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A capital Scot: microscopes and museums in Robert E. Grant's zoology (1815–1840)

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Abstract. Early nineteenth-century zoology in Britain has been characterized as determined by the ideological concerns of its proponents. Taking the zoologist Robert E. Grant as an exemplary figure in this regard, this article offers a differently nuanced account of the conditions under which natural-philosophical knowledge concerning animal life was established in post-Napoleonic Britain. Whilst acknowledging the ideological import of concepts such as force and law, it points to an additional set of concerns amongst natural philosophers – that of appropriate tool use in investigation. Grant's studies in his native Edinburgh relied heavily on the use of microscopes. On his arrival in London, however, he entered a culture in which a different set of objects – museum specimens – held greater persuasive power. This article relates changes in Grant's ideas and practices to the uneven emphases on microscopic and museological evidence amongst European, Scottish and English natural philosophers at this time. In so doing, it identifies the reliance of London-based natural philosophers on museology as constituting a limiting effect on the kinds of claim that Grant sought to make regarding the nature of life.

Introduction

The Scottish natural philosopher Robert Edmond Grant (1793–1874) had by the mid-1830s become one of the most respected practitioners of zoology in Britain. Having recently been appointed to the newly created chairs in zoology and in comparative anatomy at the University of London, he was gaining in reputation amongst his compatriots at the Muséum d'histoire naturelle (the European centre of post-Napoleonic zoology), and was beginning to instil a commitment to comparative anatomy in a new generation of zoological thinkers. Little seemed likely to stand in the way of his attainment of widespread recognition as an authority on the nature of life. Yet within thirty years, Grant's views were being characterized as an embarrassment to the emerging community of zoologists in Britain.[1] It would not be until the re-evaluation of his science a century or more later that his reputation amongst early nineteenth-century investgators

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1 Adrian Desmond, 'Robert E. Grant: the social predicament of a pre-Darwinian transmutationist', *Journal of the History of Biology* (1984) 17, pp. 189–223.

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of life would begin to be acknowledged. How did this rising natural-philosophical star lose favour so quickly?

Since the publication of Adrian Desmond's *The Politics of Evolution* in 1989, the conventional answer to this question has been that Grant fell out of political favour. Desmond's work relates the intimate links between London's zoologists and the radical and conservative ideologues that inhabited the city during the 1830s and 1840s. Conservative commentators associated Grant with the radical end of the English political spectrum, and there does appear to have been some truth to their assessment. Desmond finds Grant railing against the injustices of the Royal College of Surgeons and Oxford and Cambridge education, campaigning against the Poor Law of 1834, and agitating for the establishment of democratic medical government.[2] He suggests that it was Grant's beliefs that led both to his exclusion from London society and to the lack of traction for his contentions regarding the nature of life amongst natural philosophers. The inability of Grant to establish his natural philosophy can, it seems, be attributed in large part to the dominance of London during this period by a conservative Anglican elite.

Whilst I accept that zoological claims of this time were indeed ideological, this article highlights that the radical implications of Grant's ideas were not the only factor affecting their lack of recognition during his lifetime. Recent historiography has downplayed the controversiality of Grant's contentions, preferring instead to concentrate on the common ground that he shared with his rivals.[3] In contrast, the narrative conveyed here fully acknowledges the radical implications of Grant's natural philosophy. Nevertheless, building on especially Jutta Schickore's recent work on early nineteenth-century microscopy,[4] it also demonstrates that ideological concerns were not the only factor contributing to Grant's lack of acknowledgement amongst his students and peers. Grant's science floundered in no small part because questions of the kind to which he sought answers simply did not seem particularly significant to London-based natural philosophers. Grant's early investigations were especially concerned with discovering the nature of the simplest perceptible forms of organic being. Microscopic observation played a central role in these researches. However, microscopes cannot be said to have been understood by London's natural philosophers as reliable scientific instruments during

2 Adrian Desmond, *The Politics of Evolution: Morphology, Medicine, and Reform in Radical London*, Chicago: The University of Chicago Press, 1989, esp. pp. 25–100.

3 For example, though James Elwick in his *Styles of Reasoning in the British Life Sciences: Shared Assumptions, 1820–1858*, London: Pickering & Chatto, 2007, notes the different personal approaches of Grant and his principal rival, the Hunterian Museum conservator Richard Owen, he argues that they both adhered to a common epistemology of 'analysis–synthesis'. See esp. p. 41. Similarly, James Secord's *Victorian Sensation: The Extraordinary Publication, Reception, and Secret Authorship of* Vestiges of the Natural History of Creation, Chicago: The University of Chicago Press, 2003, pp. 64–65, emphasizes that Grant did not portray his beliefs as theologically heterodox.

4 Jutta Schickore, *The Microscope and the Eye: A History of Reflections, 1740–1870*, Chicago and London: The University of Chicago Press, 2007; and especially Schickore, 'Error as historiographical challenge: the infamous globule hypothesis', in Giora Hon, Jutta Schickore and Friedrich Steinle (eds.), *Boston Studies in the Philosophy of Science* (2009) 267, *Going Amiss in Experimental Research*, pp. 27–45. Schickore's work also downplays relations between natural-philosophical and ideological conviction at this time.

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the 1820s and 1830s. Instead, London zoologists and medical men emphasized the power of anatomy – and with it of museums – to reveal the inner workings of, and relationships between, bodies.[5] I contend here that it was this implicit emphasis on museology (and concomitant de-emphasis of microscopy), as much as any explicit ideological agreement amongst Grant's opponents, that prevented his beliefs from gaining firmer purchase in the metropolis.

Secondarily, this article emphasizes the significance of Grant's geographical and institutional situations for the changing emphases of his natural philosophy. The success of the effort to conceptualize early nineteenth-century British zoology as more than just a footnote to the considerable achievements of Charles Darwin can be in large part attributed to the recent emphasis on place in the study of science.[6] Desmond, Nicolaas Rupke and (more recently) James Elwick's demonstration of the role of Grant and Richard Owen in establishing zoology in the academies of early nineteenth-century London have opened up a new conception of the significance of the science in the city.[7] Post-Napoleonic London can now be understood as a significant site of early nineteenth-century European zoology, comparable to major centres of natural-philosophical endeavour such as Paris. Nevertheless, historians have also begun to show that London was by no means the only place in which British zoology occurred.[8] By paying attention to the contexts in which Grant's earliest investigations were conducted, as well as to the relevance of these to his later thought, this article seeks to acknowledge the broad range of influences on metropolitan natural philosophy during the 1820s and 1830s. In so doing, it presents a somewhat differently nuanced account of the relation between Scottish and English zoology than that conveyed by most extant accounts.

The article begins, then, by outlining the European context for Grant's zoological research in Edinburgh, before moving on to discuss his articulation of an ideal of uniform operation of natural law, and his attempts to transfer these concepts to the British capital. Throughout, I emphasize that Grant's move from Edinburgh to London did not merely involve the importation of a set of attitudes and beliefs from Scotland to England. Rather, it shows that, following his arrival in London, Grant encountered a rather different set of institutional and investigative conditions than he had enjoyed in his native city. Early nineteenth-century zoology cannot, I suggest, be reduced to the

5 Elwick, op. cit. (3), pp. 29–32.

6 For a recent overview of geographical studies in the history of science see Dairmid A. Finnegan, 'The spatial turn: geographical approaches in the history of science', *Journal of the History of Biology* (2008) 41, pp. 369–388. Recent essay collections in this vein include David N. Livingstone and Charles W.J. Withers (eds.), *Geographies of Nineteenth-Century Science*, Chicago: The University of Chicago Press, 2011; and Marie N. Bourguet, Christian Licoppe and Otto Sibum (eds.), *Instruments, Travel and Science: Itineraries of Precision from the Seventeenth to the Twentieth Century*, London and New York: Routledge, 2002.

7 Desmond, op. cit. (2), esp. pp. 25–41, 81–100; Nicolaas A. Rupke, *Richard Owen: Victorian Naturalist*, New Haven, CT and London: Yale University Press, 1994, esp. pp. 55–69; Elwick, op. cit. (3), esp. pp. 18–25.

8 Secord, op. cit. (3), esp. pp. 191–221, 261–275; Helen Cowie, *Exhibiting Animals in Nineteenth-Century Britain: Empathy, Education, Entertainment*, Basingstoke: Palgrave, 2014, pp. 31–51; Carla Yanni, *Nature's Museums: Victorian Science and the Architecture of Display*, Baltimore: Johns Hopkins University Press, 1999, pp. 62–110; Dairmid A. Finnegan, *Natural History Societies and Civic Culture in Victorian Scotland*, London: Pickering & Chatto, 2009, pp. 67–89; Desmond, op. cit. (2), pp. 41–77.

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ideological conflicts of its time and places in any simple way. Rather, a tradition of zoology emerged in London out of a complex set of interactions between beliefs regarding the veracity of microscopic magnification, the place of specimens in the comparison of organic bodies, and (on the more explicitly ideological level) the relative significance of force and of law as causes of transformations within and between bodies.

Force, law, and the natural-philosophical context of Grant's zoology and comparative anatomy

Grant was one of the earliest advocates of a systematic or 'philosophic' zoology in Britain.[9] Following a relatively privileged upbringing in Edinburgh, he had around 1811 begun to read classics at the city's university, studying Greek and geometry. He also found himself attracted to the highly respected medical faculty of that institution. Medical education in early nineteenth-century Edinburgh was by no means confined to subjects considered necessary for the attainment of professional certification. Rather, it constituted a broad-based investigation into the nature and philosophy of living bodies (focused above all on the human body).[10] Having studied under such Edinburgh luminaries as Robert Jameson, Marshall Hall and Thomas Charles Hope, it was as an aspiring natural philosopher that Grant (having received an inheritance from his father) became one of the first Britons to tour Europe at the close of the Napoleonic wars.[11]

Grant travelled extensively on the Continent, visiting established natural philosophers and savants, and coming into contact with many of the most respected intellectual figures of early nineteenth-century Europe. On his return to Scotland he appears to have used the last of his inheritance to embark on a range of observations on and experimental investigations of its native fauna (detailed below). It was on the strength of these investigations that he was appointed professor at the newly founded University of London in 1827. In becoming the first ever professor of zoology in England, Grant became a member of this radical intellectual establishment, founded on a commitment to utilitarianism and the associated ideal of a law-determined political

9 Details of Grant's life can be found in Sarah E. Parker, *Robert Edmond Grant (1793–1874) and His Museum of Comparative Anatomy*, London: Grant Museum Special Publications, UCL, 2006; Adrian Desmond and Sarah Parker, 'The bibliography of Robert Edmond Grant', *Archives of Natural History* (2006) 33, pp. 202–213; and [anon.], 'Biographical sketch of Robert Edmond Grant, M.D., F.R.S.L. & E, &c.', *The Lancet* (1850) 56, pp. 686–695. Other work that addresses Grant's work directly includes Desmond, op. cit. (1); Adrian Desmond, 'Robert E. Grant's later views on organic development: the Swiney Lectures on "palaeozoology," 1853–1857', *Archives of Natural History* (1984) 11, pp. 395–413; Phillip R. Sloan, 'Darwin's invertebrate program, 1826–1836: preconditions for transformism', in David Kohn (ed.), *The Darwinian Heritage*, Princeton, NJ: Princeton University Press, 1985, pp. 71–120; James Secord, 'Edinburgh Lamarckians: Robert Jameson and Robert E. Grant', *Journal of the History of Biology* (1991) 24, pp. 1–18. On philosophic zoology in Britain see Philip F. Rehbock, *The Philosophical Naturalists: Themes in Early Nineteenth-Century British Biology*, Madison: University of Wisconsin Press, 1983.

10 L.S. Jacyna, *Philosophic Whigs: Medicine, Science, and Citizenship in Edinburgh, 1789–1848*, London and New York: Routledge, 1994, esp. pp. 65–73, 115–124; Christopher Lawrence, 'The Edinburgh Medical School and the end of the "Old Thing" 1790–1830', *History of Universities* (1988) 7, pp. 259–286, esp. 279–286.

11 [Anon.] op. cit. (9), p. 689–690.

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economy.[12] Following his subsequent acceptance of the related chair of comparative anatomy (which had been rejected by Johann Friedrich Meckel the Younger on economic grounds), he also found himself with a unique opportunity to demonstrate the relevance of zoology to medical knowledge. Indeed this possibility came, as will be seen, to exert a profound influence on the zoology that he propounded at the university. The relation between zoology, comparative anatomy and medical science at this time was by no means as straightforward as extant accounts suggest.

Grant's natural-philosophical convictions accorded well with those of the university's founders. For example, his publications articulate a conception of animal life as determined by universally operating laws. This commitment went against many accounts of zoological nature in Britain at this time and, as Desmond emphasizes, was frequently associated by its opponents with the theologically suspect 'materialisms' of the French Enlightenment.[13] As a figure accused of such dangerous beliefs, Grant has come to be identified as an exemplar both of the movement to reform medicine along natural-philosophical lines, and of attempts to establish zoology as an academic discipline in Britain. Furthermore, his belief (detailed below) that medical knowledge ought to be refounded on natural-philosophical grounds accorded zoology a utilitarian rationale as a foundational science for medical education.

Grant's vehemence regarding the explanatory efficacy of natural law differentiates him from many of his British natural-philosophical peers. Taking a position inspired by his Continental peers, Grant consistently emphasized that it was through an understanding of the nature of the non-organic that the key to knowledge of life could be found. The microscopic structure of the simplest organisms, he believed, could be explained in terms of the laws that determined physical and chemical nature. Such contentions remained at the margins of British zoological consideration throughout the period. Though much British zoology prior to the 1850s and 1860s emphasizes the unity of *life*, claims regarding the unity of *nature* – and especially natural law – found less prominence.[14] As is well known, it was not the possibility of the development of

12 That is, to the Ricardian conception of political economy as a mathematical science that would describe the laws governing economic exchange. As the university's first professor of the subject, John R. McCulloch, put it, 'Political economy is the science of the laws which regulate the production, distribution, and consumption of those articles or products which have exchangeable value, and are either necessary, useful, or agreeable to man.' John R. McCulloch, *The Principles of Political Economy: With a Sketch of the Rise and Progress of the Science*, Edinburgh: William and Charles Tait, 1825, p. 1. On Ricardo and McCulloch see Mary Poovey, *A History of the Modern Fact: Problems of Knowledge in the Sciences of Wealth and Society*, Chicago and London: The University of Chicago Press, 1998, pp. 196–199. On the foundation of the University of London and its subsequent institution as University College London see Negley Harte and John North, *The World of UCL, 1828–2004*, 2nd edn, London: University College London Press, 1991, esp. pp. 9–22, 58.

13 Desmond, op. cit. (2), pp. 84–85; Secord, op. cit. (3), p. 64. On relations between mechanistic natural philosophy and natural law see John V. Pickstone, *Ways of Knowing: A New History of Science, Technology and Medicine*, Manchester: Manchester University Press, 2000, esp. pp. 87–88.

14 Though the popularity and controversial status of such works as Robert Chambers's *Vestiges of the Natural History of Creation* (1844) demonstrate that there was certainly interest in such issues. See Secord, op. cit. (3), esp. pp. 91–93. Nineteenth-century distinctions between the unity of life and the unity of nature are most clearly brought out in Timothy Lenoir, *The Strategy of Life: Teleology and Mechanics in Nineteenth-Century German Biology*, Dordrecht, Boston, MA and London: D. Reidel, 1982, esp. pp. 26–37.

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life from inorganic nature that framed the most controversial mid-nineteenth-century zoological debates, but the possibility that a being as apparently complex as the human had somehow grown or developed out of a simpler or 'lower' organic form.

Regarding the reform of medical knowledge, Grant's speeches and articles contributed to a broad-based movement in Britain that sought to integrate the study of the human body with that of animals. By reconceptualizing human bodies in relation to the insights of comparative anatomy, early nineteenth-century anatomists sought to make consideration of the human body more 'philosophic'. Many seventeenth- and eighteenth-century medical men had conceived of the human body as separate from animal life – as the crowning material stage of a step-like 'chain of being' in which all natural bodies were separate and distinct.[15] From 1815, however, representatives of an emerging medical reform movement began to contend that a properly philosophical study of man would consider the various parts of the human body in relation to their anatomical 'analogues' as they appeared throughout nature. It was necessary, medical reformers argued, to start with the simplest forms of anatomical existence, and work up towards the human, relating the appearance of each new form to those below it.

As Desmond's work highlights, this conception of comparative anatomy had significant political connotations, especially in its insistence that that the human body was best understood in relation to 'lower' forms of life. Less clear, however, is the relevance of these debates of seemingly more esoteric zoological claims regarding natural law. As detailed below, many opponents of reform contended that different classes of the natural world (such as chemicals, plants, animals and humans) had been created by heavenly forces brought into existence for that very purpose. The contention that zoological nature was subject to a universally operating set of natural laws could not in this view be invoked as justification for reformers' calls for democracy and self-government. On the contrary, each stratum of nature was governed by laws that were appropriate to it and it alone. For adherents of this view, the claim that all natural laws operated in all bodies constituted a threat to the natural order of society.

It is worth detailing the context for such conservative natural-philosophical concerns at this point. Studies of eighteenth-century natural philosophy have highlighted how, from the seventeenth century onwards, a divergence of interests can be seen as emerging in European culture and politics. These studies show how the concerns of the aristocratic elite regarding the maintenance of absolute personal authority came to be renegotiated in terms of an appeal to mutual assent as a guarantor of natural-philosophical truth. With the emergence of an ideal of 'civil society', knowledge came to be understood as something that must be agreed upon by a community of equals, as well as (as had been the case since before the Renaissance) declared to be true by an established authority.[16]

15 Arthur O. Lovejoy, *The Great Chain of Being: A Study of the History of an Idea*, Cambridge, MA: Harvard University Press, 1936. See also William Bynum, 'The Great Chain of Being after forty years: an appraisal', *History of Science* (1975) 13, pp. 1–28; Nick Hopwood, James Secord and Simon Schaffer, 'Seriality and scientific objects', *History of Science* (2010) 48, pp. 251–285, esp. pp. 253–255.

16 Steven Shapin and Simon Schaffer, *Leviathan and the Air-Pump: Hobbes, Boyle, and the Experimental Life*, Princeton, NJ: Princeton University Press, 1985, esp. pp. 283–284, 320–331; Horst Bredekamp, *The Lure of Antiquity and the Cult of the Machine: The Kunstkammer and the Evolution of Nature, Art, and Technology*

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Representatives of museums, natural-philosophic societies and botanical and zoological gardens began to articulate a conception of knowledge as something agreed upon by a community of competent observers, as well as gleaned from authoritative texts or principles. During much of the eighteenth century, questions relating to the relative emphasis to be put on these two kinds of natural-philosophical knowledge had remained unresolved. The emerging ideal of gentlemanly mutual agreement and that of an authoritative, established land-owning elite existed side by side without being seen as inherently oppositional.[17] Yet following the anti-aristocratic, self-determining sentiment that came to the fore during the French Revolution, debates relating to such issues became matters of immediate political concern.[18]

This tension between the ideals of gentlemanly agreement and aristocratic authority was in part played out in natural-philosophical discourse as a contest between the relative power of 'force' and of 'law'. Many philosophers believed that nature required constant intervention by an immaterial, active and guiding force or 'principle'. Others, in contrast, stressed the self-defining, self-generating properties of nature, treating it as God's second, non-textual 'book' which possessed independent moral and legislative authority.[19] Again, both tendencies had existed prior to the French Revolution. For example, many proponents of Enlightened thought in France insisted that nature was nothing more than the expression of mechanical principles playing themselves out in matter, and that the immediate, active presence of heavenly influence on Earth could not be discerned through the study of life. Many in England, on the other hand, engaged in a search for vital fluids that might be identified as means by which organisms could be animated by heavenly power.[20] For most of the eighteenth century, disputes between 'vitalists' and 'mechanists' were relatively easily contained within participants' broader commitments to other ideals, such as establishing the respectability or gentlemanliness of their activities.[21] Yet by the early nineteenth century, an author's choice between such concepts had begun to be seen as indicative of their commitment to seemingly irreconcilable political positions.[22] In early nineteenth-century London, the interventionist, force-centred conception of creation remained pre-eminent. As will be seen, the publications advocating a law-determined notion of nature that Grant produced following his move there are split between an evident need to establish personal authority

(trans. Allison Brown), Princeton: Markus Wiener, 1995, pp. 19–36, 86–91; Paula Findlen, *Possessing Nature: Museums, Collecting, and Scientific Culture in Early Modern Italy*, Berkeley, LA and London: University of California Press, 1994, esp. pp. 101–108.

17 Bredekamp, op. cit. (16), pp. 86–91.

18 Catherine Gallagher, *The Body Economic: Life, Death, and Sensation in Political Economy and the Victorian Novel*, Princeton, NJ: Princeton University Press, 2006, pp. 7–34; Emma Spary, *Utopia's Garden: French Natural History from Old Regime to Revolution*, Chicago and London: The University of Chicago Press, 2000, esp. pp. 209–220.

19 L.S. Jacyna, 'Immanence or transcendence: theories of life and organization in Britain, 1790–1835', *Isis* (1983) 74, pp. 310–329.

20 Roger K. French, 'Ether and physiology', in Geoffroy N. Cantor and M.S.J. Hodge (eds.), *Conceptions of Ether: Studies in the History of Ether Theories 1740–1900*, Cambridge: Cambridge University Press, 1981, pp. 111–134.

21 French, op. cit. (20), pp. 130–132.

22 Gallagher, op. cit. (18), pp. 28, 32–34.

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within a culture focused on natural-theological conceptions of heavenly power, and a hope that it would be possible to confirm as natural 'law'-centred democratic ideals that the French Revolution was seen to embody.

Yet it is not possible, I believe, to reduce absolutely the post-Revolutionary debates regarding force and law to the contestation of a purely social question regarding differing ideals of state organization. Nick Hopwood notes that the tendency of histories of the life sciences to focus exclusively on their theoretical aspects has been at the expense of a more thorough awareness of the practical conditions under which such ideas came to prominence.[23] This article accords with Hopwood in insisting that neither political nor theoretical contentions determined early nineteenth-century zoological natural philosophy. The claims of early nineteenth-century natural philosophers and anatomists were indeed imbued with ideological weight. Nevertheless, I argue here, early nineteenth-century Britons' evaluations of the legitimacy of competing claims relating to zoological and anatomical nature were also dependent on a parallel set of considerations regarding the most appropriate means by which such knowledge might be established. The plausibility of different ideological convictions regarding zoological nature was mediated by an interrelated set of contentions concerning the tools and techniques most appropriate to natural-philosophical investigation.

Grant's attempts to articulate a zoology that was law-determined, progressive and democratic had to be reconciled with his changing geographical context and institutional situation, and the changing emphases of natural-philosophical practice that accompanied this. Having departed from a situation in which, as the recipient of an inheritance from his father, he had been by and large free to interrogate nature as he saw fit, on his arrival in London he found himself in a context in which the tools he had previously relied on most heavily – microscopes – were often dismissed as unreliable. It was only through his appeal to a set of entities that could command greater mutual assent – museum specimens – that he was able to convince his London peers of the relevance of his zoological studies to their own comparative anatomical and medical concerns. In such a context, the radical notion of organic self-determination that his early publications articulated came to be severely restricted.

Atomic natural philosophy in early nineteenth-century Europe

Grant's commitment in his earliest publications to what John Pickstone characterized as a 'bottom-up' conception of life was grounded in an appeal to atomistic chemistry as a source of analogy by which living forms might be better understood.[24] In 1808, John Dalton had controversially (see below) postulated that chemical nature was fundamentally composed of atomic molecules.[25] The notion of an organic 'atomism' analogous to

23 Nick Hopwood, *Haekel's Embryos: Images, Evolution and Fraud*, Chicago: The University of Chicago Press, 2015, pp. 10, 12.

24 John V. Pickstone, 'How might we map the cultural fields of science? Politics and organisms in Restoration France', *History of Science* (1999) 34, pp. 347–364, esp. 349–351. See also Pickstone, op. cit. (13), pp. 118–119.

25 John Dalton, *A New System of Chemical Philosophy*, London: R. Bickerstaff, 1808.

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that which was being promoted for the non-organic world by Dalton remained a feature of Grant's work throughout his life.[26] One instance in which connections between chemical atomism and Grant's zoology and comparative anatomy became especially clear occurred in 1833, when he gave the opening lecture for the medical faculty of the new university. This speech focused on what Grant suggested to be the ideal accomplishments of a man of medicine. He claimed that such accomplishments should include proficiency in ancient and modern languages, the philosophy of mind, natural philosophy and, above all, chemistry – an investigation of 'the phænomena which result from the motions of invisible atoms at insensible distances'.[27] For Grant, the 'complex living processes performed in the laboratories of living beings' were 'as much the domain of the chemist' as were the phenomena of non-living nature.[28]

Chemistry seemed to Grant to present a disciplinary ideal upon which both zoology and comparative anatomy could be modelled. As he informed the assembled faculty, 'Comparative Anatomy, like Chemistry and Botany, spurning its origin as subservient to man's œconomy or to Medicine, has assumed an independent rank among the sciences.'[29] Long-established, apprenticeship-focused modes of medical training had almost invariably taken the human body as their starting point of investigation.[30] In stark opposition to this assumption, Grant claimed in his University of London lectures (which were also being published at this time) that 'everywhere the natural philosopher and the chemist are making encroachments on the province of the physiologist. Everywhere do we find the laws of natural philosophy in operation in our bodies'.[31] Not only zoology, but also the study of medicine itself had to start with that of nature

26 Sloan, op. cit. (9), pp. 77–80.

27 Robert E. Grant, *On the Study of Medicine: Being an Introductory Address Delivered at the Opening of the Medical School of the University of London, October 1st, 1833*, London: J. Taylor, 1833, pp. 6–9. Grant's commitment to atomism is also indicated by his promotion of the candidacy of the then-Daltonian chemist Edward Turner to the faculty of the University of London in 1827. See UCL Special Collections MS ADD 43–448 – 1827 Professorships (Q–W). Turner would return this favour in his support for Grant's later unsuccessful application for a lectureship in physiology. See Edward Turner, 'To James Mill, Esq. chairman of the education committee' *The Lancet* (1835) 26, p. 844; and Desmond, op. cit. (2), pp. 98–99.

28 Grant, op. cit. (27), p. 9.

29 Grant, op. cit. (27), p. 10.

30 Susan C. Lawrence, *Charitable Knowledge: Hospital Pupils and Practitioners in Eighteenth Century London*, Cambridge: Cambridge University Press, 1996, p. 81.

31 Robert E. Grant, 'Lectures on comparative anatomy and animal physiology, delivered during the session 1833–4', *The Lancet* (1833–1834) 21 , pp. 89–99, 121–128, 155–159, 193–200, 225–236, 265–279, 345–353, 393–402, 425–433, 473–481, 505–514, 537–546, 569–577, 617–626, 649–657, 697–707, 729–738, 761–771, 809–816, 841–848, 873–883, 905–911, 953–962; (1834) 22, pp. 1–10, 65–73, 97–106, 129–139, 177–186, 209–215, 257–265, 289–297, 337–345, 369–376, 401–410, 433–440, 481–487, 513–520, 545–554, 577–586, 609–616, 641–648, 673–681, 705–713, 737–745, 785–794, 817–824, 865–875, 913–920. Quote from [Lecture IV] (1833–1834) 21, p. 198. This emphasis on the role of natural philosophy in medicine is also stated in a later address to the BMA. See Robert E. Grant, *On the Present State of the Medical Profession in England: Being the Annual Oration Delivered before the Members of the British Medical Association, 21st October, 1841*, London: Henry Renshaw, 1841, pp. 16–20. On connections between medical reform and the rhetoric of natural philosophy at this time see especially John H. Warner, 'The history of science and the sciences of medicine', *Osiris*, 2nd series (1995) 10, pp. 164–193, esp. 169–170.

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as a whole. In this context, organic atoms constituted a critical stepping stone between inorganic matter and the human body.

Grant's articulation of an atom-like, or 'globular', conception of life can be placed in the context of a broader contemporary movement that utilized microscopy to reveal the fundamental structures of bodies. By the 1810s, literature relating to 'granules' or 'globules' of living matter had become a distinctive feature of microscopic investigation. Marcello Malpighi and Antoni van Leeuwenhoek had described seeing microscopic 'globular' structures in living tissue as early as 1665.[32] But it was not until the nineteenth century that the concept that bodies were entirely made up of these globules came to play an integral role in the development of ideas about organic nature. Most frequently, the apparent globularity of both animal and plant tissue was highlighted as pointing to the importance of 'life' (rather than the previously distinct categories of animal and vegetable) as a philosophical object of analysis. Early in the century, such German *Naturphilosophen* as Lorenz Oken and Franz von Walther had speculated that all living matter was made up of combinations of simple globular 'infusoria'. Less speculative German-language authors such as Meckel and Josephus and Carolus Wenzel began to observe globules in all types of living tissue over the next few decades.[33]

Apart from perhaps Leeuwenhoek, all of these figures would have been aware of the influential speculations of Gottfried von Leibniz regarding the fundamentally 'monadic' constitution of existence. Leibniz had suggested – in a contention that seemed to some dangerously close to the deistic monism of Baruch de Spinoza – that all forms of existence, including mental perceptions, could be understood in terms of a universal 'plenum' constituted by imperceptible mathematical points. These points, or monads, had no material presence in Leibniz's metaphysics. Nevertheless, they were consistently appropriated by natural philosophers such as Charles Bonnet, and especially French materialists such as the Comte de Buffon, Pierre Louis Maupertuis and Baron d'Holbach, as referring to the physical presence of monads in nature. Leibniz was held to have predicted the existence of microscopic organisms ('zoophytes') that could not be perceived by the unaided eye.[34]

During the early nineteenth century, Leibniz's notion of the 'monadic' composition of existence was frequently interpreted in terms of a commitment to a law-determined, atomic materiality. Pickstone points to a brief but vociferous fashion for globular theories of life during the 1820s amongst such Paris-based natural philosophers as Geoffroy Saint-Hilaire (or Geoffroy, as he was commonly known), Henri Milne-Edwards, and

32 Marc J. Ratcliff, *The Quest for the Invisible: Microscopy in the Enlightenment*, Farnham and Burlington: Ashgate, 2009, esp. pp. 47–54.

33 L.S. Jacyna, 'Romantic thought and the origins of cell theory', in Andrew Cunningham and Nicholas Jardine (eds.), *Romanticism and the Sciences*, Cambridge: Cambridge University Press, 1990, pp. 161–168, 165. Schickore, 'Error as historiographical challenge', op. cit. (4), pp. 33–34. See also Daniel J. Nicholson, 'Biological atomism and cell theory', *Studies in History and Philosophy of Science Part C: Studies in the History and Philosophy of the Biological and Biomedical Sciences* (2010) 41, pp. 202–211, 203–204.

34 Olivier Rieppel, 'The reception of Leibniz's philosophy in the writings of Charles Bonnet (1720–1793)', *Journal of the History of Biology* (1988) 21, pp. 119–145.

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Henri Dutrochet.[35] As well as emphasizing that 'life' in general (rather than plant or animal life alone) constituted their principal category of analysis, Dutrochet and his contemporaries sought to constitute a 'vital physics' in which simple forms of life would be explained by laws relating to non-organic phenomena.[36] Monads, globules and atoms all entered into a common language of democratic reform, in which minute particles were understood to be fundamental elements of natural existence.

An atomist in Edinburgh: Grant's radical globulism

Grant's investigations prior to his arrival in London were intensely concerned with the nature of the simplest forms of living matter. The origins of this interest can be traced to his extensive tour of continental Europe at the end of the Napoleonic wars. As the then-principal centre of the Western intellectual world, Paris featured prominently in his travels. Whilst there, he came under the influence of such well-known French *savants* as Geoffroy, Georges Cuvier and Jean-Baptiste Lamarck, the latter of whose research on invertebrates appears to have inspired Grant's lifelong interest in these organisms. On the same trip, he also met many of the leading zoological natural philosophers of the Germanic territories, including Meckel and Friedrich Tiedemann.[37]

On his return to Edinburgh in 1820, Grant established a site in which he could conduct his own investigations, a merchant friend's (a Mr Alexander Wilson) unused property on the banks of the Firth of Forth. Here (his sympathetic *Lancet* biographer claimed), 'he was able to keep hundreds of marine animals alive, and constantly under observation'.[38] And it was here that he undertook the majority of his sponge research. The Firth of Forth possessed a wide variety of sponges, an organism that was both locally abundant and had occupied a highly ambiguous status in eighteenth-century natural-philosophical classification. The organisms had been alternately classed as plants and animals, without any resolution of the matter. Grant declared them to be animals on the basis that they circulated water through themselves.[39]

Microscopes were central to these investigations. Decanting still-immersed and living sponges from the firth into glass jars and removing them to his temporary study, Grant magnified them to reveal numerous 'ventricles' permeating their external surfaces. He

35 John V. Pickstone, 'Globules and coagula: concepts of tissue formation in the early nineteenth century', *Journal of the History of Medicine and Allied Sciences* (1973) 28, pp. 336–356. See also Phillip R. Sloan, 'Organic molecules revisited', in Jean Gayon (ed.), *Buffon '88: Actes du Colloque international pour le bicentenaire de la mort de Buffon (Paris, Montbard, Dijon, 14–22 Juin 1988) (Science, histoire, philosophie)*, Paris, *c.*1992, pp. 415–438.

36 John V. Pickstone, 'Vital actions and organic physics: Henri Dutrochet and French physiology during the 1820s', *Bulletin of the History of Medicine* (1976) 50, pp. 191–211; John V. Pickstone, 'Locating Dutrochet', *BJHS* (1978) 11, pp. 49–64.

37 Desmond, op. cit. (1), p. 197. Desmond, op. cit. (2), pp. 41–59. Sloan, op. cit. (9), pp. 77–80.

38 [Anon.], op. cit. (9), p. 693.

39 Robert E. Grant, 'Observations and Experiments on the Structure and Functions of the Sponge' [I–II], *Edinburgh Philosophical Journal* (1825) 13, pp. 94–107, 333–346; [III–IV], (1826) 14, pp. 113–124 and 336–341; and [V] *Edinburgh New Philosophical Journal* (1826–1827) 2, pp. 121–141. See especially [III], p. 124. On prior attempts to classify sponges see Susannah Gibson, 'On being animal, or, the eighteenth-century zoophyte controversy in Britain', *History of Science* (2012), pp. 453–474, 469–471.

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claimed that it was possible to observe that minute particle-like bodies in the water only ever moved outward from some of these ventricles, which he termed 'faecal orifices'. He concluded that water must be taken in through the other observable ventricles, and so termed these 'pores'.[40]

Of particular interest to Grant regarding the cause of this circulation in sponges was a 'thin gelatinous matter' that covered their interior. And it was this matter that, when magnified, seemed to him to reveal the cause of the movement of water. When *in situ* around the 'faecal orifices', he noted, it appeared completely 'homogeneous'. Yet after removing it from the sponge, placing it in a small amount of water and subjecting it to 'a little agitation', it 'resolve[d] itself almost entirely into minute, pellucid, green-coloured granules, which have a singular tendency to reunite'.[41] Significantly for Grant, these small granules, observable only at high levels of magnification, appeared to possess the ability to move of their own accord. In a series of papers for the *Edinburgh New Philosophical Journal*, he argued that it was these granules' capacity for movement (which he suggested could be caused by 'minute filaments' protruding from them) that produced circulation.[42]

Grant also accorded these minute bodies a critical role in the reproductive process. The internal gestatory processes of nominally 'higher' animals such as mammals and birds meant that their initial stages of growth were only amenable to post-mortem examination. The green substance of the sponges, in contrast, was transported outside its host organism via larger granular bodies or (as Grant termed them) 'ova', opening the earliest stages of development to examination.[43] These 'ova' seemed to Grant to disintegrate into a 'thin transparent film' on contact with the surfaces of his jars, out of which the simplest forms of the sponges' mature anatomy could be seen to emerge.[44] Grant noted that his microscope could detect nothing in the ovular structure but 'transparent granular bodies, like those lining the canals'.[45] Even the reproductive organs of the species were composed of simple globular entities.

Summing up his research on the sponges in 1827, Grant suggested that the gelatinous matter 'appears entirely composed of very minute, transparent, spherical or ovate granules, like monades', noting that 'indeed, most of the fleshy parts of organized bodies appear to be composed of similar pellucid granular or monade-like bodies in different states of aggregation'.[46] Microscopic granules or globules appear as fundamental units of organic matter in Grant's early publications.

40 Grant, op. cit. (39), [I], pp. 105–107.

41 Robert E. Grant, 'On the structure and nature of the Spongilla friabilis', *Edinburgh Philosophical Journal* (1825–1826) 14, pp. 270–284, 281.

42 Grant, op. cit. (41). Robert E. Grant, 'Observations on the spontaneous motions of the ova of the Campanularia dichotoma, Gorgonia verrucosa, Caryophyllea calycularis, Spongia panicea, Sp. papillaris, cristata, tomentosa, and Plumularia falcata', *Edinburgh New Philosophical Journal* (1826) 1, pp. 150–156, 152.

43 Grant, op. cit. (41), p. 282.

44 Grant, op. cit. (41), pp. 282–283. It is perhaps relevant in this context to note Charles Darwin's long-standing concerns regarding the differences between sexual and asexual reproduction. See M.S.J. Hodge, 'Darwin as a lifelong generation theorist', in Kohn, op. cit. (9), pp. 207–243, 210–213.

45 Grant, op. cit. (41), p. 283.

46 Grant, op. cit. (31) [Lecture V] (1833–1834) 21, p. 124.

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Grant also emphasized that globules arise 'spontaneously' from inorganic matter, and cannot therefore be subject to laws or forces different to those that applied to the non-living world.[47] In his first lecture at the University of London, he declared that 'the simplest organized bodies, as Monades and Globulinæ, originate spontaneously from matter in a fluid state', and that 'these simple bodies … are the same with the gelatinous globules which compose the soft parts of Animals and Plants'.[48] This, as he told his audience, implied that the simplest animals could be explained 'on the principles of Chemistry or Mechanics'.[49] Grant envisaged a nature that developed upwards from physical, non-organic forms of existence. The development of organisms was nothing more than the expression of laws that had been established at the start of Creation.

Radical atomists and conservative forces in London

In 1820s London, participants in the then-nascent medical reform movement were the most enthusiastic adopters of monad-centred organic atomism. A number of physiologists and anatomists known for their reformist opinions highlighted the above-described propositions of Continental naturalists regarding the elementary, self-defining composition of living bodies. The Unitarian Thomas Southwood Smith informed readers of the radical *Westminster Review* that he had demonstrated the uniform, globular structure of tissues at the private medical school in Webb Street.[50] Similarly, in an article in the *London Medical Gazette*, military surgeon Samuel Broughton proclaimed that his microscopic observations led him 'to coincide with Dr. M. Edwards in all essentials'. Broughton took inspiration from the possibility that 'every thing susceptible of life may derive all its parts from one constant and primitive molecule, of an uniform character, spherical and colourless, and more or less developed as the animal may be simply formed or otherwise'.[51] For these figures, as for Grant, chemical and physical laws were the most likely means by which such entities might be explained.[52] Smith's connection with the *Westminster Review*'s founders, Jeremy Bentham and James Mill, meant that his anatomical and physiological articles found a wide, politically conscious audience. Similarly, Grant's lectures were published in the medical journal *The Lancet*, at that time the mouthpiece for an emergent conception of medical organization that

47 On spontaneous generation at this time see John Farley, *The Spontaneous Generation Controversy from Descartes to Oparin*, Baltimore and London: Johns Hopkins University Press, *c.*1977, esp. pp. 39–46, for the French and British context.

48 Robert E. Grant, *An Essay on the Study of the Animal Kingdom: Being an Introductory Lecture at the University of London on the 23rd of October, 1828*, 2nd edn, London: J. Taylor, 1829, p. 18. See also Sloan, op. cit. (9), pp. 82–86.

49 Grant, op. cit. (48), p. 18.

50 Thomas Southwood Smith, 'Life and organization', *Westminster Review* (1827) 7, pp. 208–226, esp. 215–216.

51 Samuel Broughton, 'On the elementary nature of animal structures', *London Medical Gazette* (1828) 17, pp. 496–497. See also John Bostock, *An Elementary System of Physiology*, 3 vols., London: Baldwick, Craddock and Joy, 1824–1827, vol. 1, pp. 28–32.

52 See esp. Smith's articles on the nervous system: Thomas Southwood Smith, 'Nervous system', *Westminster Review* (1828) 9, pp. 172–197 and 451–479.

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contrasted the self-defining, self-organizing capacities of medical practitioners with the undemocratic, paternalist powers of the medical colleges.

More generally, atomism seemed to many to confirm that the constitution of nature accorded with the egalitarian, democratic ideals of organization then associated with the French Revolution. The prominent republican Richard Carlile's *Address to Men of Science* (1821) proclaimed chemists to be 'the greatest of all revolutionists, for they have silently and scientifically undermined the dogma of the priest' by enabling us to 'consider ourselves but as atoms of organized matter'.[53] Like Unitarians such as Smith, Carlile insisted that it was only by recognizing and acting according to the truths of nature as revealed by natural-philosophical investigation that communities might be organized satisfactorily. It was only through the universal recognition of the chemical composition of all bodies that humans would fulfil their proper place in creation. If all children were taught that 'man, as a part of a whole, or as an atom of matter, is immortal but … that [that] atom can retain no sense of a former existence', the 'proper character' of mankind would be realized. If this plan were instigated, 'the representative system of government would be found to be the only necessary government amongst them [the people]'.[54] Carlile, along with his many followers, argued that the truths of chemistry pointed the way to the instigation of a truly democratic and egalitarian politics. Like Carlile, reform-minded philosophical zoologists and medical lecturers saw a rationale for democratic government in their conceptions of corporeality.

It should be emphasized, however, that though chemical-atom-like globules could be construed as democratic, self-organizing entities, this was not the only possible interpretation. Schickore notes the diversity of physical forms that globules took at this time.[55] A range of positions regarding their animation and its apparent causes existed. For example, many of the more natural-philosophy-oriented gentlemanly elite, concerned with the compatibility of conceptions of nature with the doctrines of the Anglican Church, opposed what they believed to be the dangerous implications of conceptualizing bodies as composed of countless self-determining particles. Prior to the 1820s, philosophers such as Samuel Taylor Coleridge and Humphry Davy had appealed to the explanatory power of a 'vital' force that they understood as the active manifestation of God's immediate presence on Earth.[56] Coleridge's texts articulate a Kantian, 'transcendental' philosophy of nature, founded on a belief in the vital, creative powers of human spirit and divine will. Advocating a deeply historical vision of the creation of a step-like chain of being, these texts oppose what they characterize as the overly mechanistic tendencies of law-determined accounts of creation. Coleridge insisted on the continual, active creation of nature by forces imposed from 'above', and was particularly suspicious

53 Richard Carlile, *An Address to Men of Science*, London: R. Carlile, 1821, pp. 5–6. See also Jacyna, op. cit. (19), pp. 326–327.

54 Carlile, op. cit. (53), p. 44.

55 Schickore, 'Error as historiographical challenge', op. cit. (4), pp. 33–35.

56 On Coleridge see Trevor H. Levere, *Poetry Realized in Nature: Samuel Taylor Coleridge and Early Nineteenth-Century Science*, Cambridge: Cambridge University Press, 1981. On Davy and his opposition to Daltonian atomism see David Knight, *Humphry Davy: Science & Power*, Cambridge: Cambridge University Press, 1992, pp. 73–80.

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of what he saw as the dangerously democratic implications of a world composed of uniform – and therefore implicitly equal – elementary parts. He aimed to propagate a 'vital chemistry', in which the transmutation of inorganic matter was caused by divine creative powers, to rival the science of simple elements associated with Antoine Lavoisier.[57]

Coleridge and Davy were joined by William Whewell in their advocacy of this force-centred, elitist vision of creation and intellectual discovery. These influential figures associated doctrines such as Dalton's theories with a subversive republicanism, and appealed to an idealistic vision of historical development in order to preserve the authority of philosophical truth.[58] Such weighty opposition could have far-reaching consequences. In 1828, botanist Robert Brown (later acclaimed as the discoverer of 'Brownian motion') circulated a private pamphlet 'on the general existence of active molecules in organic and inorganic bodies'. This paper could easily have been interpreted as confirming the globular observations of Milne-Edwards. However, the following year – after a number of well-respected botanists declared that they had failed to observe the molecules – Brown published a clarification that dissociated his work from that concerning organic 'globules'.[59]

Nor was globulism itself invariably cited as proof of the self-defining powers of organic molecules. One of the most authoritative statements of organic globulism in 1820s Britain had explicitly denied the possibility that bodies could be created by the agglomeration of individually independent particles. In 1822, Davy's fellow 'animal chemist' Sir Everard Home suggested in his lectures at the Royal College of Surgeons that all tissues were composed of spherical particles connected by fibres of organic matter.[60] In contrast to Grant, who would conceive of globules as agents causing the circulation of water in sponges, Home saw them as passive building blocks for different kinds of bodily structure. Home's globules could not move around on their own, but were organized by gas inherent in the blood and other fluids. As he claimed, he had set out to prove that 'human blood, in the act of coagulation, evolves a gaseous matter, which, as soon as it is disengaged, pervades the coagulum in every direction; passing throughout the serum in currents which become permanent tubes'. Having established to his satisfaction that this was the case, he then went on to describe the

57 Levere, op. cit. (56), esp. pp. 64–69, 171–179 and 216–219. On the role of such transcendent theories in zoology and physiology see Jacyna, op. cit. (19).

58 Knight, op. cit. (56), pp. 73–80; Owsei Temkin, 'Basic science, medicine, and the romantic era', in Temkin, *The Double Face of Janus and Other Essays in the History of Medicine*, Baltimore: Johns Hopkins University Press, 1977, pp. 352–357, esp. 356.

59 Robert Brown, 'A Brief Account of Microscopical Observations … on the Particles Contained in the Pollens of Plants; and on the General Existence of Active Molecules in Organic and Inorganic Bodies', London, 1828 (not published). Brown, *Additional Remarks on Active Molecules*, London, 1829. See also Sloan, op. cit. (9), pp. 92–98.

60 Everard Home, *Lectures on Comparative Anatomy; in Which are Explained the Preparations in the Hunterian Collection, Illustrated by Engravings*, London: Longman, Hurst, Bees, Orme and Brown, 1823; and Home, *Supplement to the Foregoing Lectures on Comparative Anatomy, Illustrated by Engravings*, 5 vols., London: Longman, Bees, Orme, Brown and Green, 1828, vol. 5., pp. 170, 194. On Home see Edwin Clarke and L.S. Jacyna, *Nineteenth-Century Origins of Neuroscientific Concepts*, Berkeley, Los Angeles and London: University of California Press, 1987, pp. 58–60.

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composition of all organic tubes as globular.[61] Hence whilst his publications depict both blood vessels and nervous fibres as composed of globules, these function as passive material for the organization of life by vital gases. With the dissipation of Davy and others' attempts to formulate a vitalist chemistry during the 1820s, Home's speculations regarding the gaseous ordering of globules largely disappeared from natural-philosophical discourse. More influential was the contemporaneous contrast between organic atomism and vitalism drawn by the poet and coiner of the term 'phrenology' Thomas Forster. By the end of the decade, Forster's suggestion that globulism and vitalism formed two mutually exclusive hypotheses, and that each was 'at least as tenable' as the other, had come to define the British debate.[62]

By the late 1820s globulism had taken on theologically suspicious connotations – an association that was to last even beyond the establishment of cell theories at the end of the 1830s. Forster, despite refusing to side with either vitalism or globulism, was interpreted by opponents as a supporter of the latter.[63] As late as 1849 the comparative anatomist Richard Owen raised the spectre of atheistic atomism to promote his own interpretation of Continental comparative anatomy to his High Church audience. Repeating a claim that he had first aired in 1837, Owen proclaimed that if

> we reject the idea that these [homological] correspondences are manifestations of some archetypical exemplar on which it has pleased the Creator to frame certain of his living creatures, there remains only the alternative that the organic atoms have concurred fortuitously to produce such harmony.[64]

Even after John Goodsir had seemingly established the inherent vitality of Schleiden and Schwann's 'cells', Owen could still invoke organic 'atomism' as a threatening spectre when addressing his largely elite, High Church audience.[65]

To those who considered the presence of active forces to be critical to the explanation of nature, the proposition that the universal operation of chemical and physical law was responsible for the development of organic nature seemed absurd. As Desmond points out, despite the prominence of law-determined conceptions of life amongst Continental natural philosophers, such contentions met with strong resistance in Britain.[66] British philosophers working within natural-theological frameworks emphasized the need to address bodies as integrated wholes expressive of God's active presence

61 Home, *Lectures on Comparative Anatomy*, op. cit. (60), pp. 5–6, 20–39.

62 Thomas Forster, *Somatopsychonoologia, Showing that the Proofs of Body Life and Mind Considered as Distinct Essences Cannot be Deduced from Physiology but Depend on a Distinct Sort of Evidence: Being an Examination of the Controversy Concerning Life Carried on by MM. Laurence, Abernethy, Rennell, & others*, London: R. Hunter, 1823, p. 112. See also Temkin, op. cit. (58), p. 356.

63 Temkin, op. cit. (58), p. 356.

64 Richard Owen, *On the Nature of Limbs: A Discourse*, Chicago and London: The University of Chicago Press, 2007; first published 1849, p. 40; See also Owen, *The Hunterian Lectures in Comparative Anatomy; May–June, 1837*, Chicago and London: The University of Chicago Press, 1992; first published 1837, pp. 87–88, 122.

65 On the development of cell theories in Britain see L.S. Jacyna, 'John Goodsir and the making of cellular reality', *Journal of the History of Biology* (1983) 16, pp. 75–99; Jacyna, '"A host of experienced microscopists": the establishment of histology in nineteenth-century Edinburgh', *Bulletin of the History of Medicine* (2001) 75, pp. 225–253.

66 Desmond, op. cit. (2), e.g. pp. 351–358.

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in earthly creation.[67] They did this primarily through the description and analysis of gross anatomy. Anatomists at London's hospitals during the 1820s tended to take individual bodies rather than types of organic structure as their principal loci of investigation.[68] Though comparative anatomists inspired by natural theology sought to compromise with the notion that bodies could be analysed into systems or elements that transcended any one species, they were careful to reject 'bottom-up' explanations of organic development. Following the French comparative anatomist Georges Cuvier, Owen emphasized the independent creation of different 'types' or 'plans' into which anatomical forms such as bones or nerves could be classified.[69] Grant, Southwood Smith and others' suggestion that complex skeletal or nervous structures could only be properly understood in the light of the monadic constitution of nature seemed to many to be fundamentally opposed to the findings of natural theology.[70]

Though enthusiastically advocated by reforming medical men, then, the assertion that life was fundamentally globular was at best obscure to many of London's natural philosophers. At worst, such claims were subversive of the biblical account of creation adhered to by the Anglican Church. If there was no need for the Creator to intervene to produce new natural forms, what likelihood was there that he had performed other, seemingly less significant, miraculous feats? Identification of anatomical diversity was of far greater interest to Anglican natural philosophers. By observing differences between the anatomies of individuals and species, humanity would become more keenly aware of the plenitude of God's creation. The discernment of microscopic nature was by no means the best, and certainly not the most reliable, way that humanity might come to know God. For these philosphers, unadorned sight was perfectly adequate to comprehend His benevolence in living nature.

Microscopic trust and the elision of globular life

In a trend that parallelled its rapid decline amongst French natural philosophers, London zoologists and physiologists had all but given up on the globule thesis by the mid-1830s.[71] If London-based natural philosophers found the existence of spontaneously emerging globules problematic in principle, however, it was the then-uncertain status of the microscope as a trustworthy aid to observation that constituted a critical condition for this decline amongst medical men. Physicians doubted the veracity of observations made with microscopes at least as much as they did the specific claims that were being made for microscopic objects.

Much early nineteenth-century distrust of observations made with microscopes can be attributed to prevailing understandings of perception. Jonathan Crary identifies a fundamental tension evident in many post-Renaissance conceptions of perception. He relates

67 Jacyna, op. cit. (19).

68 Pauline Mazumdar, 'Anatomy, physiology and the reform of medical education: London, 1825–1835', *Bulletin of the History of Medicine* (1983) 57, pp. 230–246.

69 Rupke, op. cit. (7), pp. 117–113.

70 Desmond, op. cit. (2), pp. 93–94. Mazumdar, op. cit. (68), pp. 234–240.

71 On the French context see Pickstone, 'Locating Dutrochet', op. cit. (36).

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the emergence from the sixteenth century of a conception of observation predicated on the existence of a disembodied, rational mind. This conception of mind, he suggests, centres on the figure of the camera obscura and associated tools for displaying imagery, such as magic lanterns. According to Crary, before the re-evaluation of its cultural status during the nineteenth century, the camera obscura functioned as an intellectually pervasive 'philosophical instrument' that presented contemporaries with both a means of observing, and a model for conceptualizing, human observation. The human subject – removed in the operation of the camera obscura from the act of representation – accompanied and legitimated a notion of the universal existence of a rational knower acting through the human body. Notably, this subject remained independent of the sense organs by which it perceived the world.[72] Conceptions of perception that flourished in western Europe during the seventeenth and eighteenth centuries were predicated on a fundamental differentiation between sense experience and rational insight.

Critically, this 'disembodied' mode of subjectivity positions the human body as the only medium through which experience of the world can be effected. It thereby identifies minds as inherently individuated, mutually alienated, entities, confined to the sensory experiences of their specific corporeal hosts. This brings into question the possibility of any one mind's ability to produce universally true natural knowledge. How can reliable truths be arrived at if all sensation and observation are necessarily bound up in the different experiences afforded by different bodies?

As is now widely recognized, the principal seventeenth- and eighteenth-century response to this dilemma called for a multiplication of rational witnesses. Philosophers such as Robert Boyle, seeking to establish the veracity of apparently rational insights into nature, had sought to make the truth-value of perceptions of nature dependent on the sensory experiences of a large number of 'reputable' individuals. If a group of suitably 'disinterested' observers with different sensory perspectives could be persuaded to agree on the existence and meaning of a given phenomenon, they claimed, then its truth would no longer be contingent on the unreliable bodily experiences of any one individual.[73]

Within such an epistemic context (and despite continued efforts to improve microscopes),[74] microscopy remained a problematic means of producing natural truth. The technical constitution of microscopes during this period almost invariably required that witnesses perceive an event or image individually – the 'group' means of guaranteeing observational truthfulness could not easily be applied to minute objects accessible only via a single set of lenses, against which only one eye could be placed at any one time. As Schickore shows, the veracity of sense impressions relating to moving microscopic objects or those at the edge of a microscope's magnification power were

72 Jonathan Crary, *Techniques of the Observer: On Vision and Modernity in the Nineteenth Century*, Cambridge, MA and London: MIT Press, 1990, pp. 25–66. Cf. Isobel Armstrong, 'The microscope: mediations of a sub-visible world', in Roger Luckhurst and Josephine McDonagh (eds.), *Transactions and Encounters: Science and Culture in the Nineteenth Century*, Manchester and New York: Manchester University Press, 2002, pp. 30–54.

73 Shapin and Schaffer, op. cit. (16), pp. 25–26; Crary, op. cit. (72), pp. 51–53.

74 Schickore, *The Microscope*, op. cit. (4), pp. 26–29.

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understood as very difficult to establish.[75] Marc Radcliff notes that one way microscopists sought to overcome this problem during the eighteenth century was to emphasize the harmony of their observations with already established classificatory categories.[76]

The need to overcome problems associated with the unreliability of microscopic observations carried out by lone observers constituted a central feature of discussion of the instruments in early nineteenth-century Britain. Even into the 1840s, microscopy was portrayed as an activity still in the process of being integrated into a culture of display and witnessing. In 1841, Daniel Cooper, member of the recently founded Microscopical Society of London and editor of the short-lived *Microscopic Journal and Structural Record*, presented its readers with his recollections of 'The rise and progress of microscopic science', which he chiefly located in the previous decade.[77] Above all, Cooper's article attributed such 'progress' to the cultivation of a public interest in the instrument – a consequence, he suggested, of the development of tools and techniques that facilitate the public display of microscopic phenomena. Whilst he noted that the solar microscope (a sun-powered microscope projector) had been used for 'the gratification of the public' for some time, it was, he suggested, only with the recent development of 'oxy-hydrogen' or flame-powered illumination that such displays could be made reliable.[78] A similar 1837 discussion by the optician Charles R. Goring lamented the lack of definition of images produced by most microscope projectors. Nevertheless, it suggested, projected images were to be valued: 'as these may be *contemplated by two or three persons at once*, where any dispute or difference of opinion may happen to occur as to their real character, it may be cleared up satisfactorily by their joint scrutiny'.[79] Such accounts emphasized that reliable microscopic observation could best be guaranteed by the multiplication of witnesses to demonstrations. The 'advance' of microscopic observation at this time was intimately connected with the development of means by which invisible nature could be made visible to an audience.[80]

Though microscopic evidence begins to be appealed to more and more often in discussions of physiological nature during the 1820s and 1830s, claims that did not accord with established expectations were still met with a great deal of scepticism. Microscopes were not widely trusted as investigative tools, and many physiologists and natural philosophers remained sceptical regarding specific claims relating to

75 Schickore, *The Microscope*, op. cit. (4), pp. 84–88.

76 Ratcliff, op. cit. (32), pp. 211–215.

77 Daniel Cooper, 'A brief sketch of the rise and progress of microscopic science, and the principal means enumerated which have tended to its general advancement', *Microscopic Journal and Structural Record* (1841) 1, pp. 1–4.

78 Cooper, op. cit. (77).

79 Charles R. Goring, 'On solar engiscopes, and the exhibition of tests by them', in Charles R. Goring and Andrew Prichard, *Micrographia: Containing Practical Essays on Reflecting, Solar, Oxy-Hydrogen Gas Microscopes; Micrometers; Eyepieces &c, &c.*, London: Whittaker and Co., 1937, pp. 82–98, 82–83, original emphasis.

80 On other efforts to overcome this problem see Schickore, *The Microscope*, op. cit. (4), pp. 44–46, 64–66; Jacyna, 'A host of experienced microscopists', op. cit. (65); and L.S. Jacyna, 'Moral fibre: the negotiation of microscopic facts in Victorian Britain', *Journal of the History of Biology* (2003) 36, pp. 39–85. Goring's use of 'test objects' is addressed in Schickore, *The Microscope*, op. cit. (4), pp. 114–120.

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microscopic observation.[81] Suggesting that the fundamental 'elements' of bodies were to be found at the microscopic level could thereby be considered unorthodox regardless of their purported significance for the understanding of life more generally. At least before the articulation of cell theories from the late 1830s, uncertainty regarding the nature of the very small meant that radically reform-minded medical men accorded a more central place to microscopic evidence in their conceptions of bodies than did moderate reformers or members of the Anglican elite. Thus in his discussion of Milne-Edward's claims, Southwood Smith lamented what he characterized as the 'neglect' of microscopic evidence – a circumstance that he considered 'fatal to the advancement of science'.[82] The chemical physiologist John Bostock's comment that 'the errors into which this instrument has led even … the most skilful in its application, would have the effect of inducing us to place but little confidence in hypotheses and explanations derived from it' is more typical of the medical men of this time.[83] For many members of London's medical community, observations made at the edges of the magnifying capacities of microscopes were not to be relied upon.

Those who remained doubtful regarding the implications of an atom-like constitution of nature emphasized the need for caution in evaluating microscopic evidence. In particular, critics appealed to differences in the technical capacities of microscopes in their efforts to undermine such controversial beliefs. Blaming microscopes rather than individual observers enabled those sceptical of such claims to signal their doubts without bringing the 'disinterestedness' of the latter into question. In 1827 Joseph Jackson Lister and Thomas Hodgkin cast doubt on globular claims by emphasizing the inadequacy of the tools utilized by their predecessors. Lister and Hodgkin suggested that the perception of microscopic globules was caused not by the phenomena under investigation, but by the lenses of microscopes which (unlike their own) had not been corrected to account for chromatic and spherical aberration. Hence Milne-Edwards had been honourably misled by the inadequacies of the tools that he used: 'he described what he saw, and he only saw amiss through the imperfection of his instruments'.[84]

Though Lister later asserted his belief in the individually self-defining, spontaneous actions of microscopic particles in the circulating fluids of the *Sertularia* (a type of Hydrozoa),[85] his and Hodgkin's comments were interpreted as casting serious doubt

81 Jacyna, 'A host of experienced microscopists', op. cit. (65), esp. pp. 229–232.

82 Southwood Smith, op. cit. (50), pp. 213–214.

83 Bostock op. cit. (51), p. 31 n. See also e.g. W. Rhind, 'Examination of the opinions of Bremser and others on the equivocal production of animals', *Edinburgh Journal of Natural and Geographical Sciences* (1830) 2, pp. 391–397, 394 n.

84 Thomas Hodgkin, and Joseph J. Lister, 'Notice of some microscopic observations of the blood and animal tissues', *Philosophical Magazine* [2nd series] (1827) 2, pp. 130–138, 136; Joseph J. Lister, 'On some properties in achromatic object-glasses applicable to the improvement of the microscope', *Philosophical Transactions of the Royal Society of London* (1830) 120, pp. 187–200. Schickore, 'Error as historiographical challenge', op. cit. (4), pp. 34, 36–37, overlooks the appeal to microscope veracity in Hodgkin and Lister's commentary.

85 Joseph J. Lister, 'Some observations on the structure and functions of tubular and cellular Polypi, and of Ascidae', *Philosophical Transactions of the Royal Society of London* (1834) 124, pp. 365–388, 377. On Lister see also Schickore, *The Microscope*, op. cit. (4), pp. 120–124.

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on the existence of organic globules. Two years after their initial publication, London anatomist Richard Grainger, whilst admitting that Milne-Edwards's conclusions were 'the results of such cautious and repeated examinations, that it is scarcely possible to doubt their accuracy', nevertheless noted that his own observations using a 'very excellent microscope' had led him to agree for the most part 'exactly' with Hodgkin.[86] By the mid-1830s, even such radically minded medical men as Thomas King had to admit that the globule thesis was 'not yet sufficiently demonstrated'.[87] Observers wary of the seemingly radical implications of the globule hypothesis could by this time confidently assert along with John Fletcher that 'the whole doctrine of the globular structure of the tissues and fluids in general of organized beings has been represented, on very respectable [i.e. Hodgkin and Lister's] authority, as founded on a microscopical illusion'.[88] Microscopes, rather than individual observers, appear in these comments as the principal sources of observational error. It was as much the doubtful status of these tools as any direct victory of conservative over radical politics that undermined Grant's and others' attempts to establish a conception of life as subject to the laws of physics and chemistry.[89]

The authority of London's museums

In comparison with the concerns surrounding the reliability of microscopic vision, bodies of evidence in museums seemed to offer a particularly reliable resource regarding the nature of living creation. By the end of the eighteenth century, the original aristocratic impulse towards collection as a means of demonstrating one's power over art and nature had begun to be rivalled by an alternative rationale, centred on the potential of such activities to liberate and enlighten their respective nations. Museums had begun to be understood as places of utility, the ordering and study of which could contribute to a wider enlightenment of humanity. Such conceptions became especially prominent in France following the Revolution of 1789. The collections at the royal Jardin des

86 Richard D. Grainger, *Elements of General Anatomy*, London: S. Highley, 1829, pp. 26–27, also 424. On Hodgkin's hostility to spontaneous generation see Thomas Hodgkin, *Lectures on the Morbid Anatomy of the Serous and Mucous Membranes*, 2 vols., London: Simpkin, Marshall and Co., 1836–1840, vol. 1., pp. 216–219.

87 Thomas King, *The Substance of a Lecture, Designed as an Introduction to the Study of Anatomy Considered as the Science of Organization; and Delivered at the Re-opening of the School, Founded by … Joshua Brookes, Esq. in Blenheim Street October 1st, 1833*, London: Longman, Rees, Orme, Brown, Green and Longman, 1834, p. 27.

88 John Fletcher, *Rudiments of Physiology*, 3 vols., Edinburgh: John Carfrae & Son, 1837, vol. 1., pp. 87–89, quote and reference to Hodgkin and Lister as an authority at 89. See also vol. 1., pp. 133–134, and vol. 2., pp. 24–25. Schickore, 'Error as historiographical challenge', op. cit. (4), pp. 36–38, notes the adoption of this rhetoric amongst German microscopists.

89 Cf. Desmond, op. cit. (2). For alternatives to Desmond's position see Secord, op. cit. (9); Pietro Corsi, 'Before Darwin: transformist concepts in European natural philosophy', *Journal of the History of Biology* (2005) 38, pp. 67–83, esp. 70–72; Boyd Hilton, 'The politics of anatomy and an anatomy of politics', in Stefan Collini, Richard Whatmore and Brian Young (eds.), *History, Religion and Culture: British Intellectual History 1750–1950*, Cambridge: Cambridge University Press, 2000, pp. 179–197; Pietro Corsi, 'A devil's chaplain calling?', *Journal of Victorian Culture* (1998) 3, pp. 129–137.

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plantes, for example, underwent a fundamental realignment as a national body of natural objects, indicated by their renaming as the Muséum d'histoire naturelle. Cuvier, Geoffroy and Lamarck were all employees of this new institution.[90] Disputes between these figures regarding the unity and transformability of the organic world, as well as the possibility of reconstructing now-extinct organic forms, have been read as disagreements not only regarding the constitution of nature, but also regarding the specific direction in which post-Revolutionary France should be heading.[91]

In Britain, the establishment of new gentlemanly societies, gardens and museums was central to the process of natural-philosophical enlightenment. For example, between the end of the Napoleonic wars and the 1830s, the Royal Society was joined by the Geological, Linnean, and Zoological Societies as established features of London's intellectual landscape. These institutions provided focal centres for the collection and interpretation of minerals, plants and animals from throughout the empire and the globe.[92] The emergence of these societies paralleled that of a movement in natural philosophy based around utilitarian ideals and the universality of natural law.[93] Nevertheless, such sentiments never dominated these spaces – rather, societies, gardens and museums were sites in which the notion of a law-determined nature was brought into contact with the notions of elite propriety and natural fecundity outlined above in relation to Coleridge and his circle.

Of the British institutions that outwardly devoted themselves to the improvement of the nation, it was the museum and gardens of the Zoological Society that had most relevance for Grant's advocacy of a zoology subject to chemical and physical law. The Society's Regent's Park gardens provided polite society (and later the general populace) with a novel form of 'rational recreation', simultaneously demonstrating the dominance of empire, promoting awareness of animals as potential sources of entertainment, and generating new objects of zoological study.[94] The society museum was especially important for the fulfilment of this latter role, providing a repository for the specimens of animals that had died in the gardens, as well as those donated to the institution.[95] Grant was a highly active member of this institution during its early years, attending meetings and providing anatomical studies for its *Proceedings* on such varied topics as the heart of the Indian tortoise, the cranium of the grampus, and the cloaca (the opening of the intestinal, reproductive and urinary tracts) of the condor.[96]

90 On Cuvier's museological activities see Martin Rudwick, 'Georges Cuvier's paper museum of fossil bones', *Archives of Natural History* (2000) 27, pp. 51–67.

91 Spary, op. cit. (18), esp. pp. 193–195; Toby P. Appel, *The Cuvier–Geoffroy Debate: French Morphology in the Decades before Darwin*, New York and Oxford: Oxford University Press, 1987, e.g. pp. 188–201.

92 Richard Drayton, *Nature's Government: Science, Imperial Britain, and the 'Improvement' of the World*, New Haven, CT and London: Yale University Press, 2000, pp. 106–124.

93 Desmond, op. cit. (2), esp. pp. 134–144.

94 Harriet Ritvo, *The Animal Estate: The English and Other Creatures in Victorian England*, London: Penguin, 1990; first published 1987, pp. 205–242.

95 Adrian Desmond, 'The making of institutional zoology in London, 1822–1836' [Parts I and II], *History of Science* (1985) 23, pp. 153–185, 223–250.

96 Robert E. Grant, 'On the heart and the structure of the blood vessels of the large Indian tortoise (Testudo Indica, Linn.)', *Proceedings of the Zoological Society of London* (1833) 1, pp. 43–44. Grant, 'On the cranium

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Museums also became the subject of political and nationalistic concern in Britain during the 1820s and 1830s. For example, the British Museum became a focus for reform agitation. This institution had initially begun to emerge around the collections made by Sir Hans Sloane during the mid-eighteenth century. By the turn of the nineteenth century the museum had become a place at which gentlemen naturalists and collectors routinely deposited unwanted or unmanageable collections (often for a price). This haphazard mode of acquisition was paralleled by an equally unsystematic approach to classification and display.[97] From the end of the Napoleonic wars, British natural philosophers and medical men began to draw highly unfavourable comparisons between their own national collection and the heavily invested-in, well-organized museum collections in Paris. Having recently visited the Muséum d'histoire naturelle, the anatomist William Lawrence denounced the organization of its British equivalent, noting that 'these great facilities have been … greatly neglected'. He bemoaned the fact that '[w]e have no national collection of living animals, no museum of natural history, no public institution for teaching natural science'.[98] Twenty years later, in a similar vein to Lawrence, Grant declared the zoological collection at the British Museum an 'opprobrium to the British Nation and these enlightened times' in his evidence to a parliamentary committee set up to investigate the possibility of reforming the institution.[99] Moderate anatomists such as Owen also joined the growing chorus for reform. Comparing the state of British museums with those in other countries (and especially with those in France) constituted a means by which a broad range of reform politics could be expressed in terms of national interest[100] – a tactic particularly apposite for such as Grant, whose Scottish background invited suspicion regarding his loyalty to England.[101] Collecting and organizing specimens in the name of a specifically 'British' natural philosophy helped justify the introduction and development of practices and concepts that had been first developed in revolutionary settings on the Continent. It is no coincidence that much of the most respectable zoology of this period was articulated by Owen, in his role as conservator of the Royal College of Surgeons' Hunterian Museum.

Further, the prestige of museums helped validate those claims relating to microscopic nature that accorded with gross anatomists' conclusions. The differentiation by comparative and human anatomists of bodies into distinct material types or 'elements'

of the round-headed grampus (Delphinus globiceps, Cuv.)', *Proceedings of the Zoological Society of London* (1833) 1, pp. 65–66. Grant, 'On the cloaca of the female condor (Sarcorhamphus gryphus, Dum.)', *Proceedings of the Zoological Society of London* (1833) 1, p. 78.

97 On the early years of the British Museum see Neil Chambers, *Joseph Banks and the British Museum: The World of Collecting, 1770–1830*, London, 2007, esp. pp. 42–50 for the zoological collections.

98 William Lawrence, *An Introduction to Comparative Anatomy and Physiology: Being the Two Introductory Lectures Delivered at the Royal College of Surgeons*, London, 1816, pp. 87–88. Following his early involvement in campaigns for medical reform, Lawrence increasingly sided with the college council in its opposition to radical medical politics. See Desmond, op. cit. (2), pp. 257–258.

99 *Report on the Select Committee of the British Museum; Together with Minutes of Evidence, Appendix and Index …*, London, 1836, p. 37.

100 Elwick, op. cit. (3), p. 11.

101 Desmond, op. cit. (2), pp. 112–114.

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such as bones, muscles and nerves was becoming increasingly common at this time. During the 1830s, British zoologists particularly invested in the anatomical delineation of higher animals, such as the Vertebrata, observed these same elements in the smallest discernible forms of life. In his dismissal of the globule hypothesis as 'bold and fanciful', Peter Mark Roget highlighted German Christian Gottfried Ehrenberg's alternative conclusion that distinct structural elements could be discerned in even the minutest beings:

> All these fanciful dreams have been dispelled by the important discoveries of Ehrenberg, who has recently found that even the Monas termo is possessed of internal cavities for the reception and the digestion of its food; and who has rendered it probable that their organization is equally complex with that of the larger species of infusoria, such as the Rotifera, in which he has succeeded in distinguishing traces of a muscular, a nervous, and even a vascular system.[102]

Owen went further, suggesting that Ehrenberg had discovered 'that in many of the genera [of monads] … the alimentary canal is provided with a distinct anal outlet'. Moreover, he pointedly suggested that 'the larger faecal pores of the *Spongiae* may also be considered in the same relation to the digestive system'.[103] The apparent discovery of distinct anatomical structures in organisms that had been characterized as the simplest possible forms of life seemed to disprove once and for all the claim that bodies were composed of chemically derived globular entities. When using tools that could not guarantee agreement amongst observers, zoologists were, it seemed, best advised to confine their claims to those that accorded with the expectations regarding bodily organization that had been formed in relation to more reliable investigative means.

Grant's anatomical zoology

The differences between Grant's focus in and around Edinburgh and his work after taking up the chairs of zoology and of comparative anatomy at the University of London in 1828 are clearly shown by the research publications he produced at each location. Grant's articles published in Scottish journals relied on extended observations of animals kept alive in his Firthside property. In addition to the local sponge population, they addressed such topics as sounds made by sea slugs and the phosphorescence produced by sea pens.[104]

In contrast with his Edinburgh-based investigations, Grant's researches in London yielded only one paper focusing on the minute study of living organisms. Shortly after his appointment to the university, he subjected a sample of water found in some nearby 'stagnant pools' to microscopic observation. Grant reported that he was able to observe the motions of the *Furcocerca viridis*, an infusorial 'animalcule' named by

102 Peter M. Roget, *Animal and Vegetable Physiology Considered with Reference to Natural Theology*, 2 vols., London: William Pickering, 1834, vol. 1, pp. 185–186.

103 Richard Owen, 'Remarks on the Entozoa, and on the structural differences existing amongst them: including suggestions for their distribution into other classes', *Transactions of the Zoological Society* (1833–1835) 1, pp. 387–394, 389.

104 Robert E. Grant, 'Sounds produced under water by the Tritonia arborescens', *Edinburgh Philosophic Journal* (1826) 14, pp. 185–186. Grant, 'Notice regarding the structure and mode of generation of the Virgularia mirabilis and Pennatula phosphorea', *Edinburgh Journal of Science* (1827) 7, pp. 330–334.

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Lamarck and described by renowned Germanic zoologist Johannes Müller. Intriguingly for Grant, whichever way he turned the vessel in which the sample was held, the organisms always collected on the side of the glass most exposed to a source of light.[105]

Though relatively short, this text is significant because it demonstrates both a continuation of Grant's interest in the nature of microscopic organic forms, and a shift of intellectual focus. Whereas his publications on the sponges had exhibited a concern with the emergence of globules as the 'simplest' organic beings, this article concerns itself with the far better-established (and thereby less controversial) class of 'infusoria', and above all with the possible causes of their animation:

> The motions of *Infusoria* are by many believed to be automatic, and Lamarck conceives them to result merely from the action of various imponderable fluids pervading all bodies … It is interesting, however, to observe, that an agent so extensively diffused over nature as light has an obvious and powerful influence on the motions of the *Furcocerca viridis*, an animalcule which exhibits nearly the simplest known form of animal organization.[106]

Critical to this shift is a concern not with demonstrating the activity or chemical origin of the most basic living particles, but with the nature of organic activity in general and its possible causes. Most discussions of animal responsiveness at this time emphasized the role of the nervous system as an agent of bodily movement. The apparent absence of nerves in the *Furcocerca viridis* thereby seemed to imply that it should not be able to respond to stimuli. Lamarck, Grant observed, had sought to explain this apparent discrepancy by positing a motive vital force internal to the organism. Grant's portrayal of their movement as 'caused' by light – a stimulus external to the body of the animals – circumvented the necessity of invoking such a force.

Grant reported little further research in this experimental vein. In subsequent publications, including his course on comparative anatomy and animal physiology at the University of London, he concentrated almost exclusively on the description and comparison of gross anatomical forms, and on relating those forms to the functions of life. In the context of 1830s London, Grant sought both to establish a conception of zoological nature as determined by physical laws, and to reform medicine by refounding knowledge of the human body on a broader consideration of animal anatomy. Hodgkin and Lister's claims regarding the illusory nature of globules had dealt this former aim a serious blow. What did seem possible, however, was that the latter might be achieved via the collection, production, description and utilization of museum specimens.

In showing how organisms' gross anatomical structures formed a gradual progression from the simplest to the most complex, Grant was following the work of (amongst others) Geoffroy Saint Hilaire.[107] Geoffroy was engaged until 1832 in an extended

105 Robert E. Grant, 'On the influence of light on the motions of infusoria', *Edinburgh Journal of Science* (1828–1829) 10, pp. 346–349.

106 Grant, op. cit. (105), p. 349.

107 Desmond, op. cit. (2), pp. 56–58. The characterization of Grant in Elwick, op. cit. (3), pp. 20, 71–74, as articulating a conception of life as developing from simple to 'compound' rather than 'complex' is accompanied by a very different interpretation of his natural philosophy. That Grant was not primarily concerned with advocating a 'fusional' or 'centripetal' notion of organic development is demonstrated by the discussion below.

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dispute with his counterpart at the Muséum d'histoire naturelle, the highly respected Georges Cuvier, over the extent to which organic nature could be characterized as a unified whole.[108] In contrast to Owen, Grant's anatomical investigations at the Zoological Society sought to break down Cuvier's proposed *embranchements* by which natural forms were classified into broad, essentially dissimilar, categories.[109] In this sense, we can see Grant continuing his already-discussed interest in establishing a normative position regarding natural (rather than simply organic) unity. However, Geoffroy's 'unity of type' in organic structures said very little about relations between organic and inorganic nature. By concentrating on describing relations between anatomical structures and living functions, Grant also ceded epistemological ground in his advocacy of the unity of nature and the universality of natural law.

Although Grant's research in London has been characterized as calculated to support Geoffroy, and as broadly inspired by the transmutationist ideas of Jean-Baptiste Lamarck, it would be a mistake to assume that either natural philosopher's ideas provided a complete conceptual framework for his lectures.[110] As indicated by the quotation from the article on *Furcocerca viridis*, Lamarck's characterization of vital fluid did not feature prominently in Grant's work, though both shared an interest in organisms that were difficult to classify as either plant or animal, and both were interested in the possibility that life developed out of inorganic matter. Similarly, Grant shared Geoffroy's belief that basic elementary forms could be traced throughout zoological nature, but placed greater emphasis on the development of life from microscopic organic structures. In this sense, Grant's lectures can be understood as an attempt to synthesize the work of the two French naturalists, similar to the way in which Cuvier's and Geoffroy's followers in France and Britain sought a synthesis of their more antagonistic views during the 1830s and 1840s.[111] The role of Germanic philosophy and zoology in this process was crucial, as it provided clear conceptual tools for an understanding of nature as a progressive, end-directed process that did not have to rely on active intervention of a disembodied or immaterial force.[112]

Grant followed European 'philosophic' naturalists in seeking to explain the development and existence of relations between different systems of organs. In his *Lancet* lectures, the skeletal, nervous and digestive systems are each described in turn, starting with characterizations of their 'simplest' manifestation and working up to their most complex (generally, though not necessarily, to be found in a universal 'Man'). According to Grant (following Geoffroy), each set of organs displays a gradual progression of form, and the explanation for changes in form along this continuum is to be found in changes to the functional requirements of a particular organ. Thus the fact that the skull bones of fish present a closer resemblance to vertebrae than do the fused

108 Appel, op. cit. (91). The year 1832 was that of Cuvier's death.

109 Desmond, op. cit. (2), p. 56.

110 For a discussion of the relation between these figures and their followers see Pietro Corsi, 'The revolutions of evolution: Geoffroy and Lamarck, 1825–1840', *Bulletin d'Musée d'anthropologie préhistorique de Monaco* (2012) 51, pp. 97–122

111 Appel, op. cit. (91), pp. 202–237.

112 Lenoir, op. cit. (14), pp. 6–16.

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skulls of higher organisms such as mammals demonstrates two things; first, it shows that fishes' unfused skulls are lower down the skeletal developmental scale than those of mammals, and therefore closer to the 'simplest' condition in which bones can be found (in this case as countless minute 'spicula' in the sponges);[113] second, it demonstrates that fish are 'perfectly adapted' to their environment – a circumstance that requires the accommodation of muscles suited to producing the lateral bodily motion necessary to move through water. This latter (Grant suggests) would not be possible with a fused skull.[114]

Explanations along these lines do not necessarily invoke the functional requirements of the external environment as an immediate explanation for all anatomical forms, but consider each form in relation to the whole body and its environment. This is most clear in Grant's lectures on nervous anatomy. These follow Cuvier in emphasizing the significance of relations between the anatomical elements of organisms. Grant considers the simplest discernible form of the nervous system (though crucially not the first manifestation of mental function) to be that of the starfish, described by Friedrich Tiedemann in 1816.[115] This system, according to Grant, consists of 'a simple circle of nervous filament around the centre of the alimentary canal … placed near the mouth so as to watch over the kind of substances that are conveyed into [it]'.[116] In this 'low' state the nerves have a relatively direct relation to external environmental conditions, their primary function being to ensure that the digestive system receives appropriate sustenance from without. But in organisms in which other functional systems play a greater role, the nervous system's most significant relation is with its internal environment. Hence in arachnids the relatively minor role played by the sense organs means that the supra-oesophageal ganglion serving them is small. In contrast, the importance of the organs of motion for the continuance of arachnid life means that the ganglia relating to them are of greater size.[117] As the nervous system is traced upwards through the animal kingdom, its form becomes increasingly dependent on the relative importance of different anatomical structures, rather than the direct influence of external environmental conditions, for keeping the animal alive.

The principal means by which life is seen to develop in Grant's lectures is that which had been advocated by Meckel during the 1810s: the successive arrest of embryological development along a preordained plan, regulated by the operation of natural law. Although Grant draws on Karl Ernst von Baer's 'law of divergence' in insisting that the development of species' bodies does not follow one smooth progressive path from simple to complex, he nevertheless tends (as would his contemporary Robert Chambers) to assume that all anatomical structures can be seen to progress along a

113 Grant, op. cit. (31) [Lecture IV] (1833–1834) 21, pp. 196–200.

114 Grant, op. cit. (31) [Lecture XII] (1833–1834) 21, pp. 544–546. On Grant's views on perfect adaptation see Secord, op. cit. (3), pp. 64–65.

115 Friedrich Tiedemann, *Anatomie der Röhren-Holothurie der pomeranzfarbigen Seesterns und Stein-Seeigels: Eine im Jahre MDCCCXII vom Fransösischen Institut gekrönte Preisschrift*, Landshut: Joseph Thomannschen Buchdrückerei, 1816. See also Elwick, op. cit. (3), pp. 76–78.

116 Grant, op. cit. (31) [Lecture XXXVI] (1834) 22, p. 483.

117 Grant, op. cit. (31) [Lecture XXXVII] (1834) 22, pp. 515–516.

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gradual unilinear developmental path as they develop into their most complex forms.[118] Hence anatomical structures found in adult specimens 'lower' down the scale find their parallel in still-developing human or mammalian bodies. Although Grant does not claim that the maturing human embryo passes through every lower anatomical form, it nevertheless constitutes for him the principal example of higher animals' recapitulation of the history of zoological development during their gestation.[119] This (at this time highly speculative) practice of comparing lower organic forms to anatomies of higher embryos accorded well with the broader emphasis on museological evidence in Britain at the time.

Nevertheless, other aspects of Grant's portrayal of the progress of organic structure in his University of London lectures seem more in accordance with his belief in natural unity than with his later, comparative-anatomy-centred zoology. One example of this (his suggestion that tissues were made up of spontaneously created, mutually independent globular 'atoms') has already been discussed. Another, more prominent, theme of the lectures is his discussion of the gradual formation of the distinct anatomical systems evident in more complex or higher animals.

In Grant's view, all the most basic functions necessary for the continuation of life are fulfilled not only by the collective operation of different anatomical structures evident in more complex organisms, but also at the most basic level by a 'gelatinous matter' similar to the one that he first encountered in his sponge research. He suggests that this basic organic substance contains within it the potential for the development of all organs that fulfil specialized functions. Hence 'all the systems that enter into the composition of animal bodies are successively developed from a primitive, simple, homogeneous, cellular tissue which at first composed the whole body'.[120] For example, after describing the experiments relating infusoria and light, Grant notes the nature of the simplest structures that can be associated with independent action. In the gelatinous state, 'nervous', 'muscular' and 'digestive' functions of life are 'diffused through every part of the homogeneous cellular tissue of the body, which possesses the same properties in every part, and is infinitely divisible without destroying its vitality'.[121]

Contending that functions such as motion and volition – conventionally associated with distinct organs or entities such as muscles, the brain or even an incorporeal 'soul' – are evident in the simplest living matter enabled Grant to emphasize his belief in the uniform operation of law in organic nature. The suggestion that muscles, brains and other organs generally presumed to be functionally specific had their origins in a single substance marks an extension of Continental anatomists' contentions regarding the independence of anatomical structure and living function. Geoffroy had argued that the opercular or gill-covering visceral arch bones of fish were 'the same' bones as

118 Evelleen Richards, 'A question of property rights: Richard Owen's evolutionism reassessed', *BJHS* (1987) 20, pp. 129–171, esp 133–134. I am grateful to one of the anonymous reviewers of this paper for drawing my attention to this article. For von Baer's embryology see Hopwood, op. cit. (23), pp. 16–24.

119 See, for example, Grant, op. cit. (31) [Lecture XXXIII] (1834) 22, p. 369; [Lecture XXXVII] (1834) 22, p. 513.

120 Grant, op. cit. (31) [Lecture II] (1833–1834) 21, p. 126.

121 Grant, op. cit. (31) [Lecture XXXVI] (1834) 22, pp. 481–482.

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those that form the inner ear in mammals, and that consequentially anatomical structures could not be usefully classified according to the functions they fulfilled without also referring to their position in an overall 'unity of plan'.[122] Grant went further, suggesting that all life developed from an original, functionally undifferentiated, state. This contention can be seen as a confirmation of the characterization of nature as inherently developmental, progressing from simple to complex – a concept most prominent in what Timothy Lenoir characterizes as the 'teleo-mechanic' natural philosophy prevalent in Germanic territories at this time.[123] Like Germanic zoologists such as Meckel and von Baer, Grant was concerned with establishing how specialized organic forms arose from an initially 'homogeneous' substance. But where von Baer concentrated on the embryological development of individual organisms as wholes, Grant sought to explain the emergence of specialized forms present throughout organic nature, such as muscles and bones.[124]

Describing tissues and organs as arising out of the differentiation of a simple homogeneous substance was a way for Grant to reconcile his emphasis on the universality of natural law with the seemingly well-distinguished anatomical 'elements' he sought to explain in his lectures. In his museum and in the lectures he gave at the University of London, Grant addressed one anatomical specimen at a time, moving up an anatomical series and relating each organ to the specific environmental and bodily circumstances that he believed explained its structure. At the same time, his continual comparison of the anatomical elements of lower-animal adult forms with higher-animal embryos seemed to demonstrate parallels between all organic structures.[125] Specimen-based comparative anatomy presented a convincing means by which the study of human organs could be linked with that of the development of animal life. However, anatomical tools were not well suited to the conveyance of Grant's belief that these structures were ultimately of chemical origin. In the absence of any established means of demonstrating the points at which such systems did in fact initially emerge, he appears to have simply asserted his views as truth. Though it is possible that he presented students with microscopic evidence or illustrated these points with drawings, there is no hint of this in either his published or his unpublished writings.

The extent to which Grant's reliance on prepared specimens determined his capacity for promoting his subject thereby indicates a limiting effect of museum-centred natural philosophy upon zoological discourse in London at this time. Whilst museum anatomy was a very powerful means of associating and comparing particular structures of human and animal bodies, the comparison of gross anatomical specimens was not well suited to illustrating the nature, origin or development of organic phenomena that were difficult to perceive or to preserve. The significance accorded museums in English natural philosophy during the early nineteenth century concentrated attention on 'higher' anatomy at the expense of the microscopic and experimental studies that were more popular on

122 Appel, op. cit. (91), pp. 84–90, 97–104, esp. 88–90, 97–100.
123 Lenoir, op. cit. (14), pp. 24–30.
124 Lenoir, op. cit. (14), pp. 80–81.
125 On embryology and anatomical specimens see Hopwood, op. cit. (23). esp. pp. 10–13, 24–27.

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the Continent (and that had constituted the main focus of Grant's research in Edinburgh).[126]

Further, the aspects of Grant's zoology that were most congruent with his teaching at the University of London – comparisons between and explanations of specific anatomical parts – were also highly susceptible to appropriation within different and even opposing explanatory frameworks.[127] The clearest example of this is the adaptation of his emphasis on the gradual progress of anatomical structures to natural-theological contentions by his students. For example, having been commissioned to write the treatise on zoology for the natural-theological Bridgewater series, Roget enrolled on Grant's course in 1832, and subsequently based a substantial proportion of his final text on its progressive anatomical schema. Yet Roget's work downplayed Grant's emphasis on the unity of natural law. Instead, Roget emphasized that abrupt distinctions existed between species, and postulated that organic change was produced by a 'subtle and pervading principle'. He also insisted that living nature was 'utterly irreducible to the known laws which govern inorganic matter'.[128] Other attendees of Grant's classes at the University of London interpreted his anatomy in a similar fashion. Edwin Lankester and Edward Meryon both published works addressing zoology that admitted the possibility of a continuum of anatomical forms. Nevertheless, both denied that man could be included in this continuum, and Lankester was particularly concerned to stress the impossibility of the spontaneous development of life out of inorganic matter.[129] Though Grant's university lectures promoted an uncompromisingly law-determined notion of zoological development, this did not prevent his students from appropriating those aspects of them that accorded with their own particular conceptions of life, nature and divine creation.

Perhaps the clearest illustrations of this tendency to interpret Grant's work in ways that did not necessarily accord with his convictions are the early publications of William Benjamin Carpenter, one of Grant's students most sympathetic to his notion of nature as a unity. Although Carpenter's texts (published during the mid- to late 1830s) value microscopic observation, they cast doubt on the possibility of observing fundamental atom-like organic forms.[130] It was only after the establishment of cell theory that Carpenter's publications began to represent bodies as made up of collections of nominally independent microscopic parts. Even then, they emphasized what they

126 By the last third of the century, however, museums were coming to be routinely utilized as spaces for experimentation as well as dissection. See Alison Kraft and Samuel J.M.M. Alberti, '"Equal though different": laboratories, museums and the institutional development of biology in late-Victorian northern England', *Studies in History and Philosophy of Biological and Biomedical Sciences* (2003) 34, pp. 203–236.

127 On Grant's teaching practices see Parker op. cit. (9), pp. 16–20.

128 Roget, op. cit. (102), esp. pp. 9, 21.

129 Edward Meryon, *The Physical and Intellectual Constitution of Man Considered*, London: Smith, Elder and Co., 1836, esp. pp. 25–45. Edwin Lankester, 'The natural history of creation', in [anon.], *Lectures Delivered before the Young Men's Christian Association at Centenary Hall and Freemason's Hall, 1847–8*, London: James Nisbet & Co., 1864, pp. 1–32, esp. 5–6.

130 William B. Carpenter, *Principles of General and Comparative Physiology, Intended as an Introduction to The Study of Human Physiology, and as a Guide to the Philosophical Pursuit of Natural History*, London: John Churchill, 1839, e.g. pp. 14 n., 19, 23.

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portrayed as the impossibility of cells developing from inorganic matter, as well as the wide range of cell-like entities of which tissues are made up.[131] Carpenter's early publications indicated his belief that physiological studies have to be distinguished from conceptions of life as chemically derived, and that there was little evidence for the contention that nature is built up of agglomerations of essentially similar (and therefore implicitly equal) parts.

Conclusion

Museums, and the specimens they contained, played a critical role in the constitution of zoology as an academic discipline in London during the early nineteenth century. As spaces that could be experienced by multiple witnesses relatively easily, they seemed a particularly reliable means of constituting knowledge. In addition, individual museum specimens could be utilized for the purposes of instruction more readily than individual microscopes. A specimen preserved in a jar could be held up for a whole class to see at once, whereas a microscope preparation demanded that each observer witness phenomena separately.

The emphasis in London on museological anatomy, however, placed constraints on the kinds of tool to which zoological authors might appeal. This, in turn, led to an emphasis on certain questions regarding the nature of life, and a de-emphasis on others. Establishing agreement amongst observers seemed far more easily obtainable via the collection and display of specimens than through their magnification. Microscopes were indispensable in attempts to answer such problems as what the simplest unit of life is, or whether life develops out of non-life. However, the relative distrust of microscopy amongst London zoologists and medical men meant that such questions came to be seen as less interesting than those concerning relations between anatomical structures. In this context, the question whether or not the understanding of human bodies might be informed by that of zoological nature as a whole became particularly prominent. Focus on museological specimens – along with the importance of museums as sites in which zoologists could maintain institutional positions – contributed to a concentration on the nature of human–animal relations.

Although relations between life and non-organic nature were becoming culturally important elsewhere at this time (for example in Germany),[132] it was the connection of humanity to a historically distinct 'animal' kingdom that most interested the majority of British intellectuals concerned with living nature. Grant's reliance on specimens following his move to London reflected both a broader focus on museums as authoritative sites

131 William B. Carpenter, 'Report on the results obtained by the use of the microscope in the study of anatomy and physiology: part II – on the origin and function of cells', *British and Foreign Medical Review* (1843) 15, pp. 259–281. For Carpenter's hostility to spontaneous generation during the 1840s see Carpenter, 'Natural history of creation', *British and Foreign Medico-Chirurgical Review* (1845) 19, pp. 155–181, esp. 168–173. Though see also Andrew Reynolds, 'Amoebae as exemplary cells: the protean nature of an elementary organism', *Journal of the History of Biology* (2008) 41, pp. 307–337, 315–317.

132 On this difference see Lenoir, op. cit. (14), pp. 35–37; Schickore, *The Microscope*, op. cit. (4), pp. 143–144.

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of intellectual production, and the relatively marginal status of other means of constituting zoological knowledge in Britain at this time. His ideological commitment to an uncompromisingly law-determined conception of creation, in which life could be explained by 'the principles of chemistry or mechanics', came to be articulated by him in relation to anatomical series rather than to the microscopic 'atoms' that had initially seemed so promising.

Although museums were critical to the instantiation of zoology as an academic discipline in Britain, they can thereby be understood as constituting a limiting effect on discourse regarding the nature of animal life at this time. Indeed, perhaps the most famous nineteenth-century debate regarding the nature of life, that during the 1860s between 'Darwin's bulldog' Thomas Henry Huxley and Richard Owen (and Bishop Wilberforce), centred on the interpretation of a single anatomical specimen of an organic 'element' that was to play a particularly prominent role in nineteenth-century natural philosophy: the nervous system. The apparently critical status of anatomical disputes during the 1860s indicates the central role that museum specimens had come to play in the constitution of zoology as an academic discipline. Despite being infused with the ideological concerns of its proponents, early nineteenth-century zoology did not reflect the broader politics of its time in any simple way: the very terms of zoological debate also depended to a considerable extent on assumptions relating to the kinds of tool and technique that could legitimately be appealed to in its investigation.

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