Introduction

The pivotal role of the germ theory of disease in modern medicine is widely acknowledged in medical history and beyond. Typical comments are that it was 'probably the most important single concept for the history of modern medicine'[1] and that in the late nineteenth century it helped 'transform every aspect of medicine'.[2] Historians have also argued that it was central to the 'scientific revolution in medicine' of the last quarter of the nineteenth century, which was forged around the growing role and authority of the laboratory in medical investigation and practice.[3] There are perhaps more celebratory histories of 'the microbe revolution' than of any other episode in medical history.[4] The names of Louis Pasteur (1822–95), Robert Koch (1843–1910) and Joseph Lister (1827–1912) – the key 'discoverers' and 'innovators' – are well known. Their lives and work have been the subject of many academic studies, as well as popular biographies and radio and television programmes.[5] There are a number of histories of medical bacteriology and many journal articles on the changing understanding of specific diseases. However, there is no recent study of the development and spread of the germ theory in medicine.[6] In this volume I begin to make good this deficiency by explor-

1 R. E. McGrew, *Encyclopaedia of Medical History*, London, Macmillan, 1985, 25.
2 C. E. Rosenberg, *The Care of Strangers*, Baltimore, MD, Johns Hopkins University Press, 1987, 141.
3 A. Youngson, *The Scientific Revolution in Victorian Medicine*, London, Croom Helm, 1979; J. V. Pickstone, ' Ways of Knowing: Towards a Historical Sociology of Science', *BJHS*, 1993, 26: 433–58.
4 The genre began with P. de Kruif, *The Microbe Hunters*, London, Jonathan Cape, 1926. Cf. A. L. Baron, *Man Against Germs*, London, Robert Hale, 1958; R. Reid, *Microbes and Men*, London, BBC, 1974; P. E. Baldry, *The Battle Against Bacteria*, Cambridge, Cambridge University Press, 1965; H. Koprowski and M. B. A. Oldstone, eds., *Microbe Hunters: Then and Now*, New York, Medi-Ed Press, 1996.
5 On the three heroes see: R. Dubos, *Pasteur and Modern Science*, Madison, WI, SciTech, 1960, rep. 1988; G. L. Geison, 'Louis Pasteur', in C. C. Gillispie, ed., *The Dictionary of Scientific Biography*, New York, Charles Scribner, 1974, 350–416; idem., *The Private Science of Louis Pasteur*, Princeton, NJ, Princeton University Press, 1995; P. Debré, *Louis Pasteur*, Baltimore, MD, Johns Hopkins University Press, 1998; T. D. Brock, *Robert Koch: A Life in Medicine and Bacteriology*, Madison, WI, Science Tech, 1988; F. F. Cartwright, *Joseph Lister*, London, Longmans, 1963; R. B. Fisher, *Joseph Lister, 1827–1912*, New York: Stein and Day, 1977.
6 W. Bulloch, *The History of Bacteriology*, London, Oxford University Press, 1938; W. D. Foster, *A History of Medical Bacteriology and Immunology*, London, Heinemann Medical, 1970. On disease his-

ing how, why and to what extent germ ideas and practices were used, and with what effect, by the medical profession in Britain in the period 1865–1900. I do so around four propositions: (i) Rather than discussing a single germ theory, we need to explore the many *germ theories of disease* (and germ theories of other phenomena) current after 1865; (ii) we should give equal place to germ *practices*; (iii) we must always consider ideas on how the *body reacts to germs* and not leave this question until the emergence of formal immunological models from the mid-1880s; and (iv) we examine the *new meanings of science in medicine* that were linked with the new knowledge of germs.[7]

The first and most important theme to acknowledge is the range of *germ theories of disease* current between 1865 and 1900.[8] In the 1860s and 1870s, there were many views on what disease-germs were, for example, chemical poisons, ferments, degraded cells, fungi, 'bacteria' or a class of parasites. Indeed, it was likely that there was a spectrum of disease agents, from simple chemical poisons through to worms. The plurality of germ theories was acknowledged by some contemporary doctors and scientists; for example, John Drysdale (1817–92), in his *Germ Theories of Infectious Disease* in 1878, identified at least ten types of 'infectious miasms': 'chemical ferments', 'organised ferments', morphologically specific parasites, physiologically specific parasites, saprophytes, animal graft-germs, vegetable graft-germs and chemical septic products (liquid or gaseous).[9] However, the key issues in the mid-1860s were

tories see, for example, R. and J. Dubos, *The White Plague: Tuberculosis, Man and Society*, Boston, Little Brown and Co., 1952; A. M. Brandt, *No Magic Bullet: A Social History of Venereal Disease in the United States since 1880*, 2nd edition, New York, Oxford University Press, 1987; N. Rogers, *Dirt and Disease: Polio Before FDR*, New Brunswick, NJ, Rutgers University Press, 1992. Further studies can be expected following the impact of C. E. Rosenberg and J. Golden, *Framing Disease: Studies in Cultural History*, New Brunswick, NJ, Rutgers University Press, 1992.

7 S. E. D. Shortt, 'Physicians, Science and Status: Issues in the Professionalisation of Anglo-American Medicine in the Nineteenth Century', *MH*, 1983, 27: 51–68.

8 The notion that there were many germ theories was the basis of the work of Richard Shryock and Phyllis A. Richmond, though the implication of their work was that after 1870 the 'true' germ-theory was finally accepted. R. H. Shryock, 'Germ Theories in Medicine Prior to 1870: Further Comments on Continuity in Science', *Clio Medica*, 1972, 7: 81–109; P. A. Richmond, 'The Germ Theory of Disease', in A. M. Lilienfield, ed., *Times, Places and Persons: Aspects of the History of Epidemiology*, Baltimore, MD, Johns Hopkins Univeristy Press, 1980, 84–93. Margaret Pelling and Christopher Hamlin have been the strongest advocates of *theories* rather than *the theory*. M. Pelling, *Cholera, Fever and English Medicine, 1835–65*, Oxford, Oxford University Press, 1978; idem., 'Contagion/Germ Theory/Specificity', in W. F. Bynum and R. Porter, eds., *Companion Encyclopaedia of the History of Medicine*, London, Routledge, 1993, 309–34; C. Hamlin, 'Politics and Germ Theories in Victorian Britain: The Metropolitan Water Commissions of 1867–9 and 1892–3', in R. MacLeod, ed., *Expertise and Government: Specialists, Administrators and Professionals, 1860–1919*, Cambridge, Cambridge University Press, 1988, 111–23.

9 J. J. Drysdale, *The Germ Theories of Infectious Diseases*, London, Baillière, Tindall and Cox, 1878. John James Drysdale was a Liverpool doctor who published homeopathy, scientific materialism, theories of life and 'pyrogens' – fever-producing chemicals in the blood. In the early 1870s, he published a number of articles on microorganisms with W. H. Dallinger (1842–1909). R. G. H., 'Obituary: Rev. W. H. Dallinger', *JRMS*, 1909, 29: 699–702.

around the boundary of complex chemicals and life-forms: Were disease-agents living or not, could they arise *de novo* or were they always 'ancestral'? There was also great uncertainty over whether germs were cause, consequence or mere concomitants of disease, not to mention which diseases were associated with germs. One problem for my emphasis on germ theories of disease is that contemporaries usually wrote of a single theory.[10] I shall return to this question in the Conclusion, but it is worth noting that part of the reason was political. Proponents of all of the theories of disease advanced their ideas as firm principles, because to admit that there were many theories would have weakened their position. Conversely, critics were only too happy to highlight the number of theories to show the uncertainties amongst germ-theorists.

After 1880, there was a growing consensus in medicine that most disease-germs were 'bacteria', and more agreement on their properties and how they were transmitted. However, there was never closure on even a single bacterial model for germs or their actions in any branch of the profession. In medicine, although not in the wider culture, the word 'germ' began to be used less and less over the period, as 'bacteria' and 'microorganisms' became the *lingua franca* of modern medicine.[11] In 1881, the germ theory of disease was defined in a medical lexicon as 'the idea that the origin of many diseases lay in the pathogenic actions of certain micro-organisms when introduced into the body'.[12] This definition indicates that the 'reality' of germs was no longer disputed. However, questions about how different 'bacteria', in different diseases, produced their 'pathogenic actions' and how they were 'introduced into the body' remained open. There was also, of course, the major issue of the body's reactions to the 'pathogenic actions' of 'introduced' bacteria. The change from germs to 'bacteria', as we will see, was not without its problems. Many 'bacteria' remained beyond the capture of microscopy and the new laboratory techniques. Equally, it proved difficult to determine their physical, chemical and biological effects in the body, and to construct accounts of the relations between their often localised presence and the systemic effects seen in clinical syndromes. Thus, I have to explain why, despite these uncertainties and against quite concerted opposition, bacterial theories of disease continued to gain supporters and spread.

In Britain, as elsewhere, there was a group of germ-theorists, mostly

10 One of the first histories wrote as though there was a single theory. E. M. Crookshank, 'The History and Present Position of the Germ Theory of Disease', *PH*, 1888–89, 1: 16–9, 53–6.

11 For a model study of the public reception and uses of germs in the United States, see: N. Tomes, *The Gospel of Germs: Men, Women and the Microbe in American Life*, Cambridge, MA, Harvard University Press, 1998.

12 This definition from the *Oxford English Dictionary* is based on the one given in H. Power and L. W. Sedgwick, *New Sydenham Society's Lexicon of Medicine and the Sciences*, London, New Sydenham Society, 1881. J. K. Crellin, 'The Dawn of Germ Theory: Particles, Infection and Biology', in F. N. L. Poynter, ed., *Medicine and Science in the 1860s*, London, WIHM, 1966, 57–76.

doctors and scientists, who developed and championed the new ideas and practices. However, the differences between germ-theorists were often as great as those between them and their opponents. I pay particular attention to the latter and to alternative explanations of disease, avoiding the common presumption that there were no theories of disease before germs, or that alternatives were undeveloped and 'unscientific'.[13] Indeed, histories of germ theories of disease have tended to give too much emphasis to germs and ignored the medically much more important story of 'theories of disease'. This is somewhat surprising, as germ theories, and then bacteriology, have been seen as important factors in a major shift in the dominant conception of disease in Western medicine.[14] This change has been described in many ways, but at its simplest it can be seen as moving from defining diseases by their symptoms and results to defining them in terms of processes and causes. The changing constructions can be illustrated by reference to tuberculosis.[15] In the early nineteenth century, the disease was known as consumption, or *phthisis*, from the Greek word for 'wasting'. This characterisation was based on a holistic view of the symptoms and results; patients wasted away as their body literally consumed itself. In the first half of the nineteenth century, the term 'tuberculosis' came to be used, referring to the localised pathological process of tubercle (nodule) formation in the lungs.[16] Thus, the disease was defined by a process and its results, but these were now described at the tissue and cellular levels. However, the identification and acceptance of the *Tubercle bacillus* in the 1880s as the essential cause, over an extended period it must be said, led to the creation of an aetiological definition of the disease. Indeed, the disease eventually took on the name of its cause – TB, short for *Tubercle bacillus*, the entity that entered the body and started the process of tubercle formation, which impaired respiration and circulation, to produce wasting.

13 P. A. Richmond, 'Some Variant Theories in Opposition to the Germ Theory of Disease', *JHM*, 1954, 9: 290–303. But note the comments on Richmond's approach in N. Tomes, "American Attitudes toward the Germ Theory of Disease: Phyllis Allen Richmond Revisited', *JHM*, 1997, 52: 17–50.

14 O. Temkin, 'Health and Disease', O. Temkin, in *The Double Face of Janus and Other Essays in the History of Medicine*, Baltimore, MD, Johns Hopkins University Press, 1977, 436–8; K. Codell Carter, 'The Development of Pasteur's Concept of Disease Causation and the Emergence of Specific Causes in Nineteenth Century Medicine, *BHM*, 1991, 65: 528–48.

15 Andrew Cunningham's interesting argument that there is no continuity between pre- and post-bacteriological constructions of disease is addressed implicitly throughout the volume. I think he is wrong for three main reasons: first, he overestimates the degree of difference between pre- and postgerm models of disease; second, he neglects the coexistence of different models amongst different groups of practitioners; and third, many contemporary doctors found no problem recognising continuities, despite epistemological differences. A. Cunningham, 'Transforming Plague: The Laboratory and the Identity of Infectious Disease', in A. Cunningham and P. Williams, eds., *The Laboratory Revolution in Medicine*, Cambridge, Cambridge University Press, 1992, 209–44.

16 Tubercles were small rounded projections or nodules of a particular grey-yellow consistency that became the defining postmortem sign of consumption. Its root is the same as the botanical term 'tuber'.

Historians have often preferred to characterise the overall change as one in the dominant ideal-type model of disease, with the physiological conceptions of disease being replaced by the so-called ontological ones. The physiological view fashioned diseases as disturbances in normal functioning or structure that resulted from the patient's predisposition interacting with a configuration of personal and environmental influences, including injuries and poisonings. Diseases were inseparable from the sick person; indeed, they were often seen positively as the body's way of healing itself. Ontological models made diseases 'things' or entities that were separate from the patient. On this view, diseases developed when pathogenic entities arose in the body (e.g. cancer cells) or entered the body (e.g. bacteria) and spread their effects locally or systemically. Ontological conceptions were associated more directly with causal definitions of disease and were seen by many doctors to open up new approaches to diagnosis, prevention and treatment by recognising and removing causes. While accepting that there was an overall transition from physiological to ontological models as ideal types, I suggest that this change was complex and uneven.[17] For example, in 1900, the terms 'phthisis', 'consumption', 'tuberculosis' and 'TB' were all used concurrently and often as alternatives, despite their distinct origins and meanings. The dominant medical view was that the development of the disease required both the *Tubercle bacillus* and a vulnerable human constitution, and there was a growing awareness that bacilli only produced disease in a minority of those infected.

My second proposition is that *germ practices* – seeing, killing, culturing, altering and representing germs – deserve as much attention as germ theories.[18] However, I do not want to concentrate on laboratory practices because those developed in the field were just as important, as were relations between the two areas of practice. Many existing medical and sanitary procedures, such as disinfection, isolation, antisepsis, anti-inflammatory remedies and vaccination, were redefined as germ practices after 1865. The style of laboratory work was carried into the field, as in antiseptic surgery, and field experience set the parameters for laboratory investigations of aetiology and pathogenesis.

The neglect of practice in extant histories of germs is exemplified by the emphasis given to Koch's postulates – the steps necessary to prove disease causation by germs – compared to attention given to his technical innovations in microscopy, culturing and experimental pathology, not to mention his work in clinical and preventive medicine and his technically innovative publications.[19] The extent to which the development of bacteriology as a technical specialism contributed to the eclipse of 'germs' in the 1880s is debat-

17 J. M. Bruce, 'The Dominance of Etiology in Modern Medicine, *BMJ*, 1910, ii: 246–7.
18 A. S. Evans, 'Causation and Disease: The Effects of Technology on Postulates of Causation', *Yale Journal of Biological and Medicine*, 1994, 64, 513–28.
19 K. Codell Carter, 'Koch's Postulates in Relation to the Work of Jacob Henle and Edwin Klebs', *MH*, 1985, 29: 353–74. An exception is Brock's biography of Robert Koch.

able. The terms of debate certainly changed, as speculation and principles were replaced by facts, practical demonstrations and precise models. Certainly, 'bacteria' were made available for doctors to see and attempts were made to spread knowledge of the techniques. However, in other ways things became less certain. The adoption of new methods of investigation produced more aetiological claims from more sources, so it became harder to keep up and assess the proliferation of ideas. Many suspected 'bacteria' continued to elude the new practices, or their properties could not be fixed; hence the notion of 'germs' remained useful, not least for the possibility that many diseases were due to the germs of bacteria, in the sense of their ultramicroscopical, unculturable and hence uninoculable 'spores' – the 'seeds' of the seeds of disease. I include some discussion of 'failed' aetiological claims, although not as many as I expected. I suspect that there would be more in a study of Germany or France, but in Britain the volume of laboratory investigations of germs and bacteria was smaller, and not always targeted towards constructing aetiological claims and achieving recognition.

I am also interested in the interactions between theory and practice, although I do not assume that the two are necessarily or simply linked. Indeed, with antiseptic surgery, one of the great icons of the germ era, I suggest that for long periods theory and practice were deliberately decoupled. In public health, practice was often said to be ahead of theory. This issue requires careful handling, as germ theorists and then bacteriologists were always keen to claim that their ideas and laboratory work led to practical benefits. In other words, they promoted a linear module of innovation: pure science leading to applied science, to technologies and then social consequences.

My third theme is that disease-germs cannot be considered in isolation from ideas about *the body's reactions to them*. Contemporaries were only too aware that most people recovered from infections, and hence germ theories of disease necessarily implied theories of health. One powerful and persistent argument against any germ-theory was that germs did not invariably produce disease. The need to look at explanations of the body's defences has been recognised by historians for the period after 1885, but then only in terms of the development of immunological theories. There has been little consideration of the less specific immunological thinking developed earlier, around notions of the body's refractoriness, predisposition, openness, diathesis or constitutional strength, which continued to be used well into the twentieth century.[20] I will argue that in Britain the dominant metaphor in germ theories of disease and health was the botanical one of 'seed and soil'. In many cases this was literally true. Bacteria were classified as plants, as were other likely pathogenic organisms, for example, fungi and fern spores. Only in the

20 P. H. Mazumdar, 'Immunity in 1890', *JHM*, 1972, 27: 312–24; S. MacKenzie, 'The Powers of Natural Resistance, or the Personal Factor in Disease of Microbe Origin', *TMSL*, 1902, 25: 302–18.

1890s was the now more popular military analogy of invading germs in conflict with the body's defences used extensively.

Fourth, I will suggest that germ theories and practices were not just theoretical and practical innovations; they were also carriers of *new meanings for science in medicine*.[21] The place of scientific knowledge and methods in medicine was debated vigorously from the mid-nineteenth century, being central to the transition of medicine from a status to an expert profession, in which science became the basis for identity and work. The notion of there having been a 'scientific revolution in Victorian medicine' once hinged on the assumed impact of germ theories. There has been a move in medical history to downplay the clinical and social benefits of germ and other medical laboratory sciences, and to play up their ideological value in modernising the profession.[22] I take issue with those historians who have suggested that laboratory medicine was promoted on its promise rather than its actual results. Instead, I argue that laboratory-derived ideas and practices were important resources in the reshaping of prevention, diagnosis, treatment and patient management, although they make no assessment of specific outcomes.

I want to emphasise at the outset that this volume is a *medical history of germs*. It explores how different groups of practitioners within medicine understood and used the new germ science and technology. I have not written a history of bacteriology,[23] microbiology,[24] immunology[25] or even laboratory medicine.[26] I discuss themes such as spontaneous generation,[27] pleomorphism,[28] classification and evolution,[29] but only when they were relevant to the making and spread of germs ideas and practices in medicine.[30] My approach is to consider in turn different areas of practice, looking at how

21 J. H. Warner, 'Science in Medicine', *Osiris*, 1983, 1: 37–85; idem., 'Ideals of Science and Their Discontents in Late Nineteenth Century American Medicine', *Isis*, 1991, 82: 454–78;

22 Youngson, *Scientific Revolution*, *passim*.

23 The standard works that focus on medical bacteriology are: Bulloch, *History of Bacteriology*, and Foster, *Medical Bacteriology*. On other aspects of the subject, see: K. Vernon, 'Pus, Sewage, Beer and Milk: Microbiology in Britain, 1870–1940', *History of Science*, 1990, 28: 289–325.

24 Microbiology was very much a French term. See: C. Salomen-Bayet, 'The First Bio-medical Revolution: Slow Shaping of Microbiology, France', in Y. Kawaita et al., eds., *History of Therapy: Proceedings of the Tenth International Symposium of Comparative Medicine: East and West*, Tokyo, Ishiyaku EuroAmerica Inc., 1990, 173–92, and C. Salomen-Bayet and B. Lécuyer, *Pasteur et la Revolution pastorienne*, Paris, Payot, 1986. Also see: H. A. Lechevalier and M. Solotorovsky, *Three Centuries of Microbiology*, New York, McGraw Hill, 1965; P. Collard, *The Development of Microbiology*, Cambridge, Cambridge University Press, 1976.

25 A. M. Silverstein, *A History of Immunology*, San Diego, CA, Academic Press, 1989; D. J. Bibel, ed., *Milestones in Immunology: A Historical Exploration*, Madison, Science Tech, 1988.

26 Cunningham, *Laboratory Revolution*, *passim*.

27 J. E. Strick, *The British Spontaneous Generation Debates of 1860–1880: Medicine, Evolution and Laboratory Science in the Victorian Context*, Unpublished PhD Thesis, Princeton University, 1997.

28 M. Wainwright, 'Extreme Pleomorphism and the Bacterial Life Cycle: A Forgotten Controversy', *Perspectives in Biology and Medicine*, 1997, 40: 407–14.

29 W. F. Bynum, 'Darwin and the Doctors: Evolution, Diathesis and Germs in Nineteenth Century Britain', *Gesnerus*, 1983, 40: 43–53.

30 The volume that is closest to mine is Foster, *Medical Bacteriology*.

different professional groupings attempted to understand diseases and to prevent, diagnose, control, manage and treat diverse afflictions. The distinct interests and resources of different groups enabled them to produce distinct theories and meanings, and to fashion diverse germ practices. The different discourses on germs that I explore were not developed in isolation from one another; hence, I consider the interactions between different groups within Britain and internationally. One advantage of this method is that it offers the opportunities for comparative history and to test just how 'local' medical cultures were in the late nineteenth century. My comparisons with the construction and use of germ theories in other countries are not as extensive as I would have liked.[31] Needless to say, Bruno Latour's *The Pasteurisation of France* was a major influence on my work, less for its philosophical propositions than for its ambitious attempt to account for the ways in which germ ideas and practices were spread and used.[32] Relations between British germ theorists and those in France and Germany, especially the powerful schools of Pasteur and Koch, are important parts of the story. However, I suggest that we need to revise any notion of British backwardness or inferiority. For most of the period I discuss, Lister was as important an international figure as Pasteur or Koch. There were many British germ workers, and there was no shortage of publications and debate. British investigators were more than willing to challenge their continental colleagues; for example, Charlton Bastian (1837–1915) (see Figure 3) took on Pasteur over spontaneous generation in the late 1870s and Edward Klein (1844–1925) (see Figure 2) disputed Koch's work on cholera through the late 1880s and early 1890s.

Germ theories had no essential meaning, nor did germ practices dictate specific preventive or therapeutic strategies. As Tomes and Warner have recently argued, the historical task is not to study 'the acceptance of the germ-theory of disease but to fix its meaning', although I think that 'meanings' better captures their intent.[33] This is, of course, a potentially huge venture, especially if germ theories did 'transform every aspect of medicine'. Thus, I have been necessarily selective in the local cultures that I have studied, concentrating on veterinarians, surgeons, public health doctors and general practitioners and physicians through the lens of tuberculosis. Given time and space, I would like to have included an analysis of nurses' germs,[34] patholo-

31 The value of such work is evident in Mendelsohn's outstanding study of France and Germany. J. A. Mendelsohn, *Cultures of Bacteriology: Foundation and Transformation of a Science in France and Germany, 1870–1914*, Unpublished PhD thesis, Princeton University, 1996.

32 B. Latour, *The Pasteurization of France*, Cambridge, MA, Harvard University Press, 1988. But see: S. Sturdy, 'The Germs of a New Enlightenment', *Studies in the History and Philosophy of Science*, 1991, 22: 163–73, and S. Schaffer, 'The Eighteenth Brumaire of Bruno Latour', Ibid., 174–92.

33 N. J. Tomes and J. H. Warner, 'Introduction to Special Issue on Rethinking the Reception of Germ Theory of Disease: Comparative Perspectives', *JHM*, 1997, 52: 16.

34 On nurses' germs see: A. Bashford, *Purity and Pollution: Gender, Embodiment and Victorian Medicine*, Houndmills, Hants., Macmillan, 1998.

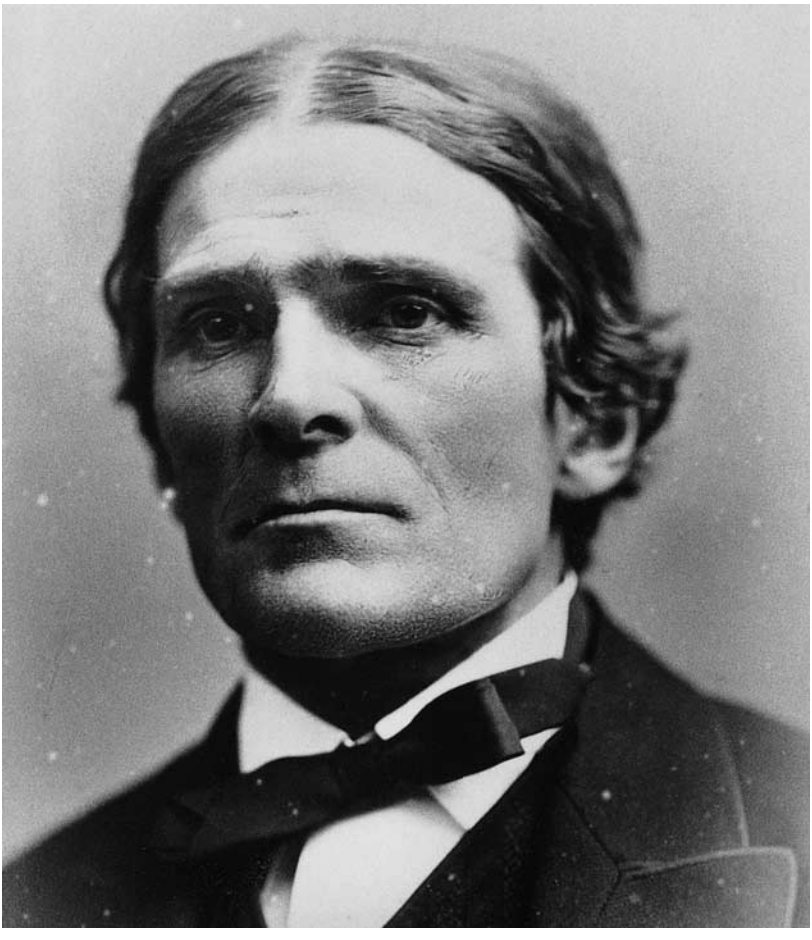

Figure 1. John Burdon Sanderson (Reproduced by courtesy of the Wellcome Institute Library, London)

gists' germs, obstetricians' germs,[35] colonial doctors' germs[36] and, of course, bacteriologists' germs. I have not ignored the latter, but there are a number of good histories of medical bacteriology, and until the twentieth century this was a small group. Until then, most germ workers were part-time bacteriologists with interests and loyalties in other professional domains. The groups and topics that I consider are those where germ theories and practices were most developed, debated and used. However, I have not been rigid

35 I. S. L. Loudon, *Childbed Fever: A Documentary History*, London, Garland, 1996.
36 M. Worboys, 'From Miasmas to Germs: Malaria, 1860–1880', *Parassitologia*, 1994, 36: 61–8.

Figure 2. Edward Emanuel Klein (Reproduced by courtesy of the Wellcome Institute Library, London)

about boundaries and do consider interactions and translations between these and other medical subcultures, as well as nonmedical groups. After 1880, germs were mainly associated with communicable and septic diseases, but they were also linked with many other conditions, from arthritis to scurvy, and from cancer to constipation. Restrictions of space and time mean that I have not been able to look at the full range of diseases in which germs were implicated, so I have concentrated on the major debates and changes as experienced by practitioners.

My approach, through practitioners and their interests, means that I do not privilege the 'discovery' of specific germs and the establishment of disease aetiologies. Germs may have been 'discovered', in the sense of being first