of Scrophulous Supperation the ureters are much enlarged - one kidney is injected black & red, the bladder is also thickened and fasciculated.
BB.45	GLAHM:121404	The upper half of the Penis of a Jew as the prepuce is removed it explains Circumcision there are also two large Chancres on the Glands (Solomon Porter)
CC.58	GLAHM:121427	Uterus Vagina & Vulva Vagina is obliterated about an inch within the Vestibulum probably from long continued Venereal inflammation.
EE.28	GLAHM:121058	Inflamation & Suppuration with ulcer in the posterior part of the posterior lob cerebri the Dura Mater near the lateral Sinus was corroded & the Sinus neatly dissected round (Mrs. Bell's Case) died suddenly there were rather tumours internal on the [blank] suspected venereal disease (case wrote)
LL.32	N/A	Ulcer & thickening in Schneiders Membrane from the Lues Venerea (Patient in Westminster Hospital)
LL.33	N/A	The other Side of the Nose Ditto - the Septum Nasium about the middle & lower part gone before & behind excepting one pillar about the middle the disease was recovering & the Membranes had

1785 catalogue number	**The Hunterian accession number**	**Description**
		united those of the one side with those of the other at the anterior & posterior edges - the Mouths of the Eustachian Tubes in both were much thickened
LL.36	GLAHM:122415	A longitudinal middle section of the Tibia on which a large node probably venereal was formed the leg had been injected the bone afterwards steeped in an acid the Node resembles much the Callus of Bone and is also evidently vascular
N/A	N/A	Twelve specimens of portions of crania or sculls affected with ulcuration from Lues Venerea. NB The sculls affected with Lues Venerea in the collection seem to exhibit a peculiar appearance. There are a prodigious number of small irregular ulcurations seeming as if the Bones was gnawed with Insects. These gradually spread so as to form larger ulcers & then this appearance becomes in a great measure lost.

Table 5-4: Venereal specimens in William Hunter's collection as catalogued in 1785.

William Hunter’s collection

William Hunter’s school and museum were, arguably, one of the most important in London at that time. Hunter did not just collect anatomical specimens but also art, books, geological specimens, natural history, coins, and anthropological objects, to name just a few. His museum was encyclopaedic in its coverage (for a broad overview of the collection see Campbell et al 2018). He was an avid collector, known for his determination to acquire everything he could. One coin collector, Francis Carter, recalled:

> God grant I may be able to keep mine from his clutches. He had the impudence to tell me, in his own house, that he was glad to hear of my loss by the capture of the Grenades as it might force me to sell him my Greek coins, an anecdote that should not be forgot when you write his life. (as quoted in Keppie 2007: 19)

This section examines evidence of venereal disease in Hunter’s collection (see table 5-4 for full list). It is important to note that the catalogue used in this chapter was based on a version overseen and annotated by Hunter himself, indicating that it likely reflects his own views towards the specimens. The same preparations described here – at least, those that are still extant in The Hunterian - will be genetically analysed in the final chapter.

Of Hunter’s 19 specimens, 13 were examples of lesions of the bone. In reality, this number was likely to be considerably higher. Hunter had a special interest in bone anatomy, particularly in the relationship between vascularisation and ossification (McDonald and Russell 2005). Notably, this is evident in specimen LL.36, where Hunter emphasises the vascularity of the node on a tibia. As such, the number of bones in his museum was so high that the Trustees simply gave up cataloguing them:

> The collection of diseased Bones is so extensive that it would require nearly as much time & labor to describe each Bone particularly as has been bestowed on all the other parts of the Catalogue taken together - we shall not therefore attempt it, but mention only number of Specimens & general circumstances so as to be able to ascertain sufficiently to Glasgow this part of the Collection. (inc. inflammation, caries, exfoliation, rickets, molities ossium, incurvation, hydrocephalus, anchylosis, fracture, exostosis, spina ventosa) (Fordyce et al 1785: 396).

When the anatomy collection in the University of Glasgow was re-catalogued by John Teacher in 1900, the bones were finally fully described. Teacher included 59 specimens of bone displaying syphilitic lesions (Teacher 1900). Although it is impossible to know which specimens Hunter would also have categorised as venereal, there is clearly an emphasis in his collection on bone lesions. However, this appears to reflect his greater interest in their general pathology rather than venereal disease, demonstrating once again that many specimens collected from venereal patients were used to present symptoms rather than diseases. The other specimens in his collection reinforce this. They are a rather eclectic selection of cases, all with the emphasis on the underlying lesion rather than the disease. Much of the description focuses on the pathological processes taking place in the tissue, such as the 'thickened and fasciculated' bladder of a surgeon, or the 'thickening in Schneiders membrane'.

Specimen BB.45, the 'penis of a Jew', perfectly illustrates how venereal disease was usually an aside from the purpose of a preparation (figure 5-3). The preparation is noted as belonging to Solomon Porter, a Jewish criminal who was executed in 1771 along with three others – Levi Weil (a surgeon supposedly trained in Leiden), his brother Asher Weil, and Hyam Lazarus - after a violent robbery that caught the attention of the public. The case is well-documented; Endelman describes how the response to it was connected to a perceived increase in Jewish crime and immigration (Endelman 1999: 196–203). After the men were hung, their bodies immediately became valuable medical commodities. The *Kentish Gazette* reported that:

> Two eminent tooth drawers of this town had a scramble for the teeth of the four Jews: one of the gentlemen, however, stealing a march upon the other, had nearly extracted three sets before the second operator arrived, who was therefore obliged to content himself with the teeth of the fourth poor wretch, (the Doctor) which he soon dislocated, and put into his pocket, and they will probably ere long adorn the mouths of some of the Bon Ton; a Jew's Eye is proverbially precious – why not a Jew's tooth. (*Kentish Gazette* 1771)

Figure 5-3: The 'penis of a Jew' displaying chancres of the glans penis. The black beading on the surface is wax that has been injected into the penis and seeped through. GLAHM 121404 at The Hunterian.

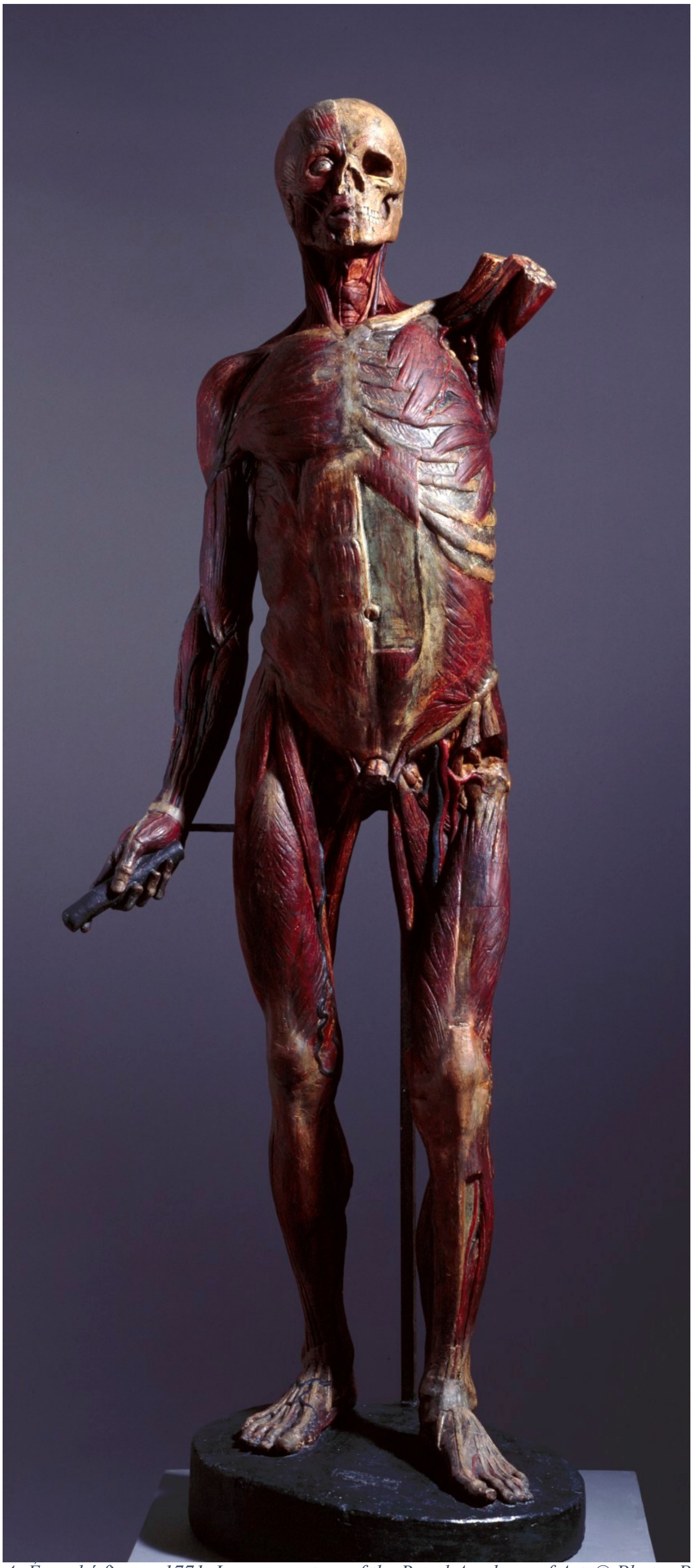

Figure 5-4: Écorché figure, 1771. Image courtesy of the Royal Academy of Art, © Photo: Paul Highnam.

Three of the bodies were delivered to Surgeon's Hall for public dissection, and one to the Royal Academy to be dissected by William Hunter for the education of artists (*Oxford Journal* 1771). Levi Weil, as the leader of the gang, was almost certainly one of the bodies sent to Surgeon's Hall; after his dissection, he was hung in chains in one of the niches there used to display criminals (*Oxford Journal* 1771: 17; Burke 1772: 161). The dissection itself was a public spectacle, drawing in huge crowds evidently eager to see the criminal Jews punished. The mass of people wishing to observe was so great that the two surgeons attending the dissection – David Bayford, the professor of anatomy at the College, and William Bromfeild, surgeon and anatomist – were supposedly forced to enter the building through the window (*Kentish Gazette* 1771). Antisemitic feeling at the dissection was high; Jewish citizens who had gathered to watch the execution were 'very ill-treated by the populace', with one receiving 'a violent blow across the face' (*Caledonian Mercury* 1771).

Although there has been some confusion over which of the bodies was sent to the Royal Academy, sufficient evidence exists to show that this was Solomon Porter.[24] Later in the month, one paper clearly stated that Porter's body had been dissected at the Royal Academy by William Hunter:

> Solomon Porter the Jew, lately executed for Murder and Robbery at Chelsea, was the Person anatomized and lectured on by Dr. Hunter, before the Royal Academy on Thursday last; he was reckoned by all the most experienced of the faculty present, to be one of the finest mascular Subjects that has been dissected these many Years past: one of the Statuaries belonging to the Academy is preparing a cast of him in Plaster in Paris. (*Manchester Mercury* 1771)

While a single newspaper article on its own is, of course, not conclusive, one student at the Royal Academy – John Russell (1745-1806), an English painter – recalled 'the dissection of Solomon Porter' he had attended in December 1771 (as quoted in Mathews 2005: 119). Porter is also named in Hunter's catalogue, and it is far more probable that he took the preparation from the cadaver he dissected at the Royal Academy than one of those dissected by Bayford and Bromfeild at Surgeon's Hall. After Porter's body was dissected

[24] This confusion began not long after the trial itself, with one account mistakenly stating Levi Weil was sent to the Royal Academy (Jackson 1794: 22). More recent research has repeatedly mistaken the Royal Academy body for one of the Weil brothers (i.e. Massil 2011; Chaplin 2014; Reichman and Dysert 2018).

for the students of the Royal Academy, Hunter had an écorché made using plaster of Paris – something he was eager to do, as the student James Northcote (1746-1831) described in a letter how the dissection only lasted for two lectures so that the body would still be fresh for the plaster (Northcote 1771). It was before this stage that Hunter removed the penis, as it is preserved with the skin intact in order to show circumcision. The écorché is still held in the Royal Academy (figure 5-4); closer inspection shows only a stump where the penis should be.

Venereal disease was likely the last thing from Hunter's mind when he decided to preserve Porter's penis. After the sentencing, newspapers claimed that the four men were the first Jews to be dissected in the country – making their commodified remains valuable as rarities (*Manchester Mercury* 1771). This may very well be correct, at least of the cadavers legally sourced from Tyburn. Of the known criminals dissected at Surgeons' Hall, only three other potentially Jewish names appear, all after the year in which Solomon Porter was dissected: Peter (Pedro) Tolosa in 1777, Emanuel Pinto in 1783, and Jacintho Phararo in 1790.[25] Other than their names, it is uncertain whether these three were Jewish. Tolosa was only ever described as a 'Spaniard', and Phararo as a Genoese sailor (Burke 1779: 168; *Derby Mercury* 1790). Given the explicit descriptions of the Porter and the other three men as Jewish, it seems likely that Tolosa and Phararo would also have been described as such if they were. Pinto was also a sailor, although Portuguese; he was accompanied by a Portuguese clergyman to his death (*Hampshire Chronicle* 1783). Of course, anatomising as a punishment was not the only source for bodies in the eighteenth century. Graverobbing was a very real concern for the synagogues of London; the Great Synagogue maintained a roster for members to watch over the dead, with three armed watchmen on duty every night (Roth 1950). Named preparations were not uncommon in either John or William Hunter's museums, but those that were named were done so with a purpose. Chaplin describes how named bishops and clergymen helped promote the idea that post-mortem dissection was a noble, necessary and religiously acceptable practice (Chaplin 2012). In this case, viewers would undoubtedly have heard of the incident, which promoted a massive printed response and was still being cited by journalists as late as the 1830s

[25] A full list of criminals executed at Tyburn then dissected at Surgeons' Hall can be found in Chaplin (2009: 343–52); this was cross-referenced with Alexander ([n.d.]) and Kaganoff (2005) to find potentially Jewish subjects.

(Felsenstein 1999: 237–39). They perhaps even read that these were the first Jews to be dissected in England. Collecting the penis of Solomon Porter, then, could almost be seen as a form of trophy hunting: the acquisition of a rare specimen to be displayed with pride.

It is worth exploring William Hunter’s assertion that the penis was there to ‘explain Circumcision’. It is unclear whether this was meant to demonstrate circumcision as a medical procedure to his students of anatomy, or to explain the phenomenon of circumcision in the Jewish community. As a medical procedure, circumcision could be used to treat phimosis (the tightening of the foreskin over the penis), typically as a symptom of prolonged venereal disease. Medical ‘circumcision’, however, often referred to simply slitting the prepuce, rather than removing it, in order to save as much of the foreskin as possible, with full removal being reserved for only the last resort (Andree 1779: 71; Hunter 1786: 235). Hunter’s was not the only collection with a preparation demonstrating circumcision. Of the venereal specimens, Monro’s collection included a prepuce ‘cut off in gonorrhoea’ and the RCS included in the syphilis series a ‘penis from which the prepuce has been circumcised’ (‘Monro Catalogue’ 1798: 509; Royal College of Surgeons in London 1830: 59). However, he would also not have been the only collector to include circumcision as an cultural phenomenon; R.J. Jordan’s anatomical museum included an example of circumcision ‘as daily performed by the Israelites and Mahomedans’, and John Heaviside’s collection had the ‘penis of a Negro who had been circumcised’ (Heaviside 1818: 7; Jordan 1861: 37).

Regardless of Hunter’s intentions, the specimen reflected Jewish medical stereotypes; although stereotyped associations between Jews and syphilis would not be strongly established in medical discourse until the nineteenth century, there were long historic roots to such thinking (Gilman 1991: 96–98). Theories of origin for the initial epidemic of syphilis at the end of the fifteenth century mainly focused on the Columbian exchange – that is, that syphilis was a New World disease which had been imported to Europe during the voyages of Columbus. However, one alternate theory connected the outbreak with the 1492 expulsion of Jews from Spain (Cohn Jr 2018: 192). John Howard (d. 1811), a surgeon at Middlesex Hospital, wrote in his 1787 treatise on venereal disease that this theory seemed ‘to throw much light on this very intricate subject’. He went on to associate this with a lack of cleanliness of Jews:

> The greater part of these people were merchants of the ancient kingdom of Granada, many of them had been shut up within the walls of the city of that name; and had long suffered under civil and military persecution. Under these circumstances, it is not to be supposed, that they could have been properly attentive to cleanliness. The leprosy was a common disease among them … and if the venereal disease arose as a modification of the Leprosy among these people, they must have spread it, far and wide. (Howard 1787: 240–41)

Similarly, Nikolai Falck (1736-1783), a London-based physician, described how venereal disease could arise *de novo* in Jewish people as 'filthiness was always a characteristic of the Jews; especially among the lower class, where actually, vermin feed upon vermin' (Falck 1772: 80).

Venereal disease also implicitly connected the specimen to another, more broadly held, eighteenth-century stereotype of Jews: that they were lustful and sexually promiscuous. These stereotypes were widely accessible through popular culture: on the stage, in written works, and in artistic depictions (Wolper and 1973' ס). It was held that Jewish men disproportionately had extra-marital sexual activity, including the use of prostitutes, as depicted most famously in Hogarth's *The Harlot's Progress* where an innocent young woman from the country is corrupted into selling her sex to a wealthy Jewish merchant. Ultimately, she is infected with syphilis and dies. The medical connection between Jews, syphilis and sex was emphasised by the nature of the preparation. The penis is severed at its base from the rest of the body and presented on its own. Simon Chaplin describes how this isolation of parts affects viewing:

> By stripping away the patient's body to leave only the morbid organ, Hunter was able to reinforce his identification of patient with disease. In the eyes of Hunter's medical visitors - his pupils and his peers - the agency of the patient in his or her own medical care was increasingly immaterial. (Chaplin 2012: 236).

As previously described, anatomical preparations could carry moral stories. As well as being a diseased man, Porter was famously a criminal. Meredith Gamer argues that the criminal écorchés of the Royal Academy were viewed punitively (Gamer 2014). This is reflected in the diaries of the artist John Russell, who appears to be particularly affected after watching Porter's dissection while studying at the Royal Academy: he described how, immediately afterwards, he encountered a woman who had broken her leg, whose cries ‘brought to my Mind the Torments of the damned in Hell’. He added of Porter that he prayed for the ‘poor fall’n man at the Throne of Grace’ (as quoted in Mathews 2005: 119). Through its many layers of meaning, the preparation of Porter has a narrative: a criminal who does not live a life of sobriety was caught and punished, not only by the law and dissection, but by nature through the form of venereal disease. There were clearly many reasons for Hunter to preserve this particular specimen, and many ways it could be viewed by those with access to his museum: as an objective example of syphilitic chancres seems low on the list.

Hunter’s collection neatly supports the concept that museums were not intended to be repositories for nosological categories of disease but instead offered a different type of system of knowledge. Specimens were collected for their individual value in displaying particular types of lesions, or for more complex reasons. While they no doubt had value in teaching the pathology of syphilis and gonorrhoea, venereal specimens could also be used to illustrate a variety of diseases (such as in the case of strictures), surgical processes (as with circumcision and bronchotomy) or physiology (like the vascularisation of bone callouses). Specimens also had meanings outside of medical theory; the case of Solomon Porter illustrates how curatorial choices did not necessarily reflect a desire to preserve types of pathology. Their use implies a particular approach to disease that emphasised lesions and symptoms over nosology.

Conclusion

The systems of categorisation in medical museums offered medical practitioners simultaneously both a stable definition of the core symptoms of venereal disease, and room for flexibility in incorporating other pathological elements. The understanding of cause-and-effect, particularly in the eighteenth century, as lesions causing diseases rather than diseases causing lesions meant that any lesion seen in the museum could potentially shape a user’s understanding of syphilis or gonorrhoea. The reverse was also true, and specimens that were designated as venereal had other ways of being read: whether to illustrate other diseases, or even for non-medical purposes. This, importantly, reflected a flexible approach to defining disease; one that was seen in the nebulous attempts to define venereal disease as seen in previous chapters. The collections were, unsurprisingly, dominated by specimens that were easier to find, as they were long-lasting symptoms of syphilis that would have been more available in the dissecting room. Specifically, a large proportion of the preparations were lesions of the bone or upper respiratory symptoms. The absence of other tertiary symptoms of syphilis reflected the knowledge available at the time: although the museums begin to tentatively include other visceral preparations, such as the dura mater and a case of aneurysm, the connection between the lesion and syphilis was typically downplayed. While many of the arguments over defining venereal disease described in this thesis were not reflected in collections, there were some cases of museums being influenced by debates of the time. The debates over urethral ulceration in gonorrhoea, categorisation of ulcers, and the effects of mercury were played out in the specimens collected. Students and medical practitioners were influenced by the tangible evidence they could see in museums, making the preparations themselves actors in the social networks of knowledge.

In the following chapter, I use genetic analysis to investigate the possible bacterial or viral causes of the pathologies described as venereal in William Hunter's museum. The perspective gained in this chapter will help to interpret and frame any results found.

Chapter 6 – ‘No experiment is to be made’: Recovering Ancient DNA from Venereal Specimens

> They [anatomical preparations] will only be looked at: no experiment is to be made, by pressing or bending, to try their strength or texture...Many of them are the result of patient labour, and not easily restored; many of them such rarities as are not easily recoverable. (W. Hunter 1784: 112)

Introduction

This chapter explores the potential use of ancient DNA (aDNA) as evidence for a historical question; specifically, how was venereal disease defined over the course of the eighteenth century? As aDNA studies of pathogenic bacteria rapidly increase in number, I seek to use this work on a broader level to explore how the two fields can work together, combining evidence in new ways. Anatomical preparations and museum specimens can provide unique insights into this emerging interdisciplinary work, as they have rich cultural context while still providing biological evidence. This approach has been used to great effect in natural history; recently, for example, modern taxonomic methods have helped shed new light on Captain Cook’s voyages (Robinson and Vane-Wright 2018). However, it has not been used so far for pathological specimens. Here, I have targeted anatomical specimens that were diagnosed in the eighteenth century with venereal disease. The historical context for these particular specimens has been discussed in depth in chapter five. In this final chapter, I attempt to extract pathogenic DNA from the same specimens in order to establish the biological component of disease in each case.

In the background section, I explore how aDNA has been used so far to understand historic diseases. This has mostly focused on archeologically recovered human remains with visible signs of disease such as plague (*Yersinia pestis*) and tuberculosis (*Mycobacterium tuberculosis*). As well as providing necessary scientific context, this highlights the collaborations that are already established between historians and scientists within various fields. The section then examines the technical challenges facing this project. First, the problems of DNA recovery from ethanol-stored specimens are outlined. Second, the attempts made so far to sequence historic *Treponema pallidum* genomes are discussed. The methods section shows how I have tried to work around these problems by testing and adapting extraction techniques.

After this has been established, the results are shown. Bacterial DNA was successfully extracted and sequenced for *Mycobacterium tuberculosis* in test samples. The venereal specimens yielded a number of potentially historically interesting pathogens; *Staphylococcus aureus*, *Yersinia enterolotica* and *Haemophilus influenza*. However, there was no significant recovery of DNA for *Treponema pallidum* or *Neisseria gonorrhoeae*, or any other bacteria associated with STDs. The discussion section explores the implications of the pathogens that appear to be present, and potential reasons why others were not found. Importantly, the results mark the first successful recovery of aDNA from eighteenth-century wet specimens and show that they are a viable resource for future research. Finally, limitations for this study are discussed and suggestions made for alternative methods going forward.

Background

Introduction to microbial ancient DNA research

The recovery of ancient DNA (aDNA) from historic and archaeological specimens is a relatively recent technique. The first aDNA was purified in 1984 from a museum specimen; the dried muscle of a quagga (*Equus quagga*), an extinct zebra-like species (Higuchi et al 1984). Higuchi's team were able to sequence stretches of mitochondrial DNA that were then compared to the mountain zebra (*Equus zebra*), showing that they shared a most recent common ancestor (MRCA) 3-4 million years ago. In the early 1990s, researchers began to use these techniques to explore the possibility of sequencing DNA from bacteria inside excavated human bones. The first success was reported by Spigelman and Lemma (1993), who used PCR to detect residual *Mycobacterium tuberculosis* DNA in skeletons excavated from burial mounds associated with the ancient Near East. Since then, pathogenic DNA has been recovered from ancient sources to detect a wide variety of organisms, including *Yersinia pestis*, the smallpox virus, and *Brucella melitensis* (Kay et al 2014; Wagner et al 2014; Duggan et al 2016).

Since the first recovery of bacterial aDNA in 1993, methods and techniques have significantly improved. Early studies relied on using PCR and restriction mapping[26] or Sanger sequencing[27], techniques that were challenged by the low starting quantity and quality of DNA; also, due to its targeted nature, it is difficult to retrieve information from PCR that is phylogenetically informative (Stone and Ozga 2019). Now, however, aDNA studies utilise next generation sequencing (NGS), particularly the NGS technology commercialised by Illumina (Illumina, US). While Sanger sequencing is limited to sequencing a single strand of DNA at once, NGS is able to simultaneously sequence many DNA fragments, allowing much larger quantities to be sequenced in a shorter period of time.

An Illumina-based NGS workflow follows three basic steps: library preparation, amplification and sequencing. Once a sample of DNA has been acquired, it is first fragmented into short fragments of approximately 200 base pairs length. In aDNA studies, this step is usually unnecessary as DNA is already fragmented through natural degradation. After the sample is fragmented, a known sequence of synthetic oligonucleotides (known as an adapter) is ligated to the ends of fragments. The resulting pool of fragmented DNA with adapters attached is known as the library. The library is then amplified using PCR to provide an enriched sample for sequencing. The sample is first loaded onto a flow cell. This is a glass slide coated with complementary sequences to the adapters. This results in the library attaching to the surface of the cell via the adapters. Fragments are attached in randomly spaced points, and then amplified, creating homogenous clusters.

The exact steps of sequencing at this stage vary depending on the equipment used. The Illumina NextSeq 500 sequencer, which was used in this study, uses sequencing by synthesis. The adapter that is ligated to the fragments include a short primer sequence that provides a starting point for DNA synthesis. Nucleotides used to synthesise the second

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[26] Restriction mapping is a method used to sequence unknown DNA using restriction enzymes which fragment the DNA at specific bases. The restriction sites are then mapped to determine the full sequence.
[27] Sanger sequencing is a sequencing method that uses chain termination to map DNA. Nucleotides with fluorescent labels attached are used to extend DNA strands. The fluorescent labels are read to determine the sequence. Sanger sequencing is limited to sequencing a single strand of DNA at one time.

DNA strand are fluorescently labelled according to one of the four bases they may contain (A, C, G and T). The sequencing is performed in cycles, one nucleotide per cycle, and at each cycle the sequencer detects the fluorescence that is emitted by the incorporated nucleotide. This information is then used to determine the identity of the base and eventually the sequence of the entire synthesised strand and consequently the sequence of the original fragment. Because fragment clusters are spaced out across the flow cell, thousands can be sequenced at once.

The introduction of NGS was a huge boon for aDNA studies. As aDNA degrades over time into fragments of up to 200 base pairs, massively parallel sequencing of shorter fragments was much more efficient than using Sanger sequencing. It also made shotgun sequencing a possibility – the untargeted sequencing of all DNA found in a sample rather than small targeted loci. This method is considered superior to targeted sequencing of 16s ribosomal RNA gene - which is commonly used as a bacterial taxonomic marker - as this approach can produce skewed amplification results due to polymorphisms in ancient microbes (Ziesemer et al 2015). Researchers quickly adopted shotgun sequencing to enable large-scale sequencing of aDNA, using it to sequence and draft woolly mammoth and Neanderthal genomes (Knapp and Hofreiter 2010). However, studies must be careful in their interpretation of shotgun sequencing results, as there is frequently less than 10% endogenous DNA found in archaeological specimen extractions (Knapp and Hofreiter 2010). Use of the technique has enabled researchers to discover unexpected bacteria in material. For example, Vågene et al (2018) were able to discover the presence of *Salmonella enterica* in skeletons from a burial associated with *cocoliztli*, a mysterious disease outbreak in Mexico from 1545-1550, which they proposed as a potential causative candidate. Shotgun sequencing has also been used to investigate changes in the human microbiome over time, focusing on extractions from coprolites (preserved faeces) and dental calculus (Warinner et al 2015).

Degradation and contamination in ancient DNA

A major obstacle to recovering aDNA is low preservation in human remains. DNA begins to destabilise and decline exponentially in just the first 20 days post-mortem (Bär et al 1988). This is particularly relevant to spirit-preserved anatomical specimens, as bodies would have been kept in a natural environment for dissection before being preserved in ethanol. Damage to DNA over time occurs in three ways: fragmentation, blocking lesions and miscoding lesions.

Studies with modern DNA have shown that hydrolysis is the primary force in DNA fragmentation (Lindahl 1993). This is due to hydrolytic depuration – a chemical reaction that results in the remove of the purine bases, guanine (G) and adenine (A), from their phosphate backbone. The exposed abasic site is then vulnerable to fragmentation. This reaction leaves a recognisable fragmentation signature in aDNA which can then be used to help authenticate that DNA samples are ancient and not from modern contamination; A and G bases are overrepresented upstream to the 5` ends of fragments (Briggs et al 2007). Further work has shown that G may be especially overrepresented, as it is thought to require less activation energy to be removed (Overballe-Petersen et al 2012). As well as providing a genetic signature, degradation helps authenticate aDNA through quantifying fragment length, as DNA is typically found in fragments of less than 200bp (Sawyer et al 2012).

Blocking lesions – alterations of DNA that prevent amplification by DNA polymerases – appear to occur mainly through nucleotide modifications and cross-links. These can prevent a significant portion of aDNA being sequenced, as they are found in up to 40% of fragments (Heyn et al 2010). The full mechanisms of nucleotide modifications causing blocks are not yet known, although research has shown that oxidation of pyrimidines (cytosine, C, and thymine, T) and modification of G bases may be particularly relevant (Höss et al 1996; Heyn et al 2010). Crosslinks between molecules can occur through alkylation and Maillard reactions (Rizzi et al 2012). Use of *N*-phenacylthiazolium bromide (PTB) is recommended in extraction protocols as it is thought to potentially help break down these crosslinks; however, evidence for this is mixed so far (Poinar et al 1998; Willerslev and Cooper 2005; Rohland and Hofreiter 2007).

Miscoding lesions are also common, where damage to aDNA causes permanent modifications of bases that results in nucleotide misincorporations during PCR amplification which change the results of downstream sequencing. The majority of these are C to T substitutions, which occur due to the deamination of C to uracil (U) (Brotherton et al 2007). During the amplification step, U bases are converted to T. Treatment of template DNA with uracil *N*-glycosylase is shown to reduce these lesions drastically (Hofreiter et al 2001). However, they can be useful as another authentication marker, as it has been shown that the rate of these substitutions occurring at the 5` end of fragments correlates with the age of aDNA (Sawyer et al 2012).

The bulk of loss of DNA in samples, however, appears to be through diffusion to the surrounding environment (Kistler et al 2017). Preservation is dependent on the environment a specimen is in, what type of tissue the source is, and the structure of the target microbe. A cold, dry environment is thought to be best at preserving aDNA, with some of the oldest recovered samples so far coming from specimens found in permafrost (Stone and Ozga 2019). The type of tissue is also influential, with tissues like teeth and bones creating a more closed system that preserves higher amounts of DNA (Hansen et al 2017). For pathogen studies, however, these anatomical regions may be less useful as they have lower microbial diversity and loads (Margaryan et al 2018). Finally, the structure of the microbe itself may contribute to aDNA preservation. For example, *M. tuberculosis* is well known for its robust cell wall, which helps preserve its structure for longer periods of time as well as retain DNA (Donoghue et al 2015). These factors will all contribute to the likelihood of retrieving pathogen aDNA from any specimen; they are not, however, a guarantee.

Due to the low quality and quantity of template aDNA, these studies are especially vulnerable to contamination. The possibility of modern DNA dominating samples has been a concern since the field began, with some early studies being discredited due to contamination (Hagelberg et al 2015). Gold standards to reduce risk were suggested by Cooper and Poinar in 2000, who emphasised using physically isolated work areas, controls and replication. Since then, the introduction of authentication tools such as *mapDamage* has helped add a degree of certainty to interpreting results by checking mapped sequences for expected fragmentation signatures (Ginolhac et al 2011). However, clean room practices continue to be essential, especially when looking for pathogenic aDNA which may make up less than 0.1% of a purified sample (Key et al 2017). A dedicated working area, separate to labs that use modern DNA, is vital to avoid risk. Ideal facilities are positively pressurised to avoid inflow of air, and maintain sterility through measures such as nightly UV irradiation, full-body suits and strict workflows (Fulton and Shapiro 2019).

Genetic and Molecular Studies of *Treponema pallidum*

Molecular studies of the venereal syphilis have been difficult, as *T. pallidum* is not fully cultivable *in vitro*. Conditions were established in the 1980s that allowed limited replication of motile and virulent *T. pallidum* (Fieldsteel et al 1981). Even with improvements over time, however, this still does not allow for continuous cultivation (Radolf et al 2016). This limitation means that there is still much to learn about the pathogenesis of syphilis. The work on genetics and kinetics in the human body that has been done so far is summarised here.

Genetics

Syphilis is caused by the bacterium *T. pallidum* subsp. *pallidum* (referred to henceforth as *T. pallidum*). However, there are also a number of closely related diseases caused by other subspecies of the bacteria: yaws (*T. pallidum* subsp. *pertenue*, referred to henceforth as *T. pertenue*), and bejel (*T. pallidum* subsp. *endemica*, referred to henceforth as *T. endemica*). The clinical presentations of these diseases are described in chapter one. The three subspecies have very little genetic variation between them. Therefore, identifying *T. pallidum* genetically with aDNA presents a challenge.

The breakthrough for genetic understanding of *T. pallidum* and its relatives came with a landmark DNA-DNA hybridisation paper (Fieldsteel and Miao 1980). This study showed that *T. pallidum* and *T. pertenue* were genetically indistinguishable, which led to their reclassification as subspecies. The low genetic variability found by Miao and Fieldsteel was confirmed by Čejková et al (2012), who compared whole genome sequences of the two subspecies and discovered less than 0.2% difference.

Many other genetic studies of *T. pallidum* have also concentrated on comparisons between the different treponemal diseases. This is both of historical and clinical interest, as finding genetic signatures for each subspecies would be diagnostically useful. For example, Noordhoek et al. (1989) investigated a SNP in the *tpf-1* gene in *T. pallidum* and *T.*

pertinue, which is thought to code for an outer membrane protein. This appeared to show variation between yaws and syphilis; however, a later study found this trait was not subspecies specific (Noordhoek et al 1990). Similarly, Cameron et al. (1999) located a SNP in the gene encoding glycerophosphodiester phosphodiesterase, although this could only be used reliably to differentiate strains of *T. pallidum* and not between subspecies. More successfully, Centurion-Lara et al. (2006) discovered that variability in the flanking regions of the *ttp15* gene could be used to distinguish *T. pallidum* subsp. *pallidum*, *pertenu* and *endemicum* (responsible for bejel).

Comparative genomics has now found 22 genes which may potentially account for the difference in virulence and invasiveness between syphilis, yaws and bejel (Radolf et al 2016). 12 of these belong to the *tpr* gene family, which are thought to play a role in immune system evasion (Radolf and Desrosiers 2009). Sequence diversity in this family closely matches differences originally defined from clinical manifestations and modes of transmission (Centurion-Lara et al 2013). Further studies into these candidates may yield insights about the pathogenesis of treponemal disease.

These methods have also been used to attempt to discover the origins of venereal syphilis in the Western world. Current theories include the Columbian exchange, which posits that syphilis was brought from the New World by Christopher Columbus; and the Unitarian theory, which states that the treponematoses are a single disease which manifests differently between environments (see chapter one). Harper et al. (2008) attempted to address this debate by using phylogenetics to compare 21 genetic regions of *T. pallidum, T. pertenue* and *T. endemicum*. This showed that *T. pertenue* was the first subspecies to emerge, followed by *T. endemicum* and most recently *T. pallidum*, supporting an evolution that followed human migration from hot and humid areas to more dry regions. It also showed that New World strains of *T. pertenue* were more closely related to *T. pallidum* than Old World strains. This evidence would support movement of yaws from the Old World, through Asia, into the New World; which then could have been introduced back into the Old World as venereal syphilis. In other words, phylogenetic evidence appeared to support the Columbian exchange hypothesis. However, it is important to note that on its own, this evidence is not conclusive.

Kinetics

An understanding of the kinetics of *T. pallidum* in the body is important to understand how to target sampling for genetic analysis. As described in greater detail below, attempts to recover syphilitic aDNA have been difficult due to the low bacterial load in bony tissue. Investigating tissues which have known higher bacterial loads will improve the chances for recovering aDNA.

The abilities of *T. pallidum* to attach to mammalian host cells and extra-cellular matrix is well-documented (Fitzgerald et al 1977; Hayes et al 1977; Quist et al 1983; Fitzgerald et al 1984). In culture, this attachment improves the survivability of the bacteria; this may be due to its dependence on the host for nutrition, for protection or for anchorage (Norris et al 2001). They are also able to penetrate endothelial intercellular junctions (Thomas et al 1988). The combination of rapid attachment and motility contribute to *T. pallidum*’s invasiveness and virulence.

In initial infection, quick attachment to host cells followed by rapid dissemination through the lymph and blood is thought to be an important step in infection (LaFond and Lukehart 2006; Radolf et al 2016). *T. pallidum* is measurable by serological tests in the blood within 24 hours of infection, with loads increasing over a period of 10 days (Salazar et al 2007). This load increase is caused by replication of the bacteria at the initial site of infection (Sell et al 1985). *T. pallidum* is then rapidly spread to other tissues. In rabbit models, it can be found using serological tests in the spleen in particularly high loads - as well as the kidneys, liver and brain - as early as 10-14 days after infection (Salazar et al 2007). The bacteria remains virulent throughout these tissues, as shown by experiments which used skin, brain, spleen and lymph tissue to infect other animals 45 days after infection (Rosahn et al 1948).

High numbers of spirochetes are detectable in primary lesions, where they are concentrated around the walls of capillaries in a perivascular pattern (Martín-Ezquerra et al 2009). During the secondary phase, *T. pallidum* is still present in lesion biopsies, although it is characterised by presence in the lower mucosa and epidermis at this stage (Martín-

Ezquerra et al 2009). It has also been shown that high loads of circulating bacteria are present in blood during the secondary phase (Cruz et al 2010).

At some point in the secondary phase, the immune system overcomes the high load of *T. pallidum* and burden is reduced, initiating latency. Details of how this occurs and where the bacteria then resides are uncertain (Radolf et al 2016). Sell (1985) showed that in rabbits that had been previously infected with syphilis, inoculations of *T. pallidum* resulted in rapid clearance with remaining organisms focused around hair follicles, erector pili muscles and nerve fibres. It has been theorised that these are immune protected niches, and *T. pallidum* uses these types of locations to hide from the immune system during the latent phase (Norris et al 2001). It has also been found that lymphatic tissue can still be used to infect other animals during latency (LaFond and Lukehart 2006).

Even less is known about *T. pallidum* burden and distribution during the tertiary stage. It has been shown, however, that low numbers of spirochetes are detectable in cutaneous tertiary gumma (Handsfield 1983). Overall, this body of research points to mucocutaneous lesions – primary, secondary and tertiary – and lymphatic tissue as prime tissues to find *T. pallidum*.

Ancient DNA studies in *Treponema pallidum*

Finding treponemal aDNA has, so far, been contentious. Early studies were successful in using PCR to amplify *T. pallidum* DNA from paraffin-embedded tissues (Burstain et al 1991; Zoechling et al 1997). This led to the hope that syphilitic DNA would be recoverable from archaeological specimens as well. Kolman et al. (1999) were able to detect *T. pallidum* in 200-year-old skeletal remains, while using extensive precautions against contamination; however, they used 15g of bone to get results, while typical aDNA studies use significantly smaller amounts of <1g.

Studies over the following decade were not so successful. Barnes and Thomas (2006) investigated 59 eighteenth and twentieth century skeletons for both *M. tuberculosis* and *T. pallidum*. They were able to amplify DNA from the former but not the latter, despite having a large number of specimens to test. Similarly, Bouwman and Brown (2005) were unsuccessful in amplifying *T. pallidum* from a set of 46 bones dating from ninth to nineteenth centuries. They concluded from their own efforts that ancient DNA could not be used to investigate venereal syphilis. This was followed by von Hunnius et al. (2007), who were once again unable to retrieve syphilitic DNA from skeletal specimens.

These studies all attempted to use skeletal remains to find syphilitic DNA. In order for this to be successful, pathogens must be taken into bony material via remodelling or the blood (Bouwman and Brown 2005). As outlined previously, the kinetics of *T. pallidum* during the various stages of syphilis are not well understood, but it appears that the highest load of the pathogen may be in the skin and lymphatic system rather than the bone. Von Hunnius et al. (2007) confirmed that the numbers of spirochetes in the bone at latter stages of disease were not significantly high in a rabbit model. Therefore, soft tissues may make a better target for the recovery of syphilitic DNA. All studies published as of yet appear to target skeletal remains, although one unpublished thesis was able to recover potential treponemal DNA from South American mummies (Kaye 2008).

In order to counter the pathogen load in adult bones, studies have targeted different sampling sites. As well as soft tissues, neonatal and infant remains with congenital syphilis also represent a better site for DNA retrieval due to a much higher spirochete burden. This approach found success when Montiel et al. (2012) amplified non-specific treponemal DNA from four infant skeletons with pathological signs of treponemal disease, excavated from crypts in the Huelva province of Spain dating from the sixteenth or seventeenth century. Targeting infant remains has continued to yield positive results and uncover ancient treponemal DNA (Guedes et al 2018; Schuenemann et al 2018; Meffray et al 2019). These successes reinforce the theory that early failures were due to low treponemal counts in the bone and show that soft tissues could equally be a promising source.

The advent of newer technology has also provided new opportunities for the study of ancient syphilis. Recovery of aDNA has previously relied heavily on PCR targeting, and the introduction of NGS has enabled researchers to avoid many of the pitfalls that are associated with this. Although Bouwman and Brown (2005) concluded that retrieval of venereal syphilis DNA is not possible, one of the same researchers stated more recently that NGS had now made it ‘highly likely’ that *T. pallidum* will soon be sequenced in ancient specimens (Bouwman and Rühli 2016). This prediction turned out to be wholly accurate; the first whole genome study of ancient syphilis was published by Schuenemann et al. in 2018, who were able to use NGS to reconstruct three *T. pallidum* subspecies genomes**.** Two of these were *T. pallidum* subsp. *pallidum*, responsible for syphilis, and one was *T. pallidum* subsp. *pertinue*, responsible for yaws. In that study, DNA was sampled from skeletons excavated from a convent burial ground, which was in use from 1681-1861. All samples were from infants, using only 50mg of ground bone (compared to 15g in earlier studies based on adults). The genomes were constructed to a sufficient depth to investigate genes related to virulence, which appeared to be largely similar to modern strains. They also provided evidence for potential horizontal recombination events between the subspecies, which were previously thought to be clonal.

So far, syphilis has proven difficult to sequence conclusively from historic human remains. Improvements have been based on two major changes. First, targeting remains with a higher treponemal load has shown high success rates, specifically so far by taking samples from infant remains. Second, the introduction of next generation sequencing has enabled genomic reconstruction even when bacterial remains are a miniscule portion of DNA purified from the sample. This project, therefore, aims to use both of these factors to improve the chances for recovering aDNA. First, specimens that are more likely to have an increased load of bacteria will be targeted; in this case, soft tissue specimens. Second, the study will use shotgun sequencing to increase the chances of capturing any remaining treponemal DNA. The particular issues of using soft tissue specimens, which are preserved as in Hunter’s collection as wet preparations, are explored in the next section.

Ethanol preservation & DNA extraction

The focus of The Hunterian’s anatomical collections are the preparations left to the University of Glasgow by William Hunter. This collection is a mix of dry and wet specimens. Wet specimens were preserved in either spirit of wine or oil of turpentine, both methods of spirit preservation. Exact details of the composition of fluids are difficult to know; however, both are alcohol-based and so they can be compared to ethanol preservation. The specimens predate the use of formaldehyde.

Ethanol preservation is routinely used in the storage of natural history specimens in museums. Previous studies have found that ethanol storage is favourable for extracting DNA (Dillon et al 1996; Chakraborty et al 2006; Zimmermann et al 2008). However, these studies focus on recent specimens (within 5 years of collection) and 95-100% ethanol. These conditions differ to those of specimens in The Hunterian, which are over 200 years old and stored in alcohol which has likely reduced to ~40% ethanol (Barnes et al 2000).

Recommendations for the use of ethanol storage for long term DNA extraction come with caveats. First, as mentioned, a high percentage concentration ethanol is recommended, and it is suggested that even at 75% DNA degradation can occur within a year (Nagy 2010). Nagy also recommends a high ratio of ethanol to tissue (5:1), replacement of ethanol regularly when the specimen is first preserved, and injection of the specimen with ethanol. Replenishment of alcohol in the early stages appears to be particularly important, as without this the acidification of DNA can occur (Jackson et al 2012). Fortunately, eighteenth-century advice for preserving specimens to the best effect was in line with these recommendations. John Hunter specified the need to replace the fluids regularly when first preserving specimens 'because the first Spirit, which enters the Substance of the Part to be preserved, will be considerably lowered, and discoloured' (J. Hunter 1809: 33–34). He also described injections of spirit into the specimens themselves in order to avoid putrefaction (J. Hunter 1809: 28, 31). Although he was aware of the need to use the strongest spirit possible, he was limited in this by what was available at the time. Anatomists typically used rectified spirits - wine purified through repeated distillations - although turpentine was also occasionally used (Chaplin 2009: 149).

Ethanol preservations are also sensitive to time and heat; long term preservation is recommended in -80 C (Nagy 2010). Unfortunately, the collection at The Hunterian have been subject to varying temperatures over long periods of time, as specimens are not kept in temperature-controlled conditions. Finally, lipid leaching is a risk in ethanol-preserved specimens. It is well established that mammal specimens release amino acids and lipids into storage fluids (Marte et al 2003). As Barnes et al (2000) note, this is likely to result in DNA escaping into the fluid meaning that when this is changed during conservation efforts, DNA may be lost. When the collection was reorganised in 1900 by Teacher, he remounted a large proportion of the specimens; however, his notes regarding this have not survived and unfortunately records do not note which were changed (Teacher 1900: xviii–xix). Any other ethanol changes have not been recorded, so it is difficult to know how often this has happened or quantify how much DNA may potentially have been lost.

Results of extractions from archived, spirit-preserved specimens have so far been mixed. Studies have tried using different extraction methods to find which are most successful. There are three main types of DNA extraction; organic, chelation or solid phase. All types must follow the same basic steps. First, the cells must be lysed (i.e. broken open) to release the DNA. Second, the DNA must be separated from the rest of the contents of the cell. And finally, precipitated DNA must be purified to remove other unwanted molecules. Organic extraction uses chemical solutions, particularly phenol and chloroform, to separate DNA. Chelation extraction uses chelating beads to bind with DNA. Solid phase extraction uses centrifuges to pass sample solution through a silica membrane, which binds with DNA molecules. Using different methods can result in differing yields of purified DNA from samples.

De Bruyn et al. (2011) were successful in extracting DNA from alcohol-preserved fish collected in 1924 and 1930. This was achieved using an adapted silicon-based method, after failure of other methods including phenol-chloroform and QIAgen’s mini kit. Austin and Arnold (2006) achieved a 57-78% success rate in extracting genomic and mitochondrial DNA from a variety of ethanol-preserved museum specimens by using DNEasy, another silicon-based kit. Junqueira et al. (2002) compared extracting DNA from ethanol-preserved flies by using a variety of methods: DNAzol, an organic reagent; Chelex, a chelating reagent; and a standard phenol-chloroform method. Phenol-chloroform obtained no results, and DNAzol was the most effective at extracting DNA.

However, these studies target natural history collections, and sample the DNA of the specimen itself rather than associated pathogens. Attempts to recover pathogenic DNA from ethanol-preserved human material appear to be less common. Barnes et al. (2000) used specimens from John Hunter’s collection in the Royal College of Surgeons to attempt to purify *Helicobacter pylori* DNA, using both silicon-based and phenol-chloroform methods. These were unable to produce any PCR amplification targeting *H. pylori* or human mitochondrial DNA. More recently, Devault et al. (2014) were successful in using an organic extraction method and high-throughput sequencing to construct a *Vibrio cholera* genome from a nineteenth-century, wet-preserved gut specimen. However, this particular specimen appears to have been prepared using turpentine rather than spirits. Any success in this project will, therefore, mark the first recovery of DNA from eighteenth-century spirit specimens.

Ancient DNA, defining diseases, and retrospective diagnosis

Most of this thesis has focused on the history of how venereal disease was defined, diagnosed and debated from a social perspective. This chapter takes a different approach by introducing the biological aspect of venereal disease. It is important to address here how these two types of evidence can be used together, while avoiding making anachronistic claims or diagnoses about eighteenth-century disease.

Retrospective diagnosis is the practice of assigning a modern diagnostic label to historical figures. Often this targets famous people: for example, Frederic Chopin has been diagnosed with cystic fibrosis, Robert Burns with bipolar disorder, Hieronymous Bosch with schizophrenia, Nietzche with various neurological disorders, and so on (O’Shea 1987; Hemelsoet et al 2008; Charlier and Deo 2018; Hansen et al 2018). Karenberg (2009) summarises two major problematic aspects to this practice. First, it is speculative. Patients are diagnosed without ever being examined, based on texts written in a different culture and time from our own. Although diagnosis-by-letter was common practice in the eighteenth century, modern diagnosis depends on both clinical examination and laboratory results. Second, it is anachronistic and based on the assumption that our modern labels are the ‘correct’ ones to apply. As our own knowledge of medicine and disease changes, so too will how we interpret diseases in the past. Adding to this, there is often an assumption of a one-to-one mapping of historic and modern disease labels. Arrizabalaga (2002) points out the problems of this when investigating typhus, a term which has been historically used to describe many different diseases in the past but a single modern one. To combat these issues, Mitchell (2016) has suggested ways to improve the reliability of diagnoses, focused on reinforcing proper academic rigor by examining textual documents critically and within their social context.

Retrospective diagnosis also typically ignores the importance of the social aspects of disease. Cunningham (2002) stresses that ‘the identity of any disease is made up of a compound of elements, of which the biological or medical is only one, and sometimes the least important one’. In concentrating on what modern disease a historical figure had, we risk overlooking the actual patient experience and the social context of their disease. However, this does not mean that retrospective diagnosis could never be useful. Mitchell (2011) points out that, while this method may not be critical enough for understanding individuals and society, it is still helpful for understanding the actual microbes underlying the disease and their history, evolution and epidemiology.

Biological evidence must be used in combination with historical research to better understand both the disease itself and its social construction. For any of the specimens used in this project, finding genetic evidence of the presence of *T. pallidum* or *N. gonorrhoeae* would not be enough to simply say that the patient was suffering from syphilis or gonorrhoea, which had their own definitions during the period. Similarly, finding other pathogens in specimens diagnosed with venereal disease would not warrant overturning that diagnosis and pronouncing it incorrect.

Cunningham (2002) suggests that rather than trying to study the diseases of patients, we investigate how their diagnosis happened. In taking this approach, the biological component of a historic patient’s diagnosis can add to a bigger picture, rather than replacing it. Being aware of what modern diseases medical practitioners would include in the umbrella of ‘venereal disease’ during the process of diagnosis can help us potentially understand how symptoms were clustered and what shared aspects of those diseases were ultimately important in defining venereal disease. As seen throughout this thesis, the clinical definition of syphilis was highly unstable.

For example, previous historians have suggested that syphilitic chancres described in the eighteenth and nineteenth centuries may actually be attributable to chancroid, a necrotising disease caused by the bacteria *Haemophilus ducreyi* (Oriel 1994: 31–33). As discussed in previous chapters, the differential diagnosis of genital ulcers was a controversial topic in the eighteenth century. As *H. ducreyi* causes ulcers that are distinctive from those caused by *T. pallidum,* having evidence that the two were both considered under the venereal disease label would help us better understand the diagnostic process of ulcers. In this way, we can use distinctive kinds of evidence together in order to understand historic diseases and medical practice without resorting to anachronisms.

Ethics

Ethics approval was granted by the ethics committee of the College of Medical Veterinary and Life Sciences in the University of Glasgow. DNA analysis of human remains in Scotland is legally regulated by the Human Tissue Act 2004, which states that consent for analysing DNA is not required when at least 100 years have elapsed since the time of death (Human Tissue Authority 2017). Most specimens in this study were collected in the eighteenth century, and one around the turn of the nineteenth century, meaning all were deceased outside this timeframe.

Of course, ethical obligations should go beyond the minimum requirements of the law. While consent is not strictly required for these specimens, it is important to understand the context they were acquired in. Sources of bodies for eighteenth- and nineteenth-century anatomists to dissect are notoriously questionable. Graverobbing was an open secret among practitioners, and although all bodies were considered targets, vulnerable populations were especially affected such as the poor or, in North America, black and native cemeteries (Halperin 2007; Walker et al 2014). However, this was not the source for all pathological specimens. Some were obtained during legitimate post-mortems undertaken in hospitals and patient's homes (Chaplin 2012: 102–3). Many bodies were also obtained legally through executions via the Murder Act of 1752, which stipulated that the Company of Surgeons dissected the bodies of murderers (Mitchell et al 2011). It is often impossible to tell how individual specimens were obtained, as the information is simply not provided. In the case of the specimens used in this project, only one has a clear background on how it was obtained: VD3, the penis with a chancre, which was taken during a legal dissection after the execution of Solomon Porter and is discussed in more detail in the previous chapter.

Although there has been some discussion of the ethics of obtaining aDNA, this is typically focused on the effect on marginalised communities. For example, indigenous North American scientists have made calls for community consultation on aDNA studies of ancestral remains that could have potential impacts on modern Indigenous identities (Bardill et al 2018). Similarly, studies using remains that are considered looted are highly contentious, with a recent genetic study of a mummy resulting in the Chilean Monuments

Agency launching an investigation into how scientists obtained the corpse (Zimmer 2018). The lack of standard ethical guidance within the field means there is a risk of aDNA studies exploiting bodies for science in a way that mirrors grave robbing for dissection, as Highet (2005) argues happened with early anthropological studies that used Native American archaeological remains. The recent recovery of treponemal DNA by Guedes et al. (2018), for example, used bodies from a burial ground known to be associated with enslaved African people for their work; the published paper overlooks the significant question of whether this is an acceptable source of cadavers for ethical scientific study.

The use of human remains for aDNA studies in British collections has produced less discussion, although the case of Charles Byrne - an eighteenth-century Irishman with acromegaly (a hormone disorder resulting in excessive growth) - is of particular relevance. Byrne’s refusal to donate his body for dissection is well known. After his death, he requested that his body be buried at sea. His friends watched over his casket on the journey to protect it from anatomists; nonetheless, John Hunter somehow managed to obtain Byrne’s body anyway. Byrne’s skeleton remains in the collection at the Royal College of Surgeons to this day, and despite his objections being common knowledge he has been subject to a variety of analyses. Most recently, DNA was obtained from one of Byrne’s teeth in order to identify a genetic mutation related to acromegaly (Chahal et al 2011). Notably, the authors of the paper made no mention of Byrne’s background beyond that his skeleton was ‘acquired by the surgeon John Hunter’. Doyal - a medical ethicist - and Muinzer – a lawyer – argued in response that it was time to rebury Byrne as per his wishes, from both an ethical and a legal perspective (Doyal and Muinzer 2011; Muinzer 2013). However, the Royal College of Surgeons rejected the suggestion at the time (‘Royal College of Surgeons Rejects Call to Bury Skeleton of “Irish Giant”’ 2011). Muinzer has continued to publicly campaign for the reburial of Charles Byrne; as a result, the Royal College of Surgeons finally acquiesced in 2018 to at least discuss the matter further (Devlin 2018). This protracted defence of the scientific use of a body known to be stolen illustrates how much work the aDNA community still needs to do with regard to ethics.

Finally, as well as consent, there is also the issue of testing valuable and limited historical resources to destruction. This chapter began with a quote from Hunter regarding this aspect of the preparations: ‘Many of them are the result of patient labour, and not easily restored;

many of them such rarities as are not easily recoverable' (W. Hunter 1784: 112). It is important to preserve these specimens for the historical record. Although sample sizes have been kept minimal, taking any samples runs the risk of changing the appearance of the specimens.

In order to attempt to establish an ethical framework in this research, I have referred to the Institute of Conservation's (ICON) guidance to help researchers and curators make decisions around scientific sampling of museum objects (Quye and Strlič 2019). The ICON guidance begins by asking if the sampling being proposed is 'possible', i.e. whether the object is too sensitive for modification and if the museum's research policy allows it. In this case, appropriate permissions were requested through curators at The Hunterian, who granted them in accordance with their research policy. Second, the guidance asks whether sampling is 'essential' to answer the proposed research question, or if it is completely unnecessary or potentially non-invasive sampling methods could be used instead. For these specimens, it is necessary to take a small sample to test for DNA. Although some efforts have been made to extract DNA from museum specimens without any destruction, these are not well established and their effect on pathological specimens is unknown (Rohland et al 2004; Thomsen et al 2009; Hofreiter 2012). This means that taking small samples for destruction would likely pose less risk.

After 'essential' and 'possible' has been established, the ICON guidance recommends ensuring that the research question is both well-defined and that the sampling is relevant to the question. Although this study is speculative, there are specific goals in mind as well as the potential to make important contributions to the field. The preceding chapter examining the specimens from a material culture perspective has helped to define their context before sampling; genetic analysis is relevant to this study as it will add a biological dimension to our understanding of the monist-dualist debate. ICON guidance also recommends researchers carefully consider their sampling methods to take the least risk possible. It is important to acknowledge the advantages and limitations of the proposed methods of sampling. As DNA has not previously been sequenced from eighteenth-century spirit specimens, there were no established methods for extraction. To reduce risk, methods were tested on modern ethanol-stored specimens to demonstrate their effectiveness before being used with historic specimens. Finally, the physical size of samples was kept to a minimum and preferentially taken from areas which would be less aesthetically noticeable.

Returning to the question of consent, the source of most of the specimens used here is unknown, and the patients are anonymous, except for Solomon Porter; his samples were therefore excluded from the study. Before any future work involving Porter’s remains, I would suggest heeding Bardil’s call to include the affected community in any research, and consulting with modern Jewish authorities to determine the best course of action. This case highlights the need for proper due diligence and historical collaboration when undertaking scientific studies.

Methods

Specimen sampling

Specimens were all chosen from the anatomy and pathology collection at The Hunterian, Glasgow, UK (table 6-1). With the exception of one, all were donated by Dr William Hunter (1718-1783), eighteenth-century anatomist and obstetrician. Records were not kept for dates of specimen collection, although it is likely that all were prepared between his arrival in London in 1740 and his death in 1783. VD1 - included as a more recent comparison - was donated by J.K. Kelly, a gynaecologist at the Glasgow Royal Infirmary. Again, the precise date for the specimen is unknown; it was likely collected around the turn of the twentieth century. All eighteenth-century specimens pre-date the introduction of formaldehyde and were stored in distilled alcohol. As Barnes et al. (2000) have previously noted, changing the ethanol for a specimen during routine conservation is likely to reduce the likelihood of DNA recovery. Many of the specimens were remounted and had their ethanol replaced around 1900 by the pathologist J.H. Teacher, although records are unclear on which specimens he refreshed. Conservation records since are patchy, and it is unclear how regularly the spirits have been changed. The preservation methods for GLAHM:121849 are unknown.

Samples were taken from specimens with the assistance of curatorial staff. The seal for jars was opened using a heated scalpel blade. Specimens were then removed from their jar and placed in a clean area, where samples were taken using either single-use, sterile scalpels or biopsy guns. Biopsy guns were sterile, single-use Max-Core guns (Bard Medical UK) with a needle gauge of 18g and sample notch length of 18mm. At least two samples were taken from each specimen. Tuberculosis samples were approximately 25 milligrams each. As no weighing scales were available in the pre-PCR lab where syphilis samples were taken, sample size was approximately 5mm x 5mm or a single biopsy core. After sampling, the specimens were returned to their jars and the ethanol replaced. The jars were then resealed. Samples were placed into individual 0.5mL sterile microcentrifuge tubes in 90% ethanol (diluted with sterile, RNAse-free water) and stored at 4°C.

Sample designation	Accession number	Current description	Donated by	Original diagnosis	Anatomic region sampled
TB1	GLAHM:120926	Tuberculosis of the lungs: phthisis pulmonalis.	William Hunter	Tuberculosis	Lung
TB2	GLAHM:120927	Tuberculosis of the lungs: phthisis pulmonalis.	William Hunter	Tuberculosis	Lung
TB3	GLAHM:121339	Tuberculosis of the kidney.	William Hunter	Tuberculosis	Kidney
VD1	GLAHM:121849	Pyosalpinx.	J.K. Kelly (fl. 1908)	Gonorrhoea	Ovary
VD2	GLAHM:121427	Inflammatory occlusion of the vagina.	William Hunter	Venereal inflammation	Cervix and vagina
VD3	GLAHM:121404	Chancres of the glans penis.	William Hunter	Chancre (non-specific)	Penis
VD4	GLAHM:121054	Gumma of the pia mater.	William Hunter	Venereal disease	Pia mater
VD5	GLAHM:121058	Tumour of the brain.	William Hunter	Tumours with suspected venereal disease	Dura mater
VD6	GLAHM:120909	Syphilis of the nose.	William Hunter	Lues venerea	Nasal septum mucosa

Table 6-1 - Details of specimens used from The Hunterian, Glasgow.

Methods development

DNA extraction in this project faced compound issues due to both the difficulty in recovering treponemal aDNA and recovering DNA from historic spirit specimens, as outlined in the introduction. In order to mitigate these, a scheme of staged testing was devised for extraction methods. The aim was to find an off-the-shelf method which could easily be replicated to extract DNA from other museum collections of anatomical specimens.

A range of extraction methods (described fully below) were first all tested with modern ethanol-preserved specimens, GLAHM:126971 and GLAHM:126873. GLAHM:126971 is a wood mouse (*Apodemus sylvaticus*) specimen, collected in 2003. GLAHM:126873 is a short-tailed field vole (*Microtus agrestis*) collected in 2008. Both were preserved in ethanol only. Samples weighing approximately 25 milligrams were taken for testing from the liver of each specimen. At this stage, the aim was to ensure that all kits were compatible with spirit specimens. One extracted sample from GLAHM:126971 (the wood mouse) was also sequenced and screened with *FastQ Screen* to ensure that DNA from the expected species had been extracted; this software aligns a portion of all sequenced reads against the chosen organisms to check if they are present (Wingett and Andrews 2018).

A second stage of testing was then done using three historic specimens with tuberculosis, namely specimens TB1, TB2 and TB3 (table 6-1). These were chosen as *M. tuberculosis* DNA is retained more consistently from historic remains than treponemal DNA, due to the microbe’s cell structure (Donoghue et al 2015). This meant that the second stage would specifically test whether eighteenth-century spirit specimens were viable sources of aDNA without adding the uncertainty of recovering treponemal DNA. The second stage was used to select the most effective method before moving onto testing the venereal specimens.

Contamination

Contamination with modern sources is a known issue when examining ancient DNA. There is a particular risk with the soft tissue specimens used due to previous handling by museum staff, and as they cannot be directly cleaned without risk of damage. In order to avoid surface contamination, core biopsies were used wherever possible. All procedures took place in a contained fume hood, after a rigorous cleaning protocol of surfaces and tools using ethanol, detergent, Microsol and at least one hour exposure to UV light. Protective clothing (gloves, disposable coats and face masks) was used at all times.

Pre-PCR processing of the tuberculosis and venereal samples occurred in different locations. Tuberculosis samples were processed in a contained area within a building where modern DNA research occurs. However, the lab space is not used to routinely amplify *M. tuberculosis* DNA or culture mycobacterial strains, which lowers the risk of contamination with modern bacterial DNA. Venereal samples were processed in a dedicated area within a building where no modern DNA research takes place, as recommended to avoid contamination (Cooper and Poinar 2000).

All post-PCR processing was done in a modern DNA lab. To ensure that no contamination occurred, negative blank controls were introduced at both the extraction and library preparation stages during all procedures, and any mapped sequences were tested for aDNA fragmentation patterens using *mapDamage 2.0* (Jónsson et al 2013). Key et al. (2017) recommends checking for homogenous distribution along the genome as an extra authentication step; this was done visually using *Tablet* (Milne et al 2010).

Extraction, library preparation and sequencing

A variety of extraction kits were tested with the modern mouse samples and historic tuberculosis samples to determine which worked most effectively, with the goal of maximising DNA yield (table 6-2). Three off-the-shelf kits were selected: DNEasy Blood & Tissue (Qiagen), DNA IQ (Promega), and DNAzol (ThermoFisher). All three kits were also tested with and without the addition of PTB (N-phenacylthiazolium bromide), which has been shown to increase the amount of DNA recovered in some ancient specimens. Two replicates were extracted for each combination of kit, PTB and specimen. The resulting amount of DNA (ng) from starting tissue (mg) was compared using an ANOVA test with Excel.

For the venereal specimens, all samples were purified using the DNEasy Blood & Tissue (Qiagen) kit following manufacturer’s instructions. Extraction took place in the dedicated ancient DNA space, separate from modern DNA work. A number of the samples underwent library preparation with the NebNext Ultra II kit (New England Biolabs), following manufacturer’s instruction but removing the size selection step (table 6-3). The resulting libraries were quantified using a Qubit Fluorometer (ThermoFisher Scientific) and checked for average fragment size with a 2100 Bioanalyzer (Agilent). Libraries were sequenced with Illumina NextSeq. Negative controls with quantifiable DNA were also sequenced for comparison.

A full, step-by-step version of the final extraction and library preparation protocol is included in Appendix C.

Analysis

After sequencing, all venereal samples were processed using *Centrifuge* ver 1.0.3, a microbial metagenomics classification program (Kim et al 2016). The *Centrifuge* index for all completed bacterial and viral genomes was used as a reference. This index is based on the current NCBI taxonomy and uses the associated genomes stored in the NCBI database. *Centrifuge* aligns reads generated from samples to this full index of genomes and presents an overview of which organisms the sample had matched reads to.

It is important to note that the result of a partial alignment in *Centrifuge* is not necessarily confirmation that the bacteria or virus is present in the specimen, but rather a guide that they may potentially be. Output is presented for all organisms in the indexed database, regardless of whether a match can be considered positive or not. *Centrifuge* can align the same sequenced fragment read to multiple organisms; this means that false positives are common. These may be due to shared stretches of genomic sequences, highly conserved sequences, artefacts of PCR, or trace amounts of contamination from the lab environment. To narrow the number of genomic alignments down, *Centrifuge* results were initially filtered for false positives by removing any matches with less than 100 unique reads (meaning unique to that particular genome, rather than reads that could also match with other genomes), and less than 25% maximum potential coverage. Maximum potential coverage was calculated by multiplying total number of aligned reads with maximum read length, taken as a percentage of the genome size. In order to narrow down to endogenous bacteria, common environmental bacteria which are known possible contaminants and also not of pathological interest were filtered from results (Salter et al 2014). The remaining candidates from metagenomic screening were then checked for medical relevance. This produced a shortlist of potential bacterial and viral matches (table 6-6).

Reference genomes for these microbes were downloaded from the GenBank database to be analysed more closely (table 6-6). The sequenced reads for each sample were aligned to the reference genomes using *Bowtie* ver 2.2.5 software[28] (Langmead and Salzberg 2012). *Samtools* ver 1.1 software was used to convert the resulting SAM alignment file (text format) to the binary, compressed BAM format, then sort the reads and filter for mapped reads only (Li et al 2009). Duplicate reads, which are likely to be PCR artefacts, were then removed with *Picard* ver 1.139 software (Broad Institute [n.d.]). Genomic coverage (the percentage of the reference genome that has been sequenced and matched) and depth (the average number of reads per base) were calculated using *pileup* ver 1 software (Vanderkam et al 2016).

[28] Command line used with the following flags: *bowtie2 -t --phred33 -k 10 -p 12 -x*

Results

Extraction

DNA extraction from the modern rodent samples was successful with DNEasy, DNAzol and DNA IQ. A subset of reads for the sample sequenced was screened with *FastQ Screen* to confirm the presence of *A. sylvaticus*. The screen found 85% of the 500,000 reads processed aligned with the *A. sylvaticus* genome. 13% of the reads aligned with the human genome, but of these only 1.8% were unique hits and the rest were shared across multiple genomes. This confirms that DNA extracted from the specimen as expected.

DNA extraction from the three tuberculosis samples was successful with DNEasy (with and without PTB) and DNA IQ (without PTB only) (table 6-2). All attempts to use DNAzol and DNA IQ with PTB were unsuccessful. Combined extraction results (nanogram of DNA purified per milligram of tissue) for the three successful methods were compared using an ANOVA test, which found no significant difference between them ($p=0.16$). However, DNA IQ was successful with only 50% of samples, while both DNEasy methods had a 100% success rate. As there was no significant difference between using PTB and not ($p=0.88$), the additional step appears to not be useful in extracting from spirit-stored specimens. For this reason, DNEasy without the use of PTB was selected as the most sensible choice to use with the proceeding specimens.

All venereal samples were extracted with DNEasy without PTB (the final full step-by-step protocol is available in Appendix C). Samples from VD5 were excluded from the study after failure during the extraction process. Amount of DNA extracted from each sample after library preparation and PCR is in table 6-2.

Mycobacterium tuberculosis sequencing

Libraries were prepared and sequenced for each TB specimen, using the sample with the highest yield for every successful extraction method (table 6-2). Each sample was analysed separately first (Table 4). All sequenced samples per specimen were then combined and analysed together, in order to maximise available reads (table 6-4).

After alignment to the reference genome, each specimen showed some traces of *M. tuberculosis*[29] (table 6-4). However, the reads generated from both TB2 and TB3 covered less than 10% of the genome with an average coverage depth of less than 1x, meaning there is a low level of certainty for the presence of the bacteria. TB1 was significantly more successful, with 70.3% of the *M. tuberculosis* genome covered at an average 2x depth.

Venereal specimen sequencing

After *Centrifuge* results for the samples were filtered for as described in the methods section, most had no remaining potential genome matches of sufficient quality to continue analysis. For completion, *Centrifuge* results of all samples for common causes of sexually transmitted diseases are shown in table 6-5; it should be noted that none of these results were significant enough to pass the filtering method described in the methods. Two samples had potential bacterial matches after filtering: from specimens VD2, a vagina diagnosed with venereal inflammation, and VD6, a nasal septum perforation thought to be caused by syphilis. All the bacteria remaining in *Centrifuge* results after filtering were then aligned and analysed as previously described; the potential bacterial match, aDNA authenticity, depth of coverage and percentage of genome coverage are shown in table 6-6.

Ancient DNA validation

In order to ensure that contamination prevention techniques were successful, any negative controls with quantifiable traces of DNA were sequenced, and all sequences were checked for known signs of ancient DNA. All samples from venereal specimens were mapped to the human genome[30] using *bowtie-2* and checked with *mapDamage* for aDNA fragmentation patterns. Five out of eight samples contained mostly human DNA (>90%), as expected. One (VD2A) contained 72% human DNA, which is notably lower but not of significant concern. Both samples from VD3 contained very low amounts of human DNA

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[29] H37Rv strain, NCBI GenBank reference NC_000962.3
[30] Genome assembly GRCh38 (Genome Reference Consortium Human Build 38)

(16% and 4%), indicating that the library was made up of primarily contamination and/or artefacts.

In the negative control, the human DNA showed *mapDamage* profiles expected from modern samples, with no discernible pattern of base pairs in relation to fragmentation. This appeared to be trace amounts of contamination, as only 0.68% of the total reads generated from the sample aligned with the human genome. The human genomic coverage for the negative was 21.6% with an average depth of 0.28x. Small amounts of contamination are expected, as although many cautions were taken we were not able to replicate an ideal ancient DNA environment (i.e. not a positively pressurised work area, face masks rather than full-head coverage, in a space shared with other workers).

Both samples from one specimen, VD3, did not show a clear aDNA fragmentation pattern. Combined with the low yield of human DNA, sequences from the specimen were considered artefacts of contamination and invalid. VD3 was therefore excluded from further study. Human DNA in all other specimens showed the expected fragmentation profile of ancient DNA: a rise of A and G with a corresponding drop of T and C in the bases just before fragmentation. This indicates that the human DNA was from the specimen, rather than from contamination. *mapDamage* profiles for alignment against the human genomes are shown in figures 6-1, 6-2 and 6-3 for an example venereal sample (VD6A), VD3 and the negative control. The complete set of *mapDamage* plots is included in Appendix D.

All bacterial sequences were also authenticated using *mapDamage*. This showed an expected profile of increased A and G bases upstream to the 5` end of fragmentation. The exception to this was the presence of *Moraxella osloensis* in sample VD2A, which is discussed below (see figure 6-4 for *mapDamage* plot). Reads from the sequenced negative control were also mapped with all potential candidates. The pathogen traces found in the negative control covered at most 1.01% of the target genome, except for *M. osloensis* which is addressed in the discussion (table 6-6). Alignments from the negative control did not show an aDNA signature when checked with *mapDamage*. Together this indicates that any traces of these bacteria in the negative control were artefacts and not from cross-contamination. Two examples of bacterial *mapDamage* profiles, one from the tuberculosis specimens and one from the venereal specimens (VD6A), are shown in figures 6-5 and 6-6. The complete set of *mapDamage* plots is included in Appendix D.

Tables and figures

Specimen	Extraction method	Starting mg of tissue	Concentration (ng/uL)	ng DNA/mg tissue?	Library prepared and sequenced?
TB1	DNEasy	24	0.49	2.0	
	DNEasy	25	0.62	2.5	Yes
	DNEasy + PTB	25	0.78	3.1	Yes
	DNEasy + PTB	27	0.57	2.1	
	DNA IQ	27	0	0	
	DNA IQ	26	0.13	0.5	Yes
	DNA IQ + PTB	25	0	0	
	DNA IQ + PTB	27	0	0	
	DNAzol	27	0	0	
	DNAzol	24	0	0	
	DNAzol + PTB	24	0	0	
	DNAzol + PTB	25	0	0	
TB2	DNEasy	25	0.10	0.4	

Specimen	Extraction method	Starting mg of tissue	Concentration (ng/uL)	ng DNA/mg tissue?	Library prepared and sequenced?
	DNEasy	27	0.11	0.4	Yes
	DNEasy + PTB	25	0.06	0.3	
	DNEasy + PTB	26	0.14	0.5	Yes
	DNA IQ	24	0	0	
	DNA IQ	26	0.29	1.12	Yes
	DNA IQ + PTB	28	0	0	
	DNA IQ + PTB	25	0	0	
	DNAzol	28	0	0	
	DNAzol	26	0	0	
	DNAzol + PTB	28	0	0	
	DNAzol + PTB	26	0	0	
TB3	DNEasy	24	0.22	0.9	
	DNEasy	24	0.22	0.93	Yes
	DNEasy + PTB	26	0.22	0.86	Yes
	DNEasy + PTB	25	0.12	0.49	
	DNA IQ	27	0.11	0.39	Yes

Specimen	Extraction method	Starting mg of tissue	Concentration (ng/uL)	ng DNA/mg tissue?	Library prepared and sequenced?
	DNA IQ	28	0	0	
	DNA IQ + PTB	27	0	0	
	DNA IQ + PTB	27	0	0	
	DNAzol	26	0	0	
	DNAzol	27	0	0	
	DNAzol + PTB	26	0	0	
	DNAzol + PTB	24	0	0	

Table 6-2 - Extraction results from second stage testing using specimens with Mycobacterium tuberculosis. Concentration of DNA was calculated using a Qubit Fluorometer (ThermoFisher Scientific).

Specimen	Sample	Quantity of DNA (ng) after library preparation	Average fragment length (bp)
VD1	A	0.81	217
VD1	B	1.36	205
VD2	A	3.35	245
VD2	B	1.33	198
VD3	A	0.96	349
VD3	B	1.04	355
VD4	A	3.28	218
VD4	B	Undetectable	N/A
VD6	A	26.1	207
VD6	B	Undetectable	N/A

Table 6-3: Results of extraction and library preparation from venereal specimens. Specimen VD5 was excluded at the extraction phase after user error. Quantity of DNA was calculated using a Qubit Fluorometer (ThermoFisher Scientific). Average fragment length was measured using a 2100 Bioanalyzer (Agilent).

Specimen	Extraction method	% reads aligned w/ *M. tuberculosis*	Matched reads	Total reads	% genome coverage	Avg coverage depth
TB1	DNEasy	0.1	14759	15437906	25.22	0.47
	DNEasy + PTB	0.16	345145	21284605	48.78	1.1
	DNA IQ	0.1	16206	16504740	29.38	0.51
	Combined reads				70.3	2.09
TB2	DNEasy	0.01	342	5492567	0.51	0.01
	DNEasy + PTB	0.05	6213	12567087	5.57	0.12
	DNA IQ	0.05	2849	6276507	2.87	0.06
	Combined reads				8.54	0.19
TB3	DNEasy	0.002	849	40464373	1.25	0.02
	DNEasy + PTB	0.004	1465	36256480	2.22	0.04
	DNA IQ	0.01	479	7827618	0.82	0.01
	Combined reads				4.15	0.08

Table 6-4 - Sequencing results from second stage testing using specimens with Mycobacterium tuberculosis. Reads aligned was provided from bowtie2. Genome coverage and depth was provided by pileup, as detailed in the methods section.

Sample	Bacteria	Genome Size	Matched reads	Unique matched reads
VD1A	Neisseria gonorrhoeae	4967431	11	3
VD1B	Chlamydia trachomatis	1376168	4	2
	Neisseria gonorrhoeae	4967431	2	1
	Treponema pallidum	1138607	1	0
VD2A	Neisseria gonorrhoeae	4967431	38	20
	Chlamydia trachomatis	1376168	20	7
	Treponema pallidum	1138607	11	1
VD2B	Neisseria gonorrhoeae	4967431	9	6
	Chlamydia trachomatis	1376168	6	4
	Treponema pallidum	1138607	1	0
VD4A	Neisseria gonorrhoeae	4967431	4	3
	Chlamydia trachomatis	1376168	2	2
VD6A	Neisseria gonorrhoeae	4967431	26	8
	Chlamydia trachomatis	1376168	11	8
	Treponema pallidum	1138607	15	4

Table 6-5 – Results generated by centrifuge for venereal samples showing potential matches with common pathogens that cause STDs. VD3 was excluded at this stage as its profile matched results from the negative sample and appeared to be the result of PCR artefacts only. All show only very low matches, indicating an absence of these bacteria. The results were therefore excluded from further analysis, and are only provided here for completion.

Sample	Bacteria	GenBank Reference	Matched reads	Total reads for sample	% all reads matched	% genome coverage	Avg. coverage depth	aDNA signature present
VD2A	Moraxella osloensis	GCF_001553955.1	3627	10508426	0.04	14.83	0.22	No
VD6A	Staphylococcus aureus	GCF_000013425.1	30420	94566292	0.03	54.25	1.56	Yes
	Yersinia ruckeri	GCF_000964565.1	19929	94566292	0.02	26.84	0.74	Yes
	Yersinia enterocolitica	GCF_000009345.1	16697	94566292	0.02	23.52	0.56	Yes
	Shewanella baltica	GCF_000178875.2	14910	94566292	0.02	16.99	0.51	Yes
	Haemophilus influenzae	GCF_000027305.1	3849	94566292	0.004	15.68	0.46	Yes
Negative control	Moraxella osloensis	GCF_001553955.1	2999	11804782	0.03	8.56	0.29	No
	Staphylococcus aureus	GCF_000013425.1	150	11804782	0.001	0.55	0.06	No
	Yersinia ruckeri	GCF_000964565.1	145	11804782	0.001	0.58	0.07	No
	Yersinia enterocolitica	GCF_000009345.1	140	11804782	0.001	0.47	0.06	No
	Shewanella baltica	GCF_000178875.2	239	11804782	0.002	0.51	0.07	No
	Haemophilus influenzae	GCF_000027305.1	351	11804782	0.003	1.01	0.29	No

Table 6-6 - Alignment results for samples with venereal disease, indicating bacteria that may have been recovered. Results for the same organisms are included from the relevant negative control for comparison.

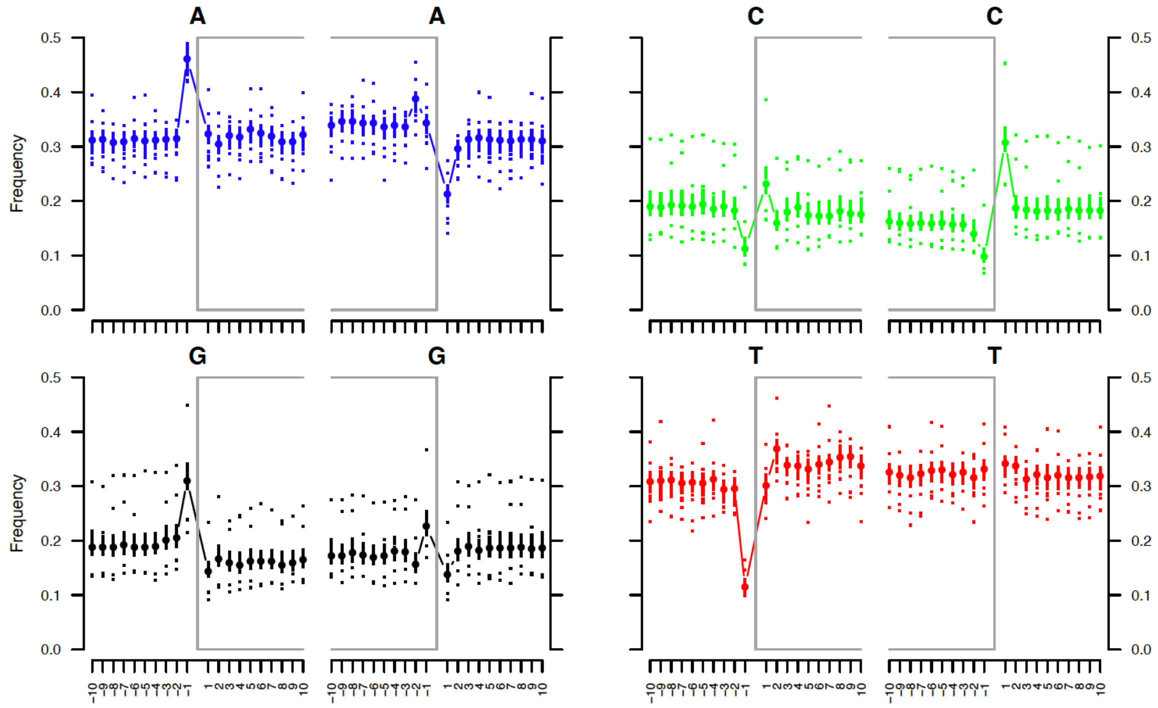

Figure 6-1: mapDamage plot for sample VD6A after alignment to the human genome. The increase of As and Gs, and decrease of Ts and Cs at the 5 prime end is characteristic of ancient DNA fragmentation.

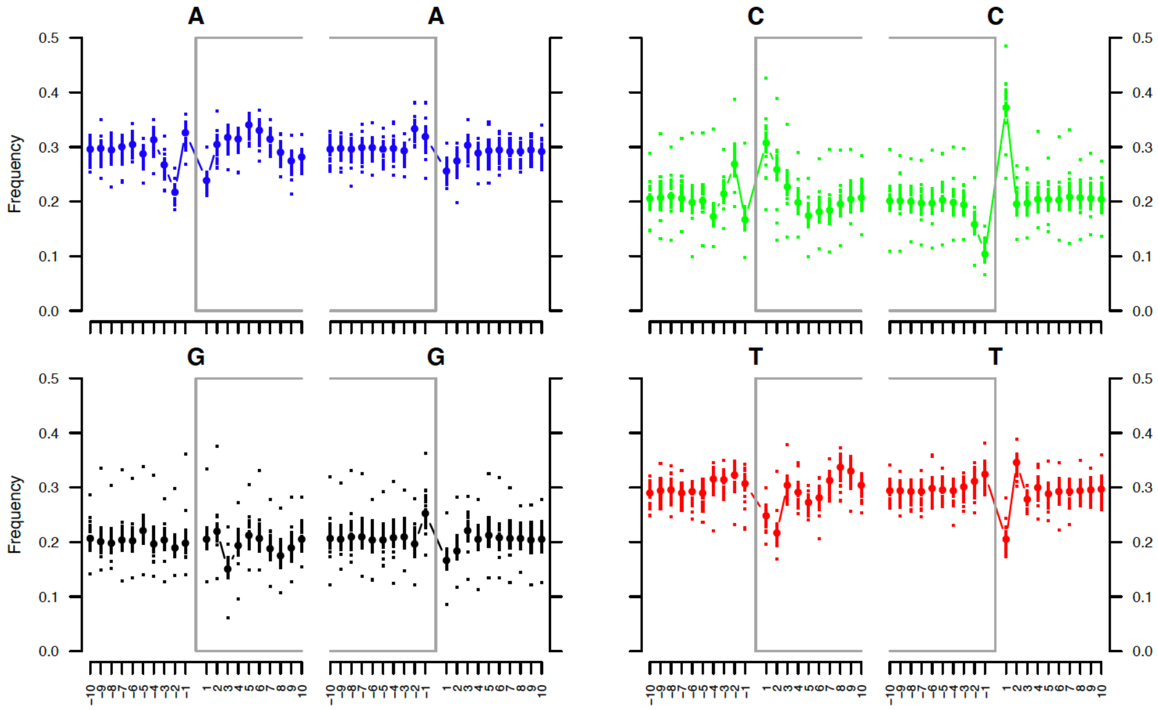

Figure 6-2: mapDamage plot for sample VD3A after alignment to the human genome. There is not a sufficiently clear fragmentation profile to authenticate this sample as aDNA.

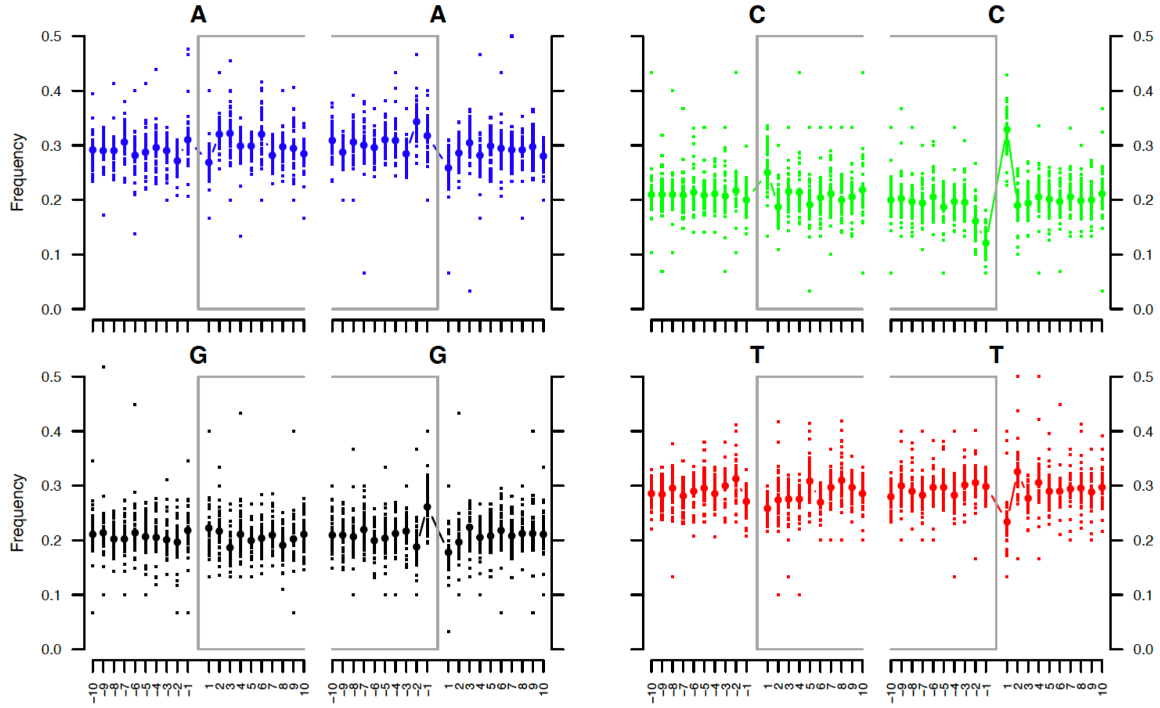

Figure 6-3: mapDamage plot for the negative control after alignment to the human genome. There is no aDNA fragmentation pattern.

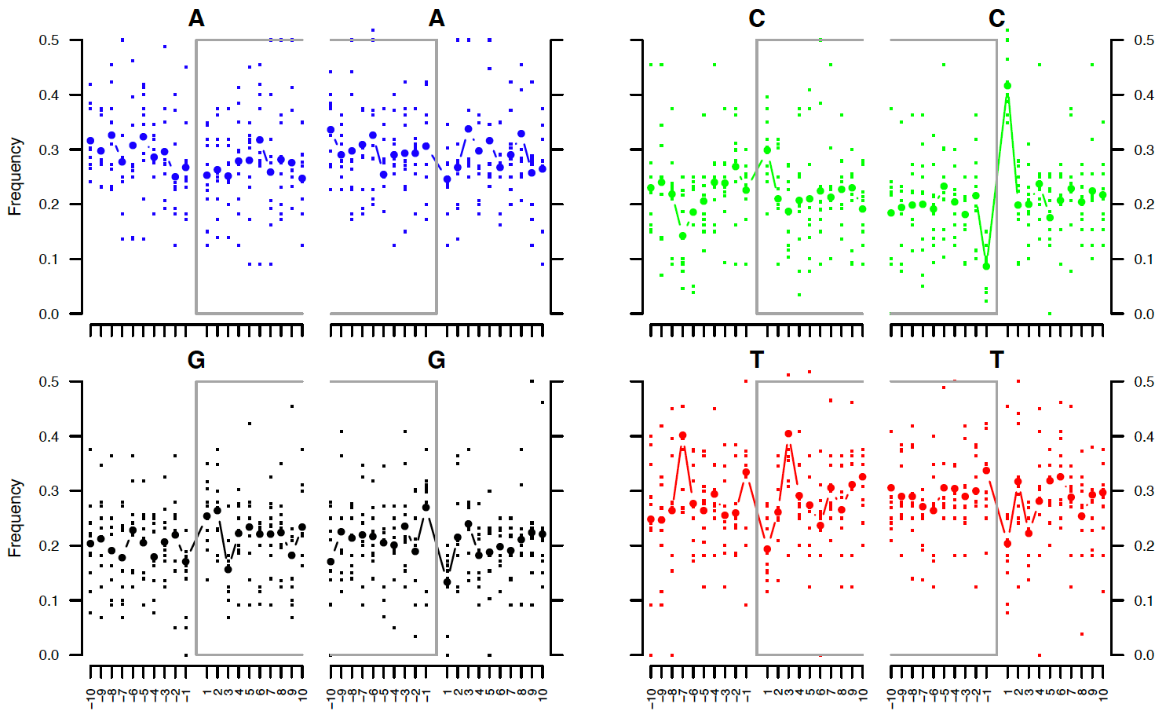

Figure 6-4: mapDamage plot for sample VD2A after alignment to M. osloensis. There is no aDNA fragmentation pattern.

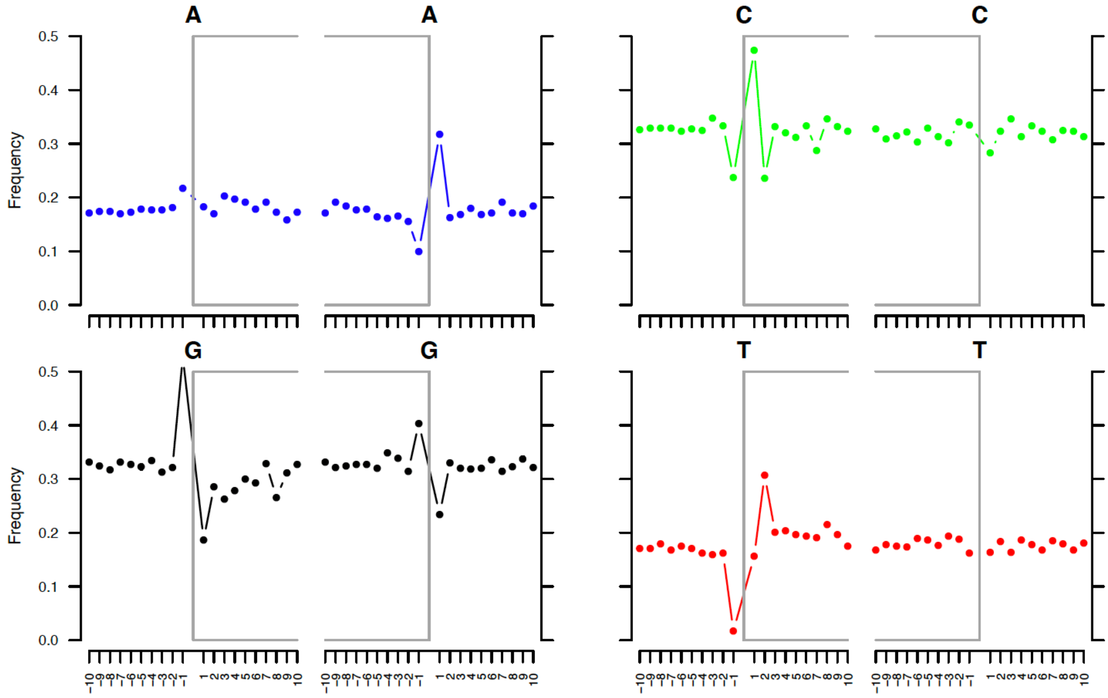

Figure 6-5: mapDamage plot for combined samples from specimen TB1 after alignment to the M. tuberculosis genome. The increase of As and Gs, and decrease of Ts and Cs at the 5 prime end is characteristic of ancient DNA fragmentation.

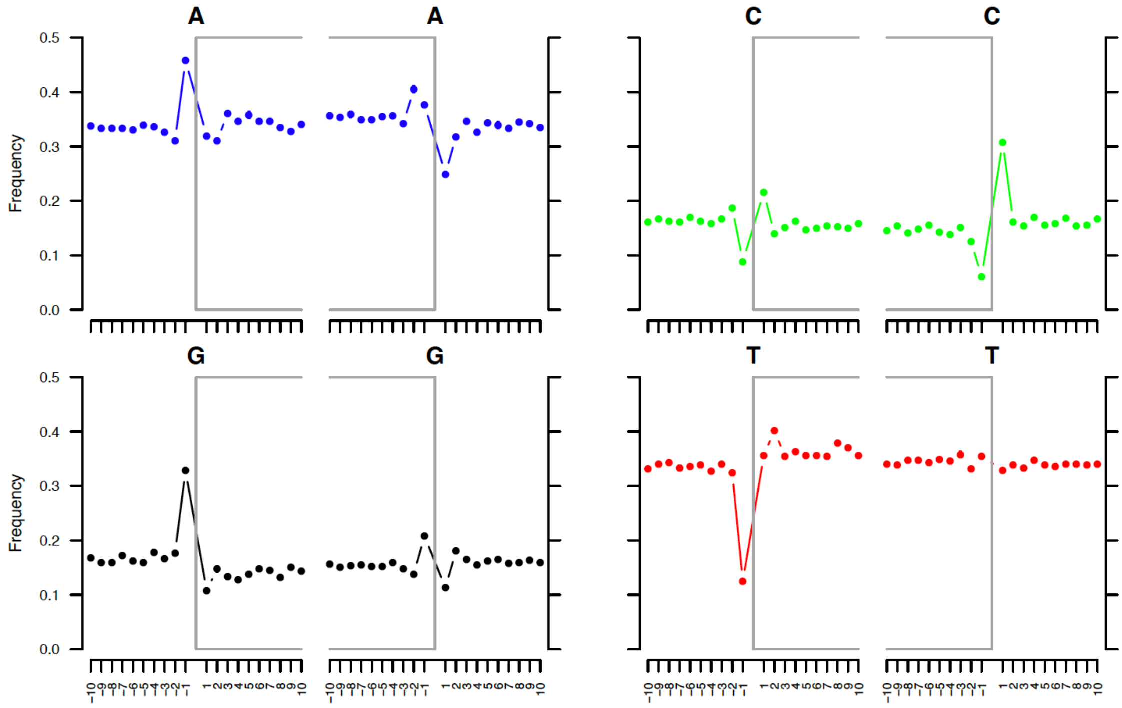

Figure 6-6: mapDamage plot for sample VD6A after alignment to the S. aureus genome. The increase of As and Gs, and decrease of Ts and Cs at the 5 prime end is characteristic of ancient DNA fragmentation.

Discussion

Ancient DNA recovered from eighteenth-century venereal specimens

VD2 (the specimen showing vaginal occlusion) presented traces of *Moraxella osloensis*, covering almost 15% of the genome with 0.2x average coverage (table 6-6). However, *mapDamage* results showed this bacterium was likely to be modern, as it did not have the expected profile for aDNA. DNA for *M. osloensis* was also found in high quantities in the negative control, covering 8.5% of the genome (table 6-6). *M. osloensis* is also known to be part of the skin microbiome; it is therefore highly likely that this is contamination (Cosseau et al 2016).

VD6 (the specimen showing nasal perforation) showed the only positive aDNA results out of all the specimens, presenting potential traces of *Yersinia* spp., *Shewanella baltica*, *Haemophilus influenzae*, and *Staphylococcus aureus* (table 6-6). Two *Yersinia* species were potential matches in the sample: *Yersinia enterocolitica* and *Yersinia ruckeri*. *Y. ruckeri* and *S. baltica* are known primarily as pathogens of fish, with no connection to human infection, and therefore not of pathological interest. *Y. enterocolitica* is a known pathogen in humans, causing yersiniosis; a disease typically characterised by fever, diarrhoea and abdominal pain. It is usually spread through contaminated food or water, particularly pork (Aziz and Waheed 2019). While the bacterium is usually restricted to the gastrointestinal tract, it is able to disseminate through the body via the bloodstream (a process known as bacteremia) and can cause both cutaneous and respiratory tract infections (Bottone 2015). Due to the possibility of high load in the bloodstream and the presence of an aDNA signature as shown by *mapDamage*, it is possible that the finding of *Y. entereocolitica* is authentic. However, there are no cases in the literature of *Y. enterocolitica* associated with nasal septum perforation, meaning that it cannot be confidently connected to the physical evidence.

H. influenzae is a common pathogenic bacterium of humans which colonises the nasal cavity (Margolis et al 2010). Although only 15% of the genome was covered by sequenced DNA, the presence of *H. influenza* is much more probable due to this context. Finally, significant amounts of the *S. aureus* genome were isolated from this specimen. *S. aureus* is found colonising the nasal cavity in up to 30% of the human population (Sakr et al 2018). It is also thought to be associated with slow-healing nasal septum perforations, where a previous study found it was present in 88% of cases (Hulterström et al 2016). Combining this context with relatively strong genome coverage – 55% with an average 1.5x depth – indicates a stronger certainty for presence of *S. aureus* in this specimen. Sequenced reads for both bacteria from sample VD6 both show aDNA signatures in *mapDamage* results. *S. aureus* and *H. influenza* can also be further connected with the physical symptoms present, as they have been known to cause nasal septal abscesses, which can lead to perforations and ultimately saddle-nose deformity – a complication most commonly associated with syphilis (Chundu and Naqvi 1986; Cheng et al 2019).

Is it possible that the comorbidity of a nasal septum abscess and a case of food poisoning was interpreted as venereal disease? The possibility that this particular combination of symptoms was seen as venereal may shed some light on differential diagnosis in the eighteenth century. Before the rise of laboratory medicine, diagnosis largely depended on how a practitioner interpreted the array of symptoms and patient history they were presented with (Berger 1999). This was especially difficult for venereal disease, where many of the symptoms overlapped with those found in other diseases. Ulcers of the nose had to be distinguished from those caused by scurvy, scrophula or sinus abscesses (Howard 1787: 114–16). As previously mentioned, the common symptoms of yersiniosis are fever, diarrhoea and abdominal pain. Fever and diarrhoea are both good examples of the complexity of eighteenth-century diagnosis; sometimes they were taken as symptoms of a disease, however they were often simply considered on their own with no further diagnosis necessary. Diarrhoea, for example, was a standalone category in the bills of the mortality (Ashton 2005: 4). Fevers were considered so complex that an entire strand of debate and theory was dedicated to them alone (DeLacy 2017: 19-54). However, fever and diarrhoea had also long been associated with venereal disease (Astruc 1737b: 7).

The decision process of a practitioner to define a case of diarrhoea, for example, as simply 'diarrhoea' or part of something larger (i.e. venereal disease) was implicit knowledge, typically not verbalised in written case notes. Typically, a combination of symptoms was required before the doctor could be confident. For example, Howard notes that it was 'very seldom that a case of ozæna [inflammation of the nasal cavity] comes on without other manifest venereal symptoms’ (Howard 1787: 114). Unfortunately, although records show that this patient was being treated for lues venerea in Westminster hospital, there are insufficient identifying details to track down any complete patient history that could show which symptoms led to this particular diagnosis (Fordyce et al 1785: 285–86). This means it is impossible to say whether the combination of diseases characterised here could fully account for the patient experience or the diagnostic process. Hunter’s entry for this particular specimen, however, does note that ‘the disease was recovering’, although it is difficult to pinpoint whether he is referring only to the nasal perforation or to the patient’s state as a whole. An alternate interpretation of the evidence could be that the patient received food poisoning while in recovery from another disease; yersiniosis is known to be fatal, particularly in immunocompromised patients (Rahman et al 2011; Aziz and Waheed 2019).

If we do speculate that this particular patient was not suffering from syphilis, but rather a combination of other bacterial infections, this helps to illustrate how unstable the eighteenth-century diagnosis of syphilis was. As discussed throughout this thesis, venereal disease was increasingly difficult to define over this period, with many medical practitioners describing the same disease in different ways. This instability led to the proposition that syphilis and gonorrhoea were, in fact, separate and distinct diseases. In order to attempt to prove or disprove this theory, many doctors performed experiments on their patients by inoculating the matter of syphilis or gonorrhoea and watching the results (see chapter four). If we take the example of this patient, it is easy to see how these experiments got such mixed results. Confirmation that other infections were being diagnosed as syphilis shows why it took so long for the dualist theory to become accepted; when doctors could not consistently diagnosis one disease, it is not surprising that this was difficult to then separate out into two diseases.

However, this case shows how difficult it is to do more than speculate with regards to retrospective diagnosis, even when both biological and textual evidence is available. It is possible that the presence of a nasal perforation was the symptomatic tipping point for categorising fever and diarrhoea as venereal disease. It may also be that these were present alongside a sexually transmitted bacteria that wasn’t recovered through DNA extraction, resulting in a more complex presentation of symptoms. While *H. influenzae* and *Y. enterocolitica* may both potentially be the cause of the nasal septal perforation, they can also both simply be colonisers in a health nasal cavity and their presence may be coincidental. While a more detailed patient history would help in increasing confidence, this is not available. Even with these limitations, however, the possibility provides an unusual lens for considering the process behind diagnosing venereal disease.

Absence of pathogenic DNA in other venereal specimens

There are several potential reasons why the extractions may have failed to recover *T. pallidum* DNA from any specimens – and as emphasised by Stone and Ogza (2019: 183), 'absence of evidence must not be interpreted as evidence of absence'. First, there was a high chance many of the specimens were not from truly syphilitic patients, as was potentially the case with specimen VD6. Consultation with a pathologist determined that it was unlikely that the lesions in either specimens VD2 (vaginal occlusion) or VD4 (gumma of the pia mater) were caused by STDs. The ulcer present in VD3 (chancre of the penis) was uncharacteristic of syphilis, although the diagnosis could not be ruled out. This, of course, was part of the goal of the project: to determine the biological cause of specimens labelled syphilitic/venereal through eighteenth-century diagnosis. Unfortunately, no viable alternatives were presented through metagenomic analysis. This still does not necessarily indicate a failure for the same reasons. Potentially, the cause of the pathology could also be due to something not detectable through genomic analysis of bacteria and viruses, i.e. cancers.

Considering the high element of chance involved in finding aDNA and low number of venereal specimens found suitable for extraction, this project was also at a disadvantage with numbers. In successful aDNA recovery studies, sample size is often higher with only a small fraction returning results. For example, Bos et al. (2016) were able to extract *Yersinia pestis* from only five out of twenty teeth sampled from a mass plague burial. Considering this rate of extraction is from teeth, which are considered one of the best substrates for DNA preservation, the success rate for soft tissue – which provides a much more open system through which DNA loss can occur – is likely to be lower (Adler et al

2011). Illustrating this issue, although *M. tuberculosis* was sequenced, it was only significantly recovered from one out of three of the specimens tested. In the other TB specimens, although some *M. tuberculosis* reads were found using *Centrifuge*, they were not present in enough quantity to be considered significant. These issues are compounded by the fact that *T. pallidum* is a particularly tricky bacteria to recover, due to its fragility and low tissue loads.

Future directions

The results from this project should not rule out the potential for repeating this experiment with other collections, which may have a wider range of specimens to choose from. For example, of the specimens selected from The Hunterian, only one had a potential chancre present – the stage of syphilis which has the highest treponemal load. This specimen was filled with wax, making it more difficult to take tissue samples, and no positive results were obtained. In comparison, there are eight extant specimens from John Hunter's collection (now kept at the Royal College of Surgeons) that are historically diagnosed as having chancre (Royal College of Surgeons in London 1830: 59–60). Increasing the sample size in this way would improve the chances of DNA recovery.

It is also worth continuing an approach that investigates the eighteenth-century diagnostic category of 'venereal disease'. This has the potential to reconstruct historic genomes of a variety of bacteria that can cause STDs, such as *Neisseria gonorrhoeae*. Due to the localisation of bacteria to soft tissue, wet specimens present a unique opportunity to recover these genomes for the first time. Due to the changing definition of venereal disease over this period, as outlined in this thesis, it is also a historically useful diagnosis to investigate. Future researchers should be open to analysing anatomical specimens and continuing to work alongside historians.

None of the aligned genomes were sequenced in this instance to a sufficient depth to perform in-depth genomic and phylogenetic analysis. Repeated sequencing of the captured libraries may potentially capture enough reads for this to be possible at a later date, without the need for further sampling. The aims of this project, however, were simply to identify potential causative bacteria in diseases historically identified as venereal: further genomic analysis is outside the scope of this thesis.

Conclusion

Despite mixed results from the venereal specimens, the overall result is a positive message: it is definitely possible to sequence bacterial DNA from eighteenth-century spirit-preserved anatomical specimens. This marks the first successful sequencing from anatomical specimens of this century and opens up these museum collections for future potential research.

The most significant finding was a mix of pathogens in one specimen, GLAHM:120909, which was described as erosion of the nasal septum from lues venerea. Two of the bacteria, *S. aureus* and *H. influenzae*, potentially accounted for the septal erosion. *Yersinia enterocolitica*, a pathogen spread typically through food poisoning, was also identified. Although detailed patient records are not available for this case, the diagnosis of venereal disease could potentially be linked to the bacteria found. This would provide a new perspective on the process of diagnosis in the eighteenth century by demonstrating which diseases may have been included under the categorical umbrella of ‘venereal disease’, which in turn can shed light on the debate between monism and dualism. Unfortunately, limitations mean it is not possible to state anything conclusively in this case. Nonetheless, it has been shown here that the aDNA and historical analysis can provide different types of evidence to build a fuller understanding of a patient case.

Chapter 7 – Conclusion

> Whoever has taken pains to study syphilitic diseases, has no doubt found that no affection is so ill defined, and no diagnosis so uncertain. What is syphilis? What are the symptoms? What are symptoms which are quite unconnected with it? These questions have not yet been settled, and are subjects of eternal dispute; until they are solved, no progress can be made with any certainty. (Ricord 1842: 52)

The definition and diagnosis of venereal disease was an overwhelming source of difficulty for medical practitioners in the eighteenth and nineteenth centuries. This was partially resolved by the process of separating venereal disease into a number of distinct diseases, principally syphilis and gonorrhoea, which is the focus of this thesis. The long-established narrative of this separation typically progresses through the work of Francis Balfour, Andrew Duncan, John Hunter Benjamin Bell and Philippe Ricord. Even as early as 1819, one writer described the 'history of this important improvement in our art' by specifically citing Balfour, Duncan and Bell ('Saint-Marie on Syphilis' 1819: 199–200). This description has remained virtually unchallenged to this day. In this thesis, I have analysed the role of these key figures in establishing the dualist doctrine, and also shown that there was a considerably broader ongoing debate through the inclusion of lesser-known medical treatises, student essays, hospital records and catalogues of medical museums.

When Francis Balfour introduced the dualist doctrine in 1766, it rapidly spread among his peers at the University of Edinburgh and the Edinburgh Medical Society. Andrew Duncan and Benjamin Bell were among this group, but it also included a number of international medical practitioners who brought the theory with them after they left Britain – for example, Benjamin Rush (Philadelphia) and Johan Clemens Tode (Copenhagen) – and the other students at Edinburgh who debated the theory long before published works began to appear on it. This network of colleagues was vital for allowing the theory to gain a foothold, as seen when compared with the reception of William Ellis's 1771 work. Ellis, a mere apothecary in London, had few apparent social connections and, unlike Balfour, his work was simply ignored. When Kuhn described the early adoption of a new paradigm, he theorised that the first to embrace it did so as a matter of 'faith' (Kuhn 1996: 156–58). He suggested that this may ultimately be down to 'personal and inarticulate aesthetic considerations'; those who supported it initially would then go on to produce more 'hardheaded' arguments to convince the rest of the scientific community. I have shown here that such initial leaps of faith could be motivated by social networks.

As the debate progressed, however, medical practitioners needed firmer evidence to be convinced by the dualist doctrine. The theoretical arguments developed by Balfour and Duncan convinced very few who were outside their social circle, and these arguments swiftly resolved into circular debates with the same talking points repeated by most writers. The evidence needed by the rest of the scientific community came in the form of inoculation experiments, a practice in which the experimenter would inoculate the matter of syphilis or gonorrhoea into a patient to see what disease developed. The earliest of these was the now infamous experiment by John Hunter, in which he injected (allegedly) himself with gonorrhoeal discharge, and then developed the syphilitic symptoms. However, this experiment was not done with the monist-dualist debate in mind, but rather to investigate the progress of the disease. The first to publish experiments that directly addressed the debate was Benjamin Bell, who described several students' attempts to inoculate themselves. Following Bell, dozens of others repeated these experiments in order to observe the proof for themselves. Ultimately, these experiments were brought together by Ricord, who provided a rigorous set of hundreds of observations. Thus, I demonstrate that while social networks were required to begin the shift towards dualism, the importance of social influence reduced over time and instead, tangible evidence took its place. The rejection of theoretical arguments and acceptance of experimental evidence also reflects a broader shift in the degree that eighteenth-century science depended observation. Lorraine Daston has described how observation became its own epistemic category during the eighteenth century (Daston 2011).

In medicine, observations also often took the form of dissection and the preservation of anatomical preparations. Richard Bellis has argued that this observational shift changed how medical practitioners understood disease, marking a move away from the traditional case history and towards morbid anatomy (Bellis 2019: 257–59). Examination of the venereal specimens in a number of medical museums demonstrates the rejection of the case history approach. Instead of demonstrating a specific disease, specimens often simply showed a specific lesion that was then generalised and used as an example of multiple diseases that shared that pathology. The specimens examined here showed how flexible the definition of a disease could be, something that was also seen in medical treatises. The difficulty in diagnosing venereal disease and emphasis on lesions is confirmed by the genetic analysis of the pathogens found in an anatomical specimen that was described by William Hunter as syphilitic. This analysis showed that potentially a case of food poisoning and a nasal infection had been diagnosed as venereal. The instability in defining disease played a central role in the competition between the monist and dualist doctrines, as the lack of shared assumptions made it difficult to produce a fixed definition of a single venereal disease, let alone the two distinct diseases - syphilis and gonorrhoea. Given this absence of a foundation, it is perhaps unsurprising that theoretical evidence alone was insufficient to persuade people of the dualist doctrine.

Although the genetic analysis did not successfully retrieve DNA from any pathogens associated with venereal disease, the sequencing of *Mycobacterium tuberculosis*, *Yersinia enterocolitica*, *Staphylococcus aureus*, and *Haemophilus influenzae* marks the first successful extraction of ancient DNA from an eighteenth-century anatomical preparation. This thesis has also shown that medical museums offer a unique opportunity for scientific analysis, as the specimens have a rich historical context. Genetic information can, therefore, be used to answer historical questions as well as illuminate the nature of the pathogen itself. Future researchers should continue to use medical museums as a source for ancient DNA and employ these methods for potential breakthroughs in the history of medicine.

Another potential avenue for future research would be the use of quantitative social network analysis to better understand paradigm shifts. Formal social network analysis of those on both sides of the debate as it progressed could provide quantitative evidence and strengthen my hypothesis that social connections were vital for early adopters of a new theory. This analysis could more precisely identify the tipping point when social networks become less vital, the size of a network required to begin a paradigm shift, and whether networks still played a role as a paradigm became more accepted. This would improve our understanding of how scientific communities interact to produce new knowledge. This episode makes a rich subject for controversy studies and could also easily be explored further using other theoretical frameworks outside of Kuhn and paradigm shifts.

Overall, this thesis has shed new light on the role of the social and types of evidence at different stages of a the introduction of a new scientific theory. This was also the first comparative study of medical museums used to investigate knowledge of a specific disease, and the first study to successfully recover ancient DNA from specimens in those museums. Together, these factors present a novel perspective on building knowledge in the eighteenth century and provide new tools to understand how syphilis and gonorrhoea came to be defined.

Appendix A – Printed Sources

This appendix lists all printed primary sources that were used for data analysis. Not all of these texts were cited directly within the body of the thesis. Any that are not found in the general bibliography are therefore given in the reference list following the table.

References given in italics were not counted when specifically considering the number of monist and dualist *authors* in order to avoid duplication.

Data

Reference	**Does the work discuss the monist-dualist debate?**	**If so, is the author a monist or a dualist?**
Abernethy 1814	No	
Acton 1841	Yes	Undecided
Adams 1795	Yes	Monist
Allan 1819	Yes	Dualist
Andree 1779	No	
Andree 1781	Yes	Monist
Anon 1821	Yes	Dualist
Anon 1825	Yes	Dualist
Astruc 1737	No	
Bacot 1829	Yes	Monist
Barker 1801	Yes	Dualist
Becket 1765	No	
Bell 1793	Yes	Dualist
Blair 1798	No	
Boerhaave 1763	No	
Bostwick 1848	Yes	Dualist
Boyle 1824	Yes	Dualist
Brand 1787	No	
Buchan 1796	Yes	Undecided

Reference	**Does the work discuss the monist-dualist debate?**	**If so, is the author a monist or a dualist?**
Butter 1805	Yes	Monist
Cardwell 1833	Yes	Dualist
Carmichael 1814	Yes	Dualist
Carmichael 1818	No	
Carmichael 1842	Yes	Dualist
Caton 1807	Yes	Dualist
Childs 1843	Yes	Dualist
Clare 1781	No	
Clubbe 1782	No	
Clubbe 1786	No	
Cockburn 1718	No	
Colles 1837	No	
Cooper and Green 1832	Yes	Dualist
Courtneay 1829	Yes	Monist
Culverwell 1841	Yes	Dualist
Daran 1766	No	
Deacon 1789	No	
Desruelles 1830	No	
Devergie 1837	No	
Douglas 1737	No	
Duncan 1772	No	
Duncan 1778	Yes	Dualist
Ellis 1771	Yes	Dualist
Falck 1772	No	
Foot 1786	Yes	Monist
Foot 1790	Yes	Monist
Fordyce 1767	No	
Franks 1846	No	
Gataker 1755	No	
Godfrey 1797	Yes	Monist

Reference	**Does the work discuss the monist-dualist debate?**	**If so, is the author a monist or a dualist?**
Gordon 1786	No	
Goss and Company 1827	No	
Greaves 1815	No	
Guthrie 1817	Yes	Undecided
Hales 1765	No	
Hallett 1822	No	
Hamilton 1820	No	
Harris 1742	No	
Hennen 1820	No	
Hodson 1789	No	
Houlston 1792	Yes	Undecided
Howard 1787	Yes	Monist
Hunter 1786	Yes	Monist
Innes 1783	Yes	Monist
Jourdan de Pellerin 1750	No	
Judd 1836	Yes	Monist
Key 1747	No	
Kiernan 1811	Yes	Monist
Lalouette 1777	No	
Lawrence 1830	No	
Meyer 1813	Yes	Monist
Mooney 1756	No	
Morgagni 1769	No	
Neale 1786	No	
Nisbet 1787	Yes	Monist
Ogle 1791	No	
Parker 1845	Yes	Dualist
Peake 1788	No	
Pearson 1800	No	
R.J. Brodie & Co 1845	No	

Reference	**Does the work discuss the monist-dualist debate?**	**If so, is the author a monist or a dualist?**
Ralph 1840	Yes	Dualist
Rees 1802	Yes	Monist
Renny 1782	Yes	Undecided
Ricord 1840	Yes	Dualist[31]
Roberts 1788	No	
Rock 1745	No	
Ryan 1844	Yes	Dualist
Samwell 1786	No	
Sanches 1790	No	
Sawrey 1802	Yes	Monist
Schetky 1818	Yes	Monist
Simmons 1780	Yes	Monist
Skae 1844	No	
Skey 1840	Yes	Undecided
Smyth 1771	No	
Solomon 1797	No	
Stevenson 1803	Yes	Dualist
Stuart 1738	No	
Swediaur 1787	Yes	Monist
Thomas 1780	Yes	Monist
Thomas 1780	Yes	Monist
Thornton 1816	Yes	Dualist
Titley 1831	No	
Tongue 1801	Yes	Dualist
Travers 1830	Yes	Monist
Turner 1737	No	
Vaughen 1843	Yes	Dualist

[31] As discussed within the thesis, Ricord was not technically a dualist, since although he separated syphilis and gonorrhoea, he did not consider gonorrhoea to be caused by a contagion. However, he is counted here for simplicity, as his work separating the two was a significant development in dualism.

Reference	**Does the work discuss the monist-dualist debate?**	**If so, is the author a monist or a dualist?**
Wallace 1833	Yes	Monist
Weatherhead 1841	Yes	Dualist
Welbank 1825	No	
Whately 1801	Yes	Monist
Whitsed 1813	No	

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This list of references contains the printed works from the above table that are not included in the bibliography.

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Appendix B – Anatomical Specimens

This appendix lists all anatomical specimens found in the six museum catalogues described in chapter five and summarised in table 5-1. The catalogue number for each specimen is listed in its original format. In cases where numbering is continuous throughout a catalogue, only the number is included. In cases where numbering restarts with each section, the section is also included.

William Hunter, 1785

The modern accession number for each specimen in The Hunterian is also listed here where known.

Catalogue Number	Description	Accession Number
X.89	The kidnies of a young Surgeon who died Frantic had a Suppression of urine from Stricture in consequence of Gonorrhoea there was a Supperation in the apex(?) of the Prostate Gland which etended to the bulb of the urethra - the kidnies are taking on the tuberculated appearance of Scrophulous Supperation the ureters are much enlarged - one kidney is injected black & red, the bladder is also thickened and fasciculated.	
BB.45	The upper half of the Penis of a Jew as the prepuce is removed it explains Circumcision there are also two large Chancres on the Glands (Solomon Porter)	GLAHM:121404
CC.58	Uterus Vagina & Vulva Vagina is obliterated about an inch within the Vestibulum probably from long continued Venereal inflammation.	GLAHM:121427

Catalogue Number	Description	Accession Number
EE.28	Inflamation & Suppuration with ulcer in the posterior part of the posterior lob cerebri the Dura Mater near the lateral Sinus was corroded & the Sinus nearly dissected round(?) (Mrs. Bell's Case) died suddenly there were rather(?) tumours internall on the [blank] suspected venereal disease (case wrote)	GLAHM:121058
LL.32	Ulcer & thickening in Schneiders Membrane from the Lues Venerea (Patient in Westminster Hospital)	
LL.33	The other Side of the Nose Ditto - the Septum Nasium about the middle & lower part gone before & behind excepting one pillar about the middle the disease was recovering & the Membranes had united those of the one side with those of the other at the anterior & posterior edges - the Mouths of the Eustachian Tubes in both were much thickened	
LL.36	A longitudinal middle section of the Tibia on which a large node probably venereal was formed the leg had been injected the bone afterwards steeped in an acid the Node resembles much the Callus of Bone and is also evidently vascular	GLAHM:122415
	Twelve specimens of portions of crania or sculls affected with ulcuration from Lues Venerea.	

Alexander Monro *primus* and *secundus*, 1798

Section	Number	Description
Fracture	62	Caries, with thickening of the Periosteum in different parts of the Extremities of a child; supposed to be from Lues Venerea. The arties are well injected.
Fracture	62.A	Ditto, from the same subject.
Fracture	62.B	Ditto.

Section	Number	Description
Rickets	3	Rickety Skeleton of an Adult Females, where most of the Bones of the Body are affected with Venereal Caries.
Caries	4	Piece of a Skull Cap affected with the Venereal Caries.
Caries	5	Ditto.
Caries	7	Skull affected in various places with Caries, probably Venereal.
Caries	8	Scull Cap affected with Corona Veneris.
Caries	9.A	Part of the occipital bone affected with caries in Lues.
Caries	11	The Maxilla Superior, top of Pharynx & Tongue, where a large hole is eroded in the roof of the mouth & the uvula destroyed by lues venerea. In mouth 41a.
Caries	12	The Os Frontis of another subject Carious from the same cause. Vessels of Gallus(?) are seen from the Periosteum.
Bones cast out	48	Bone from the Nose, in Lues Venerea.
Skin	57	Skin of the Face of a Rickety Person who had the Lues Venerea
Larynx & lungs	1	The Tongue Vilum(?) Pendulum Uvula & Larynx with ulcerations from the Lues Venerea.
Larynx & lungs	4	Inside of the Larynx & Trachea of a Women ulcerated in several places. She died with violent Coughing which ended in suffocation. Half a year previous to death she had been sent from the Infirmary, seemingly cured of Lues Venerea.
Diseases of male organs	58	The Bladder, Prostate Gland & Penis. The Urethra cut open the whole length to shew Ulcurations from a Gonorrhoea of 3 months continuance.
Diseases of male organs	63	Penis with Phymosis from Gonorrhoea - cut off after death

Section	Number	Description
Diseases of male organs	66	Prepuce cut off in Gonorrhoea
Diseases of male organs	67	Ditto.
Diseases of male organs	67.A	Prepuce. See Cases V.21.p.62

Guy's Hospital, 1829

Catalogue Number	Description
1049A	A Rib affected with Necrosis; the effect of Syphilis. Cat LVI 69, Brookes's Collection
1093A	Clavicle, affected with extensive Periosteal Inflammation, from Syphilis. There is Necrosis of the Scapular extremity. Cat LVI 15, Brookes's Collection
1116	Radius, affected by Periosteal inflammation. Syphilitic
1217	Portion of Tibia, exhibiting Periosteal inflammation, with Sloughing from Hospital Gangrene: injected. Venereal. See Prep.1376
1376	Tendon, sloughing from Hospital Gangrene, attacking a Venereal Sore of the Leg. Belongs to 1217.
1670	Portion of Elongated Tongue, weighting 2 ounces 2 1/2 drachms (Troy); removed, by a ligature, from a patient of Sir Astley Cooper, 53 years of age. - The enlargement followed Pytalism for Syphilis: it was indolent, and little sensible; and had been of upwards of six months duration. Old Museum Book, No 58. Case of T. Lawrence, a Seaman.
1708	Larynx; shewing Oedema Glottidis, from Syphilis: Epiglottis destroyed by prior disease.
1709	Larynx; shewing Oedema Glottidis, from Syphilis. The patient died in Lazarus' Ward. He was admitted with slight ulceration of the Throat and Fauces; was otherwise well: exposed himself to cold, was seized with Dypsnoea, and died in three day.

Catalogue Number	Description
2401	Urethra, inflamed, from Gonorrhoea. Old Museum Book, No 32
2420	Extremity of the Penis; shewing a Chancre, opening into the Urethra, and separating the Glans from the Corpora Cavernosa.
2687	Wax Model of part of the Abdomen, thickly covered with Lichen, interspersed with a few small Pustules. (Venereal)
2688	Wax Model of part of an Arm, sprinkled with Lichen, intermixed with a few small Pustules. (Venereal)
2689	Wax Model of part of the Abdomen, with clusters of Venereal Lichen on the decline.
2690	Wax Model of part of the Arm, sprinkled with Lichen: the Papulae large, and some of them desquamating. (Venereal)
2691	Wax Model of part of an Arm, sprinkled with Venereal Lichen, having a good deal of the character of Ecthyma.
2692	Wax Model of part of an Arm affected with Venereal Lichen, in character approaching to Ecthyma.
2693	Wax Model of part of an Arm affected with Venereal Lepra: some of the spots are at their height; others are on the decline.
2695	Wax Model of a considerable part of the Abdomen, affected with Venereal Lepra.
2701	Wax Model of the Face of a Woman affected with Venereal Psoriasis.
2717	Wax Model of the Face of an adult Male, affected with Venereal Lichen passing into Ecthyma.
2718	Wax Model of an Arm thickly covered with Ecthymatous Pustules. (Venereal)
2719	Wax Model of the fore Arm, affected with Venereal Ecthyma.
2733	Wax Model of the Face of a Woman affected with the smooth Venereal Tubercle.
2739	Wax Model of the Arm; Shewing a large and foul Ulcer, the result of Syphilis and Mercury.
2802	Plaster Cast of the Abdomen and upper part of the Thighs; shewing very extensive Phagadenic Ulceration (Venereal)

Catalogue Number	Description
2803	Plaster Cast of the Pubic Region; shewing the Penis greatly mutilated, from Phagadenic Ulceration (Venereal)
2807	Wax Model of a Penis; shewing numerous Venereal Warts on the Glans and Prepuce.

Royal College of Surgeons, 1830

The modern accession number for each specimen in the Royal College of Surgeons is also listed here where known.

Catalogue Number	Description	Accession Number
81	The anterior part of the penis of a person who had a gonorrhoea at the time of his death. The urethra is laid open, and bristles are put into the enlarged lacunae.	RCSHC/P 30
149	A calvaria, very extensively ulcerated on its internal surface; and in which the diplöe has been almost entirely removed. [A large circular portion of the inner table has been destroyed, leaving only a thin film of the outer table, but there is scarcely any appearance of disease on the exteernal surface of the skull. Whether the affection were considered venereal or not, there is no record. It has every appearance of the absorption having been produced by pressure from within.]	RCSHC/P 849
419	A portion of the os frontis, which was thrown off, after having been much acted on by the absorbents. The diplöe is almost entirely destroyed by ulceration, the two tables of the skull being separated from each other through almost their whole extent. The disease was probably venereal.	

Catalogue Number	Description	Accession Number
476	The anterior part of a skull, in which the os frontis is affected by the venereal disease, [internally as well as externally.]	RCSHC/P 714
477	A calvaria, very extensively ulcerated on its external surface only. [Probably venereal.]	RCSHC/P 720
478	A skull, the frontal and parietal bones of which are extensiveely affected by venereal (?) ulceration. The fangs of the remaining teeth aree eexpoeed, in consequence of the alveolar processes having been absorbed.	RCSHC/P 716
479	A calvaria, which is ulcerated both on the external and internal surfaces. In one part the ulceration has penetrated through the bone, so as to produce a considerable aperture. [This specimen has the following memorandum written within it: "Sept. 3. 1779. Died about 5 weeks ago, aged 19. G. Brande;" and in addition, in Mr. Hunter's hand-writing, "Supposed to be venereal."	RCSHC/P 848
480	A calvaria, very extensively ulcerated. [Probably venereal.]	RCSHC/P 721
481	A calvaria, in which the parietal bones are extensively ulcerated. "Supposed to be venereal."	
482	A similar specimen, in which the os frontis is principally affected. "Supposed to be venereal."	RCSHC/P 719
483	A similar specimen. A large portion of the right parietal bone has been destroyed.	RCSHC/P 717
484	A skull, with the loweer jaw; in which the palate, part of the nasal bones, and orbits are destroyed. All the teeth of the upper jaw have separated, and the alveolar processes have been removed: in the lower jaw two molares only remain, and these are retained	RCSHC/P 715

Catalogue Number	Description	Accession Number
	merely by the curved points of their fangs; the alveolar processes having been almost entirely absorbed.	
485	The basis of a skull, in which the palate is almost entirely destroyed.	RCSHC/P 722
486	A lower jaw, of which a great part is destroyed by ulceration.	
487	A clavicle, scapula, and humerus, on which there had been venereal ulcers.	
488	A portion of the os frontis, the ulnae, femur, and tibia, of the same inidividual, affected by venereal ulceration.	
489	A tibia, affected by the venereal disease.	RCSHC/P 738
490	A fibular, [apparently belonging to the preceding tibia,] from which grew a large venereal excrescence.	RCSHC/P 746
609	A section of the os frontis of a man who died in St. George's Hospital; to show a scrofulous thickening of the pericranium. He had seeveral hard tumours on the skull, which the physicians and surgeons mistook for venereal affections; but from the history of the case itself, there was no reason for coming to that conclusion. The man died consumptive: and upon examining those swellings, they appeared to be a scrofulous increase of the periosteum only.	RCSHC/P 356
714	A natural phymosis of the prepuce.	
715	A penis with phymosis.	RCSHC/P 1381

Catalogue Number	Description	Accession Number
716	A penis on which the operation for phymosis has been performed.	RCSHC/P 1383
717	A penis from which the prepuce had been circumcised.	
718	A penis in which the preepuce is adhering to the glans, in consequence of chancre. [The skin is closely contracted oveer the anterior surface, barely leaving an aperture for the passage of the urine. A remarkable circumstance is observable in this preparation, viz. hair has been produced on the anterior part of the penis, probably in consequence of increased action in the vessels of the part, as in the preparation No. 117.]	RCSHC/P 1382
719	A penis with a natural paraphymosis.	
720	A penis in which the fraenum and part of the urethra have been destroyed by chancre. A bristle is placed in the aperture thus formed.	RCSHC/P 1391
721	The anterior part of a penis in which ulceration had taken place at the fraenum, and made an opening into the urethra, which remained after the ulcer had healed. A bristle in introduced into the external meatus of the urethra, and tied round the septum between the two passages.	RCSHC/P 1392
722	A penis where a chancre had existed on the glans; to show that the sore had not been filled up by granulation while healing.	
723	The anterior part of a penis showing the same appearance.	RCSHC/P 1387
724	A penis in which the prepuce and corona glandis have been destroyed by chancre: to show the	

Catalogue Number	Description	Accession Number
	appearance of the parts after the healing of a venereal ulcer.	
725	A penis in which great part of the glans is destroyed.	
726	The anterior part of a penis, in a state of extensive ulceration, protruding through a large ulcer in the prepuce.	RCSHC/P 1394
727	A penis where the glans is protruding through the upper part of the prepuce in consequence of ulceration; but the parts have been perfectly healed.	RCSHC/P 1386
728	The scrotum, with the remains of a penis which has been almost wholly destroyed by the venereal disease: the part, however, is not healed.	RCSHC/P 1390
729	A penis, with small warts on the prepuce; and an accumulation of caseous or semi-cuticular matter on the glans, from neglect.	RCSHC/P 1393
730	The prepuce covered by large venereal warts; the glans penis being destroyed.	RCSHC/P 1384
731	The section of a head to show a venereal affection of the septume nasi and palate. The septume has been destroyed, and the os palatum is exoliating.	RCSHC/P 1226
732	Part of a head to show a venereal affection of the ossa nasi, septum, superior maxillary bones, and palate; on all of which parts great ravages have been committed.	RCSHC/P 1227
733	A septum narium in which there is a large opening that remained after the healing of a venereal ulcer.	RCSHC/P 1228

Royal College of Surgeons of Edinburgh, 1836

Catalogue Number	Description
276	Two sections of a frontal bone greatly increased in thickness, probably from venereal inflammation.
290	Caries of the bones of the cranium, and face of a person who died of syphilis. The inner surface of the frontal bone shews marks of high vascularity. Part of the upper maxillary bones has been separated; and on the centre of the right parietal bone is the mark of an exfoliation. See the case in vol. i. of Edinb Med Chir Trans. Presented by George Ballingall.
292	Venereal inflammation of the os frontis injected.
293	Venereal caries of the cranium. The peculiar worm-eaten appearance is well seen. It is not known why the trephine had been applied.
294	Inflammation and caries of the cranium, probably venereal.
296	Extensive exfoliation, probably from venereal inflammation.
297	A skull-cap, the surface of which is rough from venereal inflammation. The disease must have terminated.
298	A skull-cap exhibiting indications of having been affected with syphilitic inflammation.
299	A skull-cap with indications of venereal inflammation on its external surface. The inner surface shews marks of high vascularity and disease of the dura mater.
300	Venereal caries in the skull-cap, chiefly at its back part, in the actual state of progress.
301	A skull-cap rough with venereal caries on both surfaces.
302	A skull-cap affected with syphilis. There are three diseased parts, shewing different stages of the affection; the largest forming a good specimen of exfoliation. The bone is particularly heavy.
303	A skull-cap affected with venereal caries. On the right side there is a deep excavation of the bone.

Catalogue Number	Description
304	A skull-cap which has been affected with syphilis. It exhibits the recovery of the bone after exfoliation.
307	Skull affected with venereal caries; the ethmoid, turbinated bones, ossa nasi, ossa lacymalia, vomer, nasal plates of the upper maxillary bones, and the palatine bones were destroyed. Some time after the disease was stopped in its progress, the cranium became affected, and exfoliation took place to a great extent; the dura mater was destroyed by ulceration, fungus cerebri ensued, and the patient died.
308	Great destruction of the bones of the face from venereal disease. The disease had terminated.
309	Skull with venereal caries on the os frontis. The disease had terminated.
310	Skull very extensively marked with venereal caries.
311	Skull affected with venereal caries.
312	Skull affected in many detached places with venereal caries; the disease in active progress.
313	Skull marked with venereal caries; the bones of the nose, and the palatine plate of the upper maxillary bone, partially destroyed.
314	Skull of a negro very extensively affected with venereal caries.
315	Portion of os frontis, with an indentation of its external surface, and a small perforation over the longitudinal sinus, probably from venereal disease.
356	Clavicle affected with syphilitic caries.
359	Caries, with osseous deposition on the surface of an os humeri, probably syphilitic.
360	An os humeri affected with venereal inflammation.
361	Os humeri affected with venereal inflammation. From the same body as the last. A section has been made, to shew the alteration of the internal structure.
370	Ulna enlarged and carious, probably from venereal inflammation.
371	Diseased ulna, the result of venereal inflammation.

Catalogue Number	Description
373	Diseased radius, probably venereal.
382	Os femoris affected with venereal inflammation.
383	Diseased os femoris, probably syphilitic; from a churchyard. It is very light.
384	Os femoris having a venereal node extending downwards on its inner surface.
385	Section of an os femoris exhibiting the nodes distinct from the old bone: from a venereal patient.
390	Section of an os femoris having an enlargement of the cylinder, probably produced by syphilis.
392	Section of an os femoris having a venereal node on its surface.
403	Os femoris of the right side increased in bulk and weight by venereal inflammation. From the dissecting-room.
404	Tibia of the right side, from the same subject, similarly affected.
405	Left thigh-bone of the same subject.
406	Left tibia of the same subject.
417	Tibia inflamed, probably from syphilis. From a churchyard along with No. 391.
418	Tibia affected by syphilitic inflammation.
419	A large node probably venereal, on the back of the tibia.
420	Tibia enlarged by venereal inflammation.
421	Node on tibia, from venereal inflammation.
426	Venereal inflammation of the tibia and fibula, which are uncommonly heavy.
427	General enlargement of the tibia from venereal inflammation.
428	Disease of the tibia, probably venereal.
429	Venereal node on the tibia.
432	Syphilitic exostosis of the tibia.
435	A venereal node on the tibia ulcerating.
436	Portion of a tibia having a node produced by venereal inflammation.

Catalogue Number	Description
437	Portion of a tibia shewing syphilitic exostosis.
438	Portion of a tibia, with a venereal node.
447	Tibia and fibula of the right leg of a person affected with syphilis. The disease continued for twelve years, during the greater portion of which time mercury was taken. A large portion of the bone extending along nearly two-thirds of the anterior spine, is separating, and the bone exhibits osseous deposition, cares, and necrosis. Presented by Professor Thomas.
448	Tibia and fibula of the left leg of the same person, exhibiting similar appearances. Presented by Professor Thomson.
452	The lower part of the fibula carious from venereal inflammation.
453	Caries of the fibula, probably from venereal disease.
454	Fibula diseased, probably from venereal inflammation.
466	Metatarsal bone of the great toe of the left foot affected with caries, the consequence of a general syphilitic affection. Presented by John Campbell.
473	Skull-cap from a syphilitic patient. The caries is very extensive, and a large portion of the whole thickness of the frontal bone is very nearly detached by the process of exfoliation.
845	Fungus cerebri occurring after destruction of the bones of the cranium, and ulceration of the dura mater, in consequence of syphilis. See No. 474
862	Portion of a dura mater from a child who had syphilitic caries of the skull opposite this part.
1300	Epiglottis wasted and the membrane of the larynx thickened by chronic inflammation. The disease supposed to be venereal. The patient died suddenly after being admitted into the Lock Hospital. Bell's Surg. Observ. Vol.i. p.18
1311	A remarkable ulcer in the sacculus laryngis, probably venereal.

Catalogue Number	Description
1317	Epiglottis destroyed, and a venereal ulcer on the glottis. See case of Mary Ann Mellon, in Bell's Surg. Observ. Vol.i p.32. She was brought into the Middlesex Hospital, and in half an hour fell back in her bed, and expired without a struggle.
1318	Ulceration and sloughing in the throat, from a patient in the Lock Hospital.
2128	Urethra very much contracted nearly through its whole ectent. This state of the passage is produced by the inflammation of gonorrhoea, or by the improper use of irritating injections. In such a case the urethra feels tense and hard along all the lower part of the penis.
2129	Cast of a urethra and bladder, of which the former was nearly in the same state as in the last preparation. At a, there is a sudden narrowing of the canal; from a to b, the diminution is continued; at c, the canal again remarkably diminished; at d, the deep indentation in the wax was occasioned by the caput gallinaginis.
2147	Sloughing of a large portion of the urethra. The patient had been for some time under the care of a surgeon, who, he suspected, had made false passages with the bougie. He became alarmed, and went to the Lock Hospital, but died the day on which he was admitted.
2562	A venereal ulcer eating into the body of the penis.
2566	Specimen of cancer of the penis in the form of cauliflower excrescences from the glans and prepuce. The disease extended to the corpora cavernosa. Amputation was performed, and the patient recovered; but the disease recurred, on which the penis was dissected out from under the pubes. Violent haemorrhage took place two hours after, probably from the corpora cavernosa. The wound healed, but the disease returned in a few months, and the patient died of it in about a year after. The disease was venereal, and the patient, who was a clergyman, had been deposed. Presented by professors Thomson and Turner.

St. Bartholomew’s Hospital, 1846

Entries marked with an asterisk (*) are specimens that are not explicitly described as venereal but are listed as syphilitic in the catalogue’s indexes.

Section	**Catalogue Number**	**Description**
Diseases of Bone	185	Section of a Girl's face in which syphilitic Necrosis and ulceration affected large portions of the maxillary and malar bones. The separate portions of bone were exfoliated.
Diseases of Bone	A.27	Section of a Tibia enlarged in its lower third by the external formation of new bone. The new bone is penetrated by some small irregular ulcers, probably of a syphilitic nature.

Section	Catalogue Number	Description
Diseases of Bone	A.34	Parts of a Tibia, Clavicle, Humerus, and Skull, from a man who died with syphilis. The shaft of the tibia I enlarged by the expansion of its walls and by external formation of new bone. In one part, the walls and new bone covering them are penetrated by small irregular ulcers. The same disease has affected the middle of the clavicle; and in it the ulceration has extended so far that a slight force broke the remaining portion of its shaft. In the humerus the lower half of the haft is thickly covered by light and porous new bone, through which many ulcers of various size have penetrated; some of these extend deep into the original wall of the humerus, portions of which also appear to have suffered necrosis. In the skull the outer tables of the frontal and right parietal bone present an uneven tuberculated surface, seamed and starred, like the surface of confluent small blisters; through this, numerous distinct and coalescing ulcers penetrate, and reaching the diploe spread therein in wider spaces, and in a few instances pass also through the inner table. The outer table of the left parietal bone is tuberculated but not ulcerated. There is a similar but less extensive disease on the inner table of the right parietal and occipital bones.

Section	**Catalogue Number**	**Description**
Diseases of Bone	A.35	The Skull, Femur, and Bones of the right upper extremity of a man who died with syphilis. They present, in a less advanced form, similar appearances to those last described. Thee tuberculated character which the outer table of thee skull assumes previous to its ulceration, is shown on the upper part of the frontal bone; and the stages in the progress of the little ulcers which penetrate and spread through the new bone, may be traced on the clavicles in which the processes has just begun, and on the radius and humerus on which it is more advanced; while on the femur, whose shaft like theirs in much enlarged by the formation of new bone, there are many small round and oval apertures with smooth borders, indicating that similar ulcers have been healed. Presented by William Beaumont, Esq.
Diseases of Bone	A.58	A Skull-Cap, exhibiting some of the effects of syphilis. In some situations there has been a complete destruction of the bone through both tables of the skull; at the borders of the apertures thus made, thee disease seems to have stopped, and the parts appear to have cicatrised, for their edges are thin, smooth, and hard. In other situations, ulceration appears to have been in progress, the bone in these parts exhibiting a rough surface, a porous texture, and many small deeply penetrating holes. The spaces left by the removal of the bone are filled by membrane in which there are several small deposits of new bone: and the outer surfaces of all the portions of the skull which remain between the ulcers, are tuberculated, seamed, and starred, as in A.34

Section	Catalogue Number	Description
Diseases of Bone	A.59	A Skull-Cap, large portions of which have been destroyed by syphilitic ulceration like that in the preceding specimen. The two preceding specimens were taken from patients who died in the venereal wards of the hospital while Mr. Pott was surgeon.
Diseases of Bone	A.63	A Skull-Cap, exhibiting extensive syphilitic ulceration of its outer table. The ulcers are distinct, large and round. Some of them, especially one on the frontal bone, show that they commenced in an annular form, an ulcerated groove forming round a portion of diseased bone, which portion was subsequently removed by the widening of the groove. The inner table is very vascular and less extensively ulcerated. Parts of the outer table are tuberculated.
*Diseases of Bone	A.65	A Skull-Cap, exhibiting extensive superficial ulceration of the outer table.
*Diseases of Bone	A.70	A Skull-Cap, exhibiting several distinct roundish ulcers, some of which have penetrated both its tables. They commenced in the outer table and present traces of the same primary form as those in A.63
Diseases of Bone	A.82	S Skull-Cap, exhibiting extensive tuberculated syphilitic ulcerations of the parietal bones, with thickening and hardening of the inner table.
Diseases of Bone	A.84	Portions of a Skull, with syphilitic ulceration of the frontal bone extending into the frontal sinuses and through the inner table of the skull.
Diseases of Bone	A.86	Portion of a Tibia with new bone formed round the middle of its shaft, and ulceration extending through part of the new bone to its surface: the effects of syphilis.

Section	Catalogue Number	Description
Diseases of Bone	A.89	A Skull exhibiting the effects of syphilis. The palate, septum nasi, and the lateral boundaries of the nose, are destroyed by ulceration extending as high as the middle turbinated bone. The outer table of nearly all the upper part of the skull is tuberculated and very extensively ulcerated, and in several places the ulceration has penetrated the inner table.
Diseases of Bone	A.90	The Skull-Cap of a young woman, in which, in the course of syphilis, the greater part of the outer table of the frontal portion of the frontal bone suffered necrosis, and was nearly separated from the adjacent bone. A deep groove has formed round the dead portion, and a large part of its under surface is separated. The inner table has not perished, but beneath the centre of the necrosed portion there are several irregular ulcerated openings in it. There are two small superficial ulcerations of the external table near the sagittal suture, on corresponding parts of the two parietal bones.
Diseases of Bone	A.105	A Skull-Cap, exhibiting extensive Necrosis, which, apparently, succeeded syphilitic ulceration of the outer table of the frontal bone. A groove has formed around thee dead bone, and extends for some distance beneath its edges. There are cicatrices of old ulcers on the parietal bones: and the skull is heavy.
Diseases of Bone	A.107	A Skull, with syphilitic Necrosis and Ulceration of a portion of the left parietal bone. The dead bone has been in part removed. The frontal bone is tuberculated as in syphilitic disease.

Section	**Catalogue Number**	**Description**
Diseases of Bone	A.109	A Skull-Cap, in which there are several distinct syphilitic ulcers. The ulcers are nearly circular, and affect corresponding parts of both tables. Some of them present an annular form, a groove of ulceration extending round a central portion of diseased bone which is gradually removed as the groove widens towards the centre.
Diseases of Bone	A.111	A Skull-Cap, exhibiting extensive Necrosis of the outer table, and, to a small extent, of the inner table, of the frontal bone. The necrosis, as in the similar specimens, A.105 and 107, occurred in the course of syphilitic ulceration.
Diseases of Bone	A.112	A Skull, in which, in the course of syphilitic disease, there occurred necrosis of several large portions of the frontal and parietal bones. Many of the sequestra were completely separated, and the surface of the diploe and inner table exposed by their removal appears to have healed smoothly; but many other portions in which the necrosis extends through both tables of the skull, are only partially detached. The portions of the skull, which remain between those that have suffered necrosis, appear quite health: they were not even increased in vascularity.

Section	**Catalogue Number**	**Description**
Diseases of Bone	A.123	The Upper part of a Skull, exhibiting the effects of syphilitic ulceration and necrosis. A large portion of the frontal bone exfoliated long before the patient's death; and the borders of the aperture, as well as the surrounding surface of the bone, are smoothly healed. A necrosed portion of the occipital bone was removed about a month before the patient's death: the aperture remains with ulcerated margins. There are also irregular superficial ulcerations on the external table of both the parietal bones; and on many other parts of the skull are appearances of the bones having been unnaturally vascular.
Injuries of Bones and Joints	58	Portion of a Humerus, which has been fractured near the middle of its shaft. New bone is formed upon its outer surface, immediately above and below the fracture. The extremity of the lower potion of the bone has perished, and is in progress of exfoliation. The fractured surfaces were united by a soft substance; and a distinct capsule has been formed around the ends of the bone by the condensation of the surrounding cellular tissue. From a girl twenty-three years old. The fracture was caused by external violence six years before death, while she was affected with syphilis. Presented by William Taylor, Esq.

Section	**Catalogue Number**	**Description**
Injuries and Diseases of the Brain etc	22	Portion of Cerebrum, exhibiting an abscess in its anterior lobe, which was communicated with the lateral ventricle of the same side. The patient was a man forty years old, who appeared to die exhausted by syphilis and the effects of mercury. The only cerebral symptoms were extreme restlessness and delirium at night. The case is related by Mr. Earle, in the Medical and Physical Journal, Vo. xxiii, p.89, London, 1810

Diseases of the Heart	58	A Heart, with a Sac attached to the left side of its left ventricle. The sac is spheroidal in form, and upwards of three inches in its greater diameter. Its walls are composed of the exterior of the ventricle, the pericardium, and a dense tissue by which the opposite surfaces of the pericardium were adherent. It is lined by irregularly laminated coagula: the phrenic nerve runs over its anterior part; it communicates with the cavity of the ventricle by an oval aperture, about a quarter of an inch in diameter, the margins of which are smooth and round. A portion of white glass is passed through this aperture. The muscular substance of the ventricle immediately around the aperture has disappeared, and is replaced by a dense white tissue. The rest of the heart is healthy: but its exterior is covered by false membrane by which it adhered to the pericardium. It may be presumed, that theee was in this case a rupture, or an ulceration, through the wall of the left ventricle; that the blood was prevented from being effused into the cavity of the pericardium, by adhesions previously formed between its two surfaces; and that these adhesions, and the pericardium for a considerable distance around the aperture, were stretched by the force of the blood, so as to form a sac, in nearly the same manner as a false aneurism is formed after the destruction of the coats of an artery by the distension of its sheath. From a woman thirty-seven years old, who had had syphilis for many years in its worst form. She had long been under observation at the Penitentiary; but had presented no distinct sign of disease of the heart. She

Section	Catalogue Number	Description
		died with dysentery and slight bronchitis. Presented by Dr. Baly.
Injuries and Diseases of the Nose, Mouth etc	17	A Tongue and Pharynx, exhibiting extensive sloughing of their mucous membrane, which was considered to be the effect of mercury administered to a syphilitic patient.
Injuries and Diseases of the Pharynx etc	8	The Base of a Tongue, with the Pharynx and other adjacent parts. A large portion of the mucous and submucous tissues of the pharynx, and of one margin of the epiglottis, is destroyed by sloughing and ulceration. The mucous membrane covering the upper part of the larynx is oedematous and, in some parts, superficially ulcerated. From a girl who was greatly debilitated by the effects of syphilis and mercury.
Injuries and Diseases of the Larynx etc	5	A Larynx and Trachea, with the base of the Tongue. The whole of the epiglottis, and part of the arytenoid cartilages, with their connecting folds of membrane, have been removed by ulceration.

Section	Catalogue Number	Description
*Injuries and Diseases of the Larynx etc	8	A Larynx, exhibiting a large well-defined ulceration of the mucous membrane extending into the substance of the cricoid cartilage, which is partially ossified. Around the ulcer the mucous membrane is thickened and puckered. From a woman twenty-four years old, who had had signs of laryngitis for a week, and died suffocated by the closure of the glottis. Case-Book, Vol. i, p.24, No.55
Injuries and Diseases of the Larynx etc	9	A Larynx, exhibiting necrosis and separation of the left arytenoid cartilage, and of part of the cricoid cartilage. Previous to the necrosis the separated portions of cartilage had become osseous. The opening in the front of the trachea was made during life, for the relief of respiration. The patient, a man between forty and fifty years old, had been profusely salivated for syphilitic disease. After this, dyspnoea and other signs of obstruction in the larynx gradually increased for a month; and when they had been for several days extremely severe, the opening was made through the cricoid cartilage and the first ring of the trachea. The patient lived eight days, and died with pleurisy. The case is related by Mr. Lawrence, in the Medico-Chirurgical Transactions, Vol. vi p.223 London 1815. Case-Book, Vol. i p. 121, No. 144
*Injuries and Diseases of the Larynx etc	24	A Tongue, with part of a Larynx, in which a circumscribed irregular ulceration has destroyed the epiglottis, the right arytenoid cartilage, and the fold of mucous membrane connecting them.

Section	Catalogue Number	Description
*Injuries and Diseases of the Penis and Urethra	10	A Bladder and Urethra opened from the superior and anterior part. The mucous membrane of the bladder and urethra is thickened in its whole extent; but no part of the urethra appears especially contracted. Several small ulcerated openings have been formed in the spongy part of the urethra, near the bulb. The cut surfaces of the corpus cavernosum exhibit a sloughing appearance, in consequence of the escape of urine into it. The glans penis has been entirely removed by ulceration.
*Injuries and Diseases of the Penis and Urethra	25	A Glans Penis, exhibiting a large ulcer with a ragged irregular surface extending from below into the urethra.
*Injuries and Diseases of the Penis and Urethra	26	Sections of a Penis, in which the glans and a part of the corpus cavernosum have been removed by ulceration.
*Injuries and Diseases of the Penis and Urethra	27	Portion of a Penis, with warts upon the prepuce and the surface of the glans. Previous to the growth of these, the glans appears to have been protruded through an ulcerated aperture in the lower part of the prepuce.

St. George's Hospital, 1866

The entries in this catalogue are highly detailed, and inclusion of the full description would take this thesis over the word limit. To avoid this, each description has been shorted to two sentences. The catalogue is available online (as listed in the bibliography) and information provided is sufficient to locate each specimen for full details.

Section	**Catalogue Number**	**Description**
Series II	25	Tibia, showing the effects of chronic inflammation ... Hence the inflammation of the bone was conjectured to be due to syphilis.
Series II	57	Skull-cap, the external surface of which is in many places covered by an extensive deposit of new bone, presenting a mamillated appearance … This preparation was taken from the body of a man, aged 26, who was admitted, on the 25th of October, 1842, into the Lock Hospital.
Series II	58	Skull-cap the external surface of which is in many places, in a state of caries, especially over the frontal bone … From a patient affected with syphilis.
Series II	60	A Skull, the bones of which are extensively affected by ulceration, probably syphilitic. On the frontal bone, the disease has been principally confined to the external table; but in one or two places both tables have been destroyed.
Series II	61	Extensive Ulceration of the Bones of the Skull, probably the result of syphilis. Both tables are affected, and in several places, the whole thickness of the bone has been destroyed.
Series II	62	Skull, the frontal and parietal bones of which are affected with ulceration, probably syphilitic. On the right side of the frontal bone, the external table only is affected.
Series II	63	The Bones of the Cranium, showing the effects of ulceration, presumed to be syphilitic. No history exists.

Section	**Catalogue Number**	**Description**
Series II	64	The Lower end of Humerus, extensively affected with syphilitic ulceration. The back part of the outer condyle, and adjoining portion of the shaft, are extensively ulcerated, the ulceration extending on to the articular surface.
Series II	65	The Radius, Ulna, and Bones of the Hand, from a patient affected with syphilis. Part of the circumference of the head of the radius presents a slightly worm-eaten appearance; and below this, a quantity of new bone, of a porous texture, has been deposited.
Series II	66	Femur, extensively diseased from the effects of syphilis. The lower three-fourths of the shaft of the bone are perforated on the surface with innumerable small foramina, and covered with a deposit of new bone, in the form of thin nodulated and flattened laminae, of an exceedingly porous texture.
Series II	67	The Vault of the Skull, in which the trephine had been applied on account of symptoms caused by syphilitic disease. The patient, a man, aged 42, remarkably muscular and well developed, but of dull mental power, was admitted into the Lock Hospital, on October 2nd, 1858.
Series II	68	Syphilitic Caries of the Skull, showing, in front, the disease in an active condition in several places; behind, the depressed cicatrices of similar ulceration; and internally, deposit of new bone from the dura mater, which was found coated by fibrinous deposit. The history was not known; but the disease was inferred to be syphilitic, from the presence of a cicatrix on the glans penis.

Section	Catalogue Number	Description
Series II	85	Exfoliation from the inferior surface of the basilar process of the Occipital Bone. This preparation was removed from a patient who had been for a long time suffering from syphilis, for which he had been repeatedly mercurialised.
Series II	87	Exfoliation of a large portion of the Frontal Bone, from a patient affected with syphilis. In some parts the whole thickness of the skull is involved.
Series II	88	Three portions of necrosed bone from the cranium … She was 44 years of age, and first contracted syphilis at the age of 24.
Series II	101	This preparation shows the effect of trephining in syphilitic disease of the skull. The upper portions of the parietal bones have been preserved.
Series II	83	Specimen of aneurysm of the ascending aorta bulging into the right ventricle of the heart, and considerably obstructing the orifice of the pulmonary arterey, associated with an aneurymal pouch of the septum of the ventricles … The patient had been verry intemperate, and the subject of syphilis.
Series II	255	A portion of a femur affected with syphilis. A part of the shaft only has been preserved; this has been cut longitudinally, so as to display the interior.
Series II	256	The calvaria, affected with syphilitic disease. It is generally thickened, and porous new bone has been deposited over the greater part of the inner surface. On the inner surface of the right parietal bone is a small circle of rough new bone, probably the remnant of a syphilitic node.

Section	**Catalogue Number**	**Description**
Series II	257	A skull, extensively destroyed by syphilitic disease. There is a large hole through the vertex, nearly three inches long and about half as wide, at the expense of the parietal and frontal bones; and there is another perforation of rather smaller size through the middle of the frontal bone.
Series II	266	Calvaria, affected by syphilitic disease. There is spongy carious bone, somewhat discoloured by exposure, upon the frontal and both parietal bones.
Series VII	85	Specimen, showing partial destruction of the arytenoid cartilages, which are beginning to exfoliate, along with exposure, from ulceration, of the cornua of the os hyoides and of the thyroid cartilages … He underwent a course of mercury for secondary syphilitic symptoms and an ulcer in the throat.
Series VII	102	Specimen showing extensive ulceration of the mucous membrane forming the rima of the glottis and the parts of the larrynx above … For some time before death, she had been suffering from rupia and syphilitic sore throat, which were relieved by mercurial fumigations.
Series VII	108	Specimen showing extensive ulceration (from secondary syphilis) of the lining of the membrane of the larynx, and complete destruction of the epiglottis.
Series VII	126	Necrosis of the cricoid cartilage … He had had syphilis in early life, but not recently.

Section	Catalogue Number	Description
Series VIII	176	Specimen showing syphilitic disease of the dura mater, with meningeal apoplexy. There is a membrane loosely attached to the inner surface of the dura mater, covering the right menisphere, which is nearly decolorized; and in the midst of this and attached to it is a hard thick mass of yellow and opaque organized lymph.
Series IX	20	Preparation showing syphilitic ulceration of the oesophagus, in the neighbourhood of the glottis, along with unusual enlargement of the glands at the root of the tongue. The specimen was removed from the body of a man named William W., aged 26, who died from excessive dyspnoea, which came on along with sudden salivation.
Series IX	21	Specimen showing extensive ulceration of the fauces and adjoining structures, especially on the left side, the glottis being much affected, and the hyoid bone quite exposed, and projecting from the ulcerated surface … The specimen was removed from the body of a patient who died in the Lock Hospital with secondary syphilis.
Series IX	22	Specimen showing extensive sloughing of the fauces and adjoining structures, of a syphilitic nature. The hyoid bone has been completely exposed in one or two parts; and on the left side of the base of the tongue one of its cornua is seen projecting from the sloughing surface.

Section	Catalogue Number	Description
Series IX	69	Specimens showing a large fistulous communication between the rectum and the vagina … The specimen was removed from the body of Charlotte B., aged 21, who died of phthisis, and who frequently had been the subject of syphilis.
Series XII	17	Bladder and urethra to show the entire sloughing of the mucous membrane of the former, and its separation en masse from the walls of the bladder, except near the commencement of the urethra, where some loose shreds were still adhering to the lower part of the bladder … There did not appear to be any obstruction to the instruments that were passed for him, though he stated he had suffered from stricture 13 years ago, and had had repeated attacks of gonorrhoea.
Series XII	55	Stricture with dilatation of the urethra. The patient, Thomas B., aged 45, was admitted September 9, 1840, with stricture of the urethra, the result of a cicatrix at the orifice. Urinary abscess followed, and inflammation of the chest, of which he died November 22nd.
Series XII	60	Specimens of stricture of the urethra, followed by extensive ulceration, with destruction of the greater portion of the mucous membrane of the canal behind, and enormous hypertrophy of the muscular coat of the bladder. The structure was supposed to have followed a sore on the penis about two and a-half years previous to death.

Section	**Catalogue Number**	**Description**
Series XII	61	The urethra and bladder taken from a patient labouring under gonorrhoea. Phimosis exists, and some ulceration of the mucous membrane is seen at the membranous portion of the urethra.
Series XIII	35	Chronic inflammation of the testicle with hydrocele of the tunica vaginalis … He stated that he had had an attack of gonorrhoea about a year previous to his admission, which was followed some time after by inflammation of the testis, and effusion of the fluid in the tunica vaginalis.
Series XXI (drawings)	55	Syphilitic disease of cranium. See Preparation 57, Series II, where history is given.
Series XXI (drawings)	78	Red softening of the central portions of the brain produced by syphilitic disease of the bones of the cranium. For history, vide Path. Soc. Trans. Vol X p.8
Series XXI (drawings)	181A	A chance upon the lip and cheek of a young woman who is the subject of a syphilitic eruption.
Series XXII (casts and models)	82	A collection of sixteen models illustrating syphilitic affections of the male and female generative organs. Presented by H. Lee, Esq
Series XXII (casts and models)	83	A syphilitic sore of the tongue. Presented by H. Lee, Esq.

Appendix C – Extraction and Library Preparation Protocol

This appendix lists the full methodology used for extraction and library preparation, which is summarised in chapter six. Only the final protocol is detailed, and not the protocol used in testing stages.

Extraction

Extraction protocol is modified from the DNEasy Blood & Tissue (Qiagen) kit.

Notes on contamination.

To avoid cross-contamination, ensure that only one sample is ever exposed to the air at one time. To avoid contamination from the researcher, only open Eppendorfs from above and avoid touching the inside of the lid. All extraction takes place in a dedicated pre-PCR lab. Other contamination procedures are outlined in chapter six.

Day 1: tissue lysis.

1. Clean all surfaces and equipment using:
    a. laboratory grade detergent.
    b. 90% ethanol.
    c. Microsol.
2. Leave all surfaces and equipment exposed to UV-C light for at least one hour.
3. Finely cut each sample with a single-use sterile scalpel.
4. Store in 1.5mL Eppendorf with 180µL ATL buffer and 20µL proteinase K. Mix by inverting.
5. Incubate samples overnight at 56°C, or longer if required to lyse completely.

Day 2: extraction.

1. Clean all surfaces and equipment using:
    a. laboratory grade detergent.
    b. 90% ethanol.
    c. Microsol.

2. Leave all surfaces and equipment exposed to UV-C light for at least one hour.
3. Add 200µL AL buffer to each sample.
4. Incubate samples for 10 minutes at 56°C.
5. Add 200µL 100% ethanol to each sample.
6. Transfer the 600µL contents to a fresh spin column. Centrifuge for 1 minute at 9,500 RPM.
7. Discard the collection tube and put the spin column into a fresh collection tube.
8. Add 500µL AW1 buffer. Centrifuge for 1 minute at 9,500 RPM.
9. Discard the collection tube and put the spin column into a fresh collection tube.
10. Add 500µL AW2 buffer. Centrifuge for 4 minutes at 12,000 RPM.
11. Discard the collection tube and put the spin column into a 1.5mL Eppendorf.
12. Add 100µL AE buffer and incubate at room temperature for 1 minute.
13. Centrifuge for 1 minute at 9,500 RPM.
14. Leaving the spin column in the same Eppendorf, add 100µL AE buffer and incubate at room temperature for 1 minute.
15. Centrifuge for 1 minute at 9,500 RPM.
16. Discard the spin column and keep the sample in the Eppendorf.

Library Preparation

Library preparation is modified from the NebNext Ultra II (New England Biolabs) kit.

Typically after the extraction phase, DNA is fragmented. However, as outlined in chapter six, ancient DNA is already fragmented due to degradation. Accordingly fragmentation is skipped in this protocol. Similarly, the size-selection stage is skipped.

End preparation and adapter ligation.

End preparation ensures all DNA fragments have blunt-ends with no overhangs, which allows the adapters to ligate with them in the next step. This stage takes place in a dedicated pre-PCR lab.

1. Clean all surfaces and equipment using:
    a. laboratory grade detergent.
    b. 90% ethanol.

    c. Microsol.
2. Leave all surfaces and equipment exposed to UV-C light for at least one hour.
3. Add 3µL end prep enzyme mix and 7µL end prep reaction buffer to each sample. Mix using the pipette.
4. Incubate samples in a thermocycler with the lid heated to 75°C for:
    a. 30 minutes at 20°C.
    b. Then 30 minutes at 65°C.
    c. Hold at 4°C.
5. Dilute adapter mix with TE buffer to 1:10.
6. Add 30µL ligation master mix, 1µL ligation enhancer, and 2.5µL of the diluted adapter mix to samples. Mix using the pipette.
7. Incubate for 15 minutes at 20°C.
8. Add 3µL USER enzyme to the samples.
9. Incubate samples in a thermocycler with the lid heated to 47°C for 15 minutes at 37°C.
10. Clean up samples using 87µL SPRI beads:
    a. Add beads and incubate for 5 minutes at room temperature.
    b. Place Eppendorfs on a magnet and discard the supernatant.
    c. Add 200µL 80% ethanol and incubate at room temperature for 30 seconds. Place samples on a magnet and discard the supernatant.
    d. Repeat step 8.c.
    e. Leave to dry for 5 minutes at room temperature.
    f. Remove samples from the magnet, add 17µL TE buffer and pipette mix with the SPRI beads. Incubate for 2 minutes at room temperature.
    g. Place samples on a magnet and transfer 15µL supernatant to a PCR tube.

PCR amplification.

Preparation for this stage takes place in the dedicated pre-PCR lab. The samples are then transferred to the PCR lab. Samples should be transferred on the same day in insulated packaging packed with ice.

1. Add 25µL well-mixed PCR master mix, 5µL index primer (unique to each sample) and 5µL universal primer. Mix using a pipette.

2. **Transfer samples to PCR lab.**
3. Place samples in a thermocycle with the following cycle:
    a. Initial denaturation: incubate for 30 seconds at 98°C.
    b. Denaturation: incubate for 10 seconds at 98°C.
    c. Annealing and extension: incubate for 75 seconds at 65°C.
    d. Repeat steps 3.b and 3.b for 15 cycles.
    e. Final extension: incubate for 5 minutes at 65°C.
    f. Hold at 4°C.
4. Clean up samples using 45µL SPRI beads:
    a. Add beads and incubate for 5 minutes at room temperature.
    b. Place Eppendorfs on a magnet and discard the supernatant.
    c. Add 200µL 80% ethanol and incubate at room temperature for 30 seconds. Place samples on a magnet and discard the supernatant.
    d. Repeat step 8.c.
    e. Leave to dry for 5 minutes at room temperature.
    f. Remove samples from the magnet, add 33µL TE buffer and pipette mix with the SPRI beads. Incubate for 2 minutes at room temperature.
    g. Place samples on a magnet and transfer 30µL supernatant to an Eppendorf.

At this stage the library is prepared and ready for further quality checking and analysis.

Appendix D – mapDamage Graphs

This appendix includes the full set of graphs generated by the *mapDamage* program as described in chapter six. Graphs are presented for each sample. Note that sample VD5 is not listed as the sample was excluded during the extraction stage. See chapter six for an explanation on interpreting these graphs.

TB1

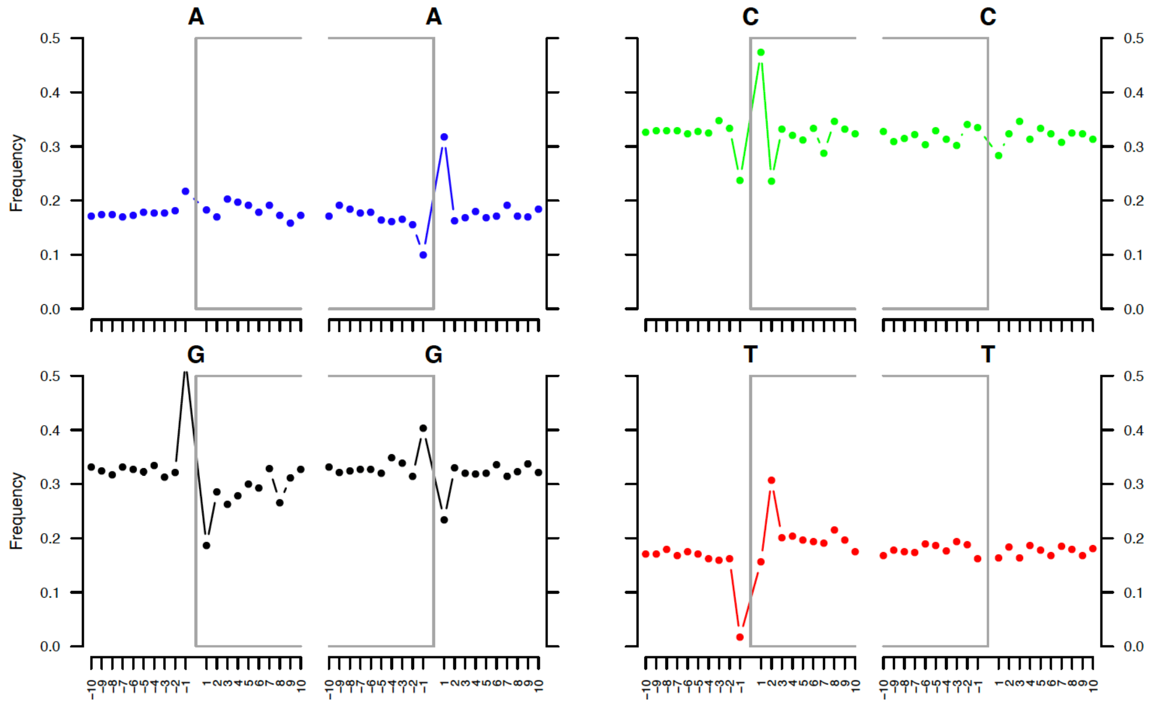

Figure 1: mapDamage *results for sample TB1 alignment with* M. tuberculosis.

VD1

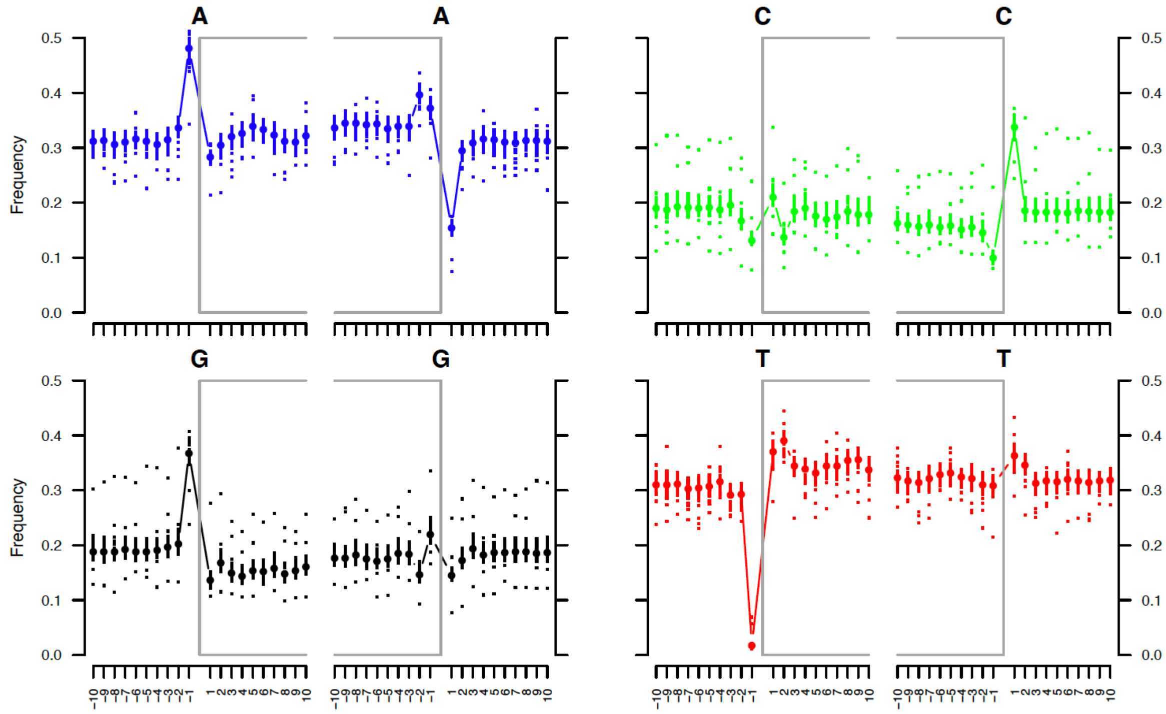

Figure 2: mapDamage *results for sample VD1A alignment with* Homo sapiens.

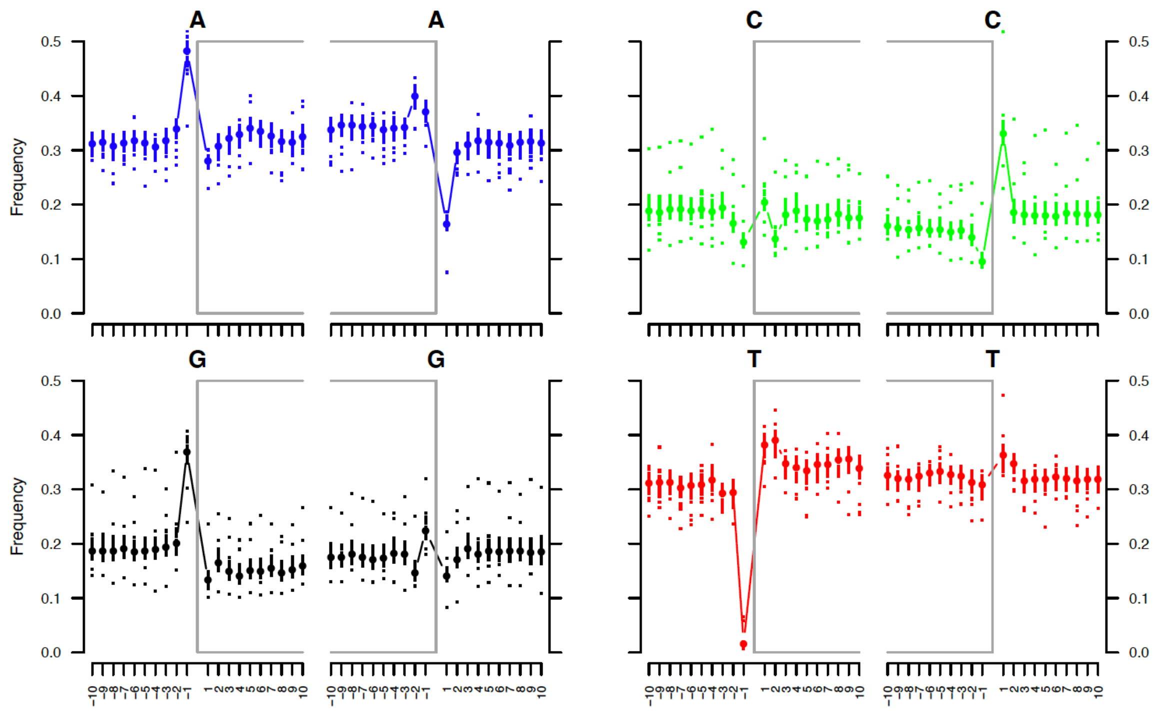

Figure 3: mapDamage *results for sample VD1B alignment with* Homo sapiens.

VD2

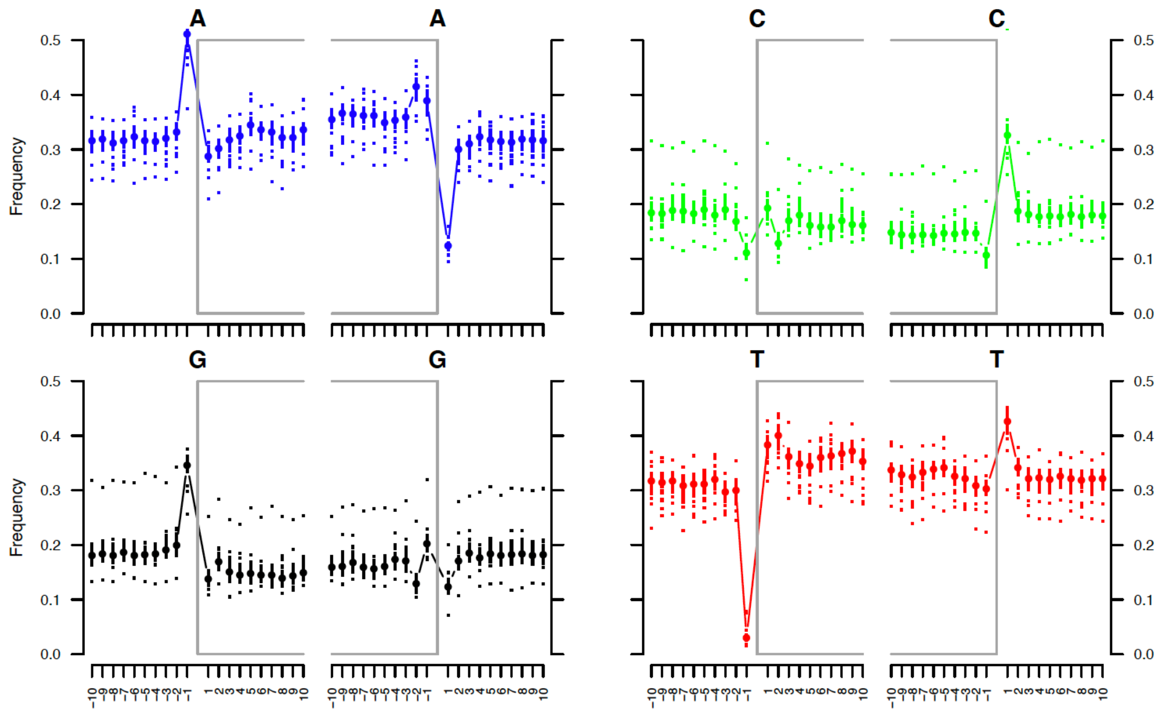

Figure 4: mapDamage *results for sample VD2A alignment with* Homo sapiens.

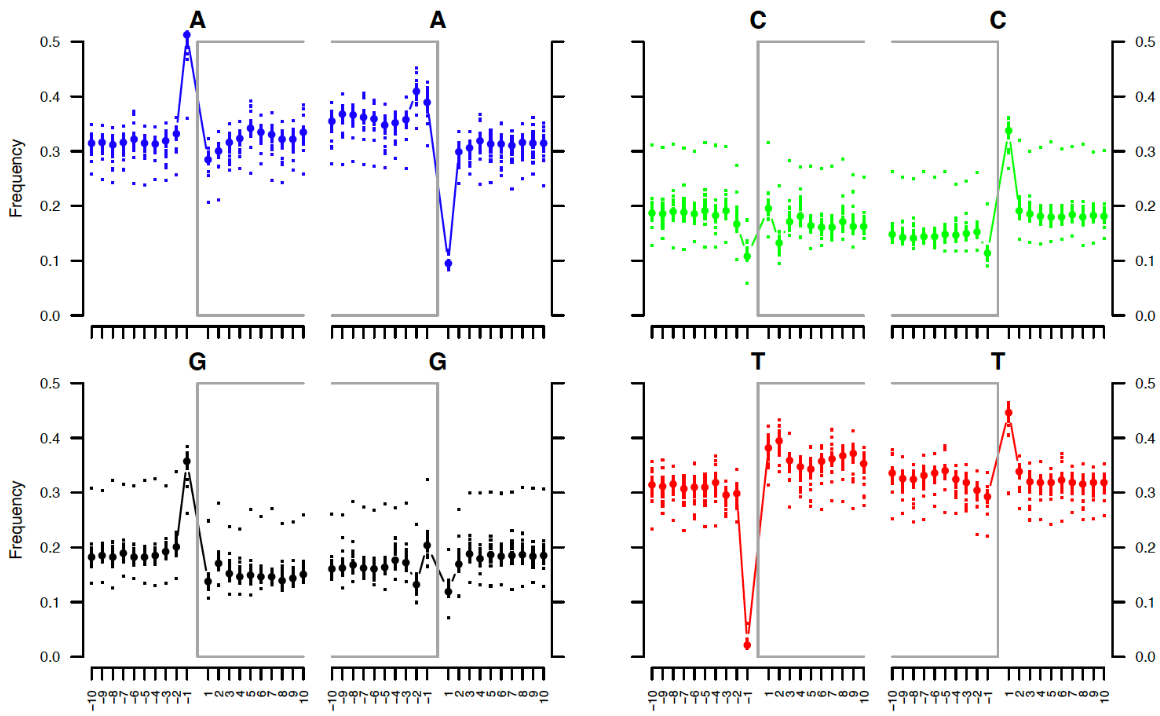

Figure 5: mapDamage *results for sample VD2B alignment with* Homo sapiens.

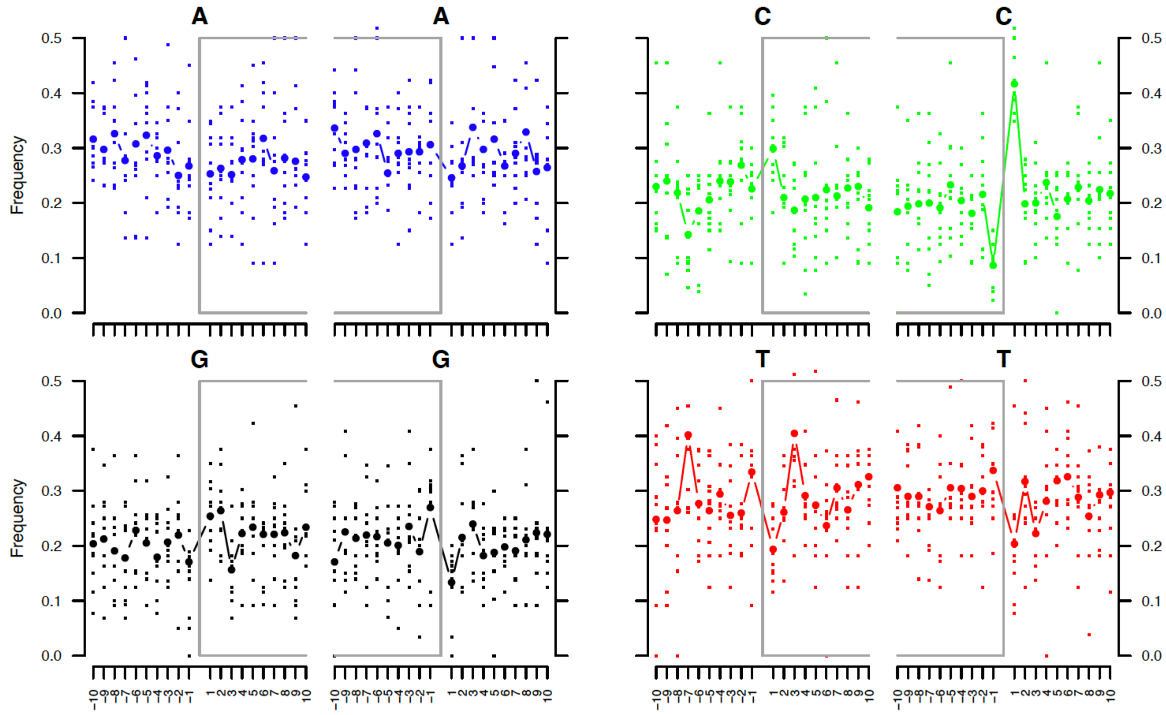

Figure 6: mapDamage *results for sample VD2A alignment with* M. osloensis.

VD3

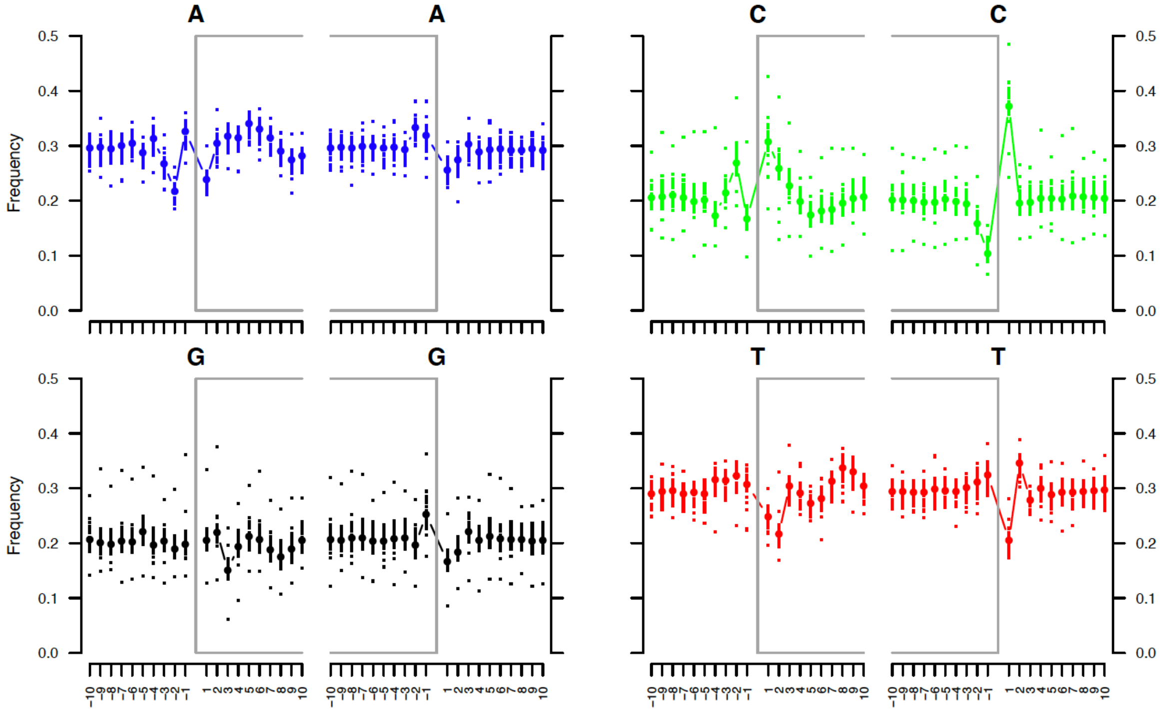

Figure 7: mapDamage *results for sample VD3A alignment with* Homo sapiens.

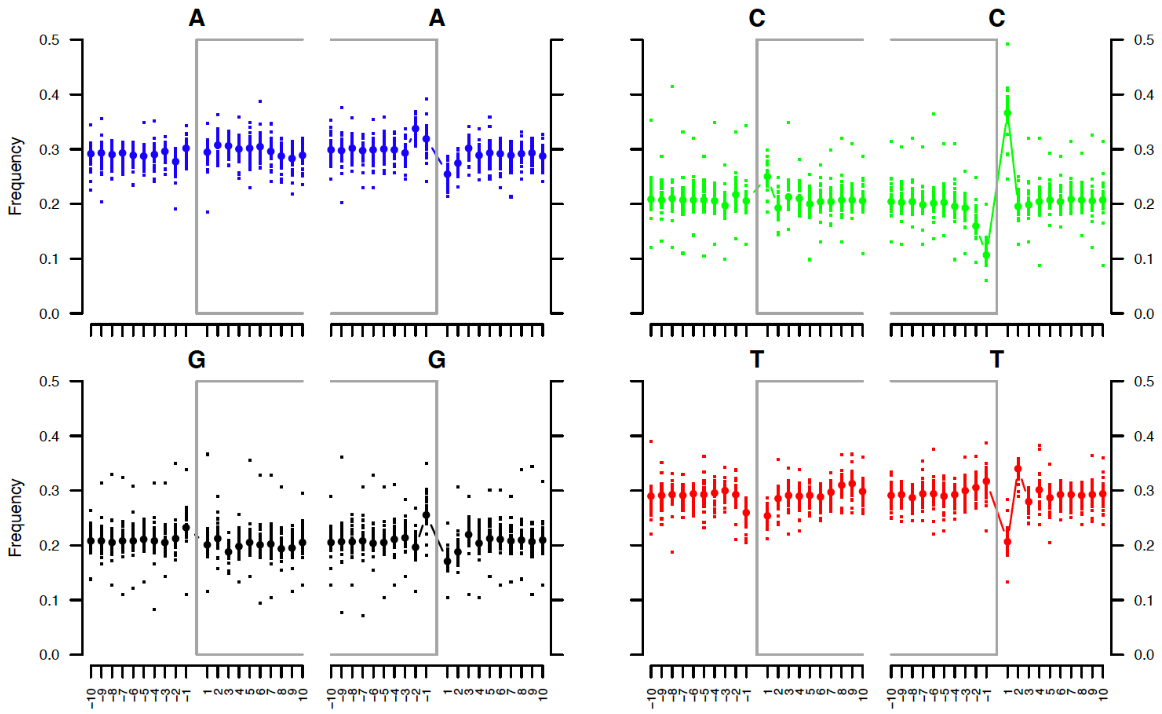

Figure 8: mapDamage *results for sample VD3B alignment with* Homo sapiens.

VD4

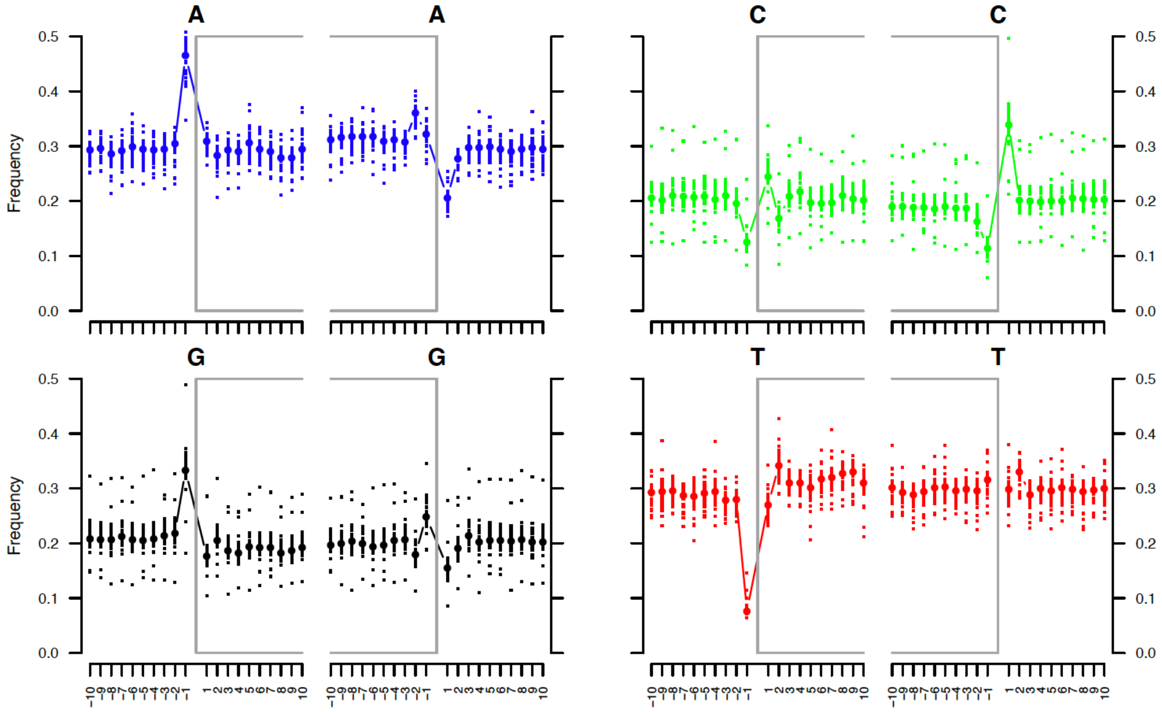

Figure 9: mapDamage *results for sample VD4A alignment with* Homo sapiens.

VD6

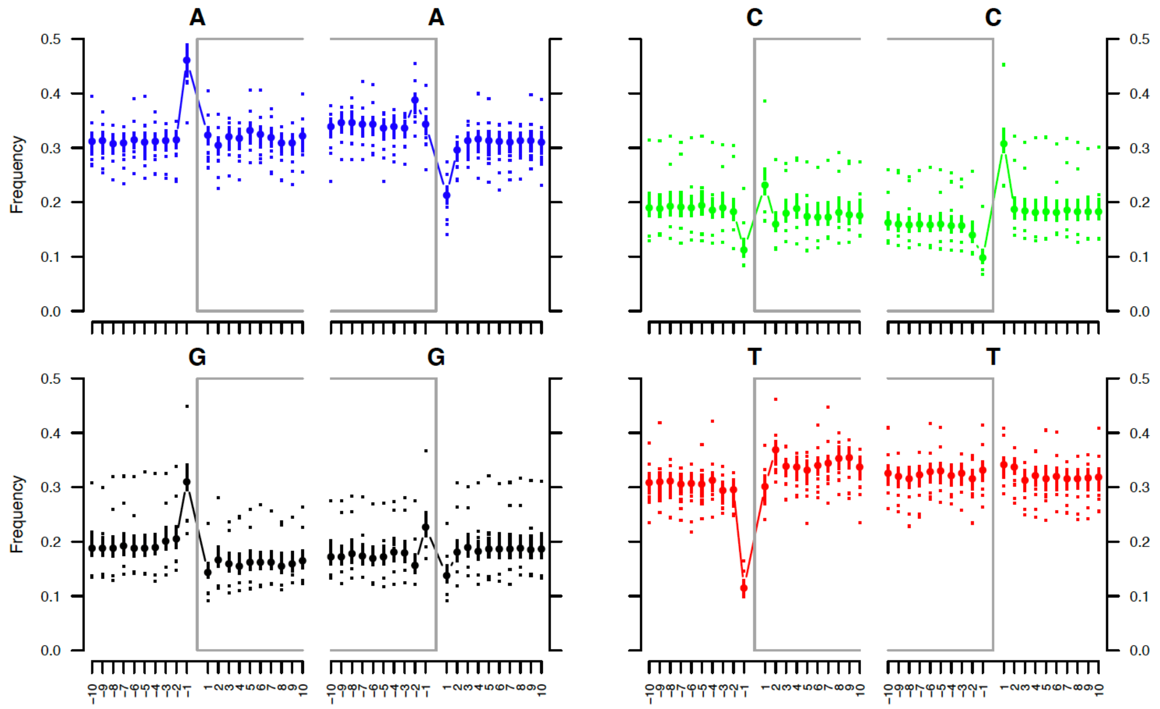

Figure 10: mapDamage *results for sample VD6A alignment with* Homo sapiens.

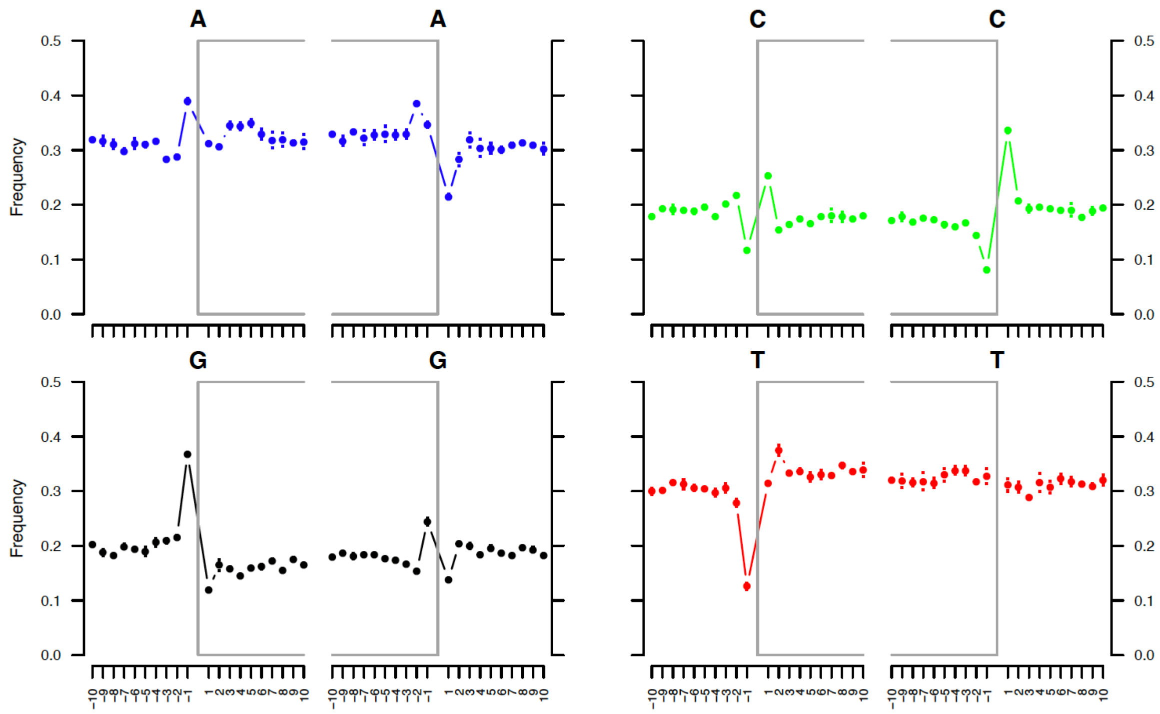

Figure 11: mapDamage *results for sample VD6A alignment with* H. influenzae.

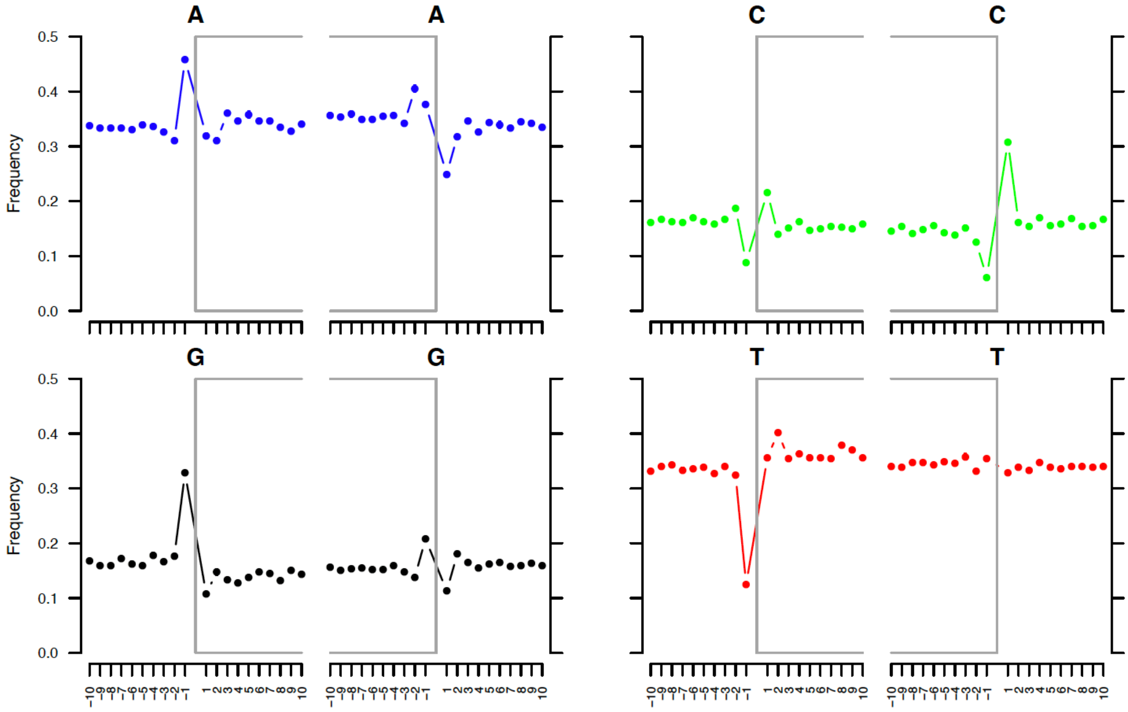

Figure 12: mapDamage *results for sample VD6A alignment with* S. aureus.

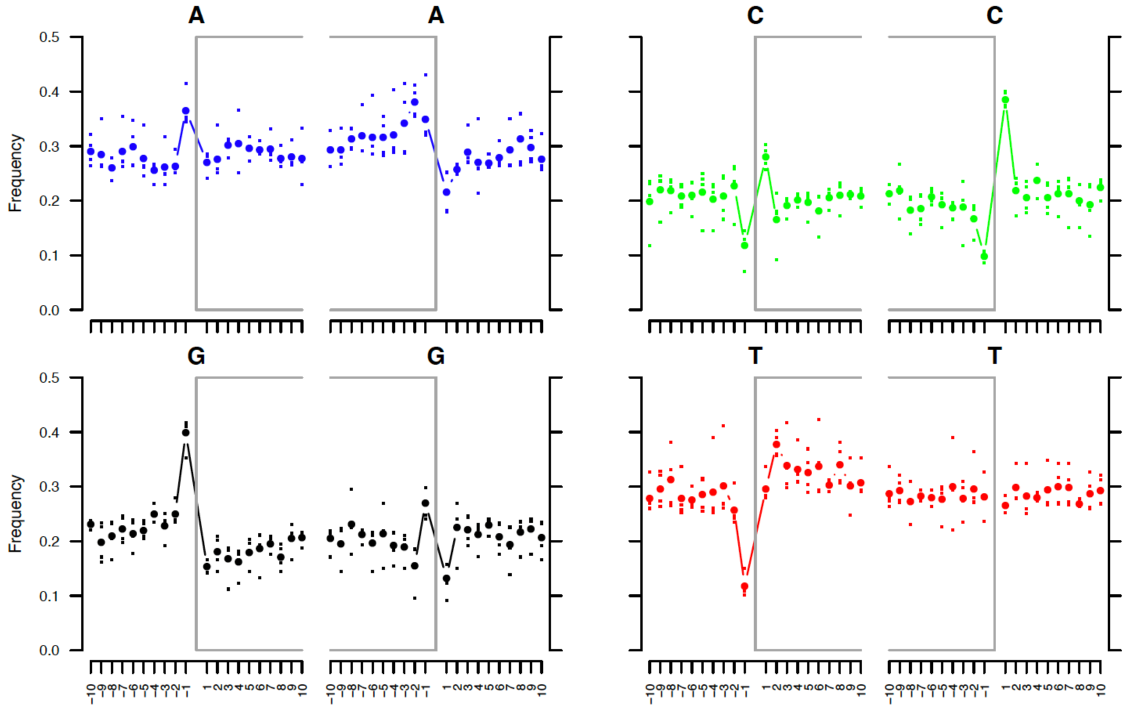

Figure 13: mapDamage *results for sample VD6A alignment with* S. baltica.

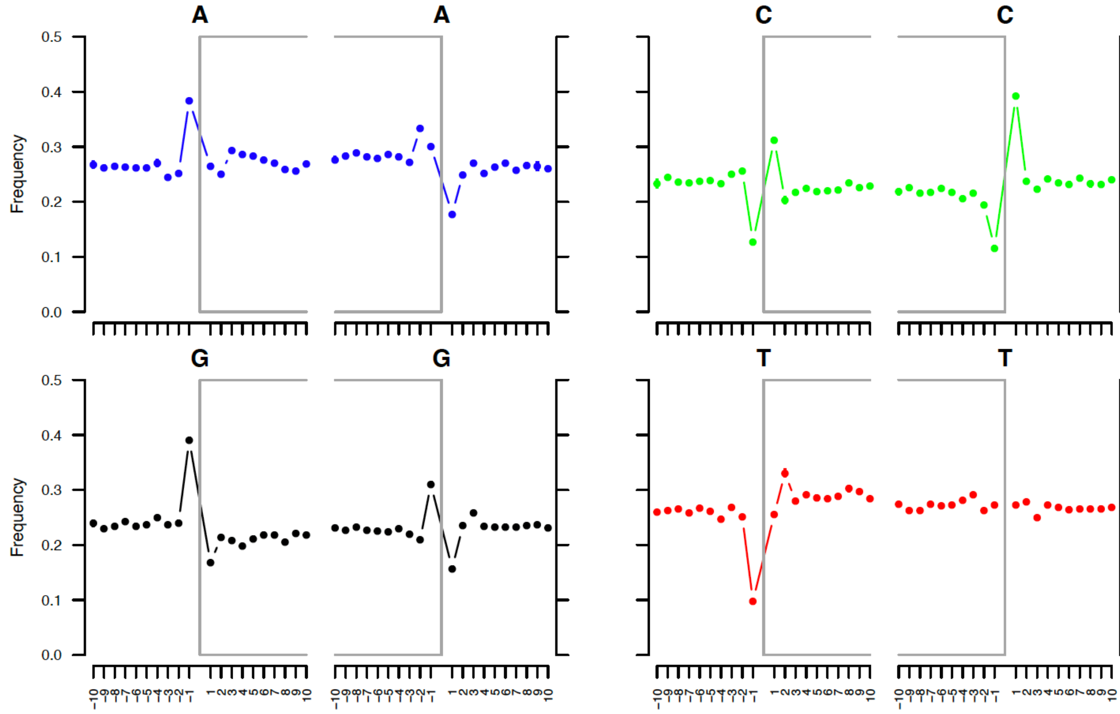

Figure 14: mapDamage *results for sample VD6A alignment with* Y. enterocolitica.

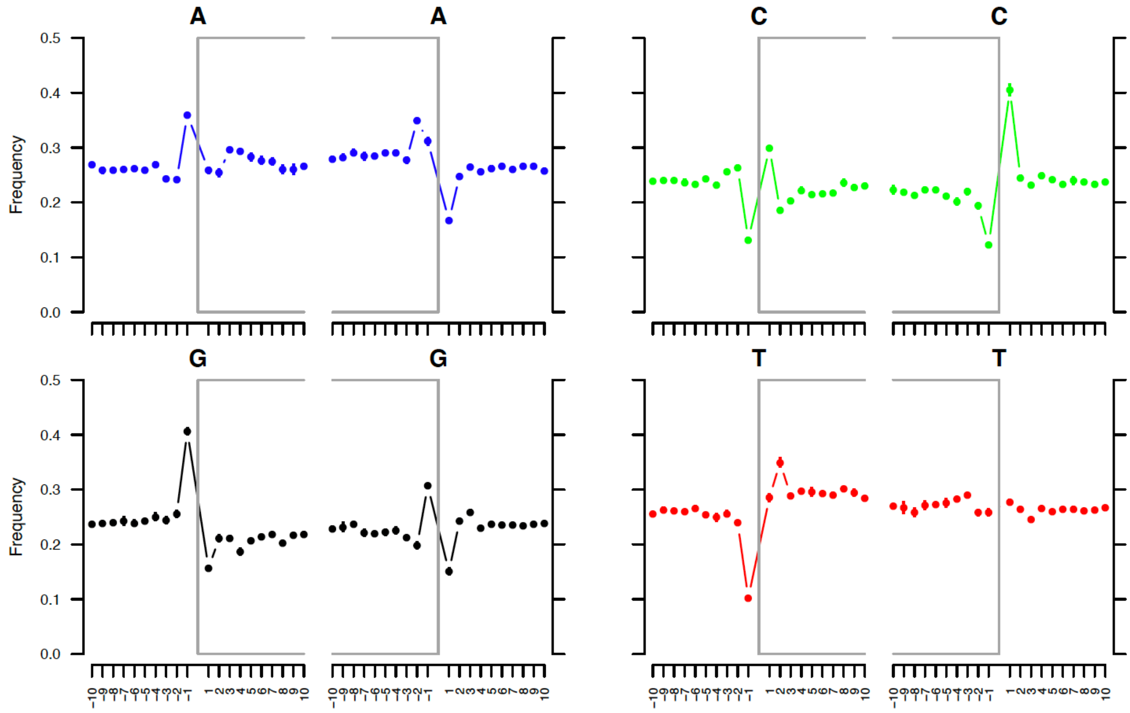

Figure 15: mapDamage *results for sample VD6A alignment with* Y. ruckeri.

Negative Control

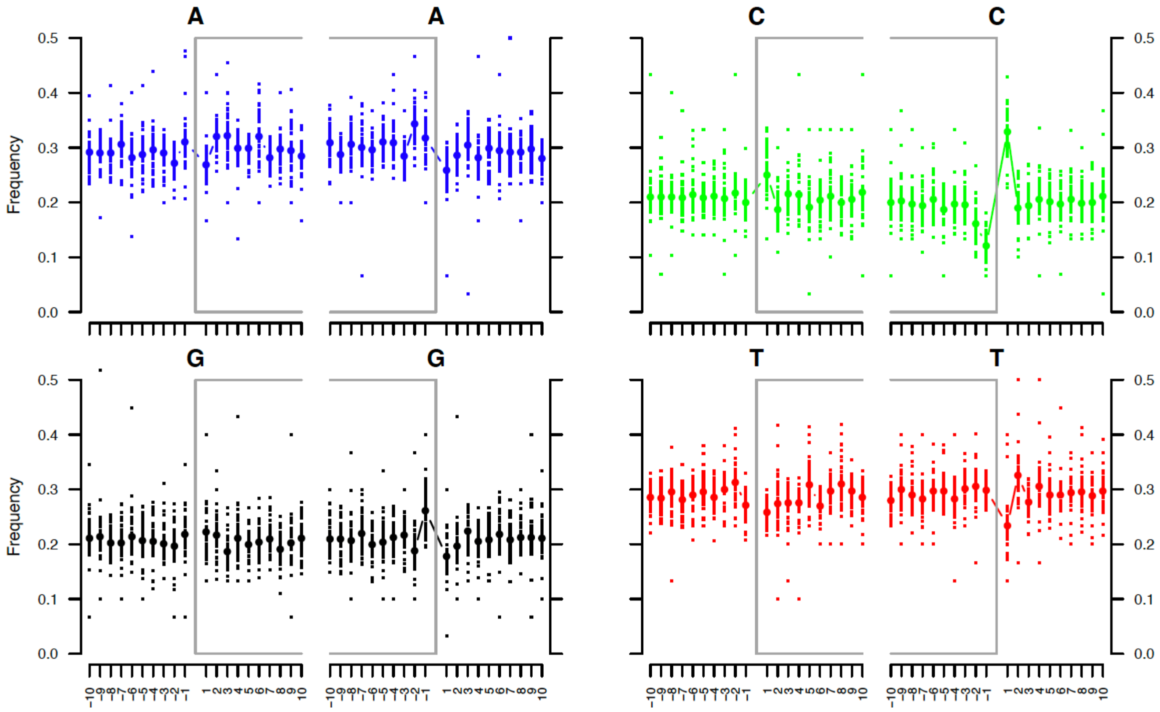

Figure 16: mapDamage *results for the negative control alignment with* Homo sapiens.

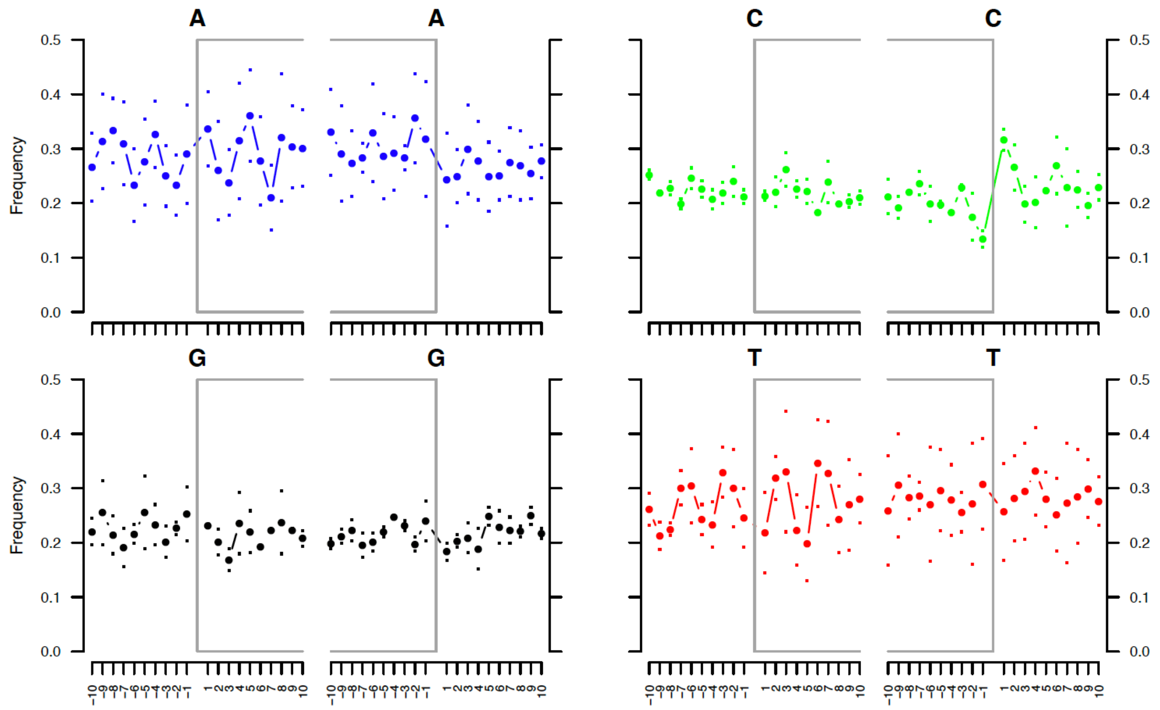

Figure 17: mapDamage *results for the negative control alignment with* H. influenzae.

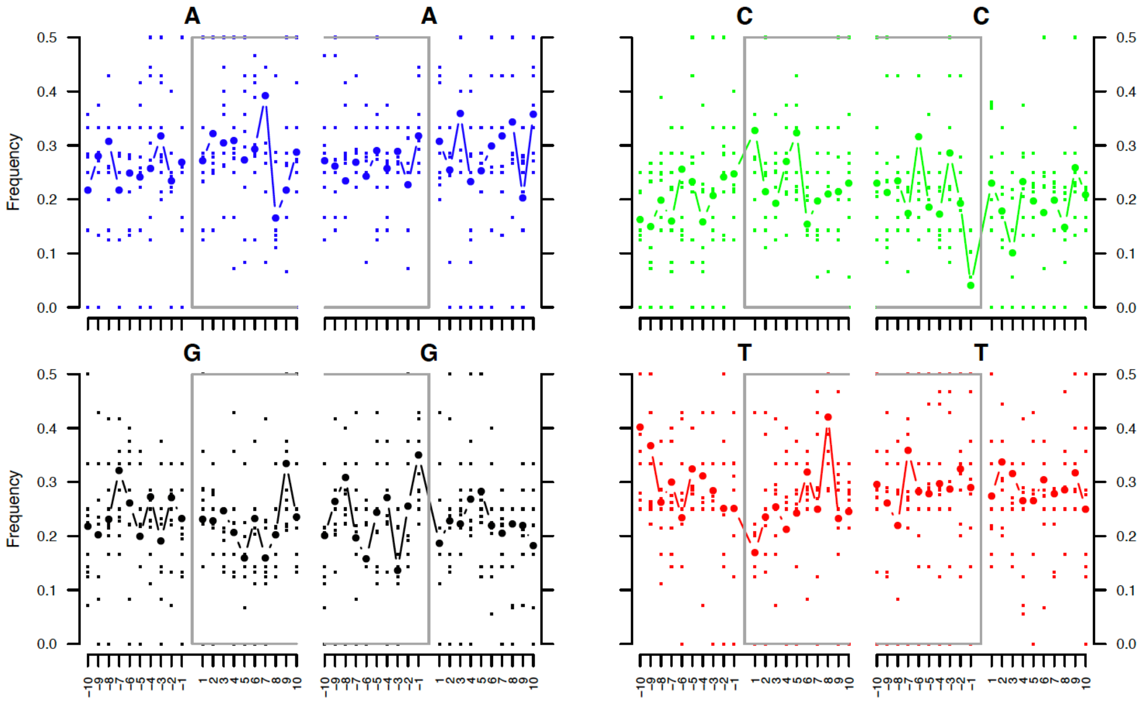

Figure 18: mapDamage *results for the negative control alignment with* M. osloensis.

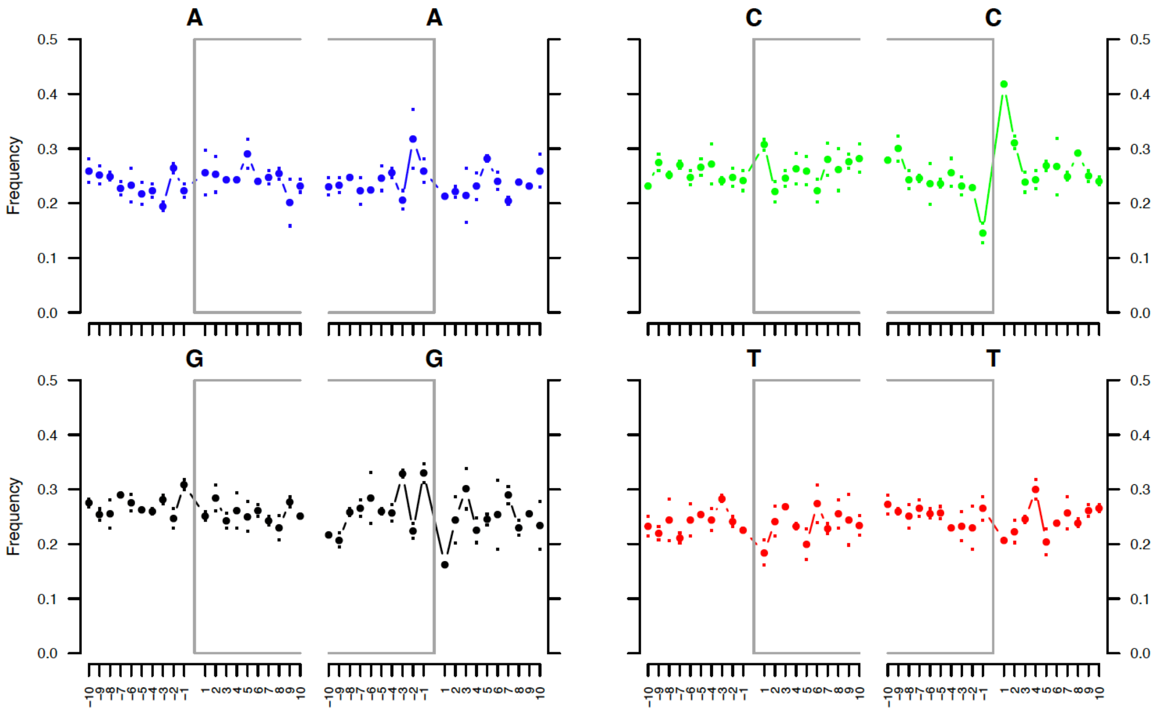

Figure 19: mapDamage *results for the negative control alignment with* S. aureus.

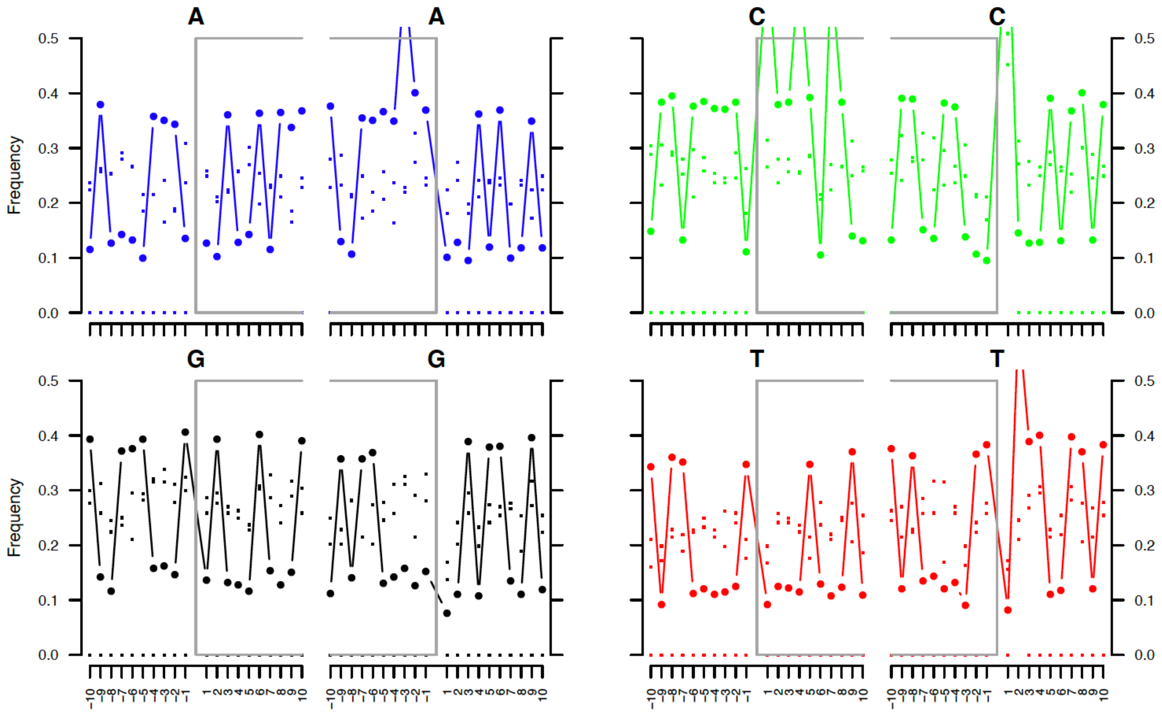

Figure 20: mapDamage *results for the negative control alignment with* S. baltica.

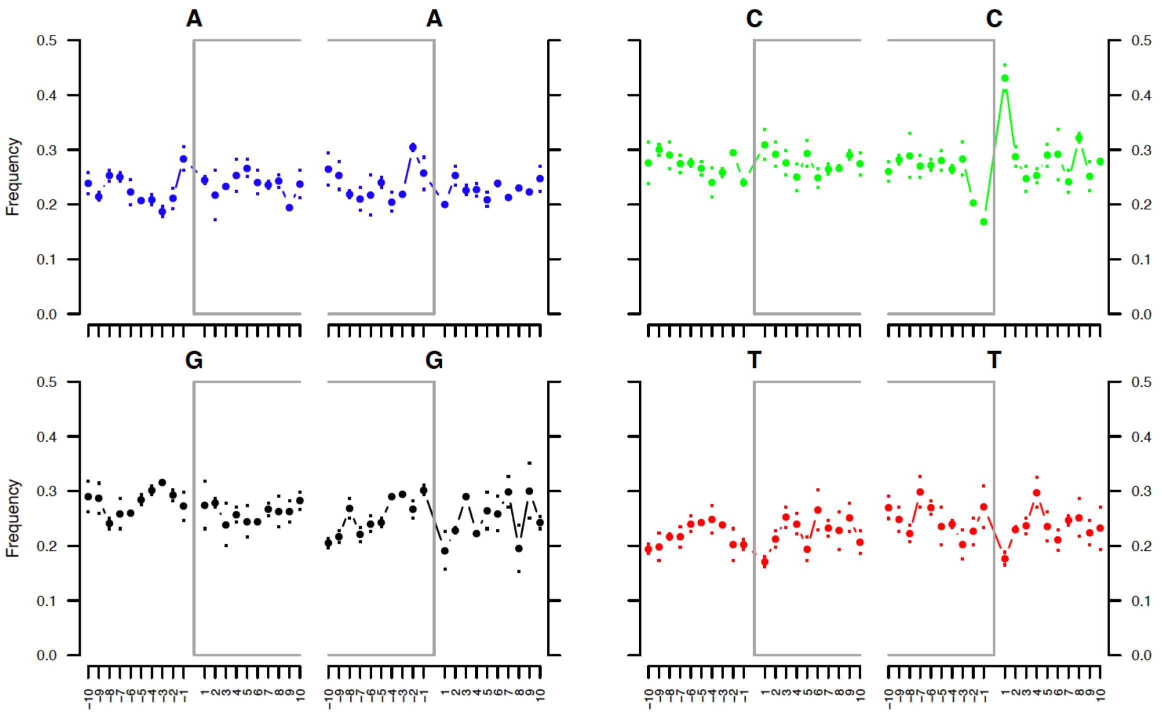

Figure 21: mapDamage *results for the negative control alignment with* Y. enterocolitica.

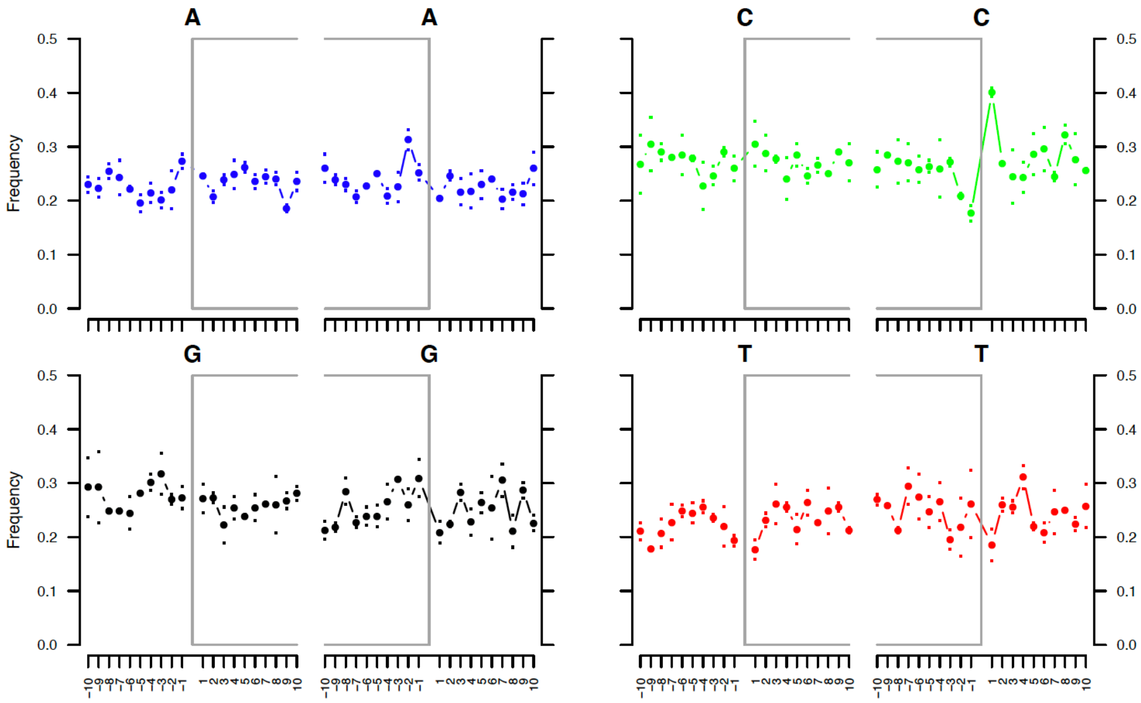

Figure 22: mapDamage *results for the negative control alignment with* Y. ruckeri.

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