Fiber, Medicine, and Culture in the British Enlightenment

Hisao Ishizuka

Fiber, Medicine, and Culture in the British Enlightenment

Hisao Ishizuka

Fiber, Medicine, and Culture in the British Enlightenment

palgrave
macmillan

Hisao Ishizuka
Senshu University Japan
Kawasaki shi, Tama-Ku, Japan

ISBN 978-1-137-58092-4 ISBN 978-1-349-93268-9 (eBook)
DOI 10.1057/978-1-349-93268-9

Library of Congress Control Number: 2016957418

Printed on acid-free paper

This Palgrave Macmillan imprint is published by Springer Nature
The registered company is Nature America Inc.
The registered company address is: 1 New York Plaza, New York, NY 10004, U.S.A.

Acknowledgments

This project has a fairly long history going back to my years (1998–1999) of postdoctoral research fellowship granted in England by the Wellcome Trust under the title “Fiber Theory in Eighteenth-Century Medicine.” Therefore, my first debt goes to the Wellcome Trust and Catherine Crawford at Essex University, who not only helped me to gain this grant but also led me to find this fascinating topic. The research on this project was substantially finished in the early 2000s, but several circumstances here in Japan combined to prevent publication for some years. During these years, however, I profited from valuable criticism given by my friends, especially those brilliant scholars joining together as the workshop “BMC” (Body, Medicine, and Culture) at Keio University, Hiyoshi. I also wish to thank my colleagues in the Department of English at Senshu University for providing an ideal environment in which to write and teach.

Portions of this book have appeared in earlier form in the following publications. An earlier version of Chap. 1 appeared as “Visualizing the Fibre-Woven Body: Nehemiah Grew’s Plant Anatomy and the Emergence of the Fibre Body,” in *Anatomy and the Organization of Knowledge, 1500–1850*, edited by Matthew Landers and Brian Muňoz (Pickering & Chattos [now Routledge], 2012, 113–28), and is included here with permission from Taylor & Francis. An earlier version of Chap. 2 and a portion of the Introduction and Conclusion were published as “‘Fibre Body’: The Concept of Fibre in Eighteenth-Century Medicine, c.1700–c.1740,” in *Medical History* [56 (October 2012): 562–584] and appear here by permission of Cambridge University Press. An earlier version of Chap. 3

appeared as "The Elasticity of the Animal Fibre: Movement and Life in Enlightenment Medicine," in *History of Science* [44 (December 2006): 435–68], and is printed here by permission of Sage. An original Japanese draft of Chap. 6 appeared as "Maku to Hida no Kaibougaku: Faiba bodi to Barokisumu" in *Jinbungaku-Nenpo* [*The Annual Bulletin of the Humanities*] [42 (2012): 1–34]; the revised English version of it appears here by permission of The Institute of Humanities, Senshu University. All materials are expanded here. I am grateful to the editors and the anonymous reviewers for all their comments and suggestions on these papers.

My foremost thanks go to the commissioning editor at Palgrave Macmillan who was first interested in my project and gave me an opportunity to compile my works into book form. I would also like to thank the editors and anonymous reader at Palgrave Macmillan for their careful reading of the manuscript and for their interest in my work. I wish to express my gratitude for their helpful comments and suggestions, although of course I am solely responsible for any errors and shortcomings.

This book is dedicated to my parents and my mother-in-law. It is a meager return for all that I owe them. Finally, my deepest thanks go to my wife, Aoi, whose unfailing love has always encouraged me. Without her kind support and warm affection I could not have completed this project.

Contents

List of Figures

Introduction

Fiber vibrated at the heart of eighteenth-century medicine. Although almost forgotten now, fiber attracted enormous interest among eighteenth-century medical scientists. Unsurprisingly, Herman Boerhaave and Albrecht von Haller, the two doyens of eighteenth-century medicine, both subscribed to the idea of fiber to develop and systematize their respective medical theories, which indicates how critical the concept of fiber was during the century. It is no exaggeration to say that if the nineteenth century was the age of the cell, the eighteenth century was the age of fiber.

This book is the first full-length and in-depth study of fiber and the "fiber body," the body configured and informed by the concept of fiber, during the British Enlightenment. It explores the pivotal role fiber played in eighteenth-century medicine as a defining, underlying concept in varied fields from anatomy, physiology, pathology, and therapeutics to the life sciences. The era of the Enlightenment witnessed the rise and development of "fiber medicine," a body of medical knowledge based on the notion of fiber. Setting the fiber as the ultimate building unit of the animal body, many eighteenth-century medical authors fabricated fiber theory (i.e., the theoretical articulation of fibers) in multifarious forms. The human body, formerly seen as the expression of the four humors, was now reconfigured as wholly composed of solid fibers. Consequently, the body's health and illness were believed to depend on the condition, qualities, and state of the fibers.

Any medical historians reasonably familiar with eighteenth-century medicine are aware of how full the medical discourses are of mentions of the fibers, and they may have dimly sensed that the fibers are a critical key in disclosing the knowledge of Enlightenment medicine, both of iatromechanism and of iatro-vitalism. With so obvious an omnipresence of fibers, however, historians have never yet engaged in a project to gain an overall picture of fiber medicine in Enlightenment medicine.[1] Kevin Siena's recent overview of the medical knowledge of the Enlightenment contains a useful summary of medical theory of the era but fails to recognize the significance of the concept of fiber, which should have constituted the physiological bedrock of what Siena presented as the "pliable body," a malleable, porous body that constantly interacts with the environment.[2] Other medical historians have similarly overlooked the significance of fiber. Instead of giving a full account of it, they have focused on the nerve and its cognate theories. For "nerve" rather than "fiber" has been privileged as the key term in eighteenth-century medical discourse in general.[3] This neurocentric interpretation of eighteenth-century medicine, starting with Willis in the mid-seventeenth century and continuing through Cheyne in the early eighteenth to Cullen in the second half of that century, obscures the importance of fiber. Rather than provide a sweeping generalization about eighteenth-century medicine in terms of nerves, this study will attempt a comprehensive re-evaluation of fiber and fiber medicine in the British Enlightenment.

Unlike the nervous body initiated by the neuro-anatomical revolution in the preceding century, the eighteenth-century fiber body has been largely ignored. Current historiography on eighteenth-century medicine rarely touches upon the significant roles played by fibers. These physical components of the body have been considered by medical historians only in terms of their connection with the Hallerian notions of sensibility and irritability, which are respectively ascribed to the nervous and the muscular fibers.[4] This fallacious tendency had already begun in the nineteenth century: Virchow, a founding father of cellular pathology, looking back upon the former century, remarked on the long reign of the fiber-tissue doctrine, which he conceived to have originated with Haller: "[The Hallerian] conception [of the fibre] was soon still further expanded, and the doctrine that fibres serve as the ground work of nearly all the parts of the body, and the most various tissues are reducible to fibres as their ultimate constituents, was longest maintained in the case of the very tissues in which…the pathological difficulties were the greatest—in the so-called cellular tissue."[5] The association of the fiber with Haller's doctrine of the bodily tissue has obstructed scholars in reaching a correct understanding of fiber and fiber theory, which was clearly articulated well before Haller's systematic adaptation. The rediscovery and reinvestigation of fiber and the fiber theory of the first half of the eighteenth century will therefore contribute to a more authentic account of early eighteenth-century medicine. My research shows that the period of "iatromechanism" (a medical doctrine based on mechanical laws derived from such fields as geometry, mathematics, and hydraulics)[6] is not an infertile era in the history of medicine,[7] but rather a time of very energetic pursuit of the formation and elaboration of fiber medicine. Even after nervous vitalism—iatro-vitalism informed by the knowledge of the nerves—swept the medical world, fiber and fiber theory continued at a deeper level to feed into the knowledge of medicine. As such, "fiber medicine" is probably a more appropriate designation for eighteenth-century medical sciences.

From a broader perspective of the history of medicine, the development of eighteenth-century medicine has been depicted as a gradual progress from the mechanical view of the body to the vitalistic conceptualization of the body dating to around the mid-eighteenth century.[8] Accordingly, the medical theory of the eighteenth century has been described as a progressive development from mechanism to vitalism. In the iatromechanistic view, the body, imagined as a hydraulic machine, is composed of pipes, with fluids perpetually circulating through these pipes. The vitalistic view, on the other hand, sees the body as primarily a nervous and sensible organism that is regulated by the brain and the nervous system. Fiber and fiber theory do not appear to fit anywhere within these views. This book proposes that fiber, far from being one of the categories or subsets of the vascular or nervous system, underlies both mechanical and vitalistic understandings of the body and the resultant theories. In so doing, this book will comprehensively describe the fiber-related discourse of eighteenth-century medical theory.

A preliminary remark should be made on the range covered by this book: the materials I consulted are primarily written in English by British authors. An important exception is Boerhaave, whose writings deeply influenced British authors and who was also widely plagiarized by them. Thus, in the present book the terms "fiber medicine" and "fiber theory" by and large designate British fiber medicine and fiber theory. Nevertheless, I presume that it was a pan-European phenomenon—for in addition to Boerhaave, other important figures subscribed to and contributed to fiber theory, for example, Albrecht von Haller, Charles Bonnet (who developed the theory of fiber psychology), Denis Diderot, Emanuel Swedenborg (who penned a book-length study of fiber), and Tiphaigne de la Roche (who exploited fiber theory in his utopian fiction).[9] All these and other figures make up the wealth of literature on fiber in the pan-European context.

Fiber first entered into the English vocabulary at the end of the fourteenth century as word meaning "a lobe or portion of liver," with its plural meaning "entrails"; these meanings are now obsolete.[10] Although the OED registers 1607 as the earliest use of fiber in the new sense, and, theoretically speaking, the concept of the fiber as a basic component of animal and plant life goes back far beyond that date,[11] it was not until the late seventeenth century that fiber was clearly and schematically defined as such. In Thomas Blount's *Glossographia* (1659), "fibres" were simply defined as the "threads or strings of Muscles and Veins," along with another meaning, the small threads of roots.[12] This definition of the fiber was not clear enough to distinguish it from the "nerve," which was defined in the same dictionary as "a Sinew" both in a physical and in a mental sense (i.e., strength, force, power). Since antiquity, the nerves and the sinews had been used interchangeably; for example, when Helkiah Crooke in his anatomical textbook written in 1615 classified the vessels into three kinds, as "Veins, Arteries and Sinews," he meant by the last vessel the nerves which arose from the brain.[13] Neither the fiber nor the nerve were sharply discriminated from each other, and they did not attain the high status in anatomy and physiology that they acquired in later years. It is only toward the end of the seventeenth century that fiber established itself as the minimum building unit of the body, as the following chapters will show.

In the eighteenth century, fiber lays a foundation for knowledge. Quite simply, to the question "What is man?," the answer of the eighteenth-century medical authors would be "fiber." The fiber for them accounted for nearly everything concerning the body and to a lesser degree the mind. According to the fiber theorists, man begins life as a "stamina," an elementary fiber originally enclosed in the loin of Adam; man grows as the fibers expand, develop, and differentiate into the body parts (organs), which are variously (and successively) interwoven by the fibers. In the process of growth, the mental and physical faculties unfold according to the states and the degrees of the fibers; sexual impulse, for instance, begins at the proper time when the fiber-vessels unfold in proportion to the person's years to secrete the fluids fit for sexual stimulation. While in the younger years man's fibers are soft and pliable, man gradually and inevitably grows old as the fibers become harder and harder, such that they no longer admit animal fluids, and finally death occurs. In the afterlife, man's immaterial soul assumes at resurrection a fiber-textured vehicle to receive rewards or punishment. In these ways, fiber touches on everything concerning life, death, and even afterlife.[14]

Nicholas Robinson, an iatromechanist of the early eighteenth century, was only one such medical writer who drew heavily on the idea of fiber to explain all the physiological phenomena regarding the body and the mind: animal economy (i.e., all the functions of the body) and its aberration (diseases), temperament (individual constitution), and the individual differences in mental abilities such as moral sense, taste, and the faculty of feeling—all these depend in one way or another on the capacity and the nature of the system of the fibers.[15] For Robinson, life depends on the "Harmony of the several Fibers" for its motion; sensation and motion also proceed from the "fine Threads" of the nervous fibers.[16] The different springiness of the fibers determines individual constitutions or temperaments, traditionally considered to be composed of variable combinations of the four humors.[17] Many kinds of differences—the difference of nationality (between English and French), the difference of the individual talent (between the idiot and genius), the difference of individual taste, moral sensibility, and sexual impulse—all are most determined by fibers.[18] Thus, Robinson concludes that "all the Parts of the Animal Oeconomy, the Intellectual Faculties themselves not excepted, are depending on the Fibres."[19] The overreaching significance conferred upon fiber led a skeptic author to suspect that every individual fiber was "a rational Being" that was endowed with a faculty to discriminate "what was convenient or hurtful to it."[20]

The fibers' all-embracing functions critical to life and constitution remained in the later eighteenth century, as John Elliot, a natural philosopher with some reputation, summarized as follows:

> As on the action of the fibres the *functions*, so on the state of the fibres the *constitution*, of the body seems to depend. If the fibres are strong, the individual is strong; if weak, he is feebler. If the fibres are very irritable, he is passionate; if the contrary, inactive and dull….Their state depends also very much on that of the atmosphere. If the atmosphere is heavy, cold, and dry, the fibres are elastic and strong. If light, hot, and moist, the contrary. Moderate cold strengthens or braces up these fibres; but excess of heat

> weakens them. Hence heat makes up feeble and faint; cold the reverse. From knowing the state of the fibres, we are directed to apply the suitable remedies. If they are relaxed, bracing and stimulating remedies are indicated; but if too tense, those of a contrary nature.[21]

Fibers here determine the life functions as well as the conditions of the body; further, they interact with the environment, the effects of which condition the state of the fiber solids. Elliot further argues that nervous disorders are improperly so called because they proceed mostly from the pathological state of the tone of the fibers.[22] The knowledge of the fibers, not the knowledge of the nerves, provides the keys to medical practice.

Among many functions that the fiber assumes in eighteenth-century medicine, we can single out a key critical function: vibration. As the following chapters show, the concept of vibration is variously called "elasticity," "tone," "tension," "contraction," "contractility," and even "sensibility" or "irritability" by the various strands of medical authors according to their theoretical positions. In the medical world of the eighteenth century, the fiber body incessantly vibrates. Christopher Nugent's essay on hydrophobia (1753) is a case in point. Without relying on the circulation paradigm that the iatromechanists embraced or an active principle such as the nervous fluid proclaimed by the iatro-vitalists, both of which Nugent thought inappropriate for an account of the progressive motion of morbid affection, Nugent explained the mechanism of hydrophobia and other contagious diseases with recourse to fiber-vibration physiology and pathology. Nugent dismissed the active agent (nervous spirits) as the agent of affection. He utilizes the example of a snake bite, noting that it would take 30–60 minutes for the viper's poison to take effect and cause spasms and convulsions; therefore, he concluded that the nervous spirits were not the immediate cause of contagion.[23] Nugent, instead, argued for a "vibrative Contagion" that gradually communicates the morbid vibratory "spasmodic Emotions" from one infected set of fibers to others, until the "spasmodic Contagion" catches from "Fibre to Fibre, and Part to Part" and finally arrives at the nobler organs to cause a deadly effect on life.[24] Thus, the time lag between the insensible stricture of the coarser solid that was bitten and the final effects upon the nobler organs could be explained by the gradual advancement of a specific type of "morbid Vibrations."[25] Hence, Nugent contends that "Vibration, Pulsation, and Oscillation" of the solid fibers are the principal motions in animal functions, and that health comes from "the natural salutary Oscillations" of the solids, whereas irregular or preternatural oscillations lead to disorders.[26] Behind Nugent's fiber-vibration theory stands the grand view of a dynamic universe of nature that never ceases to vibrate: "All Nature vibrates…and is in a constant Tenor of Pulsation through all its Parts."[27] Nugent conceived the body as fibers constituted and fibers vibrated (fibers are "always kept upon the Stretch," and "are constantly in *Exercise*").[28] In what follows, I shall show that Nugent's fiber-vibration theory exemplifies the general paradigm of the eighteenth-century fiber body at large.

This book is composed of three parts; Parts I and II examine the fiber body from the medical perspective, while Part III addresses some of the cultural dimensions of the fiber body. The first two parts constitute the main body of the argument of this book. The cultural part appears to be ancillary to the medical part; however, as the fiber body would never be born or grow without the socio-cultural contexts, at least two cultural aspects of the fiber body should be addressed: the Baroque and the culture of sensibility, both of which provide a meaningful context to the emergence (the Baroque) and the development (the culture of sensibility) of the fiber body, though the cultural implications and contexts of the fiber body are strewn throughout and mixed with the medical part.

Chapter 1 concerns the emergence of the fiber-woven body in the latter half of the seventeenth century. The idea of fiber as the fundamental building unit of the body emerged from the concerted efforts of mid-seventeenth-century natural philosophers' investigations of the microstructure of the body through the microscope. After the Cartesian renovation of the body as a hydraulic machine, many natural philosophers discerned hitherto unseen vessels through both microscopic observations and the anatomical injection technique, and their discoveries culminated in the idea of the vascularity of the body. Along this discovery, anatomists inspecting tissues through microscopes found that tissues seemed to be woven like embroidery; the body was dexterously stitched by Nature's needle into finely woven textiles. Knowledge of the body's vascularity and texture brought about a new understanding of the body as entirely woven of elementary fibers.

In *The Anatomy of Plants* (1682), Nehemiah Grew crystallized the fragmented ideas of discrete anatomists and microscopists who studied body organs into a coherent whole. By visualizing the complete fibrosity of the body and by exploiting the metaphor of textiles to describe the hidden fabric of the inner body, Grew paved the way for the emergence of fiber theory and the fiber body to which most anatomists and physiologists of the Enlightenment subscribed.

Chapter 2 attempts to deliver a comprehensive account of fiber medicine as elaborated by the iatromechanists from c. 1700 to the 1740s. With the rise of solidism at the turn of the century, solid fibers were seen to perform a pivotal function in the animal economy as the whole body was conceived of as composed of nothing but fibers. Referring to a wide range of medical fields, this chapter elucidates the ways that fiber served as an indispensable concept or framework for iatromechanists to establish their medical theories. Following in Grew's footsteps, anatomists saw the body as wholly interwoven by fiber-threads. In physiology and pathology, fiber, with its innate property of elasticity, played an indispensable role in understanding how health was maintained or disturbed. In the life sciences, fiber was deemed the most appropriate concept to explain animal growth within the preformationist framework, a dominant paradigm in Enlightenment embryology. Moreover, the concept of fiber was employed to determine individual constitutions and differences in gender and rank.

This chapter also highlights the metaphorical dimension of fiber as an integral part of fiber medicine. The notion of the solid body as interwoven by innumerable threads like intricate embroidery contributed to a cultural understanding of the delicate body, which loomed large in the culture of sensibility. In re-evaluating the concept of fiber, this chapter seeks to redress the neurocentric view of eighteenth-century medicine and attempts to locate the fiber body amid the fundamental shift from humoralism to solidism.

At the heart of the fiber body was an insensible motion of vibration. An animal machine must move everywhere; that is, the body incessantly shakes, vibrates, undulates, and pulsates for the purpose of life. Fibers embody this important function through a property variously called elasticity, tone, or tension—an innate property residing in fibers. Chapter 3 expounds upon some issues in which the concept of elasticity is involved, particularly the idea of body image and the contentious idea of motion as it emerged in iatromechanism.

The first section of Chap. 3 deals with the body image conceived by the iatromechanists and the role elasticity of the animal fibers played in that conception. Rather than simply accepting the common assumption that body image shifts from Mechanical Man to Sensible Man, from a machine to an organism, this chapter argues that iatromechanists imagined the muscular body, a body that moves just like a muscular heart. Motion is the main topic of the second section of the chapter. Focusing on the idea of involuntary motion and its cognates, tones, tensions, undulations, and vibrations, I shall trace the important shift in the view of motion from the classical to the modern via Harvey's contribution to the development of the idea of motion. Vitalists of the second half of the century viewed the elasticity of animal fiber as merely mechanical, as a property peculiar to dead matter. The final section of this chapter concerns the aftermath of elasticity from the mid-century on. Far from dead, the concept of elasticity links the seemingly divided phases of mechanism and vitalism.

Chapter 4 examines the ways that the fiber body both remained and changed in the course of the second half of the eighteenth century as medicine fell under the sway of iatro-vitalism. The period is divided into two phases according to the dominant trend of vitalism; the first phase covers roughly the 1750s through 1780, during which nervous vitalism dominated the medical world but had to cope with the enduring influence of iatromechanism. Taking as an exemplary case the medical systems of Adair and Macbride, newly fledged iatro-vitalists, the first section of the chapter shows how the new medical theory of nervous vitalism compromised with the old regime of fiber mechanism. Focusing on the physiology of tone, the first section also seeks to highlight the enduring vision of fiber. The general framework of the physiology of tone that iatromechanists envisioned in the first half of the century remained in the paradigm of vitalists' nervous physiology.

The second section of the chapter concerns the second phase of vitalism, c. 1780–1800; during those decades, the new group, which might be called the "Irritable Fiber" school, reintroduced and reinvented the notion of irritability as a kind of primeval life-principle in the context of the Hunterian vital principle. This new school distinguished itself from the nervous one in proclaiming fiber's irritability as a priority over nervous sensibility in terms of animal economy. Highlighting the impact of the laws of irritability formulated by Girtanner on the medical theorists of the last decade, the section further argues that the fiber model disintegrated itself within the "Irritable Fiber" school rather than the nervous one.

The first two Parts are followed by the interlude section on fiber psychology (Chapter 5) before entering the cultural part. Psychology, a discourse on the soul, had not yet established itself as a distinct discipline, but a wide variety of topics on the mind were fruitfully discussed in many fields of science, including medicine. Among others, how the soul, the immaterial substance, can manifest itself and exercise faculties through, by, and with the material substance, the body, the instrument of the soul was a nagging issue among natural and moral philosophers. This chapter, "Fiber Psychology," briefly outlines how the medical philosophers coped with the aporia of the mind-and-body dualism.

Chapter 6 treats an interesting case of the interrelation between medical sciences and aesthetics: the fiber body and Baroque aesthetics. The principal focus is on membranes and folds, two critical elements of the fiber body. These elements were associated with Baroque aesthetics with a critical emphasis on sartorial rhetoric—a body with folds and membranes. The first section of this chapter deals with the discovery of texture and the Baroque (micro)-anatomy of the latter half of the seventeenth century. Tracing the shifting ideas of écorché, draperies, and the texture of living organisms, this section examines the ways that the discovery of texture was the product of the Baroque sensibility. The second section of this chapter explores how the idea and power of membranes and folds embraced by the fiber theorists of the eighteenth century were predicated on and interrelated with the principal feature of Baroques aesthetics—the dynamism of folding after folding ad infinitum. Eighteenth-century fiber theorists, particularly George Cheyne, saw membranes as the great organ allowing the living machine to act, function, and move. Membranes were regarded as the proper instrument and seat for elasticity to transmit vibrations throughout the body. The Baroque aesthetics of membranes and folds is most distinct in preformation theory and the idea of encasement—all subsequent generations are encased in the first parents as "stamina," an idea identifiable with fibers, threads, or membranes, an infinite number of which are enfolded ad infinitum in minimal space. The chapter further discusses the intricate muscle structure of caterpillars anatomized by Lyonet and the theological argument for the resurrection of the same body in relation to Baroque aesthetics.

Fibers' involuntary, vibratory motion extended into a cultural phenomenon called nervous sensibility, usually associated with the nerves, the brain, and its animal economy (nervous physiology). Chapter 7 examines the common assumption that the eighteenth century was the age of the nerve in medicine and the age of sensibility in culture. This chapter provides an alternative way of thinking about eighteenth-century medico-culture: the paradigm of fiber instead of the paradigm of the brain–nerve. Pointing out the problems entailed by the brain–nerve thesis, a thesis first advocated by G.S. Rousseau, this chapter proposes that the fiber model is more applicable to eighteenth-century medico-culture than the nervous one. First, this chapter reviews fiber medicine in general, then shows the possibility of brainless-sympathy in both medical and literary discourses, and, finally, presents a body image (the body as a musical instrument) pertinent to both mechanical and vitalistic medico-culture. Tracing the origin of sensibility not to Willis's brain anatomy, as Rousseau did, but to Grew's vision of the fiber-woven body, as observed in the first chapter, this last chapter rethinks the medico-culture of sensibility in terms of fibers.

Hisao Ishizuka
Senshu University Japan
Kawasaki shi, Tama-Ku, Japan

Notes

1. See, however, Alexander Berg, "Die Lehre von der Faser als Form- und Funktionselement des Organismus," *Virchows Archiv für Pathologische Anatomie und Physiologie und für klinische Medizin* 309 (1942): 333–460, for a long overview of fiber from antiquity to the modern era. For a relatively recent, but flabby, discussion of fiber theory, see Paul Ilie, *The Age of Minerva, vol. 2: Cognitive Discontinuities in Eighteenth-Century Thought: from Body to Mind in Physiology and Arts* (Philadelphia: University of Pennsylvania Press, 1995), esp. ch. 6.
2. Kevin Siena, "Pliable Bodies: the Moral Biology of Health and Diseases," in *The Cultural History of the Human Body in the Enlightenment*, ed. Carole Reeves (Oxford: Berg, 2010). Other useful secondary works on the history of medicine and of the body during the Enlightenment are many. See, for instance, Andrew Cunningham and Roger French, eds., *The Medical Enlightenment of the Eighteenth Century* (Cambridge: Cambridge University Press, 1990); Roy Porter, ed., *Medicine in the Enlightenment* (Amsterdam: Rodopi, 1995). Lester S. King, *The Medical World of the Eighteenth Century* (Chicago: University of Chicago Press, 1958) is dated but of some use. Guenter B. Risse, "Medicine in the Age of Enlightenment," in *Medicine in Society: Historical Essays*, ed. Andrew Wear (Cambridge: Cambridge University Press, 1992) also provides a good summary of medical theories in the Enlightenment. For the historical study of mind and body, see Roy Porter, *Flesh in the Age of Reason: The Modern Foundations of Body*

and Soul (New York: Norton, 2003); G.S. Rousseau, ed., *The Language of Psyche: Mind and Body in Enlightenment Thought* (Berkeley: University of California Press, 1990).

3. The most influential proponent of the neurocentric view of Enlightenment medicine is G.S. Rousseau; see his series of essays on the nerves, "Discourse of the Nerve," in *Literature and Science as Modes of Expression,* ed. Frederick Amrine (Boston: Kluwer Academic Publisher, 1989), 29–60; idem, "Towards a Semiotics of the Nerves: The Social History of Language in a New Key," in *Language, Self and Society: A Social History of Language,* ed. Peter Burke and Roy Porter (London: Polity, 1991), 213–75; these and other essays are now conveniently collected in his *Nervous Acts: Essays on Literature, Culture and Sensibility* (Basingstoke: Palgrave, 2004). On the centrality of the nervous system in eighteenth-century medicine, especially from the 1740s onward, see among others Christopher Lawrence, "The Nervous System and Society in the Scottish Enlightenment," in *Natural Order: Historical Studies of Scientific Culture,* ed. Barry Barnes and Steven Shapin (London: Sage, 1979), 19–40.
4. See, for instance, Roy Porter, "The Eighteenth Century," in Lawrence I. Conrad et al., *The Western Medical Tradition: 800BC to AD 1800* (Cambridge: Cambridge University Press, 1995), ch. 7, 393–94.
5. R. Virchow, *Die Cellularpathologie* (1858), 52, cited in J. Walter Wilson, "Dutrochet and the Cell Theory," *Isis* 37 (1947): 17.
6. Lester S. King, *The Philosophy of Medicine: The Early Eighteenth Century* (Cambridge, Mass.: Harvard University Press, 1978), ch. 5.
7. This inveterate view was first articulated in William Le Fanu, "The Lost Half-Century in English Medicine, 1700–1750," *Bulletin of the History of Medicine* 46 (1972): 319–48. See also Cunningham and French, eds., "Introduction."
8. See Theodore M. Brown, "From Mechanism to Vitalism in Eighteenth-Century English Physiology," *Journal of the History of Biology* 7 (1974): 179–216.
9. On Diderot and Bonnet, see Tobias Cheung, "Omnis Fibra Ex Fibra: Fibre Oeconomies in Bonnet's and Diderot's Models of Organic Order," *Early Science and Medicine* 15 (2010): 66–104. Emanuel Swedenborg, *The Economy of the Animal Kingdom Considered Anatomically, Physically, and Philosophically. Transaction*

III (The Fibre) (Philadelphia: Swedenborg Scientific Association, 1918); Tiphaigne de la Roche, *Giphantia* (London, 1761).

10. OED, s.v. "fibre."
11. See Edwin Clarke, "The Doctrine of the Hollow Nerve in the Seventeenth and Eighteenth Centuries," in *Medicine, Science and Culture: Historical Essays in Honour of Owsei Temkin*, ed. Lloyd G. Stevenson and Robert P. Multhauf (Baltimore: Johns Hopkins University Press, 1968), 123.
12. Thomas Blount, *Glossographia: or a Dictionary*, 2nd ed. (London, 1759), s.v. "fibre."
13. Helkiah Crooke, *Microcosmographia, A Description of the Body of Man* (London, 1615), 825, cited in Gail Kern Paster, "Nervous Tension: Networks of Blood and Spirit in the Early Modern Body," in *The Body in Parts: Fantasies of Corporeality in Early Modern Europe*, ed. David Hillman and Carla Mazzio (London: Routledge, 1997), 112. See also Robert Burton, *The Anatomy of Melancholy*, ed. Floyd Dell and Paul Jordan-Smith (New York: Tudor Publishing, 1938); Burton equated nerves with sinews ("*Nerves*, or sinews," [130]). The nerves as sinews, however, were still current in eighteenth-century poetry; N. Bailey's *Etymological Dictionary* (London, 1764) and Johnson's *Dictionary* listed the usage with a citation of Pope.
14. On the idea of stamina and the fiber discourse in the afterlife, see the argument of ch. 6.
15. Nicholas Robinson, *A New System of the Spleen, Vapours, and Hypochondriack Melancholy* (London, 1729).
16. Ibid., 15–16.
17. Ibid., 17–21.
18. Ibid., 22 (on nationality), 35 (on the idiot and genius), 57 (on wit and genius), 65 (on stupidity), 95–96 (on the sense of feeling), 137, 141–42 (on the sense of hearing), 146–47 (on taste), 148 (on sexual sensibility), 152–53 (on lust).
19. Ibid., 159.
20. Anon, *A Letter to George Cheyne* (London, 1724), 57. The said fiber's rational faculty reminds us of Glisson's materialistic and atheistic notion of irritability; however, fiber theorists of the eighteenth century were shrewd enough not to make such dangerous implications.

21. J[ohn] Elliot, *Elements of the Branches of Natural Philosophy Connected with Medicine*, 2nd ed. (London, 1786), 220; see also idem, *Philosophical Observations on the Senses of Vision and Hearing* (London, 1780), 190–91.
22. Ibid., 222, 224–25.
23. Christopher Nugent, *An Essay on the Hydrophobia* (London, 1753), 130–34.
24. Ibid., 154, 159, 162, 138–40.
25. Ibid., 154.
26. Ibid., 42, 45–46.
27. Ibid., 42.
28. Ibid., 44–45.

PART I

Prelude to the Fiber Body in the Latter Half of the Seventeenth Century, c.1650–1700

CHAPTER 1

Visualizing the Fiber-Woven Body: Emergence of the Fiber Body

This chapter deals with the emergence of fiber theory in the latter half of the seventeenth century. Although medical writers did not fully establish fiber theory until the early eighteenth century, anatomists, physiologists, natural philosophers, and microscopists of the late seventeenth century made significant contributions to the formation of fiber theory and the idea of the fiber body. Nehemiah Grew (1641–1721), a plant anatomist, made one such crucial contribution to the emergence of the idea of the fiber body by most explicitly articulating the two constituent features of fiber theory: the idea of the fiber as the minimum constituent of the body and the idea that the whole body is variously interwoven of nothing but these fibers.

Focusing on Grew's anatomical works, this chapter illuminates the significance of the new understanding of the body as fiber-woven textiles fully visualized in his plant anatomy. Grew combined fragmented ideas from anatomists and microscopists who studied the organs of the body into a coherent whole. By visualizing the complete fibrosity of the body and by exploiting the metaphor of textiles in describing the hidden fabric of body's interiority, Grew paved the way for the emergence of fiber theory and the fiber body, to which most anatomists and physiologists of the Enlightenment subscribed. This chapter also attempts to show that Grew's image of the fiber body as something that is interwoven and interconnected by and through fibers provided an antidote to the weakening of the societal bonds of late seventeenth-century England.

H. Ishizuka, *Fiber, Medicine, and Culture in the British Enlightenment*, DOI 10.1057/978-1-349-93268-9_1

In the following section, I shall first treat the rise of the notion of fiber as the basic building unit of the body, touching on the microscopic observation of the micro-structure of the various materials that have a crucial impact on the view of the body as wholly composed of vessels; then I elucidate on the discovery of "texture," exploring the new perception of the body as woven textiles, which culminates in Grew's vision of plant anatomy, the theme of the second section. The final section addresses the socio-cultural background from which fiber theory emerged.

1 Prelude to the Fiber-Woven Body

1.1 From Minima to Fiber

What is the minimum building unit of the body? What uniform element composes this visible, tangible world of matter and especially this living body? Although the modern concept of tissue appeared with Bichat in the early years of the nineteenth century, a similar concept was already present in the minds of the ancient philosophers, from Empedocles to Aristotle.[1] Aristotle's conception of the "similar parts" and the "dissimilar parts" is perhaps most closely related to the modern idea of tissue[2]; according to Aristotle, the similar parts are the parts that may be divided several times while still retaining the same nature, while the dissimilar parts are composed of various similar parts. This division of the body was favored by anatomists and survived well into the seventeenth century.[3] The traditional anatomists did not seem to hold a strong motive that made them explain the composition of the body starting with the minimum unit of the body.

There was another Aristotelian doctrine both important and useful for understanding the basic constituent of the body—*minima naturalia*, the smallest particles fixed by nature.[4] In Aristotle's account, the minima was inseparable from the theory of substantial form. It was supposed to be the temporary state of matter, the vehicle of "form"; once mixed, they lost their separate entities and merged into a homogeneous compound.[5] Thus, Aristotle's minima differed from the concept of atomic particles of Democritus, which held them to be indivisible, unchangeable, indestructible entities endowed with tangible qualities, thus serving as the ultimate building block of all matter.[6] And yet, the concept of *minima naturalia* underwent a significant change in the hands of subsequent medieval commentators on Aristotle's texts, who conflated minima particles with the particles of the flesh described by Aristotle in the biological context. Accordingly, the minima came to signify the smallest biological structural unit.[7] Furthermore, during the Middle Ages, the minima began to acquire a more direct physical meaning. While still distinguishable from atomistic particles, minima were thought to be closer to them; Julius Scaliger (1484–1558), for example, thought of minima as the first building blocks of a whole.[8]

When the corpuscularian philosophy gained momentum in the seventeenth century, the scholastic *minima naturalia* was increasingly replaced by, or conflated with, the minima of atomistic particles endowed with three-dimensional physical qualities. The seventeenth-century revival of atomism, however, safely purged it of any atheistic implications associated with the system of Democritus.[9] As Boyle pronounced, *minima naturalia* "must have [their] determinate *bigness* or *size*, and [their] own *shape*."[10] For corpuscularian and mechanical philosophers, the shape of the atom or particle is often crucial in explaining the sensible qualities, as fire atoms produce the sensation of heat through their pointedness.[11] It is no wonder, then, that corpuscularian philosophers had great expectations of the newly introduced instrument, the microscope; with its help, they hoped to discern the particular sizes and shapes of the minute particles, so far only hypothetical entities. Their expectation was not realized, but the application of the microscope to the living body led some anatomists to search for a still smaller unit of the body, which was equivalent to the physicist's atom, and to recast the scholastic minima (already conflated with the biological unit) into the constituent uniform unit of the living body. The hypothetical entities designating minima, such as Leeuwenhoek's globule, Malpighi's gland, and Grew's fiber, all emerged in this context.[12]

In a rather short span of time toward the end of the seventeenth century, however, the fiber rather than the other two candidates gained its place as the possible theoretical limit of the living body. One reason involves accepting that the figure of the fiber rather than that of the atom is apt for the minima of the body. The anatomists observed through the microscope the living body's new micro-worlds as something resembling fibers and depicted these strange landscapes employing the fiber trope, as I shall show in this chapter. For instance, the texture of the skin, examined under the microscope by Hooke, appeared to consist of "a great many small filaments, which are implicated, or intangled one within another, almost no otherwise then the hairs in a lock of Wool…; but the filaments are here and there twisted…or interwoven, and here and there they join and unite with one another, so as indeed the whole skin seems to be but one piece."[13] Even Leeuwenhoek, who had initially thought the globule to be the fundamental unit of the matter, was overwhelmed by evidence of an abundance of longitudinal rather than spherical elements; the worlds made up by the fiber, the filament, the thread, and the pipe eclipsed those made up of the globule: "those Membranes [of the carneous fibers of muscles] are made up of so many filaments or threds…. Observing these Membranes more narrowly, I saw, that they do wholly and only consist of small threds running through one another; of which some, to my eye, appear'd to be 10, 20, and sometime 50 times thinner than a hair."[14] Persuaded by these observations, Leeuwenhoek finally dropped his own theory of globules in 1682, though he first doubted it as early as 1677.[15] Having found that the globules composing the muscular strings were not globules but "Rimples," Leeuwenhoek imagined that there must be still smaller elements which could be further resolved into much smaller units:

> If every Muscle be composed of so many thousands of Muscular chords, each inclosed with its particular membrane, and every Muscular chord be made up again of so great a number of Muscular strings, and every Muscular string be yet further composed of such number of filaments, perhaps 200, why may not each of these filaments themselves be yet a Muscle and contain or be made up of a lower or smaller degree yet of filaments, and each of them be inclosed with a membrane, since we yet find that our furthest discoveries come short of seeing the utmost curiosity of Nature.[16]

This process seems endless: "who knows but that still there may be another inferior order of filaments, and the every one of these two and thirty hundred filaments contained in one single Muscular string, may be yet father composed of great number of less filaments?"[17] The Chinese-box-like structure of the filaments within a filament reminds us of the traditional notion of the similar part, which is likewise divided into the same substance (theoretically this process is endless). The ultimate (the smallest) element would not be discernible even by the most powerful microscope, but it could be analogically inferred from the Chinese-box-like structure of the filament (the fiber): it must have the same figure as before.

1.2 *The Body as Vessels*

Another reason the fiber was singled out among other candidates concerns the new perception of the body as wholly composed of vessels. Around the same period when the microscopists were avidly scrutinizing the finer texture of substances, anatomists began to discover hitherto unseen vessels in the inner space of the body through combination of the new technique of anatomical injections with microscopic inspections.[18] Harvey's discovery of the circulation of blood and the Cartesian renovation of the body as a hydraulic machine constituted the background for the development of the injection technique. Christopher Wren suggested in 1665 that the injection technique might be serviceable for discovery of the new vessels.[19] Wren's anticipation was soon fulfilled by Frederik Ruysch (1638–1731), the professor of anatomy at Amsterdam whose superb technique of injections came to be known as the "Ruyschian art."[20] Ruysch's method enabled him to discover and clearly show the unexpected vessels in almost all living tissues, from bones to ligaments to tendons to membranes.[21] Ruysch became the most influential proponent of the vascularity of the body, the idea of which had already circulated among the Dutch medical circle.[22]

The vascularity of the body was also demonstrated by another instrument, the microscope. Malpighi had discovered the capillary blood vessels in the lungs as early as 1661, and their marvelous distribution and appearance throughout the whole body were much more closely examined by Leeuwenhoek over many years.[23] Following the discovery, many anatomists began to examine the ever-finer texture of various organs such as the liver (by Glisson), the heart (by Lower), the glands (by Wharton and Malpighi), the kidney, the lungs, the tongue (by Malpighi), the brain (by Willis), and the genital organs (by de Graaf), the results of which were incorporated in the magnificent atlas of *Anatomia humani corporis* (1685) by Bidloo.[24] As the Cartesian hydraulic machine provided the most persuasive model for understanding bodily function,[25] the physiology of secretion was key to unearthing the mysterious process of life. The complicated sieve-like structure of the organs (especially of the glands), as Malpighi imagined, might be responsible for the selective process (i.e., to select the specific fluid from the circulating fluid, mainly the blood), but more probably the vascular configurations and distributions peculiar to the organ were assumed to account for the process of secretion.[26] Ruysch convincingly demonstrated that there were not two vascular systems distributed alike through the body.[27] As a result of Ruysch's injection experiments, the functions of the tissues were all ascribed to the infinite variety of disposition and peculiarities of their vascular supply.[28] The increasingly refined vascular physiology and the hidden vascularity of the body successively discovered using anatomical techniques served to establish the new perception that the body was wholly composed of vessels.

The parenchyma provides an illustrative case for the formation of the complete vascularity of the body. The traditional anatomists assumed the parenchyma as "the Entrails."[29] More specifically, the parenchymous parts were believed to designate those fleshy parts of the body consisting of "a mass or coagulum of blood," filling up the voids between the vessels; therefore, they were supposed to be devoid of vessels.[30] In the early 1660s, however, Edmund King, an expert anatomist in England, overturned this assumption. Convinced by his own experiments that most parenchymous parts were made up of vessels, which were "curiously wrought and interwoven (probably for more Uses, than is yet known),"[31] King made several experiments of the same kind on the various glands, including the testicle. These experiments led him to confirm his new idea that the parenchyma was nothing else but a "Congeries of Vessels and Liquors without any intermediate substance."[32] It happened that two anatomists on the Continent reached the same conclusion regarding the parenchyma in the 1660s: Steno on the muscles and Malpighi on the lungs and the kidney respectively laid bare the true nature of the parenchyma.[33] The corollary of this discovery was rather simple: if the parts hitherto believed to be non-vascular ("Interstices between the Vessels")[34] turned out to be nothing but a congeries of vessels, then the whole body could be construed as composed of the masses of vessels. Consequently, almost all the entrails (i.e., the heart, the lungs, the spleen, the liver, etc.) were found to consist of various vessels, and in many cases, they looked fibrous.

From this context, it could be argued that the figure of the fiber was evoked as the minima of the solid body in tandem with the renewed interest in the body as wholly composed of vessels. Strictly speaking, the fiber differs from the vessels, but the terminology employed by anatomists was far from precise, especially in the field of microscopic anatomy, because anatomists relied on everyday language (such as ropes, strings, filaments, threads, pipes, bushes, and forests) to describe the newly discovered micro-worlds. Leeuwenhoek, in describing the structure of a hair, for instance, did not hesitate to employ several technical terms interchangeably, as he says the whole hair consisted of little strings, or fibers, or pipes, or vessels.[35] The interchangeability and malleability of the word "fiber" combined with the understanding of the vessel[36] served to conflate the closely interrelated views—one that sees the body as wholly made up of vessels and one that sees the body as made up of the innumerable fibers.

1.3 The Body as Textiles

As seen above, the scholastic minima were gradually reinterpreted as the atomistic building block endowed with definite, tangible qualities. The primary properties of atomistic matter—bulk, figure, and motion or rest—were, however, not sufficient to explain the world. Boyle frequently referred to the notion of "texture" (the internal disposition or configuration of the matter) as a determining feature to produce sensible qualities and other natural phenomena. Boyle ascribed the different effects of the same heat on two eggs—the one prolific, the other barren—to the different arrangements of their textures.[37] Texture even explained supernatural phenomena such as the resurrection of the body.[38] If a slight mechanical alteration of the texture of a body changes its sensible qualities, argues Boyle, God can work by "changing the texture of a portion of matter" in transforming the vile body into the glorious one.[39] The corpuscularian philosophers reintroduced the theory of form through the backdoor, by inventing the notion of texture, which would explain the otherwise unintelligible phenomena, especially those of the biological domain.[40]

Around the same period when the corpuscularian philosophers reinterpreted the scholastic theory of form in terms of texture, the microscopists amply observed the finely woven texture of micro-worlds.

The success and popularity of Hooke's *Micrographia* (1665) undoubtedly lie in its outstanding details of the subtle texture of matters (both in verbal and pictorial—but the visual representations are more striking). As the newly emerged world revealed by the microscope was entirely new and unexpected, the microscopist had to borrow from the common language terminology or metaphors to make sense of the otherwise unintelligible micro-world.[41] A set of metaphors from the textile and weaving industries was an apt choice, for the substance (especially the living body) was, in closer analysis, seen to be woven like embroidery or a garment. As a result, descriptions of the microscopic world are fraught with "textile" words peculiar to woven fabric, such as "text(ure)," "context(ure)," "intertext(ure)," "cloth," "wool," "lace," "warp and woof," "knitting," "spinning," "weaving," "interweaving," "thread," "filament," and, of course, "fiber." Hooke, for instance, having examined several kinds of mushroom, compared their texture to "a kind of cloth":

> Having examin'd also several kinds of Mushroom, I find their texture to be somewhat of this kind, that is, to consist of an infinite company of small filaments, every way contex'd and woven together, so as to make a kind of cloth.[42]

The sponge (a kind of zoophyte) was seen to consist of an infinite number of the small fibers, "curiously jointed or contex'd together in the form of Net."[43] The cloth metaphor was even more explicitly employed in describing the surfaces of rosemary: "There are multitudes of leaves, whose surfaces are like this smooth, and as it were quilted, which look like a curious quilted bag of green Silk." And he went to conclude that "Nature in this [is], as it were, expressing her Needle-work, or imbroidery."[44]

It is no wonder, then, that anatomist contemporaries of Hooke also appropriated the world of textiles for the complicated but marvelously contrived micro-structure of the living body. Edmund King found that the parenchymous parts turned to consist wholly of vessels "curiously wrought and interwoven," and compared them to "a piece of fine Cloth (which consist of so many several minute Hairs, call'd *Wool*)."[45] Glisson, another anatomist of the era, also found the textile metaphor useful for his description of the texture of the skin: "[Proper fibers] being much of the condition of thread, are as it were woven into a kind of cloth… [and] they better resemble that texture of wool which is seen in felts."[46]

The visual representations sometimes even more effectively exhibit the anatomists' perception of the textile body. Edmund King's figure of the "Embroidery of Veins and Arteries" gives clearer evidence of how he perceived the texture of the testicles in terms of textile embroidery. Displaced onto the two-dimensional space, the texture surprisingly resembles a piece of textile.[47] Another example can be seen in Willis's scheme of the nervous system of the neck, which is like a transparent piece of textile. Other examples from anatomical illustrations amply show the textile image of the body. These include *Bibliotheca Anatomica*, a valuable collection mainly selected from later seventeenth-century anatomical writings in Europe, ranging from Bartholin, Glisson, Lower, Malpighi, Willis, Diemerbroeck, and Bidloo to Ruysch[48] (Fig. 1.1). An appendix attached to the first volume of James Drake's *Anthropologia Nova* is, in its scale, a more compre-

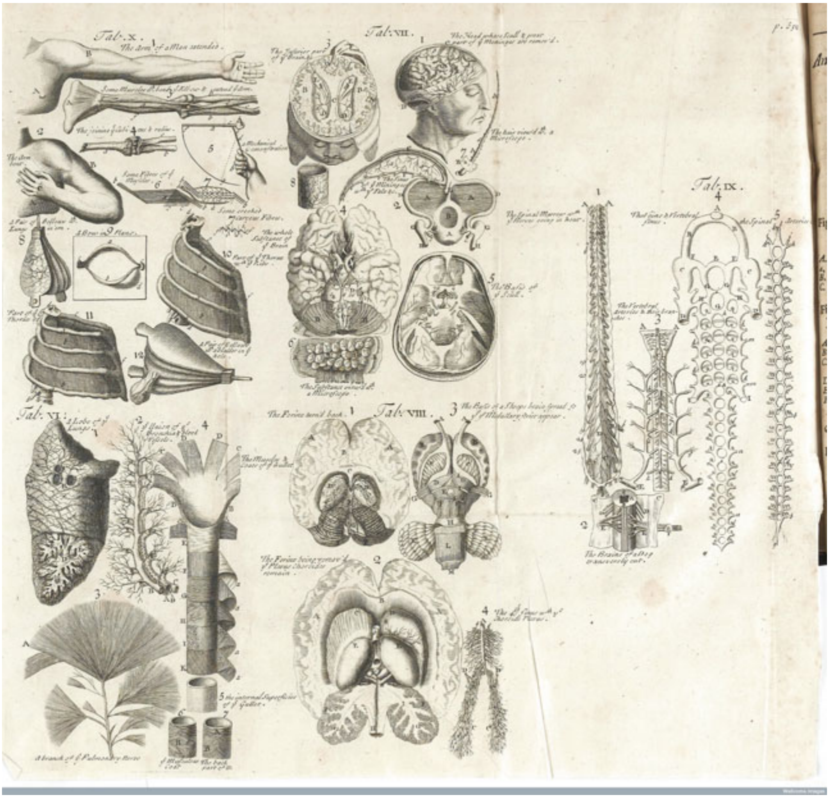

Fig. 1.1 Internal parts of the body, from *Bibliotheca Anatomica* (1711–1714); Wellcome Trust Image Collection

hensive collection of the anatomical illustrations, drawing on the same sources as in *Bibliotheca Anatomica*.[49] Thomas Willis's gorgeous plates for *Pharmaceutice Rationalis* are more compelling in the size, detail, and vividness of the images of the specimen. At times, the anatomical specimens are displayed in the form of a piece of cloth, which indicates that the micro-texture of the membranes is closely related to the textile fabrics.[50] The textile-like patterns embedded in these anatomical tables are clearly shown in some of these figures as if they were an anatomical pattern book of the human body.[51] What these anatomical illustrations lay bare is that the animal/human body is dexterously stitched by Nature's needles into finely woven textiles. Going deeper into the hidden recess of the invisible space of the living body, strangely the anatomists found themselves beholding the external coverings (the woven clothes) in which the living body is ordinarily enclosed.

2 Grew's Plant Anatomy and the Fiber Body

2.1 Grew and the Fiber

When Nehemiah Grew compiled his 1670s work into the *Anatomy of Plants* (1682), the metaphor of embroidery, textiles, and weaving, on which he heavily relied in depicting the anatomical structure and texture of plants, was already familiar to anatomists. And yet, it was Grew who gave a decisive step to the notion of fiber theory and the fiber body by presenting a lucid and comprehensible understanding that the whole living body was variously knit and interwoven by an infinite number of fibers, which were thought to be the minima.

In the *Anatomy of Plants,* Grew clearly distinguished the two types of tissue (or structural unit)—the parenchymous and the ligneous ("the *Pithy Part* and the *Lignous Part*"[52]). All the parts of the plant are composed of these basic tissues; but more fundamentally, the two types of tissues are distinguished by, and therefore built up by, two basic elements: the more or less spherical units called bladders and the elongated vessels. And yet, more importantly, both basic elements consist of "Fibres." He concludes the discourse with an illustration of the texture of the pith and by extension of the whole plant:

> [A]s the *Vessels* of a *Plant*, *sc*. the *Aer-Vessels* and the *Lymphaducts* are made up of *Fibres*; according to what I have in their discourse above said; so the *Pith* of a *Plant*, or the *Bladders* whereof the *Pith* consists are likewise made up of *Fibres*. Which is true also of the *Parenchyma* of the *Barque*. And also of the *Insertions* in the *Wood*. Yea, and of the Fruit, and all other *Parenchymous Parts* of a *Plant*. […] Whence it follows, that the whole *substance*, or all the Parts of a *Plant*, so far as *Organical*, they also consist of *Fibres*.[53]

Thus, Grew established the fiber as the minimum unit of the plant structure. In his last work, *Cosmologia Sacra* (1701), a religious and philosophical treatise, Grew rendered in a more lucid expression that the whole plant was composed of "two Species of Fibres," and argued that "all the

Parts, from the Root to the Seed, are distinguished one from another, only by the different Position, Proportion, and other Relations and Properties, of those two sorts of Fibres."[54] Although these fibers were ultimately invisible, therefore, hypothetical, he alleged that even those parts that were neither formed into "visible *Tubes*, nor into *Bladders*" were "yet made up of Fibres."[55]

Searching for the invisible texture of the plant's fabric, Grew employed the metaphor of the textile and weaving more amply than any other anatomist. For example, he described the roots "as a piece of Cloath," and the parenchyma of the skin "as a Glove is to the Hand."[56] They are only the tip of the iceberg.[57] The notable example among others is the one about the texture of the pith, whose "Contexture" is totally "*Fibrous*." Here Grew made an explicit analogy between Nature's work and "*Needle work*":

> [T]he *Vessels* running by the length of the *Root*, as the *Warp*; by the *Parenchymous Fibres* running cross or horizontally, as the *Woof*: they are thus *knit* and as it were *stitched* up together. Yet their *westage* seemth not to be simple, as in *Cloath*; but that many of the *Parenchymous Fibres* are *wrapped* round about each *Vessel*; and, in the same manner, are continued from one *Vessel* to another; thereby knitting them altogether, more closely, into one *Tubulary Thred*; and those *Threds*, again, into one *Brace*: much after the manner of the *Needle work* called *Back-Stitch* or that used in Quilting of Balls.[58] (Fig. 1.2)

Grew's text, as it were, is stitched and closely embroidered by the cluster of textile metaphors. And, indeed, Grew was highly conscious of employing the textile trope. When Grew compared the whole body of a plant to a piece of "*fine Bone-lace*" in explaining the "true *Texture* of a *Plant*," he explicitly referred to women working on a cushion, because both the texture of a plant and "*Cloth-Work*" are contrived in the same way.[59]

Just as Hooke's *Micrographia* was praised for the minutely detailed visualization, so did Grew's work owe its success to the gorgeous pictorial representations of a plant's structure. The illustrations amply demonstrate the fibrosity of the inner and outer structures of plants as wonderfully woven fabrics. Both in the verbal description and in the pictorial representation, he succeeded in visualizing the inner structure of plants as a textile fabric.

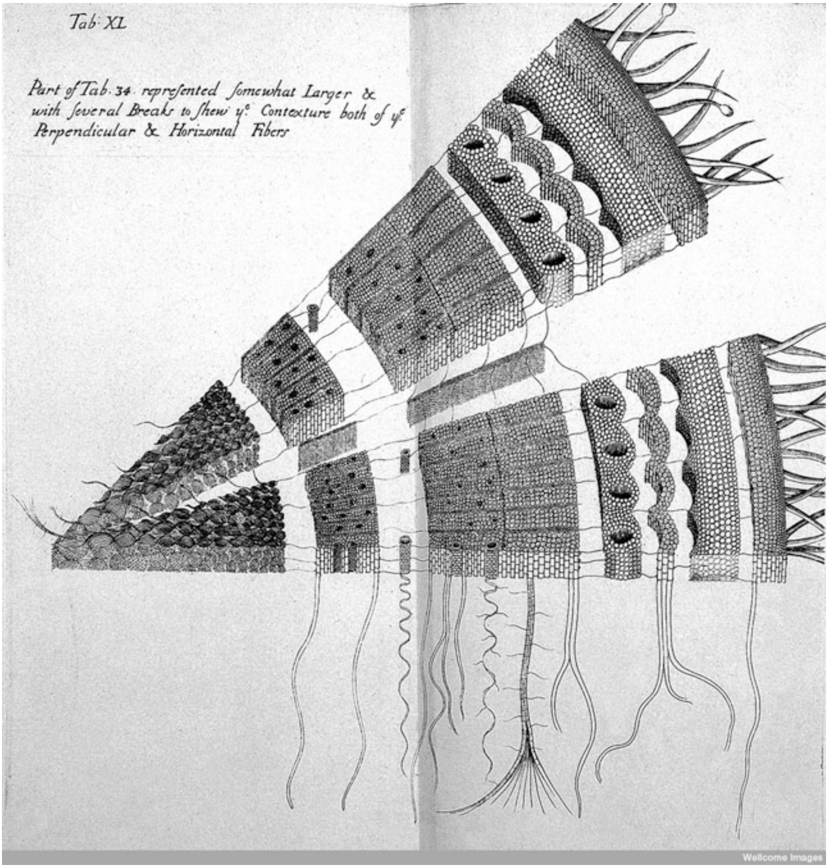

Fig. 1.2 "Contexture of Perpendicular and Horizontal Fibers," from Nehemiah Grew, *The Anatomy of Plants* (1682), table 40; Wellcome Trust Image Collection

2.2 Plants and Animals: Comparative Method

The idea of the fiber-woven body seems to be restricted to the vegetative world, and not to be applied to the animal one, whose complex structures make difficult an easy adaptation. So, how can Grew extend the fiber body to the animal kingdom? The key lies in the analogy and comparison of the plant with the animal. Indeed, Grew had studied animal anatomy before he engaged in plant anatomy,[60] and one of his aims in his study of plant anatomy was to demonstrate that plants had similar organic structures to those of animals, and by extension that plants were contrived in the same manner as animals ("*a* Plant *is, as it were, an* Animal *in Quires; as an* Animal *is a* Plant*, or rather several* Plants *bound up into one* Volume"[61]). The rationale for the analogical thinking was the principle of uniformity of nature, that is, nature has a uniform plan to contrive natural creatures. This view seems to have been shared widely among anatomists and microscopists at that time.[62] The marvelous micro-structure of the tiny insects seen through the microscope (they had a whole set of the same organs as those of other animals) may have promoted this view.

The analogical relation between plants and animals was always present in his mind.[63] For example, Grew's distinction of the two types of tissues in plant anatomy was based on a traditional classification of the body in animal/human anatomy (e.g., the division of the body into the spermatic parts and the fleshy parts, or into the vascular parts and the parenchymous parts). Moreover, the correlation of the vessels between plants and animals appeared to be obvious, for "as the *Sanguineous Vessels* in an *Animal* are composed of a number of *Fibres*, set round, in a *Tubulary Figure*, together: so are these *Lymphaducts* or a *Plant*."[64] The apparent lack of some organs in plants correlative to those of animals did not mean that plants were inferior to animals; even though plants were, in some cases, not endowed with organs identical to those of animals, plants were, instead, supplied with organs analogical to those of animals. Grew explained away the apparent lack of viscera in plants with recourse to the comparative method: "what the *Viscera* are in *Animals*, the *Vessels* themselves are in *Plants*. That is to say, as the *Viscera* of an *Animal*, are but *Vessels* conglomerated: so the *Vessels* of a *Plant*, are *Viscera* drawn out at length."[65] Finding a great agreement between the animal and the plant, Grew implied that the body of animals was also composed of fibers, and argued that the fibers composing the body of an animal were "of two general Kinds" as in the plant.[66]

Around the time when Grew's last writing was published, the idea of the fiber body had just entered into the realm of human anatomy, to which Grew's analysis of plant anatomy had a great contribution. Therefore, we should revise the Whiggish interpretation of Grew that the analogies and metaphors he employed "misled" him to concentrate on cell walls (the woven fabrics), not on their content, as Bolam argues—the view that mistakenly puts him in the place of the unfortunate precursor of the discovery of cell.[67] On the contrary, the textile and weaving metaphor and the analogy between plants and animals—Grew's analytical tools for plant anatomy—would rather make Grew's account more plausible and cogent for the late seventeenth-century anatomists, who, in another realm, discovered the complete vascularity of the animal/human body whose organs were spun with finely woven textiles. To put it differently, Grew's view of the complete fibrosity of the plant's body would serve to consolidate into a coherent whole the otherwise fragmented and isolated vision of anatomists of the discrete organs of the animal/human body.[68]

3 Fibers and Society

3.1 Atheism and Natural Theology

There is no doubt, as many historians have argued, that especially in later seventeenth-century England, there was a vivid apprehension and deep fear of phenomena that people called "atheism"; however, these phenomena were extremely shadowy, despite the exaggerated rhetoric used by accusers. The Puritan Revolution left a deep psychological scar on the minds of those who shared a widespread revulsion against political radicalism and religious "enthusiasm."[69] Hobbes's materialism and Epicurus's atomism were perhaps the main strands of the heterodoxy of the time (the later seventeenth century added to them Spinoza's pantheism).[70] New science, with its association with atomistic philosophy (a chance-driven world of the fortuitous concourse of atoms), was always in danger of acquiring the label of heresy, although Restoration atomism was considered by its defenders to have been baptized along the line set by Gassendi and Charleton (God had endowed matter with an internal principle of motion at Creation).[71] Many mechanists took up Gassendi and Charlton's stratagem of rehabilitation of atheistic atomism. Corpuscularian mechanism could easily raise the specter of a materialist view of the world totally devoid of intelligent beings.[72] Many supposed that God's direct intervention was not necessary; therefore, it often was regarded as atheism.[73]

Natural philosophers defended against charges of atheism in the form of natural theology (or physico-theology)—the argument from design, an attempt to prove the existence of God by pointing to the complexity and beauty of the natural world. The newly invented microscope provided powerful evidence that proved the incredible beauty and regularity of the natural world and the purposefulness of God's design in nature. Microscopic research into living nature and anatomical observations of the body of living creatures were essential to demonstrate divine providence and an end in nature, to purge any implication of atheism from their philosophy. Natural philosophers thought that as a divine architect God must have a design, which was made visible in His products of living nature thanks to the modern engine, the microscope.

In this context, what the above-discussed microscopists-cum-anatomists discovered was not only the fiber or the texture of the body but also God's unmistakable intelligence and existence in nature, which were embedded in the wonderfully woven fabrics of the body. The fiber body enabled precisely that which atomistic matter theory attempted but could not accomplish: namely, to purge as completely as possible the atheistic innuendo of their philosophies. This is one reason why the atomistic particle was not adopted as the minimum or the theoretical limit of the living body, even though many anatomists considered that the fiber was formed of atoms (earth particles) cohered with a glue-like substance. The fiber of living beings, rather than the atomistic particle of matter, was an appropriate choice for many apologetics.

3.2 Biding and Re-Weaving Social Body

The shift from atom to fiber, placed in a broad social perspective, also reflected a change from the chaotic social and political order of the Civil War period to the relatively stable social regimen of the Restoration. The familiar parallel between the physical body and the social body could be easily evoked in these periods—the potentially fortuitous atom and the chaotic social order in which the "individual" atom (the Greek word "atomos" means "undividable") purposelessly moves and "dances" around.[74] As Stephen Clucas argues, the radical instability of matter (atom) with its potential for disintegration and consolidation, which would unconsciously raise the deep-seated anxiety of social and moral disorder, was the focal theme in seventeenth-century discourses on atomism.[75] It is a short step from a Demo-critic to a demo-cratic view of atomism, as John Evelyn's lines show: "No Monarch rules the Universe. / But chance and Atomes make this All / In order Democraticall / Without design, or Fate, or, Force."[76] Seen in this context, Grew's vision of the fiber body is considered to emerge as a social antidote to the apparent weakening of societal bonds, which atomistic philosophies could not remedy (on the contrary, the atomistic mechanism seemed to escalate the debilities of the social body). It could be argued that the formation of the fiber body at that period was interrelated with a broad social and cultural concern for restoring and re-constituting the social order, and with the pressing need of re-binding and re-weaving the relation of the individual to the society as a whole. This would probably explain the fact that the fiber body in its most explicit form was first articulated by Grew, whose country witnessed unprecedented turmoil throughout the seventeenth century.

4 Coda: The Rise of Solidism

It requires a radical step within medical theory to recognize the significance of the fibers as not only the component of the vessel but also the essential agent to the solids as a whole; this step is a move from the traditional medical theory of humors to that of what later historians would call solidism.[77] The Galenic humoral physiology and pathology had long taken a firm grip of medical practitioners and theorists alike; it was only in the course of the eighteenth century that the Galenic picture was gradually replaced by the modern one. Though this is not the place for a detailed tracing of the change, the rise and development of fiber theory were inseparable from the gradual shift of medical doctrine from humoralism to solidism. The fact that Hoffmann and Baglivi, whom later historians usually characterized as the founders of solidism, put a great emphasis on the role of the fiber in their medical theories testifies to this connection.[78] Working slightly earlier than these two founders of solidism, Isbrand de Diemerbroeck (1609–1674), a professor of medicine and anatomy at Utrecht University, consciously tried to alter the significance attached to solids, by dislodging the humors' all-sweeping importance. In a section treating the division and parts of the body, de Diemerbroeck, denying the traditional threefold division of the body into "*things containing, things contained, and things that move or have in themselves the power of motion*" (in Hippocrates), or into "*Solid part, Humours, and Spirits*" (in Galen), boldly asserted that only the solid parts (or the containing parts) were the true parts of the body.[79] Although the solids parts need to be nourished by the humors (so the solid parts were also traditionally called the "nourished parts" in contrast to the "nourishing parts" of the humors),[80] the humors cannot be called a part of the body, because, by definition, the part must be joined to the whole in continuity not in contiguity, as "Wine contained in a vessel cannot be called a part of vessel…because there is no continuity between them."[81] The humors cannot be parts, he continues, until they, by concoction, are changed into the substance of the parts of the body, for "a bone is not blood, and blood is not a bone."[82] Therefore, even though people cannot live without the humors, they are not necessarily the parts of the body.[83] Moreover, and this is crucial to the formation of solidism, it is from the solids that actions immediately proceed; actions, as commonly believed, do not come from the humors or spirits, which were sometimes technically called the "impetuous substances."[84] For the humors and spirits are bred and moved by the solids, such as the heart and the brain, not the other way round. It is the action of the solids on the fluids that makes the latter integrated into the organism of the body:

> So the Heart and other solid Parts are not moved by the humours and spirits, but act upon the humours and spirits, they move, attenuate and concoct them till at length they turn their apt particles into a substance like themselves, and so apply and unite them to themselves, and make them parts of the body, which they were not before they were applied and assimilated.[85]

In de Diemerbroeck's system, the solids almost take over the privileged role of the spirits, which he manages to relegate to the "medium" of the soul. Traditionally, the spirits were regarded as the "instrument" of the soul, as Crooke indicates: "By spirits we understand the primary and immediate instrument of the soule, which the Stoicks calleth the Band which tyeth the soule and the body."[86] By contrast, de Diemerbroeck tries to neutralize the meaning of the "instrument" into a rather prosaic notion of "medium": "the Spirit is no more an Instrument that moves the Body, than the Air is the Instrument that moves the Sight or Hearing. So neither are the spirits the Instrument of the soul, but only the necessary *Medium*, by which the active Soul move the instrumental Body."[87] Thus, by dethroning spirits from their privileged seat, de Diemerbroeck opens up the new possibility for solids, a possibility which fiber theorists of the subsequent generations soon capitalized on. The chapters that follow explore the ways that these fiber theorists struggle to depart from the traditional doctrine of humoralism to create a new body of knowledge on solids.

Notes

1. Friedrich Solmsen, "Tissues and the Soul: Philosophical Contributions to Physiology," *Philosophical Review* 59 (1950): 435–68.

2. For this division, see, for instance, J.B. Bambrough, *The Little World of Man* (London: Longman, 1952), 53; Samuel Collins, *A System of Anatomy* (London, 1685), 3; R.K. French, *Anatomical Education in a Scottish University, 1620. An Annotated Translation of the Lecture Notes of John Moir* (Aberdeen: Equipress, 1975), 1; French's note to Moir, 73–74, note 10.
3. See, for instance, Thomas Gibson, *The Anatomy of Human Bodies Epitomized*, 6th ed. (London, 1703), ii; Francis Glisson, *English Manuscripts of Francis Glisson (1) From* Anatomia Hepatis (The Anatomy of the Liver), ed. Andrew Cunningham (Cambridge: Wellcome Unit for the History of Medicine, 1993), ch. 2 and passim.
4. Andrew G. Melsen, *From Atomos to Atom: The History of the Concept of Atom* (1952; New York: Harper & Brothers, 1960), 41–43.
5. Norma E. Emerton, *The Scientific Reinterpretation of Form* (Ithaca: Cornell University Press, 1984), 90 and passim.
6. Ibid.
7. Ibid., 87; Melsen, 66.
8. Melsen, 74.
9. Emerton, ch. 3–4; Catherine Wilson, *The Invisible World: Early Modern Philosophy and the Invention of the Microscope* (Princeton: Princeton University Press, 1995), 52.
10. Robert Boyle, *Selected Philosophical Paper of Robert Boyle*, ed. with an introduction by M.A. Stewart (Cambridge: Hackett, 1991), 41.
11. Robert Hugh Kargon, *Atomism in England* (Oxford: Clarendon Press, 1966), 72, 74; see also [Margaret Cavendish], *Poems and Fancies* (London, 1653), 10.
12. On Malpighi, see Guido Giglioni, "The Machines of the Body and the Operations of the Soul in Marcello Malpighi's Anatomy," in *Marcello Malpighi, Anatomist and Physician*, ed. Domenico Bertoloni Meli (Firenze: Leo S. Olschki, 1997), 163.
13. Robert Hooke, *Micrographia* (London, 1665; rpt. New York: Dover, 1961), 160.
14. Leeuwenhoek, "Mr. Leeuwenhoek's Letter…," *Philosophical Transactions* 12 (1677): 900; see also idem, "Microscopical Observations on the Structure of Teeth…," *Philosophical Transactions* 12 (1677): 1003.
15. H.A.M. Snelders, "Antoni van Leeuwenhoek's Mechanistic View of the World," in *Antoni van Leeuwenhoek 1632–1723*, ed.

L.C. Palm and H.A.M. Snelders (Amsterdam: Rodopi, 1982), 66–67; Leeuwenhoek, "Structure of Teeth," 1002–5 and passim.
16. Leeuwenhoek, "An Account of…the Internal Texture of the Flesh of Muscles…," *Philosophical Collections* # 5 (1682): 154–55.
17. Ibid., 157; see also *Philosophical Transactions* 12 (1682): 904; "An Abstract of a Letter…Concerning Scales…," *Philosophical Transactions* 14 (1684): 590–1; idem, "Microscopical Observations on the Structure of the Spleen," *Philosophical Transactions* 25 (1706–7): 2310.
18. F.J. Cole, "The History of Anatomical Injections," in *Studies in the History and Method of Science,* ed. Charles Singer (Oxford: Clarendon Press, 1921), vol. 2, 287–88.
19. Cole, 292.
20. Ibid., 303.
21. Ibid., 304; G.A. Lindeboom, "Boerhaave's Concept of the Basic Structure of the Body," *Clio Medica* 5 (1970): 203–4; Edward Ruestow, "The Rise of the Doctrine of Vascular Secretion in the Netherlands," *Journal of the History of Medicine* 35 (1980): 272.
22. Ruestow, 272; on the vascularity of the body, see ibid., 268–70.
23. Luigi Belloni, "Marcello Malpighi and the Founding of Anatomical Microscopy," in *Reason, Experiment, and Mysticism in the Scientific Revolution,* ed. M.L. Righini Bonelli and William R. Shea (New York: Science History Publications, 1975), 98; Marian Fournier, *The Fabric of Life: Microscopy in the Seventeenth Century* (Baltimore: Johns Hopkins University Press, 1996), 129; Ruestow, 271. Leeuwenhoek detected the vessels even in the dense mass of the semen. Interestingly, he equated these vessels with the fibers and the strings called by English scientists; G.A. Lindeboom, "Leeuwenhoek and the Problem of Sexual Reproduction," in L.C. Palm, 138–39.
24. Fournier, 136–38.
25. Theodore Brown, "Physiology and the Mechanical Philosophy in Mid-Seventeenth Century England," *Bulletin of the History of Medicine* 51 (1977): 25–54.
26. Fournier, 133–34.
27. Cole, 304.
28. Ibid., 307.
29. E. Chambers, *The Cyclopaedia* (London, 1728), s.v. "parenchyma"; Stephen Blancard, *A Physical Dictionary* (London, 1684), s.v. "parenchymata."

30. Chambers, s.v. "parenchyma"; Edward Phillips, *The New World of English Words,* 6th ed. (London, 1706), s.v. "parenchymous parts."
31. Edmund King, "Some Considerations Concerning the Parenchymous Parts of the Body," *Philosophical Transactions* 1 (1665–66): 316–17.
32. Idem, "Some Observations Concerning the Organs of Generation, Made by Dr. Edmund King," *Philosophical Transactions* 3 (1668): 1044.
33. DSB, s.v. "Stensen"; "Malpighi's 'Concerning the Structure of the Kidneys': A Translation and Introduction by J.M. Hayman, Jr.," *Annals of Medical History* 7 (1925): 242–63.
34. King, "Parenchymous," 316.
35. *Philosophical Transactions* 12 (1677), 1003–5.
36. See Leeuwenhoek's equation of the vessels to the fibers, above note 23.
37. Ibid., 33.
38. Ibid., 30; Lester S. King, *The Road to Medical Enlightenment 1650–1695* (London: Macdonald, 1970), 65.
39. Ibid., 208.
40. For this point, see Lester S. King, "Stahl and Hoffmann: A Study in Eighteenth Century Animism," *Journal of the History of Medicine* 19 (1964): 128.
41. Wilson, 57.
42. Hooke, 138.
43. Ibid., 135.
44. Ibid., 141; cf. preface, "Natural Textures…may be made in Looms…how Tapestry or flowered Stuffs are woven."
45. King, "Parenchymous Parts."
46. Glisson, *English Manuscripts of Francis Glisson (2): Lectures and Other Papers*, ed. Andrew Cunningham (Cambridge: Cambridge Wellcome Unit for the History of Medicine, 1998), 53.
47. King, "Organs of Generation," 1043–47. Compare this to the textile design (of embroidery) made around mid-seventeenth century; *The Needles Excellency: A New Booke Wherein are Diuers Admirable Workes Wrought with the Needle*, 12th ed. enlarged (London, 1640); Marie Schuette, *The Art of Embroidery* (London: Thames and Hudson, 1963); Patricia Wardle, *Guide to English Embroidery* (London: Her Majesty's Stationary Office, 1970).

48. Daniel Le Clerc and Jon Jacob Magnet, *Bibliotheca Anatomica, Medica, Chirurgia, &c.* (London, 1711–14), vol. 1, 13.
49. James Drake, *Anthropologia Nova*, vol. 1, appendix (London, 1707).
50. In Thomas Willis, *The Remaining Medical Works of Thomas Willis* (London, 1684). See also *Bibliotheca Anatomica*, p. 488, Tab. II, fig. vi; 570, Tab. V, fig. 11–15; Drake, Tab. 38, fig. 1; Willis, 15, Tab. 6–7.
51. See also *Bibliotheca Anatomica,* 652, Tab. VI, fig. 1, 3; p. 570, Tab. III, fig. 5–9 (Lower's heart); 488, Tab. II, fig. 5; 227, Tab. VI; Drake, Tab. 38, fig. 3–6; Willis, 14, Tab. I, V; 15, Tab. II, V.
52. Nehemiah Grew, *The Anatomy of Plants. With an Idea of a Philosophical History of Plants and Several Other Lectures Read before the Royal Society* (London, 1682), 19.
53. Ibid., 20–21.
54. Nehemiah Grew, *Cosmologia Sacra: or, a Discourse of the Universe as It Is the Creature and Kingdom of God* (London, 1701), 18.
55. Grew, *Anatomy*, 121. Contemporaries also observed that Grew discovered the more minute fibers composing the bladders, which made up the Pith; see the editor's notes to Leeuwenhoek's letter in *Philosophical Transactions* (660).
56. Ibid., 59, 62.
57. Other examples are "as it were…a Diversified Woof" (for the uniform contexture of the parenchymous part of the barque), "Threds…Braced together in the form of *Net-Work*" (for the texture of the barque), "Fine and close *Needle-work"* (for the fibrous structure of the pith), "a piece of *Linsy-Woosly Work*, or like manner other *Manufactures* in which the *Warp* and the *Woof* are of different Sorts of *Stuff*" (for the insertions in the wood) (64, 65, 77, 114).
58. Ibid., 77.
59. Ibid., 121–22; see also "An Account of Some Books: *The Comparative Anatomy of the Trunks of Plants* by Nehemiah Grew," *Philosophical Transactions* 10 (1675): 486–89, in which the reviewer summarizes Grew's comparison.
60. DSB, s.v. "Grew."
61. "The Epistle Dedicatory," n.p.
62. See Leeuwenhoek, "A Letter…Concerning the Seeds of Plants…," *Philosophical Transactions* 17 (1693): 702–4; "An Account of a

Book of Malpighi," *Philosophical Transactions* 19 (1695–97): 557–58; "An Account of Diverse Schemes of Arteries and Veins," 1182. On Malpighi's comparative method, see also Belloni, 106; Fournier, 59–60.

63. He also wrote the *Comparative Anatomy of Stomachs and Guts*, which is included in his *Musaeum Regalis Societatis, or a Catalogue and Description of the Natural and Artificial Rarities…* (London, 1681).
64. Grew, *Anatomy*, 112.
65. Ibid., 131. Other illustrations of the analogy between plants and animals are seen in 60 (transformation); 66 (the fiber); 77 (skin); 84 (nutrition).
66. Grew, *Sacra*,18.
67. Jeanne Bolam, "The Botanical Works of Nehemiah Grew, F.R.S. (1641–1712)," *Notes and Records of the Royal Society of London* 26 (1971): 227–28. See also Agnes Arber, "Nehemiah Grew, 1641–1712," in *Makers of British Botany: A Collection of Biographies by Living Botanists*, ed. F.W. Oliver (Cambridge: Cambridge University Press, 1913), 54.
68. The anatomists also often found in the micro-structures of the organs their similarity to the morphological form of the plant; branches, twigs, leaves, and trees were recurrently mentioned in anatomists' writings and shown in the illustrations, and sometimes those illustrations of animal/human anatomy weirdly resembled the micro-fibrous structures of the plant. So, Grew's choice of the study of plant anatomy for explicating the animal/human anatomy was not fortuitous, for the inner animal/human body (the animal kingdom) was increasingly viewed as the place inhabited by the vegetable kingdom.
69. Samuel I. Mintz, *The Hunting of Leviathan* (1962; rpt. Bristol: Thoemmes Press, 1996), ch. 3.
70. Grew wrote *Cosmologia Sacra* as an antidote to Spinoza's philosophy (preface n.p.).
71. Neale C. Gillespie, "Natural History, Natural Theology, and Social Order: John Ray and the 'Newtonian Ideology,'" *Journal of the History of Biology* 20 (1987): 21.
72. Michael Hunter, *Science and Society in Restoration England* (Cambridge: Cambridge University Press, 1981; rpt. Aldershot: Gregg Revivals, 1992), 15.

73. Atheism, in this period, meant the belief that God does not exist or the universe perpetuates without the divine intervention; however, the term was often employed by controversialists to their opponents who they thought did not conform to orthodox theology. The heterodoxies of the period include Hobbes's materialism, Spinoza's hylozoism (matters endowed with life), and atomism. Very few professed themselves as true atheists.
74. John Rogers, *The Matter of Revolution: Science, Poetry, and Politics in the Age of Milton* (Ithaca: Cornell University Press, 1996), 36. On the dance metaphor, see [Cavendish], 5; Stephen Clucas, "Poetic Atomism in Seventeenth-Century England: Henry More, Thomas Traherne and 'Scientific Imagination'," *Renaissance Studies* 5 (1991): 335.
75. Clucas, 328–29.
76. Ibid., 333.
77. See J. Bostock, *Sketch of the History of Medicine, from its Origin to the Commencement of the Nineteenth Century* (London, 1835), 181ff; P.J. Cabanis, *Sketch of the Revolutions of Medical Science, and Views Relating to its Reform* (London, 1806), 158ff.
78. On Baglivi, see Frederick Stenn, "Giorgio Baglivi," *Annals of Medical History* 3 (1941): 183–94; T.S. Hall, *History of General Physiology* (Chicago: University of Chicago Press, 1969), vol. 1, 373; on Hoffmann, see Bostock, Cabanis. Twentieth-century medical historians have tended to slight the contribution of Hoffmann to formation of solidism; see King, *Road*, ch. 5; probably because his principles are found scattered through his voluminous works, as Cabanis suggested (160).
79. Isbrand de Diemerbroeck, *The Anatomy of Human Bodies, Comprehending the Most Modern Discoveries and Curiosities in the Art*, translated from Latin by William Salmon (London, 1689), 4; the original version of Latin was published in 1672.
80. Helkiah Crooke, *Microcosmographia, or a Description of the Body of Man* (London, 1615), 30.
81. de Diemerbroeck, 3.
82. Ibid., 4.
83. Ibid.
84. Crooke, 30.
85. de Diemerbroeck, 5.

86. Crooke, 30; see also D.P. Walker, "Medical Spirits in Philosophy and Theology from Ficino to Newton," in *Music, Spirit, and Language in the Renaissance*, ed. Penelope Gouk (London: Variorum Reprints, 1985).
87. de Diemerbroeck, 6.

PART II

The Fiber Body in Eighteenth-Century Medicine

CHAPTER 2

"Fiber Body" in the Era of Iatromechanism, c. 1700 to 1740s

This chapter deals with this important aspect of British medical theory in the anatomy, physiology, pathology, therapeutics, and biology of the first half of the eighteenth century. I shall show that the implications of fiber in eighteenth-century medicine are significantly broader than one might assume. In anatomy, the fiber as the minimal building unit became the key to the inner mysteries of the body. In physiology and pathology, fiber, with its innate property of elasticity, played an indispensable role in understanding how health was maintained or disturbed. In biology (i.e., life sciences), fiber was deemed to be the most appropriate concept to explain animal growth within the preformationist framework, a dominant paradigm in enlightenment embryology. Moreover, the concept of fiber was employed to determine individual constitutions and differences in gender and social rank. In short, fiber and "fiber theory" occupied a critical place in eighteenth-century medicine, particularly in theoretical medical discourse. Eighteenth-century medical discourse from c. 1700 to 1740s is pervaded with fiber-related terms and descriptions such as "membranes," "web," "stamina," "weaving," "vibrating," "folding," "tone," and "tension," rather than "nerves" and the "nervous system." These and similar fiber-related words constitute the terminology of the "Fiber Body." The prevalence of this vocabulary bears witness to a concerted effort of medical theorists to transform the older medical theory of the "humoral" and fluid body into a theory of solidism.

H. Ishizuka, *Fiber, Medicine, and Culture in the British Enlightenment*, DOI 10.1057/978-1-349-93268-9_2

1 The Anatomy of the Fiber-Woven Body

The fiber theory, narrowly understood as the theory that assumes that the whole body is composed only of fibers, was first formulated in the anatomical field in the late seventeenth century. From the mid-seventeenth century, natural philosophers and plant and animal anatomists explored the micro-structure of body parts through the microscope. They eventually proposed that fibers were the minimum building unit of bodily components, and perceived the body as entirely interwoven of elementary fibers. This new understanding of the body was first articulated and visualized in *The Anatomy of Plants* (1682) by Nehemiah Grew. By the end of the seventeenth century, this idea was introduced to the field of human anatomy. On the Continent, Friedrich Hoffmann, a professor at the University of Halle, set forth a doctrine of solid pathology in his medical textbook, *Fundamenta Medicinae* (1695). His doctrine posited fibers as the fundamental building unit of the body, suggesting that "fibres are the basic threads and filaments of all the parts"; he saw the body as being skillfully woven of these threads.[1]

One sign of the transition of fibers into human anatomy in England can be seen in a medical text by Bernard Connor, a renowned Irish-born physician. In 1697, Connor published in Latin a controversial book on miracles, which claims to provide medical proof for miraculous cures.[2] Because of this scandalous assertion, his book stirred the minds of clerics and medical practitioners alike. In the present context, Connor's book is important in that he presented a rudimentary idea of fiber anatomy. Seeing the body as composed of two kinds of fine threads (i.e., "vessels and vascular filaments"), Connor perceived the structure of the human body in a similar way to that of the later Enlightenment medical practitioners.[3] The "vessels" refer to the veins, arteries, nerves, and lymph ducts, which, according to most medical writers of that time, compose the entire body. Nevertheless, Connor argues that the countless "vascular filaments" also participate in the composition of the body by comprising bones, cartilages, ligaments, membranes, tendons, muscles, and glands. These filaments are laid over one another and form "little plates of filaments," which swell up in length and breadth through the action of the blood, finally forming the "splendid structure of the human body."[4] Identifying solids as thread-like substances, Connor also thought, in much the same way as the later iatromechanists, that bodily health consists of the interaction of solids and fluids.[5] Because Connor died in 1698, soon after this publication, his research was unfortunately not extended.

In the year of Connor's death, the idea of fiber anatomy found clear expression in James Keill's small textbook on human anatomy. Keill, a Newtonian physiologist and anatomist, for the first time in the history of English anatomical textbooks departed from the traditional division of the human body, and consequently from the common position taken by most authors of anatomical textbooks, of dividing the human anatomy into similar and dissimilar parts and contained and containing parts, or of describing which parts belong to which side of the body. Keill pronounced such a fastidious definition and division of components unnecessary and of no great use for students, since the fact that "*All the Parts are made up of Fibres*" was sufficient basis for the anatomical knowledge of the body. After defining the three kinds of fibers from which all body parts are formed, Keill offered a final criticism of the traditional division of the body:

> Now the several Parts of the Body are formed by various textures and different Combinations of some or more of these Fibres; and therefore tho' commonly the Bones, Nerves, Ligaments, Cartilages, Veins and Arteries are reckoned Similar Parts, that is Parts made up of one Sort of Fibres, yet all of them have either more or less of different sorts of Fibres, and may be called Dissimilar Parts, as well as the Lungs or Stomach.[6]

The seemingly similar parts are actually composed of different kinds of fibers, which reveals the composite texture (structure) of the body parts; hence, Keill's statement that there are "*No Similar Parts*" in the body.[7] Keill later modified this view. He withdrew the above statement from the fifth edition and added a new phrase to the passage that defined the three kinds of fibers, "And most of them, when examined with a Microscope, appear to be composed of still smaller Fibres."[8] Although Keill's version of "fiber anatomy" was rather unelaborated, his innovative rendition of fiber theory in human anatomy was widely shared by other anatomists, as Keill's book became a standard textbook.[9] The enduring idea of fiber anatomy can be seen in Quincy's equally popular *Medicinal Dictionary*, published almost a century after Keill's book; notwithstanding the announced "improvements" made by the latest authors, it still listed the same description of the body as composed of fibers.[10] Many medical practitioners of diverse theoretical backgrounds embraced the idea of fiber anatomy, whether or not they were more inclined to the mechanical philosophy, Newtonian physics, or a quasi-vitalistic natural philosophy.

The complete version of fiber anatomy as developed in the first half of the eighteenth century can be described as follows: the simplest fibers (i.e., the smallest unit of solid body that is unable to be dissolved by any force), when united, forms other tangible fibers that are applied to each other in a parallel direction. These tangible fibers constitute the smallest membranes, which in turn, if bound together, form the smallest vessels. From the smallest vessels, united in a longitudinal direction, arise the membranes of a second degree with their characteristic thickness and strength, which again are bound together to create vessels of the second degree. This cyclic process from the fibers/vessels to the membranes and again to the vessels continues up to the largest "vessels" (i.e., the viscera), which are composed of all the fibers, vessels, and membranes found in the human body. Therefore, through various textures and different combinations of fibers, the membranes and the vessels successively constitute the substantial parts of the body.[11] Cheyne, an intriguing natural philosopher who subscribed to the fiber-membrane theory, depicted fiber anatomy using an illuminating descriptive tincture that was typical of the era:

> All the solids of the Body…resolve themselves…into such [least] Fibres at last. They are probably platted and twisted together…or make the larger sensible Fibres; and these again are either united in Bundles to form the *Muscles, Tendons, Ligaments*, &c. or woven into a fine *Web*, like cloth, to make the *Membrane*, the coats of the Vessels, &c.[12]

Therefore, what is the fiber that makes up all the solid animal bodies? First, the nature of the fibers was that of threads or filaments, and fibers were often characterized as long, slender, white threads in the form of filaments.[13] The thread-like nature of fiber was of particular concern to the anatomists as they depicted the body as entirely interwoven of thread-like fibers. It must be stressed that the most minute fiber or vessel was nothing but a hypothetical entity that was not visible even with the help of various types of instruments. The nature of the smallest fiber was interpreted by analogy with the larger sensible vessels that were visible and which by close inspection were found to be composed of numerous further minute fibers, which in turn were made up of even more minute fibers. This process seemed to continue indefinitely to an ultimate limit that could only be speculated. This limit was generally called the "least fibre," although it was sometimes called the least "vessel,"[14] and sometimes, confusingly, the "nerve."[15] Anatomists were perplexed by the smallness of the fibers, the extremely large number of which posed the sheer impossibility of counting them. Keill, for instance, argued that the fibers of a muscle, which were nine times smaller than a strand of hair, were each made up of a hundred smaller fibers. He then stated that "each of these must have had Nerves, Veins and Arteries," and each of them are made up of a hundred more fibers, then still more fibers, and so on.[16] Boerhaave too mused on the minuteness of the least vessels and calculated that 100 million of them might be contained in one grain of sand.[17]

The classification of the different kinds of compound (sensible/visible) fibers was no less confused than the nature of the simplest (invisible) fibers. Some anatomists divided fibers into three classes according to the degree of softness and flexibility, that is, from the softest to the hardest.[18] Other anatomists classified fibers according to their functions, as either motive or sensitive, which could probably be traced back to the animistic definition of fiber by the English physician and physiologist Francis Glisson.[19] Whatever the division of the fibers, fiber in general is much the same in its original formation; therefore, the different states and properties of the specific parts, or the whole formation of the individual body, largely derive from the various textures and combinations of the different kinds of fibers.[20] By extension, the different physiological and pathological states of the physical temperaments of individuals are partly determined by the anatomical warp and weft of the fiber-woven body (see below).

Even more significant than the idea of the body being entirely fibrous is the use of metaphor to describe fiber anatomy. Detailed research into the micro-structure of the inner parts of the body inspired anatomists to employ a variety of metaphors for fibers derived from weaving, textiles and embroidery, to articulate what they saw. As the eighteenth-century theorists inherited the concept of fiber anatomy from the anatomists and natural philosophers of the preceding century, so they described the body, from top to bottom and from the smallest to the largest parts, using metaphorical terminology drawn from the seventeenth-century concept of fiber anatomy. Descriptions of fiber anatomy were accompanied by references to weaving practices ("interwove," "weave," and "knit") and products such as "cloth" and "embroidery." Fibers, identified with threads or filaments, became the appropriate material for knitting and weaving the body.

More than any other body part, the membranes or coats received scrupulous attention, because of their natural similarity with cloth. Cheyne compared the process of weaving the fiber-threads into membranes to that of clothmaking, stating that the fibers were "woven into a fine *Web*, like

Cloth, to make the *Membranes*."[21] Cheyne elsewhere described the innermost coat of the stomach as "Carpet-like."[22] Even for Boerhaave, who usually preferred the mechanical–hydraulic metaphor to the fiber-woven one, the membrane appeared to be "a kind of sheet where the filaments or threads are closely interwoven (as in Linen)."[23] The membranes were not only interwoven of fibers; they were also stitched together by blood-vessels (themselves ultimately composed of fibers). Observing the spectacular texture of membranes interwoven with perplexing inter- and-cross connectedness between and within the vessels, the anatomists sometimes employed picturesque rhetoric. Quincy's description of the blood-vessels in the membranes is typical: "the innumerable Divisions, Windings, and Turnings, serpentine Progressions, and frequent Inoculations, not only of Veins and Arteries together, but also of Veins with Veins, and Arteries with Arteries," adding, in testimony of the metaphoric tradition, a stock figure from the rhetoric of textiles: "[all of them] make a most agreeable Embroidery and delicate Net-work."[24] Thus, in their discourse on fiber anatomy, the medical practitioners, astonished by the "wonderful texture" of the human body, closely compared it to a complex textile.[25]

The anatomical discourse of the fiber-woven body as textile or cloth had important consequences. First, it endorses the principle of continuity of the body, which plays a vital role in fiber physiology and pathology. If the fibers successively enter into the composition of all the solids of the body (from fibers to membranes to vessels and viscera), the body as a whole can be imagined as materially continuous from beginning to end ("animal Bodies…are in a manner framed of one continued Maze of innumerable Canals, in which Fluids are incessantly circulating"[26]). This physical continuity would ensure the physiological function of the fiber-vessels, that is, the perpetual circulation of the fluids. The second consequence of the anatomical discourse of the fiber-woven body is related to a cultural interest in the delicate body. To understand this connection, we need to consider the concept of the "solid," and how it is conceived in the discourse on fiber anatomy. The solids need not be as hard and strong as the bones or the tendons, the hardness and strength of which are made possible only by the gradual hardening of extremely soft fibers. In other words, the solids are solid not because their material properties imply hardness, but because they are "continuous and continent parts of the body"; they are defined as such in opposition to the fluids, which are contained in the solids.[27] Fiber-anatomists conceived the solid body not so much as a physically dense matter but as a delicate, fragile, and flexible entity interwoven of unimaginably slender threads and extremely tenuous membranes. Bone, the hardest part of the body, was a critical issue in the discourse on its delicate texture. Nesbitt, for instance, dismissed as "a vulgar error" the hitherto prevailing notion that bones are originally formed from the cartilaginous matter[28]; instead, he insisted that the cartilaginous substance was "fibrous," and therefore that the bones are originally formed from the "bony" fibers ("bony" in the sense that they are the constituent part of the bones).[29] Alexander Monro *primus*, a specialist on the micro-anatomy of bones, also discussed the ossification process. He described the bones as being composed of a large number of "Plates," "made up of Fibres or Strings," and "united by smaller irregularly disposed Fibrils," which being interwoven with the former plates (the larger fibers) made up of "a reticular Work."[30] While the bones are solid substances, the bony structure is here represented as a textile-cloth, similar to other fibrous, textile-like parts. Monro refuted the concept that bones do not have a fibrous texture by arguing that however solid and compact the bones may appear, they were once soft membranes, "nay a mere Gelly." To support this, he referred to repeated observations of a developing embryo, which attest to a gradual hardening of a once-tender substance.[31]

The discovery that the bones, the hardest part of the human body, were originally a jelly-like soft substance provided evidence for the anatomists' concept of the solid body as tender and delicate. If even the hardest matter was once fibrous, there should be no difficulty in believing that the other solid parts were also tender and delicate. Thus, the notion of the "solid" body as interwoven by innumerable minute threads like an intricate embroidery contributed to a cultural understanding of the delicate and tender body, a body very receptive to external stimuli, a body that loomed large in the burgeoning culture of sensibility and the commercialized fashionable society of the eighteenth century.[32] To acknowledge a plausible connection between the fiber-woven body in fiber anatomy and the cultural formation of the delicate (later called "nervous") body would force us to rethink the putative medical origin of the culture of sensibility, which is customarily attributed to the Willisian revolution of brain anatomy and the exploration of the nervous system by its eighteenth-century successors. Although this point cannot be further pursued here, the discourse on fiber theory, fiber anatomy, and the fiber-woven body in early eighteenth-century medicine is intimately related to the emergent cultural concern of the sensible body, which precedes the rise of the discourse on the nervous system in medical theory from the 1740s onward.[33]

2 Physiology and Pathology of Fibers

2.1 *Fiber Physiology*[34]

Early eighteenth-century medical practitioners, who saw the body as a hydraulic machine, commonly assumed that life depends on the uninterrupted circulation of fluids through innumerable winding, "hollow" vessels. The doctrine of obstruction suggests that physiological dysfunction is caused by blockage of these minute vessels by bodily fluids causes.

The fragile solids, however, are always subject to wear and tear. The solids are perpetually wasted and impaired by the force of circulating fluids that furnish nutritious matter. As such, circulation must constantly supply the proper animal juices to nourish and repair the solids. It then becomes important to ask how the blood, the universal fluid from which all the other fluids or humors are derived,[35] circulates through the vessels. It cannot be from a force innate to the fluids themselves, since they are not endowed with a "self-moving Principle."[36] The blood is moved by the impulse of the "muscular" heart, the vital engine of the hydraulic machine. However, the force of the heart seemed to be too weak to convey the fluids through every nook and passage of the minutest extremities.[37] Full circulation must be aided by an impulsive force of the vessels and membranes (the solids) themselves, as well as the heart. Since the heart functions through the muscular mechanism of fibers, that is, as instruments of motion, the solid vessels themselves, by means of the complicated mechanism and texture of their muscular fibers, can also propel the fluids. It is not in the fluids, therefore, but in the solids as a whole, the amalgam of innumerable vessels, that we will find the chief spring of force.

Morgan's description of the ubiquitous presence of muscular fiber illustrates this: the muscular elastic fibers were "every where twined and interwoven with the Blood-Vessels, not only in the Muscles strictly so called, but also in the Glands, the muscular Coats, and universally wherever any Blood-Vessels [were] to be found."[38] The sum of forces exerted upon the blood is explained by the elastic fibers taken together, with the force of the heart accounting for only a part. We now need to question how the fibers move the fluids. This can be explained by the innate "elasticity" of the animal fibers. Many medical theorists maintained that the vital motions of the animal economy (with circulation seen as an epitome) were not possible without this inherent property of elasticity in the fibers. Browne Langrish, for instance, went so far as to say that without this property of the fibers, "Life could not subsist but a few Hours, or perhaps minutes."[39] Similarly, Cheyne insisted on the axiomatic function of the elastic fibers by suggesting that "in Elasticity alone, the force, power and pleasure of life and of the animal functions, consists."[40] In a word, "the whole Business of the Animal Life" is derived from the elasticity of the animal fibers.[41]

Elasticity is an innate property residing in all fibers, by which they restore themselves to their former state if they become stretched.[42] All the fibers in the living body were assumed to be in a state of "Violence" or "Distraction" as the fibers were unnaturally drawn out to a greater length by the violent stretching force of the fluids.[43] The proper action of the fluids in distending and stretching the vascular parts should be counteracted by the equally natural and continual exertion ("Conatus"[44]) of the solid elastic fibers that resist the action of the fluids and restore the former state.[45] The living body's state of health or derangement depends on this precarious equilibrium between solids and fluids; that is, on the elasticity, or faculty of restitution, of the former, and on the influent force of the latter against the solids.[46] If animal fibers lacked elasticity to impel the fluids, the body would fall into some kind of disorder.[47] In the framework of circulatory physiology, life depended on the circulation of the blood; ultimately, however, this meant that life relied on the elasticity of the fibers.[48] This important aspect of fibers applies equally to two other fields: solid pathology and fiber-based therapeutics.

2.2 *Fiber Pathology*

The long-standing doctrine of humoralism, which attributed all diseases to imbalances of the four humors, was gradually superseded by the new doctrine of solidism at the turn of the eighteenth century. Accordingly, medical theorists investigating the origins of diseases began to focus on solids, particularly fibers. Although the emergence of fiber-solidism owed much to the anatomical conception of the fiber-woven body, the anatomical notion that the whole body is composed of only fibers was not sufficient to give rise to fiber-solidism. For example, Connor, one of the first theorists to promote the anatomical idea of the fiber body, clung to humoral pathology without acknowledging the vital role of solids to which later fiber-solidists ascribed critical importance: "The solid Parts of the Body have no Motion (or Life) of their own, but such as they borrow from the Blood and Spirits."[49] To Connor, all diseases had "their first Seat in the Blood."[50] The perceptive insight of such early theorists as de

Diemerbroeck, who did not subscribe to the anatomical idea of the fiber body but insisted that solids preside over humors and spirits as the principal mover, had to await the establishment of the idea of the fiber-solid body.

The critical juncture can be found in the writings of Giorgio Baglivi (1668–1707), an Italian iatromechanist and the founder of solid pathology. Baglivi was fully aware of the anatomical idea of the body composed wholly of fiber-threads: "The human Body is a Bundle of Fibres variously interwoven and corresponding to one another."[51] Baglivi located the two centers of movement in the animal economy: the heart and the dura mater (of the brain). From these, two kinds of fibers are derived: the motor or muscular fibers and the membranous fibers. The dura mater serves as a second heart, continuing the heart-like pulsating motion of contraction and dilation. Instead of animal spirits or humors, these two sets of fibers perform the principal tasks of the animal economy and are subject to "Convulsions or Relaxations."[52] Baglivi attributed all disorders of the animal body to deviant states of these fibers. Too much tension or laxity or "a loose Flagginess" of the fiber-solids could obstruct the motion of the "Humours and Sprits."[53] Thus, Baglivi revived the long-forgotten ancient doctrine of the Methodists who, like him, ascribed disease to the states of the solids; all disorders proceed from either stricture or relaxation.[54]

Baglivi's work enabled early eighteenth-century medical theorists to recognize the importance of solids in treating disease.[55] As some medical writers came to appreciate the power of solids, they were no longer regarded as passive matter but as an active mover of fluids.[56] In the early stage of the development of solid pathology in Britain, Bartholomew Beale drew upon Baglivi's doctrine of solids, lamenting that it had been neglected for many years[57] and insisting that solids are the main and sometimes sole cause of many diseases.[58] The disorders of human bodies, according to Beale, are falsely attributed to vitiated fluids.[59] Humors or animal juices do not become morbid by themselves because the qualities of bodily fluids are primarily a result of the elastic forces of the solid fibers.[60]

It should be noted that, although Baglivi's efforts to revive the ancient doctrine of Methodists were important to the formation of fiber-solid pathology, the British context also included some precursors with views close to the Methodist doctrine of "strictum and laxum." As early as 1651, Glisson suggested a view similar to that eighteenth-century fiber-theorists would embrace. In a treatise on rickets, Glisson argues that the "vitiated *Tone*" of the body is disease itself because the diseased state ("an extreme laxity…and flaccidity of the parts") immediately hurts internal functions and is "inherent into the solids parts of the body."[61] Toward the end of the seventeenth century, William Cole, a doctor of medicine at Oxford,[62] and John Colbatch, an English apothecary and physician,[63] in works on apoplexy and gout, respectively, rely on the Methodist doctrine of strictum and laxum without acknowledging it. In particular, Colbatch elaborated a physiopathology of tone in which diseases derive from either the tensity or laxity of the nervous fibers: "the whole *Oeconomia Animalis* is performed by Relaxation and Contraction," and when the "nervous Fibers" lose their due "Tone," they cannot dislodge morbific matter from the body.[64] Colbatch's frequent use of the analogy of "bow" and "strings" to refer to the stretched or loosened state of fibers presages the later fiber-solidists, who were willing to borrow the same analogy.[65]

After Baglivi and these English precursors came Herman Boerhaave, a doyen of medicine in the first half of the eighteenth century. He succinctly systematized fiber-solid pathology in his extraordinarily popular textbook, *Boerhaave's Aphorisms*, later supplemented by van Swieten's lengthy commentaries. Boerhaave begins by discussing "the most simple solid fibre" and classifies diseases according to whether they proceed from "a weak and lax Fibre" or "a stiff and elastic Fibre." He then discusses diseases of "the least and larger Vessels" which proceed from the same causes as those of the least fiber, and he finally turns to defects of the humors, which are secondary.[66] Many followers of Boerhaave ascribed to the notion of fiber pathology ("the Doctrine of Distempers which proceed from the Rigidity or Relaxation of the Fibres"),[67] which accords with that of the ancient Methodists. The focal point of solid pathology should be sought in fibers and their state of tone or elasticity.

Although Boerhaave has been recognized as a modernizer of the Methodist idea of "strictum and laxum,"[68] it is equally remembered that he only touched upon fiber pathology ("*Boerhaave* gives a succinct and rational Account of every thing relating to this Doctrine [of Methodists]… in nine Pages only of his *Aphorisms*")[69] and that detailed explication of fiber pathology awaited subsequent medical authors. Boerhaave's theory of pathology, at least his majestic *Academic Lectures*, is predicated in principle on the system of various orders of vessels which correspond to the sizes of the blood particles running through them; therefore, this theory is the counterpart of the physiology of secretion. In this system, disorders proceed from congestion of fluids, but to explain why solids fail to execute their function, Boerhaave draws not on tone or elasticity but on the concept of cohesion. The degree of cohesion, defined as the power of attraction between the particles composing a solid-fiber, determines the state of the solid.[70] In this sense, the British iatromechanists who embraced fiber pathology were not blind followers of Boerhaave but reinvented his work for their own use.

There is an important point to make regarding fiber-solid pathology. The "one disease theory" of fiber pathology can be seen in two contexts: one concerns the principle of continuity discussed above; the other is related to a nosological aspect of solid pathology. As argued in the section on fiber anatomy, the body is imagined as successively woven out of elementary fibers, from the strands of hair and the nerves, to the vessels and viscera. The fiber-woven body is bundled together by these same fiber-threads in such a way that every part is continuous with every other part; one series of vessels is continuous with another, higher series of vessels. The corollary of this reasoning (i.e., the principle of continuity) is that the dictum deduced from the simplest fibers is equally applicable to the larger fibers or vessels, so that if one wants to seek the explanation of the diseases of the small or large vessels, one has only to look for the diseases of the most minute vessels.[71] In this view, the morbid state of the smallest fiber would designate a similar morbid state in all the other fibers, due to their continuity. For example, John Arbuthnot integrates the disease theory based on fiber anatomy with the principle of continuity: "of these [smallest] Fibers, [are constituted] the Vessels, of these Vessels the Viscera or Organs of the Body; therefore the Weakness and Laxity of the Fibers, Vessels, Viscera, and all Parts of the Body may be considered as one Disease," though he admits that disease is not always "universal" (i.e., there is a weakness or a strength of some parts which appear to be absent in other parts).[72]

Another aspect of the "one disease theory" is that it implies a homogeneous view of diseases that reduces the source of disorders to one continuously linked pathological state of the fibers, that is, loss of tone or elasticity, caused by their being either too relaxed and weak, or too rigid and tense.[73] Interestingly, medical practitioners were less interested in the considerable rigidity of the animal fibers as a specific cause of diseases, than in their laxity. Theoretically speaking, both states "above or beneath the Balance of Nature," as suggested by Robinson,[74] occasioned diseases, but cases are more often ascribed to a too relaxed than a too rigid state. Edward Strother, for instance, following Baglivi stated that an "*Atonia*, or a *Laxity*, is the Basis of many Disorders."[75] In fact, there seems to be a deep-seated assumption that the too-rigid state is not essentially pathological, but rather a kind of deviant or excessive consequence of a process that would otherwise be beneficial; in other words, that excessive rigidity of animal fibers is caused by a therapeutic activity which, had it not been excessive for the weakened fibers, would have benefited them. Thus, moderate exercise would strengthen the solids, but excessive exercise would dry up the fibers and render them rigid.[76] Moreover, an over-strained motion first tightens the fibers (i.e., puts them in a state of tension), but the tightened fibers afterwards recoil and become more relaxed.[77] In this sense, the second dimension of the "one disease theory" of fiber pathology is further abstracted, leading to a one specific causation of diseases—weakness of fibers. As James acclaims, "there is no fault in the whole Body, except only a Weakness of the Fibers, which is considered abstractly as a Disease, independent of all others."[78]

2.3 Therapeutics

Therapeutic activities largely focused on the loosened fibers, in order to restore their lost tone or "Springiness." Besides blood-letting and medicinal drugs,[79] fiber-based therapeutics was practiced within the perspective of the traditional six non-naturals—air, bodily motion, food and drink, excretion and retention, passions, sleep and waking. In diet, a stimulating substance such as "acrid" matter would increase the oscillating motion of the solid-fibers,[80] and a mineral "Diuretick" water would restore the lost tone of the weakened fibers through the water's astringent quality.[81] However, a caution should be raised against the excessive ingestion of "modish" dishes with high salt and spices, which would render the fibers dry, "crispy" (i.e., crinkly), and tense, and deprive the fibers of tension.[82] Interest was also focused on air: it was believed that the state of the atmosphere has a great influence on the fibers, since we constantly absorb air through every pore of the body.[83] Thus, cold and dry air was thought to brace and stiffen the fibers, not only by condensing, but also by "congealing the Moisture" that relaxes the fibers. Cold air produces strength and activity[84] by giving "great Energy to the Fibres,"[85] while moisture or moist air would render the fibers more lax and flaccid, diminishing their elasticity and retarding circulation, so that the animal juices would become slimy and eventually stagnate.[86] The idea that cold air braces the fibers exalts cold and dryness over heat and moisture, which duly led the British to appreciate their northern climate for its beneficially dry, cold, and bracing effect on lax fibers.[87] Passions should also be given due attention for, if excessive, they would contract and tighten the fibers into springs of "violent convulsion."[88] Intense study and excessive sex ("Venery") were thought to be similar in the sense that they exhaust the animal spirits; they deprive the fibers of the nervous juice to the point of wearing out and debilitating the tone of the fibers. The immoderate passions—sex and study—were of an exceptional category; the fibers were believed to be stretched and tightened if those activities exceeded the standard set by nature, although the resultant state of the fibers after immoderate coitus was all the more relaxed and flabby.[89]

Among the non-naturals, however, exercise seemed to receive the most assiduous attention; more precisely, vibratory, oscillatory motions such as gentle shock, shaking, minute vibrations, and pulsations brought on by exercise (or any other means), rather than exercise per se, were assumed to be the most critical ingredients of cure and prevention. Thus, moderate exercise would give a "gentle Shock to all our Fibres," increasing their contractile power,[90] and motions such as riding and walking, by shaking the whole frame, would bestow it with firmness.[91] The curative virtues of shaking the fiber-machine were astonishingly revealing, for by being shaken, the vibrations of the solids are quickened, and the body becomes relatively lighter, with the ligaments and the muscles cleared of their "Excrements"; moreover, superfluous particles are "dislodged and shook off" by exercise, while animal spirits or juices are rendered finer.[92] This vibrating virtue was even more surprisingly effective; it could prevent not only "contagious" ulcer,[93] but plague or "Epidemical Distempers,"[94] both of which were caused by invisible worms or "Animalcules" ("imperceptible Insects") floating in the air.[95] We constantly ingest the seeds of diseases from the air or from food and drink.[96] These seeds could bring distempers unless a "perpetual Pulsation" imperceptible to our eyes could beneficially shake off these insects before they secure a place in our bodies.[97] Whatever increased the vibratory motion of the solids could be therapeutic—bleeding, vomiting, and everything that acts as a stimulus, such as riding, "gestations," friction, and even music.[98] Even the symptoms of certain diseases may be therapeutic agents, as when a fit of gout or a spasm of a nervous disorder is said to remove other complaints by "concussion" and brisk motion.[99]

2.4 *Cold Regimen Versus the Hot or Warm Regimen*

Behind these varieties of fiber therapeutics which primarily targeted loosened, flaggy, and relaxed fibers was a deep-seated socio-cultural concern about the hot or warm regimen which was believed to cause general degeneracy in the population. Already at the end of the seventeenth century, John Locke promoted the use of the cold regimen for children. He argued that they should not be too warmly clothed, their feet should be washed in cold water every day, and they should play in the open air instead of by a fire; otherwise, the softness of parents would cause children's health and their constitution to deteriorate.[100] It is likely not coincidence that, around the same period when Locke published his stoic teachings of the cold regimen, medical writers began to revive the long-neglected habit of cold bathing. Among these, John Floyer most explicitly advocated for the therapeutic use of cold water over the warm regimen.[101] Floyer argued that ancient Britons had a habit of cold bathing, but it fell out of use over the centuries. The final blow to this démodé custom came in the seventeenth century when the ritual of baptismal immersion ceased to be practiced, and crucially, the hot diet (regimen) from warmer climates was introduced to the English people through growing foreign trade.[102] Stimulating items, such as "Tabaco, Tea, Coffee, Wine, and Brandy-Spirits, and Spices," were all "unnatural to English Bodies" which inhabited a cold climate in which the cold regimen is natural.[103]

Following Locke's thinking and anticipating eighteenth-century propaganda against the warm regimen, Floyer condemned the modern lifestyle which sought to warm the body—"to confine our selves in our warm Houses to much, to use too many Cloaths, to warm our Beds, to frequent hot Baths, soft Beds, hot Periwig, perfumed Snuff."[104] This hot regimen served only to make the body too tender, lax, and unmanly.[105] The result of this "vicious Regimen of Men of its Age"[106] was the rise of nervous distempers, such as hysteria, hypochondria, and apoplexy.[107] Cold bathing could restore the lost "Tone" of the solids by giving a beneficial shock to fibers and preventing nervous and other complaints.[108] Floyer's early crusade against the folly of the hot regimen set the stage for critics in subsequent generations from John Brown to Buchan to Adair who believed that cold gives vigor to the body, while heat makes it effeminate.[109]

Considering the fortifying effect of cold water, medical practitioners recommended cold bathing as exercise, as Francis Fuller advised in his immensely popular treatise on exercise. Like Floyer, Fuller fully recognized the mischief of the "too warm Regimen," against which cold baths could have a beneficial effect by bracing the fibers.[110] Apothecary John King followed these precursors such as Floyer and Baynard in popularly advocating the beneficial use of cold bathing as a form of exercise.[111]

From a broader point of view, the revival of cold bathing as exercise to strengthen the soft flesh can be situated at the critical juncture when the classical therapeutic views of hot and cold reversed. Traditionally, medicine had used the hot water or hot regimen to expel ill humors from the body.[112] Moreover, the ascendency of the cold regimen in fiber medicine marked a more radical change in European thought. Following Aristotelian and Galenic thought, heat was preferred over cold due to associations with maleness, perfection, and a good temperament, while cold was linked to femaleness, imperfection (a lack of heat) and a fragile (diseased) temperament.[113] Glisson clearly contrasted heat and cold based on the classical hierarchy: "as the activity and agility of the Body is attributed to the Heat, so the tardity and slothfulness of it is in great part ascribed to Cold."[114]

The eighteenth-century regime of the fiber body witnessed a complete alteration of this hierarchy. The inaptness to motion, the desire to rest, slowness, sloth, and idleness, these sources of distempers became associated with heat instead of cold, while activity, agility, vigor, and strength which preserve and promote health were associated with cold. At a deeper level, the ascendancy of the cold regimen over the hot one had social meanings and implications. As Vigarello argues, the new bourgeois class invented the moral value and the physical codes of cold—simplicity, vigor, rigor, strength, asceticism, and autonomy—and pitted them against the social symbols of the aristocratic class associated with heat or warm, such as weakness, delicacy, luxury, softness, effeminacy, refinement, and corruption.[115]

3 Fiber Biology: Fiber as Stamina

The concept of fiber in eighteenth-century medicine was extended into the mysterious realm of the life sciences. Especially in investigations on the origin and development of the embryo, and on the processes of man's growth and decline, the concept of fiber was used for a more cogent clarification of the otherwise unfathomable phenomenon of life. In this section, the important place that fiber occupied in the life sciences of the era will be discussed.

From the latter part of the seventeenth century, the mechanical theory of embryonic development loomed large—the doctrine of the pre-existence of the germ, according to which all generations were seen as a mere growth (extension) of the germs (or animalcules) that were encased in the first parents (Adam or Eve) at the beginning of the world. The astonishing demonstration by the Dutch naturalist, Jan Swammerdam in 1669 showing how a butterfly goes through successive stages in its life cycle in such a manner that one stage is enclosed within another (egg, larva, pupa, adult), contributed greatly to the formulation of the pre-existence theory. Swammerdam carefully observed the deceptively abrupt metamorphosis of the butterfly as an orderly, progressive development from egg to butterfly. His analysis revealed the seemingly radical alterations of the structure's appearance as the continuation of an already structurally formed organization. Exploiting Swammerdam's observation, Nicolas Malebranche, a Cartesian philosopher and priest, suggested the idea of the encasement of germs, saying that the first female contained all the subsequent germs that were prearranged and preordained to hatch from the inside of all the females descended from her. Fanciful as it sounds today, the doctrine of pre-existence, with the idea of encasement, was the most cogent and consistent theory for the mechanical philosophers, for it matched the mechanical view of the world, behind which God, as both Creator and Architect, presided. Moreover, it "mechanically" endorsed the theological concept of original sin. Theologically acceptable and theoretically persuasive, the preformation doctrine of encasement was widely disseminated by 1700, and firmly established in the medical field.[116]

How does fiber theory relate to the preformation doctrine? In order to understand this relation, we should pursue the interlocking ideas of fibers, solids, "animalcules," and "stamina." Fiber anatomy demonstrated that the solids of the body are entirely fibrous, but what were the fibrous solids in their original state, and how did they grow or develop? The majority of the medical writers of the era resorted to the idea of "stamina" as a way to consider the beginning of life. Assuming that original parts existed in the seed (or embryo) from the beginning,[117] the idea of stamina was set as the biological basis from which all the solids took their departure.

The medical theorists argued that stamina are organized from the start, not as a formless fluid body but as a complete organization of solids. According to them, the essential solid parts must be distinguished from the accidental parts later added to the original stamina by means of nutrition: everything essential to the animal was deemed to be "stamina," while the rest was added by the nutritious fluids.[118] This is consonant with the metaphoric usage of the Latin word *stamina* (plural of stamen), which in classical Latin means "warp threads," that is, the supporting threads stretched on a loom, under and over which the weft threads are woven to produce a textile. This metaphoric usage of stamina is already seen in discussions of generation in Jean Fernel's *Physiologia* (1567) and Andreas Laurentius's *Historia Anatomica* (1602).[119]

The original stamina almost concurred with the solids, the quantity of which was surprisingly small.[120] The process of incredibly minute stamina growing into mature solids was imagined as their enlargement by the impelling force of the nutritious fluids. This image presupposes that stamina form vessels. Within these vessels, the contained fluids circulate to distribute nutrition for growth. Therefore, the stamina are sometimes identified with the "Animalcules" in the semen, the hypothetical organized bio-substance[121] in which all the vessels of the body are originally contained.[122] The number of the vessels comprised by the stamina or animalcule is inconceivable; it actually exceeds the vessels of the adult body, for in the process of growth, the great number of soft, tender vessels compound together and become more compact and solid, forming sensible vessels, cartilages, or bones.[123] As incalculable as the number of vessels in the stamina or the animalcule, equally inconceivable is the weight of the stamina: some calculated that 3000 million vessels in the stamina were not equal in weight to a grain of sand,[124] while Wintringham, drawing on Leuwenhoek and Keill's mathematical calculation of the animalcule, computed the weight of the stamina at 1/92408129934910602442073 75200th part of a grain![125]

The question here is how one can imagine that such minute stamina comprise all the vessels, or, how one can make sense of the idea that the originally vascular (vessel-textured) stamina grow into an animal body.[126] The observation and knowledge of how the adult body of an insect was enclosed in the larva or the pupa provided the medical writers the clue to the mystery of the stamina. Here, Swammerdam's observation and drawings of the "nymph" (pupa) of a fly offered illumination by revealing the figure of an animal having all the preformed features of an adult, features that await expansion[127] (Fig. 6.5). The drawings compellingly displayed the unfolding image of the parts: layer after layer, folding after folding, plait after plait, the curling, curving, and folding parts were laid on top of each other, awaiting future expansion. In this sense, the doctrine of preformation was not only about the idea of preexisting germs that explained subsequent generations; it was also about the informative and powerful image of un/en-folding with regard to growth and development. Hence, drawing on the image of an insect's transformation, the medical theorists could argue that the stamina or animalcules were enfolding by themselves the series of layers of the folded parts, which would stretch and expand, as clearly expressed in Cheyne's remark:

> [T]he Solid Parts of the *Animalculs* [sic] are as it were folded and wrapped up in *Plaits*, and these Folding are wrapp'd together by surrounding Membranes, which in process of Time are rent and torn, by the encreas'd Force of the Fluid and Augmentation of the Solid Parts; As is commonly observ'd in the Transformation of all Insects.[128]

This image of the unfolding of stamina was precisely what growth meant: "Growth is nothing, but the unfolding of the original *Membranes* and *Fibres*."[129] Here, the fibers and membranes were evoked, not only because the solids were originally fibrous, but also because the fibers and the membranes agreed with the un/en-folding image through a metaphorical association, and structural affinity, with a pliable textile that enjoyed the elastic property of extending, condensing, and contracting. The stamina constituted the fibers, always already plural, because they were formed simultaneously. Hence, by definition, the fibers, the solids, the stamina, and the animalcule all equated with each other; "Fibres" were the "stamen, or matter of the animal,"[130] and the "Stamina" were the "Solids of a human body."[131] Moreover, the equation of stamina with fibers was supplemented by the etymological meaning of stamina, "*warp threads*,"[132] sometimes also described as "Lines" or "Lineaments."[133] The metaphorical and visual dimensions of the preformation theory in embryology were at one with the metaphorical, structural, and functional aspects of fibers in fiber theory (their minuteness and slenderness, their quasi-infinity of number, their natural affinity with threads, and the innate elasticity that makes them capable of expansion and contraction). In this sense, fiber anatomy, fiber physiology, and fiber biology mutually refer to and reinforce each other, and this efficacious interconnectedness is the real strength that constitutes the alluring consistency of fiber theory.

4 Fiber Constitution

As the discourse on fiber took an increasingly ascendant place in the medical theory of the early eighteenth century, a radical shift occurred in understanding, perceiving, and in some cases even experiencing the body. The long-enduring humoral theory, on which the knowledge of physical and moral temperaments rested, was gradually superseded by a fiber-based understanding of the temperaments (at least in the theoretical system of medicine, for the older physiological belief about humors persisted in the popular mind). According to the old humoral system, the proportion in the mixture of four humors (phlegm, black bile, yellow bile, blood), each with its own quality (cold and wet, cold and dry, hot and dry, hot and wet, respectively) determines the preponderant temperament of the individual: phlegmatic–dull temperament, melancholic–gloomy temperament, bilious–choleric (quarrelsome) temperament, and sanguine–balanced and cheerful temperament.[134] However, after iatromechanical philosophy reinforced the primacy of blood among the four humors and transferred the properties of the other humors to blood itself, and the physiology of circulation discredited humoral physiology, diversity of temperament needed to be founded on something other than the humors. Fiber could now serve this purpose.

Although the fundamental tenets of humoralism were largely discarded by the new fiber-based solidism, the fluids still played an important, though not critical, role in the knowledge of temperaments, the difference of which was thought to lie in the various motions of the blood ("different Constitutions [are] no other than various Motions of the Blood"[135]). The motions of the blood varied first by the different size and quantity of the "moving Fibres," and more importantly by the fibers' "Pulse and Tone," which determined their strength and vigor.[136] Thus, endowed with the vigor to move the blood and thereby alter its qualities, the elasticity or tone of the fibers was seen as crucial in determining the different qualities of constitutions.

Robinson provides an interesting case for the new classification system of temperaments that re-aligns the traditional four types of constitutions according to the degree of elasticity of the fibers. First, the "biliose" constitution, also known as the bilious or choleric, arises from the highest degree of elasticity in the solids, inclining the individuals of this temperament to gratify their passions; naturally their intellectual faculties are lively, vivacious, and "abounding with the sublime Wit," and genius resides in this constitution. Second, the sanguine constitution is derived from the less elastic impulse of the heart and arteries, at least less elastic than the "biliose"; the sanguine's solid way of thinking is apt for the discoveries of experimental knowledge. Third, the fibers of the "phlegmatick" constitution have less elasticity, whereby all impulses are weaker, and the motions and secretions slower; because of this reduced elasticity, the phlegmatic's intellect is not appropriate for a quick apprehension of objects offered to the senses, but he can retain most of what he perceives so as to improve upon inventions first discovered by others. The melancholy temperament, the last temperament, is only "phlegmatick" to a greater degree.[137]

Fiber-based constitutions were polarized—people had either very elastic or very weak fibers—although a variety of intermediate degrees was admitted.[138] People with very elastic fibers are generally lean and dry; they have strong, hard muscles, and clean, firm bodies; they are naturally impatient, prone to action,[139] and subject to inflammatory diseases. Sometimes, they are called "hot constitutions" since they have stronger fibers than others.[140] People with weak and lax fibers, on the contrary, have thin hair, are small, have soft, loose muscles, a fair skin, and since their extremities, because of their "cold constitutions," are often cold, they are prone to catch cold on the slightest occasion; they are frequently lazy, indolent, and dull, and subject to chronic diseases.[141] Sometimes, the traditional discourse on the polarity between robust people who live in the country and the luxurious and indolent men of the city was superimposed on the theory of fiber-based constitutions: robust country people tended to have strong fibers, while lazy, weak city people had flabby fibers.[142] However, tense, over-strained fibers could become rigid, too stiff, and eventually unelastic or "callous." In people endowed with such fibers, the advantages of firm health might be offset by the disadvantages of lesser mental and sensory capacities, as Cheyne included in this category, "*Ideots*, *Peasants*, and *Mechanicks*."[143]

Implicit in the system of fiber-based constitutions was the belief that social distinction among particular types of intellect was physically embedded in the tone and texture of the fibers. Contemplating the immense variety of human mental capacities, Robinson reasoned that since the souls of all people must be equal, the difference between the idiot and the genius must be sought in the body, that is, the fibers.[144] All the "sublime Flights and extatick Visions" the genius enjoyed were owing to the "due Modulation of the Solids," the "happy Structure of the Fibres"—the arteries very springy, the blood easily moveable, the secretion of the animal spirits naturally large, and the nervous system adjusted to the highest pitch its natural standard would admit.[145] All this ensured such strong impulses of the ideas on the sensorium as to sufficiently produce an elegant turn of thought and a quickness of memory. Natural stupidity, on the other hand, came from "an over Laxness in the Fibres of the Brain" which produced the very opposite effect.[146] For Blackmore, the alleged intellectual backwardness of Africans, as well as the variety of monstrous and irregular minds in general, was the result of Nature's error, that is, the "improper Length, Size or Situation of a Fibre."[147]

As a robust man with tense fibers would be stigmatized as obtuse, so in the delicate man of finer fiber, a variety of nervous distempers, such as "hypo," spleen, or hysteria, would be ambiguously counterpoised to his superior mental capacities.[148] Indeed, this was the age of "English Malady," an epithet that signaled, paradoxically, the superior rank of the nation and of certain individuals; for being afflicted by certain diseases was believed to be rather desirable so long as the disorder was of a less serious degree.[149] In the course of the eighteenth century, the medico-cultural myth of nervous sensibility—that a person is more delicate if they have finer nerves—intensified with the full-grown culture of sensibility, especially from mid-century on.[150] It should be noted, however, that at this point, in the first half of the century, especially before the 1740s, the nervous system was not the sole physical factor underlying the privileges of the higher orders; rather, it was only a part of the larger system of the fiber-solids. What was essentially important in determining social and cultural distinctions was not the nerves and their sensibility, but the fibers and their elasticity.

Although the notion of stamina predisposes us to regard the fiber-solids as innate and unchangeable throughout life,[151] the notion of tone or elasticity implies that fibers are highly malleable under the influence of the non-naturals.[152] The malleability of the fiber-based constitution is clearly seen in northern people of firmer habits and "superior Elasticity of the *Muscular Fibres*," who underwent considerable constitutional change in a southern climate. Tennent suggested that fibers of the northern people, the "superior" elasticity of which is largely due to the cold atmosphere, became lax and weak when exposed to the heat and humidity of the south. (Note the implied assumption of the superiority of cold northern people and the inferiority of hot southern people.) In a hot and humid climate, the particles of the blood combine, whereby the blood acquires a greater degree of viscidity and eventually stagnates; it is for this reason that northern people are so susceptible to a mortal fever upon their arrival in the West Indies.[153] It is of great interest to see how the concept of the plasticity of fiber-constitutions resonated with cultural concerns regarding the malleability of man. The discourse on the fiber-based constitution is one of the general points that differentiates the first half of the century (epitomized by the solids in general and the fiber in particular, with its innate property of elasticity) from the second half (exemplified by the nervous system in general and the brain or the nerves in particular, with the innate power of sensibility). Toward the end of the century, the diversity of humankind and the differences within specific groups of people (e.g., social rank, class, or gender) would be founded in biological and anatomical differences, signs of which were embodied in the nervous system and other systems of the body. The relatively malleable system of fiber-solids of the earlier eighteenth century gave way to the more innately codified system of the nerves and the brain, which eventually led to the establishment of a "nervous" foundation for the racial sciences of the nineteenth century.[154] By the beginning of the Victorian era, the fluid-and-flux constitution, as formulated by traditional humoralism, had been completely replaced by the scientific classification of constitutional "types." Yet in the eighteenth century, especially in its earlier half, the idea of fiber-based constitutions, through their innate elasticity flexibly interacting with the environment (roughly equivalent to the six non-naturals), was sustained, fluctuating between the sheer fluidity of humors of the older era, and the rigid and crude codification underlying some of the more sinister elements of the coming era.

5 Coda

By scrutinizing the prominence of the discourse on fibers in the medical theory of the first half of the eighteenth century, this chapter has attempted to redress the medical historians' fallacious tendency to see eighteenth-century medical theory in terms of either mechanism (the hydraulic machine composed of pipes and the fluids running through them) or vitalism (the sensitive organism composed of the brain and the nerves). The concept and metaphor of fibers were frequently invoked and became a reference point to explain anatomical structure, physiological functions, pathological processes, therapeutic practices, biological phenomena, and constitutional differences. Arguably, the medical practitioners of the era needed the concept of fibers, rather than that of vessels, muscles, or nerves, since fibers comfortably met the demands of the various interlocking areas of medicine. In anatomy, the idea of fiber was most appropriate for conceiving the body as wholly woven from a thread-like substance; in physiology, pathology, and therapeutics, medical theory was made plausible by the idea of the tone or elasticity of fibers capable of incessant vibration; in biology, the image of fiber-membranes identifiable with stamina was in harmony with the preformationist explanation of the mysterious process of "un/en-folding"; and lastly, the malleability of fiber was in full conformity with the equally malleable idea of constitutions interacting with the environment. It should be emphasized that metaphors such as weaving, elastic vibrating, and un/en-folding, rather than the mere nature or properties of the fibers per se, played a significant role in conceptualizing the fiber theory of each field, all the more so when the metaphor mediated between fiber theory and the socio-cultural realm. In this sense, the metaphorical dimension of fiber was an integral part of fiber theory, not an obstacle to objectivity. Paradoxically, it may have been fortunate for the fiber-theorists that the ultimate fiber was never found, since therefore they could only imagine what it would be like; and it was this hypothetical and imaginary substance that fueled the imagination, sustaining fiber theory and its many layers of metaphoric density. If the cell of the nineteenth century became the "ultimate fact" that the medical scientists required,[155] the fiber of the eighteenth century was a kind of "necessary fiction" for medical practitioners of the earlier era.

Notes

1. Friedrich Hoffmann, *Fundamenta Medicinae*, introduced and translated by Lester S. King (London: Macdonald, 1971), 13–14, 16. On Hoffman's solid pathology, see Ian M. Lonie, "Hippocrates the Iatromechanist," *Medical History* 25 (1981): 113–50.
2. Bernard Connor, *Evangelium Medici: seu Medicina Mystica* (London, 1697); I used an Amsterdam edition of 1699. On Connor, see Liam Chambers, "Medicine and Miracles in the Late Seventeenth Century: Bernard Connor's *Evangelium Medici* (1697)," in *Ireland and Medicine in the Seventeenth and Eighteenth Centuries,* ed. James Kelly and Fiona Clark (Farnham: Ashgate, 2010), 53–72.
3. Ibid., 10.

4. Ibid.; see also 16, and idem, "A New Plan of an Animal Oeconomy" in an appendix to *The History of Poland* (London, 1698), vol.1, 293; "*the solid Parts [are] all made of Vascular Fibres.*"
5. Connor, *Medici*, 17.
6. James Keill, *The Anatomy of the Humane Body Abridged; or, a Short and Full View of all the Parts of the Body* (London, 1698), 2.
7. Ibid., 2.
8. Keill, *Anatomy*, 5th ed. (London, 1714), 2.
9. Herman Boerhaave, *A Method of Studying Physick*, trans. Mr. Samber (London, 1719), 149; E. Chambers, *Cyclopaedia* (London, 1728), s.v. "fibre"; George Cheyne, *The English Malady* (1733) rpt., ed. with an introduction by Roy Porter (London: Routledge, 1991), 61; Robert James, *A Medicinal Dictionary* (London, 1745), s.v. "fibra" (this entry covers more than 20 pages, comprising a small treatise on fiber theory in a Boerhaaverian vein; pages are unnumbered, and the subsequent pagination in brackets is mine); M.N., *Anatomy Epitomized and Illustrated* (London, 1737), 4; Peter Paxton, *A Directory Physico-Medical, Composed for the Use and Benefit of all such as Design to Study and Practice the Art of Physick* (London, 1707), 4.
10. John Quincy, *Lexicon Physico-Medicum; or a New Medicinal Dictionary*, 10th ed. with new improvements from the latest authors (London, 1782), s.v. "fibres."
11. James, s.v. "fibra," [13–14]; Boerhaave, *Method*, 141–42, 147–49, 150–51, 164–66; Gerald van Swieten, *The Commentaries upon the Aphorisms of Dr. Herman Boerhaave*, 2nd ed. (London, 1771), vol.1, 98–101.
12. Cheyne, *English Malady*, 62. Cheyne is one of the most important medical men who subscribed to fiber theory; he published a Latin treatise on fiber, *De natura fibrae* (Londini, 1725), in which he elaborates the fiber-solid pathology of chronic diseases (i.e., nervous diseases), anticipating his later popular work *The English Malady*. A similar rendition of the above quotation is to be seen in the Latin book, 1–2. On Cheyne, see Anita Guerrini, *Obesity and Depression in the Enlightenment: The Life and Times of George Cheyne* (Norman: University of Oklahoma Press, 2000). For a similar statement, see Bernard Lynch, *A Guide to Heath through the Various Stages of Life* (London, 1744), 14–16.

13. Chambers, s.v. “fibre”; Daniel Le Clerc and Jon Jacob Magnet, *Bibliotheca Anatomica, Medica, Chirurgica, &c.* (London, 1711–14), vol. 2, 394.
14. Edward Barry, *A Treatise on a Consumption of the Lungs* (London, 1722), 78–79; Boerhaave, *Method*, 152, 164.
15. This view was generally attributed to Boerhaave; Flemyng called it “Boerhaave’s doctrine” (Malcolm Flemyng, *The Nature of Nervous Fluid, or Animal Spirits Demonstrated*, [London, 1751]), xiii. Confusingly, Boerhaave himself elsewhere discussed the simplest fibers as the basic unit; Boerhaave, *Method*, 146; Swieten, 38–39; G.A. Lindeboom, “Boerhaave’s Concept of Basic Structure of the Body,” *Clio Medica* 5 (1970): 203–8. Boerhaave’s use of the term “nerves” seems to refer to the ultimate vessels, the functional (nutritional) units, whereas the basic structural unit he called “the least fibres”; see L.J. Rather, “Some Relations between Eighteenth-Century Fibre Theory and Nineteenth-Century Cell Theory,” *Clio Medica* 4 (1969): 191–202.
16. James Keill, *An Account of Animal Secretion, the Quantity of Blood in the Humane Body, and Muscular Motion* (London, 1708), 130.
17. Boerhaave, *Method*, 149.
18. Keill, *Anatomy*, 2; M.N., 2–3; John Quincy, *Physico-Medicum: or, a New Physical Dictionary* (London, 1719), s.v. “fibre.” A similar way of dividing the fibers according to the degree of flexibility can be seen in their four-part classification as fleshy, nervous, tendinous, or osseous (bony); see Chambers, s.v. “fibre”; George Cheyne, *An Essay on Gout* (London, 1720), 78.
19. See Stephen Blancard, *A Physical Dictionary* (London, 1684), s.v. “fibrae”; Chambers, s.v. “fibre”; Thomas Gibson, *The Anatomy of Humane Bodies Epitomized*, 6th ed. (London, 1703), v; Nicholas Robinson, *A New Theory of Physick and Diseases, founded on the Principles of the Newtonian Philosophy* (London, 1725), 46–47; cf. Baglivi’s classification of the fibers, see E. Basthlom, *The History of Muscle Physiology: From Natural Philosophers to Albrecht von Haller* (Copenhagen: Ejnar Munksgaard, 1950), 181.
20. Cheyne, *English Malady*, 64.
21. Ibid., 62.
22. George Cheyne, *Philosophical Principles of Natural Religion* (London, 1705), 225.
23. Boerhaave, *Method*, 163.

24. *Lexicon*, s.v. "membrane"; see also Benjamin Martin, *The Philosophical Grammar; Being a View of the Present State of Experimented Physiology, or Natural Philosophy* (London, 1735), 272, which reads the same expression; Stephen Hales, *Statical Essays: Containing Haemastaticks* (1733), rpt., with an introduction by Andre Cournand (New York: Hafner, 1964), n.p., ("an inimitable Embroidery of Blood-Vessels"). During this period, fiber theory provided no general account of the membrane per se; membranes were studied and treated only as a constituent of specific parts, for example, the pleura for the thorax or the meninges for the brain; see James Douglas, *Myographiae Comparatae Specimen: or, a Comparative Description of All the Muscles in a Man, and in a Quadruped*, a new edition with additions (Dublin, 1755), xi; Keill, *Anatomy*, 19. There were several kinds of coats, usually divided into three as muscular, nervous, vascular; see Anon, *Physical Essays on the Parts of the Human Body and Animal Oeconomy* (London, 1734), 57; Barry, *Lungs*, 47–48; James Drake, *Anthropologia Nova; or, a New System of Anatomy* (London, 1707), vol.1, 58–61, 67ff; Jeremiah Wainewright, *A Mechanical Account of the Non-Naturals* (London, 1707), 3ff.
25. Hales, n.p.
26. Ibid., n.p., intro, no. 3
27. Chambers, s.v. "solids."
28. Robert Nesbitt, *Human Osteogeny Explained in Two Lectures* (London, 1736), 2–4.
29. Ibid., 8–12; see also M.N., 5–7.
30. Alexander Monro [*primus*], *The Anatomy of the Humane Bones* (Edinburgh, 1726), 9.
31. Ibid., 34–35.
32. See G.J. Barker-Benfield, *The Culture of Sensibility: Sex and Society in Eighteenth-Century Britain* (Chicago: University of Chicago Press, 1992).
33. On this point, see ch. 7.
34. For a further detailed argument on this, see ch. 3.
35. John Arbuthnot, *An Essay Concerning the Nature of Aliment* (London, 1731), 74; James Keill, *Secretion*, 107–8; Robinson, *Theory*, 15; Thomas Short, *A Discourse Concerning the Causes and Effects of Corpulency* (London, 1727), 51.
36. Robinson, *Theory*, 23.

37. Thomas Morgan, *Philosophical Principle of Medicine* (London, 1725), 138–39.
38. Ibid., 139.
39. Browne Langrish, *A New Essay on Muscular Motion* (London, 1733), 49.
40. Cheyne, *An Essay on Regimen* (London, 1740), xii; also see viii; Arbuthnot, *Aliment*, 156; Cheyne, *Fibrae*, 3.
41. Cheyne, *Gout*, 80; also see Chambers, s.v. "fibre"; Browne Langrish, *The Modern Theory and Practice of Physic,* 2nd ed. (London, 1738), 52–4; Quincy, *Lexicon*, s.v. "fibre."
42. Cheyne, *Natural Religion*, 224–25; Langrish, *Theory*, 58; Lynch, 274; Nicolas Robinson, *A New System of the Spleen, Vapours, and Hypochondriack Melancholy* (London, 1729), 16.
43. James, s.v. "fibra"[3]; Quincy, *Lexicon*, s.v. "fibre"; Robinson, *Theory*, 17.
44. Morgan, *Philosophical*, 126.
45. Ibid., 127; Lynch, 275–76.
46. Arbuthnot, *Aliment*, 148–9; Edward Strother, *An Essay on Sickness and Health* (London, 1725), 260.
47. Arbuthnot, *Aliment*, 148; J. Browne, *Institutions in Physick, Collected from the Writings of the Most Eminent Physicians* (London, 1714), xviii; James, s.v. "fibra"[17]; John Quincy, *Medico-Physical Essays* (London, 1720), 45; Robinson, *Theory*, 49–50.
48. Browne, xviii.
49. Connor, "New Plan," 298.
50. Ibid.
51. G. Baglivi, *Practice of Physick* (1696; London, 1704), 307.
52. Baglivi, *Practice*, 292.
53. G. Baglivi, *Specimen quatuor librorum de fibra motrice et morbosa* (Rome, 1702), 259; idem, *Practice*, 160.
54. Basthlom, 179; James, s.v. "Methodics."
55. See Thomas Apperley, *Observations in Physick, both Rational and Practical* (London, 1731), 15.
56. Browne, xix; Morgan, *The Mechanical Practice of Physick* (London, 1735), 145; "in all animal Motion, the original active Force is intrinsically in the Solids, and the Fluids only act as they are acted upon."

57. Bartholomew Beale, *An Essay Attempting a More Certain and Satisfactory Discovery Both of the True Cause of all Diseases* (London, 1706), 57.
58. Ibid., 54. See also Cheyne, *English Malady*, 82, where he summarized his tenet of solid pathology, saying that every disease is a disease of the solids rather than of the humors.
59. Ibid., 57.
60. Ibid., 57; James, s.v. "fibra"[14]; Quincy, *Essays*, 30–31, 44.
61. Francis Glisson, George Bate and Ahasuerus Regemorter, trans. in English by Phil. Armin, *A Treatise of the Rickets: Being a Disease Common to Children* (London, 1651), 66.
62. William Cole, *A Physico-Medical Essay Concerning the Late Frequency of Apoplexies* (Oxford, 1689); apoplexy depends on "*too great Laxity*" of the fibers of the brain (41). Like Glisson and Colbatch, Cole frequently employs the term "tone" or "tensity" (19, 54, 56, 98, 99, 104–7 and passim).
63. John Colbatch, *A Treaties of the Gout,* in *Novum Lumen Chirurgicum: or, a New Light of Chirurgery* (1697; London, 1704). Colbatch was a friend of Cole, and this work was dedicated to him.
64. Ibid., 277.
65. Ibid., 276, 280, 283. On the eighteenth-century use of the bow metaphor, see ch. 7.
66. Herman Boerhaave, *Boerhaave's Aphorisms concerning the Knowledge and Cure of Diseases* (London, 1715), 5–16; and Drake, 450–51; Robinson, *Theory*, 86.
67. James, s.v. "Methodics."
68. James M. Adair, *Commentaries on the Principles and Practice of Physic* (London, 1772); "The great *Boerhaave*…has…adopted the strictum and laxum of the Methodists" (47); R. James, *The Modern Practice of Physic* (London, 1746), v.
69. James, s.v. "Methodics."
70. Boerhaave, *Academic Lectures*, vol.5, "Of Pathology, or the Nature of Diseases," 255–411; esp. 258, 281–83.
71. James, s.v. "fibra" [13].
72. Arbuthnot, *Aliment*, 149.
73. Langrish, *Theory*, 2.
74. Robinson, *Theory*, 81.

75. Edward Strother, *Criticon Febrium: or, A Critical Essay on Fevers* (London, 1716), 53. John King, apothecary, had the same opinion ("a Laxity of the Solids…which is most often the Case"); *An Essay on Hot and Cold Bathing* (London, 1737), 33.
76. James, s.v. "fibra"[11].
77. John Quincy, *Medicina Statica: Being the Aphorism of Santorius, Translated into English, with Large Explanations*, 4th ed. (London, 1728), 426.
78. James, s.v. "fibra" [5].
79. On bleeding, see Langrish, *Theory*, 115; on drugs, George Cheyne, *An Essay of Health and Long Life* (London, 1724), 215–16; James, s.v. "fibra"[8–9].
80. Arbuthnot, *Aliment*, 136, 115.
81. Richard Blackmore, *A Treatise of the Spleen and Vapours; or, Hypochondriacal and Hysterical Affections* (London, 1725), 79.
82. Langrish, *Theory*, 30.
83. Ibid., 3–5; he argued that little change of air had a great influence on tubes.
84. John Arbuthnot, *An Essay Concerning the Effects of Air on Human Bodies* (London, 1733), 56.
85. Clifton Wintringham, *The Works of the Late Clifton Wintringham, Physician at York* (London, 1752), vol.1, 29; see also Cheyne, *Health*, 31; Langrish, *Theory*, 6–9, 11; Archibald Pitcairn, *The Works of Dr. Archibald Pitcairn* (London, 1715), 117.
86. Arbuthnot, *Air*, 61–2; James, s.v. "fibra"[4]; Lynch, 139; Short, *Corpulency*, 10–12; Wintringham, *Works*, 22–25.
87. Cheyne, *Health*, 31; John Tennent, *Physical Enquiries*, 2nd ed. (London, 1749), 1–2.
88. Cheyne, *Health,* 159; Morgan, *Philosophical*, 374; Short, *Corpulency*, 24, 73.
89. Short, *Corpulency*, 25, 46–47; also Langrish, *Theory*, 39; Quincy, *Medicina*, 426.
90. Ibid., 246.
91. Quincy, *Medicina*, 426; also 324.
92. Quincy, *Essays*, 43; see also Lynch, 282–83.
93. Barry, *Lungs*, 274.
94. Apperley, 87.
95. Ibid., 85.
96. Ibid., 85–86.

97. Ibid., 90–91; also Barry, *Lungs*, 274–75 on ulcer.
98. Cheyne, *Health*, 94–95; James, s.v. "fibra"[5, 7]; Quincy, *Essays*, 45–46; Quincy, *Medicina*, 332; Swieten, 67–69.
99. Quincy, *Medicina*, 421; also see Cheyne, *Health*, 132.
100. John Locke, *Some Thoughts on Education* (London, 1693), 4–7.
101. John Floyer, *The Ancient Psykhroloysia Revived: or, and Essay to Prove Cold Bathing both Safe and Useful* (London, 1702).
102. Ibid., "Dedication," n.p.
103. Ibid.
104. Ibid., 128.
105. Ibid., 130–31, 134–35, 139.
106. Ibid., 86.
107. Ibid., 87.
108. Ibid., 91–92, 88.
109. John Brown, *An Estimate of the Manners and Principles of the Times*, 3rd ed. (London, 1757), 89; William Buchan, *Domestic Medicine*, 2nd ed. (London, 1772), 164; James M. Adair, *Medical Cautions, for the Consideration of Invalids* (Bath, 1786), 30–32. Cf. Anon, *The Best and Easiest means of Preserving Uninterrupted Health to Extreme Old Age* (London, 1748), ch. 5 "Of the Cold Bath" and ch. 6 "Of the Danger of keeping the Body too warm."
110. Francis Fuller, *Medicina Gymnastica* (London 1705), 219–21.
111. King, 50–52.
112. Georges Vigarello, *Concepts of Cleanliness: Changing Attitudes in France since the Middle Ages*, trans. Jean Birrell (Cambridge: Cambridge University Press, 1988), 114.
113. Thomas Laqueur, *Making Sex: Body and Gender from the Greeks to Freud* (Cambridge, Mass.: Harvard University Press, 1990), 28–29.
114. Glisson, 36.
115. Vigarello, 119–20. See also Michael Stolberg, *Experiencing Illness and the Sick Body in Early Modern Europe* (Basingstoke: Palgrave, 2011), "Pathological Heat," (139–42).
116. Charles W. Bodemer, "Regeneration and the Decline of Preformationism in Eighteenth Century Embryology," *Bulletin of the History of Medicine* 38 (1964): 20–31; Virginia P. Dawson, *Nature's Enigma: The Problem of the Polyp in the Letters of Bonnet, Trembley and Réaumur* (Philadelphia: American Philosophical Society, 1987), 42–45; Jacques Roger, *The Life Sciences in*

Eighteenth-Century French Thought, ed. Keith R. Benson, trans. Robert Ellrich (Stanford: Stanford University Press, 1997), ch. 6.
117. Chamber, s.v. "stamina."
118. Ibid.; Clifton Wintringham, *An Enquiry into the Exility of the Vessels in a Human Body* (London, 1743), 9–10.
119. Cf. Walter Pagel, *William Harvey's Biological Ideas: Selected Aspects and Historical Background* (New York: Hafner, 1967), 239.
120. Chamber, s.v. "stamina"; also N. Bailey, *An Universal Etymological English Dictionary* (London, 1730), s.v. "stamina."
121. Keill, *Secretion*, 127–28.
122. Boerhaave, *Method*, 155. Sometimes, the stamina were said to be contained in the animalcule; Wintringham, *Exility*, 2–3.
123. Arbuthnot, *Aliment*, 43.
124. M.N., 93; Martin, 298.
125. Wintringham, *Exility*, 18–19. Cheyne, an ardent supporter of the encasement doctrine, claimed that the infinite number of animalcules should exist "in the bigness of a pin's head"; Cheyne, *Remarks on Two Late Pamphlets Written by Dr. Oliphant, against Dr. Pitcairn's Dissertations* (London, 1702), 43–44.
126. One aspect of Needham's criticism of preformationism was on precisely this point, that is, the disproportion between "the great Expansion of the Web and minuteness of the animalcule"; Turbervill Needham, *Observations upon the Generation, Composition, and Decomposition of Animal and Vegetable Substances* (London, 1749), 6.
127. Clara Pinto-Correia, *The Ovary of Eve: Egg and Sperm and Preformation* (Chicago: University of Chicago Press, 1997), 31.
128. *Remarks*, 44; also Cheyne, *Health*, 203–4; *Natural Religion*, 232.
129. Cheyne, *Gout*, 79; also Cheyne, *Health,* 203–4; James, s.v. "fibra" [23].
130. Chambers, s.v. "fibre."
131. Bailey, s.v. "stamina."
132. Chambers, s.v. "solids"; also see OED, s.v. "stamina." Cf. Floyer, "The complaints of *Mala stamina vitae*, when the *Web* and the *Woof* are not well struck together" (282).
133. Daniel Turner, *De Morbis Cutaneis, A Treatise of Diseases Incident to the Skin*, 2nd ed. (London, 1723), 169; also Cheyne, *Regimen*, 174; Needham, 8.

134. See Mary Lindemann, *Medicine and Society in Early Modern Europe* (Cambridge: Cambridge University Press, 1999), 12–13.
135. Short, *Corpulency*, 63.
136. Browne, xxii; Robinson, *Spleen*, 17–18; but see Arbuthnot, *Aliment*, 146, on an alternative view of the fluids affecting temperaments.
137. Robinson, *Spleen*, 19–22.
138. Cheyne, *Health*, 82–84.
139. Short, *Corpulency*, 55.
140. James, s.v. "fibra" [10].
141. Short, *Corpulency*, 56; also James, s.v. "fibra" [10].
142. James, s.v. "fibra" [10].
143. Cheyne, *Health*, 160.
144. Robinson, *Spleen*, 30ff.
145. Ibid., 56–57.
146. Ibid., 65, 73.
147. Blackmore, 263–64. Cf. Cheyne, *Health,* 82–84; he mentioned two kinds of human races—those that govern and those that are governed.
148. Cheyne, *English Malady*; idem, *Health*, 82.
149. Ibid.; Blackmore, 90.
150. See on this point Barker-Benfield.
151. Cf. Robinson, *Spleen*, 15.
152. Short, *Corpulency*, 63–64.
153. Tennent, 1–4. Tennent cautions that "tho' a person leaves England in the most healthful State, the Constitution must undergo a Change, that threatens to terminate in a stagnation of the Blood, perhaps a total Stagnation, which is *Death*, and indeed is too often the Case" (3).
154. See H.F. Augstein ed., *Race: The Origin of an Idea, 1760–1850* (Bristol: Thoemmes Press, 1996); Nancy Stepan, *The Idea of Race in Science: Great Britain, 1800–1960* (London: Macmillan, 1982). Charles White, a disciple of John Hunter, in his *An Account of the Regular Gradation in Man, and in Different Animals and Vegetables* (London, 1799) appropriated Camper's theory of facial angle to the racial hierarchy of human race (134 and passim).
155. See L.S. Jacyna, "The Romantic Programme and the Reception of Cell Theory in Britain," *Journal of the History of Biology* 17 (1984): 13–48.

CHAPTER 3

Elasticity of Animal Fiber: Motion, Tone, and Life of the Fiber Body

1 Introduction

In the early 1720s, George Cheyne, an iatromechanist of a Newtonian bent, extolled the medical concept then in vogue among iatromechanists—"Elasticity"—as "the noblest Instrument of all the Action and Functions of an animated Body."[1] The lavish eulogy conferred on elasticity, however, seemed to be rather abruptly curtailed by the harsh condemnation of it from the ranks of people, we may loosely call iatro-vitalists. The vitalists, equating elasticity with the mechanical property as such, severely downplayed the mechanical body image favored by iatromechanists in favor of their purportedly new concepts of sensibility, irritability, or other related concepts of the life-principle. Thanks to the vitalists, as late as 1750 the body came to be seen as a living organism fully endowed with the life-principle, rather than as an automaton-like machine largely executed by the mechanical property of elasticity. The overall shift from mechanism to vitalism seemed to be so radical and irreversible that even Alexander Monro *primus*, once a good pupil of Boerhaave, the doyen of iatromechanism, changed his mind as the century progressed and opposed his master's doctrine: "it is not merely by Elasticity the arteries of living animals act, they have also an energy which Life communicates to them as well as to the other contractile parts of the body."[2] Totally devoid of life, the concept of "elasticity" was, for vitalists, seen as the obverse of their idea of life-principle elements such as sensibility and irritability. Our modern assessment of elasticity in eighteenth-century medicine has unfolded in

H. Ishizuka, *Fiber, Medicine, and Culture in the British Enlightenment*, DOI 10.1057/978-1-349-93268-9_3

the shadow of the eighteenth-century vitalists' evaluation of it, encouraging a view of the "elastic" body as merely "mechanical." In fact, the rather scant scholarly attention paid to the concept of elasticity from this era clearly reflects our low estimation of it. One of the purposes of this chapter is to re-assess the importance of the idea of elasticity of the animal fiber in its own right, that is, in its specific historical terrain; in doing so, I want to suggest that, far from being an ephemeral concept disappearing in the face of the ascendancy of vitalistic theory, elasticity in fact served as the mediator between mechanism and vitalism, and even more, it was the crucial concept for reconsidering the vexed relationship between them.

Another principal aim of this chapter involves the contentious issue of the body image (or the body model) articulated in medico-cultural discourses of the Enlightenment. Broadly speaking, the great majority of scholars have agreed that the body image or model abiding epistemologically in the imaginations of philosophers, medical men, and the learned elite underwent a substantial shift from being a mechanistic model originating in the Cartesian automaton and working just like a clock to being a vitalistic organism endowed with sensibility perceptively interacting with its surrounding environment. Sergio Moravia set the general outline on this issue in his seminal essay, in which he surveyed a general shift from the mechanism of the early eighteenth century to the vitalism of the latter half of the century which dictated that "[the body] is no longer a machine, but an *etre sensible*," which possesses "dynamic forces and impulses" that "have nothing to do with the working of a machine."[3] Even otherwise-astute scholars like Barbara Stafford follow the steps paved by Moravia in her characterization of the image of man in a flourishing passage typical of her style: "The living human being was no longer the Cartesian inflexible machine, manufactured from clockwork cogs and wheels…. Rather, the organism was a sensible fluidity, shaped by the equally mutable environment."[4] Such general shift of the body image from "Mechanical Man" to "Sensible Man," from a machine to an organism, would become convincing, by paralleling it with something like the shift in medical theory from iatromechanism (the concept of the vascular system in which the heart as the principal spring of motion acts independent of mind or soul) to vitalism (in which the brain and the nervous system work as a central reactive organism in service of mind, soul, or life-principle).[5] It is not my aim to deny wholeheartedly this general shift. Bringing the concept of elasticity to the forefront, I want simply to suggest in this chapter that underlying the seemingly radical rupture between machine and life, is a strong element of continuity.

In the first section, I shall elucidate what sort of body image was conceived in iatromechanism, and what role the elasticity of animal fibers played in it. The argument of this section touches on the subject of the "body image." In the second section, I shall explore the contentious idea of "motion" as it emerged in iatromechanics, and appropriation of the concept of elasticity in establishing the fiber as the agent of motion. Motion is thus the main subject of that section of this chapter. I shall trace the important shift in the view of motion from the classical to the modern, via Harvey's unacknowledged contribution to the development of the idea of motion. In the final section, I shall delineate the aftermath of "elasticity" from the mid-eighteenth century on, showing how the concept of elasticity was assessed and misrepresented by the newly emerging vitalists. Analyzing the implication of the idea of elasticity elucidated in the previous sections, I shall suggest that the spectral but strong presence of "elasticity" pervades the new vitalist concepts of sensibility and irritability.

2 The Body in Iatromechanism

2.1 The Vascular Body

The mechanical body image referred to by Stafford and Moravia is largely predicated upon the Cartesian automaton, and does not really refer to the idea of the mechanical body conceived by iatromechanists of the early eighteenth century. Exemplified in the mega-system of Herman Boerhaave, iatromechanism was the most successful and widespread medical theory at the time. Many British medical men crossed the sea to the Netherlands in order to study medicine at Leyden University where Boerhaave achieved his triumph. These medical men imported the teachings of Boerhaave into Britain. In particular, the Edinburgh Medical School, founded 1726, was so enormously influenced by Boerhaave's system that when Cullen, in his lecture conducted in the latter half of the eighteenth century, exposed an opinion of the nature of diseases different from that of Boerhaave, he was seriously cautioned by his patron not to contradict Boerhaave's theories.[6] Such medical figures as Alexander Monro *primus*, George Cheyne, James Keill, John Quincy, Richard Mead, and Thomas Morgan, whom we will encounter in subsequent sections of this chapter, could all be loosely classified as iatromechanists in spite of their different intellectual, social, and cultural backgrounds, in that they all animadverted on both iatrochemistry and animistic theories that had been popular from the middle of the seventeenth century. These iatromechanists opposed both the animist view that the animal body in every corner was governed and administered by the omnipresent soul, and the iatrochemists who relied upon the (ultimately) occult notions of fermentation, effervescence, and putrefaction in order to explain an animal economical functioning. Instead, these men deemed the animal body to be an intricately complex machine, the maintenance of which depended on the uninterrupted circulation of the blood from the heart, the machine's center, to the peripheral members. In terms of what model or image, then, did they conceive the machine body? In other words, what did they need to get the machine calibrated?

It is arguably correct to say that iatromechanists would dismiss the image of the clock-like device as the model for the animal machine, for although the notion of the animal body as clock was sometimes effectual in a strictly figurative sense (the animal body works *like* a clock, independent of transcendental, supernatural, or occult agents), the cogs and wheels were not the image that iatromechanists wanted to exploit (the animal machine is not a clock that is composed of cogs and wheels).[7] Instead, what they empirically observed inside the body was the indisputable fact of the vascularity of the body—the animal body was wholly composed of numerous vascular tubes, pipes, vessels, or canals, as they were variously called. The iatromechanical view of the vascular body or the vascularity of the body was widely shared among many medical men of the era. Keill in 1708 announced that this idea was "now agreed on by all who understand the Fabrick of the Body," assuming, for his part, that "the whole Body is nothing but *Tubes* or *Vessels* full of Blood or Liquors separated from it."[8] Cheyne also confessed his loyalty to the iatromechanical view of the body: "We know very well that there is nothing in the *Animal Machin*, but an infinity of branching and winding Canals, fill'd with Liquors of different Natrues[sic], going to some perpetual round."[9] One example that illustrates the entrenchment of this idea in a wider sphere outside the medical world can be found in an assertion of Addison in one issue of his hilarious *Spectator* (1711): "I consider the Body as a System of Tubes and Glands, or to use a more Rustick Phrase, a Bundle of Pipes and Strainers."[10]

This vascular body, composed of an infinite number of hollow tubes and pipes running through the body like a maze, is customarily referred to as the hydraulic machine, with the heart-engine as the center of the animal machine. Monro *primus* remarked on the image of the animal machine, "if we have any notion of an Animal, it is its being a Hydraulick Machine, which has Liquors moving in it as long as it has Life."[11] To the extent that these tubes were made of a hollow thread-like substance, it made little difference whether they were called tubes, pipes, or vessels. The crucial thing was that there was a hollow space inside the thread-like substance, through which bodily fluids could run and circulate around the whole body. The unobstructed circulation of the blood and its derivative fluids from the heart, which worked like a pump, through the winding canals to the extremities was regarded as life itself; as one obscure medical writer put it succinctly, "Life it self…is, in one Word, the Circulation of the Blood."[12] Moreover, all animal functions such as sensation and motion, whether voluntary or involuntary, depended on circulation.[13] If some condition arose (e.g., the pipes became too rigid or flaccid, or the humor became viscid because of indigestion) to obstruct the free flow of the fluids, disorderly function of the animal economy would result, and sometimes cause a variety of diseases. Flow and obstruction, ostensibly simple phenomena, underwrote the physiological system of iatromechanists, and this economy of circular physiology required, and was required by, the vascular body anatomically understood and explored. What the iatromechanists drew on in configuring the image of the animal body was not the image of cogs and wheels but predominantly that of tubes and the pipes. In fact, the vascular body has a longer history traced back to seventeenth-century anatomists' and physiologists' concerted efforts to unearth the clandestine interiors of the body, and to microscopists' as well as natural philosophers' intense study of the micro-structure of bodily texture. Microscopic discoveries by Leeuwenhoek, Malpighi, Swammerdam, and others in the seventeenth century played an especially important part in the construction of the view of the vascular body, revealing the hollow space of the vessels in which the bodily fluids were supposed to run. At that time, the physiology of secretion was deemed to be the key to unlocking the mysterious process of life function. The doctrine of vascular secretion in tandem with the view of the vascularity of the body, both developed by seventeenth-century physiologists and anatomists, became the new basis of mechanistic physiology, which was superseded in the early eighteenth century by circulation physiology.[14] But here it suffices to say that the iatromechanists' hydraulic machine was distinguished more by its vascularity, with innumerable tubes and pipes running through, and composing, the body, than by its subordination to the laws of mechanics, statistics, and hydraulics.

2.2 Elasticity and Fiber

And yet, was this eighteenth-century iatromechanist model of a hydraulic machine, or the vascular body, really different from a Cartesian animal machine? Descartes also constructed the image of the body on the basis of the hydraulic machine, and many other outstanding iatromechanists of the seventeenth century, such as Borelli, Bellini, and Pitcairn, compared the animal body to an artificial hydraulic mechanism that functioned in terms of statics and hydraulics.[15] So, then, what is the difference between the vascular body of the eighteenth century and the hydro-static machine of the previous century? La Mettrie's note to Boerhaave's *Institution* provides an interesting hint on this point, as he questions the validity of the mechanical analogy and the applicability of hydro-mechanics to medicine, concepts he thought of as Boerhaaverian. La Mettrie, once a pupil of Boerhaave, pointed out that "were its [the human body's] vessels metal tubes…, the [hydro-mechanical] principles would then be sufficient to explain their actions," but the "metal tubes" of machinery were obviously different from the vascular tubes of the human body, which were "made up of elastic fibres admitting reciprocal elongation and contractions"; therefore the fluids of the human body did not follow the laws of hydraulics or hydrostatics.[16] Although La Mettrie rather deliberately reduced his master's theory to one addressing a strictly limited mechanism, whereas Boerhaave himself conceived of the body as involving an interaction between the solid elastic vessels and the fluids (the body as "an Assemblage of small elastic Solids"),[17] La Mettrie's criticism of a presumably Boerhaaverian system serves to throw into a sharp relief the difference between seventeenth-century mechanism and its eighteenth-century counterpart—the belief in the "elasticity" of animal fibers. The iatromechanists' hydraulic, vascular machine was not a hydro-static one traversed by a series of hollow "metal-like" tubes, through which the circulating fluids passed, nor was it a Cartesian machine the center of which was a furnace-like heart burning a "fire without light" to send off the blood; rather, it was a flexible, or more precisely, elastic machine, the components of which were not metal tubes but elastic fibers. Elasticity and fiber were thus what distinguished eighteenth-century iatromechanism from the previous century's mechanical theories.

The elasticity of animal fiber was, as it were, the linchpin of iatromechanist theory, although it has been paid only scant attention by medical historians. Cheyne's encomium to the function and property of fiber which I mentioned in the opening of this chapter is worth citing again: "[Elasticity] is the noblest Instrument of all the Action and Functions of an animated Body…. Growth and Motion both, that is, the whole Business of the Animal Life, is owing to the Springiness of these *Fibres*. … And in this Contraction and Restitution of an Animal *Fibre*, the greatest Mysteries of the whole Structure consist."[18] Like Cheyne, most iatromechanists maintained that any vital motions (animal life) were not calibrated without this essential property. Browne Langrish was only one of those who embraced this idea in saying that "[w]ithout this Property in the Fibres, Life could not subsist but a few Hours, or perhaps Minutes,"[19] and claimed that the theory of diseases owed much to the knowledge of elasticity.[20] What was, then, the elasticity in which "the greatest Mystery" of the body was supposed to lodge, and how did it sustain life?

First of all, elasticity was not merely a property of being flexible. More precisely, elasticity was defined as the innate property of the fiber by which it endeavored to restore itself to its former (natural) state when the fiber was stretched to any length beyond its natural state. Elasticity was the inherent power of restoration and restitution residing in the solids composing the fibers.[21] As I shall argue below, the actively motive power formerly supposed to reside in the fluids was by this time found in the solids, and this active power of the solids came to be identified with elasticity: "'tis certain in Fact that the Solids are indued with Elasticity, as a constant uniform Spring or Power of Motion," while the fluids had no such property or active force at all.[22] At its most extreme, this "original active Force" of the solid-fiber was absolutely independent of the bodily fluids; it did not depend on any force derived from animal spirits or subtle juices secreted from the brain or any other parts,[23] or on the mixture, effervescence, or rarefaction of any fluids or liquids.[24] That this power was essentially intrinsic to the solids was evidenced by the fact that when the fibrous bodies (muscular fibers) were taken out of the body, they contracted and restored themselves against any stretching force.[25] However, it would be impossible for life to maintain itself only by the power of the solids; the very power of the solids to return to their original state would not be initiated without being triggered by some external force added to them in the first place. Even though Morgan, an ardent adherent of solidism, exorcised the motive power from the fluids, he admitted the natural action of the fluids to distend and stretch the vascular parts, against which the solid-fibers exerted a continual effort to restore themselves.[26] On this mutual interaction between the fluids' distension and the elastic fibers' contraction depended all the motions and functions of the animal body, including the circulation of the blood, the most vital motion of animal economy.

2.3 The Body as a Muscular Heart

For iatromechanists, life depended on the circulation of the blood—but how was the blood, the universal fluid, made to circulate? It was not thought to be effected by the innate property or principle of the fluids, for as seen in Morgan, most iatromechanists did not admit the fluids to have the active self-principle ("self-moving Principle"[27]). It was only the impulses from the solids, that is, the muscular heart and the fibrous parts of the vessels, that propelled the blood to move; in other words, the blood was supposed to circulate not only by the impulse of the heart but also by the elastic power of the fibrous vessels: "The Fluids of the Body are principally propelle'd, by the Action of the Heart, and the *elastic* Force of the Fibres of the containing Vessels."[28] As the muscular composition of the heart allowed itself to propel the blood, so the complicated mechanism of a muscular composition of fibrous vessels enabled the blood to circulate. For example, the coats of the artery were thought to consist of three layers, the middle of which was composed of the "muscular fibres" in service of "*Muscular Action*."[29] It is important to note here that the muscular fibers not only entered into the "muscles" in a narrower sense of the word, but also insinuated themselves into other bodily parts that were not ordinarily regarded as "muscles," such as the glands and the (blood) vessels. Morgan's vision of the ubiquitous presence of muscular fibers is a case in point. For him, the muscular fibers were "every where twined and interwoven with the Blood-Vessels, not only in the Muscles strictly so called, but also in the Glands, the muscular Coats, and universally wherever any Blood-Vessels [were] to be found."[30] The fibrous coats or membranes were identified by Cheyne with a kind of muscle, or at least he deemed that they worked as the muscles did: "when ever a Coat consists of *Fibres* of whatever kind, excepting those for *sensation* or *Nutrition*, it is a sure *Indication* that this Coat acts as a *Muscle*."[31] The sum of the force exerted to pump the blood was sought in all the elastic (muscular) fibers taken together, and the force of the heart was only a share of it.

The ubiquitous presence of the muscular fibers throughout the body is further confirmed by the universal circulation of the blood, the pathway of which is not limited to the blood-vessels in their strictest sense. As Keill claimed, the blood not only referred to the bodily fluids running through the blood-vessels, but also designated the animal fluids in general that passed through the innumerable pipes and vessels, the source of which originated in the blood: "by Blood I understand not only the Fluid in the Veins and Arteries but likewise that in the *Lymphatducts*, *Nerves*, or any other Vessels of the Body, because they are all Parts of the Blood, separated for it by the Force of the Heart."[32] John Quincy's illuminating survey of the whole course of circulation epitomizes what iatromechanists envisioned as the universal circulation of the fluids and the ubiquitous presence of the muscular fibers. Quincy, a perspicacious iatromechanist of a theoretical bent,[33] in his essay on gout elaborated his view on the system of circulation, which he divided into three stages in accordance with the traditional process of digestion ("concoction"), equating the process of circulation with that of digestion. The first stage begins with the stomach and intestines (which also indicates circulation was imagined to be a kind of digestive process preparing for animal fluids) where the chyle, being concocted, infused through "Lacteals" into the blood, which was itself sent off to the second scene of "Digestion and Alteration"; the second circulation was done in the heart and arteries where the finer animal fluids were prepared to be properly secreted by the principal glands or viscera, the semen by the testicles, the bile by the liver, and so on (and what could not be attenuated finely enough for further secretion was to be strained off by the kidneys and ejected by urine). The last stage of circulation and digestion was in the "*Fibres*," those "fine Threads of which the Solids of the whole body" were "formed." The animal juices prepared here in "the most minute Meanders" were diffused into solids with their due moisture and nourishment. In this last circuit, the primal force to circulate, digest, and attenuate the animal fluids into the most minute particles was not the power of the heart or the arteries as in the second stage, but the "tonick, elastic Force of the *Fibres*."[34] What Quincy imagined here is the muscularly active, elastic process in which the solid-fibers vigorously exerted a kind of muscular motion in their whole body, that is, in the solid-fibers as a whole. The whole mass of fluids ("Humours") is thought to keep moving by "the Undulations, Vibrations, and Concussions of the *Fibres*" proceeding from their natural elastic force.[35] The regular alternate motion of dilation and contraction, systole and diastole of the muscular heart, was processed not only in the heart and arteries but also in almost all the other solid parts wherever the muscular fibers were insinuated. The elasticity or elastic power of the fibers—a contractile motion to restore the prolongation of the fibers to their former state—precisely recapitulates what the muscular heart exerted, an alternate movement of systole and diastole.

According to Keill, the "Fibres of the Muscles" occupied by far the greatest part of the body.[36] It should be noted here that the term "fibres" designates not only the muscular fibers in a narrower sense of those that entered into the muscles and composed them, but, as in the case of Cheyne, Morgan, and Quincy, it also refers to the elastic fibers that enter and interweave ubiquitously into the solid parts. Morgan saw the lungs as the muscles, the glands as the "secretory" muscles.[37] Given that the whole body is composed of the fibers, it could be argued that the body imagined by iatromechanists is predicated on the model of the muscular movement of the heart. This would be all the more cogent if we compare Quincy's three-stage system of circulation to the traditional view of three-stage concoction process, successively done in the gut, the liver, and the various parts of the body. Quincy in a sense modified the démodé system of digestion in light of a newly fledged medical theory. Quincy's iatromechanically updated version of the digestive system was the newer counterpart to the older idea that the human body is just a giant stomach. In the old system, digestion is something that does not happen exclusively in the stomach but occurs throughout the body, so the human body could be seen as a stomach constantly concocting[38]; in the new system, circulation and digestion happen not exclusively in the heart and the blood-vessels, but occur wherever the fibers are present, so the human body could be seen, as it were, as a giant heart whose muscular movement is to be reflected everywhere in the body. It is true that the idea of the body and animal economy of iatromechanism is predicated on the dynamics of the hydraulic machine, and yet that is not sufficient to apprehend fully the way in which iatromechanists perceived the body. The muscularly moving body, a body that acts, moves, and exerts itself just like a muscular heart—this is precisely what iatromechanists imagined in light of their fashionable new medical system.

3 Elasticity, Fibers, and Motion

3.1 Motion, Muscles, and the Will: The Classical View of the Muscular Body and Its Rupture

One might argue that such a muscular body image has a long history, reaching far back to ancient Greece and Rome, where the figures of gladiators were displayed, and manifesting itself since then in the figures of the muscular man that have been widely produced in a variety of forms throughout human history, most prominently in the *écorché statuette*.[39] Especially after Vesalius's innovative anatomical research, myology (the study of muscles and their anatomy) as well as muscle physiology always occupied one corner of medical studies; the recurrent display of the figures of muscular men in the anatomical tables would reflect medicine's preoccupation with muscularity and the muscular body. So, what is new about eighteenth-century iatromechanism with regard to the muscular body? One might also feel that I have conflated muscularity with elasticity, so that the elastic body was misleadingly equated with the muscular body. In response to these concerns, I shall unravel the historical complexity with which elasticity was invoked and gained a firm foothold in a new medical system.

Generally speaking, the notion of elasticity was scientifically adopted first by Jean Pecquet, a seventeenth-century French physiologist, to denominate the impulsive or propulsive force of the air, a phenomenon already known by some natural philosophers like Pascal and Giles Persone de Roberval. Literally translated from the Greek noun, *elater*, the term, "elasticity," was widely used and standardized by English natural philosophers such as Walter Charleton, Henry Power, and Robert Boyle ("spring" and "springiness" were the favorite terms for Boyle and Hooke).[40] Seventeenth-century iatrochemists attempted to explain away the otherwise clandestine phenomena of animal economy by applying the notion of the elasticity of air to the bodily fluids. The concept of the elasticity of air and its adaptation to the system of bodily fluids still enjoyed popularity among medical men well into the eighteenth century; one has only to review Richard Mead's position on the tenuously elastic atmosphere, or Keill's view on the blood's particles hitting and deflecting off one another by the virtue of elastic power.[41] In this light, the introduction of the concept of elasticity into the solid-fibers could be said to derive from the concept originally attributed to the fluids. However, I wish to show here an alternate route, the origin of which can be traced back to the ancient era.

Since Roman times, motion or movement had largely been divided into two kinds: voluntary motion/movement, in which the will intervenes, and involuntary motion/movement, which is totally independent of the will—a movement such as digestion, respiration, or pulsation of the heart. Galen was one of the earliest physicians to carve out muscles as a critical agent in movement, and claimed that the muscles were the "instrument of the will."[42] Before Galen, muscles were very sparingly referred to, for example by Hippocratic writers who deemed muscles simply a kind of flesh, and preferred to argue using the terms "sinew/tendon" or "flesh." Yet, by the time Galen wrote his magnum opus, it became indispensable to argue about muscles, largely because they articulated the autonomous agency of the willed subject.[43] We can walk, run, jump, talk, or walk slowly or speak quickly, because we have the organs of motion called muscles, which are the instrument of voluntary motion—that is, the instrument of the will. We can walk slowly when we will (choose) to do so. As Kuriyama shrewdly pointed out, the concatenation of muscles, will, and the autonomous agent are intimately related to the emergence of the particular conception of the Western subject that identifies us as genuine agents.[44] Ever since Galen, the notion that muscles were the embodiment of the will had remained a firm belief among medical men. John Bulwer's rather outdated treatise on muscles, published in 1649, provides us with an illustrative case. Here, Bulwer summarized what had been recurrently claimed of muscles and the will:

> The neerest and immediate *Instrument* or the *Motive Faculty* for the exercise of *motion*,…is a *Muscle*; from whence *moving* proceeds, as from a *Motor*, whence among Physicians it is reciprocal and Convertible, to *move* and to have *Muscles*: for, no part without the endeavour of a *Muscle*,…is stirred up to any *voluntary motion*:…. And there is no *Muscle* to be found in the Body, but it can expedite such *voluntary motion*. Since all *voluntary actions* of the Soul are perform'd by *motion*, and all *motion* necessarily implyeth the use of *Muscles*.[45]

Moving is equivalent to having muscles; conversely, having muscles always indicates motion. Similarly, the willed movement of the soul (voluntary motion) is to be executed by the use of muscles; the use of muscles in turn marks that there is always a will. Almost 50 years after Bulwer's essay on muscles was published, and when intense interest in muscular physiology began to surge, Boulton, one of the muscle physiologists and anatomists of the new era, could still rehearse the hackneyed panegyric on muscles: "Muscular Motion is the very *Index Animi*…. It's the Ultimate Result of our most secret Thoughts and of our Will….[A] Muscle should be termed an Ignoble part."[46] By loss of a single bit of muscles, our faculties, natural, vital, or animal, would be significantly vitiated. So, muscles' nobler use contributes to the "perfection of Man."[47]

Thus, it could be argued that in the classical view of a muscular body or muscularity, the will, its immediate instruments (muscles), and their external embodiment (motion), taken together, composed the triple unit (trinity) constituting the kernel of living human beings. The figure of a muscular body externalized this classical trinity concerning muscles. And yet, there occurred a rupture initiated largely by Harvey's discovery of the circulatory system, that would undermine the linchpin of the classical view of muscularity. In short, before Harvey, most anatomists did not assume the heart to be composed of muscles, because the pulsation of the heart was an involuntary movement, which required no voluntary will, and therefore needed no muscles. In effect, Galen dismissed the anatomically proper but very vague view presented in the Hippocratic treatise *On the Heart* that the heart had some kinds of muscles, and he did not admit any kinds of muscles to exist in the heart simply because it moved of its own accord, independent of the will.[48] What would happen, however, if the heart, the exemplar of the agent of involuntary motion, were found to be composed of nothing but muscles? Surely it would highlight a serious contradiction. This had possibly occurred to medical men since Harvey's physiological discovery of the circulation of the blood and his insinuation that the heart functioned like a pump had served to direct their attention to the mechanical cause of the involuntary motion of the heart. Certainly, it was not Harvey who first asserted that the heart was composed of nothing but muscles; it was Steno of the Netherlands in 1664, and then Richard Lower of England in 1669. But Harvey delivered the decisive stroke in making the contradiction (that involuntary motion does involve muscles) visible and distinct, for his discovery of the circulatory system initiated the subsequent anatomical research into cardiac musculature.[49] Even early in the eighteenth century, the deeply felt contradiction was still present in a medical textbook written by Peter Paxton, in which he explained the mechanism of voluntary and involuntary motions: voluntary motion was performed by muscles, which were the "the direct and proper Instruments of voluntary Motion" employed at "the Will of the Man," whereas involuntary motion was performed by "the membranous parts" independent of the will. But Paxton conceded the one exception to this rule; there was an organ that was entirely muscular but whose motion was involuntary, "there being but one part purely and intirely Muscular imployed in that [involuntary] Motion, viz. the Heart."[50] Paxton left this contradiction unresolved.

So, how can this paradox be resolved? It seems to me that most effective way to clear up this problem would be to establish a new micro-agent of motion, voluntary or involuntary, instead of the muscles as the gross-agent of voluntary motion. The new agent that could compensate for a fissure in the classical idea of muscular motion brought forth by Harvey's anato-physiological discovery of the heart would be precisely the fiber, endowed with elasticity, an essential functional property of the solids.

Harvey himself anticipated that the fiber could constitute an agent of motion. A good pupil of a prominent Italian anatomist, Fabricius, whose favorite themes of study included muscular motion, Harvey spent much time on the study of muscles and muscular movement between 1616 and 1628; part of his achievement can be found in his Latin manuscript, *De motv locali animalivm* (1627), a seemingly scholastic explication of previous writers' opinions on the muscles.[51] Here, Harvey, in his usual manner, deliberately found a way to uphold Aristotle's view of muscular motion by almost misconstruing Aristotle's term "*nervus*" as "sinew," and by drawing on the authority of Fabricius and Riolan who maintained that the chief organ of movement was in the sinewy parts of the muscles not in the flesh, a point favored by Aristotle. In fact, quite contrary to received opinion, Harvey's Aristotle is familiar with muscles, referred to by Aristotle as "*nervus*," which means either "sinew" or "nerve," depending on the context in which the term appears. Galen took the word to mean "nerve," and so judged that Aristotle did not know about muscles.[52] But Harvey almost always interpreted Aristotle's "*nervus*" as "sinew," and assumed that Aristotle rightly attributed motion to sinews. "Aristotle…says that movement is to be related more correctly to sinews….[T]he heart is abundantly supplied with sinews on account of the movement."[53] In face of the nomenclature issue, Harvey boldly suggested that the principal organ of motion should be properly called "sinews" (*nervi*) rather than "muscles"(*musculi*).[54] And after surveying Fabricius and Riolan's opinions on muscles, he went further by saying that since the sinew is a "simple particle" whereas muscle has a complex structure, it is better to posit a "multiplicity of fibres" as a single unit for a principal organ of motion, some of which can or cannot be stretched while others do otherwise. These considerations eventually led Harvey to propose a more correct term than "sinew": "Is it not more correct to term the fibres [*fibrae*] concealed in the heart and in the intestines, and wheresoever there is movement, sinews and fibres rather than muscles?"[55]

We might construe Harvey's intimation of the fibers as the principal organ of motion as a prefiguration of what eighteenth-century iatromechanists wanted to embrace—all the more so because his fibers were "concealed in the heart and in the intestine," the motion of which was involuntary. These muscular fibers that Harvey pre-empted were not the noble organs called muscles, as the traditional anatomists would extol. Harvey's fibers were much closer to the fibers that Cheyne would acclaim in his comments on the elasticity of the fibers as the noblest instrument of all the actions and functions of the body. I am not arguing here that iatromechanists had in mind Harvey's idea of fiber as an agent of motion; rather what I wish to contend is that the dilemma occasioned by Harvey's investigation of the heart and the circulation of the blood, and his incipient idea of the fibers as a solution to this dilemma, would account to a significant degree for the development of the idea of "motion" in general and of the "elasticity" of the fibers in particular. The classical view of muscularity dictated that wherever there are muscles, there is movement, and therefore there is will. After Harvey's rupture with the classical view of muscular motion, the iatromechanists would rather have said that wherever the fibers are, there is motion, and therefore there is involuntary non-will.

As I discussed above, Paxton was not able to solve the contradiction of the motion of the heart, which was both muscular *and* involuntary, precisely because he couched his theories in the classical paradigm of muscularity; the idea of fiber as a new micro-agent of motion was therefore unavailable to him. The new way of seeing muscular motion, however, had already been propounded by Jean-Baptiste Verduc, a French anato-physiologist at the turn of the eighteenth century, who committed himself to the "modern" paradigm of muscularity. For Verduc, the classical way of treating motion and muscles was no longer effective. He categorically denied the ancient distinction between voluntary ("animal") and involuntary ("natural") motions, and claimed that the motions of the involuntary parts (the lungs, the intestines, and the heart) were not different from those of the voluntary parts, because there was now a relatively new consensus that "the Heart is a true Muscle." Like the iatromechanists discussed in the previous section, Verduc postulated the view that all the parts of the body were "nothing but Muscles expanded or dilated."[56] But the "muscles" he designated here were not the same muscles as the those responsible for voluntary motion (as dictated by the classical view of the muscles and motion), since they were also found in the involuntary parts—and, as the modifiers “expanded or dilated” in fact illustrate, the “muscles” to which he referred were grounded in involuntary motion rather than voluntary. He thus relied mostly on the notion of the (muscular) fibers rather than on the muscles for explanations for the agents of motion, his opinions seconded by the latest achievements of his contemporaries such as the muscle physio-anatomists Steno, Borelli, Willis, and Mayow.[57]

Such a new way of seeing muscles, based primarily on involuntary motion rather than voluntary and on the concomitant idea of fiber as the micro-agent of motion, became firmly entrenched in the minds of medics as the century progressed. When Alexander Stuart put forward a general scheme of muscular action in 1739, he was deeply immersed in the full implication of the refurbishment of the concept of muscles and motion. “The universal instrument of all animal motion,” he argued, was “a MUSCLE.”[58] But, as in Verduc, the “muscle” Stuart designated was not that of the classical view of motion, for Stuart proclaimed the existence of “the smallest muscular fibres” which comprised the muscle to be the agent of motion.[59] Referring to Glisson’s experiment of the fibers, he further contended that each small fiber had “an alternate diastole and systole,” manifesting the very involuntary movement that the heart represented.[60] So, all animal motions, voluntary or involuntary, were assumed to be executed by the “muscles” understood by the common epithet of “fibers.”

Certainly, the idea of fiber as the agent of motion was not new; most anatomists had assumed that motion was executed in the direction determined by the arrangement of the muscular fibers (whether they were oblique, lateral, spiral, etc.), and since the sixteenth century, the fibrous structure of muscles had been meticulously observed and analyzed by anatomists. But it was only in the area of the morphological function of the fibers that anatomists researched intensely; the fibers in this sense were the ancillary instrument, an instrument of the instrument (muscles) of the will, for they served as a proper channel for the spirits or *pneuma*, which were sent off by the ordinance of the will (mind) to travel along the properly arranged lines that the fibers determined to direct.[61] In this case the fiber was the epithet of the muscles, the agent of the will, while in the new iatromechanistic view, the “muscle” was the epithet of the fiber, primarily the agent of the non-will. In other words, the view of the fiber as the morphologically determining agent of motion, which became increasingly sophisticated in the latter half of the seventeenth century, still remained within the classical paradigm of muscular motion and muscularity. When the fibers are said to embody the agent of motion in the new, iatromechanist sense, they must be assumed to encompass the physiological, motile, and kinetic function—exemplified as the involuntary motion of the heart's diastole and systole—rather than the anatomical, morphological, and structural one. And the notion of elasticity, which was by the early eighteenth century assumed to be inherent in the fibers, would be exploited by iatromechanists for the functional agent of motion.

3.2 Moving, Vibrating, and Living: A Shift in the Idea of Motion

It could thus be argued that Harvey played a double role; that is, he punctured the long-standing belief on muscularity and the will, and simultaneously prescribed the panacea for the rupture, although Harvey could not use the term "elasticity" because it had not yet been coined, and so was unavailable to him. Next, we have to investigate the contested relationship between motion (moving) and life (living) to gauge the way that the classical idea of motion, always relating to life, was superseded by the modern concept of motion embraced by iatromechanists, and examine what motion is all about in iatromechanism.

Since ancient times, moving and movement had given eloquent testimony that a creature was living and sensitive. Before the modern era (before, roughly, the seventeenth century), "motion" had been imbued with a far more mysterious aura, in which everything relating to life and living beings was hidden.[62] Bulwer, for instance, in the section of his work entitled "Of the honour and dignities of animal motion," stated that a "living creature" was defined as a "moving" animal, and supposed that if one were deprived of all the muscles—the noble organ—there would remain so few bodily parts or organs that one could not be identified as human.[63] The meaning Bulwer wanted to convey here would be not only a morphological one in which man could not be recognized as human if deprived of the muscles which occupied most parts of the body, but also a functional one—that is, one could not move without muscles, an instrument of motion.[64] The soul, the principle of life, is only made known through the motion of its instrument, the body.[65] In this light, muscles were not only the instrument of motion, and by extension of the will, but also the external embodiment of the soul and life (living principle). What would happen, then, to the very concept of motion, when the agent of motion was replaced by the fiber in a new iatromechanical age?

For a long time, local movement was deemed by physics and natural philosophy as the very basis and cause of changes in quantity and quality of matter.[66] The importance of Harvey's discovery of the circulation of the blood in respect to motion was to bring into the animal body the very concept of motion (i.e., circulatory movement). After Harvey, medical men believed that in a living creature, circulation greatly affected the changes of the body.[67] Yet, a substantial incorporation of Harvey's discovery into medical theory took a fairly long time.[68] Among many possible reasons for this, the most cogent was the long-standing reign of humoral theory in the field of medical pathology. Circumscribed by an intellectual framework of humoralism, the interest of medical men was likely to be focused on the quality of the blood rather than on the phenomenon of circulatory movement, as was evident from blood transfusion experiments. It was only during the last two decades that some innovative medical men like Bellini and Pitcairn promulgated the new idea that disorders of the body were essentially caused by the obstruction of the circulation of the blood. They still thought, however, that it was principally the fluids (humors) that moved; therefore, the tacit assumption that the solids were motionless and inactive while the fluids were active and motile survived. To the extent that the fluids were endowed with motive faculty, power or principle (something animal spirits enjoyed), it was the fluids, not the solids, that functioned as the agent of motion. As late as the early eighteenth century, Paxton, who held the traditional view of muscularity, stubbornly subscribed to this belief, stating that diseases proceeded from the fluids because only the fluids moved and changed their place, whereas the "adhering and consistent" (that is, solid) parts were incapable of moving from the "Firmness and Fixedness of their Nature."[69] The solids, "the Organical and Consistent Parts," were assumed to have no powers in and of themselves to move and act; they were only actuated by the "subtle and nimble Fluids."[70] So, if muscles were the instrument of motion by which the members were moved, it was really the nimble spirits or fluids that moved the muscles, and the circulating blood added the strength and power to the motion.[71]

When solidism, as it was later called, was center-stage at the turn of the eighteenth century, the inveterate constraint imposed on the minds of medical men was finally removed, and they (iatromechanists-cum-solidists) ventured to reverse the relationship between the fluids and the solids. In short, thanks to G. Baglivi, an Italian iatromechanist, the "Doctrine of the Solids" was fully established among many who began to realize the importance of the solids in diagnosing and treating the body. The solids were no longer regarded as passive matter incapable of moving and acting on their own, but were now thought to be active movers, and assumed all roles once fulfilled by the fluids as the agent of motion. Conversely, dislodged from their former critical and noble roles, the fluids (humors) were relegated to the status of an ancillary agent that served only to maintain the due tension of fibers or solids by their moisture; the fluids were essential to the body in so far as they moistened the fibers.[72] The causes of diseases were sought primarily in the solids, not in the fluids, for even if vitiated, putrefied, and stagnating animal juices occasioned some disorders by obstructing the pipes, the changes that the fluids underwent were mainly effected by the morbid state or the motion of the solids; if the solids lacked the necessary elasticity, the motion imposed on the fluids became critically feeble, so that the animal juices would deteriorate into a "sizie" and "gross," which in turn led them to stagnate in the minute canals.[73]

The active power attributed to the solids (fibers) is nothing but the "elasticity" of the fibers, which we have already seen in the above section. What kind of motion is it, then, precisely, or what modality does it have, and how does the elastic motion of the fibers conceived by iatromechanists differ from the muscular motion or local movement identified as an external embodiment of the will and the soul (life)? Our common sense would tell us that we cannot palpably sense a tactile sensation of elastic motion of the fibers (solids), except by the sensible motion of the pulsation of the heart or the arteries; alternatively, we might be sensible to a certain extent to elasticity when we apply pressure to the skin and feel the resisting force of muscles corresponding to the force given to them. The elastic motion assumed by iatromechanists was, however, not primarily sensible to the extent that a person could plainly feel it. Rather, the modality of elasticity was that of insensible motion, something like extremely infinitesimal vibration or tremulous motion rarely perceptible to our senses. For iatromechanists, the fiber-solids were always accompanied by a minute vibration, an infinitesimal, diminutive undulation or oscillatory motion—an insensible, minute motion imperceptible to our eyes; as Barry put it in an incisive remark: "every living Part of a human Body has a perpetual Pulsation…imperceptible to our Eyes."[74] Vibrating was vital to the body, for without continual oscillating motion of the solids, living creatures would fail to maintain life. As discussed earlier, the solids, composed of the fiber-vessels in which the fluids were running, moved themselves mainly in the service of uninterrupted circulation equivalent to digestion, in the process of which the fluid-particles were, by the vibrating motion, further attenuated to pass into the more minute vessels.[75] If the solid-fibers became too rigid and lost their necessary elasticity, the circulation of animal and nutritious juices would be propelled only by the heart, and poor nutrition would result.[76]

Elasticity of the fibers, the vibrating motion of the solids, the circulation and digestion of the fluids, life-maintenance and provision of nutrition, all taken together, converged into an invisible vibration, a certain mysterious internal movement, or an imperceptibly infinitesimal motion of the internal body. According to this notion, animated beings are living because they are moving, and yet "moving" as understood by iatromechanists no longer designated what Bulwer had understood by moving—that is, that moving, as an external sign of the will, makes the soul known, and by extension makes living visible. For iatromechanists, living identified with moving signifies the invisible, involuntary, and internal motion or motility of the fibers' *frisson*[77] rather than the external manifestation of voluntary motion. Certainly, in the aftermath of iatromechanism, von Haller would attempt an externalization and visualization of *frisson* in his experiments with sensibility and irritability. But what von Haller and other neuro-physiologists did was to expose to the view a sensibility embedded within the body, not a mere externalization of motion. When the rupture occurred in the classical view of muscular (voluntary) motion, and the fiber was called forth as an agent of (involuntary) motion in tandem with the upsurge of solidism and a concomitant evaluation of the solids, the concept of motion that molded the phenomena of life underwent a radical alteration: a *frisson* of involuntary motion was thought to be deeply embedded in the substratum of the living body.[78]

3.3 Tension, Tone, Tonus, and Elasticity

To make more intelligible the concept of a *frisson* of a fiber's internal involuntary motion, let me show it from another point of view, paralleling it to another concept of motion, one variously referred to as "tension," "tone," or "tonus." The elasticity of the fiber was often abreast of, and sometimes conflated with, a motion such as pulsation, undulation, or vibration. To make the matter more complicated, elasticity also concurred with "tension," "tone," "contraction," "contractile power," or sometimes even with "stiffness" and "strength."[79] Langrish depicted the fibers of the body during life as in a state of being stretched and becoming tense, that is, a state of "Tension."[80] That fibers were during life unnaturally extended and tensed was known from the oft-cited phenomenon that when an incision is made on muscles, the muscular fibers fly back and cause the wound to gape. Robinson refers to this hyper-tension as a "State of Violence,"[81] while Cheyne remarked in a similar vein that all the fibers of the body were in a "State of *Distension*."[82] It should be noted here that being distended and stretched was not considered to be the same as being merely elongated to an unnatural length, for to be tense implies that the subject of tension (the fiber in this case) must possess potential to resist the power that strives to stretch it. Since this counter-power of resistance was nothing but a "contractive" power inherent in the fiber, it was equated with "elasticity" in so far as it resembled the motion of returning to a former (natural) state, and was hence called "restitutive Force."[83] Without tension, the fiber would have no elasticity. As the relaxed, loosened string, if cut, would not contract, so the non-tensile fiber such as the fiber soaked in water, if cut, would not contract. Iatromechanists predicated their developing medical theory on the contrary states of tension and relaxation.

It is worth pondering whether tension is a kind of motion, for being tense implies the power of contracting and pulling. Apparently, tension or tone is not motion, since, being static, the fiber does not change from one place to another. However, tension is in essence a motion, traditionally defined as "tonus," the medical use of which can be traced back to ancient times when Galen classified a variety of muscular motions and commented on the last kind of motion as "tonus."[84] "Tonus" or "tonic action" is so-called when something making no apparent movement is, in reality, active, a special kind of motion closer to today's "active posture." Usually motion is motion when something moves—for example, when the body executes some action like walking or running through the use of muscles. But how about a case of standing still? In this case, there occurs no gross movement within the body, but one cannot stand still without exerting one's muscles to resist falling down. And what of raising an arm and keeping it in a raised position? The arm retains the posture only when the arm exerts its muscles internally so as to prevent it from falling. These invisible, insensible motions, apparently accompanied by no external, visible movement but in effect some energetic exercise and activity within, are called "tonic motion."[85] This "tonic motion" may occur even when one is unconscious, as in the case of sleeping, during which evacuation is retained by dint of "tonic motion." According to the classical view, motion meant in essence a local movement, moving from one place to another, a motion that was meaningful only when it was externalized. Within this theoretical framework, "tonic motion" had found its place in a supplementary, shadowy existence of authentic motion. This supplementary concept of motion, however, appeared on the central stage when a disruption occurred in the classical view of muscularity, which induced an urgent need to invent a new agent of motion, as we have observed above.

It is interesting to note here that, as in the case of the fiber discussed above, Harvey also seemed to prefigure the notion of elasticity in terms of "tonic motion." Regarding the actions of muscles, Harvey argued that the essential element of the muscles was the "contractile element," and therefore muscular movement was executed by "pulling" rather than "pushing" (all motions were occasioned by this simple alternation of pushing and pulling, as Aristotle said).[86] He went on to endorse Galen's opinion that "contraction" and "tension," or "tonic movement," were the same muscular motion ("by contraction is made the movement from relaxation to rigidity, and this is tension and it is made by contraction").[87] Of the "tonic motion," Harvey, commenting on Galen's depiction of tonus, remarked that "the greatest usefulness of tonic motion is that it makes muscles be still by alternately getting rid of, and restoring, resistance and by regulating it."[88] The translator complained of the obscurity of this passage, and ascribed it to Harvey's omission of some words.[89] It seems more likely, however, that Harvey tried to convey what later anato-physiologists defined as elasticity in terms of "tonic motion," because the term elasticity was unknown to him.

It is also interesting to note that the notion of "tonus" was reinvented and fully elaborated by Georg Stahl, a distinguished medical philosopher of animism, at the end of the seventeenth century. Stahl was famous as a radical advocator of animism in the face of mechanical philosophy and his medical philosophy of animism is said to have had an impact on eighteenth-century medical vitalism (especially the Montpelier school); his medical theory of the living organism, however, shared much with that of iatromechanists in terms of the idea of "tonic motion." As Kevin Chang has convincingly demonstrated in his paper on Stahl's notion of tonic motion, against the background of the post-Harverian circular physiology, Stahl formulated "tonic motion" as the agent of life or vital energy that resists the ceaseless process of putrefaction by driving the blood to the determined parts—it is a kind of "a second motor."[90] Significantly, Stahl expanded the classical Galenic notion of tonus as postural motion and conflated it with the Methodist notion of "*strictum* and *laxum*"—"the contractions and consequent relaxations of the body parts," which are at work on a microscopic scale.[91] From our point of view, it is evident that the Stahlian notion of tonic motion has elements in common with that of elasticity as variously articulated by eighteenth-century British iatromechanists who sometimes associated elasticity with tonus. British iatromechanists, however, seemed not to refer to Stahl's work; this may have been because they wanted to distance themselves from an animist. Instead of Stahl's tonic motion, British iatromechanists turned to Friedrich Hoffmann, Stahl's colleague, and Giorgio Baglivi, the founder of solidism, both of whom, as Chang discussed, attempted to address the Methodist notion of "strictum and laxum" when forming their mechanical medical theories.[92] As mentioned in Chap. 2, the Methodist doctrine of strictum and laxum was continued and reformulated in various forms by seventeenth-century English medical authors and by the authoritative Boerhaave in the early eighteenth century; British iatromechanists could appropriate the mutually related notions of tonus, tonic motion, and the "strictum and laxum" of Methodist beliefs from these various sources.

To the eyes of iatromechanists, the affinity of "tonic motion" with the elasticity, the tension or the *frisson* of the fiber might be indisputable: both motions are invisible, insensible, and imperceptible to our eyes, and, critically, they do not have any local movement; moreover, they resist some force in restoring themselves to a former state or in maintaining a certain posture; they are internal and involuntary minute vibration-like movements in contrast to external and local motion. So, when the elasticity of the fiber was posited as the new functional agent of motion, it situated itself in a lineage descended from the shadowy presence of "tonic motion."

Thus, iatromechanists envisioned in the muscular body the amalgamation of a relatively tangible motion of circulation and digestion, and an insensible motion of vibration, *frisson*, restitution, tension, and tonus. This was a "moving" no longer subsumed in the paradigm of the classical idea of motion—a motion sustaining life and signaling that animals are living. Clearly, the modality of the elasticity of the fiber is that of a motion without (local) motion, and life (animal functions) depends on this *frisson* (elasticity) of an animal fiber. And this is precisely what Cheyne meant when he declared that "the whole Business of the Animal Life, is owing to the Springiness of these Fibres."[93]

3.4 Exercise and Vibration

Now that we have observed that the body image of iatromechanism was grounded in such a special kind of motion, we are in a good position to comprehend why exercise was so earnestly recommended in eighteenth-century therapeutics. Exercise, understood by eighteenth-century medical men, did not merely designate an ordinary physical exertion like running and walking, a motion wholly agreeing with the classical view of muscular motion, executed by an intervention of the subject's volition. Since the internal vibration, *frisson*, and elasticity implanted in the living body were admitted to reside in the core of life, it follows that exercise should have included involuntary motion. Francis Fuller, in his widely circulated textbook of gymnastics *Medicina Gymnastica*, reprinted many times throughout the century, defined exercise in just this way: "By *Exercise*…I understand all that Motion or Agitation of the Body, of what Kind soever, whether voluntary or involuntary."[94] Any form of exercise bringing about an oscillatory and shaking motion, among which riding was the paramount example,[95] was particularly encouraged, for these motions "imitate[d]" the internal vibratory motion (such as tension, *frisson*, and elasticity) in "repeated Exercise."[96] By the successful imitation of these motions, the circulation of the blood and the process of digestion would be promoted and excellent nutrition of the body would result. Fuller thus proclaimed that health and well-being of the individual was, to a significant degree, owing to the effects of "a General Motion [i.e., exercise] super-induced to [the] internal Motions."[97] As an exercise like riding would affect the body from outside by imitating the internal motion, so, conversely, the intake of medicine into the body would work therapeutically from inside much in the same manner as "a total Exercise of the Body," enacted by putting the "Fibres" upon "frequent Contractions."[98] In this sense, the intake of drugs also counted as "exercise."[99]

That the form of exercise encouraged at this time was not overly vigorous, but consisted of moderate and gentle kinds of motion, rightly co-ordinates with the fact that non-voluntary motion occupied the central place in the paradigm regarding the concept of motion. This is helpful in considering the revival of music therapy in the eighteenth century, for we cannot understand why music therapy was revived at this time as a kind of gentle exercise without taking into consideration the centrality of non-voluntary elastic motion.[100] Regarding music as a kind of exercise, Quincy praised the mechanical effects of music upon the "Animal

Threads," caused by the concussion (undulation) of the air occasioned by a musical instrument. The "least Stroke imaginable" upon the fibers of the whole body must move the component of the fibers in all their parts, and give corresponding "Concussions" according to their "Degree of Tension."[101] Here, the body is imagined as a kind of musical instrument capable of syncopating with other musical instruments, with the fibers ("Animal Threads") comparable to a kind of musical strings. For David Stephenson, an ardent "mechanical" medical theorist, the human body, consisting of the elastic fiber-solids, is comparable to "a most finish'd exquisite string'd musical Instrument" that is extremely susceptible to the least impressions from the outside, such as the "smallest Sound or Motion of the Air" which causes the whole animal frame to "vibrate inwards and outwards."[102] Endowed with "the most exquisite Sensation," this elastic, vibratory body, "a most prefect musical Instrument" accounts for the phenomenon of sympathy or antipathy because it is affected by a vibratory motion throughout the fiber body.[103] This is exactly the sympathizing body which we recurrently come upon throughout the eighteenth century in the medico-cultural scene of sensibility. Thus, the metaphorical rendition of the body as various musical instruments, especially as stringed instruments, and its cultural manifestation in the sympathizing body, cannot be apprehended without the registering of the elastic fibers in the medical scene. Exercise and vibratory non-voluntary motions were infused together in the musically sympathizing body.[104]

4 Elasticity after Vitalism: Elasticity and Life

After around 1740, voices labeling iatromechanism as specious became increasingly loud, and accordingly the elasticity of the animal fiber was demoted to a mere mechanical agent, as we have seen in Monro's apostasy against his ardent engagement in mechanical philosophy. The nerves were deprived of the attribution of elasticity that iatromechanists once admitted of them; the nerves, the argument went, were not like the tense string of a harpsichord, but rather something more delicate and inactive, devoid of any innate physical property, and thus unable to fulfill their mission of conveying and transmitting sensation and motion without receiving the vitalistic property or energy from the mind or the soul. The perceived center of the organism shifted from the muscular heart to the sensitive brain, with a concomitant shift of the vital instrument from muscular fibers to the nervous system. Accordingly, the key to the mysteries of the living organism and the kernel of life would be sought not in the elasticity of the animal fiber but in the sensibility of the nerves. But what actually happened to elasticity after the dethronement of iatromechanism in the medicine of the second half of the century? Did it simply disappear in the face of the ascendancy of vitalism? Or was the concept of elasticity subsumed into the new concepts of sensibility and irritability, so that we can see a certain continuity between them? It seems that there was a tension in vitalists' thinking. For they were willing to disregard the concept of elasticity as something belonging to dead matter, while at that same time they were unwilling to admit that their new concepts of life-principle resemble elasticity, which they wanted to extirpate. To delineate fully this complex story is a very demanding task; I confine myself here to an analysis of the way in which elasticity was fully mechanized by vitalists, and the ways that the criterion distinguishing elasticity from vital properties was made unsustainable.

4.1 Elasticity Mechanized

In the iatro-vitalists' writings on the nature of vital properties such as irritability or sensibility, especially those of the theoretically oriented medics from the mid-century on, we are often struck by the painstaking efforts of vitalists to differentiate the concept of the vital principles or properties (irritability/sensibility) from that of elasticity—the concept belonging to the previous age of iatromechanism—which they supposed to be "mechanical" or "non-vital." In vitalists' writings, we repeatedly encounter vitalists' reminder that elasticity was not the same property as those that they promoted; it was a dead force belonging to dead matter, so it had nothing to do with that which is vital one. As one commentator on Haller's physiology glossed, the "elasticity" of the fiber "pervades all parts [of the body] without exception" and "endure long after death," therefore, its nature had "no similarity to irritability…and vital power," the special property that did not equally dispersed all the parts of the body, but had seats in muscular fibers only and vanished soon after death.[105] Elasticity was deemed to be a property of dead matter, since the power to contract (i.e., elasticity) continued after death in the same way that dead matter wholly devoid of life retained the contractile and restitutive power. Irritability, a Hallerian vital principle (*vis insita*), differs fundamentally from elasticity in that it ceases to act after death and obeys the laws of life only; therefore, it is "more proper to life."[106] Irritability should also be differentiated from elasticity in that while this dead force is common to all animal fibers, by extension, to all material (inanimate) substance, irritability is limited to particular bodily parts, called "muscular fibres," which are part of the living body or tissues.[107] Thus, devoid of life-principle and sharing much with inanimate substance in the mechanical property and laws of matter, elasticity, for vitalists, was properly called mechanical. The author of *Memoirs of Albert de Haller, MD* (1783) cautions the reader not to confuse Haller's irritability with elasticity; the latter is "a property purely mechanical" and produces "merely mechanical changes" of the body.[108] The author's usage of modifiers for "mechanical"—"purely," "merely"—incidentally reveals his strategy to limit the property of elasticity to mechanical one; at the same time, this might indicate that the exact criterion distinguishing vital irritability from mechanical elasticity was still unstable, and his emphasis might reflect anxiety on the part of vitalists on this matter.

The strong need to see elasticity as purely mechanical was also found in Haller's rival, Robert Whytt, an iatro-vitalist with an animistic bent. In his detailed study on involuntary motions, Whytt tried to tap into the mysteries of involuntary motion—"spontaneous" movement without any attendant deliberateness or consciousness, which therefore, was called "Automatic." But Whytt argued that the term "automatic" was inappropriate, since it implied that involuntary motion was produced in "a mere inanimate machine" like an automaton "purely by virtue of its mechanical construction."[109] Later in his essay, Whytt equated this "automatic" and purely "mechanical" property with that of elasticity. Although he ardently opposed Haller on the existence of irritability and its responsibility for involuntary muscular motion, Whytt agreed with Haller on the issue of elasticity.[110] More strongly than Haller, Whytt tried to relegate the property of elasticity to the realm of dead matter. Repudiating Baglivi's doctrine of elasticity, Whytt argued that elastic body was "no more than a piece of dead inactive matter" without a generating power, and that the sharpest needle applied to the "spring of a watch" did not make such vibratory motions as the animal (living) frame would in reaction to sharp stimulus.[111] Elsewhere in the essay, Whytt strengthened the equation of the property of elasticity to that of dead matter. Whytt reasoned that if the muscular motion from a stimulus was produced by "the solid elastic fibres" of the muscles, then the alternate movement of the irritated muscles should be like the regular "vibrations of [an] elastic body," the automatic oscillation performed at equal intervals by the elastic body, such as "a musical cord, or a bell." Muscle did not, however, follow such "mechanical" movement; for instance, it became remarkably slower when it lacked strength.[112] Later in his essay, Whytt again argued against the motive faculty of elasticity, comparing it to the regular movement of a "pendulum" of a clock which performed at equal intervals.[113] Clearly, in vitalists' minds, elasticity found its place only in the realm of dead mechanical matter.

4.2 The Principle of Life/Death and Its Dilemma

The mechanical analogy of the clock that Whytt employed in describing the nature of elasticity would reveal Whytt's strategy to confine elasticity to the realm of the dead inanimate matter. For, as we have scrutinized in the first section regarding the body image (or model), the iatromechanists' more proper body image was that of the muscular living heart rather than the cog and wheel of the clock. Certainly, iatromechanists had in mind the solid elastic matter such as taut spring or tight string, but only in connection to the living (i.e., moving) body; there was no clear distinction between the dead elastic body and its living counterpart. Whytt deliberately misconstrued iatromachanists' elastic body image as that of the "inanimate" and the "dead" in order to draw a sharp contrast between living (the vitalistic body) and dead (the iatromechanistic body). In a sense, vitalists made a strategic bifurcation of iatromechanists' elasticity—in which no distinction was made between dead and living—into the dead and the living, appropriating the living aspect of elasticity for their new concept of irritability or sensibility, and leaving the term elasticity to designate that which was dead.[114] This leads us to suspect that there might be a similarity and continuity between mechanical elasticity and vital properties which vitalists would be unwilling to admit. The modifiers vitalists employed in articulating the true nature of elasticity, such as "purely mechanical" or "merely mechanical," would imply that there might be a "not-purely mechanical" nature to elasticity, which might resemble the vital principle they embraced. Haller's commentator hinted such was the case. Although he argued that elasticity had no similarity to vital power, he stated that elasticity somehow shared the vital principle: "It by no means obeys the laws of life alone, but may endure long after death."[115] He wanted to emphasis that elasticity should conform to the law of the dead matter, but he insinuated that elasticity was also involved in vital principles. Was elasticity dead or alive? And how can we distinguish irritability from elasticity, both of which are endued with similar, if not the same, vital properties? The confusion and dilemma many vitalists faced seem to stem from the point that they tended to interpret the vital principle (irritability/sensibility) and elasticity as being mutually exclusive, in accordance with the principle of the polarity of life and death, deliberately ignoring the overlapping properties of elasticity.

Let us return to Hallerian notion of irritability contra elasticity. All animal fibers were endowed with a considerable degree of contractile power, and this power was called elasticity. Irritability, a peculiar contractile power, on the other hand, was possessed by the muscular fibers only. The question then is whether or not the muscular fibers were endowed with *both* irritability and elasticity. The Hallerian answer would be that they did indeed have both properties, as Haller stated that a muscle was "endowed [with] at least threefold force [elasticity, irritability and sensibility]."[116] So how can these properties differentiate from one another? As mentioned above, the criterion was whether one belonged to dead matter or the living organism. Elasticity was elasticity because the elastic movement (something like vibration or oscillation) continued after death, while irritability was so called because irritable motion (something like living tremulous motion) ceased soon after death. One wonder how we can discern the elastic motion from the irritable one, as the two were extremely similar phenomena (tremulous involuntary motions). In theory, vital physiologists would contend that the elastic motion resembles the mechanical motion, so one could thus distinguish it from vital irritable motion, as Whytt suggested; but in reality, such theoretical criteria were extremely precarious because vital physiologists had to account for numerous vital phenomena (irritable motions) after death.

The enigma by which vitalists were preoccupied and perhaps were fascinated was the vital involuntary motions of muscles extracted from the body after death, particularly those of the amphibious or poikilothermic animals of vigorous nature such as frogs, vipers, eels, tortoises, and lizards. In particular, the muscles of the hearts, the most irritable muscular parts of the body, displayed the alternate contractions for some time after they were taken out of the body. Whytt provided copious instances of this weird fact: the heart of an eel, divided in two parts, continued its vibrations over 20 minutes; the hearts of vipers also continued their alternative motions for several hours after being severed from the body; the hearts of the chick taken out of the shell beat an hour after its head was cut off; the hearts of a decapitated young pigeon began to contract when stimulated by a few drops of Whytt's saliva, and many others.[117]

Obviously, irritable motions continue even after death, as Haller at one place admitted, "Irritability continues after death."[118] Does this overstep the criteria that vitalists set for differentiating the nature of elasticity from that of irritability? According to the criteria, vibratory (elastic) motions observed after death should be relegated to the realm of the inanimate matter of "death," but the enigmatic involuntary motions after death, which clearly show "signs of life,"[119] contradict the criterion predicated upon the polarity of life and death. Vitalists found signs of life, the testimony to vital properties that they wanted to advocate, in the zombie-like involuntary motions manifested in the extracted muscle. The involuntary motions after death thus deconstruct the binary principle of life and death as well as the seemingly irreconcilable pair of irritability/sensibility and elasticity. In considering the similarity and continuity of elasticity and vital properties, it is also interesting to note here that the body part that vitalists were quite amazed to observe possessing signs of life was nothing other than the muscular heart, the motions of which had led the iatromechanists to find the prototype of elasticity—it is as if the separated hearts haunted the mind of vitalists.[120]

4.3 Ambiguity of Elasticity and the Dilemma of the Nerves

There are some vitalists who even further transgress their own criteria on the vital principle and come to virtually negate the distinction between the supposedly mechanical force of elasticity and the vital property of irritability. Haller himself increasingly found it untenable to sustain the distinction. As Steinke argued, all three forces of the muscles—elasticity, irritability, and *vis nervosa*—appear to produce the same effect of contraction. Haller described elasticity as a "kind of dead irritability" and suggested that irritability might be a "stronger grade of the dead contraction"; eventually, he came to regard the three contractile powers as the same, different only in degree.[121] Andrew Wilson is another medical figure to find difficulty in making a clear distinction, for he compares irritability to elasticity, finding only "a seeming difference": elasticity and irritability are "precisely analogous…in [their] phenomena."[122] For Wilson, all of the animal fibers are in a state of perpetual vibratory motion to promote the circulation of the blood, independent of the action of the heart.[123] Wilson equates this oscillatory state of the irritable fibers with that of tone and elasticity:

> In attenuated subjects of irritability, such as animal fibres, it [irritability] implies a vibration upon irritating contact back through the whole length of the fibre.—It implies that the fibre itself is in a state of tension or distension sufficient to brace it, and preserve it in that constant state of elastic mobility, which is the characteristic of living animal fibres.—An actual state of irritability in living animal fibres, implies a constantly influent, active substance, keeping the fibres tense.[124]

Here, the living state of irritability and that of "elastic mobility" are commingled; they are the same in their resultant phenomena produced from the same active substance such as animal heat or other circumstances of "the internal agitative…motions" of the vital fluids.[125] If all these causes cease upon death, the animal fibers lose their elasticity, and therefore also their irritability. Collignon seems to share a similar view, for he feels little need to make a distinction among "natural elasticity," "*vis restitutiva*," and tone that the animal fibers are said to possess. For him, it suffices to know that the above state of the fibers gives strength and firmness to the living body.[126]

Why did some iatro-vitalists find it untenable to sustain the distinction, while medical authorities like Cullen and Monro attempted to set the limit? The answer would be an epistemological one, for the epistemological framework of the fibers tenaciously remains after the theoretical discourses of medicine shifted the focus to the nervous system: The epistemology of the fibers infringes on the realm of the nerves. This is especially because the nerves embrace the dilemma, that is, the nerves are by definition not solid or tense, while at the same time they are supposed to be relaxed or braced up just like a tense string. Let me here clarify the dilemma of the nerves.

Most, if not all, anatomists and physiologists of the later eighteenth century assumed that the nerves were not tense or solid, since they were originally composed of the medullary substance of the brain, which was very pulpy. Not least, they placed a special emphasis on the point that the nerves could not vibrate in an elastic manner and strongly denied the elastic property of the nerves. The extreme softness of the medulla of the brain plainly shows the nerves' unfitness for performing vibratory motion.[127] The nerves and the nervous system were, however, supposed to oscillate in a similar manner of elastic motion in order to communicate the neural message to and from the brain; or, they were to be in a state of tone (or perpetual vibratory motion) to maintain life. If unstrung, a variety of disorders, especially nervous ones, would be brought forth. The contradiction of the anatomical nature of the nerves and their functional aspect would be solved in some way or other. Some medical writers displaced the vibratory function of the solid body with that of the extremely subtle fluids such as Newtonian aether pervading the universe or the electric universal fluids, which traveled in a form of tremulous motion through the pores of the slack nerves[128]; others, like Cullen, incorporated the moving fibers and the vascular system into the integrated system of nerves so as to supplement the pulpy nature of the nerves with the tonic power.[129] Despite these promising solutions, the unacknowledged indebtedness of the nerves to the epistemology of the fibers reveals itself in some cases.

The description of H. Smith, one of the many nerve doctors of the late eighteenth century, of the properties of the nerves is a case in point. Smith identifies the active force of the "nervous fibres" to contract themselves as the medium of moving muscles. Smith does not call it irritability or some other vital property, but implies that this power was the kind of tone, for it acts even when the fibers seem to be at rest.[130] Surprisingly, Smith goes on to compare this contractile power to that of a musical string in a very mechanical manner. The weight is suspended by the musical string, hanging on the wall, which branches out another string suspending another weight passing over a pulley fixed in the wall; if the string is cut on some point of the upper part, it immediately contracts. This shows that the string, before division, exercised its contractile power, which means that the string is "always in a state of active energy." Smith applies this apparently mechanical "active energy" to that of the nervous fibers of the living body: "This power is the same in the nervous fibres of the body, which may be seen in a fibre cut transversely; for it contracts itself towards its fixed points, and thus causes the gaping of all wounds made in the body."[131] This way of explaining the contraction of the fibers in terms of gaping of wounds is familiar to iatromechanists, who explain the nature of elasticity of the fibers in the very same manner. Although Smith never mentions elasticity, the vitalistic active energy inherent in the nerves is here commingled with that of mechanical property of elasticity. Smith's ambiguous usage of the terms "nervous fibre," "nerves," and "fibres," which are sometimes interchangeable, may indicate that the nerves' vital property is overshadowed by the enduring epistemology of the fiber.

A more remarkable case is to be found in David Macbride's explication of irritability. In common with all other iatro-vitalists, Macbride sees the nervous system as part of the living solids that are during life in "a state of incessant vibration"; however, Macbride strongly denies that the vibratory motion is that of elastic chords on the ground that the "nervous chords bear not the least resemblance" to the elastic chords.[132] When he develops a cogent argument on the critical function of irritability with which the soul would move muscles, however, Macbride relies on the analogy of the musical string as in the case of Smith, and virtually equates irritability to elasticity: "the soul would be no more capable of moving any particular muscle, or set of muscles, if their fibres in general had not the property of irritability, than a musician would be capable of bringing music out of a violin, if its strings were not endowed with the property of elasticity."[133] He then extends this analogy of musical instruments to all of the animal functions of the living body ("the motions and actions of living animals may be likened to musical sounds"), and argues that if the structure of a musical instrument is defective, the music will deviate, although the musician is supposed to exert his dexterous skills; in the same way, if the structure of the body is incomplete, the actions of living animals will be disordered in spite of the soul's immaculate power.[134] Macbride's overall image of the living body is predicated on that of a stringed musical instrument, which leads him to unconsciously bring the mechanical property of elasticity into the living one of irritability. Here, we should not minimize this analogy as a rhetorical device which is only derivative from the original intention. Nor is it incidental that both Smith and Macbride had recourse to the musical strings endued with elasticity for analogy, for the analogy of the stringed musical instrument is the crucial link that shows the epistemological continuity between the iatro-mechanists and the iatro-vitalists.[135]

We can detect a fundamental if tense continuity rather than a disruptive break in the shift from mechanism to vitalism. As we have seen above, what is the sensibility or irritability eagerly pursued by vitalists except a kind of involuntary motion such as trembling, vibrating, and oscillating, which iatromechanists would be ready to sanctify as the essential property of elasticity? And how are these vital properties, internalized by the dark interior of the living organism, made known except by externalizing such properties through trembling, non-voluntary motion? Such continuity will be made even more intelligible in the next chapter.

5 Conclusion

It could be argued from a broader perspective that if we re-evaluate the eighteenth-century Enlightenment overall in terms of "motion" rather than of "sensation," the shift from mechanism to vitalism might be negligible compared to the more radical transformation of the concept of motion from a classical idea of voluntary muscular motion to a non-voluntary, modern version of motion. Jaynes ably concluded that when the long-standing association of motion (physics) and animated behavior (life) was severed, the explanation of animate motion resided only in the "correlation of that motion with a nervous system and the stimuli around it," which constituted a "huge" step.[136] And yet, before hastily attributing life to nervous sensibility, we can connect physical motion, even if invisible, and animated behavior by elastic fibers. Thus, the huge step should be sought not in the shift from mechanism to vitalism, but in the sea-change experienced in the idea of motion.

Finally, a brief concluding remark on the issue of the body image referred to in the introduction of this chapter, which concerns the major historiographical issue of the Enlightenment overall. It is now a truism that the Enlightenment is the age of the senses liberated and restored rather than that of reason. Recent historiography of eighteenth-century studies, especially that of the medico-cultural field, tells us that in reconsidering the features of Enlightenment culture and society in terms of the senses, the contested themes are "the culture of sensibility" and "the medico-cultural discourse of the nerve."[137] G.S. Rousseau is one of the pioneering scholars who paid critical attention to the nerve and its relation to sensibility. He assiduously investigated the origins of sensibility, tracing it back to a prominent mid-seventeenth-century brain anatomist, Thomas Willis, whose revolutionary neuro-anatomical research into the brain and the nervous system triggered the subsequent century's efflorescence of the culture of sensibility largely by way of John Locke's sensationalist psychology. Setting aside some thorny issues found in his sweeping analysis of the medico-cultural discursive formation of the nerve-cum-sensibility paradigm,[138] I want to raise a rather axiomatic issue concerning the centrality of the very paradigmatic trinity itself, "the senses (or sensation)—nerves—sensibility." The body image of the Enlightenment has been constructed under the auspices of this trinity of "the senses—nerves—sensibility." Our proper reassessment of the elasticity of the animal fiber, however, would present us with an alternative axis, another paradigmatic trinity of "motion—fibers—elasticity." Contrary to the hegemonic paradigm of the nerves, which is vitalistic in nature, I would suggest that the latter axis of motion—fibers—elasticity, which is supposed to be mechanical, in fact underlies and substantiates the body image of the Enlightenment. Having observed how iatromechanists envisioned the body, and what specific model or body image they embraced, we can no longer postulate a naïve assumption that the mechanical body of iatromechanism is just a mechanical machine to be replaced by the living organism of vitalists; being a fiber-elastic body, it rather foregrounded the subsequent conceptualization of the body as living. The image of the fiber-elastic body is the means by which the image of "Mechanical Man" and that of "Sensible Man" are simultaneously tied and deconstructed.[139]

Notes

1. George Cheyne, *An Essay on Gout* (London, 1720), 79.
2. "The Manuscript Lecture Notes of Alexander Monro *primus*" (c. early 1750s), 97, cited in D.W. Taylor, "Discourses on the Human Physiology by Alexander Monro *Primus* (1697–1767)," *Medical History* 32 (1988): 72.
3. Sergio Moravia, "From *Homme Machine* to *Homme Sensible*: Changing Eighteenth-Century Models of Man," *Journal of the History Ideas* 39 (1975): 45–60, 58.
4. Barbara Maria Stafford, *The Body Criticism: Imagining the Unseen in Enlightenment Art and Medicine* (Cambridge, Mass.: MIT Press, 1991), 417.
5. See Theodore M. Browne, "From Mechanism to Vitalism in Eighteenth-Century English Physiology," *Journal of the History of Biology* 7 (1974): 179–216; Christopher Lawrence, "The Nervous System and Society in the Scottish Enlightenment," in *Natural Order: Historical Studies of Scientific Culture,* ed. Barry Barnes and Steven Shapin (London: Sage, 1979), 19–40.
6. A. Doig, J.P.S. Ferguson, I.A. Milne and R. Passmore, ed., *William Cullen and the Eighteenth Century Medical World* (Edinburgh: Edinburgh University Press, 1993), 31; Christopher Lawrence, "Ornate Physicians and Learned Artisans: Edinburgh Medical Men, 1726–1776," in *William Hunter and the Eighteenth-Century Medical World,* ed. W.F. Bynum and Roy Porter (Cambridge: Cambridge University Press, 1985), 153–76; Andrew Cunningham,

"Medicine to Calm the Mind: Boerhaave's Medical System, and Why it was Adopted in Edinburgh," in *The Medical Enlightenment of the Eighteenth Century,* ed. Andrew Cunningham and Roger French (Cambridge: Cambridge University Press, 1990), 40–66.
7. On the clock metaphor, see Otto Mayr, *Authority, Liberty, and Automatic Machinery in Early Modern Europe* (Baltimore: Johns Hopkins University press, 1986).
8. James Keill, *An Account of Animal Secretion* (London, 1708), 109.
9. George Cheyne, *Philosophical Principles of Natural Religion* (London, 1705), 24.
10. Addison, *The Spectator*, ed. Donald F. Bond (Oxford: Clarendon Press, 1965), 471, (#115).
11. *The Works of Alexander Monro, MD* (Edinburgh, 1781; originally 1732), 327. See also L.S. Jacyna, "Animal Spirits and Eighteenth-Century British Medicine," in *The Comparison Between Concepts of Life-Breath in East and West*, ed. Yosio Kawakita, Shizu Sakai, Yasuo Otsuka (Tokyo: Ishiyaku EuroAmerica, 1995), 139–61; "this notion of the living body as a 'hydraulic Machine' was the *only* model of organism then available" (146).
12. B. Grosvenor, *Health, an Essay on its Nature, Value, Uncertainty, Preservation, and Best Improvement* (London, 1716), 4.
13. Ibid., 4.
14. The secondary studies on seventeenth-century microscopists are numerous; among others, see Marian Fournier, *The Fabric of Life: Microscopy in the Seventeenth Century* (Baltimore: Johns Hopkins University Press, 1996); Edward Ruestow, "The Rise of the Doctrine of Vascular Secretion in the Netherlands," *Journal of the History of Medicine* 35 (1980): 265–87. See also ch. 1 of this book.
15. Kathleen Wellman, *La Mettrie: Medicine, Philosophy, and Enlightenment* (Durham: Duke University Press, 1992), 63.
16. Cited in Wellman, *La Mettrie*, 119–20.
17. See John P. Wright, "Metaphysics and Physiology: Mind, Body, and the Animal Economy in Eighteenth-Century Scotland," in *Studies in Philosophy and Scottish Enlightenment*, ed. M. A. Stewart (Oxford: Oxford University Press, 1990), 262.
18. Cheyne, *Gout*, 79–80.
19. Browne Langrish, *A New Essay on Muscular Motion* (London, 1733), 49.

20. Idem, *The Modern Theory and Practice of Physic,* 2nd ed. (London, 1738), 38.
21. James Buchanan, *Linguae Britannicae vera Pronunciato, or a New English Dictionary* (London, 1757), s.v. "elasticity"; Cheyne, *Gout*, 80; idem, *The Philosophical Principles*, 224–5; Langrish, *Modern Theory*, 58; Nichols Robinson, *A New System of the Spleen, Vapours, and Hypochondriack Melancholy* (London, 1729), 16.
22. Thomas Morgan, *The Mechanical Practice of Physick* (London, 1735), 145; see also idem, *Philosophical Principles of Medicine* (London, 1725).
23. Ibid., 145.
24. Morgan, *Philosophical*, 125.
25. Morgan, *Mechanical*, 145.
26. Morgan, *Philosophical*, 127.
27. Nicholas Robinson, *A New Theory of Physick and Diseases, Founded on the Principles of the Newtonian Philosophy* (London 1725), 23.
28. Cheyne, *Gout*, 223.
29. Ibid., 226; see also James Douglas, *A Description of the Peritonaeum, and of the Parts of the Membrana Cellularis* (London, 1730), 26; Robinson, *New Theory*, 23.
30. Morgan, *Philosophical*, 139.
31. Cheyne, *Philosophica*, 224.
32. Keill, 107.
33. On Quincy, see N. Howard-Jones, "John Quincy, M.D. [d.1722], Apothecary and Iatrophysical Writer," *Journal of the History of Medicine* 6 (1951): 149–75.
34. John Quincy, *Medicina Statica: Being the Aphorism of Santorius, Translated into English, with Large Explanations,* 4th ed. (London, 1728), 409–11; Quincy included "Nerves" in the last instruments of digestion; these nerves were probably the conductors of the nervous (nutritious) juices (*Succus Nervousus*) (431). Quincy also supposed the "minutest fibres" as the seat of operation of medicines; all the vascular parts of the human body were those seats for medicinal particles to be further attenuated and passed into the smaller canals; see Howard-Jones, "John Quincy," 173.
35. Ibid., 411. Quincy also thought that the dura mater acted as a pump, transmitting pulsations to the *succus nervousus* and bringing about a tonic motion of the nervous system; see Howard-Jones, "John Quincy," 156; Quincy, *Medicina Statica*, 207.

36. Keill, 109.
37. Morgan, *Philosophical*, 142; 172–73. Cf. Langrish, *New Essay*, 52; he regards the fluids as the antagonist, so the solids and the fluids as a whole act like a muscular movement.
38. For an illuminating explanation of the old system of concoction in three stages, see Michael Schoenfeldt, "Fables of the Belly in Early Modern England," in *The Body in Parts: Fantasies of Corporeality in Early Modern Europe*, ed. David Hillman and Carla Mazzio (London: Routledge, 1997), 243–62.
39. See Martin Kemp and Marina Wallace, *Spectacular Bodies: The Art and Science of the Human Body from Leonardo to Now* (Berkeley: University of California Press, 2000), 78ff.
40. See Charles Webster, "The Discovery of Boyle's Law, and the Concept of the Elasticity of Air in the Seventeenth Century," *Archive for History of Exact Sciences* 2 (1965): 441–502.
41. Richard Mead, *A Treatise Concerning the Influence of the Sun and Moon upon Human Bodies, and the Diseases thereby Produced*, 2nd ed. (London, 1748); Keill, 30–31; also see La Mettrie, "fluids contain elastic globules," cited in Wellman, *La Mettrie*, 120.
42. See Shigehisa Kuriyama, *The Expressiveness of the Body and the Divergence of Greek and Chinese Medicine* (New York: Zone Books, 1999), ch. 3 "Muscularity and Identity." I owe much of my argument here to Kuriyama's excellent study on muscularity. On Galen's theory of muscle physiology, see E. Bastholm, *The History of Muscle Physiology* (Copenhagen: Ejnar Munksgaard, 1950), 74–96; Galen, *De Motu Musculorum*, trans. Charles Mayo Goss as "On the Movement of Muscles by Galen of Pergamon," *American Journal of Anatomy* 123 (1968): 1–25.
43. Ibid., 129–30, 144.
44. Ibid., 144.
45. John Bulwer, *Pathonyotomia* (London, 1649), 4.
46. Richard Boulton, *A Treatise of the Reason of Muscular Motion* (London, 1697), 5.
47. Ibid., 5–6.
48. Kuriyama, *Expressiveness*, 149–50. Fernel also thought of the heart as not composed of muscles; see Bastholm, *Muscle Physiology*, 116; Georges Canguilhem, *La formation du concept de reflexe* (Paris, 1977) [Japanese translation, 31–32].

49. On Lower, see Robert G. Frank Jr., *Harvey and the Oxford Physiologists: A Study of Scientific Ideas* (Berkeley: University of California Press, 1980), 210 ("In demonstrating this unique action of the heart, Lower in a very real sense completed the work Harvey had begun").
50. Peter Paxton, *A Directory Physico-Medical* (London, 1707), 52–53.
51. William Harvey, *De motv locali animalivm* (1627), edited, translated, and introduced by Gweneth Whitteridge (Cambridge: Royal College of Physicians at the University Press, 1959).
52. Ibid., ch. 9 and notes 69–73.
53. Ibid., 69. Again in his famous *The Anatomical Exercise*, Harvey exalted Aristotle as an adept in the anatomical knowledge of muscles: "Aristotle was acquainted with the muscles, and did not unadvisedly refer all motion in animals to the nerves, or to the contractile element, and therefore called these little bands in the heart nerves." *The Works of William Harvey, MD*, translated by Robert Willis (London, 1847), *On the Motion of the Heart*, ch. 17, 81; the first English text of 1653 reads, "Aristotle did know the muscles when he did refer all the pains and motion in creatures to the nerves, or that which is contractable, and therefore call'd those tendons in the heart, nerves"; *The Anatomical Exercises* in English translation, ed. Geoffrey Keynes (New York: Dover Publications, 1995), 111; also see 107.
54. Harvey, *De motv*, 69.
55. Ibid., 3. See also 117.
56. J. Baptiste Verduc, *Traité de l'usage des parties, dans lequel on explique les fonctions du corps* (Paris, 1696); John Baptist Verduc, *A Treatise of the Parts of a Humane Body*, now made English by J. Davis, MD (London, 1704), 328.
57. Ibid., part 2, ch. 11.
58. Alexander Stuart, *Three Lectures on Muscular Motion* (London, 1739), xlii.
59. Ibid., xliv. To be more precise, the muscle was supposed to be composed of the nerves and the vessels, but as the nerves lacked the property of elasticity, Stuart attributed to the vessels the property and agency of motion (i.e., elasticity); Stuart reasoned that these vessels should be composed of further smaller and, ultimately, smallest muscular fibers.
60. Ibid., xliv.

61. Gabriele Fallopio (1523–62) was among the most important muscle anatomists, and a contemporary of Vesalius. William Croone cited Fallopio as an authority in his *On the Reason of the Movement of Muscles* (1664); Croone also lays particular emphasis on the fibers of muscles in explaining muscular motion; see Margaret Nayler's introduction to William Croone, *On the Reason of the Movement of the Muscles*, with a translation by Paul Maquet (Philadelphia: American Philosophical Society, 2000), 27, and Croone's text, 87, where Fallopio was cited as showing that the fibers served as the orderly arranged channels of the spirits, the voluntary agents of movement.
62. See Julian Jaynes, "The Problem of Animate Motion in the Seventeenth Century," *Journal of the History of Ideas* 31 (1970): 219–34, 219.
63. Bulwer, 2.
64. See also Boulton, 6; Harvey, *De motv*, 15.
65. Bulwer, 3.
66. Jaynes, 219; Harvey, *De motv*, 15; Ian M. Lonie, "Hippocrates the Iatromechanist," *Medical History* 25 (1981): 113–50, 115.
67. Lonie, 116.
68. William Colman, "Mechanical Philosophy and Hypothetical Physiology," in *The Annus Mirabilis of Sir I. Newton*, ed. Robert Palter (Cambridge: Cambridge University Press, 1970), 329.
69. Paxton, 147.
70. Ibid., 160.
71. Ibid., 147.
72. Thomas Apperley, *Observations in Physick, both Rational and Practical* (London, 1731), 29; Quincy, *Medicina*, 401; Morgan, *Philosophica*, 140–41; Cheyne, *Gout*, 92.
73. Bartholomew Beale, *An Essay Attempting a More Certain and Satisfactory Discovery both of the True Cause of all Diseases* (London, 1706), 53–56; Cheyne, *Gout*, 97ff; Cheyne, *An Essay of Health and Long Life* (London, 1725), 20, 117, 179–80; Robinson, *New Theory*, 81–86.
74. Edward Barry, *A Treatise on a Consumption of the Lungs* (London, 1727), 274; see also John Quincy, *Medico-Physical Essays* (London, 1720), 40.
75. Quincy, *Medico-Physical*; Langrish, *Modern Theory*, 43–50; Robinson, *New System*, 112; Robinson, *New Theory*, 16.

76. James Drake, *Anthropologia Nova; or, a New System of Anatomy* (London, 1707), vol.1, 466.
77. Although the iatromechanists of Britain did not use this term, I prefer it because it aptly expresses the nuance of an insensible, vibratory motion, with its overtone and implication.
78. Medical historians tend to lay an emphasis on the workings of "animal spirits," "nervous fluids," "subtle fluids (aether)," "nerves," and the mechanism of the muscular structure (tendons, flesh, fibers, arteries, etc.) in describing the history of muscular motion; but these things seem to be rather trivial and negligible, compared to the more fundamental shift in the idea of motion.
79. Langrish, *New Essay*, 47 (contraction), 50 (tension); Cheyne, *Gout*, 96; Francis Fuller, *Medicina Gymnastica: or, Every Man his own Physician*, 9th ed. (London, 1777), 50–54 (stiffness, strength, tension).
80. Langrish, *New Essay*, 50 ("all…Fibres are, during Life, in a State of Tension; that is, every Fiber seems to be stretched out beyond its natural State of Rest").
81. Robinson, *New Theory*, 17.
82. Cheyne, *Gout*, 80.
83. Morgan, *Philosophical*, 127.
84. The concept of "tonus" seems to come originally from the Stoics, and Galen inherited it from the Stoics; for the Stoic concept of tonus, see A.A. Long, *Stoic Studies* (Cambridge: Cambridge University Press, 1996), 52–3; 212–13; J.M. Rist, *Stoic Philosophy* (Cambridge: Cambridge University Press, 1969), 86–88. In Stoic physics, "tonus" is the physical property of *pneuma* (logos), the divine fire, which pervades and maintains the universe by the cohesive force of "tonus." The Stoics think of "tensional movement" as "vibrating" and define it as "simultaneous movement in opposite directions" and distinguish it from local movement.
85. C.S. Sherrington, "Note on the History of the Word 'Tonus' as a Physiological Term," in *Contribution to Medical and Biological Research: Dedicated to Sir William Osler by his Pupils and Co-Workers* (New York: P.B. Hoeber, 1919), vol.1, 261–68.
86. *De motv*, 15.
87. Ibid., 115, 117.
88. Ibid., 119–21.
89. Ibid., 120, note 1.

90. Ku-Ming (Kevin) Chang, "*Motus Tonicus*: Georg Ernst Stahl's Formation of Tonic Motion and Early Modern Medical Thought," *Bulletin of History of Medicine* 78 (2004): 767–803, 777.
91. Ibid., 793–95, 774, 781.
92. Ibid., 795.
93. Cheyne, *Gout*, 79.
94. Fuller, 28.
95. Cheyne, *An Essay of Health*, 94ff; Fuller, *Gymnastica*, 164ff; Quincy, *Medicina Statica*, 328, 426.
96. Ibid., 38; see also Quincy, *Medico-Physical*, 43.
97. Ibid., 35.
98. Ibid., 58; see also Quincy, *Medico-Physical*, 45.
99. Imagination was also regarded as a form of exercise; see Addison's *Spectator*, no.411, "Imagination like a gentle Exercise to the Faculties" (399).
100. On the revival of music therapy, see G.S. Rousseau, "Medicine and the Muses: An Approach to Literature and Medicine," in *Literature and Medicine during the Eighteenth Century*, ed. Marie Mulvey Roberts and Roy Porter (London: Routledge, 1993), 23–57, 38–9.
101. Quincy, *Medico-Physical*, 46. For a similar statement, see Bernard Lynch, *A Guide to Health through the Various Stages of Life* (London, 1744), 283–4. Cf. Ficino's theory of musical effects of the body; he thought the effect was on the animal spirits rather than the solids. The spirits are like the air, so have much in common with sounds transmitted by the air. The action of the spirits was analogous to musical strings and their vibration. See Daniel Walker, *Spiritual and Demonic Magic from Ficino to Campanella* (London: Warburg Institute, University of London, 1958), ch. 1. According to Penelope Gouk, Ficino's music-spirits theory was widely disseminated in the early modern era, absorbed by Robert Burton, Athanasius Kircher, and Robert Fludd; Penelope Gouk, "Music, Melancholy, and Medical Spirits in Early Modern Thought," in *Music as Medicine: The History of Music Therapy since Antiquity*, ed. Peregrine Horden (Aldershot: Ashgate, 2000), 173–94. R. Browne's *Medicina Musica* (London, 1729) was the first English book wholly devoted to this subject; Gouk, 178.

102. David Stephenson, *Medicine Made to Agree with the Institutions of Nature; or a New Mechanical Practice of Physick* (London, 1744), 54.
103. Ibid., 57.
104. See ch. 7 of this book on this point.
105. Albrecht von Haller, *First Lines of Physiology*, to which are added all the notes and illustrations of Prof. Wrisberg, 2 vols. (Edinburgh, 1786), vol.1, Wrisber's note 110, 231.
106. Ibid., Wrisberg's note; Haller's text, 226–32.
107. Haller, *A Treatise on the Sensible and Irritable Parts of Animals* (1755), reprinted in *Bulletin of the History of Medicine* 4 (1936): 657–99.
108. Thomas Henry, *Memoirs of Albert de Haller, M.D.* (London, 1783), 75–76.
109. Robert Whytt, *An Essay on the Vital and Other Involuntary Motions of Animals*, 2nd ed. (Edinburgh, 1763), 2.
110. On Whytt and his controversy with Haller, see Roger French, *Robert Whytt, the Soul and Medicine* (London: Wellcome Institute, 1969).
111. Whytt, *Involuntary*, 256–57.
112. Ibid., 274–75.
113. Ibid., 407–08.
114. Cullen, the most influential medical theorist after Haller and Whytt, also furthered this tendency in his famous systematic division of the solids into "the simple solids" and "the vital solids"; elasticity was only in the domain of the simple or inanimate solids, as he stated on the "contractility" (i.e., Hallerian irritability) of the muscular fibers, which Cullen asserted was "different from that of the simple solids, or any inanimate elastics"; William Cullen, *The Works of William Cullen*, ed. John Thomson (Edinburgh, 1827), vol.1, 10, 63.
115. Haller, *First Lines*, 231.
116. Ibid., 231. But sensibility is not proper to muscular fibers since nervous force comes from outside, and not within the fiber themselves (235).
117. Whytt, *Involuntary*, 385–99.
118. Haller, *First Lines,* 691.
119. Whytt, *Involuntary*, 399.

120. Cf. Harvey's reiteration of Aristotle's view of muscles as "a separate living creature," which "pulsate" when in action; see Harvey, *De motv*, 111.
121. Hubert Steinke, *Irritating Experiments: Haller's Concept and the European Controversy on Irritability and Sensibility, 1750–90* (Amsterdam: Clio Medica, 2005), 110–11; also see 123, note 108. Haller had used the term *vis insita* to designate elasticity; irritability had a physical force similar to elasticity.
122. Andrew Wilson, *Medical Researches* (London, 1777), 152.
123. Ibid., 191–92.
124. Ibid., 153–54.
125. Ibid., 155.
126. Charles Collignon, *Medical and Moral Tracts* (Cambridge, 1769–1772), 24; see also W[illiam] Smith, *A Dissertation upon the Nerves* (London, 1768), 107–09, 208.
127. James M. Adair, *A Philosophical and Medical Sketch of the Natural History of the Human Body and Mind* (Bath, 1787), 14–15; John Feltham, *A Popular View of the Structure and Economy of the Human Body* (London, 1803), 172; Malcolm Flemyng, *The Nature of the Nervous Fluid, or Animal Spirits* (London, 1751), 5–6; 10; Haller, *The First Lines*, vol. 1, 219–20; David Macbride, *A Methodical Introduction to the Theory and Practice of Physic* (London, 1772), 26; Alexander Monro [*secundus*], *Observations on the Structure and Functions of the Nervous System* (Edinburgh, 1783), 90; C. Uvedale, *The Construction of the Nerves*; *and Causes of Nervous Disorders* (London, 1758), 9–11.
128. A summary on this point can be found in Sayer Walker, *A Treatise on Nervous Diseases* (London, 1796), 13–15.
129. See ch. 4 on this matter.
130. H. Smith, *An Essay on the Nerves* (London, 1794), 31.
131. Ibid., 31–32. Cullen also refers to the gaping of wounds in muscles for explanation of "Tone, or Tonic Power"; see *Works*, vol. 1, 77.
132. Macbride, 26; he conjures that the vibration is of an elastic fluid.
133. Ibid., 19.
134. Ibid., 19–20.
135. See ch. 7 of this book more on this.
136. Jaynes, 234.
137. G.J. Barker-Benfield, *The Culture of Sensibility: Sex and Society in Eighteenth-Century Britain* (Chicago: University of Chicago Press,

1992); Lawrence, "The Nervous System"; Roy Porter, *The Creation of the Modern World: The Untold Story of the British Enlightenment* (New York: Norton, 2000), ch. 12; G.S. Rousseau, *Nervous Acts: Essays on Literature, Culture and Sensibility* (Basingstoke: Palgrave, 2004); Anne C. Vila, *Enlightenment and Pathology: Sensibility in the Literature and Medicine of Eighteenth-Century France* (Baltimore: Johns Hopkins University Press, 1998).

138. See ch. 7 below on this matter.
139. There remains a major issue concerning the body image, which I cannot fully address—a gender issue. The classical view of muscularity (and the muscular body) naturally involved the masculine body. What about the elastic body? It seems to me that there is an ambiguity in the gendered body image that iatromechanists embraced. While they seemed to idealize the male, masculine body for its brawny, tense, and elastic property in contrast to the feminine, slack, un-elastic body, the subtle *frisson* of fibers' non-voluntary motion would suggest and anticipate the later feminization of the body through the working knowledge of sensibility. In this sense, the fiber-elastic body also embraces an opportunity to unite and deconstruct the masculine and the feminized body images.

CHAPTER 4

Continuity and Change: "Fiber Body" in the Era of Iatro-Vitalism, c.1750–1800

1 Introduction

It is generally assumed that toward the middle of the eighteenth century, the theoretical underpinnings of medical science began to shift from mechanism to vitalism. The body as a hydraulic machine, in which the blood constantly circulates through the jumble of the vascular system for the purpose of life, was replaced by the model of the reactive organism or animated machine, in which the nervous system coordinated with external stimuli. There seems to be a series of concomitant replacements with this general shift: the heart to the brain as the center of the organism, the fibers to the nerves as the critical agent of the organism, elasticity to sensibility or irritability as the property of the living body, the mechanical principle to the vital principle, fiber physiopathology to nervous physiopathology.[1] There is no doubt that in the second half of the eighteenth century, the nervous system came to dominate the medical scene in tandem with the rise of vitalism. Animal economy, the knowledge of health and disease, increasingly became nervous. Robert Whytt, one of the most influential nerve doctors of the Edinburgh Medical School, in his popular treatise on nervous diseases, catches the modish atmosphere of nerves as fashionable ("physicians have bestowed the character of *nervous* on all those disorders whose nature and causes they were ignorant of"[2]) and helps to diffuse the nervous pathology.[3]

H. Ishizuka, *Fiber, Medicine, and Culture in the British Enlightenment*, DOI 10.1057/978-1-349-93268-9_4

Admitting that nervous physiology was the dominant and popular theory of physic in that era, medical vitalism ran the full spectrum throughout Europe, from animistic vitalism, nervous vitalism, mechanical vitalism, material vitalism to vital materialism, between which further gradations existed. Moreover, it is often very difficult to distinguish one strand from another: mechanists or vitalists, animists or vitalists. On the Continent was a version of Stahlian animistic vitalism—anima, a rational soul governs and controls the body and its organism—the idea most clearly embraced by the medical thinkers of the Montpellier Medical School (such as Bordeu and Barthez), who refurbished Stahlian doctrine with new scientific discoveries of Hallerian sensibility and irritability; the Scottish counterpart of animistic vitalism was probably Whytt, who distanced himself, however, from Stahlian animism and advanced a more unified, centralized vision of organism through the brain–nerves system, in contrast to Bordeu at Montpellier, who, like Whytt, saw the nervous system as vital to animal economy but envisioned the living organism as a beehive in which each bee (each organ) is cooperating with the others (each organ has its specific principle) to make a whole mass.[4] Furthermore, Whytt's animistic vitalism of nervous physiology was sometimes charged with atheistic materialism as he was supposed to divide the immaterial soul and expand it to the whole body.

A geographical difference should be mentioned here; in Scotland and England, at least up to the last two decades of the eighteenth century, there seemed to be no discernible materialistic vitalism (or vital materialism) in medical thinking—a view that matters or quasi-matters such as nerves or fibers are endowed with self-moving vital power or property with which an organism moves, senses, and regenerates itself—comparable to the medical thinking on the Continent, where some distinct strands of vital materialists flourished in the line of La Mettrie, Buffon, Diderot, and Charles Bonnet. This contrast is made more palpable when it comes to fiber theory; on the Continent, the two prominent fiber-theorists, Bonnet and Diderot, worked particularly on the fiber body to develop a material-vitalist version of fiber theory, what Tobias Cheung calls "fibre oeconomies," in which the fiber organism directs, regulates, and organizes itself like an automaton endowed with sensitivity that enables the fiber-machine to interact with external stimuli.[5] For Bonnet, the fiber was an organ or machine that feeds, grows, and vegetates, whereas Diderot thought of the fiber as a living animal or a worm.[6] This type of autonomous, self-regulating fiber automaton or organism rarely came to the fore in the British medical scene until the last decade of the century, when renewed interest in irritability and irritable fibers made the self-regulating fiber organism emerge for a brief moment. On the whole, English and especially Scottish medical thinkers (Monro *secundus*, Whytt, Cullen) might be labeled as nervous vitalists since they relied on the nervous system and its sensibility as the functional integration of organism and succeeded in shifting the center of interest from vascular physiology to nervous physiology, although in some cases, critical reservations should be made, as I will explain below.

Drawing a clear map of iatro-vitalism even in the British medical setting becomes more difficult as the century progresses. During the later eighteenth century, a different strand of vitalism loomed large in England, a strand most fully embodied by John Hunter, a Scottish-born naturalist and surgeon who flourished in London with his brother William. Taking a different step from British nervous vitalists, John Hunter saw life or the vital principle as superadded to inert matter or any kind of organization, however peculiarly it was modified. Evading the nagging question of whether life is immanent or emergent, Hunter drew his idea of life from experiments with a wide range of subjects, from plants, lower animals (eels, snails), and higher animals (dogs, rabbits) to human beings. These experiments on the conservation of heat against cold temperature showed that all subjects could preserve a certain degree of heat against extreme cold while alive; from this fact, Hunter assumed that living subjects had a certain power to regulate themselves against the vicissitudes of external circumstances. Crucially, this power was independent of both the blood circulation and the nervous system, as animals without circulation or the brain and the nervous system were possessed of the same power. Hunter saw this power or principle as "vital" or "living" because the subjects possessed this power as long as they were living, and he thought it superimposed to organization as all organisms had this power regardless of their different modes of organizations.[7] Hunterian vitalism, a kind of primeval vital power to resist matter's dissolution and organism's putrefaction, not unlike Bichat's idea of vitalism and Blumenbach's idea of "formative principle" (*nisus formativus*), gradually gained ground toward the end of the century.

Thus, medical theories of the latter half of the eighteenth century enjoyed a wide variety of medical vitalism, and it is almost meaningless to characterize it under the umbrella of "Enlightenment vitalism" or other epithets drawing on the uniform features shared by these vitalists.[8] Here, the term iatro-vitalism, loosely defined, only refers to the concerted efforts by the amalgam of groups (medics) that challenged and discredited the philosophy or doctrine of iatromechanism, seeing it as insufficient to explain the phenomena of life. The nuanced differences in each iatro-vitalist are mentioned in the appropriate place.

Limiting the scope of this study to the British context, however, we discern two phases of iatro-vitalism. The first phase roughly covers mid-century to the 1780s, when nervous vitalism dominated the medical scene, and yet it is here that a new trend of nervous vitalism faced adamant opponents, the mechanical and vascular physiology, with which nervous vitalism forced itself to compromise. The second phase concerns the last two decades of the century (c.1780–1800), in which the nervous model remained powerful but new strands of vitalism emerged. Boosted by the renewed attention to the phenomena of irritability, this new strand developed during the last decade into what might be called the "Irritable Fibers" group. Paradoxically, the last fiber group and not the nervous one dealt the final blow to the fiber model which had endured almost through the century. In what follows, I shall first treat the first phase of vitalism and explicate what happened to the fibers and the fiber body, whose presence and functions dominated the medical world in the first half of the eighteenth century, by surveying the compromising model (between fibers and nerves) and the enduring vision of the physiology of tone, with special attention to Cullen's system, in which the neurocentric view of the body is deconstructed by fibers, the supplementary element of the nervous system. The second section discusses the next phase of vitalism by highlighting the revival of irritability as the vital principle and sounding the impact of Girtanner's laws of irritability on the "Irritable vitalists." This chapter explores both significant continuity and the change that the fiber body embodied in the latter half of the eighteenth century.

2 A Compromising Vision: The Fiber Meets the Nerve in the Era of Nervous Vitalism, c.1750 to 1780s

2.1 *Fibers Confounded in the New Stage*

The image and language of the fiber-woven body that had thrived in the early eighteenth century continued to provide the general frame for medical writers of the second half of the century for spelling out anatomy and physiology, though the flamboyant rhetoric that earlier writers employed in depicting the fiber body disappeared from medical texts; instead, the more neutral language of anatomy took its place. However, the fiber still constituted the whole body as the fundamental building unit. For example, Charles Collignon, professor of Anatomy at the University of Cambridge, commented of the fibers that these "Threads" constituted all the solids, from the coats of the vessels, the muscles, to the bones,[9] while James Adair, a physician of Bath, in his medical text for popular readers, described the fiber anatomy in a manner reminiscent of the earlier metaphor: "All the *Solid* parts of our bodies are composed of fibers or threads, of different sizes and degrees of strength and firmness, curiously interwoven with each other, by transverse threads of a finer texture."[10] The iatromechanists' rhetorical rendition of the fiber-woven body, such as "wrap up," "interwoven," "embroidery," and "carpet-like," has here only a faint echo to be superseded by the more neutral scientific wording.

A new anatomical term entered into the fiber model: the cellular membrane or texture,[11] popularized by Albrecht von Haller. Haller takes the cellular membrane as one of two kinds of fiber (the linear and the cellular) and likened it to a "web" or "net" by which all parts of the body were joined together[12] ("a universal connecting medium" as a later writer called it),[13] because of which the communication within the body could be sustained.[14] Haller's concept of the cellular membrane was widely circulated in subsequent generations. For instance, Malcolm Flemyng in his lecture on animal economy conferred great importance on Haller's "*tela cellusosa*" in the structure and function of the living body, for this "membrane, web, or texture," by uniting together formed cells in such a manner that every cell opened to other cells contiguous to them in a structure analogous to a "honey-comb," allowed the cells to freely communicate with each other all over the body.[15] This membrane was found to follow every bundle of fibers and constituted a great part of the solids, and served as a "bond of union" by fastening and tying together every part of the body.[16] The omnipresence and contiguous continuity of the cellular substance throughout the body invokes the principle of continuity that the iatromechanists had thought the fiber-woven body embodied; they had imagined the body as fibers successively interwoven like cloth (see Chap. 2). The idea of the cellular membrane might be considered an heir to this iatromechanical principle of continuity; it is noteworthy that the rhetoric of cloth or textile is still found in the new concept ("web" and "texture") but is much neutralized.

The dense rhetoric and the baffling classification of the fibers were also simplified, but the terminological confusion stayed. Early eighteenth-century iatromechanists posited the fibers as the elementary constituent of the body, from which more differentiated body parts were supposed to derive; accordingly, some medical writers divided the fibers into "fleshy," "nervous," "tendinous," "bony," "cartilaginous," or "membranous" according to the parts they would make.[17] The different kinds of fibers had various degrees of firmness, denseness, elasticity, or sensibility fit to the specific parts that the fibers entered. While the medical writers in the latter half of the century equally acknowledged the elementary fiber's constitutional function, they often limited the fibers to the muscular system, or at most the muscular and vascular systems: the fibers, if they were narrowly defined, meant the muscular fibers.[18]

If the fiber was reduced to the specific realm, so was the nerve. The old, crude division of the fiber into the muscular and nervous kinds remained, but the nerves referred only to the nerves of the nervous system (for the service of sensation and motion); in other words, the nerves did not cover the special kind of vessels distinct from the nervous system properly defined—they were not the vessels for nourishment as the old medics had thought.[19] The restriction of the nerves to the property of the nervous system might reflect the ascendency of nervous vitalism from mid-century on. Having said that, the confusion on terminology regarding the fibers and other vessels, especially the nerves, was never wholly resolved. The expression "the nervous fibers" continued to be used referring to the nerves, but sometimes it is uncertain why the same authors employed the expression "the nervous fibers" in one place and "the nerves" in another unless we assume that they took the nerves as a derivative from the fibers, which was not always the case. Many medics circumvented the nagging issue of the strict distinction and seemed to feel liberty to use interchangeably both terms, and these terms were occasionally used as equivalent with the fibers, making the matter more confusing.

The terminological confusion between the fibers and the nerves might correspond to the equally confounding systems of medical theories after the mid-century, when the doctrine of iatromechanism was subject to severe criticism. Finding a smooth and rapid transfer of medical theory from iatromechanism to vitalism would be misleading, for it ignores the existence of many kinds of middle grounds where the new regime of nervous vitalism faced in one way or another the fiber medical theory of the old regime; consequently, some models of compromise arose within the medical scene. Richard Mead's transformation of medical doctrine around the middle of the century from iatromechanism to vitalism is a case in point. Mead's *Medical Precepts and Cautions* (1751) clearly signals his turn to nervous physiology; however, Mead still saw the human body as a "hydraulic machine," in which innumerable tubes are adjusted for the circulation of the fluids, including the subtle elastic fluid. For this "active principle," God formed the "two sorts of fibers, the fleshy and nervous" as the appropriate organs or receptacles. (This corresponds to the simplified division of the fibers into the muscular and nervous.) Each sort of fiber is interwoven in the membranes of the body and collected into bundles for performing motions; without these fibers, the active principle could never execute its functions.[20] The fiber-based hydraulic body stayed the course in Mead's writing as well as in some of the later eighteenth-century medical discourses. The great impact of the nervous system was rampant almost everywhere in the medical discourse of the later eighteenth century, but the system of the nerves and the brain needs to be negotiated, compromised with that of the fiber and the heart. Here I shall present two illustrative cases of such a compromising model, one by James Adair and the other by David Macbride.

2.2 Adair, Macbride, and Others: Finding the Middle Ground

James M. Adair, an Edinburgh-educated physician, enjoyed a considerable reputation for his criticism on fashionable diseases in the last decade of the century, but before that he had worked on a comprehensive textbook of medical theory and practice, *Commentaries on the Principles and Practice of Physic* (1772), the scope of which covered physiology, pathology, semiotics of diseases, and therapeutics in the format of his meticulous commentaries and lengthy remarks on the proposed principles.[21] In this massive text, Adair tried to graft a new trend of nervous vitalism onto the iatromechanical footing of fiber physiopathology. Drawing on the vitalistic physiology of Haller and other medical vitalists such as Gaub, Adair accepted the vital properties such as irritability and sensibility imparted to "the living solids,"[22] while the property of elasticity was reduced to a specific power common to both simple (dead) and living solids ("resides in almost all the solids")[23]; moreover, this power is called "*of the Dead Fibre*" because it is independent of nervous influence.[24] Making a division along the living (nerves) and the dead (fibers) suggests the extended influence of nervous vitalism on Adair's medical thought; indeed, he made a clear point on the importance of nervous sensibility on the organism, claiming that the nervous influence reached every part of the body[25] and that diseases proceeded from the morbid state of sensibility of the nervous system.[26] Adair's apparent nervous vitalism, however, met in a critical compromise with the fiber physiopathology of iatromechanists at many points. First of all, Adair's doctrine of animal oeconomy was predicated on the premises committed to by the earlier iatro-fiber-theorists—life was sustained by the circulation of animal fluids, which depended on the motion of the heart, "one grand organ," and other vessels.[27] Like earlier iatromechanists, Adair likened the motion of the body to that of a watch, which, "like the human body, is an automaton"[28]; in the manner that a watch performs its regular motion, health consists of the regular, steady motion of the "wheels" and the "harmony" between the fluids and the solids, whereas diseases derive from the irregularity of motion, and death comes from the halt of circulation,[29] a position exactly in accordance with iatromechanism. Curiously, this mechanical position sits side by side with the position that admits an important role of sensibility of the nerves.

The mixture of the old and new systems in which Adair seemed to find no contradiction becomes most discernible in his account of pathology. In his explanation of the predisposing causes of diseases, Adair first addresses the "Diseases of the Simple Fibre," in which he contends almost in the same manner as the Boerhaaverian fiber pathologists of the former age that many diseases proceed from the morbid degrees or states of the simple fibers, either extreme laxity or rigidity; if the fibers are too flaccid due to the want of elasticity (as is often the case), general debility results and many malfunctions of motion are induced.[30] Adair goes on to explain the difference between two similar states of fiber, the lax fiber and the tender, delicate fiber, with the help of the metaphor of musical strings, often seen in the iatromechanists' texts: "the lax fibre resembles a musical chord before it is wound up to its proper pitch, the delicate fibre, on the other hand, resembles the same wound up beyond its due tone, so that they are in opposite extremes from the natural state."[31] So far, Adair's rendition of "Diseases of Simple Fibre" remains in line with the fiber doctrine of the earlier iatromechanists. Adair, however, adds to this old regime of fiber pathology the new nervous regime. In the next section, "Simple Diseases of the Nerves," he rather abruptly turns to the discussion of a morbid state of nervous sensibility as the predisposing cause of diseases. Recognizing the power of sensibility for due performance of bodily organs as "absolutely necessary," Adair tries to elaborate on the nosological-cum-pathological account of the diseases of the nerves according to the different states of sensibility, whether it is increased, depraved, or totally lost (i.e., torpor) in conjunction with the equally variable degrees of mobility.[32] There is no conscious effort on the part of Adair, however, to link the diseases of the simple fiber (fiber mechanism) and those of the nerves (nervous vitalism). Nor does Adair explicitly say anything that suggests the primacy of the brain and the nervous system or sensibility, nor mention brain energy or power; he just leaves open the gap laid between the fibers and the nerves.

Adair, however, seems to attempt to find some solution to this predicament when he discusses the motion of the heart. As said before, Adair assumes that life depends on the proper circulation of the blood and that the heart and the arteries are the vital organs to sustain due motion; the muscles of these organs are imbued with contractile power to execute the circulation. This power proceeds from elasticity of the muscular or "moving" fibers, which in turn depends on the state of the fibers; hence, the heart and the arteries are subject to diseases common to the simple solids or fibers, such as dropsy or cachexy (as in fiber pathology), because of deficiency in elasticity or strength of the fibers.[33] And yet, the fibers' contractile power to resist and propel the circulating fluids is "assisted by the nervous power" that "animates the fibres"; consequently, the motion of the heart and the arteries is sometimes disturbed in one way or another in accordance with the different degree of nervous sensibility or power—if nervous sensibility is morbidly acute, it excites the fibers to irregular contractions and leads to spasmodic constriction in the minute vessels and some disorders result.[34] This explanation suggests the way in which the fibers and the nerves are working together to create the circular motion, though in this case the nerves are given only an assisting role. In fact, Adair occasionally hints at this cooperation and mutual interaction of the nerves and the fibers: the nerves are intimately interwoven with the fibers of each organ into which the nerves enter, and therefore, if the fibers are lax and flaccid, the "tension" of the nerves is weakened and the impression on the organs of sense might be less exquisite; on the contrary, if the fibers are too tense and elastic, the nerves, too, become tense and more irritable.[35] It is very difficult to gauge the extent to which Adair's nervous vitalism (if we may so call it) plays a part in his medical system; in one place, the nervous power is said to pervade the entire body, but in another, this power is critically modified by the state of the fibers, and in yet another place the nerves are said to have only a supplementary role in assisting the fibers' contractile power. The two systems, the fibers and the nerves, seem to coexist uncomfortably.

Adair's staunch allegiance to the iatromechanical idea of the hydraulic body can be found in his lengthy account of "Determination," which occupies nearly half of the book. Determination here refers to "impulse," "tendency," and "afflux"[36] that direct or determine the quantity and the force of the circulating fluids sent to a specific organ or the whole body; the proper amount of "determination" in each organ is necessary for maintaining a due proportion between the solids and the fluids. Adair divides "determination" into two kinds, the diminished and the increased; in the case of diminished determination, the solid parts have a greater reactive power than the contained fluids, while in the case of increased determination, the power of the fluids is excessive over the reacting solids. Adair further expands these two kinds of determinations into four subcategories according to the two kinds of velocity: determination suddenly diminished, determination suddenly increased, determination slowly diminished, and determination slowly increased. Adair then arranges the whole of medical theory based on this classification and meticulously enumerates "Causes," "Signs," and "Effects" of each case, making fastidious comments. For example, in the case of "determination slowly diminished," one of its many causes is "Debility of fibres or nerves of particular organs" and one sign refers to "General waste of flesh and strength"; one effect of this is "Various degrees of debility of the nervous system and consequent diseases."[37] Although the nervous system is involved in this doctrine of "Determination," the significance attached to it is hardly felt. Everything might be determined by the different modes within the cavities or orifices of the solid vessels as they are suddenly or slowly diminished or enlarged by the variable force, and the solids or the fluids lose their resisting power to the solids or the fluids, which might cause the morbid state of circular motion.[38] For Adair, the body is imagined as hydraulic and constituted by innumerable hollow tubular cavities, the fibers of which are endowed with contractile power (even the muscles, properly so called, are "tubular").[39] Consequently, Adair's theory of determination, however complicated it becomes and even if it contains nervous vitalism, does not exceed the general framework of iatromechanism, in which the fiber-solids and the fluids are in a dynamic state of mutual interaction. It is to be noted that the notion of determination is very close to that of elasticity, tone, or tension of iatromechanism; for Adair, health depends on the due balance or proportion between the contents (the fluids) and the resisting force of the cavities (the solids) and "determination" determines this balance—this idea resembles the iatromechanists' idea of animal oeconomy that equally depends on the reciprocal relation between the solids and the fluids. Thus, Adair's effort to graft nervous vitalism (or the important role of the nervous system) onto the grand regime of iatromechanism hardly achieves success. It suggests that the mechanical system is still a powerful opponent for newly fledged medics to cope with more than two decades after vitalism set the medical scene.

Macbride's compromising model seems to be more successful than that of Adair. David Macbride spelled out equally voluminous work on medical theory, well over 660 pages published in 1772. Macbride starts with a general view of the solids, dividing them into three systems—the vascular, nervous, and cellular systems. The first two systems comprise the living solids and the last one the simple (or "inert" in Macbride parlance) solids, equivalent to the Hallerian cellular membrane.[40] Macbride extends the living solids, which are usually allotted only to the "nervous filaments," to the vascular system.[41] As the epithet "living" suggests, animal life depends largely on these two living systems; however, the inert fiber-solids, by which the nervous and vascular systems are bound together throughout the body even into the level of the minute vessels, are given some importance in maintaining life due to its very inert nature. For, if all solids are "living" and endued with some living properties such as feeling or irritation, the animal body would be easily subject to disorder with a slight touch given by a morbific agent, which if contained within the cellular system would bring no disruption.[42] Furthermore, the cellular system would impede the regular circulation of the fluids necessary for health; for instance, the great degree of rigidity acquired by the vessels of the cellular system makes the cavities of the system clog up (the lymph or the oil are supposed to run or stay within it), which causes the living solids adjoining it irritation (or the fibers are even "melted down"), and many diseases would rise from an application of the stimuli.[43] This idea of the pathology of the cellular inert solids is similar to Adair's theory of "Diseases of the Simple Fibre" and might be regarded as a descendant of the Boerhaaverian fiber pathology.

For Macbride, however, health would be maintained and perfected by the functions of the two "living" systems, the nervous and the vascular, rather than the "inert" solids. Like Adair, Macbride sees the essence of life as free and regular circulation of the animal fluids throughout the living body ("throughout every part of the vascular and nervous systems").[44]

Here, the nervous system functions in the same way as the vascular system: both systems have their peculiar fluids—the blood and its derivative juices from the heart, the nervous fluid from the brain—to be distributed to every "minute filament."[45] If this free circulation or the motion of the living systems (solids) is somehow disturbed, many diseases follow. Again, like Adair, this doctrine seems to be almost at one with the circular physiology of the older generations; however, Macbride makes clear what Adair left equivocal, a significant contribution of the nervous system to animal economy. Explaining the main causes of the general 15 morbid states, such as "Sickness," "Pain," "Inability to sleep," and "Spasm," which predispose the body to participate in producing diseases, Macbride points out that almost every case involves a certain change in the nervous system which fails to conform to any hydraulic laws.[46]

Macbride clearly recognizes the vital role of the nerves for animal economy to be worked together with the vascular system (and sometimes the cellular system). Even in fevers, of which the vascular system is generally assumed to be the main cause, the nervous affection contributes to the morbid process. Fevers appear to proceed from the morbid increased motion from the center of the vascular system; the increased heat and the quickness of the pulse evince the intensity of motion on the part of the vascular system, but "spasmodic constriction" also participates in the morbid state as heat increases by the conjunctive effects of the quickness of motion of the blood and the morbid degree of stricture of the vessels. As the latter condition is proved not to derive from viscidity of the blood and the spasmodic nature of this condition is "arising from an affection of the nerves," it follows that the nervous system also contributes to the morbid process of fevers, which Macbride concludes "consist in the disorder of both systems," the vascular and the nervous.[47] Macbride, like Adair, attempts to compromise the two systems old and new, finding the middle ground.

The compromising vision that newly fledged medical theorists had to adopt as they faced the transformation of the regime of the fiber-based iatromechanism to the emergent nervous vitalism usually takes the form of the amalgam of the two or three systems (the cellular, the nervous, the vascular, and/or the muscular systems) and the equal number of theories (iatromechanism and iatro-vitalism or nervous vitalism) along with the concomitant ideas of the body (the hydraulic machine, the nervous sensitive organism, or the irritable body), combined with the larger division of the simple (inert) and the living solids. Accordingly, the resultant combination of these factors is much varied depending on the nuanced position of each theorist, which would resist a clear-cut appellation. This compromising system also complicates the concept and the function of the fiber. Fibers are sometimes to be classified as inert or simple solids (often identified with the cellular system or texture) and are sometimes included in the living solids (often but not always equivalent to the vascular and or muscular systems); fibers, taken in the narrower sense, are usually associated with the mechanical "dead" property (elasticity), but are often associated with life in the form of the muscular (often called "moving") fibers. In both forms, the fibers contribute to morbid processes of diseases, from the laxity or the rigidity of the fibers (as in the form of the diseases of the simple solids) or from the affection of the moving (muscular or vascular) fibers (as in the form of the affections of the living solids); furthermore, these processes are assisted by, or work with, the nervous system. To complicate the picture, the fibers are, as the constituent unit of the body, differentiated into the nerves (as the expression "the nervous fibers" suggests); so, the fibers, taken broadly, touch on all three systems.

In this inextricably nebulous situation, it is impossible or even meaningless to either establish an overall picture or arrive at a general assumption. Reorganizing the situation around the larger distinction between the fibers and the nerves, the heart and the brain, the muscular and vascular systems, and the nervous system, iatromechanism, and iatro-vitalism would be only a heuristic help (it should be emphasized that these lines are extremely precarious, as we have seen above); however, through the heuristic lens we might gauge the position of each medical writer according to their differing degrees of commitment to either fibers or nerves, the heart or the brain. Whytt and his followers are the ultra-nervous vitalists who commit themselves to the brain–nerves doctrine, but many other medics (especially those of the 1750s to 1770s), like Adair and Macbride, found themselves in the middle ground, often recognizing the necessary cooperation of the two. For instance, Andrew Wilson, a natural philosopher, making a forthright criticism against heart-based mechanical motion ("the heart is not the fountain or origin of the motion"),[48] seeks a non-mechanical agent for motion in the brain, the source of the vital principle, or "a motive power,"[49] through which "universal vitality" is disseminated or "irradiated" throughout the body.[50] Wilson is, however, not the ultra-nervous vitalist Whytt is, for his nervous vitalism is critically qualified or compromised by the other side of the camp. Wilson's nervous vitalism is predicated on the core principle of circular physiology in that the brain produces the "real glandular secretion"[51]: "the constant flux of this vital principle from the head to every point of our frame, must be considered as essential to the perpetuation of the circulation in the heart, as the secretions of other glands are to the maintenance of the circulation in them."[52] Moreover, in a similar manner as Baglivi, a fiber mechanist of the old regime, Wilson acknowledges the brain's alternate pulsations corresponding to those of the heart.[53] Admitting the pulsative actions both in the heart and in the brain as requisite to life, as well as the heart's immediate connection with the brain and the nervous system, "the secretaries of life," Wilson compares the functions of the brain and the heart in the human frame (microcosm) to those of the sun and the moon upon the earth (macrocosm) in an illuminating passage:

> The sun pervades all nature, and hence his influences in its most intricate recesses....while the moon by a special regulation and flexion of his influences, disposes that great mass of fluids...the immediate organ of his energy...into these tides and reciprocations of ebbing and flowing.... Just so in the microcosm, the brain, by the mediation and irradiation of its nerves, penetrates and animates every point of our frame...; while the heart, by its reiterated impressions and shock on both the solids and fluids...gives an additional vigour to the animation and dispositions of the whole and causes these perpetual collisions which irritate and invigorate the living frame.[54]

Wilson seems to successfully merge the old (the fibers and the heart) with the new (the nerves and the brain) and provides a most exemplary case of the compromising model.

Wilson's view of the living body as imbued with pulsations initiated by both the mechanical and the vital agencies suggests that at a deeper level Wilson agrees to the vibration–tone–tension model of the fiber body that we observed in the last chapter. Indeed, Wilson insists on the "perpetual motion" and "oscillations" of "the animal fibers everywhere" while the body is alive.[55] The next section discusses this aspect of the continuing vision of the fiber body.

2.3 *The Physiology of Tone*

The iatromechanists of the first half of the eighteenth century saw life and health as depending on the due circulation of the blood, which was principally regulated by "tone" or "elasticity" of the animal fibers. In this framework of circular physiology, animal economy was thought to rely on the tonic motion of the animal fibers of the living body, which is always in a state of vibration or tension.

It is striking that this general framework of the physiology of tone or vibration endured after the vitalistic nervous physiology gained ground. Most medical practitioners of the latter half of the century recurrently refer to the state of the tone of the living solids as the basis of physiology, with the slight differences that the nervous system takes the place of the fiber-solids, and some vital properties, variously called sensibility, irritability, excitability, sentient or vital principle, and nervous or animal power, are referred to in place of elasticity. As one writer says, if the tone of the solids, which means a "certain degree of strength and resistance," is altered, many varieties of diseases will be brought up.[56] In a similar vein, many nerve doctors count on the state of the tone of the living solids: Henry Neale, one such physician, says that perfect health relies on the due tone of the nerves; another nerve doctor, William Smith, conveys the similar idea that nervous diseases are brought about by relaxation of the nerves.[57] The cause of the lax state of nerves or undue tone of the solids is the want of nervous or other vital energies. For instance, in his essay on chronic diseases, Thomas Withers accounts for the ways in which chronic illness such as a nervous complaint is produced within the general framework of physiopathology of tone. In particular, Withers denounces the ways of high living as pathology: the want of sleep from unnatural conversion of night into day "destroys the tone of the nervous system"; great heat from the fashionable hot rooms with large fires and stoves "relaxes and enervates the animal fibres," while indolence and intemperance would injure the "tone of the nervous system and vascular system."[58]

Most therapeutic practices, therefore, are conducted to restore the unstrung animal system and its sensibility to its due tone by stimulating the living solids with the gentle vibratory motions; these include riding, sailing, dancing, music, or electrical shocks.[59] The medicinal use of electricity, increasingly popular toward the latter part of the century, is a case in point. Invested with extraordinary properties supposedly responsible for many natural and vital phenomena, including earthquakes and meteors, electricity was considered to have a surprisingly wonderful curative virtue, and many medical practitioners exploited it in their medical practices. The theoretical principle of electric therapy worked thus: a vibratory stream of electrical fluids passed over the languid nerve fibers could invigorate the unstrung nervous system or the obstructed vascular system by gently stimulating the whole system and restoring its sensibility to a due tone.[60] Finding that humidity from damp and hazy weather deprives the human body of a certain amount of electricity that is supposed to be lodged in the body, Adam Walker, a popular natural philosopher, contends that "an electrical shock" would give "tone to a flaccid fiber" and the nerves would restore their lost "tension and elasticity."[61] The electrical shock, however, should be soft and gentle, for a strong and violent shock would give a disagreeable feeling to the patient and have no salutary effect on illness. Francis Lowndess, one of many medical electricians, explained of his employment of a gentle mode of electric fluid that the point of the "gentle" devices was to "rouse and invigorate the whole system" by the gentle yet powerful shock of "Electric Vibrations."[62] This gentle shock employed by Lowndess was not much different from "General Motion," a mimetic vibration produced by exercise such as riding, advocated by Fuller—George Adams, a distinguished natural philosopher, explicitly says that it serves as "an artificial means of exercise"[63]—or it resembles the corresponding "Concussion," produced by the least stroke of a musical instrument, promoted by Quincy.[64]

The framework of circular physiology also remains almost the same: vital fluids, whether of the animal, nervous, medullary, or electrical kind, must flow through the minute canals or the clandestine meanders, or sometimes along the solid (or porous) tubes in the form of tremulous motions, in order to nourish and invigorate the body or to transmit neural information. If the due course of the flow is interrupted by some obstruction, the nervous energy (or vital power) necessary to maintain the vigorous tone of the animal solids fails to pervade the body, paving the way for many kinds of physiological dysfunctions. Moreover, the body, nervous or fibrous, is still seen as vascular; there is no point of the human body that is not vascular, and the smallest vessels made up of simple fibers are nourished by the finest fluids.[65] For example, John Brown, the founder of the Brunonian system, endorsed the same view of the circular physiology of tone. Brown sees the mechanism of circulation as the interaction of the moving fibers and the blood, which is predicated on the principle of tone. According to Brown, the muscular fibers of the vessels are distended by the mechanical pressure or energy of the blood, which stimulates the "excitability" of the fibers, producing "irritability" to make the fibers contract; the "contraction of each portion [of the fibers] sends the wave onward to another portion," then the fibers relax to make way for the next. Circulation goes on in this fashion of alternate contraction and relaxation while life remains.

The "active state of the living fibres" of the vessels to resist with "vital energy" is precisely designated by Brown as "tone."[66]

These various strands of the physiology of tone or vibration in the different medical practitioners of the latter half of the century suggest the fundamental continuity of the classical theory of fiber pathology by iatromechanists in the new era of iatro-vitalism. Even Whytt, an ultra-vitalist with a quasi-animistic mind, shares the same idea with iatromechanists regarding the vibratory motion of the vessels. The whole vascular system, including the invisible smallest vessels, must perpetually vibrate everywhere in the body for the purpose of supporting the propulsive force of the heart and larger arteries. As the smaller vessels have the same muscular fibers and coats as the larger ones, which are endowed with the proper muscular contraction involving "moving power" in addition to elasticity, the blood gently stimulates these smaller vessels into "vibratory contractions," which causes the circulation of the fluids.[67]

The major difference, if any, in the physiology of tone between the two viewpoints is that the tone referred to by vitalistic medics came to be dissociated from the mechanical notion of elasticity, which had formerly been equivalent to tone or tension. The property of elasticity is reduced to the purely mechanical, identifiable with deadness, by the iatro-vitalistic writers. The whole animal body to the utmost interiority is found to vibrate or oscillate in the form of tonic motion; the principal driving force of this perpetual motion, however, is not elasticity, which shares only the part of it, but rather the "moving power"[68] of the vital kind (nervous or animal power, brain or nervous energy, vital or sentient principle), which is infused with the soul or the mind. Therefore, tonic motion, which had earlier been confused or identified with the notion of elasticity by iatromechanists, now was mingled with vital properties such as irritability or sensibility.

So far, I have observed that the medical theory of the second half of the eighteenth century is not dominated by nervous vitalism and that many vitalism-oriented medical writers had to cope with the strong presence of iatromechanism; it suggests that the medical scene of mid- to late eighteenth-century Britain cannot be characterized as a successive transition from mechanical medicine (usually associated with the Boerhaaverian system) to nervous vitalism (often identified with the Scottish nervous school). But, what about William Cullen, the foremost authority of medicine in the British Isle during the second half of the century, whose nervous doctrine swept across the Atlantic? Next, I examine Cullen's medical system in order to exhibit that a body of knowledge of Cullen's nervous vitalism is also a product of a compromise with the iatromechanical fiber body.

2.4 Cullen's View of the Nervous System

William Cullen, professor of Medicine at Edinburgh University, was undoubtedly the most influential medical teacher of the era in the English-speaking world. Cullen's teaching of nervous physiology—wherein life and death depend on the function of the nervous system, especially that of the brain—became the hallmark of the Edinburgh Medical School, where the role of the nervous system had been given critical emphasis, especially by Alexander Monro *secundus* and Robert Whytt.[69] Cullen differs from both Monro and Whytt in the very idea of the nervous system, for he conceives the nervous system as consisting not only of nerves and the brain, but also of muscular or moving fibers (Cullen uses them interchangeably) as the supplementary element. Moreover, nerves and muscular fibers are indistinguishably connected to compose a single functional unit—an archaic idea dating back to the age of Galen, when tendons, sinews, and nerves were ill defined.[70] Thus, Cullen's idea of the nervous system—the basis of his "nervous doctrine"—contains from the start the moving or muscular fibers as an indivisible unit constituting a neuromuscular physiology.[71]

Although the moving fibers are included in the nervous system as if they were subordinate, they assume a crucial function for animal life. To put it crudely, without the moving fibers, the animal body would become inanimate and devoid of life; where there are no muscular fibers, there are no actions at all, and where there is no action, there are no animal functions at all. As Cullen puts it, "There is hardly any sort of motion, connected with the exercise of the functions, which is not performed by muscles, or muscular fibres."[72] The muscular system or the moving fibers are far from peripheral to the nervous system and the animal economy; rather, they are "the most remarkable organs" and are fundamental in animal economy.[73]

Cullen's idea of the indivisible neuromuscular system corresponds to the equally indivisible system of the neuromuscular physiology of tone, or more precisely, of the neuromuscular-vascular physiology of tone. For Cullen conferred on the blood-vessels a greater significance in animal economy than usually supposed; above all, they furnish the additional tonic power to the nerve fibers. Cullen explains that when the neural impression is transmitted to the brain from the sentient extremities, the motion excited in the nervous fibers must be vibratory; therefore, a certain degree of tension is required to sustain its vibratory motion. Now, since we know that an uncommon number of blood-vessels are interwoven into the nervous fibers and also that "every artery is in a state of tension," it is obvious that the blood-vessels determine the degree of tension.[74] Furthermore, the muscular fibers, themselves, already charged with "Tonic Power," also require an additional supply of tension from the blood-vessels which everywhere accompany the muscular fibers for the purpose of muscular action.[75]

Cullen's nervous physiology is overshadowed by tensional physiology: Cullen's view of the body as tremulous, oscillatory, and tensional is to be found in the section "Tension and Laxity" of his early *Clinical Lectures* (1765, 1766).[76] Here, Cullen argues that the body needs a certain degree of tension of the muscular and "sanguiserous" systems (i.e., of the blood-vessels) to preserve health. The animal system of the living body consists of "a tremulous oscillatory mass of matter," because of which the oscillatory motion of other bodies is immediately communicated to any parts of the vibratory organs of the body.[77] Cullen cites a very interesting case of a nephew of Dr. Boerhaave, who lost his hearing capacity but acquired a supplementary organ of hearing in every part of his body. He thus perceived the oscillatory motion as distinct words voiced by a person by means of his hand placed on a person's shoulder, which served as a hearing organ.[78] Cullen defines these oscillatory motions as mechanical, and further argues that in addition to this mechanical tension, which is mainly sustained by the stretching force of the muscular system and the distending force of the "sanguiserous" system, there is a "contracting power" residing in the animal fibers which he calls "the *tonic power* of the fibres."[79] The degree of tension of the animal fibers depends on this state of the tonic power. Hence, animal economy is supposed to vary according to these tonal (or tensional) modifications.[80] Cullen assumes that the inherent power of tonic motion or irritability of the moving fibers largely depends on the energy of the brain or "animal power" that is supposed to be the fundamental power.[81] The degree of animal power, however, depends on the state of the medullary fibers and the tension of the blood-vessels.[82] For example, in the description of the mechanism of "syncope" or fainting, Cullen singles out brain energy as one of the remote causes; if this power diminishes, a force conducted to the moving fibers of the heart from the brain also weakens, which may occasion an episode of syncope. The degree of brain energy, however, depends on "a certain fullness and tension of the blood-vessels"; if the blood is evacuated in a certain amount, tension of the blood-vessels also diminishes, and thereby lessens the amount of energy delivered to the heart, causing syncope.[83] The argument is, therefore, a kind of circular one, starting with animal power, which infuses its force into muscular or nervous fibers for their actions, but which depends on the tension of the blood-vessels that accompany the nervous and muscular fibers to maintain tonic motion.[84] Thus, in Cullen's system, the brain–nervous physiology is further deconstructed by the peripheral vascular system, which is endued with tension.

Strength of the mind and vigor of the body are required in Cullen's system for conducting a healthy and virtuous life[85]; indeed, the vigor of the moving fibers, the inherent power to contract ("contractility"), or the tone of the moving fibers, is the palpable sign of life.[86] Without this sign of the vigorous actions of the moving fibers, a living organism would be judged dead. Moreover, the whole of animal fibers, simple fibers and especially moving fibers, are always under a state of tension[87]; without this tonic motion that determines the oscillatory motions of the sentient and muscular extremities necessary for animal functions, the living organism would cease to live. Despite a promising relevancy of the nerves in Cullen's nervous physiology, a closer look at his works reveals that the nerves are a mere placeholder in the body at the service of the moving and vascular fibers.[88] As for other nervous vitalists of the era, tone, along with the moving fibers, maintains a powerful presence in Cullen's nervous physiology.

3 Irritable Fibers: Irritability Reinvented and the Rise of the New Vitalism, c.1780–1800

3.1 Irritability Reinvented and the New Vital Principle

Toward the last two decades of the eighteenth century, the concept of irritability, first proposed by Haller as the property inherent in the muscular fibers, was rediscovered and reinvented by some new medical writers of the vitalist bent as a kind of primeval vital principle distinct from other similar vital powers. Boosted by John Hunter's new idea of life, wherein life was thought to be independent of any forms of organization, the new idea of irritability introduced by these medics was construed as life itself rather than the vital properties (such as sensibility, irritability, the sentient principle, nervous power, or energy). As life itself, the newly invented irritability was supposed by these writers to be totally severed from organization, but the close association with the muscular fibers led many to maintain the material connection with the fibers. This new group, which might loosely be called the "Irritable Fibers" school, became a strong opponent of the school of nervous vitalism of the previous decade.

The medical history on the concepts of Hallerian sensibility and irritability is too complicated to describe in a few paragraphs, as Steinke fully demonstrates in his majestic work on this topic.[89] In the context of the British Isle, we can safely say that Whytt's idea of nervous sensibility against muscular irritability wielded considerable influence on the medical world at least through the 1770s. In his famous controversy with Haller, Whytt stressed again and again the preeminence of the property of nervous sensibility over that of muscular irritability. Whytt reduced irritability to a general property of sensibility, while irritability always assumed or implied feeling or sensibility; the sentient principle (which is equivalent to the soul for Whytt) unconsciously sensed or perceived the irritation or uneasy feelings and reacted accordingly.[90] Against Haller's assertion that if the communication of the nerves to the brain, where the sentient principle (soul) resides, is cut off by decollation, as in the case of the severed heart from the body, the nerves could not enable the muscular fibers to contract, Whytt made a counterargument that the soul would not depart from the body immediately after death, leaving some remnant energy in the nerves to act on the muscles, with a dangerous implication of the immaterial soul's divisibility and extension to all the body parts—an opinion Haller would never accept.[91] Some medical practitioners of the era endorsed Whytt's position. Thomas Kirkland, one such follower, espoused Whytt's conjecture of the soul's extension with the anatomical evidence that the medullary substance of the brain and the nerves was the true seat and conductor of sensation, and therefore this mucus or gluey substance could be taken as the "expanded brain"; in so doing, Kirkland concluded that irritability depended wholly on sensibility, as the irritable parts, identifiable with the expanded brain, were extended to the extremities of every part of the body.[92] Many medical writers wanted to avoid the dangerous position implicated in Whytt's idea of the extended soul and usually confined themselves to opine that both properties depended on the brain and the nervous system, or used them interchangeably with a strong implication of nervous priority.[93]

In the 1770s, when Whytt's influence was still powerfully felt, a new direction seemed to be introduced by the nervous theorists themselves to modify Whytt's monistic view of the organism as directed, controlled by the brain–nerves nexus. Partly endorsing and partly qualifying Whytt's idea of the nervous sensitive body, the body somehow spiritually centralized, they promulgated the new uses and functions of "the ganglions of the nerves," which they supposed were worked as the instrument of involuntary motion and as the checker to the power of volition.[94] Crucially, the ganglions were regarded as "little brains" to receive and disperse nervous energy throughout the body, because of which the vital energy would be communicated to the extremities even if the brain were cut off.[95] In this "new nervous organization," the soul was no longer the lone director of the body, as the ganglions "limit[ed] the exercise of the Soul's authority in the animal oeconomy."[96] Whytt's centralized brain–nervous system was critically de-centered by the ganglions.

Apart from but probably interconnected with this modification to brain–nerves' autarchy, some medical writers from the 1780s pit themselves against nervous vitalism, drawing on the newly interpreted concept of Hallerian irritability as the first vital principle, often associated with Hunter's vital principle. One of the earliest examples can be seen in John Leake's medical treatise on women.[97] Leake, a prominent physician on female diseases, assumes three bodily powers constituting the principle of life: the brain and the nervous system for sensation, the heart and the arteries for circulation, and the stomach and the bowels for aliment and nutrition—these powers assist each other just like the "movement of a clock"; if these powers are out of order, the vital function is also disordered.[98] Surprisingly, Leake adds to these three powers another vital power, "*Irritability*," as "a more latent principle of life," which does not depend on any of these powers since it continues to exist after all sensation, circulation, or any vital functions cease.[99] Leake boldly asserts that irritability is even independent of the soul, as it continues to exert power after the brain, the seat of "that spiritual something," is totally destroyed, as in the case of the irritable heart of the decollated animals.[100] Contrary to Whytt, who saw some residue of the sentient principle in the dying body, Leake finds the irritable principle as the last to take leave of the body.[101] To restore the apparent dead person, Leake proposes to give some powerful stimuli to the irritable parts only, as the nervous parts are all devoid of feeling by death; only irritability enables "the wheel of life" to turn again.[102] From these facts, Leake concludes that irritability is "*the first* *vital principle*" to commence life itself.[103] Leake's statement of irritability as "the property of the animal fibre" which contracts itself if stimulated betrays his indebtedness to Haller's concept of irritability, but Leake goes beyond Haller, who did not postulate irritability as the first principle of life as Leake does.

While Leake did not refer to Hunter's idea of the vital principle, John Hunter's influence on the newly invented concept of irritability becomes more discernible in the 1780s. Gilbert Blane's Croonian lecture on muscular motion expounds upon some of the significant aspects of the new idea of irritability. Blane in this lecture establishes a kind of pathology of irritability. He argues that the internal organs for involuntary motions (secretion, nutrition absorption, and circulation) hold a natural degree of irritability to execute their office (to expel, absorb, or circulate) in accordance with the stimulus applied to them, so health depends to a great degree on the natural state of irritability of the muscular fibers.[104] Interestingly, Blane repeatedly calls this irritability "*perception*," in analogy with sense perception; each organ of motion has its peculiar perception (irritability) to perform its natural function in consequence of the stimulus in the same manner as the sense organ has its peculiar sensibility to receive and convey specific ideas or sensations corresponding to the external impressions.[105] Endowing irritability with the perceptive faculty necessarily recalls Glisson,[106] but Blane skips over Glisson's name where he should mention it and boldly links this irritability to John Hunter's vitalism. Blane endorses the position that irritable vitality does not depend on the nervous system on the ground that animals even without the brain or the nervous system can exist. Blane here seems to deliberately conflate Hallerian irritability with Hunterian vitality, situating them on the genealogy of irritability (that opinion was "first observed by Haller, and has been confirmed by Mr. Hunter").[107] Blane further argues for the independence of irritability from nervous influence by associating it with Hunter's idea of "powers of simple life," a life force to assimilate aliment and preserve animal body from dissolution and putrefaction, which is a "proof of vitality being independent of nervous power."[108] From this fact, Blane even asserts that the influence of the nervous system impedes simple life, for an organism of simple life would survive longer if it is killed by destroying the nervous system than killed by suffocation or any other means.[109]

The Hunterian idea of vitality against the organism's dissolution finds its echo in some fields of medicine of the era and sometimes even in the theory of nervous vitalism. John Gardiner is surely one such nervous vitalist. Like his friend Alexander Monro *secundus*, he conceives the brain as "the chief seat of the living principle," from which the energy of the brain is conveyed through the nerves.[110] Gardiner defines, however, the living principle as the "cause of the preservation of the body from dissolution," a very Hunterian definition,[111] and argues that this vital principle requires another energy besides the brain energy. Reminiscent of Hunter's experiment on heat, Gardiner contends that the power of the living principle is supported by "heat" since the organism has a resisting power to cold and life extinguishes upon abatement of heat. Thus, he draws a conclusion that "a certain degree of heat must coeval with the living principle."[112] This might be called a compromising or mixed model of nervous vitalism with Hunterian vitalism.

Francis Milman's treatise on scurvy is another example indicating the extent to which Hunter's vital principle exerts its influence, although he does not explicitly mention Hunter. Against the dominant view that scurvy was a disease of the putrid fluids, Milman seeks for the pathology of scurvy in the dissolution of the solids. In order to explain the mechanism of the morbid changes of the solids, Milman turns to the properties of muscular fibers; like most physiologists, Milman supposes that the property of the muscular fiber consists in its contractility by stimuli, and like new vitalists of the irritability school, he confounds it with the primeval vital principle, "the vital power," since it begins with life as such.[113] The power of contractility inherent in the muscular fibers is identifiable with Hallerian irritability as Milman refers to Haller's definition of irritability as "*vis insita musculi*," but like other new vitalists, he transgresses Haller's strict understanding and expands its meaning to register the primeval vitality.[114] What is crucial for the pathology of scurvy is that the morbid changes of solid-fibers proceed from the diminution of this vital power. Relying on the principle propagated by Fontana, an Italian physiologist, that the destruction of the vital power leads the muscular fibers to putrefaction, Milman applies the same rule to the pathological process of scurvy.[115] He finds that the general symptoms of scurvy such as sluggishness, torpor, and lassitude are different from the usual form of fatigue (e.g., the scorbutic symptoms come on slowly and increase over days and weeks), and that the feeble state of the scorbutic is unchanged even after strong stimuli are applied; from these facts, Milman infers that there must be other sufficient cause to deprive the muscular fibers of the contractile power and weaken the fiber-solids, which ultimately putrefies the animal body—the diminution or destruction of the vital power.[116] Milman concludes that scurvy is not a disease of the fluids, but of the fiber-solids, with its seat being in the muscular fiber, and its cause in the gradual diminution of the vital power.[117] He extends this pathology of the muscular solids of the fibers to all putrid diseases, with a dictum that the diminution of the vital power inherent in the muscular fibers predisposes the body to putrefy.[118]

Milman's muscular pathology of the fiber-solids finds its place in another medical field, dermatology. Seguin H. Jackson, a distinguished dermatologist of the era, in his medical work on the diseases of the skin, frequently refers to Milman's treatise on scurvy and appreciates him as the inventor of "Muscular Pathology" as contrary to Boerhaave's humoral pathology.[119] Drawing on Milman's muscular solid pathology, Jackson attempts to advance a theory of "New Pathology."[120] Jackson still sees the human body as the hydraulic machine, the greater part of which comprises the muscular fibers—even the minute and extreme vessels such as the capillary and cutaneous vessels are muscular because Nature provides "irritability" with these minute vessels to promote circulation. As the health of the skin consists in the circulation and exudation of the fluids, the general debility of the muscular system causes the morbid, atonic state of the capillary vessels, which leads to the derangement of any vascular circulation of the skin. The pathology of the cutaneous diseases depends on the due degree of "muscular irritability" furnished within the circulating system.[121]

3.2 Apparent Death and Absolute Death

The new notion of irritability as the basis of life and the Hunterian idea of vital power as resisting putrefaction, if conjoined, find an illustrious case in the discussion on apparent death, a topic that gained wide currency among medical practitioners during the last two decades of the eighteenth century.[122] Facing the apparent dead person, the medical practitioner is forced to establish a certain criterion to distinguish between apparent death and absolute death. Witnessing that the apparent dead person may be resuscitated by artificial means, they had to re-think the definition of death, what causes death, and by extension the definition of life. In the discussion of the apparent dead, the definition of death is drastically changed, for the cessation of circulation, respiration, and the pulse, which was formerly the sign of death (Adair still thinks it is so), no longer signals one's absolute state of death because the drowned who are apparently dead without any vital signs of circulation and respiration, if stimulated by artificial means such as electrical shock, artificial warming, friction and respiration, infusion of tobacco, and so on, sometimes are restored to life. The case of the apparent dead thus defies the criterion based on the vascular system, as life continues without circulation, and it defies the laws of the nervous system as life still remains without sensation or consciousness. The muscular system, however, seems to provide a criterion conforming to absolute death since irritability, the peculiar property of the muscular fibers, still remains in the body of the apparent dead. Charles Kite, a London surgeon, is one of these medical practitioners who count on the notion of irritability to introduce the decisive criterion. Trying to identify the positive sign of absolute death, Kite enumerates a variety of possibilities such as the livid, black countenance, the dull, fixed state of the eyes, the glassiness of the eyes, the dilated pupil, the rigid state of the jaws, and the universal cold, all of which are not reliable indicators.[123] Kite even excludes putrefaction (at least incipient putrefaction) as the unequivocal sign of death since the putrefying appearance resembles that of putrid diseases; only in the advanced stages can putrefaction be counted upon.[124] Kite's final answer to distinguish life and death lies in irritability:

> Death may be distinguished into two kinds or species—apparent, and absolute. By apparent death, I mean a stoppage of the circulation, respiration, and action of the brain; the irritability, however, or that peculiar property of the muscular fibres which enables them to contract on being irritated, still remaining. By absolute death, I would be understood to signify, not only a cessation of the vital, natural, and animal functions, but where the principle of irritability is also entirely destroyed.[125]

The lack of water in the lungs proves the existence of irritability in the body of the drowned, for the irritability, "the vital principle," effectively prevents water running into the lungs by its irritable action as long as life remains in the muscular parts of the larynx.[126]

Anthony Fothergill, a renowned physician of the era, even more strongly advocates the new idea of irritability as the vital principle for the explanation of apparent death and develops a kind of a philosophy of irritability. Fothergill refutes the theories of the vital principle hitherto promulgated by medical thinkers—Harvey, who saw the soul in the blood; John Hunter, who thought the blood to be alive; van Helmont, who conceived the soul residing in the stomach; and finally, nervous vitalists, who saw the brain as the seat of the soul. None of these philosophies are appropriate to explain the phenomenon of life, which is not confined to a particular organ of the body—the heart, the stomach, or the brain.[127] Then, what is life? Fothergill contends that organization is a necessary condition to be awakened or animated by some force or agent ("Organization…is only a condition, or necessary step toward animation"); it is like a watch complete in its mechanism and waiting to be wound up, otherwise it remains silent.[128] Fothergill's thinking is here very close to Hunter's idea of vital principle superadded to organization, but curiously he passes over Hunter (who Fothergill assumes the philosopher of the blood as life) and associates the vital power with Haller's irritability, or "motory power of animal fibres," like other new vitalists who reinterpreted Haller's concept of irritability as the vital principle as such.[129] Like Leake, who postulated a primeval irritability that gives commencement to animal life, Fothergill supposes a kind of "primaeval irritability" (the *punctum saliens*) that actuates the heart of the embryo before the brain is formed, and calls it the "*primum movens* and *ultimum moriens* of the animal machine" since it never relinquishes its motion until death.[130] Accordingly, the vital principle of irritability provides for Fothergill the sure criterion to distinguish life from death. Denying Cullen's idea that the muscular fibers are a continuation of the extremities of the nerves and advocating the full independence of the irritable fibers from the nervous system,[131] Fothergill sees vitality (life as such) in irritability and death as the extinction of it.[132]

On this principle of vital irritability, Fothergill takes a further step to develop an animal economy of irritability, which would mark a radical rupture from the fiber model of Enlightenment medicine. Although Fothergill construes irritability as "the Principal Agent in the animal oeconomy,"[133] he tends to see irritability as something quantifiable—irritability is daily consumed by vital action and replenished by the lungs (by inhaling the vital air); if the stimuli applied to irritable fibers are deficient, the quantity of irritability increases, or builds up in the fibers, while if the stimuli increases, irritability diminishes.[134] As each animal fiber has its determinate portion of irritability necessary to its natural tone, which, if the stimulus is applied, excites "oscillatory motion,"[135] the "Grand secret in the art of healing" consists of the proper adjustment of the stimuli, natural or artificial, to "the exact tone of the irritable fibre."[136] In this scheme, animal economy might be calculated in the quantifiable laws of the diminution and accumulation of irritability in conjunction with the differing amounts of stimuli. Fothergill does not refer to Girtanner's laws of irritability, the topic of the next section, but the animal economy of irritability he advocates is almost at one with Girtanner's. By the time Fothergill published his work, Girtanner's laws of irritability had swept over the British medical scene.

3.3 Girtanner's Laws of Irritability and Their Impact

Girtanner's article on the laws of irritability ("On Irritability, Considered as a Vital Principle in Organized Bodies")[137] catches the atmosphere of new vitalism of the 1780s (as the title shows, Girtanner made clear his idea of irritability as a vital principle). Its success might lie in his formulation of the laws into simplified forms that were widely reused, re-circulated, and cross-referenced among a certain group of medical writers. Although no medical historians have noticed the significance of Girtanner, Girtanner's laws of irritability had a significant effect on the medical vitalists of the last decade of the eighteenth century.

Christoph Girtanner was a medical student at Gottingen and spent 1786, 1787, and 1789 in Edinburgh; it was surely in these Edinburgh years that Girtanner had a chance to read Brown's work, which Girtanner was later accused of plagiarizing.[138] In 1790, Girtanner published an article on irritability in a French journal, *Observations sur la physique*, a partial English translation of which appeared in the same year in *Edinburgh Magazine*[139]; the same material was quickly reprinted in *Medical Commentaries* the next year.[140] Two years later, Thomas Beddoes, friend of Girtanner, attached a more detailed version of Girtanner's translation (probably edited by him) with Beddoes's additional notes concerning his work on calculus.[141] The publication of Girtanner's article multiple times in quick succession might stand witness to the extent to which Girtanner's laws of irritability were widely welcomed, but some medical writers were not pleased with Girtanner. The adherents of John Brown's doctrine severely derided Girtanner for his plagiarism.[142] To be fair to Girtanner, although he was indebted to Brown's idea of excitability, Girtanner's medical system differed from that of Brown in emphasizing the primacy of the irritable fibers as the physiological bedrock of life and in clarifying the resultant laws of irritability in a simple formula.

Girtanner, like other new vitalists mentioned above, strongly advocates the primacy of irritability over nervous sensibility and the irritable fiber over the nervous fiber. Girtanner identifies three kinds of solid-fiber—the earthy, the sensible, and the irritable. The earthy fiber forms bones and is "inorganic, insensible and inirritable," while the nervous one constitutes the nerves and is equally "inirritable."[143] The irritable one, commonly called "muscular" but more rightly called "irritable,"[144] is only irritable, that is, capable of contraction upon stimulation. Every sensation and motion depends upon this irritable fiber as no stimulus can act on the nerves without the intervention of the irritable fibers; if the irritable fibers lose their irritability and become paralytic, there is no sensation even if the nerves are perfectly sound, but the reverse is not the case: if the nerves are destroyed and insensible, the irritable fibers continue to contract when stimulated, which demonstrates the total independence of the irritable fiber. Thus, Girtanner boldly inverts the common assumption of the nervous vitalists that sensibility (sensation) is the basis of life and instead asserts the primacy of irritability: "Sensation is only a secondary property, which depends on the irritable fiber, and cannot exist without it. Irritability, on the contrary, is a primary property, essential to the living irritable fibre, and absolutely independent of the nerves."[145] Girtanner further argues that the irritable fiber "pervades all organized matter" and motion, sensation, and even life itself depend upon this fiber.[146] Seeing life embodied by the irritable fiber, Girtanner concludes as follows:

> The irritable fibre, from the first moment of its existence to its dissolution, being constantly surrounded by bodies which act on it, and on which it reacts, by its contraction; it follows, that during the whole period of life, the irritable fibre is in continual action; that life consists in action, and is not a passive state, as some authors have maintained.[147]

The fiber is not in the passive but in the active state, constantly interacting with the stimuli surrounding the organism throughout life. Life, for Girtanner, crucially depends upon this irritable fiber and its property, irritability.

Upon establishing the vital significance of the irritable fiber in the living organism, Girtanner proposes the laws of irritability that the irritable fiber serves. He remarks on the three states of the irritable fiber in accordance with the three degrees of irritability: the state of health, the state of accumulation of irritability, and the state of exhaustion of irritability.[148] The second state, accumulation, is produced by the absence of habitual stimuli, such as heat, light, food, air, and the passions, and the last by the powerful action of habitual stimuli; if the sum of the stimuli acting on the fiber is not powerful and irritability is augmented, the stimuli, if applied, excite much stronger contractions; on the contrary, if the sum of the stimuli acting on the fiber is too powerful and the fiber loses its irritability, the fiber finds itself in a state of exhaustion and the stimuli, if applied, would not make it contract until the fiber accumulates again the irritable principle. Therefore, health depends crucially on the equilibrium between the acting stimuli and the irritability of the fiber acted upon—Girtanner calls this state of health “the tone of the fiber.”[149] As long as the action of the stimuli on the irritable fiber is in proportion to the degree of irritability, the fiber will be “in tone,” and the whole system is sound.[150] Accordingly, diseases are divided into two classes: diseases of accumulation of irritability, proceeding from the diminished action of habitual stimuli, and diseases of exhaustion of irritability, proceeding from the increased action of stimuli.[151] Identifying the “vital air” or “oxygene” as the source of irritability, which is united with the blood and distributed through circulation to every part of the body to be combined with stimulating substances, Girtanner further formulates the laws of irritability in a pneumatic line: “The irritability of organized bodies is always in a direct ratio of the quantity of oxygene they contain.”[152] In Girtanner’s scheme of “Universal Physiology,”[153] animal economy is thus regulated, calculated, and quantifiable according to the laws of irritability—the different degrees and combinations of stimuli, irritability, and the vital air adjusted to the tone of the fiber.

In the state of temporary exhaustion, the fiber little by little recovers its irritable principle to accumulate a certain degree of irritability; this phenomenon is a linchpin to Girtanner’s laws and is deemed by Girtanner a new discovery, although Girtanner must have borrowed the idea from Fontana, who had discovered the same phenomenon much earlier.[154] It can explain the hitherto unexplainable phenomena such as the motion of the heart and the periodical actions of the body; in particular, the rhythmic motion of the heart is the focal point. Most physiologists were bewildered that the heart continues its alternate motions of systole (contraction) and diastole (relaxation) despite the continuing presence of the stimulus, the blood in the cavities; in other words, the heart makes no contraction immediately after the blood, as stimulus, enters the cavities of the heart, which should cause immediate contraction. Haller never answered the question of why the effect (the contraction of the heart) does not immediately follow the cause (the blood as the stimulus).[155] The laws of irritability alone explain this enigma. The irritability of the heart must be exhausted during active contraction, and the heart (or its irritable fiber) finds itself in a state of temporary exhaustion, that is, a state of relaxation in which the fiber once again accumulates enough irritability to react to the stimulus. This interval of relaxation occurs in an instant, “half or three quarters of a second,”[156] so the heart seems to be constantly contracting, but it actually makes alternate motions of contraction and relaxation in accordance with "the alternate exhaustion and accumulation of the irritability of the fibre."[157] This law of irritability is a key to unlocking the hitherto mysterious phenomena of periodic motions of the body.

Girtanner's view of the living organism as subservient to the laws of irritability, conjoined with the differing degrees of stimuli, seems to attract the minds of the new vitalists, who held the primacy of irritability over nervous sensibility. Many vital medics of the 1790s quote, refer to, draw on, and elaborate on Girtanner's laws of irritability, with or without acknowledging their indebtedness. Fothergill is one of those vitalists, who, as I discussed above, fails to make mention of Girtanner but clearly owes his idea to Girtanner. Fothergill's description of animal economy as something quantifiable according to the degree of irritability and stimuli strongly recalls Girtanner's laws of irritability; moreover, Fothergill describes the irritable fiber's active state in a similar vein: "the irritable fiber is never passive, but in a constant state of action; and vitality…consists in action and reaction between the vital organs and their respective stimuli."[158] Joseph Townsend, in his popular *A Guide to Heath*, also relies heavily on Girtanner in postulating irritability of animal fibers as essential to vitality; the different states of the fiber as tone, accumulation, and exhaustion in accordance with the different power of the stimuli are symptomatic of the different states of the body.[159] All violent stimuli if long continued would exhaust the vital energy and induce morbid irritability, as in hysteria; hence, violent inflammation, for instance, results in gangrene.[160] The motions of the muscles are subservient to the laws of irritability, being "alternately contracted and released" despite the continual presence of the stimuli, in which the vital energy is alternately exhausted by exertion and replenished with "a fresh supply."[161]

Francis Penrose in his popular treatises of health and disease, almost plagiarizes from Girtanner, citing long passages from Girtanner's article on irritability to explain the mechanism of diseases (Essay III, "On Diseases").[162] Hugh Moises also, in a treatise on the blood, assimilates into his own sentences long quotations from Girtanner's laws of irritability to espouse the importance of irritability in animal life.[163]

Girtanner's impact on the medical scene of the 1790s extends to the field of psychiatry. Alexander Crichton, a renowned mental doctor of the era, starts his treatise on mental derangement with a detailed discussion of irritability and its laws, modifying Fontana and Girtanner's laws of irritability.[164] The argument of the laws of irritability lays the foundation for the analysis of physiopathology of the passions that follows.[165] Crichton describes the laws of irritability in the same fashion as Girtanner as well, employing the vocabulary of accumulation and exhaustion, the vital principles lost and repaired. All passions and their modifications act like direct stimuli on the irritable fiber and exhaust the vital principles (irritability and sensibility); if continued long, they induce a temporary delirium.[166] Drawing on Darwin's *Zoonomia* as well as Girtanner, Crichton concludes the section on irritability as follows: "Man is a fiber which bends itself into a ring, then becomes a tube, and then an animal. The principle of his motion is oxygene: ideas are motions of fibres."[167]

Girtanner's impact on the medical theory of the 1790s is most distinctly reflected in the medical philosophy of Robert John Thornton, who refashions the Brunonian system with Girtanner's doctrine. Thornton construes Brown's system, which is open to a wide interpretation, as a variant of Girtanner, for Thornton finds that Brown "attributed all the phenomena of life to the fibrous system."[168] Like other irritable vitalists, Thornton reinvents Hallerian irritability as the vital principle as such, commenting on the predominance of the heart of the chick over the brain–nerves, to assert irritability as the prime mover of the animal machine.[169] By describing the phenomena of the irritable power of the muscular fibers that survives the nervous influence, Thornton strengthens his conviction of the primacy and the independence of irritability in the same manner as Girtanner: "the nervous influence, which seemed to animate the system, and to be the prime mover and source of life, owes its restoration to that [irritable power], which was conceived to be but a secondary power."[170] He further confirms the superiority of irritability and its independence from nerves by arguing that the muscles possess "their own peculiar life."[171] Quoting Girtanner's passage without acknowledgment, Thornton also considers the "irritable fibres" or "locomotive muscles" not as passive organs, but as being in a state of constant action from stimuli.[172] Positing the irritable fiber as the basis of life, Thornton set the laws of organic life after the fashion of Girtanner's laws; the fundamental premise of the laws consists of "the *changes* that the *fibre* and *irritable principle* undergo upon the application of *stimuli*."[173] For example, when he discusses sleep, Thornton suggests that indirect stimuli such as silence, darkness of the night, and cold are required for sound sleep in order to accumulate irritability of the fiber, and warns against using feather-beds or fires in the bed-chambers, which, by increasing warmth, would exhaust the irritable principle.[174] In this fibrous animal economy, Thornton holds the laws of animal economy as being owed to the various modifications of the stimuli adjusted to the irritable fibers.[175]

3.4 Model Changed

So far, I have explored the ways in which the last two decades of the eighteenth century witnessed a new trend of vitalism distinct from (and competing with) nervous vitalism: Hallerian irritability was reinvented as the primeval vital principle in terms of the Hunterian idea of life by the medical writers of the 1780s; Girtanner’s laws of irritability had a significant impact on the vitalists of the 1790s—these new medics can be assembled under the name of the “Irritable Fiber” school, or more simply, irritable vitalists. In so doing, I have shown that toward the end of the century, the model of the nervous body stood untenable, facing a powerful opponent in the irritable vitalists. Paradoxically, however, it is from the “Irritable Fiber” school, especially that of the 1790s, that the fiber model of Enlightenment medicine disintegrates and concedes to a new model. The big rupture is brought on not by the nervous viltalists but by the fiber-irritable vitalists.

As discussed above, the “Irritable Fiber” school describes the mechanism of the living organism in terms of the variable degrees of irritability brought to action by the equally variable amount of stimuli—an animal body from the moment of birth to death, constantly expending by locomotive exertion the irritable principle (or the vital energy), which must accumulate or replenish lost energy or irritability by rest or relaxation; otherwise (without the fresh supply of irritability), the organism fails to react to the new stimulus. In this scheme, the body is imagined as something that consumes, exhausts, and accumulates the vital energy (irritability) as fuel within itself just like a steam engine, recently brought to the technological fore by James Watt.[176] Beddoes, a friend and collaborator of Watt, captures well this analogy; after linking Girtanner and Brown’s theory with that of animal electricity, recently discovered by Galvani and Valli, Beddoes articulates the mechanism of animal function as follows: “animal motion, at least that of animals analogous to man, would be produced by a very beautiful pneumatic machinery; and our nervous and muscular systems may be considered as a sort of steam-engine.”[177] For Townsend and Thornton, the continual alternate actions of exhaustion, fresh accumulation, and exhaustion again resemble the Leyden jar, an early form of the electrical condenser: “the irritability of the system is never in a permanent condition, but incessantly ebbing and flowing like the tide; constantly in motion, like the pendulum in its vibrations, or rather bearing resemblance to the Leyden phial, when it is alternately charging, discharging, and discharged."[178] The last quotation retains the older image of a mechanical clock with a faint echo of the vibration model, but the central image is that of the battery or condenser, which is rechargeable. The image of the body that accumulates and exhausts irritability like fuel or charges and discharges it like electricity seems to widely circulate among medical practitioners at the end of the century. John Abernethy, a judicious man of science, complains of the impropriety of the term commonly employed by contemporary medics who "receive [it] in a literal sense…the exhaustment of irritability during the contraction of the muscles."[179] John Herdman is another writer who feels uncomfortable with the new image presented by Beddoes: "At the beginning of the present century, the human frame was supposed to be a hydraulic machine. We are now changed into steam-engines."[180] The complaints by Abernethy and Herdman about the new usage and image may tell how the new body image was in vogue among the new generation of medical writers. Herdman's quotation aptly points out the transformation of the old image of the hydraulic machine to the new steam model. As the last chapter amply shows, however, the hydraulic machine that the iatromechanists envisioned has the underlying model of the muscular moving body that incessantly vibrates to maintain life, and as the first part of this chapter indicates, this muscular vibration model is applicable, to a certain extent, to the body image propagated by nervous vitalists. To gain a comprehensive picture of the Enlightenment body image, we only add onto this vibration model the image of the fiber-woven body in which innumerable canals, nerves, fibers, arteries, and veins are jumbled together. Now, this fiber-vibration model of Enlightenment medicine for the first time begins to be abandoned by the irritable vitalists, who still set the fiber (especially the muscular, irritable fiber) as the critical unit of animal economy but who no longer rely on any kind of vibratory motions to explain the mechanism of the living organism. The irritable vitalists often use the term "tone" to mean that the animal body keeps its healthy condition and vigor, in much the same manner as the iatromechanists and nervous vitalists. The irritable vitalists' usage of the term does not contain the implication that the iatromechanists and nervous vitalists had in mind—some kind of vibratory motion, visible or invisible; they employ it to designate an equilibrium between the stimuli and the irritability—it is not a motion but a quantifiable state or a degree of quantity.

To strengthen my argument on the model change brought about by the irritable vitalists, let me examine how Whytt managed to solve the mysterious rhythmic motions of the heart. Whytt was shrewdly aware of the enigmatic motion of the heart that repeats its alternate actions of contraction and relaxation despite the presence of the stimulating agent. Whytt tried to explain this phenomenon with recourse to the sentient principle, which determines the influence of the nerves on the fibers in order to get rid of uneasy sensation or irritation:

> if the contraction of an irritated muscle be owing to the uneasy sensation excited by the *stimulus*, as often as the first contraction does not remove this, the muscle will be agitated with alternate contractions, as being the most proper to throw off the irritating cause. If indeed, by the first contraction, the disagreeable sense of irritation be quite removed, no further motion follows; but if it still remains, new convulsive contractions succeed, and continue to be repeated alternately, till the *stimulus* either ceases entirely, and it is no longer felt, or becomes too weak to produce a new contraction.[181]

Although, strictly speaking, Whytt fails to solve the mechanism of the rhythmic motion of the heart muscles—he only explains why the muscles repeat alternate contractions—it is nonetheless interesting to note that his explanatory model is predicated on the vibrational model despite having recourse to the sentient principle (brain energy). As long as the body or the muscles are irritated by the stimulus, the sentient principle or the soul automatically orders the muscular fibers to "throw off" the cause with "alternate contractions" until it ceases to stimulate. This process is much like the iatromechanical view of the fiber-vibration model in which the body is shaking off obstructions with incessant vibrations. Whytt's sentient principle is constant, that is, never expended or augmented like the irritable principle, and the sentient principle as the governor of the organism determines what to do with the body—the nerves, the fibers, the vessels, and the animal fluids—all these are the instrument of the soul. The irritable fiber model of accumulation and exhaustion (of irritability as fuel) differs significantly from this. The irritable principle (irritability) is not constant but expended in every muscular exertion and needs to be replenished during relaxation; it never determines the force, quantity, or influence of the body parts (soul's instruments) as the sentient principle does; on the contrary, it is embedded or incorporated into the machinery of the living organism as fuel or energy to run a steam engine.

Probably, it is in the next century when S. Carnot first formulates thermodynamics in 1824 that a steam engine becomes a more convincing model for the body, as Georges Vigarello suggests.[182] The amount of energy (calories) consumed or burned in the organism is equivalent to the volume of work done; in this scheme of thermodynamics, the energy of the body comes from "calories consumed and exchanged" and from "their measured and calculated use."[183] Vigarello argues that this steam-engine model overturns that of the eighteenth century,[184] but from our point of view, the decisive step to the steam-engine model was taken much earlier by the irritable vitalists who discarded the fiber-vibration model and unintentionally refashioned it into a new one.

3.5 Darwin's Moving Fibers, a Final Version of the Fiber Body

Erasmus Darwin, one of the most significant medical philosophers of the late eighteenth century, is probably the last in our history of the fiber body to elaborate on the medical theory based on the fibers.[185] Darwin's idiosyncratic medical theory is difficult to characterize, for it is an amalgam of Whytt's nervous vitalism, Cullen's neuromuscular physiology, Brown's stimuli-reactive theory of excitability, Girtanner's irritable fiber theory, Beddoes's pneumatic medicine, and even Hartley's associationist psychology. Darwin appears to belong to nervous vitalism, since he sees "the spirit of animation" or "sensorial power" much like Whytt's sentient principle as the controlling principle over the body residing primarily in the brain and the nerves. However, Darwin shares much with the school of "Irritable Fiber" in setting the muscular fibers as the critical agent for motion and seeing fibrous contraction in terms of exhaustion and accumulation. Darwin's medical theory of the fiber might be a compromising product of nervous and irritable vitalisms. For our purpose, there are two points to be discussed in Darwin's medical system: its relation to irritable vitalism (especially Girtanner's laws), and the idea of the moving fibers.

Darwin views the essence of animal life in "animation" and starts his work with the study of motions, which constitutes the basis of the laws of organic life.[186] Darwin sets the three circumstances to produce animal motions: the stimulus, the sensorial power or the spirit of animation, and the contractile fiber.[187] Modifying Brown's system of excitability and infusing it with Hartley's associationist psychology, Darwin elaborates on the mechanism of motion. The stimulus occasions the sensorial power to activate any of the four faculties—irritability, sensibility, volition, and associability—into action, irritation, sensation, volition, and association, which produce a contraction of the animal fiber ("fibrous contraction").[188] These states successively become the stimulus to the next one, as the external stimulus induces irritation that excites the contraction of the fibers, which in turn produces sensation (pleasure or pain) and excites fibrous contraction as the new stimulus; this contraction introduces desire or aversion, which excites volition. Volition in turn becomes the new stimulus to association.[189] (Therefore, in Darwin, the stimulus includes all causes which excite the four sensorial powers into action.) Like the irritable vitalists, Darwin subscribes to the idea that health depends upon the equilibrium between the degree of stimulus acting on the organism and the spirit of animation, which for Darwin is equivalent to sound fibrous motions, while diseases proceed from unnatural and distorted motions of the fibers.[190]

Although Darwin places some importance on the brain and the nervous system as the center of the spirit of animation, not unlike Whytt's sentient principle, he shares the underlying assumption of the mechanism of motion with the irritable vitalists (like Girtanner). For the spirit of animation is, just like the irritable principle, "perpetually exhausted by the expenditure of it in fibrous contractions"; if there is "less fibrous contraction than usual," then the spirit of animation is "accumulated."[191] Conforming to the laws of irritability, upon the expenditure of the spirit of animation during contraction, the fibers cease to contract despite the presence of stimuli, until the contractile fiber receives a fresh supply of the spirit of animation from the brain.[192] The propensity for motion, whether it is irritability, sensibility, volition, or associability, corresponds to the quantity of the spirit of animation residing in the fibers to be excited.[193] As any motion involves some change of the sensorium and the change presupposes motion, Darwin terms the faculties of the sensorium "*sensorial motions*" to distinguish from "*fibrous motions*," the effect of the former.[194] It is striking that the "sensorial motions" do not hinge on vibration or the flow of the spirit like the inflowing of animal spirits through the nerves to the muscles ("The sensorial motions …are not here supposed to be fluctuations or refluctuation of the spirit of animation; nor are they supposed to be vibrations or revibrations"), but on the motions "peculiar to life."[195] What is more striking is that Darwin not only rejects the vibration model for explaining the mechanism of motion, which was almost consistently employed by both iatromechanists and iatro-vitalists (nervous vitalists), but also never refers to "tone" literally or metaphorically to designate the due degree of vigor or heath. Thus, he wholeheartedly discarded the physiology of tone, the underlying doctrine that most nervous vitalists relied upon (and which was still used by the irritable vitalists). Darwin elsewhere criticizes medical practitioners' usage of "tone" as equivalent to the vigor of animal life, pointing out that the term tone is a "mechanical term, applicable only to musical strings," and therefore, "like bracing and relaxation," cannot be applied to living organisms.[196] By confining the term tone to the realm of mechanics (or iatromechanism), Darwin once and for all distances himself from the physiology of tone.

It is very curious that Darwin situates himself further from the physiology of tone and the vibration model than any other medic, while simultaneously he attaches the most critical importance to the moving fibers. Darwin posits motion rather than sensation at the heart of animal life. Going beyond Cullen's view of neuromuscular physiology, Darwin sees the nervous system as overshadowed by the moving fibers. His emphasis on the effect that these moving fibers have on the nerves is particularly evident in his explanation of the mechanism of sensory perception and generation. Darwin pushes his theory of moving fibers for animal economy to the limit, proposing that these fibers constitute a self-regulating machine or organism.

Behind Darwin's medical philosophy lies the commingling vision of the locomotive system and the sensory system. Darwin's view is that all of the solid parts of animals consist of the extremities of the nerves. These can be subdivided into the muscular fibers ("moving organs") that have locomotive faculty and the immediate sensory organs, which also have their own particular motions because they are made up of the moving fibers.[197] The numerous ramifications of the nerves are intermixed with and accompanied by the "slender fibres." These are united as a whole, to constitute the grand sensorium system that links the extremities of the body with the brain and allows them to communicate.[198] Thus, Darwin envisions "sensorium" as the all-inclusive system that involves not only the medullary substance, spinal marrow, nerves, and organs of sense, but also the muscular, moving organs and the controlling principle of the spirit of animation that resides primarily in the brain but also throughout the body.[199]

Darwin explains the sensory process through an analogy, using the structure of the larger muscles and their motions. The immediate organs of sense, such as the retina, are often erroneously considered to be mere continuations of the medullary substance ("nervous medulla").[200] However, they consist of moving fibers endowed with contractile power that is "similar to that of the larger muscle."[201] The sensory organs, then, act like muscles, and "exactly resemble the motions or contractions of the large muscles" to produce the ideas that come from the fibrous motions. More precisely, the idea is identified as the contraction or motion of the fibers.[202] When successions of objects are presented, the retina, as the active organ, changes its configuration, and its muscular action, or "sensual motion,"[203] prompts our visual ideas. Darwin substantiates this thesis through experiments on the actions of the retina, which is the immediate organ of sight. If a subject continues to look at a red piece of silk until the eyes become tired and they are closed, the same image, only in the different color of green, will appear in the eyes. This phenomenon, which we now call the after-image, is explained through an analogy with the dynamic mechanism of muscles: the "part of the retina, which had been fatigued by contraction in one direction, relieves itself by exerting the antagonist fibres." It then produces the opposite effect (action), "as is common in the exertions of our muscles."[204] Indeed, Darwin often relies on the "great analogy" between the motions of the sensory organs and those of the muscles in order to explain how ideas are motions produced by the moving fibers. For example, our sensory organs are subject to inflammation or numbness in the same manner as the muscular fibers. Like the muscles, these organs become fatigued by continued exertion, and this can be relieved by shifting the attention to other objects.[205] The moving fibers encroach upon the realm where the nervous system appears to reign.

Just as the sensory organs act like the muscular fibers, the muscular, moving fibers (or the muscular system) act like an organ of sense. Darwin postulates that the muscular fibers act as sensory organs that feel extension. The organ of touch usually only senses pressure, along with the ideas of the figure and solidity of the object, but with no sense of extension. However, the various kinds of muscles, such as those that are hollow or longitudinal, contract themselves whenever they are stimulated by any violent force of extension (i.e., elongation/distension). In this way, the muscular fibers, like an organ of sense, feel and sense this extension and react to it by contracting. Darwin concludes, therefore, that "the whole muscular system may be considered as one organ of sense."[206] Indeed, he considers that any fibers in the body originally possess both sensory and motor faculties.[207]

Darwin is most explicit about his particular emphasis on the moving fibers in living animals when he discusses the issue of generation. He boldly extends his idea of the moving fibers into the area of biogenesis. This process begins with a single living fiber. At the earliest stage of the embryo, the speck of entity (the rudiment of embryo) seems to consist of "a living filament" from the male parent. This filament has some capacities, such as for irritation, sensation, volition, and association, which are common to all and others that are habits specific to the parent.[208] Of critical importance to Darwin's theory is that this single living filament is viewed as a moving fiber:

> I conceive the primordium, or rudiment of the embryon, as secreted from the blood of the parent, to consist of a simple living filament as a muscular fibre; which I suppose to be an extremity of a nerve of loco-motion, as a fibre of the retina is an extremity of a nerve of sensation…; I suppose this living filament…to be endued with the capability of being excited into action by certain kinds of stimulus. By the stimulus of the surrounding fluid, in which it is received from the male, it may bend into a ring; and thus form the beginning of a tube.[209]

Here, the primordial living filament is seen as the single moving (muscular) fiber that regulates itself in response to a variety of external stimuli in order to develop into a perfect organization. The muscular fiber is "moving" and "living" because it is excited into action by its response to external stimuli. Such "moving filaments," or living rings such as microscopic animalcules, successively absorb the nutritive particles and become a "living tube," which enjoys a new kind of irritability and sensibility. This process of acquiring new organs with new kinds of irritability and sensibility (or "a taste, or appetency"[210]) continues throughout the whole life: "all the parts of the body endeavor to grow, or to make additional parts to themselves throughout our lives."[211] For Darwin, the acquisition of a new part involves the production of new desire, power, and sensation, as well as "a consequent mode of action peculiar to itself."[212] Darwin here stands against the still powerful theory of preformation and negates the doctrine that sees growth as the elongation and distension of "stamina," which is identifiable with fibers[213]; for him growth is a temporal, progressive process, not a non-temporal process of stamina's elongation.

Darwin's idea is that the living or moving fibers result from the commingling of sensory and locomotive faculties, and he places special emphasis on the muscular fiber or filament in biogenesis as the self-regulating germ or machine. This shows that, although his medical philosophy is supposed to be based on the nervous system, with the brain (or sensorium commune) as the principal seat, the presence of the peripheral entity of the moving fibers, which are part of "the extremities of the nerves," is more compelling. In this sense, Darwin's idea that the fibers are the self-regulating machine or reactive organism—although it is a compromising product of nervous and irritable vitalism—severely qualifies the reign of nervous vitalism which disseminates the neurocentric view of the body.

Darwin's fiber body or self-regulating machine embodies the last form of the fiber body of the Enlightenment; no medical philosophers or theorists in the next century would attempt to construct a theory of fiber medicine as Darwin did. It should be noted here that Darwin's view of the fiber (body) in many critical points differs from the orthodox doctrines, core principles, and key ideas of the fiber body—the fiber-woven body, fiber pathology (bracing and relaxation as the key), cold regimen (e.g., cold bathing) and music therapy as principal therapy, the fiber-vibration model, the physiology of tone, and stamina as fibers (preformationism). In this light, Darwin's version of the fiber body is not the culmination of the fiber body, but it marks at once the last attempt to embody, and the first decisive departure from, the Enlightenment fiber body.

Notes

1. On the centrality of the nervous system, see, among others, Christopher Lawrence, "The Nervous System and Society in the Scottish Enlightenment," in *Natural Order: Historical Studies of Scientific Culture*, ed. Barry Barnes and Steven Shapin (London: Sage Publications, 1979), 19–40. For a general shift of medical theory, see Theodore M. Brown, "From Mechanism to Vitalism in Eighteenth-Century English Physiology," *Journal of the History of Biology* 7 (1974): 179–216.
2. Robert Whytt, *Observations on the Nature, Causes, and Cure of Those Disorders which Have been Commonly Called Nervous, Hypochondriac, or Hysteric*, 3rd ed. (Edinburgh, 1767), iii–iv.
3. On Whytt, see R.K. French, *Robert Whytt, the Soul, and Medicine* (London: Wellcome Institute of History of Medicine, 1969).
4. On the Montpellier Medical School and especially Bordeu, see Elizabeth L. Haigh, "Vitalism, the Soul, and Sensibility: The Physiology of Theophile Bordeu," *Journal of the History of Medicine* 31 (1976): 30–41; Elizabeth A. Williams, *A Cultural History of Medical Vitalism in Enlightenment Montpellier* (Burlington: Ashgate, 2003).

5. Tobias Cheung, “Omni Fibra Ex Fibra: Fibre Oeconomies in Bonnet’s and Diderot’s Models of Organic Order,” *Early Science and Medicine* 15 (2010): 66–104.
6. Ibid., 82, 96.
7. John Hunter, *Observations on Certain Parts of the Animal Oeconomy*, 2nd ed. (London, 1792), 99–129; “Experiments on Animals and Vegetables, with Respect to the Power of Producing Heat,” *Philosophical Transactions* 65 (1775): 446. On Hunter’s idea of vitalism, see Stephen J. Cross, “John Hunter, the Animal Economy, and Late Eighteenth-Century Physiological Discourse,” *Studies in History of Biology* 5 (1981): 1–110; Thomas S. Hall, *History of General Physiology*, *600 B.C. to A.D. 1900: vol.2, From the Enlightenment to the End of the Nineteenth Century* (Chicago: University of Chicago Press, 1969), 110–15.
8. See Peter Hanns Reill, *Vitalizing Nature in the Enlightenment* (California: University of California Press, 2005).
9. Charles Collingnon, *Medical and Moral Tracts* (Cambridge, 1769–72), 24.
10. James M. Adair, *A Philosophical and Medical Sketch of the Natural History of the Human Body and Mind* (Bath, 1787), 6. See also Samuel Foart Simmons, *The Anatomy of the Human Body* (London, 1780), vol. 1, xiii–xiv.
11. Having said that, the concept and use of the cellular membrane had already appeared and discussed to some length by James Douglas in *A Description of the Peritonaeum* (London, 1730), see 9–15; “serving as a Bond of Union,” and “the most remote Parts of the Body communicate with one another.”
12. Albrecht von Haller, *First Lines of Physiology*, 2vols. (Edinburgh, 1786), vol. 1, 11–12.
13. William Hunter, “The History of an Emphysema,” in *Medical Observations and Inquiries,* by a Society of Physicians in London (London, 1764), 30; Simmons, xix, 245; David Macbride, *A Methodical Introduction to the Theory and Practice of Physic* (London, 1772), 6, 15.
14. Haller, 11; Macbride, 15.
15. Malcolm Flemyng, *An Introduction to Physiology* (London, 1759), 5–6.
16. Ibid., 7.

17. For instance, see James Keill, *The Anatomy of the Humane Body Abridged* (London, 1698), 1–2 and E. Chambers, *Cyclopaedia*, 5th ed. (London, 1741), s.v., "fibre."
18. Or, if we include the cellular texture as a kind of fibers (i.e., the cellular fibers), the fibers were divided along the line of the dead (simple solids) and the living (the muscular system); the cellular fibers were regarded as a subsystem of living fibers/solids in that they served to bind the living solids.
19. See Alexander Monro [*secundus*], *Observations on the Structure and Functions of the Nervous System* (Edinburgh, 1783), ch. 25, "Whether the Nerves Convey the Nourishment to our Organs." The fact that Monro had to negate the theory of nervous nutrition even in the late eighteenth century indicates the strong presence of the old idea of the nerve.
20. Richard Mead, *The Medical Works of Richard Mead M.D.*, new ed. (Edinburgh, 1775), 342.
21. James M. Adair, *Commentaries on the Principles and Practice of Physic* (London, 1772); incidentally, he mentioned Macbride's work in the preface as one that aimed at the same objectives as his.
22. Ibid., 16–17.
23. Ibid., 13.
24. Ibid.
25. Ibid., 21.
26. Ibid., 109 ff.
27. Ibid., 170.
28. Ibid., 171.
29. Ibid.
30. Ibid., 85–87, 13.
31. Ibid., 88.
32. Ibid., 108 ff.
33. Ibid., 176.
34. Ibid.
35. Ibid., 241, 57.
36. Ibid., 326.
37. Ibid., 332–34.
38. Ibid., 335, 481, 436, 549.
39. Ibid., 596.
40. Macbride, 2–3.
41. Ibid., 2.

42. Ibid., 5–6.
43. Ibid., 43–4; also see 74.
44. Ibid., 42.
45. Ibid.
46. Ibid., 82.
47. Ibid., 146–47.
48. Andrew Wilson, *Medical Researches* (London, 1777), 194.
49. Ibid., 241.
50. Ibid., 239.
51. Ibid.
52. Ibid., 239–40.
53. Ibid., 249.
54. Ibid., 267–68.
55. Ibid., 191–92.
56. Collignon, 8. This view of solid pathology is in accordance with that of Cullen, as we will later show.
57. Henry Neale, *Practical Dissertations on Nervous Complaints* (London, 1788), 20; W[illiam] Smith, *A Dissertation upon the Nerves* (London, 1768), 143.
58. Thomas Withers, *Observations on Chronic Weakness* (York, 1777), 25, 31, 73.
59. See, for example, James Carmichael Smyth, *An Account of the Effects of Swinging* (London, 1787). Even "vomiting" is regarded as beneficial to restore the tone of the solids by "shak[ing] the glewy and tenacious matter"; see W. Smith, *Nerves*, 295–96.
60. On electric therapy of the eighteenth century, see, for instance, Tiberius Cavallo, *An Essay on the Theory and Practice of Medical Electricity*, 5th ed. (London, 1799); John Wesley, *The Desideratum; or, Electricity Made Plain and Useful* (1759) (London, 1871).
61. Adam Walker, *System of Familiar Philosophy* (London, 1799), 367.
62. Francis Lowndess, *Observations on Medical Electricity* (London, 1784), 13, 17; idem, *The Utility of Medical Electricity* (London, 1791), 6.
63. George Adams, *An Essay on Electricity*, 5th ed. (London, 1799), 503.
64. For the continuity of musical therapy as such, see, for example, John Hardman's view of the operation of sound upon the animal body; "It operates directly upon the animal fibre"; John Herdman,

An Essay on the Causes and Phenomena of Animal Life (London, 1795), 165.

65. William Smith, *Nature Studied with a View to Preserve and Restore Health* (London, 1784), 65. See also L.S. Jacyna, "Animal Spirits and Eighteenth Century British Medicine," in *The Comparison between Concepts of Life-Breath in East and West*, ed. Yosio Kawakita et al. (Tokyo: Ishiyaku EuroAmerica, 1995), 139–61.
66. John Brown, *The Element of Medicine of John Brown*, translated from the Latin, with comments and illustrations, by the Author. A new ed., revised and corrected, with a bibliographical preface by Thomas Beddoes (London, 1795), 115–16.
67. Robert Whytt, *The Works of Robert Whytt* (Edinburgh, 1768), 227–38; see also Wilson, 191–92.
68. Whytt, *Works*, 238.
69. On Cullen, see A. Doig et al. ed., *William Cullen and the Eighteenth Century Medical World* (Edinburgh: Edinburgh University Press, 1993); John Thomson, *An Account of the Life, Lectures, and Writings of William Cullen*, 2vols (Edinburgh, 1859).
70. William Cullen, *The Works of William Cullen*, ed. John Thomson, 2vols (Edinburgh, 1827), vol. 1, 14–15, 67–68, 210; see also William Bynum, "William Cullen and the Nervous System," in *William Cullen*, ed. A. Doig et al., 158; Bynum argued that what Cullen taught was not nervous physiology, but a single vision of neuromuscular physiology. My argument pushes this point further to subvert the hierarchical order of the nervous and the fibrous system.
71. Cullen's neuromuscular system, however, diverged from the archaic one in that Cullen's moving fibers are not equivalent to so-called "muscles." Cullen conceived that the moving or muscular fibers are pervasive throughout the body—"to the alimentary canal, to the fibers of the bronchiae in the lungs, and over the whole vascular system" and even "where we cannot distinctly discover the fibres"; Cullen, *Works*, vol. 1, 63. Therefore, the muscular fibers are not limited to the grand system of muscles, properly so called; wherever there is irritability, the peculiar property of the muscular fibers, there should be muscular fibers. Elsewhere, Cullen even asserts that irritability can be traced where "the muscular structure is not quite evident"; *Lectures on Materia Medica*, 2nd ed. (Philadelphia, 1775), 6. See also Simmons, vol. 1, 254.

72. Cullen, *Works*, vol. 1, 7.
73. Ibid., vol. 1, 6–7; see also Cullen, *Lecture,* 3: "the nerves and muscular fibres…form a system, whose functions may be considered as primary and fundamental in the animal oeconomy." Cullen's view of the indivisible system of nerves and muscular fibres was more or less subscribed to by other medical writers such as John Brown, Erasmus Darwin, John Herdman, and Sayer Walker; see Brown, 36; Erasmus Darwin, *Zoonomia; or, the Laws of Organic Life*, 2nd ed. (London, 1796), vol. 1, 10–11; Herdman, 42, 47; Sayer Walker, *A Treatise on Nervous Diseases* (London, 1796), 116, 136, 196.
74. Cullen, *Works*, vol. 1, 38–39.
75. Ibid., vol. 1, 79: "as the sentient fibres of the nerves every where do require, for their oscillation, to be kept in an extended state, for which very purpose the arteries every where accompany them, so the muscular fibres are every where in the same condition." Cullen's image of the arteries' "industrial and plentiful distribution" both to the nervous and muscular fibres involves the uttermost micro level of structure, as microscopic observations and injections by anatomists display that "every single muscular fibre has its artery connected with it" (Cullen, *Works,* vol. 1, 79). In much the same way as the moving fibers are not limited to the muscular parts, the vascular fibers intertwining with the sentient and moving fibers are not limited to the blood vessels.
76. William Cullen, *Clinical Lectures, Delivered in the Years 1765 and 1766* (London, 1797). These lectures were taken by his student ("*Taken in Short-hand by a Gentleman who attended*"), and therefore are a bit unreliable as an authentic text; however, I rely on this text as a valuable explication on Cullen's medical ideas.
77. Ibid., 17–18.
78. Ibid., 18.
79. Ibid., 19–23.
80. Ibid., 24, and passim.
81. Cullen, *Works*, vol. 1, 65, 70.
82. Cullen, *A Treatise of Materia Medica*, 2 vols (Edinburgh, 1789), vol. 1, 96, 107–109.
83. Cullen, *Works*, vol. 2, 362–64.

84. Cf. B. Waterhouse, MD, *The Rise, Progress, and Present State of Medicine* (Boston, 1792), 18–19, where he sees a similarity between Cullen's system and that of Boerhaave.
85. Rosalie Stott, "Health and Virtue: or How to Keep out of Harm's Way. Lectures on Pathology and Therapeutics by William Cullen c.1770," *Medical History* 31 (1987): 142.
86. See Cullen, *Works,* vol. 1, 81–82; Cullen attempts to prove that the involuntary motion like the muscular heart severed from the body after death still requires energy from the brain; if a certain stimulus is applied to the part, it renews its contraction, but these contractions are not "vigorous" and are disordered without the energy of the brain. Here, the "vigorous" (i.e., ordered, regulated) actions or contractions, not the weak and morbid contractions, are equated with well-being, what Cullen calls the "standard of health." The disordered, morbid contractions are, in Cullen's pathology, termed "spasms" or "convulsions," the pathological state of the nervous system in Cullen's sense of the term; see *Works*, vol. 2, 401 and passim.
87. Ibid., vol. 1, 125.
88. This is because unlike the fibers, the nerves lack a "peculiar organization," a necessary condition of "contractility" or "inherent Power" (i.e., tone) of the moving fibers; Cullen, *Works*, vol.1, 63–68, 77.
89. Hubert Steinke, *Irritating Experiments: Haller's Concept and the European Controversy on Irritability and Sensibility, 1750–1790* (Amsterdam: Rodopi, 2005).
90. Whytt, "Observations on the Sensibility and Irritability of the Parts of Men and Other Animals," in *Works.*
91. Whytt, *An Essay on the Vital and Other Involuntary Motions of Animals,* 2nd ed. (Edinburgh, 1763), 420–23; idem, *Works,* 287–90.
92. Thomas Kirkland, *A Treatise on Child-Bed Fevers* (London, 1774), 7–8, 18–20, 27, 37–8; idem, *An Inquiry into the Present State of Medical Surgery* (London, 1783), "On Irritability," vol. 1, 195–210.
93. For instance, see George Fordyce, *Elements of the Practice of Physic,* 3rd ed. (London, 1771), 92–93; Adair, *Philosophical*, 27; Adair, *Commentaries*, 14.

94. James Johnson, *An Essay on the Use of the Ganglions of the Nerves* (Shrewsbury, 1771), 19–22, 66.
95. Ibid., 70–71.
96. Ibid., 14, 79, 81. Monro has a similar opinion on the ganglions; Monro, ch. 19, "Of the Ganglia of the Nerves."
97. John Leake, *Medical Instructions towards the Prevention, and Cure of Chronic or Slow Diseases Peculiar to Women* (London, 1777).
98. Ibid., 219.
99. Ibid., 221.
100. Ibid., 222.
101. Ibid.
102. Ibid., 226–27.
103. Ibid., 227; also 222. See also Leake, *A Lecture Introductory to the Theory and Practice of Midwifery*, 3rd ed. (London, [1776]), 9; where a similar statement can be found as Leake indicates that this new idea had been stated before; this statement is only added to the third edition which is based on a lecture delivered on October 1773.
104. Gilbert Blane, *A Lecture on Muscular Motion* (London, 1788), 20.
105. Ibid., 22–23, 19–20.
106. On Glisson's notion of irritability, see Owsei Temkin, "The Classical Roots of Glisson's Doctrine of Irritation," *Bulletin of the History of Medicine* 38 (1964): 297–328. For an interesting argument on the disappearance of Glisson's notion of irritability during the eighteenth century in the context of Haller, see Guido Giglioni, "What Ever Happened to Francis Glisson?: Albrecht Haller and the Fate of Eighteenth-Century Irritability," *Science in Context* 21 (2008): 465–92.
107. Blane, 24.
108. Ibid., 26.
109. Ibid., 27.
110. John Gardiner, *Observations on the Animal Oeconomy* (London, 1784), 5–10, 23, 37.
111. Ibid., 3.
112. Ibid., 12–13; see also 45–47 on the experiments of the heart. Taken out of the body, the heart ceases to move but begins to contract ("recovered its irritability") and repeats palpitations by stimulus when it is put into warm water, whereas it shows no movement if cold is applied; this indicates "the necessity of heat

and moisture for maintain the full powers of the living principle." (47) This is the total reversion of the ascetic cold regimen of fiber medicine, in which cold invigorates and heat enervates the animal fibers.

113. Francis Milman, *An Inquiry into the Source from Whence the Symptoms of the Scurvy and of Putrid Fevers, Arise* (London, 1782), 60–62.
114. Ibid., 62.
115. Ibid., 65–67.
116. Ibid., 73–74.
117. Ibid., 103.
118. Ibid., 167–68.
119. Seguin Henry Jackson, *Dermato-Pathologia; or Practical Observations, from Some New Thoughts on the Pathology and Proximate Cause of Diseases of the True Skin and its Emanations* (London, 1792), 21.
120. Ibid., 48.
121. Ibid., 48–50, 114–17.
122. William Cullen, *A Letter to Lord Cathcart…concerning the Recovery of Persons Drowned and Seemingly Dead* (London, 1776); John Hunter, "Proposals for the Recovery of Persons Apparently Drowned," in *Animal Oeconomy.*
123. Charles Kite, *An Essay on the Recovery of the Apparently Dead* (London, 1788), 92–93.
124. Ibid., 100–101, 106.
125. Ibid., 107–8.
126. Ibid., 116–17.
127. A. Fothergill, *A New Inquiry into the Suspension of Vital Action, in Cases of Drowning and Suffocation* (Bath, 1795), 8–11.
128. Ibid., 12.
129. Ibid.
130. Ibid., 63.
131. Ibid., 71–72.
132. Ibid., 177.
133. Ibid., 58.
134. Ibid., 64–65.
135. Ibid., 64.
136. Ibid., 65, 178.

137. Christoph Girtanner, “On Irritability, Considered as a Vital Principle in Organized Bodies,” *Medical Commentaries* 5 (1791): 424–40.
138. On Girtanner, see Neil Vickers, *Coleridge and the Doctors, 1795–1806* (Oxford: Oxford University Press, 2004), 55–57.
139. *Edinburgh Magazine* 12 (1790): 108–14.
140. *Medical Commentaries* 5 (1791): 424–40.
141. Thomas Beddoes, *Observations on the Nature and Cure of Calculus, Sea Scurvy, Consumption, Catarrh, and Fever* (London, 1793); “Two Memoirs Translated from French of Dr. Girtanner.”
142. For instance, T. Garnett, *A Lecture on the Preservation of Health* (Liverpool, 1797), iv; William Yates and Charles Maclean, *A View of the Science of Life* (Whitehall, 1797), 22.
143. Girtanner, 425–26.
144. Ibid., 428.
145. Ibid., 426–27.
146. Ibid., 428.
147. Ibid., 435; Beddoes, 179.
148. Ibid., 433.
149. Ibid., 433–44; see also Beddoes, 173–74.
150. Ibid., 438–39.
151. Ibid., 437–39; Beddoes, 183.
152. Beddoes, 234.
153. Girtanner, 440.
154. Hebbel E. Hoff, “The History of the Refractory Period: A Neglected Contribution of Felice Fontana,” *Yale Journal of Biology and Medicine* 14 (1942): 735–72. John Felix Marchand and Hebbel Edward Hoff, “Felicia Fontana, The Laws of Irritability: A Literal Translation of the Memoir *De Irritabilitatis Legibus*, 1767; Added Material from *Ricerche Filosofishe sopra le Fisica Animale*, 1775; and Correlation of these Editions with the E.G.B. Hebenstreit German Translation, 1785,” *Journal of the History of Medicine* 10 (1955): 197–206; 302–26; 399–420.
155. Hoff, 636. Beddoes, 176.
156. Beddoes, 176.
157. Ibid., 177. Girtanner, 434.
158. Fothergill, 65, also see 178. He sees the vital air as the source of irritability as Girtanner; Fothergill insists on his originality as he says it was first hinted by him in 1783.

159. Joseph Townsend, *A Guide to Health*, 2nd ed. (London, 1795), vol. 1, 305–6.
160. Ibid., 318.
161. Ibid., 306. Interestingly, Townsend associates this process with Cullen's idea of excitement and collapse, but it is in a direct line of Fontana and Girtanner.
162. Francis Penrose, *Essays, Physiological and Practical* (London, 1794), 104–20. Penrose also plagiarized from Brown; 121ff.
163. Hugh Moises, *A Treatise on the Blood* (London, [1794]), 151–220.
164. Alexander Crichton, *An Inquiry into the Nature and Origin of Mental Derangement* (London 1798), vol. 1, Book 1, ch. 1.
165. See Louis C. Charland, "Alexander Crichton on the Psychopathology of the Passions," *History of Psychiatry* 19 (2008): 275–96.
166. Crichton, vol. 2, 169–70.
167. Ibid., vol. 1, 52. On Darwin, see below.
168. Robert John Thornton, *The Philosophy of Medicine; or, Medical Extracts on the Nature of Health and Disease,* 4th ed. (London, 1799), vol. 1, 122.
169. Ibid., vol. 1, 71.
170. Ibid., vol. 1, 75–78. Also see vol. 4, 148; "the affection of the nerves was doubtless secondary .... For the nerves are a part of the system formed from the blood."
171. Ibid., vol. 1, 104–5.
172. Ibid., vol. 3, 3. Thornton also directly quotes Girtanner without acknowledgment when he discusses temporary exhaustion of the fiber (vol. 4, 91–93).
173. Ibid., vol. 1, 257.
174. Ibid., vol. 3, 181.
175. Ibid., vol. 1, 255–58.
176. On the history of steam engine, see D.S.L. Cardwell, *From Watt to Clausius: The Rise of Thermodynamics in the Early Industrial Age* (London: Heinemann, 1971), ch. 2; Jenny Uglow, *The Lunar Men: The Friends Who Made the Future, 1730–1810* (London: Faber and Faber, 2002), ch. 9 and ch. 21.
177. Beddoes, 258.
178. Townsend, 308, Thornton, *Extracts,* vol. 3, 362.
179. John Abernethy, *Surgical and Physiological Essays, Part III* (London, 1797), "Experiments on Irritability," 145.

180. Herdman, 222.
181. Whytt, *Involuntary*, 286–87.
182. Georges Vigarello, *Concepts of Cleanliness: Changing Attitudes in France since the Middle Ages*, translated by Jean Birrell (Cambridge: Cambridge University Press, 1988), 171.
183. Ibid., 172.
184. Ibid.
185. On Darwin, see Desmond King-Hele, *Doctor of Revolution: The Life and Genius of Erasmus Darwin* (London: Faber, 1977); Maureen McNeill, *Under the Banner of Science: Erasmus Darwin and his Age* (Manchester: Manchester University Press, 1987); Roy Porter, "Erasmus Darwin: Doctor of Revolution?," in *History, Humanity, and Evolution*, ed. James R. Moore (Cambridge: Cambridge University Press, 1989); C. U. M. Smith, "All from Fibres: Erasmus Darwin's Evolutionary Psychobiology," in *The Genius of Erasmus Darwin,* ed. C.U.M. Smith and Robert Arnott, (Aldershot: Ashgate, 2005), 133–43.
186. Darwin, vol. 1, 1.
187. Ibid., vol. 1, 73.
188. Ibid., vol. 1, 66, 32.
189. Ibid., vol.1, 73–74.
190. McNeill, 152, 155.
191. Darwin, vol.1, 72, 75.
192. Ibid., vol.1, 77, 67.
193. Ibid., vol.1, 73.
194. Ibid., vol.1, 33.
195. Ibid.
196. "The Articles of the Materia Medica," in *Zoonomia,* 2nd American edition (Boston, 1803), 43. Darwin here even regards the word "reaction" as a mechanical term.
197. Darwin, vol.1, 10–11, 469.
198. Ibid., vol.1, 10.
199. Ibid.
200. Ibid., vol.1, 11.
201. Ibid., vol.1, 8.
202. Ibid., vol.1, 16, 11.
203. Ibid., vo.1, 11.
204. Ibid., vol.1, 16.

205. Ibid., vol.1, 23–25. See also vol.1, 17–18. The composite structure of the sensory organs is also deduced through an analogy with the muscles: "as the muscles consist of large fibres intermixed with a smaller quantity of nervous medulla, the organ of vision consists of a greater quantity of nervous medulla intermixed with smaller fibres" (18).
206. Ibid., vol.1, 124.
207. Ibid., vol.1, 469. Cullen also sees muscle as "an organ of sense," *Works*, vol.1, 76.
208. Ibid., vol.1, 484.
209. Ibid., vol.1, 496.
210. Ibid., vol.1, 497.
211. Ibid., vol.1, 500.
212. Ibid., vol.1, 499, 497.
213. Ibid., vol.1, 497, 506.

CHAPTER 5

Interlude: Fiber Psychology

Fiber's critical roles are not limited to animal economy per se. The realms of cognitive faculties are also referred to, and explained by the fibers, the nerves, or more often the nerve-fibers (i.e., the nervous fibers), which were supposed to mediate between the mind and the body. Here I briefly sketch some of the ways that fibers participated in cognitive and sensory processes—what I call "fiber psychology."

Traditionally and throughout the eighteenth century, man was presumed to consist of two distinct substances, the immaterial, immortal, and indivisible soul and the material, mortal, and divisible body[1]: "Man is composed of a Body and Mind, united each other…[and] the Nature of these are very different."[2] Though these substances were incongruous in nature, they must be united in man to interact with each other; otherwise, man could not think, and therefore could not exist as such.[3] The Cartesian solution that the soul lodged in the pineal gland where it received physical impressions and commanded movements still required a plausible explanation of the interaction between two incommensurable substances. For many, a Leibnizean pre-established harmony of parallel mental and physical occurrence seemed to be an alternative solution; Boerhaave, for example, took this option of "a Harmony establish'd by God" ("determinate actions of the Mind must be necessarily attended with corresponding Motion in the Body, and the contrary").[4] Even so, this was too crude to explain the micro-mechanism of the mind's activity and its interaction with the body. Moreover, the body's necessary assis-

H. Ishizuka, *Fiber, Medicine, and Culture in the British Enlightenment*, DOI 10.1057/978-1-349-93268-9_5

tance to the soul's performance was recognized as an essential condition for the commerce between soul and body.[5] On the other hand, Locke's dangerous suggestion that matter could think made the mind–body problem more troubling: if matter could think, two substances would be reduced to one, with the soul totally expunged. Everyone should avoid this heinous atheism.[6] For these various reasons, many anatomists and medical theorists drew on the more subtle entity which enabled the body to correspond with the soul; a medium which aptly connected two different substances, one that was neither purely physical nor purely immaterial. It was in these contexts that the nerve-fiber, with its physio-psychological functions, emerged as a mediator of the gross material body and the immaterial soul.[7]

It was through and by the nerve-fiber's sub-material changes that perception and cognition occurred: "our Bodies receive nothing else from sensible Objects to produce sensation, than a *Change in the Surface* of the Nerve," since "we perceive when such a Change is made."[8] Of course, the changes that occurred at the nerve-fiber's end of the sensory organs alone were not sufficient to produce perception and ideas; the same changes must propagate through the nerves to the brain center, where by the force of the animal spirits or vibrations, the changes are made in the sentient nerve-fibers which produce sensation and ideas.[9] This theory of physiological psychology (i.e., mental phenomena are explained by referring to physiological activities, or what Yolton called the "physiology of thinking," or what I call here "fiber psychology") widely appealed to eighteenth-century minds, though there were different variations of it.[10]

One version of fiber psychology involves the theory of vibrations—a theory traced back to the Newtonian concept of aether that vibrates as a medium of transmission of sensation and motion and culminates in David Hartley's doctrine of vibrations. Confusingly, the Newtonian aethereal vibration model, according to which sensation is transmitted by infinitesimal vibrations of aether within the nervous fibers, was confounded with another version of a vibration model: a model based on the tense, solid nerve-fibers that are capable of vibrating to convey the sensory data to the brain (the seat of the soul). The latter view was categorically denied by authoritative medical authors such as Boerhaave and von Haller, who argued that the flaccid, pulpy substance of nerves, unlike a musical string, were unfit for vibration[11]; Hartley, too, discounted the notion as absurd, saying Newton or any other theorists of vibration had never asserted that sensory perception was transmitted by means of vibrations; rather, it was conveyed by the minutest vibrations of aether within the slack nerves, a motion occurring on the molecular level.[12] Pemberton, Bryan Robinson, Nicholas Robinson, and early Cheyne all subscribed to the aethereal version of vibration theory, but Cheyne later discounted aether as a medium and opted for vibrations alone.[13] It is worth noting here that whether vibrations are of the solid nerve-fibers themselves (visible oscillatory motion like a tense string or bow) or of aether within the nerve-fibers (invisible minute motion like tonus[14]), vibration assumes a critical function.

Although the vibration hypothesis is generally traced back to Newton's suggestion in the Gneral Scholium of *Principia* (1687) and his more detailed explanation of it in the second edition of *Opticks* (1717), Newton probably obtained the idea from his friend William Briggs, an English physician and oculist, who first clearly advocated the vibration theory of vision in his two papers to *Philosophical Transactions*.[15] Indeed, Newton's correspondence with Briggs shows his indebtedness to his friend.[16] Briggs emphasized the importance of fibers of the optic nerves, which he insisted were more concerned with vision than other parts of the eyes like cornea, humors, or retina. In order to explain the binocular single vision (two eyes seeing a single vision), Briggs first anatomized the visual pathways that showed the two distinct fibers running independently from the brain to the eyes; he thus refuted the common idea of the mixing of two optic nerve-fibers, which usually accounted for the phenomenon of binocular single vision. Briggs then introduced the idea of vibration, or "unison" and "concordance" of two fibers, which possessed a different degree of tension like musical strings; like "*Unisons* in two Viols or Lutes," these "*Fibra concordes*" worked together as it were "*symphonical*" so that when an impression from an object strikes both fibers, it does not cause a double vision as unisons in lutes do not make a double sound.[17] Furthermore, Briggs anticipated the following objection to his vibration theory: the soft medullary fibers of the nerves do not possess sufficient tension to vibrate like musical strings; and he answered it in the way that eighteenth-century fiber-theorists fully endorsed: the nerve-fibers are like "a Spiders-Web," whose mucous or medullary substance could answer to the retina (which is the expansion of optic nerve-fibers); as the "least breath of wind" moves the web, so the "finer strokes" of lucid matter (rays of the light) cause a "vibration."[18] Briggs's anticipation of eighteenth-century fiber theory is further evident in his extension of the spider web metaphor to the mechanism of sensory perception in the brain, which was also constituted of "soft *medullary Fibres*" but fit enough to transmit vibrations.[19]

> As that *little Animal* in the *Centre* of its soft *circumtended Fibres* is sensible of the least gale of Wind, or is alarum'd by the least noise or *touches of its prey* or of an enemy from an Quarter, by the *delicate expansion* of its Fibres: So may *the Soul* much more (in the *common sensory*) being *surrounded by Fibrillae* of *expanded Nerves* and of a *finer make*; apprehend from what Quarter the several motions come from abroad, and more *minutely perceive the difference* of 'em in respect of the *diverse Organs* of sense and the different fineness or *tension* of those Nerves that belong to the same.[20]

This is precisely what eighteenth-century fiber-theorists had in mind in explaining the soul's sense perception through the delicate nerve-fibers.[21] Briggs's name, however, fell out of favor in the next century, and his work was overshadowed by Newton's, which achieved great fame because of its supposedly original idea of vibration.

Another version of fiber psychology develops from the physiological theory of animal spirits and brain traces. Rees's *Cyclopaedia*, for the description of the working of imagination, draws on this theory: "Since…the *imagination* only consists in a power which the soul has of forming images of objects, by impressing them in the fibres of the brain, it follows that the larger and more distinct the vestigia or tracks of the animal spirits, which are the…strokes, as it were, of those images, are; the more strongly and distinctly the soul *imagines* these objects."[22] As Yolton suggested, this version of physio-psychology was first elaborated in the late seventeenth century by Nicolas Malebranche, a disciple of Descartes, whose theory had a tremendous effect on the eighteenth-century theory of mind.[23] For Malebranche, two substances, soul and body, remained as they were, so the only "alliance of mind and body" rested on "a natural and mutual correspondence of the soul's thoughts with the brain traces, and of the soul's emotions with the movements of animal spirits."[24] The soul corresponded to the body, by the interposition of physiology, that is, by the medium of the fibers and animal spirits: "if any movement of the spirits occurs in this part [the origin of the nerves in the brain], which slightly changes the order of its fibers, a new perception occurs in the soul also;…the soul can never sense any thing or imagine anew unless there is some change in the fibers of this same part of the brain."[25] The pressure of the animal spirits leaves "traces" (the changes of the fibers) by "imprinting" or "engraving" on the fibers; by pursing these traces, the animal spirits bring about various mental phenomena (memory, imagination, judgment).[26] Thus, the condition of the fibers as well as the movements of the animal spirits is relevant to thinking and imagination. Malebranche's theory stayed deeply entrenched throughout the eighteenth century; Boerhaave, Haller, Bonnet, and a host of others trod the same path. Compare, for instance, the following explanation of the workings of imagination by Malebranche to Rees's above-cited passage: "Since the imagination consists only in the soul's power to form images of objects by imprinting them, so to speak, in the fibers of the brain, the greater and more distinct the traces of the animal spirits, which are strokes of the images, the more strongly and distinctly the soul will imagine these objects."[27] A century's distance dissolves into a paradigmatic continuity.

Traditionally, the existence of the subtle fluids (usually animal spirits) was thought to be a prerequisite for the interaction of the soul and the body. It is true of Malebranche's doctrine and, whatever the subtle fluids are called in the eighteenth century, it is still valid in eighteenth-century physio-psychology. Yet, at least for some, and especially when the internal senses were concerned, the subtle fluid's importance was gradually replaced by that of the solid fibers; in Malebranche, the equal balance between the fiber's physical condition and the movements of animal spirits was kept, but in later theorists, it became increasingly precarious. With the gradual demise of the animal spirits, the role that they carried was also devalued; the newly introduced subtle fluids (nervous fluids, electric fluids, or Newtonian aether) restricted their functional role mainly to transmission of the nerve impressions and impulses. As Applegarth remarked, "the *Animal Spirits* have Nothing to do primarily and actively, in comparing Ideas: [but]—Passively and subordinately to something else in the Human System, I grant they have."[28] The importance of the solids as a substance distinct from the gross matter was gradually recognized.[29] Haller, for instance, in explaining the production of the internal sense, relied on Malebranchean fiber psychology, but he conferred on the theory the solids' vital role: "the *footsteps* or *traces* of things" were "lodged or engraved not in the mind, but into the body [the medulla of the brain] itself." The mind was "obliged to think on the species the body offered."[30] The soul, not the animal spirits, as it were, read these "characters" (traces) in the same manner that we read in a book. As Bonnet, who was well versed in Malebranche's theory, and brought it to a new stage, illustrated this: "a mind which should be thoroughly acquainted with the mechanism of the brain…would there read as in a book. The prodigious number of infinitely small organs [fibers]…would to such a mind be what the characters used in printing are to us."[31]

The primacy of the solid fibers lent to fiber theory a new dimension, which would have a significant influence on the early nineteenth-century theory of mind (phrenology): the fiber became regarded as a specific organ capable of executing a certain function appropriate to it. The idea that each fiber had an individual faculty had already become commonplace by the mid-eighteenth century: "it's now an established Maxim that every Nerve in the different Parts of the Body, has its *Correspondent* in the Head."[32] Each fiber connected the particular part of the body with the corresponding particular part of the brain without confounding or mixing with each other. The corresponding fibers of the brain at certain occasions, if they received an impulse, produced the corresponding ideas or sensations[33]; Applegarth even imagined the aggregate of the corresponding fibers in the brain as a "little man": "as the whole Body is crowded up thickly with *nervous Filaments*, that have All of them their *Tallies or Corespondents* in the Brain; so, it should seem…there were in the *Sensory*…a kind of *Homulus* or *Man in Miniature*."[34] The corollary of the particularity of the fiber, the sum of which makes up the representative of man at large, is that the fiber would be endowed with distinct characters and dispositions adapted to its function or use. If the fibers were all similar in their disposition and inclination, they would be totally unfit for receiving, selecting, and propelling numerous impressions and sensations. Each fiber, therefore, should be just like the organs of sense, that is, as the organ of sight is formed for the purpose of seeing, so each "organ" of fiber would be contrived in service of its specific faculty, having its proper seat in the brain. Boerhaave had already hinted at this incipient form of phrenological principle of the (fiber-)organ localized in the brain:

> [I]t is an Opinion of my own from which I cannot easily depart, namely, that there are distinct Parts or Provinces in the common Sensory for the different Senses, in the same manner as we observe a distinct Organ destined to every external Sense…that each Nerve arose from its proper Part of the Brain, by Fibres distinct and separate from the rest of the Nerves. Hence it

> seems probable, that each set of Ideas dwell at the Origin of each particular Nerve in the Brain.[35]

But it was Bonnet, a mystic naturalist, who lent a distinct form to the fiber-organ notion. Bonnet drew on the possible similarity between fibers and the sensory organs which Boerhaave and other theorists faced, but unlike others, he pushed the comparison as far as to identify the fiber with the organ per se:

> I have thought, that if each *sense* has its mechanism, every species of sensible fibre might also have theirs. I have considered every sensible fibre as a very minute organ, which has its proper functions, or as a very small machine, which the action of objects raises to the tone appropriate to it.[36]

The fibers, for Bonnet, were no longer the passive recipients on which animal spirits' "burin" engraved,[37] but the organ-machine "appointed to produce a certain motion."[38]

The consequence of the identification of the fiber with the organ is that "the physique" and "the moral" were merged in the fiber-organ. The fiber not only mediated the mind–body, but literally embodied its mediation, for if each fiber had appropriate species of sensations or ideas, why could not each species of sensations or ideas ("the moral") have its proper (compound) fibers ("the physique"): "If all our ideas depend on fibres appropriated to them, prejudices must also have their fibres."[39] Eventually, it became possible to think that man's "character" resulted from the fibers' assemblage ("that assemblage of determinations which an infinity of fibres have contracted").[40] It is easy to see here a rudimentary, albeit rough, form of Gall's phrenology, and in fact, Gall resorted to Bonnet's idea of the fiber-organ when embarking on the theory of mind later called phrenology.[41] In a similar vein, Applegarth conjectured the existence of the specific fiber appropriate to reflection, the principal activity which distinguished man from brutes: "I judge, there is a distinct Class or Set, for the Purpose of Reflection," "the *Reflectional Nerves.*" Conversely, brutes were endowed with "Itinerant Nerves" instead of "Reflectional" ones, because they would travel to amazing distances without any external guide. Man's rationality and Brute's instinct must have "something" to mobilize their capacity, which Applegarth variously called "*Instrument*," "*Medium*," "*organised System*," or "*System of Organs*," without which man could not think and animals could not travel—a notion not remote from that of Bonnet's fiber-organ.[42]

From a radically different standpoint, but undoubtedly within the same paradigm of fiber psychology, Swedenborg developed his seemingly idiosyncratic theology. He argued that in order for God to dwell in man and give life to man, He should create in man proper receptacles and inhabitations for Himself, one for Divine Love and another for Divine Wisdom, since God himself is Love and Wisdom.[43] These two receptacles are respectively called "the will" and "the understanding," but they should not be understood in an ordinary sense of the words; as the sensory organs were organically formed for receiving certain sensations, the will and the understanding should be organically contrived for receiving Love and Wisdom and for producing affection and thought in man, with the difference that these "substances and forms" are not "extant before the eyes" like the organs of the external senses.[44] These receptacles are organized from the purest substances and have their first principles in the cortical substances of the brain, which, for Swedenborg, are the seat of soul (in the anatomical writings) and the first principle of life (in the theological writings).[45] The cortical substances are composed of innumerable little glands which were nothing other than the "heads" of the simple fibers; therefore, they are the primal principles of the simple fibers.[46] According to the forms of these "receiving-organs" (the will and the understanding), Divine Love and Wisdom could flow into these little glands, which determine man's affection and thought.[47] To put these together: there are in the brain (more precisely in the cortical substances) receptacle-organs called the will/understanding composed of the minute, invisible fibers for receiving Love and Wisdom from God (Divine Influx), which determine, in accordance with the forms of the organs, the degree of affection and thought in man. Though the picture is rather complicated, the underlying paradigm is the same: the fiber is conceived as an organ, and as a psychophysiological substance, according to which of the various phenomena in the domain of "the moral" are being determined. Like Bonnet's fiber-organ, Swedenborg's fiber is highly charged with "the moral."

Notes

1. There are a vast number of studies on the mind–body relation; for excellent discussions of this subject during the Enlightenment, see G.S. Rousseau, ed., *The Languages of Psyche: Mind and Body in Enlightenment Thought* (Berkeley: University of California Press, 1990).

2. Herman Boerhaave, *Dr. Boerhaave's Academic Lectures* (London, 1742), vol. 1, 65.
3. [Robert Applegarth], *Theological Survey, or the Human Understanding* (Salisbury, 1776), 261; Boerhaave, vol. 1, 69; Charles Bonnet, *The Contemplation of Nature* (London, 1768) vol. 1, xxxi.
4. Boerhaave, vol. 1, 69.
5. "My soul cannot take hold herself; she cannot see or feel herself; but she can both see and feel bodies, by the assistance of that to which she is united," Bonnet, vol. 1, xxxii.
6. For a detailed discussion on the notion of thinking matter, see John Yolton, *Thinking Matter: Materialism in Eighteenth-Century Britain* (Minneapolis: University of Minnesota Press, 1983).
7. For a further discussion of physiological psychology, see Roger Smith, "The Background of Physiological Psychology in Natural Philosophy," *History of Science* 11 (1973): 75–123.
8. Boerhaave, vol. 4, 226, 228.
9. Ibid., 230, 232.
10. Yolton, ch. 8.
11. On this point, see ch.3.
12. Richard C. Allen, *David Hartley on Human Nature* (New York: State University of New York Press, 1999), 108–9; C.U.M Smith, "David Hartley's Newtonian Neurophysiology," *Journal of the History of the Behavioral Sciences* 23(1987): 123–36. David Hartley, *Observations on Man* (London, 1749).
13. Yolton, 177–79; for example, see Bryan Robinson, *A Dissertation on the Aether of Sir Isaac Newton* (Dublin, 1743); Nicholas Robinson, *A New System of Spleen* (London, 1729), 102–3; Henry Neale, *Practical Dissertations on Nervous Complaints* (London, 1788), 9.
14. On this point, see ch. 3.
15. William Briggs, "A New Theory of Vision," *Philosophical Collections* 6 (1682): 167–78; idem, "A Continuation of a Discourse about Vision," *Philosophical Transactions* 13 (1683): 171–82. On Briggs, see R.R. James, "William Briggs, M.D. (1650–1704)," *British Journal of Ophthalmology* 16 (1932): 360–68.
16. Briggs sent his paper to Newton, who replied to Briggs; Nicholas J. Wade, *A Natural History of Vision* (Cambridge, Mass.; MIT Press, 1999), 100.

17. Briggs, "New Theory," 168–69, 172.
18. Briggs, "Continuation," 175–76, 181.
19. Ibid., 182.
20. Ibid.
21. On the web metaphor in the eighteenth century, see Hisao Ishizuka, "Untying the Web of Urizen: William Blake, Nervous Medicine, and the Culture of Feeling," *Liberating Medicine, 1720–1835,* ed. Tristanne Connolly and Steve Clark (London: Pickering & Chatto, 2009), 97–107.
22. Rees's *Cyclopaedia* (London, 1781–89), s.v. "imagination."
23. Yolton, 160, 183.
24. Nicholas Malebranche, *The Search after Truth*, translated from French by Thomas M. Lennon and Paul J. Olscamp (Columbia: Ohio State University Press, 1980), 102.
25. Ibid., 88.
26. Ibid., 102, 89.
27. Ibid., 89.
28. Applegarth, 251.
29. Cf. Roy Porter's introduction to Cheyne's *English Malady*, xx. For Cheyne, Porter argued, it was the solids (vessels) that were truly important, because they guaranteed the free circulation of the fluids. At the end of the century, Smith also remarked that "health chiefly depends on the regular motions of the solids"; by the "solids" he meant the "nervous fibres," H. Smith, *An Essay on the Nerves* (London, 1794), 32.
30. Albrecht von Haller, *First Lines of Physiology* (Edinburgh, 1786), vol. 2, 34, 46.
31. Bonnet, vol. 1, pp. xli–xlii.
32. Applegarth, 251; see also Boerhaave, vol. 4, 230.
33. Smith, 19.
34. Applegarth, 251.
35. Boerhaave, vol. 4, 236.
36. Bonnet, vol. 1, xxxvii, see also xxxiv, "each fibre appropriated to each species of sensation."
37. Malebranche, 89.
38. Bonnet, vol. 1, xl; the capacity of this machine depends on its original constitution (ibid.).
39. Ibid., xlii.
40. Ibid., xliii.

41. On Gall's indebtedness to Bonnet, see Erna Lesky, "Structure and Function in Gall," *Bulletin of the History of Medicine* 44 (1970): 297–314. Spurzheim acknowledged Bonnet as a precursor, "Charles Bonnet regarded each fibre of the brain as a particular organ of the soul"; *Phrenology, or, the Doctrine of the Mind; and of the Relations between its Manifestations and the Body*, 3rd ed. (London, 1825), 66.
42. Applegarth, 286, 257, 274, 258.
43. Swedenborg, *Angelic Wisdom concerning the Divine Love and the Divine Wisdom* (London: Swedenborg Society, 1859), # 360.
44. Ibid., # 373, 42.
45. Emanuel Swedenborg, *The Economy of the Animal Kingdom Considered Anatomically, Physically, and Philosophically, Transaction III (The Fibre)* (Philadelphia: Swedenborg Scientific Association, 1918), # 120; idem, *Angelic Wisdom*, # 366. Swedenborg rightly attributed the seat of the soul (mind) to the cortical membrane; on this point, see Konrad Akert and Michael P. Hammond, "Emanuel Swedenborg (1688–1772) and his Contribution to Neurology," *Medical History* 4 (1962): 255–66; J. R. Rendell, "Swedenborg on the Cerebral Cortex as the Seat of Psychological Activity," in *Transactions of the International Swedenborg Congress, Held in Connection with the Celebration of the Swedenborg's Centenary* (London: Swedenborg Society, 1910), 56–70.
46. Swedenborg, *Fibre*, # 366.
47. Swedenborg, *On the Divine Love/On the Divine Wisdom*, formally published under the title of *Doctrine of Uses* (London: Swedenborg Society, 1986), # 56; idem, *Angelic Wisdom*, # 5.

PART III

Fiber and Culture

CHAPTER 6

The Fiber Body and the Baroque: The Anatomy of Membranes and Folds

1 Introduction

In the anatomical tables of John Browne's *Myographia Nova* (1697), the flayed standing figures (écorché) welcome viewers, successively taking off the skin or the outer coverings of the body to display the superficial musculature to the eyes of the spectators. These figures are shown as if they were alive while they were being dissected although they were cadavers ready for dissection.[1] Browne's tables simply followed the long-standing convention of anatomy popular since the Renaissance. In table 12, however, we come across the strange spectacle in which the chest of the figure is flayed to expose the inner skeleton (ribs) hidden from the observers. The skin droops from the back down to the buttocks just like a cloth garment in folds; the skin looks as if it were fastened at the groin to the thigh. Is this material cloth or an amalgam of the skin or membranes thus far flayed? The same strange composition reappears in table 18 where the figure is further minutely flayed to display drape-like skin-cloth, which hangs loosely from the back to the buttocks and beneath the foot of the man who is sitting on the pedestal (Fig. 6.1). The flayed tissue (the membrane or the skin) taken from the left arm is commingled with the drape-like substance in numerous folds. The écorché is here as if he is taking off many layers of clothing or the skin tissue he was wearing. This chapter, focusing on this strange figure of a cloth-membrane in folds, explores the way that the membranes and the folds play an important role in fiber medicine and the way that drape-like

H. Ishizuka, *Fiber, Medicine, and Culture in the British Enlightenment*, DOI 10.1057/978-1-349-93268-9_6

Fig. 6.1 Flayed man, from John Browne, *Myographia Nova* (1697), table 18; Wellcome Trust Image Collection

membranes and folds intersect with the aesthetic style of the Baroque. The finely pleated draperies shown in Browne's anatomical plates invoke the Baroque aesthetics characteristic of seventeenth-century art. One might immediately recall Bernini's majestic sculpture *The Ecstasy of St. Teresa* (1647–1651), the rumpled draperies of which well illustrate the Baroquism of the folds. However, the interface of anatomy and art seen in the works of da Vinci will not be discussed in this chapter; the main aim of this chapter is to describe the ways that the imagination of the membranes and folds in fiber medicine is implicated in and overlapped with that of the Baroque style and, in so doing, extract one facet of the fiber body. The first section discusses the anatomical art of the latter half of the seventeenth century to show that the concept of texture discovered by micro-anatomy is the product of the Baroque age. The second section explores the way that the notion of the membranes and the folds in fiber medicine exert the imaginative power of the Baroque, by focusing on the elastic power of membranes and the theory of preformation predicated on the anatomy of insects.

2 Baroque Anatomy and the Discovery of Texture

2.1 Draperies and Baroque Anatomy

It is difficult to define what Baroque or the Baroque style is. In the history of the arts, the Baroque style emerged after late Mannerism had degenerated into sheer mannerism with its perverse artificiality, which was followed by Classicism. To put it bluntly, the Baroque is more naturalistic or realistic than Mannerism (sophisticated fancy) and is conspicuous in the decorative arts and exuberant with vehement passions compared to orderly and rigid Classicism.[2] Here I do not concern myself with the nagging issue regarding the Baroque. Referring to the innumerous plicae that are carved in Bernini's sculpture is enough to suggest what the Baroque style is. Following Gilles Deleuze, a French philosopher, who pondered Leibniz and the Baroque by focusing on the fold, I designate the folds or plicae as a privileged trait of the Baroque.[3] For the fold entails and represents a series of the principal features of the Baroque, that is, a decorative impetus to an excessive degree, kinetic dynamism, expressive emotions, the mixed passions of agony and rapture, infinity of space, the plasticity and elasticity of the mass (materials), and the stage effect of light and darkness.

The age of Baroque also applies to the history of anatomy—the era between the Manneristic style of anatomical tables typified by Vesalius and the Classicism of the eighteenth-century anatomical tables, an example of which is the gentle look of the skeleton-man in Albinus's anatomical plates.[4] Since Vesalius's anatomy of the human body, anatomical tables had become increasingly accurate while they polished ornamentalism to an excessive degree. This tendency can be easily seen in the anatomical plates of anatomists such as Juan de Valverde de Amusco (c.1525–1616), Adriaan van den Spieghel (c.1578–1625), and Pietro Berrettini da Cortona (1596–1669), if you observe them chronologically.[5] These anatomical illustrations already possessed the naturalistic trait seen in modern anatomical tables and had been an excessive decorative impulse that modern anatomy lacks. Particularly, during the earlier age of Baroque anatomy from the late sixteenth century to the early seventeenth century, the peculiar propensity for the decorative garment is striking: the pose of the self-dissecting figure in which the man is simultaneously dissected and dissecting himself to reveal the interior of the body by peeling one by one the skin and the musculature from the body has been a cliché of anatomical tables since the sixteenth century. Browne's muscular flaying man (écorché) is a direct descendant of the anatomical tradition of art.

Here let me distinguish the anatomical tables of the seventeenth-century Baroque style from those of the Renaissance Mannerism, contrasting the two different motifs of flaying. The representative Mannerist mode of flaying can be found in the famous figure of the flayed man with his own skin by Valverde, a Spanish anatomist around the mid-sixteenth century (Fig. 6.2). The man in the plate has a knife in one hand with which he has skinned himself and holds up his own skin like a trophy.[6] Needless to say, there is embedded the myth of satyr Marsyas, who challenged Apollo to a musical contest and lost to be punished by being flayed alive. This theme recurred in the arts of the sixteenth and seventeenth centuries.[7] There is a difference between Valverde and Marsyas in that Valverde's flayed man ripped off his own skin while Marsyas's skin was forced to be peeled off by punishment. These two, however, have much in common regarding the material skinned. The outline of the face looms large like a ghost on the skin, which testifies to the identity of the subject; Valverde's flayed man seems to show off another self. This can be seen as a variation of the "skin ego" advocated by Didier Anzieu, a modern psychologist, according to whom the skin is an imaginary unity and the organic reality to represent one's inner self.[8] Later Baroque anatomy lacks this theme. Furthermore, Valverde's

Fig. 6.2 Flayed man with his own skin, from Juan de Valverde de Amusco, *Anatomia del corpo humano* (1560); Wellcome Trust Image Collection

figure and Marsyas emphasize the point that the skin was just peeled off, and therefore, the skin had been alive just before; the skin was living and never a cloth or garment. This is all the more true because there are no rumpled draperies in Valverde's illustrations that are typical of Baroque anatomy. How do we understand the transformation of the mode of flaying from Mannerism to Baroque, from skin to rumpled cloth? One answer can be found in the shifting idea of drapery in the history of art.

Anne Hollander, a distinguished art historian, pursued the shifting image and representation of dress and drapery in painting and analyzed the meanings.[9] Hollander argued that drapery in painting until the fifteenth century was drawn faithful to nature not for a purely rhetorical purpose; it was not until the sixteenth century that drapery was released from the restraint of nature and enjoyed its own artistic life.[10] Drapery here did not represent the naturalistic image of fabric but came to express the artistic, and sometimes unrealistic, rumples and folds based on the pictorial rules; drapery became independent of nature as a purely pictorial element. This kind of pictorial drapery sometimes intensifies sensual quality or represents the spiritual holiness in a religious picture. For instance, in Caravaggio's *The Death of the Virgin* (1604), a colossal crimson drape hovers over the space above, which has no particular practical function; these draped folds as a "visionary fabric" seem to represent the visionary presence of angels and God, once the theme of the religious picture.[11] This type of drapery has an organic relationship with the picture by reinforcing its theme, enhancing the drama that happens in the picture or in the mind of the characters. In the later part of the seventeenth century, however, drapery further steps forward to be employed for its own sake. An earlier example can be seen in Anthony van Dyke's *The Countess of Castlehaven* (c.1635–1638).[12] The green drape the Countess holds is extremely non-realistic; it behaves like a living animal struggling to fly upward away from her hand toward freedom. It seems that she is trying to domesticate her pet that is unwilling to remain within her grasp. The upward-standing figure of the drape against gravity fails the soft texture it supposed to have. According to Hollander, by the end of the seventeenth century, the motif of drapery for its own sake became standard in European portraiture.[13]

It could be argued that the folds in drapery in Baroque anatomy sit abreast with those of Baroque arts, for they both had an autonomous presence. The figure of drapery in anatomical tables might initially function to mitigate for viewers their fear of the cruel act of flaying alive with artistic decoration; however, during the Baroque era, when the presence of drape and the garment intensified, the skin became the cloth and vice versa. The garment that had had a purely decorative function came to express the skin–membrane–tissues or musculature living its own life. The ambiguity seen in Browne's drapery, whether it is the skin or the cloth, can be explained in part as a feature of contemporary Baroque arts.

Pointing out the ethos that anatomy and the arts shared, however, is not sufficient to explain the crucial difference in anatomical tables before and after the late seventeenth century. Although Browne's plates were published in the end of the seventeenth century, most were appropriated or plagiarized from the earlier Baroque anatomy of Casserio and Spieghel; in this sense, Browne's work was the culmination of the "Baroque Anatomy" in its strict meaning. This version of Baroque anatomy disappeared from the stage of anatomical illustration around the turn of the century along with a flamboyant écorché. At around the same time that Browne's anatomy was published, a different version of anatomical Baroquism emerged. The critical presence of the garment-skin is as significant as before, but the emphasis shifts from the theatrical presence like a hanging banner on the stage to the ever-subtler texture of the skin-cloth. Govard Bidloo's *Anatomia humani corporis* (1685) is the exemplary case of this version of Baroque anatomy (Fig. 6.3); the various textures of tissues, such as the skin, epidermis, cuticula, coat, adipose membrane, hair, and pattern of the finger (fingerprint), are finely illustrated; these textures cannot be observed without magnification with a microscope. These membranes of the micro Baroque differ from Browne's high Baroque garment-like membrane. As will be explicated below, this micro-anatomy had a significant effect on fiber medicine and the fiber body of the eighteenth century.

2.2 Micro-Anatomy and the Discovery of Texture

As demonstrated in Chap. 1, during the latter half of the seventeenth century, natural philosophers and anatomists met the micro-world of the textures of the living body thus far unfamiliar to them through observations with a microscope and the anatomical technique of injection. Here, by elaborating on this argument, I shall find a thread that stitches the anatomical tableau to the Baroque mode of arts.

The history of the microscope is very interesting; it suddenly attracted much attention from scientists (and virtuosi) around the 1650s and 1660s only to disappear from the major scene of scientific activity within

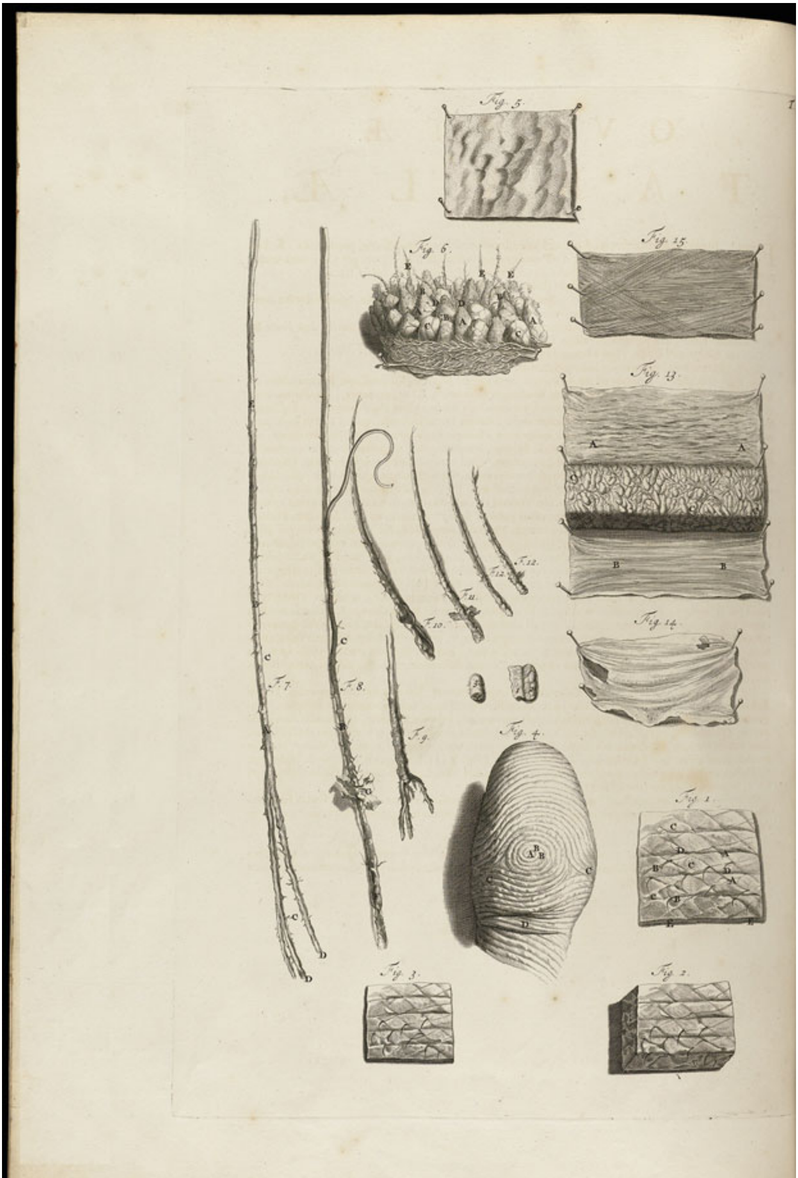

Fig. 6.3 The various textures of tissues, from Govard Bidloo's *Anatomia humani corporis* (1685), table 4; Wellcome Trust Image Collection

three decades to the great disappointment of corpuscularian philosophers. Microscopic investigation into nature's hidden secrets (i.e., the specific shape or configuration of the matter/corpuscle) was ultimately a failure, but it brought forth new dimensions and new experiences of the surfaces of the sub-visible world, which led the viewer to forge the new language for newly discovered micro-worlds.[14] When microscopists observed the finely woven texture of micro-worlds, these textures of substance seemed to resemble those of textiles or woven fabric of the ordinary world. Microscopists had to borrow from common language terminology or metaphors to make sense of the otherwise unintelligible micro-world; the old correspondence between macrocosm and microcosm underlain by the system of external resemblances was replaced by the weirdly familiar semblance between the visible and invisible worlds.[15] A set of metaphors of textiles and weaving was really an apt choice, for the substance (especially the living body) was, on closer analysis, seen to be woven just like embroidery, or the garment. Thus, the microscopic world is filled with textile terminology unique to woven fabric. Robert Hook's *Micrographia* was an exemplary case of this, and the book's success rested on the outstanding details of the subtle texture of matter (both verbally and pictorially—but the visual representations are more striking).

It is natural that microscopic observation extended to the field of anatomy contemporary to natural philosophers, for most anatomists felt a pressing need to use the microscope for observation of the apparently hidden tissues of the living body. In the 1650s, anatomists had discovered new vessels, lymphatics, and glands that even Vesalius could not see, which had been a great blow to the long-standing knowledge of Galenic anatomy. In the 1660s, anatomists increasingly looked through the microscope encouraged by these discoveries to resolve a mystery of animal economy on the micro-level. Among others, Marcello Malpighi, an Italian anatomist and physician, made a huge contribution to microscopic anatomy.[16] In his essay on the lungs (1661), Malpighi discovered the capillary network on the membranous vesicles of the lungs, through which the arteries and veins communicate.[17] This discovery was crucial to evince the circulation of the blood advocated by Harvey but never empirically confirmed. Since then, Malpighi found, one after another, the very finely textured structures in various tissues of the kidney, the spleen, and the cerebral cortex with the aid of the microscope and the injection technique. In so doing, he discredited the established idea of parenchyma that had been conceived as a mass of coagulated blood but in reality were a network-like composite structured by membranes, vesicles, and

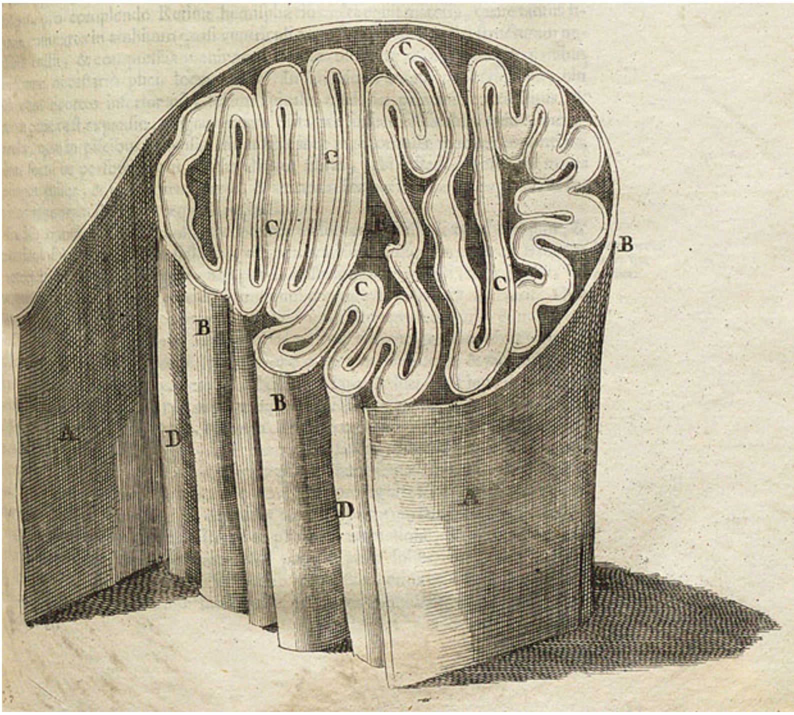

Fig. 6.4 The brain of a swordfish, from Marcello Malpighi, *Opera omnia* (1687) (*De Cerebro*, tom II page 120); reproduced with permission of the Department of Biological Sciences, Graduate School of Science, The University of Tokyo

capillary vessels.[18] Malpighi dissected the brain of a swordfish and found that an outer membrane of the optic nerve appeared to be folded like a piece of cloth, which might recall Bernini's rumpled garment (Fig. 6.4). To be fair with Malpighi, he rejected the idea shared among other anatomists that the tiny filaments as the building unit constituted the living body; instead, Malpighi assumed the smallest glands were the fundamental unit of the body. Malpighi's texts, however, are imbued with the metaphor of clothes and the image of weaving. Plant anatomy plates, in which Malpighi competed with Grew, also show that plant tissues are wholly woven of fibers; for example, the oak bark is weaved and composed of a network of fibers that run longitudinally and transversely, and Malpighi compared it to a mantle.[19] The assumption was widely shared among anatomists and microscopists that Nature or God stitches or weaves the natural living world with threads and needles; in other words, the body is a woven fabric knit by filament-like fibers (see Chap. 1).

It is important to note, here, that the image of the body woven by filament-like fibers necessarily invokes that of the cloth or the garment. The body, in this case, wears a piece of cloth not on the outer surface (the skin) of the body but inside it, in the deep hidden space invisible to the naked eye. The skin, here, does not represent the ego (as in the case of the flaying of Marsyas) but becomes part of the membrane-garments that cover the body; the skin itself is disintegrated into many layers to lose its identity. Thomas Willis, an English anatomist renowned for his work on the anatomy of the brain, spends many pages describing and illustrating the "coats" composed of various fibers; the stomach and the esophagus are composed of three layered coats, nervous, fleshy, and membranous, which have their respective functions.[20] The innermost coat is woven by the nerve-fibers just like "a certain Down," and the function of this coat is sensation; the next coat is woven by fleshy fibers, and the function of this coat is motion; the last coat is woven by membranous fibers, and the function of which is to cover and bind the whole for firmness and strength.[21] The technical word "coat" for anatomy reminds us of the image of clothes as if the stomach and the esophagus wear several layers of cloth. In fact, Willis repeatedly employed the metaphor and the analogy of weaving and textiles; the nervous coats are compared to "shaggie Silk," and the ventricle is compared to a long sleeve with a large bottom ("like a Sleeve with a more ample bottom") spreading with a short top.[22] A series of metaphors related to weaving or textiles, such as knitting, interweaving, interwoven, cloth, net, web, and wreathed, recur in Willis's texts. Willis himself was clearly aware that the coats are just like garments: "The Ventricle being after this manner like a sleeve, [is] made up of its three Tunicles, as it were a threefold Garment."[23] The word "Tunicles" here is used in the sense of membrane and the liturgical vestment.

In this way, subtle anatomy by microscope reveals the way that the body, whether outer or inner, is wholly covered with membrane-textiles. The overwhelming presence of cloth-membranes inside the body and an obsession with textiles epitomize the Baroquism of micro-anatomy. Bidloo's anatomical plates could be considered the culmination of micro-anatomy developed since the 1660s.

It might be argued that behind the discovery of texture in micro-anatomy was the sensibility of the Baroque, or that these discrete phenomena happened to meet in the figure of the garment. One such example of the intersection of anatomy and Baroque sensibility can be seen in Samuel Collins's anatomy work.[24] Collins adorned the inner parts of the human body with finely woven textiles in his impressive comparison of the human body with an elegant building. The furniture-like human body described by Collins is covered by cloth-membranes in a Baroque way. The body is divided into several layers of "floor" and "apartment" and is decorated with "fine hangings" and "choice furniture."[25] For instance, "cuticla" is compared to a fine "Vest," and the "soft Pillow" is employed for adipose membrane.[26] Taki Koji, a Japanese cultural historian, once said in an essay on the cosmos of cloth that the living space of the ruling classes of the seventeenth century was covered by cloth from top to bottom, and that they felt pleasure from living in or with such a space full of Baroque cloth or textiles.[27] Collins's furniture-like human body tries to domesticate such a Baroque pleasure. Collins's comparison of the interiors of the body to domestic interiors suggests the process to domesticate the body experienced from the later seventeenth century onward: it is a double process of domestication —in one process, the body (especially the inner one) is literally assimilated to domestic materials, including textile fabrics, and, because of that (and this is the second process), the body is increasingly domesticated[28] and, by implication, femininized, to which the idea of the woven body is closely related.

Around the turn from the seventeenth to the eighteenth century, knowledge of micro-anatomy was appropriated by medical theorists such as Baglivi and Boerhaave, who endeavored to construct a new theory based on the fiber (see Chap. 2.). In the next section, which focuses on the elasticity and the folding structure of membranes, the interrelation of fiber medicine with Baroque sensibility is explored.

3 The Anatomy of Membranes and Folds in Fiber Medicine

3.1 Power of Membranes

Once the idea of the fiber-woven body permeated the minds of anatomists and physicians in the eighteenth century, the image and the metaphor of cloth, textile, weaving, and their cognates are rampant in depicting and dissecting the body; among others, the membrane and the coat, due to the strong and natural association with cloth, overlapped with the image of textiles. Cheyne recounted how the least “Fibres” or “Threads” were “plaited and twisted together” into larger sensible fibers, which were “woven into a fine *Web*, like Cloth, to make the *Membranes*.”[29] The membranes appeared to be like a “sheet,” for Boerhaave, where the filaments and fibers were closely interwoven “as in Linen.”[30] The multilayered composition of the coats seen in the work of Willis and other seventeenth-century anatomists remained the same in the next century; the membranes or the coats of the stomach and the esophagus divide into three or four layers. The periosteum, the very thin coat like a spider’s web, turned out to be a complication of various vessels and fibers interwoven together.[31] The membranes are knit together not only by fibers and nerves but also by blood-vessels. Quincy’s description of the membrane where veins and arteries are entwined and meandering together (“serpentine Progression”) to make “a most agreeable Embroidery” may recall picturesque aesthetics, and its luxurious pattern with rumpled cloth may invoke a Baroque sensibility.[32] And yet, the extremely thin and transparent texture of the membranes suggests a fragile and vulnerable quality instead of the extravagant and bombastic dynamism peculiar to the Baroque. The delicate texture of the membranes appears to be incongruous with the energetic movement of Baroque aesthetics, but that is not true. The fiber body derives its vigor and exuberance from the membranes.

As I fully demonstrated in Chap. 3, the concept of the elasticity of animal fibers holds the key to the mysterious movement of animal economy.[33] Life would not last a minute without this elastic power of fibers.[34] Elasticity, often identified with tension or tonus, extends its power beyond the fiber-threads to the membranes, the vessels, and the whole solid. In particular, the membranes, despite an inherent thinness and apparent fragility, were supposed to be endowed with elastic power. Eighteenth-century fiber-theorists saw the membranes as a web-like tissue composed of various vessels and fibers. According to Boerhaave, membrane in Greek designates “a very pliable Body” and is nearest to cartilage, which possesses hardness next to bone but is more pliable and “most Elastick of any Part” of the body.[35] The growth of a fetus clearly indicates that membranes are changing into cartilages.[36] James Douglas argued that the peritoneum consisted, like other “Membranes,” of “a fine Contexture of Elastick Fibres,” and therefore was capable of “a great Dilatation and Contraction.”[37] According to another anatomist, membranes enjoyed elasticity and sensation from the nerve-fibers that composed them, which contracted the membranes.[38] James Drake believed the membrane of the stomach that it was made of nervous and muscular coats, but as these coats were not "Contractile," the contractile power (elasticity) lay in many "*Wrinkles*" and "*Folds*" on the surface of the membrane.[39] Thus, the membranes that eighteenth-century medicine saw were full of elastic power despite their delicate texture.

The medical philosopher most deeply committed to the theory of the membrane was probably Cheyne. Cheyne had exalted the elasticity of fibers as the noblest organ of animal economy[40]; in later in life, he came to specify the membrane as the crucial agent of animal function: "*Membranes*…are the true and only *Seats* of *Spring* and *Elasticity*, and the proper immediate Instruments of *Motion* and the *Functions* in *animal Machine*."[41] Cheyne considered "Coats and Membranes" "the great Organ" for the animal machine to run.[42]

Eighteenth-century medicine sought an intermediate substance to fill the gap between the mind (soul) and the body broached by Cartesian dualism and found nerves and fibers as such an agent. Cheyne, too, accounted for the interaction of the soul and the body with recourse to the agent of the nerve-fiber that was derived from the brain, the seat of the soul. Cheyne, in his later works, however, came to regard the membranes or "the membranous Coats" (which is tautological terminology) instead of the nerve-fibers themselves as a true instrument of animal function.[43] This is probably because the vibration theory on which Cheyne had initially insisted—a theory that the stimuli outside are transmitted to the soul by vibrations of the nerve-fibers, and the soul transmits its order through the nerve-fibers through vibrations to the muscles—was rejected by medical authorities such as Boerhaave and von Haller, who contended that the nerves derived from the soft pulpy substance of the brain were not tight like a piano string. Cheyne argued against this idea, drawing on the elastic power of the membrane:

> Because the *Brain* is pulpy, and the *Nerves* lax, some have thought both unfit for receiving or communicating *Vibrations* or *Undulations*, not considering that the great Activity of both lies in their *Membranes*, that involve every the least *Fbiril* or *infinitesimal Nerve*: they are all included and tied, as it were, in a *membranous* Bag, and fasten'd together by Threads of the same: And every one knows, *Membranes* are the most elastic, and fittest to transmit *Vibrations* of all Bodies whatsoever; their internal Substance is probably *cellular*, like the Pith of a Rush, design'd only to separate a milky Substance, (which the Ignorant call the *Liquidum Nervosum*) intended to preserve their *Elasticity*, *Glibness*, and the *vibrating* Powers of these Membranes, in which their *mechanical* Virtue alone consists.[44]

Membranes, not nerves, transmit the impulse of vibration or undulation. No one realizes the "wonderful Texture and Mechanism" of the membranes, but everyone knows that membranes are the proper tool for transmitting vibrations for their elasticity.[45] The intelligent principle or the soul acts on the body-organ by way of these "infinitesimal membranous *Sacculi*" or "*membranous* Coats," the "*elastic* and *energetic* Virtue" of which enables "*Vibrations*, *Undulations* and *Tremors*" to transmit throughout the body.[46]

Thus far, I have shown that the membranes were endowed with the power of elasticity; however, this recognition does not automatically lead to the vibrant, effervescent motion of the garment typical of the Baroque. For the invisible infinitesimal membranes are buried in the micro-space of the micro-body, unlike the rumpled drapery that creates a majestic presence in the air. And yet, the Baroquism of the membrane and the fold can be found in this infinitely small micro-space, where the membrane is folded ad infinitum, especially in the theory of preformation, the topic I pursue in the next section.

3.2 The Folds and Folding ad infinitum, or Preformation

The most nagging issue for seventeenth-century mechanical philosophers was the problem of generation of life, for a machine could not reproduce itself unlike living beings. Descartes almost in desperation advocated a mechanical version of epigenesis by means of fermentation and condensation that proved to be wholly unsatisfactory for elucidating the mysterious phenomena of life. Then, the preformation theory arrived to resolve the dilemma.[47] The preformation theory, or simply preformation, assumed that God at the beginning placed (or preformed) all germs or embryos in miniature in the loins of our forebears to be born and developed at a precise moment; all future germs of the same species are encased in the parents—the germs containing within themselves further germs, which, in turn, contain other germs, much like Russian dolls or Chinese boxes, and the process continues ad infinitum. The theory of preformation, as it were, replaces the explanation for the mysterious phenomenon of generation with creation by God's fiat, which is supernatural. Although it sounds superstitious to our minds, the doctrine of preformation enjoyed huge popularity among scientists in the latter half of the seventeenth century. For the idea conforms to the mechanical idea that nature is infinitely divisible and endorses the theological doctrine of original sin since preformation proves that original sin had already pre-existed in our first parents, Adam or Eve, the first sinners.

Nicolas Malebranche, a Cartesian priest, first advocated the preformation doctrine of encasement. By examining the germ of the tulip bulb, Malebranche discovered that it contained the different parts of the tulip, and from this, he reasoned that the germ may contain all future germs since germs contain seeds. This is also true of animals: "Perhaps all the bodies of men and animals born until the end of times were created at the creation of the world."[48] Malebranche's idea of preformation was scientifically backed up by the findings of microscopic anatomy contemporary to him; among others, Malpighi's observation of the formation of chicks and Jan Swammerdam's remarkable study of insects under a microscope had a great impact on Malebranche's theory of encasement.

Swammerdam's anatomy of insects revealed the folding structure of the membrane—how the membranes were folded together in an orderly manner in a very small space. He inspected with an astonishing skill the bodies of "insects," such as ants, flies, bees, beetles, and frogs, under the microscope. Taking the metamorphosis of insects from larva to nymph (pupa) and then to adult as a seamless process through which the same "insect-animal" develops or enlarges, Swammerdam punctured the superstitious idea of spontaneous generation to explain the mystery of insect generation. According to him, all the future organs of the adult body, such as the legs, wings, trunk, and antennae, are intimately folded inside the temporary skin (the cuticle); these bodily organs are packed in an extremely intricate and astonishingly beautiful manner in the larva or nymph.[49] Swammerdam's majestic *The Book of Nature; or the History of Insects* is suffused with the vocabulary peculiar to preformation, such as "folding," "folded," "enclosed," "folds," "plaits," "wrinkles," and "unfolding."[50] More than words, however, visual representations make a profound impact on viewers, who, having seen the drawings of insects made with astounding precision, might be persuaded themselves of the doctrine of preformation. The detailed and sophisticated illustrations of bee and fly nymphs successfully convey the way that all the bodily organs are folded and preformed. The illustration shows the later stage of the nymph (pupa) of a fly; part *a* represents "the antennae with their joints," *b* "the eyes, which are now arrived at full size," *d* "the first pair of legs, beautifully folded," and *f* "under the latter [pair of legs], again appear the wings, and their artificial convolution and beautiful folding"[51] (Fig. 6.5). Such a picture of fold

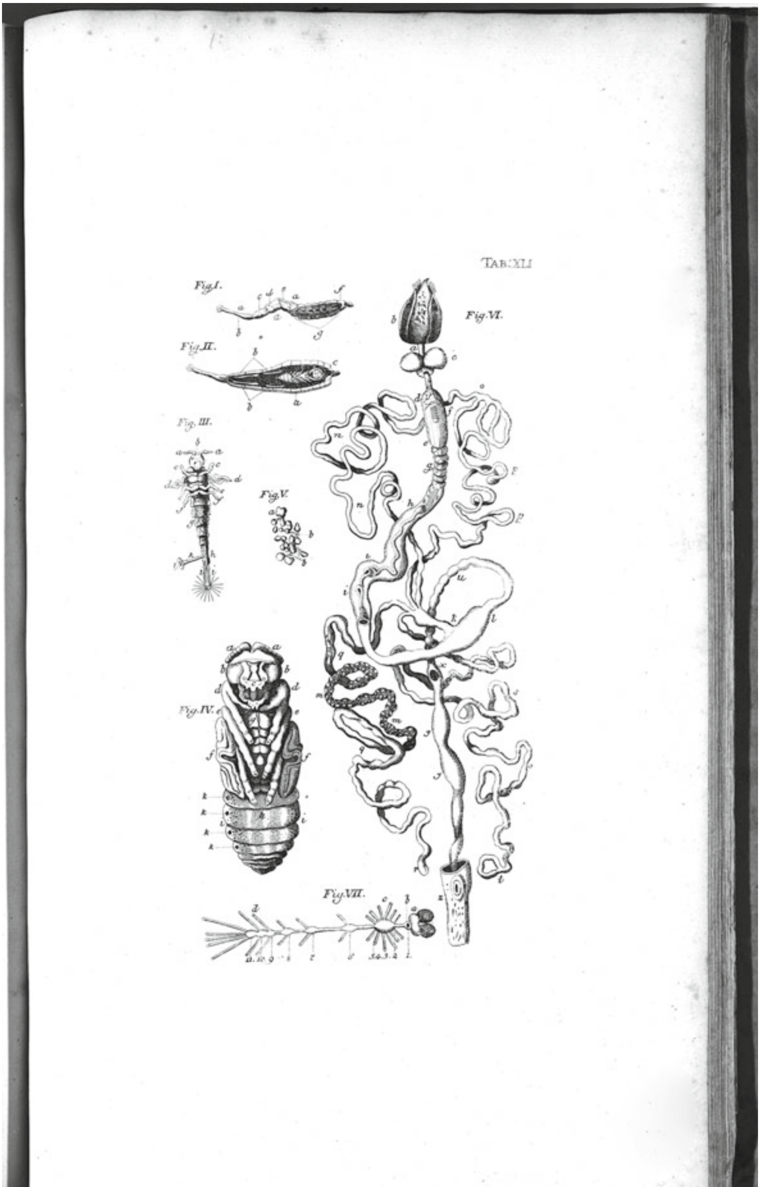

Fig. 6.5 The nymph (pupa) of a fly, from Jan Swammerdam, *The Book of Nature* (1758), table 16; reproduced with permission of the International Center for Japanese Studies (Nichibunken)

after fold, pleat after pleat, in multiple layers in encasement to await future unfolding at an appropriate time not only proves the doctrine of preformation but also provides a striking image of encasement. It is no wonder that fiber-theorists of the eighteenth century, who were obsessed with fibers and membranes, made themselves master of this image.

Eighteenth-century fiber-theorists attempted to account for the process of the generation of living beings with recourse to the image of preformation (encasement). How are solids, which were composed of innumerable small filament-fibers that are extremely pliable and elastic, generated and grown? The theory of preformation conformed to mechanical philosophy, for preformation assumed that the smallest organism or machine furnished with vessels and organs to be expanded in the future was comparable to the germ in plants. Most fiber-theorists called this primordial organism "stamina," a kind of essential part of the body preformed from the beginning, distinguishable from the accidental parts that were later added by nutrition, which had been lodged in the loins of Adam. Here, Swammerdam's image of un/enfolding in encasement was overlapped with that of the fiber body that was woven by innumerable fiber-threads and fiber-membranes.[52] Endowed with the power of elasticity, the fiber-membranes are capable of folding/unfolding ad infinitum within and without themselves.

Cheyne, a philosopher of membranes, advocated the doctrine of preformation beginning in the early years of his career.[53] Cheyne assumed that in the loins of Adam were the innumerable number of "animalcules" that had been growing to maturity since then, an unimaginably infinite number of animalcules occupied a space only as large as the point of a pin.[54] The minute animalcule, the miniature of man, had been folded in the form of membranes; at the appropriate time, the power of the fluids running in the solids increased enough to push up or unfold the folding membranes to grow or develop, which precisely resembles the process of transformation of insects:

> That some of the Solid Parts of the *Animalculs* are as it were folded and wrapped up in *Plaits*, and these Folding are wrapp'd together by surrounding Membranes, which in process of Time are rent and torn, by the encreas'd Force of the Fluid and Augmentation of the Solid Parts; As is commonly observ'd in the Transformation of all Insects: And that the *Nervous Fibres* are capable only of a determin'd Degree of Tension, without losing their *Elastick* Power of bursting; which Degree of *Tension* answers commonly to the Usual Dimensions and Bulk of the *Species* of the Animal.[55]

Cheyne elsewhere contends that growth is “nothing, but the unfolding of the original *Membranes* and *Fibres*.”[56] The original membranes are identifiable with animalcules or stamina. A fiber body composed of fiber-membranes can be said to be a product of en/unfolding of the infinitesimally small “original *Membranes*,” and the degree of tension or elasticity that the membranes enjoy determines the original makeup of the body. Fiber-theorists saw in a chain of generation of encasement theory the image of rumpled membranes folded ad infinitum.

3.3 Lyonet’s Muscles of a Caterpillar, Cheyne’s Glorious Garments

A fiber body has an affinity with the encasement structure not only in the process of generation and growth but also in the way that the fiber body is composed by fiber-threads and fiber-membranes, in which the threads make the membrane (surface), which, in turn, makes the larger thread-like canal or vessel, and which next produces the second-level membrane—this process continues ad infinitum. The way that the threads and the surfaces are intricately entangled and easily reverse each other evokes something similar to the encasement of the preformation theory. Boerhaave asks, what is a muscle? It is composed of the arteries, the veins, the nerves, the lymphatic ducts, and the like. Then, what is an artery? It is something membranous; then, what is a membrane? It is “the Texture of all Kinds of Vessels.”[57] The vessels are interwoven by various kinds of membranes, which are variously interwoven by the fiber-threads, and then this resembles an unending process of encasement: “a Vessel which is a Membrane, and which Membrane is composed of other Vessels, and those Vessels of other Membranes; which Membranes again are composed.”[58] In addition, the fiber-membranes capable of expansion and contraction are folded up to make pleats.

It seems almost impossible to visualize this intricate structure of a fiber body. The image of the Vascular Man—the blood-vessels and nerves running all over the body outline the contour of the human body—was still popular in eighteenth-century anatomy, but however sophisticated this vascular man becomes, the result would be inadequate for a precise description of the figure of the fiber body. One possible example to illustrate the style of encasement that the fiber body embodies, however, is provided by Pierre Lyonet, the Dutch natural historian, theologian, and art collector, who painstakingly dissected the caterpillar of a single species (the great moth) and beautifully illustrated it[59] (Figs. 6.6 and

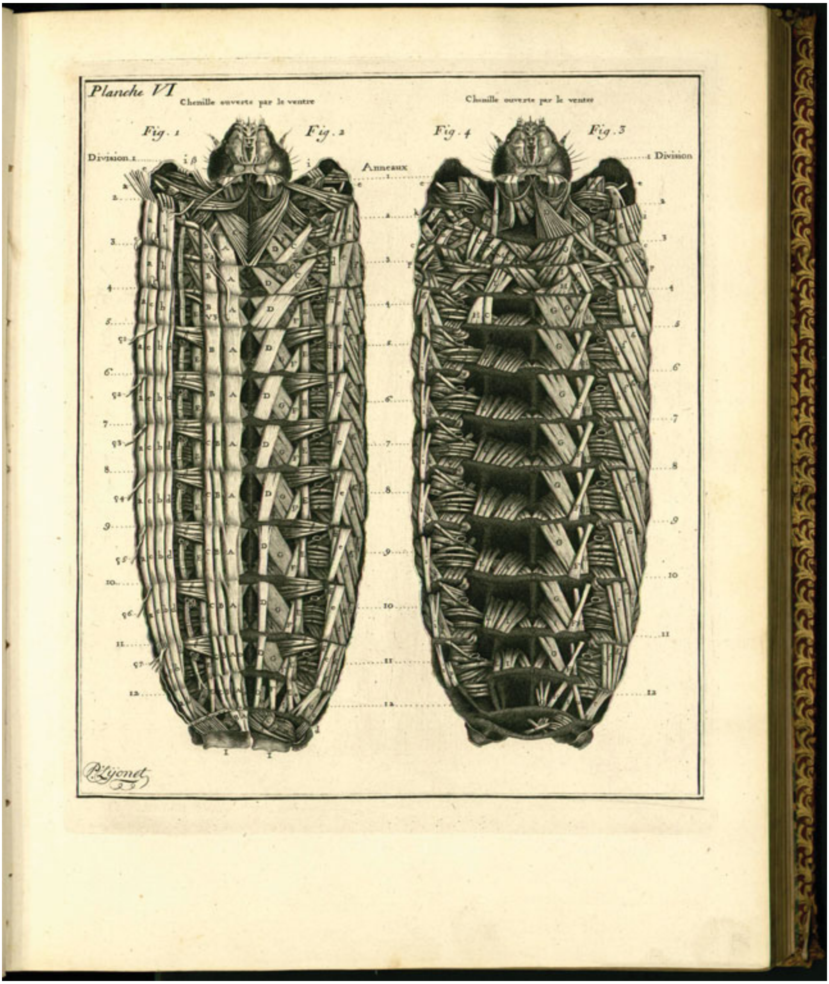

Fig. 6.6 and Fig. 6.7 Caterpillar's internal anatomy from Pierre Lyonet, *Traité anatomique de la chenille, qui ronge le bois de saule* (1760), table 6, 8; reproduced with permission of Université de Strasbourg, Service Commun de la Documentation (France)

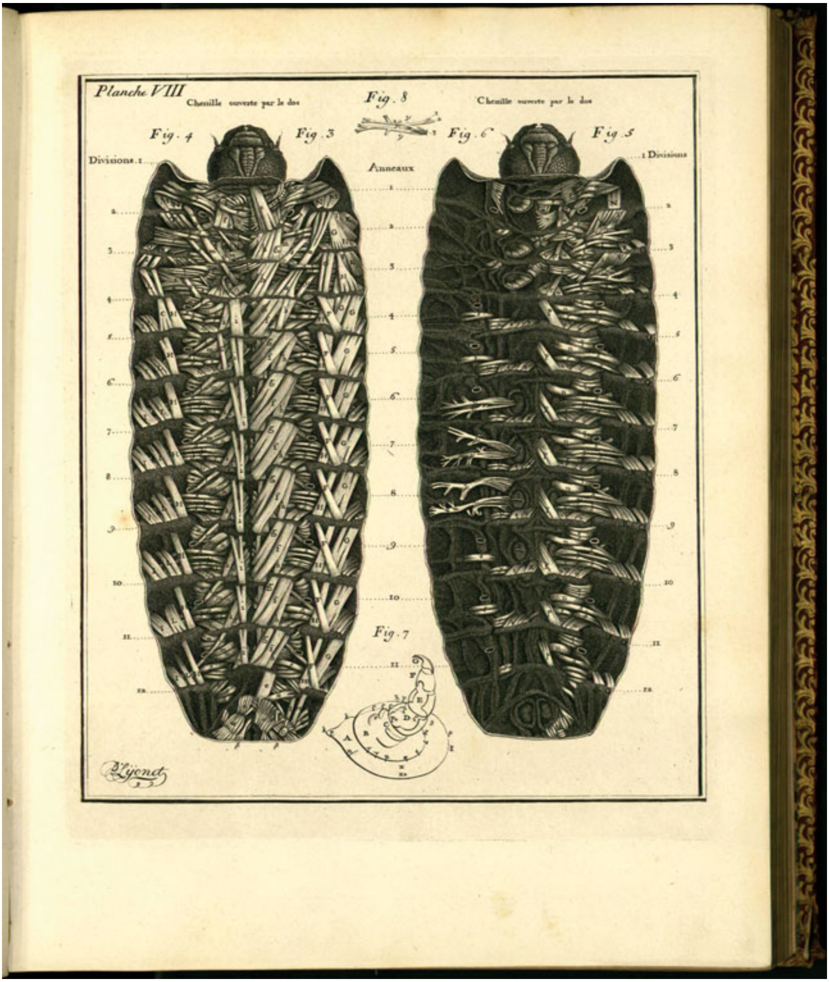

Fig. 6.6 and Fig. 6.7 Continued

6.7). These extraordinary detailed drawings and engravings based on his careful examination of the caterpillar's internal anatomy through the microscope required two and a half years of labor. The anatomical illustrations of insects and plants of the seventeenth century were marvelous enough to be reused throughout the next century; Lyonet's amazing illustrations of the insect, however, were a rare case that surpassed those of the former age.[60] Especially, what most attracted the viewer's eyes was the intricately structured muscles that are folded up together like a maze but are at the same time arranged in order.[61] The internal anatomy of the musculature of a caterpillar appears to be geometrically patterned; the multilayered floors with cellular rooms, divided by the somites, are cramped with the innumerous branches of muscles that are divided into three kinds, which might remind one of the slave ship contemporary to it. The way that the muscles of the caterpillar are jam-packed together to fold and be folded with each other seems to resemble the texture of a basket instead of that of the muscles, but when we observe the full-scale drawings instead of the reduced ones, we can discern the minute texture of the muscles that seem to enjoy some degree of elasticity peculiar to muscular fibers.

Lyonet meticulously counted each muscle of a caterpillar—for instance, 228 for the head, 2066 for the intestinal tract—and finally reached the total number, 4041.[62] Lyonet further imposed on the musculature the nervous system and the various branches of the blood-vessels. The resultant plates (pl. 9–11) are a kind of transparent cloth instead of fleshy touch probably due to the extreme complexity, but still, they well represent the en/unfolding style of encasement, for they draw an immensely complicated pattern derived from the entanglement of the nerve-fibers to the innumerable branches of blood-vessels, and from further tangling of these branches with the musculature. Plate 13, which shows the digestive system, is also striking; on the cylinder shape of the tissue leading from the gullet to the stomach and to the intestines appears the textured pattern where the muscular fibers and the membranes are interwoven together. Figure 3 of the plate is a picture of this pattern made flat on the surface, which clearly shows an analogy with the textile pattern seen in micro-anatomy. Thus, Lyonet's astonishingly well-textured plates of a caterpillar are a good, and probably the only, example for visualizing the figure of encasement of a fiber body.

Lyonet's choice of an insect for his investigation of internal anatomy was probably not fortuitous, for eighteenth-century anatomists and physiologists saw in metamorphosis the model of the radical transformation of the body in the life after death. They evoked the image of an insect's metamorphosis when they imagined that the soul departed the body after death and left for another world. Here, returning to Cheyne, let me examine how the imaginative power of the membrane extends to the life after death.

As stated above, when he was young, Cheyne supported the doctrine of preformation. This position remained the same in his later years, but when he mused again on the theory of preformation in his *An Essay on Regimen* (1740), Cheyne concomitantly disclosed the spiritual dimension latent in his early career.[63] Some studies on Cheyne argued that occult or mystic thinkers, such as Boheme, the Neoplatonists, or George Garden, had influenced the formation of Cheyne's mysticism.[64] What is relevant here is that Cheyne's mystic thinking concerning the soul and the body is teamed with fiber terminology, such as cloth, garment, membrane, fold, pleat, and en/unfolding, which constitutes part of the Baroque style. Cheyne's mystic or spiritual view of the body exemplifies a version of the fiber-medical Baroquism in which the body wears and casts off an article of clothing like a muscular man in the anatomical tables.

Cheyne, in *An Essay on Regimen,* argued that "all created *Spirits*" except God, which is purely immaterial being, had to possess the "body" proper to them.[65] The term body here means a kind of vehicle for the soul that the Neoplatonists advocated or the Paulian notion of the "glorious garment." This vehicle of the soul, the "primitive Animal Body," comes into being in this world only by confining itself into the loins of Adams as an infinitesimal point—this body is to be folded:

> This *spiritual animal Body*, at first divinely organized, may be rolled up, folded together and contracted in this present State of its Duration, into an infinitely small *Punctum Saliens,* into a *Miniature* of a *Miniature in infinitum*, lodg'd in the Loins of the Male of all Animals.[66]

Spirits and their spiritual bodies are so intimately united in the original creation that they would not separate from each other even in this secular world.[67] Our earth, our globe, however, is full of "*Pain*, *Suffering* and *Misery*"; moreover, our bodies might inherit diseases and suffering from our parents, or as long as we live on this planet, we are forced to imbibe air noxious and deleterious to our body.[68] As the spiritual animal body lodged in Adam's loins is extremely delicate and pliable, it would not endure such a coarse environment as might wound the spiritual body. In order to protect from such wounds or "injuries" that the spiritual body suffers on this planet, another new body "Crust" is worn on the primitive body ("the primarily *divinely organis'd* Vehicles") just like a surgeon lays a "Plaister on a Sore."[69] This crust is equivalent to, as Cheyne elsewhere calls it, the "Coat."[70] The original animal body (the "*liner Root*" or "the original, primary, divinely organis'd linear *Fibrils*")[71] lodged in the loins develops or expands at the proper time to form "the several new-cloath'd *Organs*, Pipes and Springs."[72] This "second Adamical machin" is made of a very coarse texture or garment, and this coat becomes denser, harder, and heavier by the continuing luxurious animal diet on this earth.[73] (Vegetable and milk diets are required against this degeneration.) However, there are some advantages with this coarse new garment-body; for this vehicle enables us to contemplate and admire the material world God created, and to communicate with other people and polish our virtue.[74] Most eighteenth-century intellectuals assumed the soul could not execute anything without the help of the body, the soul's instrument. Therefore, the second garment-body is simultaneously a prison for the spirit and a place of ordeal for us to strengthen our mind and body in this lapsed state.[75] Through the severe trial of the body like diet, the spirit begins to recuperate the original virtue, and in proportion to the degree of recovery, the coarse plaster–crust–coat becomes drier and finally crumbles into dust; in other words, the spirit gradually "drop[s] and puts off this Adamical Tabernacle" and comes to put on a new cloth, another vehicle, a glorious garment.[76] This "third" glorious body or garment is precisely at one with the primitive spiritual body ("they are one and the same"), for it is the body resurrected at the last Judgment.[77] The primitive paradisiacal body (the "*primary linear Stamina*") hidden beneath the gross garment ("Coat or Crust")[78] develops into the resurrected glorified body as a nymph metamorphoses into a butterfly. Thus, Cheyne's mystic cosmology of the spirit-body is like a theater of the spirit-body's dressing-up. The spirit and the body are folded, rolled up, wrapped up, and sometimes unfold and expand in a garment, coat, crust, tabernacle, teguments, membranes, and other textures according to their need. It surely encapsulates the spiritual aspect of medical Baroquism that the membrane and the folds enjoyed.

3.4 Resurrection of the Same Body and the Unchanging Membranes

The membranes of fiber medicine along with the concept of stamina were appropriated in the contested realm of theological discourse to support the sameness of personal identity and its related argument, the resurrection of the same body. After Locke posited the basis of personal identity not in the immaterial substance (soul) but in the same continued consciousness inherent in "a thinking thing" "whatever substance made up of," there arose an uproar about what constituted and endorsed the sameness of the individual throughout life and especially in the afterlife.[79] The Lockean notion of the self as a fluid identity would, by dismissing the substantial soul as a criterion of personal identity, cause big trouble regarding the possibility that one man may become two persons. The corollary of this is that in the future state, the same man would not necessarily receive the justice of reward and punishment of this world as the Lockean personal identity violated the principle of the resurrection of the same body (person) that it should be the same his or her body, not someone else's that is raised to receive rewards or punishments after resurrection. But what is the body that is resurrected? And how one can confirm the sameness and continuity of it, while the material body always undergoes decay and alteration? For instance, what body of a precise point of life does the resurrected body embody? And which part of it? If my dead body is cannibalized, is it my body or the person who ate my body that will resurrect? This is really a tough question.

Most eighteenth-century intellectuals solved this thorny issue by relying on the medical concept of fiber-membrane-stamina and proved the continuity of the same person during life and in the afterlife. The general reasoning is as follows: even though we are subject to change during life and our appearance continues to change, people can still identify our appearance because we retain the same identity; therefore, there must be an unchanging substance, the very core that would become the instrument of the future body. From the medical side, this unchanging substance can be referred to as stamina, which, as I observed, is the original and essential part of the solids distinguished from the accidental, additional parts afterward added by nutrition. Clifton Wintringham, a physician at York, touching on the Lockean issue of the identity of the same person, resorted to the concept of stamina as proof of the sameness of individual identity: "whole Substance of the body, except these original Stamina of the Animalcule, may be many times changed, and yet the real body continue the same, and be possessed of the same personal Identity, with regard both to Body and Mind."[80]

Conversely, from the theological side, the concept of stamina was appropriated to explain the sameness of the body. The stamina hypothesis was widespread among natural theologians of the eighteenth century. Samuel Clarke, Newton's friend, for instance, drew on this notion to prove the sameness of the body before and after death. Relying on knowledge of microscopic observations and the doctrine of preformation, Clarke maintained that "the *original Stamina*" containing all the solid parts of the body continues unchanged throughout life,[81] and that this "minute insensible seminal Principle" hidden probably in the seat of the soul shall at the resurrection "unfolds" itself as the incorruptible part of the body so that there is no confusion of bodies.[82] At the end of the century, Thomas Morell, rector of Buckland, still clung to the stamina hypothesis to refute the Lockean notion of personal identity and prove the sameness of the body before and after death: "There may be perhaps some *original fibres* of each human body, some stamina vitae or primaeval seeds of life, which may have remained unchanged through all the stages of life, death, and the grave."[83]

Isaac Watts also delineated the plausible account of the sameness of the body wholly relying on fiber medicine and on the notion of the original fiber-membrane-stamina:

> [A] new-born Infant…has some original, essential, and constituent Tubes, Fibres or staminal Particles…which remain the same and unchanged thro' all the Stages and Changes of Life….And some [medical] philosophers maintain that the Growth of the animal Body is nothing but the Dilation Stretching or Spreading of these essential and staminal Parts, these Fibres, Tubes or Membranes, by the Interposition of new additional Particles.[84]

One does not have to worry about cannibals or beasts that devour our flesh and assimilate it to their nature,[85] for the "membranaceous" parts of an animal body (as some medical and natural philosophers maintain) will not be easily digested; thus, they cannot be assimilated into the blood or nutritive juices to form the constituent parts of other animals.[86] These unchanging parts of fiber-membrane-stamina indestructible by any force constitute the core of the same person that will be united with the same soul in the afterlife.[87] It is evident that Watts's imagination of membrane-stamina has affinity with that of Cheyne. Although Watts did not make it clear that this original membrane develops into the glorified body of resurrection, he had an implication of it as he assumed that the soul in the afterlife needs some type of vehicle or garment—the membrane becomes the garment, and the garment becomes the body. The medical concept of the membrane lets its imagination take flight in the realm of afterlife.

4 Coda: Deleuze and the Fold

Gilles Deleuze, a French postmodern philosopher, once said about the Baroque predicated on the philosophy of Leibniz that it is not the essence but refers to the way that the folds generate to the infinite: “the Baroque trait twists and turns its folds, pushing them to infinity, fold over fold, one upon the other. The Baroque fold unfurls all the way to infinity.”[88] There are correspondences between several features, notions, and images of the Baroquism on which Deleuze ruminated in *The Fold* and those of the fiber body from the late seventeenth century to the eighteenth century. A drawing, “The Baroque House,”[89] that Deleuze depicts to allegorically illustrate Leibniz’s philosophy of folds almost literally applies to the fiber body’s string-like structure: the soul seated in the brain corresponds to the upper floor that “has no windows” and is “decorated with a stretched canvas diversified by folds” while the lower floor of the matter corresponds to the system of nerve-fibers that transmits or translates the material data with “vibrations or oscillations” into sounds to the upper floor “as if it were a musical salon.”[90] As I expound elsewhere in this book, the vibration of the fibers equivalent to elasticity is a notion critical to fiber physiology. Deleuze, too, touched on “a muscular conception of matter” that makes an “elastic” spirit,[91] and made an impressive statement on folding and preformation:

> Folding-unfolding no longer simply means tension-release, contraction-dilation, but enveloping-developing, involution-evolution. The organism is defined by its ability to fold its own parts and to unfold them, not to infinity, but to a degree of development assigned to each species.[92]

This passage has a strong affinity with Cheyne’s comment on preformation. (The terms “folding” and “enveloping” and the terms “tension,” “release,” “contraction,” and “dilation” are also the principal notions of fiber physiology.) The correspondence between Deleuze’s Baroque of folds and the fiber body goes on—the fiber and the texture; in the last chapter, Deleuze answered the question that what the most simple form was to designate the Baroque that is defined by the fold going to infinity—“the textile model of the kind implied by garments.”[93] He also stated, when the folds of garments and clothing that encroach on every surface of the material move out of the paintings to reach Bernini’s sculptures, the marbles that make the folds to infinity are not defined as “an art of structures but of textures."[94] If so, when the imagination of the fold that produces itself to infinity goes out of the arts to extend to the realm of eighteenth-century medicine, especially that of Cheyne, his medical philosophy would not be characterized as iatromechanism or nervous medicine, as customarily defined, but as the medical philosophy of the fiber-membrane.

Thus far in this chapter, I have examined various materials of diverse fields—Browne's muscular man and its cloth-membrane, micro-anatomy and its fold-cloth, the power of the membrane in fiber medicine, the doctrine of preformation and its ways of infinite folding–unfolding such as Swammerdam's folded pupa and Lyonet's muscular structure of a caterpillar, and the glorious body made out of membrane-garments. These seemingly disparate discourses of knowledge and body in anatomy, medicine, and culture are tied together by the texture of the membrane. If a garment with folds is another word for membrane, it is arguably true that the fiber body—the body interwoven by the fiber-membranes—is a product of the Baroque.

Notes

1. John Browne, *Myographia Nova: or, a Graphical Description of All the Muscles in Humane Body* (London, 1697). On Browne, see K.B. Roberts and J.D.W. Tomlinson, *The Fabric of the Body: European Traditions of Anatomical Illustration* (Oxford: Clarendon Press, 1992), 404–9.
2. On Baroque in general, see John Rupert Martin, *Baroque* (Oxford: Westview Press, 1977); Germain Bazin, *Baroque & Rococo* (London: Thames & Hudson, 1964); on English Baroque, see Robert Harbison, *Reflections on Baroque* (London: Reaktion Books, 2000); Judith Hook, *The Baroque Age in England* (London: Thames and Hudson, 1976).
3. Gilles Deleuze, *The Fold: Leibniz and the Baroque*, foreword and translation by Tom Conley (Minneapolis: University of Minnesota Press, 1993).
4. On this point, see Roberts and Tomlinson, ch. 7.
5. Roberts and Tomlin; Benjamin A. Rifkin, Michael J. Ackerman, and Judith Folkenberg, *Human Anatomy: From the Renaissance to the Digital Age* (New York: Abrams, 2006); Pietro Berrettini de Cortona, *The Anatomical Plates of Piettro da Cortona: 27 Baroque*

Masterpieces, with a new introduction by Jeremy M. Norman (New York: Dover, 1986).

6. On Valverde, see Roberts and Tomlin, 210–17.
7. See Claudia Benthien, *Skin: On the Cultural Border between Self and the World*, translated by Thomas Dunlap (New York: Columbia University Press, 2002), ch. 4, "Flaying." See also Daniela Bohde, "Skin and the Search for the Interior: The Representation of Flaying in the Art and Anatomy of the Cinquecento," in *Bodily Extremities: Preoccupations with the Human Body in Early Modern European Culture*, ed. Florike Egmond and Robert Zwijnenberg (Aldershot: Ashgate, 2003), 10–47.
8. Didier Anzieu, *The Skin Ego: A Psychoanalytic Approach to the Self*, translated by Chris Turner (New Haven and London: Yale University Press, 1989); Benthien, 18–19; Steven Connor, *The Book of Skin* (Ithaca: Cornell University Press, 2004).
9. Anne Hollander, *Fabric of Vision: Dress and Drapery in Painting* (London: National Gallery, 2002).
10. Ibid., 35–37.
11. Ibid., 65.
12. Ibid., 80.
13. Ibid.
14. See Marian Fournier, *The Fabric of Life: Microscopy in the Seventeenth Century* (Baltimore: Johns Hopkins University Press, 1996); Edward G. Ruestow, *The Microscope in the Dutch Republic: The Shaping of Discovery* (Cambridge: Cambridge University Press, 1996); Catherine Wilson, *The Invisible World: Early Modern Philosophy and the Invention of the Microscope* (Princeton: Princeton University Press, 1995).
15. C. Wilson, 62–63.
16. On Malpighi, see Domenico Bertoloni Meli, *Mechanism, Experiment, Disease: Marcello Malpighi and Seventeenth-Century Anatomy* (Baltimore: Johns Hopkins University Press, 2011).
17. "Malpighi's 'De Pulmonibus,'" by James Young, *Proceeding of the Royal Society of Medicine* 23 (1929–1930): 1–14.
18. Malpighi's "Concerning the Structure of the Kidneys," a translation and introduction by J. M. Mayman, Jr., *Annals of Medical History* 7 (1925): 242–63. On this point, see ch. 1.
19. Meli, 242, and the figure of oak bark on the same page.

20. Thomas Willis, "*Pharmaceutice Rationalis*," in *The Remaining Medical Works of Thomas Willis* (London, 1684), 4.
21. Ibid., 3–4.
22. Ibid., 6.
23. Ibid., 9.
24. Samuel Collins, *A Systeme of Anatomy* (London, 1685).
25. Ibid., ix–x.
26. Ibid., i.
27. Taki Koji, "The Cosmos of the Cloth," in *Yokubono Shujigaku* [The Rhetoric of Desire] (Tokyo: Seidosha, 1996).
28. See his discussion of "the natural law of Sobriety" (xlii ff).
29. George Cheyne, *The English Malady or, a Treatise of Nervous Diseases of All Kinds* (London, 1733), 61.
30. Herman Boerhaave, *A Method of Studying Physick,* translated by Mr. Samber (London, 1719), 163.
31. Alexander Monro [*primus*], *The Anatomy of the Humane Bones* (Edinburgh, 1726); Robert Nesbitt, *Human Osteogeny Explained in Two Lectures* (London, 1736).
32. John Quincy, *Lexicon Physico-Medicum* (London, 1719), s.v. "membrane."
33. For example, see George Cheyne, *An Essay on Gout* (London, 1720), 80.
34. Browne Langrish, *A New Essay on Muscular Motion* (London, 1733), 49.
35. Boerhaave, *Method*, 162–63.
36. Ibid., 163.
37. James Douglas, *A Description of the Peritonaeum* (London, 1730), 33.
38. M.N., *Anatomy Epitomized and Illustrated* (London, 1737), 3.
39. James Drake, *Anthropologia Nova; or, a New System of Anatomy* (London, 1707), vol. 1, 69.
40. Cheyne, *Gout*, 79.
41. George Cheyne, *An Essay on Regimen* (London, 1740), viii. See also *The Natural Method of Cureing* [sic] *the Diseases of the Body* (London, 1742), 78.
42. Cheyne, *Method*, 10.
43. Ibid., 35.
44. Ibid., 36; see also 94–95; idem., *Regimen*, xxv.
45. Ibid., 35.
46. Ibid., 94–95.

47. I do not dig into the distinction between the theory of pre-existence and that of preformation; here, I use preformation as designating "embodiment" or encasement theory emerged in the late seventeenth century. See Peter J. Bowler, "Preformation and Pre-existence in the Seventeenth Century: A Brief Analysis," *Journal of the History of Biology* 4 (1971): 221–44; Clara Pinto-Correia, *The Ovary of Eve: Egg and Sperm and Preformation* (Chicago: University of Chicago Press, 1997).
48. Pinto-Correia, 18–19. On Malebranche, see Andrew Pyle, "Malebranche on Animal Generation: Preexistence and the Microscope," in *The Problem of Animal Generation in Early Modern Philosophy*, ed. Justin E. Smith (Cambridge: Cambridge University Press, 2006), 194–214.
49. John Swammerdam, *The Book of Nature; or, the History of Insects*, translated by Thomas Flloyd (London, 1758); Pinto-Correia, 25–33.
50. Ibid., passim.
51. Ibid., part 2, 53; Pinto-Correia, 31.
52. George Garden, the Aberdeen virtuoso of the late seventeenth century, was a teacher of Cheyne and influenced his idea of preformation; Garden had recourse to Swammerdam's insect anatomy as evidence of preformation: "you will discern through the Transparency of their second Membrane, all the Parts of the Butterfly, the Trunk, Wings, Feelers, &c. folded up." George Garden, "A Discourse concerning the Modern Theory of Generation," *Philosophical Transactions* 16 (1691): 474–83; (476). Another foundation Garden depended on was the analogy of plants to animals; the seeds of plants are "nothing else but little Plants of the same kind folded up in Coats and Membranes" and in a like manner animals are "not the sudden product of a Fluid…but does much rather proceed from an Animalcle of the same kind, and has all its little Members folded up according to their several Joynts and Plicatures, which are afterwards enlarged and distended, as we see in Plants" (Ibid.).
53. See Anita Guerrini, "The Burden of Procreation: Women and Preformation in the Works of George Garden and George Cheyne," in *Science and Medicine in the Scottish Enlightenment*, ed. Charles W.J. Wither and Paul Wood (East Linton: Tuckwell Press, 2002), 172–90.

54. George Cheyne, *Remarks on Two Late Pamphlets written by Dr. Oliphant, against Dr. Pitcarin's Dissertations, and the New Theory of Fevers* (Edinburgh, 1702), 43–4.
55. Ibid., 44. For a similar description, see Nicholas Robinson, *A New Theory of Physick and Diseases* (London, 1725), 39.
56. Cheyne, *Gout*, 79.
57. Boerhaave, *Method*, 141.
58. Ibid., 142.
59. Pierre Lyonet, *Traité anatomique de la chenille, qui ronge le bois de saule* (The Hague, 1760).
60. Charles Bonnet, a noted naturalist, had the same opinion; see Ruestow, 282–84. On Lyonet, see F.J. Cole, "History of Micro-Dissection," *Proceedings of the Royal Society of London. Series B, Biological Sciences* 138 (1951): 159–87; R.B. Freeman, "Illustrations of Insect Anatomy from the Beginning to the Time of Cuvier," *Medical and Biological Illustration* 12 (1962): 174–83.
61. George Adams, a natural philosopher of late eighteenth century, was also attracted by it; he included in his own microscopic examination Lyonet's tables on the caterpillar's musculature with his translation. George Adams, *Essays on the Microscope* (London, 1787), ch. 6.
62. Adams, 351.
63. Cheyne has been known for his immensely popular *English Malady*, but this work is the most secular kind among his writings; to know fully his worldview, including religious mysticism, one must read *Essay on Regimen*, the least successful of his mature writings; see on Cheyne, Anita Guerrini, *Obesity and Depression in the Enlightenment: the Life and Times of George Cheyne* (Norman: University of Oklahoma Press, 2000).
64. Brian J. Gibbons, "Mysticism and Mechanism: The Religious Context of George Cheyne's Representation of the Body and Its Ills," *British Journal for Eighteenth-Century Studies* 21 (1998): 1–23; Guerrini, "Burden"; Guerrini, *Cheyne*, 13–20, 83,126, 140.
65. Cheyne, *Regimen*, 122.
66. Ibid., 7; see also idem, *Method*, 4.
67. Ibid., 8.
68. Ibid., 23.
69. Ibid., xii, 44.

70. Cheyne, *Method*, 9.
71. Cheyne, *Regimen*, 155, xii.
72. Ibid., 162.
73. Ibid., 44.
74. Ibid., 121–22.
75. Ibid., 171.
76. Ibid., 44, 171, 175.
77. Ibid., 175, 8.
78. Cheyne, *Method*, 9.
79. On a Lockean notion of personal identity and the subsequent discussion here, see Jonathan Bennet, "Locke's Philosophy of Mind," in *The Cambridge Companion to Locke*, ed. Vere Chappell (Cambridge: Cambridge University Press, 1994); Christopher Fox, "Locke and the Scriblerians: The Discussion of Identity in Early Eighteenth Century England," *Eighteenth Century Studies* 16 (1982): 1–25; Raymond Martin and John Barresi, *Naturalization of the Soul: Self and Personal Identity in the Eighteenth Century* (London: Routledge, 2000); Udo Thiel, "Locke and Eighteenth-Century Materialist Conceptions of Personal Identity," *Locke Newsletter* 29 (1998): 59–83; idem, *The Early Modern Subject: Self-Consciousness and Personal Identity from Descartes to Hume* (Oxford: Oxford University Press, 2011).
80. Wintringham, *Exility*, 30–31; also James Keill, *An Account of Animal Secretion, the Quantity of Blood in the Humane Body, and Muscular Motion* (London, 1708),134.
81. Samuel Clarke, *Discourse concerning the Being and Attributes of God*, 8th ed. (London, 1732), 361.
82. Ibid.
83. Thomas Morell, *Notes and Annotations on Locke on the Human Understanding* (London, 1794), 64.
84. Isaac Watts, *Philosophical Essays on Various Subjects*, 3rd ed. (London, 1742), 191.
85. For the chain consumption argument, see ibid., 187.
86. Ibid.
87. Ibid., 191–92. Therefore, Aristotle's idea that the skin is the last organ to be formed and the Christian belief that the hair and the nails are not worthy to be resurrected are totally inverted and debunked. For a further discussion concerning the personal identity, the resurrected body, and stamina, see Fernando Vidal,

"Brains, Bodies, Selves, and Science: Anthropologies of Identity and the Resurrection of the Body," *Critical Inquiry* 28 (2002): 930–74.

88. Deleuze, 3.
89. Ibid., 5.
90. Ibid., 4. It is what Leibniz always affirms—"a correspondence and even a communication between the two levels, between the two labyrinths, between the pleats of matter and the folds in the soul" (4).
91. Ibid., 7.
92. Ibid., 8.
93. Ibid., 121.
94. Ibid., 121–22.

CHAPTER 7

The Fiber Body and the Culture of Sensibility: From Nervous Man to Fiber Man

1 Was the Eighteenth Century a Nervous Century?

Was the eighteenth century a century of the nerves and the brain? This question necessarily touches on both the medical field per se and the cultural arena, since the thesis that the eighteenth century was predominantly a nervous century is inseparable from the cultural formation of a "nervous sensibility" and sympathy at large, which especially flourished from the middle of the century. The most prominent advocate of this thesis is undoubtedly G.S. Rousseau, a doyen of eighteenth-century studies, who in his pioneering essay on the origin of sensibility first demonstrated that sensibility can be traced back to the anatomical research on the brain by Thomas Willis in the mid-seventeenth century. By placing the seat of the soul squarely in the brain, Willis's revolutionary brain anatomy paved the way for the new Enlightenment project of the science of man, in which a radically new idea that man is essentially a nervous creature is elaborated in varied fields. The idea that man is nervous, controlled by nothing other than the brain, was transmitted philosophically through the sensational psychology of John Locke, himself a disciple of Willis, and medically through Cheyne's doctrine of nervous sensibility, as well as by major figures of iatro-vitalism such as Whytt, Monro, and Cullen, along with moral philosophers like Adam Smith. Further, the idea was promulgated by fashionable sentimental novelists such as Richardson, Sterne, and

H. Ishizuka, *Fiber, Medicine, and Culture in the British Enlightenment*, DOI 10.1057/978-1-349-93268-9_7

Mackenzie, who further popularized the nervous nature of the man of feeling and the woman of sensibility.[1] According to this grand picture, the long eighteenth century largely covers the age of the nerves and the brain, in tandem with the development of nervous physiology. Rousseau recently reinforced his view, stating that "[to] live in the world of the long eighteenth century was to subscribe to brain."[2]

This chapter examines this widely shared assumption, providing instead an alternative way of thinking of the eighteenth-century medico-culture in terms of "fiber" rather than the brain–nerve. After briefly offering some problems Rousseau's thesis embraces, I will propose that the fiber paradigm or model is more applicable to eighteenth-century medico-culture than the nervous one, first by surveying fiber medicine, and next by showing the possibility of the brainless-sympathy, and finally by presenting a body image that is pertinent to both mechanical and vitalistic medico-culture. In so doing, I attempt to modify the hegemonic understanding of the eighteenth-century culture as a nervous one.

1.1 Against Rousseau's Brain–Nerve Thesis

Rousseau's brain–nerve thesis involves a couple of problems. For one thing, Rousseau goes a bit too far into presentism in his treatment of the genealogy of the brain–nerve paradigm as he draws on what might be called "nervous evolutionism," a parallelism between the progress of human beings and that of the nervous system. In consequence, Rousseau sometimes relies on the criterion of modern neurophysiology ("we *are* synapses…we *are* our brain") to gauge the Enlightenment nervous sciences,[3] which distorts our understanding of the Enlightenment medical sciences. Second, Rousseau takes too far the concept of the Enlightenment medical program as one that was predominantly occupied with nervous physiology and especially the physiology of perception ("*all* Enlightenment physiology was nerves").[4] The Enlightenment physiological research program, however, was not necessarily preoccupied only with nerves and perception (sensibility); animal motion, or muscular movement, held a much more important place in physiological research, especially in the first half of the century (see Chap. 3). This research dealt with the thorny issue of how the body moves or is moved, that is, muscular motions rather than sensation, the fibers rather than the nerves. A good deal of physiological discussion had nothing to do with nerves or sensibility. Consequently, Rousseau's preoccupation with the nerves leads him to misunderstand Haller's physiological agenda: Rousseau takes Haller as one who privileged sensibility and the nerves over irritability and the fibers; obviously this is not the case.[5] Moreover, the privileged status of the brain and the nerves in the anatomical research of the latter half of the seventeenth century is overemphasized; the dominant feature of the anatomical research of the era was to search for an ever-finer texture of the body (see Chap. 1). Willis's anatomical research of the brain was only one of such investigations into the body.

The third problem in Rousseau's thesis concerns the validity of the nervous body image in Enlightenment medicine. Simply, the image of the nervous man doesn't fit in the iatromechanical phase, in which the fiber-based hydraulic machine, or vascular body, composed of a jumble of pipes, vessels, muscles, and fluids with the muscular heart at the center, is paramount. As Sergio Moravia in his seminal essay on the eighteenth-century body image outlines, the eighteenth century witnessed a general shift in body image from "Mechanical Man" to "Sensible Man" with the concomitant shift from iatromechanism to vitalism.[6] Rousseau's nervous body seems incompatible with the mechanical man. The primacy of the nervous system is made apparent, at least in theoretical medicine, from the mid-century onward when the Edinburgh Medical School introduced the agenda of nervous physiology in its medical program.[7] Before the ascendancy of the nervous system in medical discourses, the solid-body-machine was supposed to comprise the system of the fibers *not* the nerves. Even after nervous vitalism gained ground in the latter half of the eighteenth century, the animal body did not fully dislodge the physical substratum of the fibers, as seen in William Cullen's or Erasmus Darwin's neuro-muscular-vascular system of the body in which the fibers still played a critical role (see Chap. 4). Thus, the body image based on the nerves does not appropriately represent the complicated, shifting body image that the Enlightenment medical sciences trace.

Rousseau's strong leaning to nervous physiology raises another significant problem: the elision of the body. His emphasis on cognitive faculties such as imagination, sentiment, sensibility, and passions might come from his literary and cultural agenda, namely, that the European Romantic movement, as well as the sensibility movement, was heavily indebted to the Willisian brain–nerve revolution.[8] In highlighting these faculties, however, he severely cuts short the other important aspect of the agenda—the body. In fact, in Rousseau, there seems to be a certain bent toward seeing the nervous stocks (nerves, spirits and fibers) solely as the agents of the cognitive faculty in service of the physiological mechanism of perception. Accordingly, his description of the nerve paradigm or discourse is greatly devoted to nerves and sprits and leaves behind the fibers, the notion more connected to the corporeal body, although his initial agenda mentioned the fibers under the nervous stock. Rousseau initially states that "nerves, fibers and animal spirits" account for human knowledge and behavior but swiftly reduces this nervous stock only to nerves in saying that "nerves alone can be held responsible" for them.[9] Indeed, Rousseau's dismissal of the fibers is symptomatic of his errors, for Willis himself puts the priority on the fibers over the nerves in explicating the mechanism of the nervous system: "Fibres…are the Organs of sense and motion. Yea, the acts of their faculties are principally and more immediately executed by the Fibres than the Nerves."[10] Willis goes on to argue that the fibers draw together the muscles and other motive parts to cause motion while the nerves only carry the order from the brain; likewise, the fibers immediately receive the impression of things and represent it, while the nerves only transfer the idea to the brain. Willis also emphasized the fact that fibers and nerves appear at the same time in human development.[11] There are in Willis further instances that suggest the primacy of the fibers: for example, in his explanation of the mechanism of vomiting, the fibers, fleshy or nervous, are deemed to be the primary organs affected.[12] The fibers in Willis's nervous stock enjoy much more critical roles than Rousseau might suppose.

This leads us to the last problem, too great an all-inclusiveness of the word "nerve" as it is used by Rousseau. Rousseau's usage and meaning of the term is confusingly and embarrassingly muddled; he sometimes employs it in a modern sense, as apparent in his presentism, but also often uses it in the broader (much older) sense, encompassing animal spirits, fibers, and other related notions such as tone or tension. For example, he discusses Mandeville's idea that the tonic strength of the "nerves" differs in men and women, whereas Mandeville in fact argues about the tone or elasticity of "spirits."[13] It is inappropriate for other terms to be subsumed under nerve, for this dissolves the necessary distinctions to be made among them. Even the word *nerve* does not have a monolithic meaning; *nerve*, as Rousseau perfectly understands, initially meant something "sinewy" and "brawny," hence strength rather than delicacy or sensibility; the latter meaning was acquired as the eighteenth century progressed.

These sets of problems throw doubt on the validity of the thesis that the eighteenth century can be called a nervous century. My proposal is that it is much more appropriate to grasp eighteenth-century medico-culture in terms of fiber rather than the nerve. As I have demonstrated in the preceding pages, eighteenth-century medicine puts a critical importance on fiber, forming what might be called fiber medicine—a medical discipline including physiology, pathology, and therapeutics, informed by the concept of fiber and its resultant theory of fiber. Nervous medicine, or the medical theory based on the paradigm of the nerve, was only a part of fiber medicine; and the concept of the nerve is derived from the idea of fiber, not vice versa.

1.2 Fiber Medicine or the Fiber Paradigm: A Review

As the second part of this book fully demonstrated, eighteenth-century medicine sets fiber on firm theoretical and practical ground. Throughout the century, and despite the shift of medical philosophy (and concomitant body model) from iatromechanism to iatro-vitalism, fiber body stayed at the center-stage of eighteenth-century medical sciences. To review, the genealogy of fiber medicine can be sketched as follows: it starts with mid-seventeenth-century natural philosophers' investigation of the micro-structure of body parts through the microscope, which led them to discover what they concluded was the ultimate building unit of the body; crucially, it appeared to be a thread-like substance, and they called it "fiber." For them the bodily components were seen to be skillfully stitched and interwoven by myriad tiny fibers just like cloth or embroidery. The new understanding of the body as entirely woven by elementary fibers is crystallized by Nehemiah Grew's *The Anatomy of Plants* (1682), in which Grew took a decisive step for fiber theory in, for the first time, clearly articulating the complete fibrosity of the body and in amply employing the textile metaphor. Grew's view of the fiber-woven body entered into the field of human anatomy by the end of the seventeenth century, finding a clear expression in James Keill's small textbook of human anatomy, in which he announced a new criterion that "all the Parts are made up of … Fibres."[14]

With the rise of solidism at the turn of the century, which conferred active power on the solids, solid fibers were seen to assume the pivotal function in animal economy, especially because the solid (the whole body) was now conceived to be composed nothing but of fibers. In the course of the eighteenth century, the concept of fiber advanced to occupy a paradigmatic place among medical theorists such as Herman Boerhaave and Albrecht von Haller. Accordingly, knowledge of the body was predicated critically on the fiber: the humors no longer played an important part in determining the welfare of one's constitution; instead, the solid fibers (note not the nerves per se) were thought to hold a key to living organism. Cheyne defined the fibers as "the least and smallest Threads in the Composition, of which many unite to make one sensible *Fibre*," and designated the nerves as being "only some of these [sensible] Fibres."[15] Almost all diseases, including nervous complaints so fashionable in the century, were ascribed to either too rigid or too lax states of the fibers. As Cheyne states, "*Relaxation*, *Weakness*, and *want* of *Spring* in the *Fibres*, is the Origin of all *nervous* Distempers."[16] Health and illness depend on the precarious conditions of fluctuating states of fibers, because the fibers are susceptible to external stimuli (or environment), which is traditionally termed "six non-naturals." Cold air tightens the loosened fibers, while the hot and humid atmosphere has detrimental effects to health[17]; immoderate passions and venery when indulged too much deprive the fibers of their due tone and debilitate them[18]; moderate exercise, by contrast, especially those kinds that bring about an oscillatory and shaking motion, was regarded as the best curative and preventive virtue, since it gives a gentle vibratory shock to the animal fabric so as to increase fibers' contractile power and strengthen their tension.[19]

Within the fiber paradigm, the animal machine must *move* everywhere in the body, that is, incessantly shake, vibrate, undulate, and pulsate[20] for the purpose of life, which depends on the due circulation of the fluids. The most critical function of the fibers, therefore, is to involuntarily vibrate; the property of this function is variously called "elasticity," "tone," or "tension"—an innate property residing in fibers, by which they restore themselves to their former state if they become stretched beyond their natural disposition. Without this essential property of fibers, life would not subsist but a few minutes.[21] Even with the ascendance of iatro-vitalism from the middle of the century, this general framework of fiber body virtually endured as most vitalists referred to the state of the tone of the solids as the basis of animal economy, with the slight differences that the nervous system takes the place of the solid fibers, and sensibility the place of elasticity (but they continued to employ the words "tone" and "tension"). Many complaints, including nervous ones, come from the relaxation of the nervous system that wants the vital or nervous energies; the animal body is in a constant oscillation and the therapeutic practices are conducted to restore the unstrung nervous system to its proper tone by giving it vibratory motions.[22] Thus, health and life, in both iatromechanism and iatro-vitalism, are sustained by the vigorous motions of fiber-threads in the form of “tone” or “vibration.”

Fiber’s critical roles are not limited to animal economy per se; the realms of cognitive faculties are also explained by the fibers, which mediate between the mind and the body. Some versions of fiber psychology were developed from the late seventeenth century. According to Nicholas Malebranche’s brain-trace theory, the movement of the animal spirits occurring in the brain would change the order of its fibres, leaving traces by imprinting on the fibers; animal spirits pursue these traces and bring about cognitive phenomena. The condition of the fibers as well as the movements of animal spirits are relevant to thinking and imagination.[23] Vibration, a critical function of the fibers, is also relevant to psychology; according to vibration theory, nervous fibers are furnished with a numberless “Machinulae” for the purpose of sensation, which, if they duly vibrate, transmit ideas or impressions to the mind.[24]

It was also believed that fibers serve to determine the degree of intellectual faculties (by implication social rank), the states of the temperament (constitution), and gender differences, although it should be stressed that malleability of the fibers excludes the sheer “nervous determinism.”[25] Since everyone shares the same immaterial soul that is endowed with the same faculties, a variety of the intellectual differences among individuals should be ascribed to the condition of the soul’s instruments, especially of the fibers and their makeup. The intellectual inferiority of Africans and the natural stupidity of “*Ideots*, *Peasants* and *Mechanicks*” were said to result from the unfortunate or improper makeup and texture of the fibers, while genius’s superior intellect was supposed to derive from the “happy Structure of the Fibres.”[26] Likewise, the fibers were believed to contribute to the different qualities of individual temperaments and the differences between the sexes; if the fibers are strong and elastic, the individual has a hot and strong constitution; if weak and lax, the individual has a cold and feeble constitution.[27]

In short, eighteenth-century medicine posited “fiber” as a structural unit by which the body is successively knit and interwoven into an animal machine that involuntary moves and vibrates by the very property of the fibers. Fibers also contributed to the explanation of cognitive phenomena and individual temperaments. Eighteenth-century medicine developed on this fiber paradigm; medical discourses of the nerves only a part of this general fiber paradigm.

One might dispute this paradigm, however, by contending that it only applied to the field of theoretical medicine and that Rousseau's nerve paradigm included the cultural, and especially literary, field against the background of popular nervous practices in the consumer society led by Cheyne, Whytt, Adair, and Trotter. These fashionable nerve doctors, like the equally fashionable sentimental writers, served to diffuse the knowledge of the nerves and, as Rousseau notes, an "ordinary person in the street could quip about [the nerves]" in the world of "brainomania."[28] Certainly, there was a definite cultural phenomenon aptly called "nervous sensibility," but my point is that this nervous culture of sensibility and sympathy was embedded not in the brain–nerve but in the fibers. In fact, many of the literary representations of sympathy do not require the brain–nerve circuit. I will show this by addressing the interlocking topics mediating back and forth between medicine and culture (literature)—less fascination with the brain, the medico-culture of sympathy without the brain–nerve, and the mechanical sympathetic body.

2 Sensitive Men and the Fiber Body

2.1 The Medico-Culture of Sympathy Without the Brain–Nerve

It is generally assumed that the brain–nerve crux, as the physiological bedrock of nervous sensibility, underscored the culture of sensibility and sympathy[29]: sensibility and sympathy require the nervous system as a medium, both medically and culturally. In many literary texts, however, and especially those of sentimental literature (one of the core composites of the culture of sensibility), the brain as such was rarely referred to or addressed, particularly as encomia. As Van Sant explains, this is partly because the heart was substituted for the brain in popular vocabulary, and partly because the gross physical structure of the brain prevented the "refined" literary men from exploiting it as a literary device.[30] Sentimental literature abounds with the image of the heartstrings that vibrate, pulsate, and sympathize with other sentimental characters or scenes, but not with the vibrating brain. The subtitle of *The Beauties of Sterns*, "selected for the heart of sensibility," is symptomatic of the fact that sentimental literature capitalized on the heart, not on the brain.[31] Even if the brain was treated as part of nervous physiology in literary texts, say, in Sterne's *Tristram Shandy*, as Rousseau insists,[32] the principal focus is not on the brain itself, but on the fiber-related images and metaphors such as the "threads," "texture," "web," or "net-work" of the brain. I mention here only one example addressed by Rousseau: the lucky or unlucky organization of the body (brain) that makes the soul's sameness appear to be different. Sterne spells out a variety of medical doctrines concerning the soul's limitation according to the organization of the brain, but the expressions he uses are fiber-based ones, such as that "the subtilty and fineness of the soul" depends on "the finer net-work and texture in the cerebellum," or "a single thread of the net-work" of the brain that should be not broken.[33] In another place, Sterne is more explicit on fiber pathology: "No man thinks right whilst he is in it [the body]" because of "too lax or too tense a fibre."[34] Sterne's nervous physiology is here predicated on fiber medicine.

Sterne's exploitation of fiber-based language would suggest that sympathetic affection does not require the brain–nerve circuit. For instance, in France, when Yorick felt an intimate affection and fellow-feeling (i.e., sympathy) with a strange young girl of about 20 during his sentimental journey, he felt that he was drawn to her by "fine-spun threads."[35] Sterne comments that "Nature" "wove her [Nature's] web of kindness," entangling with "threads of love and desire," without which "the whole web" of kindness would be rent.[36] Another example is from a poem on sympathy written by Samuel Pratt, one of the very popular sentimental writers of the age. Pratt confines the source of sympathy to the heart and puts into verse the ways that the fiber-threads of sympathetic passion are spun and vibrating throughout the world as the medium of the "social pulse."[37]

The vision of the sympathizing heart spun and united by the fiber-threads without having a necessary link to the brain is not limited to the literary domain; medical theorists of the latter half of the century subscribed to a similar idea. Seguin H. Jackson, extolling sympathy as a giver of life in his essay on medical sympathy, argues that sympathy is not necessarily related to the nervous system as one might suppose. Jackson defines sympathy as an inherent quality of the moving fibers and the living solids, disqualifying the brain and nervous system as the sole agent of sympathy.[38] He further comments on the "vascular sympathy" by which the external and internal extreme vessels (especially those of the stomach) find a due balance and connection through the medium of the "sympathizing heart,"[39] reminiscent of sentimental literature. Here, we might see the influence of literature on medical discourse and not vice versa. Carter also decenters the role of the nervous system in sympathy, admitting as another agent of sympathy the cellular tissue and capillary vessels.[40] Indeed, the "cellular membrane" or "tissue" or "texture," variously so called, was the new idea of the second half of the century, which spread widely among medical writers as the universal connecting medium (see Chap. 4). This fine membrane, web, or texture joins together all parts of the body, including every minute fiber and vessel, so as to communicate all over the body, in which every cell opens into all other cells that are contiguous to it.[41] The corollary of this is that sympathetic communication becomes imaginable without the brain center. Sterne's remark in *Shandy* might be suggestive: "I could perceive an attempt towards a vibration in the strings, about the region of the heart.—The brain made no acknowledgment."[42]

The idea of sympathy without the brain, conceived both culturally and medically, might be made most explicit in the "mechanical" figure of the sensible man with the sensitized body in the sentimental literature; the man of feeling and woman of sensibility exemplify this. These sensible characters are endowed with an extreme degree of sensibility and delicate nerves for a ready sympathetic reaction to others' misery, suffering, and distress. Because of these sensible characteristics, they are usually associated with "nervous sensibility," a cultural counterpart of nervous vitalism. It is noted, however, that their sympathetic reaction should be involuntarily "automatic" and virtually "mechanical," for the sympathetic impulse or passion is said to be implanted by God in the heart of man as moral sense. In this sense, their bodies' reacting automatically with involuntary physiological signs, such as shedding tears, palpitation of the heart, and fainting or trembling concomitant to sympathetic affection, is very close to that of animals in the cruel experiments of sensibility and irritability conducted by physiologists; the bodies of animals also automatically and involuntarily vibrate, tremble, or convulse as a sign of life (sensibility or irritability) in reaction to the external stimulus applied by physiologists. Although Whytt strongly denied Haller's assertion that the irritability of the muscular fibers was independent of the brain, and dissolved the distinction into a unifying principle of sensibility, what is striking about his text about the vital (involuntary) motions is his intense obsession with the ways in which the bare, irritable parts of the brainless body persistently vibrate one after another in a vigorous reaction to the stimulus.[43] The involuntary physiological reactions that the sensible man displays in sentimental literature are at one with those automatic irritable reactions that the severed body parts of brainless animals display. Both reveal the signs of life because of—not despite—"automatic" spontaneous reactions.

Although Whytt complained that the vital, involuntary motions are misleadingly associated with those of the inanimate "mechanical" automaton,[44] the association is appropriate in the figure of the sensible man, as mechanical automatic reactivity is one of the principal features of his sensitized body. This "mechanical" feature of the sensible man is consistently highlighted by sentimental novelists.[45] For example, Yorick masters a skill to translate the emotional signifiers of the body into words, and through custom now performs this "*short hand*" skill "so mechanically" that as he walks the streets, "I go translating all the way."[46] The more interesting case with Yorick can be found in the episode referred to as "The Passport," in which Yorick is threatened with imprisonment because he doesn't have a passport, and incidentally encounters a speaking starling hung in a cage, which repeats the phrase, "I can't get out—I can't get out." As a man of sensibility, he draws a deep sympathy and affection from this encounter ("I never had my affections more tenderly awakened"). Yorick is very aware of the mechanical nature of the bird, which automatically repeats the same phrase, but inspires sympathy through mere mechanical, automatic (trained) behavior, like Yorick's translation skill which is also mechanical ("Mechanically as the notes were, yet so true in tune to nature were they chanted").[47] Yorick's sympathetic identification with a speaking bird (an artificial copying machine) signals the mechanical nature of sympathy. It also indicates that the culture of "nervous sensibility" and sympathy does not necessarily involve the vitalistic idea of the nerve–brain crux, the larger part of which draws on the "mechanical" paradigm that epistemologically belongs to the fibers.

Yorick's description of the speaking bird as singing is not fortuitous, for sympathy and music are strongly concatenated in the analogy of the stringed musical instrument. In the next section, I will unpack the consistent body image analogized to the stringed musical instrument, in order to reinforce the status of the fiber body as an exemplar of eighteenth-century culture at large. This body image underwrites the continuity between the mechanical and vitalistic phases.

2.2 Musical Strings and Musical Analogy

The analogy of the animal body as a stringed musical instrument was probably the most prominent and persistent body image in the entire course of the eighteenth century, both inside and outside the medical field. The animal frame was compared to the organ, the piano, the spinet, the harp, the harpsichord, the clavichord, the violin, or other similar stringed instruments; usually, the soul was likened to a musician, and the nerve fibers to the strings or the keys of the instrument. (The keyboard instruments like piano might be categorized as stringed in the loose sense that the main components of these instruments are strings.) Almost everyone shared this new kind of metaphorization of the body as a stringed instrument. Cheyne's image of the musician in the organ case as the soul in the brain is a case in point: "the Intelligent Principle, or *Soul*, resides somewhere in the Brain, where all the Nerves, or Instruments of Sensation terminate, like a *Musician* in a finely framed and well-tune'd Organ-Case…. These Nerves are like *Keys*, which being struck or touch'd, convey the Sound and Harmony to this sentient Principle, or *Musician*."[48]

As Jamie C. Kassler argued, the image of the body as a stringed musical instrument can be traced back to Hobbes's natural philosophy, especially in his *De corpore* (1655), in which Hobbes, reinterpreting the Stoic concept of "*tonos*"—a cohesive and binding force of *pneuma* by which the universe, like a lyre, is bound by its stretched strings—conceived the internal character of man as bundles of strings of different lengths and tensions.[49] Hobbes's image of the body as stretched strings, however, scarcely seems to influence the formation of the eighteenth-century version of the stringed body, mainly due to his dangerously materialistic philosophy; his name was never evoked in the context of the eighteenth-century medico-cultural argument for the stringed body, nor does his image seem to be dominant in the Cartesian mechanics of the seventeenth century, which is defined as a theory of percussion rather than vibration.[50] As Joseph R. Roach noted, seventeenth-century philosophers liked images of the body based on the wind or brass instruments, as exemplified in Thomas Wright's essay on the passions, which compares the passions to the trumpet.[51] The image of the wind instruments provides the appropriate body model for iatrochemists like Thomas Willis; according to his inflation theory, the chemical reaction between animal spirits running through the vessels and the arterial blood produces wind-like force, in a similar manner to the way in which gunpowder explodes.[52] Animal spirits are, as it were, "*pneuma*" or breath by which the instrument (body) is set for performance. After the fiber revolution (not the brain revolution) of the late seventeenth century, which enabled medics to see the body as a whole as a bundle of fiber strings, it is a natural consequence that the stringed instrument came to replace the wind instrument as a model. David Hume succinctly explains why the model change occurred:

> Now if we consider the human mind, we shall find, that with regard to the passions, 'tis not of the nature of a wind-instrument of music, which in running over all the notes immediately loses the sound after the breath ceases; but rather resembles a string-instrument, where after each stroke the vibrations still retain some sound, which gradually and insensibly decays.[53]

In another place, Hume explains the mechanism of sympathy that becomes instantaneously contagious from person to person with recourse to the image of the musical strings that are tuned in the same tone.[54] The ensemble of sweet melody played by the stringed instruments conforms to the refined and composed mood of the eighteen-century culture of sensibility, whereas military-like force pushed by the wind instruments agrees with the turbulent atmosphere of the seventeenth century.[55]

In tandem with the florescence of the culture of sensibility in the polite society from the middle of the century on, the analogy of the body to the stringed musical instrument was further popularized and widely circulated in the medico-cultural realm. Lawrence Sterne, one of the most famous sentimental novelists of the era, gave a playful panegyric to Mrs. Versey using a familiar analogy of the stringed instrument: "You are sensible, and gentle and tender—&from [one] end to the other of you full of the sweetest tones & modulations.… You are a System of harmonic Vibrations—You are the sweetest and best tuned of all Instruments."[56] By the end of the century, the analogy became a cliché freely exploited among medical and literary writers. William Pargeter, an alienist of the late eighteenth century, cites William Cowper's *Retirement* as a typical illustration of a dire state of low-spiritedness in the following lines, which also encapsulate the musical analogy:

> Man is an harp, whose chords elude the sight,
> Each yielding harmony dispos'd aright.
> The screws rever'd (a task which if He please,
> God in a moment execute with ease)
> Ten thousand, thousand strings at once go loose,
> Lost, till he tune them, all their power and use.[57]

These recurrent images of the body as a stringed musical instrument, lasting throughout the century (or more precisely to the Romantic era),[58] testify to the powerful presence of the fiber paradigm in the age of nervous sensibility.

As a further reinforcement of my argument, the prescription of vocal and respiratory exercise ("vocification"), such as loud speaking, strenuous singing, or playing wind instruments, gradually receded from the late seventeenth century, and was considered detrimental to health in the eighteenth century, although the idea of exercise and music cure came to be highly re-evaluated as a sure method for preserving health. Most medical advisors condemned vocal exercise as overtaxing the lungs and impeding the circulation, resulting in the rupture of the lungs' fragile texture. Richard Browne, in his *Mechanical Essay of Singing* (1727), recommends singing as far as it is done moderately, and like many others, he sees playing a wind instrument as having an ill effect, for it forces too much air against the lungs.[59] The downplaying of wind instruments in exercise (regimens) may reflect a concomitant shift of the analogy of the body as a musical instrument from that of a wind instrument to a stringed one. Sterne's remarks in *Tristram Shandy* are in this sense very suggestive: "Some… draw all their characters with wind instruments.… but it is as fallacious as the breath of fame."[60]

Here, we may add a most mechanical analogy of the sympathizing instrument provided by David Stephenson—the image of two clocks synchronizing at a distance. As a good mechanical philosopher, Stephenson offers the example of clocks to illustrate the surprising effects of the tremulous motion of sounds on a distant object ("two Clocks, which being plac'd upon the same Floor, or against the same Wall, though at the Distance of a hundred Yards or more, may notwithstanding affect each others Motion") through the "Tremors and Pulsations" communicated insensibly by the motion of each clock to the board. The clock metaphor presented by Stephenson is no longer that of the cog and wheels that the seventeenth-century mechanists assume to be a self-sustained machine; in accordance with the fiber paradigm and as a good eighteenth-century philosopher, Stephenson offers the clocks as "elastic," as the pulsations of sounds are propagated from one clock to another "by the elastic Fibres."[61] Thus, it is not surprising that Stephenson further grounds the clock metaphor on the analogy of the stringed musical instruments ("after the same Manner as two unison Chords of any two musical Instruments, if one of them be made for to vibrate or play, the other will at the same Time be brought into Consent").[62] Stephenson goes on to explain the phenomena of sympathy, such as yawning, from the elastic "Contexture" of the human body that is easily syncopated with others.[63]

In a similar manner, Christopher Nugent, a physician in Bath, explains the mechanism of sympathy at a distance with recourse to the analogy of the musical strings that are "tuned in Unison"; Nugent presents it as a "Fact" that "*similar Spasms are communicated at a Distance, from one Set of animal Fibres to another.*"[64] As a good fiber-physician, Nugent conceives the body as fiber constituted and fiber vibrated; "Vibration, Pulsation, and Oscillation" of the solid fibers are the primal motion in animal economy.[65]

From the above argument, it is understood that Stephenson's elastic machine of the vibrant clocks and the mechanically sympathizing machine of the sensible man belong to the same general paradigm of the fiber body, of which Nugent's vibration physiology is exemplary, and it is also understandable that it does not necessarily require the brain–nerves circuit as Rousseau and other medico-cultural historians may suppose.

2.3 Bow-Strings

It is true that not all writers of the above-quoted passages of musical analogy had in mind the specific image either of the nerves or of the fibers; often they confounded both images and treated them as something elastic, the chord-like substance that could be well-strung or reacted. However, the particular term utilized, or whether the authors speak literally of the nerves and fibers, is not of importance. Rather, the key is unearthing and rendering intelligible the underlying epistemological model enabling the musical analogy of the body. Vital to my argument is that these invoked substances are *elastic*—they belonged to the property of the fiber and, by extension, to the paradigm of the fiber. This general framework could be of the fiber rather than of the nerve, all the more because the nerves are by definition unqualified to be elastic, and therefore are incapable of vibration. As far as the body is conceived as such and the knowledge of the body is informed by the fiber, the nervous body would be infringed upon and overshadowed in some manner by the elastic fibers. More of such an elastic moment, in which the nervous body is disrupted by the elastic fibers, can be seen in some cases of bow-strings.

R.C. Sims, a lesser-known medical writer of the later century, argued against Priestley's material philosophy in defense of the immortality of the soul, which Priestley expunged by ascribing mental faculties to the peculiar organization of the brain. Sims repudiated such materialism, and illustrated his argument by comparing "the mental powers of man" with that of "a bow": "As the projectile operations of the bow depend upon the elastic nature of the yew or steel of which it is made, as connected with its string; so the mental operations of man depend upon the active power of the soul, as connected with his brain."[66] Sims did not deny that the brain is the instrument of the soul, but strictly placed its function within the realm of the instrument only to serve the soul; in other words, the brain was not allowed to exert by its own power, as Priestly insisted. And yet, as the soul itself could not exert its power without the medium of the brain, so the mental powers of the soul depend on "the fit condition" of the instrument brain, like "the fit string of the bow," and if the brain is, as it were, unstrung, like "unstringing the bow," several operations of the mental powers will be suspended.[67] Here, the nervous organization of the brain is overshadowed by the elastic quality of the fibers.

Another illustrative case of the bow-string is found in the unique supplementary essay "Psychological Stricture," written by Robert Applegarth, a Lockean nerve theologian inclined toward mysticism. Applegarth explained the physio-psychological mechanism of mind with recourse to the pulsations by the solid nerves of the brain. Reminiscent of Hartley's vibratory neuro-physiology and equally mystical-minded Bonnet's fiber psychology, Applegarth argued that every idea may be considered as the pulsation of some nerves ("*there is not Thinking without this Pulsation*"[68]), and that habit is nothing but the propensity of the nerves to act over again.[69] He then imagined that the body man would wear in the afterlife would be "nervous," because such an instrument of the soul would be essential to "Thinking," which is also essential to "Life," and life ("Vita") implies this instrument in its (falsely) etymological sense:

> The Origin of the *Word* in question is evidently *Bios*; which, at the same Time, that it signifies *Life*; does also signify both *a Bow*, and *a Bow-String*; or in other Terms, *Something Elastic*; Something that is capable of *Reaction*, or *Pulsation* when *stricken*.[70]

Here, life is "Nervus Archus," a bow-string capable of being elastic, reactive, pulsative, and vibrative, all the properties with which the fiber is endowed in iatromechanism. Applegarth goes on to argue that "*Person*," too, has the same meaning, for it is derived from the Latin *persona*, which he supposes signifies "*Sounding throughout*" with a "*Pulsatory*… Quality."[71] Syncopated with the analogy of the stringed musical instruments, Applegarth's image of man as an elastic bow-string pulsating and sounding throughout the body aptly captures the elastic moment in the Enlightenment thought.

Interestingly, Cullen understood the moral character of man as elastic "tone" in a similar manner, for he singled out "Reflex Sensation," a notion equivalent to the moral sense of moral philosophers, as a "character or tone" that runs throughout life. Having a great influence in distinguishing the moral characters of men, it modifies sensibility.[72] For Cullen, the degree of sensibility is determined first by the degree of tension of the animal system and second by this internal tone. All these notable examples of the elastic moment dispersed in the medical texts are only the tip of the iceberg; in many places, one can stumble on such an elastic moment, informed by the knowledge of the fiber.[73] I add one more illustration of this: De Mainauduc's notion of the nerves.

De Mainauduc, probably the most eminent animal magnetizer of the era in England (his technique was celebrated as "divine Manudactions"[74]), left a manuscript containing his secret doctrine of animal magnetism to his disciples to be published posthumously. Like most iatro-vitalists, Mainauduc sets the nervous system as the central place in his medical system. For him, the nerves are "strings of sensibility, and messengers between body and mind."[75] As the designation "strings" suggests, his notion of the nerves is kind of fiber-elastic one: "Every nerve has a tendency to recover its natural state; but when relaxed beyond the power of reinstating itself, it is declared to have lost its tone, its contractive power."[76] Mainauduc conceives the human nerves as a continuation of the universal "atmospheric" nervous system, as the human body is steeped from head to foot in the "atmosphere," just as the fish is in water. This "general atmosphere" has "innumerable strings," which he calls "Atmospherical Nerves"; their business is "to receive and to convey [the impulses] from and through every part of the atmosphere."[77] Since the human nervous system is indissolubly connected to the atmospheric one in such a way that what affects the atmospheric nerves must also affect the similar part of the nerves in the human body, magnetizers are able to practice what they call the absent treatment, the treatment of an absent patient living at a distance, through the common medium of equally elastic and tuned "sensible strings."[78] Here, Mainauduc's notion of "sensible strings" of the nerves capable of "distension and contraction"[79] is indistinguishable from that of the fibers. Mainauduc constructed the therapeutic system modeled on the long-standing fiber pathology—the nerves are "elastic" or "lax,"[80] they are "contracted" or "relaxed," so they should be modulated to the proper "tone."[81] The difference of terminology melts away in face of the powerful presence of the elastic fiber that continued to haunt the minds of people at the era of nervous sensibility.

3 Concluding Remarks and More About Fiber

In this chapter, I attempted to modulate the hegemonic tone of historiography (originated in Rousseau) that the eighteenth century is the age of the brain–nerve, in favor of the fiber paradigm. Fiber rather than nerve provides the appropriate matrix from which the eighteenth-century medico-culture of sympathy and sensibility sprang. The culture of sensibility and sympathy (the image of the body as a musical instrument is a good example of this) set up the fiber rather than the nerve as the paradigmatic agent. This alternative view of the culture of sensibility that posits the fiber body as another origin more properly fits eighteenth-century knowledge of society and the body epitomized as sensibility and sympathy. For one thing, although to *feel* is to involuntarily vibrate or quiver according to the degree of sensibility of the nerves, for the sensitized body to properly vibrate, the body should be composed of something like threads or strings; the image of the fiber-woven body precedes the nervous one as an explanatory model of sensibility. The solid yet extremely delicate structure or texture of the fiber body became the physical bedrock of sensible people, whose finer nerves, fibers, animal threads—or whatever you may call them—tremble at the slightest touch. The recurrent image of the body compared to a string musical instrument throughout the eighteenth century was founded upon the same epistemological matrix of the fiber body. The set of terms related to the fiber-thread property such as "tone," "tension," "elasticity," "vibration," "oscillation," and many others that frequently propped up in eighteenth-century medical and cultural discourses also indicate the enduring legacy of the fiber body. For another, the idea of the fiber body physically corresponds to the principle of sympathy, a distinguishing feature of eighteenth-century culture. The theorists of the fiber body imagined the body as a vast network-like structure composed of the cellular texture. The web-like continuity woven out of the cellular substances supports the consent of parts, medical sympathy, which if extended to social body furthers and embodies the principle of moral sympathy. The principle of moral sympathy—for which interconnectedness, continuity, and sociability are indispensible—could be visualized as thread-like fibers: as Tiphaigne de la Roche, a French medical theorist of sympathy, held, individuals are linked to others by the infinite number of threads through which sympathy acts.[82] As Grew's vision of the fiber body worked for the pressing need to re-bind the dangerously fragile society, the eighteenth-century version of the fiber body fed into knowledge of sympathy and sensibility, two pillars of the Enlightenment culture.

Moreover, the concept of fiber was malleable and adaptable to other discursive fields such as aesthetics. For instance, Edmund Burke's aesthetics of the sublime draws on the fiber paradigm. Burke considers the sublime experience as remedy, remedy for the languid melancholy, for the relaxed state of the nerve-fibers. Pain and terror, says Burke, act upon the same parts of the body in the same manner, that is, on the nerves and the fibers: they consist in the "unnatural tension of the nerves," for they produce "a tension, contraction, or violent emotion of the nerves," which becomes a cause of the sublime experience. It should be noted here that by "tension," he means "a violent pulling of the fibres."[83] Now why does the violent tension of the nerve-fibers brings delightful sensation to the subject? The state of "rest" and "inaction" naturally brings our body to fall into a "relaxation," taking away "the vigorous tone of the fibre" requisite for the natural and vital secretions. The consequence of this inert, enervated state is, as we can expect, melancholy ("Melancholy, dejection, despair, and often self-murder, is the consequence of the gloomy view we take of things in this relaxed state of body").[84] The remedy for this debilitated state is, in accordance with the contemporary platitude of fiber medicine, "exercise or *labor*," which entails the exertion of the contracting power of the muscles resembling "pain." "Labor" is requisite not only for natural functioning of the "coarser organs" but also for the "finer and more delicate" ones, the organs of mind and imagination: without labor, the "rousing" of the fibers, the organs of mind, therefore, the mind itself would become languid and diseased, so the nerves must be "shaken" to "a proper degree."[85] Terror acts as an agent for labor of the finer parts of the system, as far as it is so modified as not to be noxious, clearing away a "troublesome incumbrance."[86] Delight is, thus, produced in the temporary negation of inertia, in the expulsion of annoying blockage. In this sense, the sublime is a mode of exercise/labor, a purgative homeopathy of the imagination, prescribed for diseases of the nerves.

In addition to the centrality of fiber in eighteenth-century medicine, the notion of fiber encompasses a surprisingly wide range of referentiality, including a variety of fiber-related images, metaphors, and language concerning fiber anatomy (weave, textile, texture, contexture, web, net, cloth, membrane, thread) and fiber physiology (vibrate, oscillate, tremble, elasticity, tone, tension), which surpasses the referential range of the nerve.[87] Even fiber's elastic and ductile quality implicates the notional malleability of fiber and embodies the Enlightenment idea of man as flexibly interacting with the environment, whereas nervous determinism excludes such flexibility.[88] My last example illustrating the extensive cultural reach of the fiber language is "fiber verse," a kind of sub-genre encompassing a category of physico-theological (or didacto-scientific) poetry that exploited the language of fiber.[89]

Many poets, some of whom were engaged in medical practices, versified the wonder of the human body through the fiber trope. Richard Blackmore, himself a physician, was among such poet-physicians. Blackmore versified the formation of the "living fabric," utilizing the trope of "weaving"; the bones were "knit" in the adapted "joints," the sinews "spun" a thread and spread "the curious loom to weave the muscles."[90] Another poet-physician, John Armstrong, in his popular poetic guides to health, amply employed the figure of fibers as unifying conceit, making strictures against the "idle and unstrung" and "raw-spun fibres" as the cause of the vapors.[91] Armstrong describes the process of growth of the human body from childhood to old age in the paradigm of fiber medicine:

> When life is new, the ductile fibres feel
> The heart's increasing force; and, day by day,
> The growth advances; till the larger tubes,
> Acquiring (from their elemental veins,
> Condens'd to solid chords) a firmer tone,
> Sustain, and just sustain, th' impetuous blood.
> Here stops the growth....[92]

For Armstrong, the thread-like substances composing the solid body, whether nerves or fibers, should be kept in the due "tone"[93]; the nerve-fibers are made "flaccid" by whatever makes the body warmer or hotter than its mete, which is the exact correlate of fiber pathology and reflects the dictum of the then current culture of sensibility—warmth makes the body effeminate, and excessive tenderness ("soft luxury") makes the "many virtues" spoiled ("Unnerves the body and unmans the soul").[94] Hugh Downman in his popular poem on infancy wrought in the late eighteenth century follows the path Armstrong trod, drawing upon the language of fiber to depict the growth of the infant and instruct the reader on the management of children.[95] As in Armstrong, the growth of the body is predicated on fiber's evolution ("Each slender thread and fibre is evolved, / Gaining mysteriously their destined bulk / And firm elastic motion").[96] In tandem with the fiber pathology and the physiology of tone, Downman's "Babe" is to be raised according to the Spartan regimen of cold against the ill-effects of the fashionable custom of warmth, whether it is hot diet ("spices of the south"), warm air, or luxury ("polished life").[97] The "cold gale" of the north would "firmly brace" the "muscles" and give "to every limb it's healthful tone," while in the torrid zones, warmth deprives the body of its "vital powers."[98] Cold and exercise are the most salubrious therapeutics for children. Condemning the "tyrant reign of fashion," which makes the nerve-fibers "feeble," Downman extols the power of the cold bath ("…great is the power/Of cold"), due to the "benign effects" of which ("whence braced") the babe could endure the "winter's hard campaign"; moreover, by acquiring this "new tone," the children's original constitution ("stamina") in some degree could be "corrected" while the "lax Muscles swell."[99] Weak or sickly children could gain strength and recover their misfortunes by exercise, which supports the "flame/Of life itself": "… By Exercise/The quicken'd pulse and stimulated heart/More truly shape each fibre, give to each/Their tension, and elastic spring…."[100]

It was Erasmus Darwin who most skillfully exploited the fiber-weaving metaphor in didacto-scientific poetry. Although Darwin departed from the physiology of tone in his medical writings (see Chap. 4), the poetical work retains the language of the fiber. Published in 1803, his titanic mythological verse on the "Origin of Society," with its extended use of the fiber-metaphor, undoubtedly marked the height of "fiber verse." Drawing on the fiber trope, Darwin described the beginning of organic life (spontaneous generation) as follows: after the generative energies, heat, repulsion, and attraction, arise to produce atoms, "[atomic matter] Swells the spheres, and lengthens into lines. / Last, as fine goads the gluten-threads excite, / Cords grapple cords, and webs with webs unite; / And quick Contraction with ethereal flame / Lights into life the fibre-woven frame."[101] The formation of animal life and the beginning of the animal function are more vividly depicted with recourse to the fiber trope:

> Life's subtle woof in Nature's loom is woven;
> Points glued to points a living line extends,
> Touch'd by some goad approach the bending ends;
> Rings joint to rings, and irritated tubes
> Clasp with young lips the nutrient globes or cubes;
> And urged by appetencies new select,
> Imbibe, retain, digest, secret, eject.
> In branching cones the living web expands.[102]

Unlike the earlier version of fiber verse, Darwin's fiber-woven frame is not primarily mathematical, but living, or even self-living ("urged by appetencies"), in accordance with the general shift in the medical and intellectual view of man from man as machine-like to man sensible and living. Even if the central tenet changed, however, the underlying trope did not; fiber medicine still vindicated the languages of the fiber.[103]

Notes

1. G.S. Rousseau, "Nerves, Spirits, and Fibres: Towards an Anthropology of Sensibility," in *Enlightenment Crossings: Pre- and Post-Modern Discourses, Anthropological* (Manchester: Manchester University Press, 1991), 122–41. His subsequent essays on nerves and sensibility are now collected in his *Nervous Acts: Essays on Literature, Culture and Sensibility* (Basingstoke: Palgrave, 2004). On the impact of his pioneering essay, see Rousseau, *Nervous*, 159.
2. George Rousseau, "'Brainomania': Brain, Mind and Soul in the Long Eighteenth Century," *British Journal for the Eighteenth-Century Studies* 30 (2007): 176; see also idem, "A Sympathy of Parts: Nervous Science and Scottish Society," in *Anatomy Acts: How to Know Ourselves,* ed. Andrew Patrizio and Dawn Kemp (Edinburgh: Birlinn, 2006), 17–30.
3. George Rousseau, "Discourses of the Nerve," in *Literature and Science as Modes of Expression,* ed. Frederick Armine (Boston: Kulwer Academic Publishers, 1989), 48. Rousseau also draws on socio-biology and posits sensibility as "a type of eighteenth-century socio-biology"; 46; see also idem, "Towards a Semiotics of the Nerve: The Social History of Language in a New Key," in *Language, Self and Society: A Social History of Language*, ed. Peter Burke and Roy Porter (London: Polity, 1991), 214–18.
4. Rousseau, "Discourses," 40; see also "Nerves," 129 ("no topic in physiology between the Restoration and the turn of the nineteenth century was more important than the precise workings of the nerves").
5. Rousseau, "Discourses," 44. See also Hubert Steinke, *Irritating Experiments: Haller's Concept and the European Controversy on Irritability and Sensibility, 1750–90* (Amsterdam: Clio Medica, 2005), 233–34.

6. Sergio Moravia, "From *Homme Machine* to *Homme Sensible*: Changing Eighteenth-Century Models of Man," *Journal of the History Ideas* 39 (1975): 45–60; 58.
7. See Christopher Lawrence, "The Nervous System and Society in the Scottish Enlightenment," in *Natural Order: Historical Studies of Scientific Culture,* ed. Barry Barnes and Steven Shapin (London: Sage Publications, 1979), 19–40.
8. Rousseau, *Nervous*, 9; idem, "Nerves," 137.
9. Rousseau, "Nerves," 129.
10. Thomas Willis, *The Anatomy of the Brain and Nerves*, ed. William Feindel (Montreal: McGill University Press, 1965), 128.
11. Ibid.
12. Thomas Willis, *The First Part of Pharmaceutice Rationalis, or the Operations of Medicines in Humane Bodies* (London, 1679), 7, 22–25.
13. Rousseau, "Semiotics," 262; see Bernard de Mandeville, *Treaties of the Hypochondriack Diseases* (London, 1711), 173–75.
14. James Keill, *The Anatomy of the Humane Body Abridged; or, a Short and Full View of all the Parts of the Body* (London, 1698), 2.
15. George Cheyne, *The English Malady* (London, 1733), 60, 65.
16. George Cheyne, *An Essay of Health and Long Life* (London, 1724), 117; see also his Latin treatise on fibers, in which he insisted that chronic diseases of whatever sort have arisen from weakness of fibers; *De natura fibrae* (Londini, 1725), iv.
17. John Arbuthnot, *An Essay Concerning the Effects of Air on Human Bodies* (London, 1733), 56; Cheyne, *Health,* 31; Browne Langrish, *The Modern Theory and Practice of Physic,* 2nd ed. (London, 1738), 6–11; Clifton Wintringham, *The Works of the late Clifton Wintringham, Physician at York* (London, 1752), vol. 1, 29.
18. Cheyne, *Health*, 159; Thomas Short, *A Discourse Concerning the Causes and Effects of Corpulency* (London, 1727), 24–25, 46–47.
19. Cheyne, *Health*, 94–95; Robert James, *A Medicinal Dictionary* (London, 1745), s.v. 'fibrae' (this entry covers more than 20 pages, comprising a small treatise on fiber theory; pages are unnumbered; the subsequent pagination in brackets is mine), [5, 7]; John Quincy, *Medico-Physical Essays* (London, 1720), 45–46; W[illiam] Smith, *A Dissertation upon the Nerves* (London, 1768), 192, 295–96; Gerald van Swieten, *The Commentaries upon the Aphorisms of Dr. Herman Boerhaave*, 2nd ed. (London, 1771), vol. 1, 67–69.

20. Edward Barry, *A Treatise on a Consumption of the Lungs* (London, 1722), 274; also Langrish, *Theory*, 60–61; Quincy, *Essays*, 40.
21. Browne Langrish, *A New Essay on Muscular Motion* (London, 1733), 49.
22. Robert Whytt, *The Works of Robert Whytt* (Edinburgh, 1768), 227–38; Andrew Wilson, *Medical Researches* (London, 1777), 191–92.
23. Nicholas Malebranche, *The Search after Truth*, translated from French by Thomas M. Lennon and Paul J. Olscamp (Columbia: Ohio State University Press, 1980), 88–102.
24. Nicholas Robinson, *A New System of the Spleen, Vapours, and Hypochondriack Melancholy* (London, 1729), 102–03; one might think about David Hartley's vibration psychology; an emphasis, however, should be put on vibration rather than the nerves themselves; see for Hartley, Richard C. Allen, *David Hartley on Human Nature* (New York: State University of New York Press, 1999). For a more detailed account of fiber psychology, see ch. 5, "Interlude: Fiber Psychology."
25. On "nervous determinism," see Rousseau, "Discourses," 46–47; idem, *Nervous*, 212 ("a type of caste system"); idem, "Semiotics," 225–26.
26. Richard Blackmore, *A Treatise of the Spleen and Vapours; or, Hypochondriacal and Hysterical Affections* (London, 1725), 263–64; Cheyne, *Health*, 82–84, 160; Robinson, *Spleen*, 56–7, 65, 73.
27. James M. Adair, *A Philosophical and Medical Sketch of the Natural History of the Human Body and Mind* (Bath, 1787), 224–28; John Elliot, *Elements of the Branches of Natural Philosophy*, 2nd ed. (London, 1786), 222; James, "fibrae" [10]; Short, 41, 56. On gender, see Blackmore, 96, 259; James, s.v. "fibrae" [10, 13].
28. George Rousseau, "Temperament and the Long Shadow of Nerves in the Eighteenth Century," in *Brain, Mind and Medicine: Essays in Eighteenth Century Neuroscience,* ed. Harry Whitaker, C.U.M. Smith, and Stanley Finger (New York: Springer, 2005), 353–69: 364.
29. In addition to Rousseau, see, among others, G.J. Barker-Benfield, *The Culture of Sensibility: Sex and Society in Eighteenth-Century Britain* (Chicago: University of Chicago Press, 1992); John Mullan, *Sentiment and Sociability: The Language of Feeling in the Eighteenth Century* (Oxford: Clarendon Press, 1988).

30. Ann Jessie Van Sant, *Eighteenth-Century Sensibility and the Novel: The Senses in Social Context* (Cambridge: Cambridge University Press, 1993), 106.
31. Anon, *The Beauties of Sterne….Selected for the Heart of Sensibility* (London, 1782); see also Samuel Pratt, *Travels for the Heart, Written in France,* 2 vols (London, 1777).
32. Rousseau, "Temperament," 362.
33. Lawrence Sterne, *The Life and Opinions of Tristram Shandy, Gentleman* (London: Penguin, 2003), 132–35.
34. Ibid., 444.
35. Lawrence Sterne, *A Sentimental Journey through France and Italy*, ed. Melvyn New and W.G. Day (Gainesville: University Press of Florida, 2002), 90.
36. Ibid., 124.
37. Samuel Pratt, *Sympathy; or, a Sketch of the Social Passion: A Poem,* 3rd ed. (London, 1781), 12, 45; Pratt uses the nerves, but they are vibrating: "the nerves that vibrate."
38. Seguin Henry Jackson, *A Treatise on Sympathy* (London, 1781), 5–6.
39. Ibid., 92–93, 53.
40. Francis Carter, *An Account of the Various Systems of Medicine, from the Days of Hippocrates, to the Present Time* (London, 1788), vol. 1, 20–21.
41. Adair, 7; Malcolm Flemyng, *An Introduction to Physiology* (London, 1759), 5–6; Robert John Thornton, *The Philosophy of Medicine; or, Medical Extracts on the Nature of Health and Disease,* 4th ed., 5 vols (London, 1799), vol. 1, 98–99, 105.
42. Sterne, *Shandy*, 246.
43. Robert Whytt, *An Essay on the Vital and Other Involuntary Motions of Animals,* 2nd ed. (Edinburgh, 1763), 391–94, and passim.
44. Whytt, *Involuntary*, 2.
45. On the parallelism between the automaton and the man of feeling, see Alex Wetmore, "Sympathy Machines: Men of Feeling and the Automaton," *Eighteenth Century Studies* 43 (2009): 37–54.
46. Sterne, *Journey*, 77.
47. Ibid., 95. See Wetmore, 47.
48. Cheyne, *English Malady*, 4–5. For a general argument on the relation between music and the nerves in eighteenth-century medicine, see Penelope Gouk, "Music and the Nervous System in

Eighteenth-Century British Medical Thought," in James Kennaway ed., *Music and the Nerves, 1700–1900* (Basingstoke: Palgrave, 2014), ch. 3, 44–71. For a history of music and its effects on the body, see James Kennaway, *Bad Vibrations: the History of the Idea of Music as a Cause of Disease* (Farnham: Ashgate, 2012), esp. ch. 1, 2. Both Gouk and Kennaway well captured the importance of music in eighteenth-century medicine and its effects on the mind–body; they argued in the texts of music therapy or medical music (Brocklesby, Browne, and others) that the physiology of animal spirits, the nerves and the soul, explains the mechanism of the effects of music on the passions or the body. The fiber per se was not referred to; however, the language of the fiber (or the fiber paradigm) is implicated in the discourses of medical music. For instance, Browne described the mechanism of music's effects as bracing up the solids to "their proper standard" (15) and noted that moderate singing strengthens the "Tone of the Fibres" (24); Richard Browne, *Medicina Musica* (London, 1729).

49. Jamie C. Kassler, *Inner Music: Hobbes, Hooke and North on Internal Character* (London: Athlone, 1995); idem, "On the Stretch: Hobbes, Mechanics and the Shaking Palsy," in *1543 and All That,* ed. G. Freeland and A. Corones (Dordrecht: Kluwer Academic Publishers, 2000), 151–87.
50. Kassler, "On the Stretch,"170.
51. Joseph R. Roach, *The Player's Passion: Studies in the Science of Acting* (Ann Arbor: University of Michigan Press, 1985), 105.
52. For Willis's usage of the military metaphor, see Kassler, *Inner,* 190–92; Willis, 126, 129; Willis employed the analogy of the musical organ but relied on the metaphor of "wind" blown into the pipes. See also Kassler, "Restraining the Passions: Hydropneumatics and Hierarchy in the Philosophy of Thomas Willis," in *The Soft Underbelly of Reason: The Passions in the Seventeenth Century*, ed. Stephen Gaukroger (London: Routledge, 1998), 148.
53. David Hume, *A Treatise of Human Nature*, 2nd ed., ed. L.A. Selby-Bigge (Oxford: Clarendon Press, 1978), 440–41.
54. Ibid., 575–76.
55. Cf. Andrew Harper, *The Oeconomy of Health or, a Medical Essay* (London, [1785]), 20; moderate dancing, with music, inspires "the Charms of refined Sociability."

56. Lawrence Sterne, *Letters of Lawrence Sterne*, ed. Perry Curtis (Oxford: Clarendon Press, 1965), 138.
57. William Pargeter, *Observations on Maniacal Disorders* (Reading, 1792), 42.
58. Cf. the recurrent image of "Aeolian harp" of Romantic poets; see Thomas L. Hankins and Robert J. Silverman, *Instruments and the Imagination* (Princeton: Princeton University Press, 1995), ch. 5, "The Aeolian Harp and the Romantic Quest of Nature." See also Shelley Trower, *Senses of Vibration: A History of the Pleasure and Pain of Sound* (New York: Continuum, 2012), ch. 1, "Nervous Sensations."
59. On the danger of "vocification," see Gretchen Finney, "Fear of Exercising the Lungs Related to Iatro-Mechanics 1675–1750," *Bulletin of the History of Medicine* 45 (1971): 341–66.
60. Sterne, *Shandy*, 66.
61. David Stephenson, *Medicine Made to Agree with the Institutions of Nature; or a New Mechanical Practice of Physick* (London, 1744), 56.
62. Ibid., 57.
63. Ibid.
64. Christopher Nugent, *An Essay on the Hydrophobia* (London, 1753), 162.
65. Ibid., 44–46.
66. R.C. Sims, *An Essay on the Nature and Constitution of Man* (London, 1793), 43.
67. Ibid., 43–44.
68. [Robert Applegarth], *Theological Survey, or the Human Understanding* (Salisbury, 1776), 265.
69. Ibid., 254–58.
70. Ibid., 272.
71. Ibid., 272–73.
72. Cullen, *Materia Medica*, 97.
73. For example, see Cruickshank's anatomy of the skin which he thinks is like muscles in that it "contracts, relaxes even vibrates" because of its "elastic" nature and the network-like organization; William Cruickshank, *Experiments on the Insensible Perspiration of the Human Body* (London, 1796), 50.
74. [Mary Pratt], *A List of a Few Cures Performed by Mr. and Mrs. De Loutherbourg* (London, 1789), 1.

75. J.B. de Mainauduc, *The Lectures of J.B. de Mainauduc, M.D. Part the First* (London, 1798), 42, 68.
76. Ibid., 120.
77. Ibid., 13, 45.
78. Ibid., 51–52, 81, 103, 67 and passim; cf. the following idea of Bergasse, a renowned disciple of Mesmer; according to him, the conscience is the organ endowed with infinite sensibility, and is united to every point of universe by an innumerable number of fibers; see Appendix 4, "Bergasse's Lectures on Mesmerism" in Robert Darnton, *Mesmerism and the End of the Enlightenment in France* (Cambridge, Mass.: Harvard University Press, 1968), 184.
79. Mainauduc, 202; cf. Richard Mead, *A Treatise Concerning the Influence of the Sun and Moon upon Human Bodies*, 2nd ed. (London, 1748), in which the state of "elasticity of the atmosphere" is said to influence that of the "tone of the fibres" (27, 53).
80. Ibid., 119.
81. Ibid., 121.
82. Tiphaigne de la Roche, *L'Amour dévoilé ou le système des sympathistes* (n.p. 1749), 113.
83. Edmund Burke, *A Philosophical Enquiry into the Origin of our Ideas of the Sublime and Beautiful*, ed. James T. Boulton (London: Basil Blackwell, 1987), 211–13; 212 n. Burke's medical idea may come from his father-in-law, Nugent; on this point, see Aris Sarafianos, "The Contractility of Burke's Sublime and Heterodoxies in Medicine and Art," *Journal of the History of Ideas* 69 (2008): 23–48.
84. Ibid., 215.
85. Ibid., 216.
86. Ibid.
87. For some discussions of the web metaphor of the fiber body, see my "Untying the Web of Urizen: William Blake, Nervous Medicine, and the Culture of Feeling," in *Liberating Medicine, 1720–1835,* ed. Tristanne Connolly and Steve Clark (London: Pickering and Chatto, 2009), 97–108.
88. For the ductile quality of the fibers, see Harper, 50–51, "the ductile Fibres are easily capable of Inflexion and Modulation," so that much good or harm can be done to "the tender Plant of human Life." See also Smith, 110.

89. But there seems to be no clear generic coherence in the fiber verse; rather, it dispersed into many divisions among which physico-theological poetry and the poetry of sensibility are prominent.
90. Richard Blackmore, *The Creation* (1712), in *British Poets* (Chiswick, 1822), vol. 23, 212, 213.
91. John Armstrong, *The Art of Preserving Health* (London, 1744), 10. He also described the skin as "close-woven" (77).
92. Ibid., 55–56.
93. Ibid., 63, 79.
94. Ibid., 62–63, 123–25.
95. Hugh Downman, *Infancy, or the Management of Children,* 5th ed. (Edinburgh, 1790).
96. Ibid., 35. See also 70; "…When the frame/Is perfect, when the fibres have acquired/Their utmost growth…."
97. Ibid., 15, 58, 66.
98. Ibid., 65.
99. Ibid., 119. See also 122; "…the tonic force/Of Cold at every trail brace the limbs,/The heart, the brain re-act at every shock…."
100. Ibid., 141. See also 146. Another example can be seen in Henry Brooke's gorgeous scientific poem, *Universal Beauty*, in which the human fabric was "knit" by the "Sovereign Geometrician" according to his "mechanic Scheme"; [Henry Brooke,] *Universal Beauty, A Poem* (London, 1735), part 4, 5. These physico-theological poems were mainly written in praise of God's amazing skill in the formation of the universe including the human fabric: "So awful th' Almighty's forming Will, /Amazing texture, and stupendous Skill"; Ibid., 23. For a general survey and discussion of physico-theological (didacto-scientific) poetry, see William Powell Jones, *The Rhetoric of Science: A Study of Scientific Ideas and Imagery in Eighteenth-Century English Poetry* (London: RKP, 1966).
101. Erasmus Darwin, *The Temple of Nature; or, the Origin of Society: A Poem, with Philosophical Notes* (London, 1803), 21.
102. Ibid., 22–23. The word "goad" was also used in eighteenth-century diction as a cloth measure (1727), and it had another meaning, "a stick for driving cattle"; see OED, s.v. "goad."
103. For a good example of mixture of the fiber trope and the culture of sensibility, see William Hayley, *The Triumph of Temper* (London, 1781), which was immensely popular during the last two decades

of the eighteenth century. See also Samuel Pratt's *Sympathy*. I have discussed the way that the language of fiber is implicated in the poetry of William Blake; Hisao Ishizuka, "Enlightening the Fibre-Woven Body: William Blake and Eighteenth-Century Fibre Medicine," *Literature and Medicine* 25 (2006): 72–92.

Conclusion

The Demise of Fiber

Fiber rather suddenly vanishes from the medical scene in the early years of the nineteenth century. With this disappearance, a whole set of medical researches and investigations predicated on fiber also retreated from the medical scene. There is a practical reason for this: the grand premise of the fiber-body and fiber medicine, that the body is wholly composed of nothing but the elementary fibers, came to stand as untenable. In the early nineteenth century, fiber theory began to be called into question by some medical theorists who, revitalizing microscopic research, claimed to observe that the linear fiber was actually composed of the still smaller unit, the globules. Everard Home (1756–1832), a disciple of John Hunter, was one of those researchers. Drawing on Hunter's studies on the coagulation of blood in the formation of tissues, Home asserted that the ultimate fiber was actually formed out of the globules of the blood.[1] This "globule theory" advocated by Home was soon put forward as well by Henri Milne-Edwards (1800–1885), a French natural historian, who postulated that the structure of animals and plants was ultimately made up of minute globules.[2] This new discovery seems to have had devastating impact on the fiber theory; the speculative existence of the ultimate fiber no longer provided firm ground on which medical writers worked to build their theories. René-Joachim-Henri Dutrochet, one of the ardent exponents of the globule theory, accused the anatomists of the former age of their abuse of the fiber, which in reality represented nothing substantial and objective:

H. Ishizuka, *Fiber, Medicine, and Culture in the British Enlightenment*, DOI 10.1057/978-1-349-93268-9

> The word "fibre" is perhaps one of the most abused in anatomy, since it does not represent an exact idea; one gives this name, in general, to all linear or very slender organic bodies. According to this definition, one sees that the word fibre is, so to speak, only a provisional expression which one uses while waiting for exact knowledge of the true nature of the linear organ which one designates with this name.[3]

For Dutrochet and other globulists, the true nature of the linear substance lies in the globules which compose the fiber in the form of a line.

The globule, however, was proved yet another chimera observed through the spherical aberration of the microscope and, before long, this theory, too, was overtaken by a more convincing entity, the cell, most sharply defined by Theodor Schwann (1810–1882) in 1839.[4] The seamless succession of the concept of the fundamental unit of organic structure from the eighteenth-century fiber through the intermitting substance, the globule, to the nineteenth-century cell seems too glib to hold truth; the process must be complicated and could not be told in a chronological order.[5] But one thing is certain, that at the end of the long eighteenth century (the age of the Enlightenment), the fiber disappeared and the cell gained its own theoretical, experimental, and epistemological terrain.

Parallels exist between the nineteenth-century cell and eighteenth-century fiber, as L.J. Rather pointed out,[6] but these two substances differ from each other on a crucial point. Whereas the fiber has no history to tell (though it may tell one's temperament—it is a story), the cell embraces within itself history which discloses the existence of one general principle for the formation of all organic phenomena. A physiological account of tissues is equivalent to a developmental explanation, and cell formation proves that there is a common developmental principle for the most diverse elementary parts of an organism.[7] The center of gravity for critical attention shifted from the non-historical process of weaving to the historical process of growth. Along with this shift, embryology rather than neuromuscular physiology now occupied a prominent place in the life sciences; microscopic research on the living cell (e.g., protoplasm) rather than crude experiments on sensitive or irritable nerve-fibers, the mysterious but lawful growth of the cell rather than the (in)visible vibration of the fibers, epigenesis rather than preformation, the embryological law of parallelism (recapitulation theory) rather than the mother's imagination—all took firm ground alongside the cell.

As soon as the fiber was dethroned from its theoretical seat, the research on fiber began to appear an archaic episode of medical history. In the nineteenth century, some medical men still continued to investigate the true structure of the ultimate fiber. Martin Barry's research on the structure of the fiber may be the last attempt of this kind; Barry set aside the globule hypothesis and instead proposed a new discovery that the fiber was formed out of a "flat filament" within the "blood-corpuscle."[8] Barry's new discovery, however, had no impact on medical theory of the era, which had already discarded fiber theory. Once the fiber was replaced by the cell as the minimum building unit of the body, the whole set of fiber language and metaphor, "weaving," "web," "textile," "texture," "vibration," "tension," and "stamina," disintegrated. The nerve, however, survived this paradigmatic collapse and later medical historians falsely and retrospectively identified the nerve with the solid-fiber as the physical and physiological bedrock of a modern sensibility. The preceding chapters are written as a prescription for this nervous amnesia to rescue fiber's legitimate place in the history of medicine.

Fiber and Modernity

From a broader perspective of the history of medicine, fiber medicine of the eighteenth century may be posited as the transitional phase from ancient humoralism to modern solidism. The conceptual framework of humoral theory was gradually discarded during the first half of the eighteenth century, with the result that ideas of health and disease, life and death, no longer rested on the balance of the four humors but on the grades of "tone" or "tension" of the solid parts of the body. However, what part of the solids was relevant for life and health? Solids were not co-terminous with the nervous system, as the later vitalistic medical theorists claimed, but they were primarily fibers and those parts made of fibers (membranes, vessels, muscles, bones, as well as nerves). Fiber theory arguably occupied the central place in the very foundation of the modern theory of solidism.

This aspect of the relevance of fiber to solidism is more understandable if we relate it to the emergence of the modern (secular) body. As the historiography of the eighteenth century reveals, that century witnessed, in various fields, substantial transformations that laid the groundwork for what we call "modernity."[9] Recent studies on the history of the body and sexuality also point to the eighteenth century as a key period in determining how modernity would understand and experience the body.

Historians of the body, particularly of sexuality, and the scholars of related fields (gender studies, family history, or literary studies) have claimed that the earlier premodern body underwent a significant change during the eighteenth century.[10] The premodern body, once conceived as divinely given and hence understood in cosmological terms, and often perceived according to criteria more socially than biologically determined (e.g., gender), became at once precariously and happily modern and secular in the eighteenth century—happily in the sense of the liberation of the mind and the body from long-standing authoritative religious teachings (an aspect exemplified in the pursuit of happiness and the hedonistic enjoyment of bodily pleasure),[11] and precariously in the sense of the scientific underpinnings and the correlated "moral" discipline imposed on the body as alternatives to those traditional religious teachings. The "Fiber Body," derived from, and enlightened by, fiber medicine, was deeply involved in this process of transformation. Some hints have already been given in the course of this book; for instance, the correlation between the degree of sensibility as well as intellectual faculty (the moral) and that of elasticity of the fiber (the physique), the mutual relation between the social and racial distinction and the fiber-based constitutions, and the interconnection between the malleability of man and that of the fibers. And yet, there are more illustrations that attest to the fiber-body's entrenchment into the medico-cultural modernization of the body, such as the feminization of culture and the feminine passivity of the fiber-woven body; commercialization (the birth of the consumer society) and the fiber-body's animal economy; an innovative improvement of transportation (e.g., the vast construction of the network-like turnpike) and the image of a reticular-like fiber-woven body; the notion of sociability in a delicate society among sympathizing people and the interconnectedness of the fiber-body; and so on.

Here, I only put a brief remark to acknowledge the fiber-body's crucial presence in the process of this shift. With the change in the way the body was understood and experienced, from the fluid (humoral) to the solid, medical theorists exploited the solid-fiber instead of the fluid-humors as the physical basis for the reformulation of the body in its modern, secular guise; more precisely, they had little choice but to do so. Thomas Laqueur's influential thesis on the emergence of the modern sex (body) is a case in point. According to him, somewhere in the eighteenth century, modern sex was born; prior to this era, people's bodies were placed on a vertical, hierarchical axis of the "one-sex" model that was informed by the humoral system. In this one-sex model, the differences of sex were seen as those of degree, as expressed in the structural equivalence of male and female genitalia. This model was superseded by the "two-sex" model that increasingly emphasized anatomical differences, and the sexual difference was understood qualitatively. The modern bodies of men and women were seen to be incommensurable. What Laqueur left unnoticed is that the birth of the modern sex-body accompanied the formation of the fiber-body. For the body could not, in the first place, be treated in strictly anatomical, physiological, or natural terms (i.e., as the physical and solid body liberated from the domination of humors and thus from the traditional socio-cosmological underpinnings of humoral theory) without the material presence of the solid-fibers as a frame of reference to designate the new way in which the body was to be understood, perceived, or marked in the realms of sex, gender, race, ethnicity, or class. The radical shift from humoralism to solidism, hitherto relatively neglected by medico-cultural historians, is more indispensable for the understanding of the emergence of the modern body than one might assume. The fiber-body reigns amid this shift.

Notes

1. E. Home, "The Croonian Lecture. On the Changes the Blood Undergoes in the Act of Coagulation," *Philosophical Transactions* 108 (1818): 172–84.
2. On globule theory, see John V. Pickstone, "Globules and Coagula: Concepts of Tissue Formation in the Early Nineteenth Century," *Journal of the History of Medicine* 28 (1973): 336–56.
3. M.H. Dutrochet, *Recherches Anatomiques et Physiologiques sur la Structure Intime des Animaux et des Végétaux, et sur leur Motilité* (Paris, 1824), 173, cited in J. Walter Wilson, "Dutrochet and the Cell Theory," *Isis* 37 (1947): 8.
4. On cell theory, see William Colman, *Biology in the Nineteenth Century: Problems of Form, Functions, and Transformation* (New York: John Wiley, 1971), ch. 2; Thomas S. Hall, *History of General Physiology* (Chicago: University of Chicago Press, 1969), vol. 2, ch. 40; Henry Harris, *The Birth of the Cell* (New Haven: Yale University Press, 1999).
5. For example, Johann C. Reil's comparison of the genesis and growth of the fiber to the inorganic crystallization cannot be accommodated by the traditional fiber paradigm; on Reil's fiber

theory, see L.J. Rather, "Some Relations between Eighteenth-Century Fibre Theory and Nineteenth-Century Cell Theory," *Clio Medica* 4 (1969): 198–99.

6. Rather.
7. On this point, see L.S. Jacyna, "Romantic Thought and the Origins of Cell Theory," in *Romanticism and the Sciences*, ed. Andrew Cunningham and Nicholas Jardine (Cambridge: Cambridge University Press, 1990),165–67; see also Colman, ch. 3; Carolyn Steedman, *Strange Dislocations: Childhood and the Idea of Human Interiority, 1780-1930* (London: Virago, 1995), 56.
8. Martin Barry, *On Fibre* (London, 1842), 89.
9. See Roy Porter, *The Creation of the Modern World: The Untold Story of the British Enlightenment* (New York: Norton, 2000); Miles Ogborn, *Spaces of Modernity: London's Geographies 1680-1780* (London: Guilford Press, 1998).
10. See Helen Deutsch and Felicity Nussbaum, ed., "*Defects*": *Engendering the Modern Body* (Ann Arbor: University of Michigan Press, 2000); Anthony Fletcher, *Gender, Sex and Subordination in England 1500-1800* (New Haven: Yale University Press, 1995); Thomas Laqueur, *Making Sex: Body and Gender from the Greeks to Freud* (Cambridge, Mass.: Harvard University Press, 1990); Londa Schiebinger, *The Mind Has No Sex?: Women in the Origins of Modern Science* (Cambridge, Mass.: Harvard University Press, 1989). Also relevant is the historical formation of the modern self during the eighteenth century; for a nuanced and far-reaching analysis of this theme, see Dror Wahrman, *The Making of the Modern Self: Identity and Culture in Eighteenth-Century England* (New Haven: Yale University Press, 2004); he recognized the radical disruption in the closing years of the eighteenth century that witnessed the rise of the modern self distinct from the fluid identity, what he calls the "*ancient regime* of identity."
11. Porter, ch.11, "Happiness"; Roy Porter and Marie Mulvey Roberts, ed., *Pleasure in the Eighteenth Century* (Basingstoke: Macmillan, 1996).

Bibliography

Primary Sources

Abernethy, John. 1797. *Surgical and physiological essays, part III*. London.

Adair, James M. 1772. *Commentaries on the principles and practice of physic*. London.

Adair, James M. 1786. *Medical cautions, for the consideration of invalids*. Bath.

Adair, James M. 1787. *A philosophical and medical sketch of the natural history of the human body and mind*. Bath.

Adams, George. 1787. *Essays on the microscope*. London.

Adams, George. 1799. *An essay on electricity*, 5th ed. London.

Addison, Joseph. 1965. *The Spectator*, ed. Donald Bond. Oxford: Clarendon Press.

Anon. 1675. An account of some books: *The comparative anatomy of the trunks of plants* by Nehemiah Grew. *Philosophical Transactions* 10(1675): 486–489.

Anon. 1724. *A letter to George Cheyne*. London.

Anon. 1734. *Physical essays on the parts of the human body and animal oeconomy*. London.

Anon. 1748. *The best and easiest means of preserving uninterrupted health to extreme old age*. London.

Anon. 1782. *The beauties of Sterne….Selected for the heart of sensibility*. London.

Applegarth, Robert. 1776. *Theological survey of the human understanding*. Salisbury.

Apperley, Thomas. 1731. *Observations in physick, both rational and practical*. London.

Arbuthnot, John. 1731. *An essay concerning the nature of aliments*. London.

H. Ishizuka, *Fiber, Medicine, and Culture in the British Enlightenment*, DOI 10.1057/978-1-349-93268-9

Arbuthnot, John. 1733. *An essay concerning the effects of air on human bodies*. London.

Armstrong, John. 1744. *The art of preserving health*. London

Baglivi, G. 1702. *Specimen quatuor librorum de fibra motrice et morbosa*. Rome

Baglivi, G. 1704. *Practice of physick*. 1696. London.

Bailey, N. 1730. *An universal etymological English dictionary*. London.

Bailey, N. 1764. *Etymological dictionary*. London.

Barry, Edward. 1727. *A treatise on a consumption of the lungs*. London.

Barry, Martin. 1842. *On fibre*. London.

Beale, Bartholomew. 1706. *An essay attempting a more certain and satisfactory discovery both of the true cause of all diseases*. London.

Beddoes, Thomas. 1793. *Observations on the nature and cure of calculus, sea scurvy, consumption, catarrh, and fever*. London.

Blackmore, Richard. 1725. *A treatise of the spleen and vapours; or, hypochondriacal and hysterical affections*. London.

Blackmore, Richard. 1822. *The creation* (1712). In *British poets*, vol. 23. Chiswick.

Blancard, Stephen. 1684. *A physical dictionary*. London.

Blane, Gilbert. 1788. *A lecture on muscular motion*. London.

Blount, Thomas. 1759. *Glossographia: Or a dictionary*, 2nd ed. London.

Boerhaave, Herman. 1715. *Boerhaave's aphorisms concerning the knowledge and cure of diseases*. London.

Boerhaave, Herman. 1719. *A method of studying physick*. Trans. Mr. Samber. London.

Boerhaave, Herman. 1742. *Dr. Boerhaave's academic lectures on the theory of physic*, 5 vols. London.

Bonnet, Charles. 1768. *The contemplation of nature*, vol. 1. London.

Bostock, J. 1835. *Sketch of the history of medicine, from its origin to the commencement of the nineteenth century*. London.

Boulton, Richard. 1697. *A treatise of the reason of muscular motion*. London.

Boyle, Robert. 1991. *Selected philosophical paper of Robert Boyle*. Edited with an Introduction by M.A. Stewart. Cambridge: Hackett.

Briggs, William. 1682. A new theory of vision. *Philosophical Collections* 6: 167–178.

Briggs, William. 1683. A continuation of a discourse about vision. *Philosophical Transactions* 13: 171–182.

Brooke, Henry. 1735. *Universal beauty, a poem*. London.

Brown, John. 1757. *An estimate of the manners and principles of the times*, 3rd ed. London.

Brown, John. 1795. *The element of medicine of John Brown*. Translated from the Latin, with comments and illustrations, by the Author. A new ed., revised and corrected, with a bibliographical preface by Thomas Beddoes. London.

Browne, John. 1697. *Myographia nova: Or, a graphical description of all the muscles in humane body*. London.

Browne, J. 1714. *Institutions in physick, collected from the writings of the most eminent physicians*. London.

Browne, Richard. 1729. *Medicina musica*. London.

Buchan,William. 1772. *Domestic medicine,* 2nd ed. London.

Buchanan, James. 1757. *Linguae Britannicae Vera Pronunciato, or a new English dictionary*. London.

Bulwer, John. 1649. *Pathonyotomia*. London.

Burke, Edmund. 1987. In *A philosophical enquiry into the origin of our ideas of the sublime and beautiful*, ed. James T. Boulton. London: Basil Blackwell.

Burton, Robert. 1938. In *The anatomy of melancholy*, ed. Dell Floyd and Paul Jordan-Smith. New York: Tudor Publishing.

Cabanis, P.J. 1806. *Sketch of the revolutions of medical science, and views relating to its reform*. London.

Carter, Francis. 1788. *An account of the various systems of medicine, from the days of Hippocrates, to the present time*. London.

Cavallo, Tiberius. 1799. *An essay on the theory and practice of medical electricity*, 5th ed. London.

Cavendish, Margaret. 1653. *Poems and fancies*. London.

Chambers, E. 1728. *Cyclopaedia*. London; 5th ed. London, 1741.

Cheyne, George. 1702a. *A new theory of acute and slow contin'd fevers*. 2nd ed. London.

Cheyne, George. 1702b. *Remarks on two late pamphlets written by Dr. Oliphant, against Dr. Pitcarin's dissertations*. London.

Cheyne, George. 1705. *Philosophical principles of natural religion*. London.

Cheyne, George. 1720. *An essay on gout*. London.

Cheyne, George. 1724. *An essay of health and long life*. London.

Cheyne, George. 1725. *De natura fibrae*. Londini.

Cheyne, George. 1740. *An essay on regimen*. London.

Cheyne, George. 1742. *The natural method of cureing [sic] the diseases of the body*. London.

Cheyne, George. 1991. *The English Malady* (1733). Reprinted and edited with an Introduction by Roy Porter. London: Routledge.

Clarke, Samuel. 1732. *Discourse concerning the being and attributes of God*, 8th ed. London.

Colbatch, John. 1697. *A treaties of the gout,* in *Novum lumen chirurgicum: Or, a new light of chirurgery*. London, 1704.

Cole, William. 1689. *A physico-medical essay concerning the late frequency of apoplexies*. Oxford.

Coles, Elisha. 1676. *An English dictionary*. London.

Collingnon, Charles. 1769–72. *Medical and moral tracts*. Cambridge.

Collins, Samuel. 1685. *A systeme of anatomy, treating of the body of man, beasts, birds, fish, insects, and plants. Illustrated with many schemes*. London.

Conner, Bernard. 1698. *The history of Poland,* vol. 1. London.

Conner, Bernard. 1699. *Evangelium medici: seu medicina mystica*. 1697. London.

Cortona, Pietro Berrettini de. 1986. *The anatomical plates of Pietro da Cortona: 27 Baroque masterpieces.* With a New Introduction by Jeremy M. Norman. New York: Dover.

Crichton, Alexander. 1798. *An Inquiry into the nature and origin of mental derangement,* 2 vols. London.

Crooke, Helkiah. 1615. *Microcosmographia, or a description of the body of man.* London.

Croone, William. 2000. *On the reason of the movement of the muscles.* Trans. Paul Maquet. Philadelphia: American Philosophical Society.

Cruickshank, William. 1796. *Experiments on the insensible perspiration of the human body.* London.

Cullen, William. 1775. *Lectures on materia medica,* 2nd ed. Philadelphia.

Cullen, William. 1776. *A letter to Lord Cathcart…Concerning the recovery of persons drowned and seemingly dead*. London.

Cullen, William. 1789. *A treatise of materia medica*, 2 vols. Edinburgh.

Cullen, William. 1797. *Clinical lectures, delivered in the years 1765 and 1766.* London.

Cullen, William. 1827. *The works of William Cullen,* ed. John Thomson, 2 vols. Edinburgh.

Darwin, Erasmus. 1796. *Zoonomia; or, the laws of organic life,* 2 vols, 2nd ed. London.

Darwin, Erasmus. 1803a. The articles of the materia medica. In *Zoonomia,* 2nd American edition. Boston.

Darwin, Erasmus. 1803b. *The temple of nature; or, the origin of society: A poem, with philosophical notes.* London.

De Diemerbroeck, Isbrand. 1689. *The anatomy of human bodies, comprehending the most modern discoveries and curiosities in the art*. Translated from Latin by William Salmon. London.

De la Roche, Tiphaigne. 1749. *L'Amour dévoilé ou le système des sympathistes.* n.p.

De la Roche, Tiphaigne. 1761. *Giphantia*. London.

Douglas, James. 1730. *A description of the peritonaeum, and of the parts of the membrana cellularis.* London.

Douglas, James. 1755. *Myographiae comparatae specimen: Or, a comparative description of all the muscles in a man, and in a quadruped*, New ed. Dublin.

Downman, Hugh. 1790. *Infancy, or the management of children,* 5th ed. Edinburgh.

Drake, James. 1707. *Anthropologia Nova; or, a new system of anatomy,* Vol. 1. London.

Elliot, John. 1786. *Elements of the branches of natural philosophy connected with medicine,* 2nd ed. London.

Evely, John and William Cowper. 1702–3. An account of diverse schemes of Arteries and Veins…by John Evelyn…to which are Subjoyn'd a description of the extremities of those vessels, and the manner the blood is seen, by the microscope…by William Cowper. *Philosophical Transactions* 23(1702–3): 1177–1201.

Feltham, John. 1803. *A popular view of the structure and economy of the human body*. London.

Flemyng, Malcolm. 1751. *The nature of nervous fluid, or animal spirits demonstrated*. London.

Flemyng, Malcolm. 1759. *An introduction to physiology*. London.

Floyer, John. 1702. *The ancient psykhroloysia revived: or, and essay to prove cold bathing both safe and useful*. London.

Fordyce, George. 1771. *Elements of the practice of physic,* 3rd ed. London.

Fothergill, A. 1795. *A new inquiry into the suspension of vital action, in cases of drowning and suffocation*. Bath.

French, R.K. 1975. *Anatomical education in a Scottish University, 1620. An annotated translation of the lecture notes of John Moir*. Aberdeen: Equipress.

Fuller, Francis. 1777. *Medicina gymnastica*. London, 1705; 9th ed. London.

Galen. 1968. *De motu musculorum*. Trans. Charles Mayo Goss as On the movement of muscles by Galen of Pergamon. *American Journal of Anatomy* 123: 1–25.

Garden, George. 1691. A discourse concerning the modern theory of generation. *Philosophical Transactions* 16: 474–483.

Gardiner, John. 1784. *Observations on the animal oeconomy*. London.

Garnett, T. 1797. *A lecture on the preservation of health*. Liverpool.

Gibson, Thomas. 1703. *The anatomy of humane bodies epitomized*, 6th ed. London.

Girtanner, Christoph. 1790. On irritability, considered as a vital principle in organized bodies. *Edinburgh Magazine* 12: 108–114.

Girtanner, Christoph. 1791. On irritability, considered as a vital principle in organized bodies. *Medical Commentaries* 5: 424–440.

Glisson, Francis. 1993. *English manuscripts of Francis Glisson (1): From* Anatomica Hepatis (The anatomy of the liver), 1654, ed. Andrew Cunningham. Cambridge: Wellcome Unit for the History of Medicine.

Glisson, Francis. 1998. *English manuscripts of Francis Glisson (2): Lectures and other papers*, ed. Andrew Cunningham. Cambridge: Wellcome Unit for the History of Medicine.

Glisson, Francis, George Bate, and Ahasuerus Regemorter. 1651. Translated in English by Phil. Armin. *A treatise of the rickets: Being a disease common to children*. London.

Grew, Nehemiah. 1681. *Musaeum regalis societalis, or a catalogue and description of the natural and artificial rarities*. London.

Grew, Nehemiah. 1682. *The anatomy of plants. With an idea of a philosophical history of plants and several other lectures read before the Royal Society*. London.

Grew, Nehemiah. 1701. *Cosmologia sacra: Or, a discourse of the universe as it is the creature and kingdom of God*. London.

Grosvenor, B. 1716. *Health. An essay on its nature, value, uncertainty, preservation, and best improvement*. London.

Hales, Stephen. 1964. *Statical essays: Containing Haemastaticks* (1733). Reprinted with an introduction by Andre Cournand. New York: Hafner.

Haller, Albrecht von. 1786. *First lines of physiology*. To which are added all the notes and illustrations of Prof. Wrisberg, 2 vols. Edinburgh.

Haller, Albrecht von. 1936. *A treatise on the sensible and irritable parts of animals* (1755), Reprinted in *Bulletin of the History of Medicine* 4: 657–699.

Harper, Andrew. 1785. *The oeconomy of health or, a medical essay*. London.

Hartley, David. 1749. *Observations on man*. London.

Harvey, William. 1847. *The works of William Harvey, MD*. Trans. Robert Willis. London: Sydenham Society.

Harvey, William. 1959. *De motv locali animalivm* (1627). Edited, translated and introduced by Gweneth Whitteridge. Cambridge: Cambridge University Press.

Harvey, William. 1995. *The anatomical exercises in English translation*, ed. Geoffrey Keynes. New York: Dover.

Hayley, William. 1781. *The triumph of temper*. London.

Henry, Thomas. 1783. *Memoirs of Albert de Haller, M.D*. London.

Herdman, John. 1795. *An essay on the causes and phenomena of animal life*. London.

Hoffmann, Friedrich. 1971. *Fundamenta Medicinae*. Translated and Introduced by Lester S. King. London: Macdonald.

Home, E. 1818. The Croonian lecture. On the changes the blood undergoes into the act of coagulation. *Philosophical Transactions* 108: 172–184.

Hooke, Robert. 1961. *Micrographia: Or some physiological descriptions of minute bodies made by magnifying glasses with observations and inquiries thereupon*. London, 1665. Reprinted. New York: Dover.

Hume, David. 1978. *A treatise of human nature*, ed. L.A. Selby-Bigge, 2nd ed. Oxford: Clarendon Press.

Hunter, John. 1775. Experiments on animals and vegetables, with respect to the power of producing heat. *Philosophical Transactions* 65: 446–458.

Hunter, John. 1792. *Observations on certain parts of the animal oeconomy*, 2nd ed. London.

Hunter, William. 1764. The history of an emphysema. In *Medical observations and inquiries,* by a Society of Physicians in London, vol. 2, 17–69. London.

Jackson, Seguin Henry. 1781. *A treatise on sympathy*. London.

Jackson, Seguin Henry. 1792. *Dermato-Pathologia; or practical observations, from some new thoughts on the pathology and proximate cause of diseases of the true skin and its emanations*. London.

James, Robert. 1745. *A medicinal dictionary*. London.

James, Robert. 1746. *The modern practice of physic*. London.

Johnson, James. 1771. *An essay on the use of the ganglions of the nerves*. Shrewsbury.

Keill, James. 1708. *An account of animal secretion, the quantity of blood in the humane body, and muscular motion*. London.

Keill, James. 1714. *The anatomy of the human body abridged; or, a short and full view of all the parts of the body*. London, 1698; 5th ed. London.

King, Edmund. 1665–66. Some considerations concerning the parenchymous parts of the body. *Philosophical Transactions* 1: 316–320.

King, Edmund. 1668. Some observations concerning the organs of generation, made by Dr. Edmund King. *Philosophical Transactions* 3: 1043–1047.

King, John. 1737. *An essay on hot and cold bathing*. London.

Kirkland, Thomas. 1774. *A treatise on child-bed fevers*. London.

Kirkland, Thomas. 1783. *An inquiry into the present sate of medical surgery*, vol. 1. London.

Kite, Charles. 1788. *An essay on the recovery of the apparently dead*. London.

Langrish, Browne. 1733. *A new essay on muscular motion*. London.

Langrish, Browne. 1738. *The modern theory and practice of physic*, 2nd ed. London.

Le Clerc, Daniel, and Jon Jacob Magnet. 1711–14. *Bibliotheca Anatomica, Medica, Chirugica, &c.*, 2 vols. London.

Leake, John. 1776. *A lecture introductory to the theory and practice of midwifery*, 3 rd ed. London.

Leake, John. 1777. *Medical instructions towards the prevention, and cure of chronic or slow diseases peculiar to women*. London.

Locke, John. 1693. *Some thoughts on education*. London.

Lowndess, Francis. 1784. *Observations on medical electricity*. London.

Lowndess, Francis. 1791. *The utility of medical electricity*. London.

Lynch, Bernard. 1744. *A guide to heath through the various stages of life*. London.

Lyonet, Pierre. 1760. *Traité anatomique de la chenille, qui ronge le bois de saule*. The Hague.

M. N. 1737. *Anatomy epitomized and illustrated*. London.

Macbride, David. 1772. *A methodical introduction to the theory and practice of physic*. London.

Mainauduc, J.B. de. 1798. *The lectures of J.B. de Mainauduc, M.D. Part the first*. London.

Malebranche, Nicholas. 1980. *The search after truth*. Translated from French by Thomas M. Lennon and Paul J. Olscamp. Columbia: Ohio State University Press.

Malpighi's 'Concerning the structure of the kidneys': A Translation and Introduction by J. M. Hayman, Jr. *Annals of Medical History* 7(1925): 242–263.

Malpighi's 'De Pulmonibus' [Translated] by James Young. *Proceeding of the Royal Society of Medicine* 23(1929–1930): 1–14.

Mandeville, Bernard de. 1711. *Treaties of the hypochondriack diseases*. London.

Marchand, John Felix, and Hebbel Edward Hoff. 1955. Felicia Fontana, the laws of irritability: A literal translation of the Memoir *De irritabilitatis legibus*, 1767; Added material from *Ricerche filosofishe sopra le fisica animale*, 1775; and Correlation of these editions with the E.G.B. Hebenstreit German Translation, 1785. *Journal of the History of Medicine* 10: 197–206; 302–26; 399–420.

Martin, Benjamin. 1735. *The philosophical grammar; being a view of the present state of experimented physiology, or natural philosophy*. London.

Mead, Richard. 1748. *A treatise concerning the influence of the sun and moon upon human bodies, and the diseases thereby produced*, 2nd ed. London.

Mead, Richard. 1775. *The medical works of Richard Mead M.D*, New ed. Edinburgh.

Milman, Francis. 1782. *An inquiry into the source from whence the symptoms of the scurvy and of putrid fevers, arise*. London.

Moises, Hugh. 1794. *A treatise on the blood*. London.

Monro, Alexander [*primus*]. 1726. *The anatomy of the humane bones*. Edinburgh.

Monro, Alexander [*primus*]. 1781. *The works of Alexander Monro, MD*. 1732. Edinburgh.

Monro, Alexander [*secundus*]. 1783. *Observations on the structure and functions of the nervous system*. Edinburgh.

Morell, Thomas. 1794. *Notes and annotations on Locke on the human understanding*. London.

Morgan, Thomas. 1725. *Philosophical principle of medicine*. London.

Morgan, Thomas. 1735. *The mechanical practice of physick*. London.

Neale, Henry. 1788. *Practical dissertations on nervous complaints*. London.

Needham, Turbervill. 1749. *Observations upon the generation*. London.

Nesbitt, Robert. 1736. *Human osteogeny explained in two lectures*. London.

Nugent, Christopher. 1753. *An essay on the hydrophobia*. London.

Pargeter, William. 1792. *Observations on maniacal disorders*. Reading.

Paxton, Peter. 1707. *A directory physico-medical, composed for the use and benefit of all such as design to study and practice the art of physick*. London.

Penrose, Francis. 1794. *Essays, physiological and practical*. London.

Phillips, Edward. 1706. *The new world of words*, 5th ed. London, 1696; 6th ed. revised and corrected by J.K. Kersey. London.

Pitcairn, Archibald. 1715. *The works of Dr. Archibald Pitcairn*. London.

Pratt, Samuel. 1777. *Travels for the heart, written in Franc*. 2 vols. London.

Pratt, Samuel. 1781. *Sympathy; or, a sketch of the social passion: A poem*, 3rd ed. London.

Pratt, Mary. 1789. *A list of a few cures performed by Mr. and Mrs. De Loutherbourg*. London.

Quincy, John. 1719. *Physico-Medicum: Or, a new physical dictionary*. London.

Quincy, John. 1720. *Medico-physical essays*. London.

Quincy, John. 1728. *Medicina statica: Being the aphorism of Santorius, translated into English, with large explanations*, 4th ed. London.
Quincy, John. 1782. *Lexicon physico-medicum; or a new medicinal dictionary*, 10th ed. London.
Rees, Abraham. 1781–89. *Cyclopaedia*. London.
Robinson, Nicholas. 1725. *A new theory of physick and diseases, founded on the principles of the Newtonian philosophy*. London.
Robinson, Nicholas. 1729. *A new system of the spleen, vapours, and hypochondriack melancholy*. London.
Robinson, Bryan. 1743. *A dissertation on the aether of Sir Isaac Newton*. Dublin.
Salmon, William. 1714. *Ars Anatomica: Or, the anatomy of humane bodies, in seven books. Representing to the mind a true and compleat idea of the whole humane frame*. London.
Short, Thomas. 1727. *A discourse concerning the causes and effects of corpulency*. London.
Simmons, Samuel Foart. 1780. *The anatomy of the human body*, vol. 1. London.
Sims, R.C. 1793. *An essay on the nature and constitution of man*. London.
Smith, H. 1794. *An essay on the nerves*. London.
Smith, W[illiam]. 1768. *A dissertation upon the nerves*. London.
Smith, William. 1784. *Nature studied with a view to preserve and restore health*. London.
Smyth, James Carmichael. 1787. *An account of the effects of swinging*. London.
Spurzheim, J. 1825. *Phrenology, or, the doctrine of the mind; and of the relations between its manifestations and the body*, 3rd ed. London.
Stephenson, David. 1744. *Medicine made to agree with the institutions of nature; or a new mechanical practice of physick*. London.
Sterne, Lawrence. 1965. *Letters of Lawrence Sterne*, ed. Perry Curtis. Oxford: Clarendon Press.
Sterne, Lawrence. 2002. *A sentimental journey through France and Italy*, ed. New Melvyn and W.G. Day. Gainesville: University Press of Florida.
Sterne, Lawrence. 2003. *The life and opinions of Tristram Shandy, Gentleman*. London: Penguin.
Strother, Edward. 1716. *Criticon febrium: Or, A critical essay on fevers*. London.
Strother, Edward. 1725. *An essay on sickness and health*. London.
Stuart, Alexander. 1739. *Three lectures on muscular motion*. London.
Swammerdam, John. 1758. *The book of nature; or, the history of insects*. Trans. Thomas Flloyd. London.
Swedenborg, Emanuel. 1859. *Angelic wisdom concerning the divine love and the divine wisdom*. London: Swedenborg Society.
Swedenborg, Emanuel. 1918. *The economy of the animal kingdom considered anatomically, physically, and philosophically, transaction III (the fibre)*. Philadelphia: Swedenborg Scientific Association.

Swedenborg, Emanuel. 1986. *On the divine love/on the divine wisdom*, formally published under the title of *Doctrine of uses*. London: Swedenborg Society.

Swieten, Gerald van. 1771. *The commentaries upon the Aphorisms of Dr. Herman Boerhaave*, vol. 1. 2nd ed. London.

Tennent, John. 1749. *Physical enquiries,* 2nd ed. London.

The needles excellency: A new booke wherein are divers admirable workers wrought with her needle, 12th ed. Enlarged. London, 1640.

Thornton, Robert John. 1799. *The philosophy of medicine; or, medical extracts on the nature of health and disease,* 4th ed, 5 vols. London.

Townsend, Joseph. 1795. *A guide to health*, 2nd ed. London.

Turner, Daniel. 1723. *De morbis cutaneis. A treatise of diseases incident to the skin,* 2nd ed. London.

Uvedale, C. 1758. *The construction of the nerves; and causes of nervous disorders.* London.

van Leeuwenhoek, Antoni. 1677a. Microscopical observations of the structure of teeth. *Philosophical Transactions* 12: 1002–1005.

van Leeuwenhoek, Antoni. 1677b. Mr. Leeuwenhoeks letter…of the carneous fibres. *Philosophical Transactions* 12: 899–905.

van Leeuwenhoek, Antoni. 1682. An account of…the internal texture of the flesh of muscles. *Philosophical Collections* # 5: 152–160.

van Leeuwenhoek, Antoni. 1684. An abstract of a letter… concerning scales. *Philosophical Transactions* 14: 586–592.

van Leeuwenhoek, Antoni. 1693. A letter… concerning the seeds of plants. *Philosophical Transactions* 17: 700–708.

van Leeuwenhoek, Antoni. 1706–7. Microscopical observations on the structure of the Spleen. *Philosophical Transactions* 25: 2305–2312.

Verduc, John Baptist. 1704. *A treatise of the parts of a humane body.* Now made English by J. Davis, MD. London.

Wainewritght, Jeremiah. 1707. *A mechanical account of the non-naturals.* London.

Walker, Sayer. 1796. *A treatise on nervous diseases.* London.

Walker, Adam. 1799. *System of familiar philosophy.* London.

Waterhouse, B. MD. 1792. *The rise, progress, and present state of medicine*. Boston.

Watts, Issac. 1742. *Philosophical essays on various subjects,* 3rd ed. London.

Wesley, John. 1871. *The desideratum; or, electricity made plain and useful.* 1759. Reprint. London.

White, Charles. 1799. *An account of the regular gradation in man, and in different animals and vegetables.* London.

Whytt, Robert. 1763. *An essay on the vital and other involuntary motions of animals,* 2nd ed. Edinburgh.

Whytt, Robert. 1767. *Observations on the nature, causes, and cure of those disorders which have been commonly called nervous, hypochondriac, or hysteric,* 3rd ed. Edinburgh.

Willis, Thomas. 1679. *The first part of Pharmaceutice Rationalis, or the operations of medicines in humane bodies*. London.

Willis, Thomas. 1684. *The remaining medical works of Thomas Willis*. London.

Willis, Thomas. 1965. In *The anatomy of the brain and nerves*, ed. William Feindel. Montreal: McGill University Press.

Wilson, Andrew. 1777. *Medical researches*. London.

Wintringham, Clifton. 1743. *An enquiry into the exility of the vessels in a human body*. London.

Wintringham, Clifton. 1752. *The works of the late Clifton Wintringham, physician at York*, vol. 1. London.

Withers, Thomas. 1777. *Observations on chronic weakness*. York.

Yates, William, and Charles Maclean. 1797. *A view of the science of life*. Whitehall.

Secondary Sources

Akert, Konrad, and Michael P. Hammond. 1962. Emanuel Swedenborg (1688–1772) and his contribution to neurology. *Medical History* 4: 255–266.

Allen, Richard C. 1999. *David Hartley on human nature*. New York: State University of New York Press.

Anzieu, Didier. 1989. *The skin ego: A psychoanalytic approach to the self*. Trans. Chris Turner. New Haven: Yale University Press.

Arber, Agnes. 1913. Nehemiah Grew, 1641–1712. In *Makers of British botany: A collection of biographies by living botanists*, ed. F.E. Oliver, 44–64. Cambridge: Cambridge University Press.

Augstein, H.F. (ed.). 1996. *Race: The origin of an idea, 1760–1850*. Bristol: Thoemmes Press.

Bamborough, J.B. 1952. *The little world of man*. London: Longman.

Barker-Benfield, G.J. 1992. *The culture of sensibility: Sex and society in eighteenth-century Britain*. Chicago: University of Chicago Press.

Basthlom, E. 1950. *The history of muscle physiology: From natural philosophers to Albrecht von Haller*. Copenhagen: Ejnar Munksgaard.

Bazin, Germain. 1964. *Baroque & Rococo*. London: Thames & Hudson.

Belloni, Luigi. 1975. Marcello Malpighi and the founding of anatomical microscopy. In *Reason, experiment, and mysticism in the scientific revolution*. Trans. Tomas B. Settle, eds. M.L. Righini Bonelli and William R. Shea, 95–110. New York: Science History Publication.

Bennet, Jonathan. 1994. Locke's philosophy of mind. In *The Cambridge companion to Locke*, ed. Vere Chappell, 89–114. Cambridge: Cambridge University Press.

Benthien, Claudia. 2002. *Skin: On the cultural border between self and the world*. Trans. Thomas Dunlap. New York: Columbia University Press.

Berg, Alexander. 1942. Die Lehre von der Faser als Form- und Funktionselement des Organismus. *Virchows Archiv für Pathologische Anatomie und Physiologie und für klinische Medizin* 309: 333–460.

Bodemer, Charles W. 1964. Regeneration and the decline of preformationism in eighteenth century embryology. *Bulletin of the History of Medicine* 38: 20–31.

Bohde, Daniela. 2003. Skin and the search for the interior: The representation of flaying in the art and anatomy of the Cinquecento. In *Bodily extremities: preoccupations with the human body in early modern European culture*, ed. Florike Egmond and Robert Zwijnenberg, 10–47. Aldershot: Ashgate.

Bolam, Jeanne. 1971. The botanical works of Nehemiah Grew, F.R.S. (1641–1712). *Notes and Records of the Royal Society of London* 26: 219–231.

Bowler, Peter J. 1971. Preformation and pre-existence in the seventeenth century: A brief analysis. *Journal of the History of Biology* 4: 221–244.

Browne, Theodore M. 1974. From mechanism to vitalism in eighteenth-century English physiology. *Journal of the History of Biology* 7: 179–216.

Bynum, William. William Cullen and the nervous system. In *William Cullen*, ed. A. Doig et al., 152–162.

Canguilhem, Georges. 1977. *La formation du concept de refelexe*. Paris. [Japanese translation; *Hansha Gainen no Keisei*, Trans. Osamu Kanamori. Hosei University Press, 1988].

Cardwell, D.S.L. 1971. *From Watt to Clausius: The rise of thermodynamics in the early industrial age*. London: Heinemann.

Chambers, Liam. 2010. Medicine and miracles in the late seventeenth century: Bernard Connor's *Evangelium medici* (1697). In *Ireland and medicine in the seventeenth and eighteenth centuries*, ed. James Kelly and Fiona Clark, 53–72. Farnham: Ashgate.

Chang, Ku-Ming (Kevin). 2004. Motus Tonicus: Georg Ernst Stahl's formation of tonic motion and early modern medical thought. *Bulletin of the History of Medicine* 78: 767–803.

Charland, Louis C. 2008. Alexander Crichton on the psychopathology of the passions. *History of Psychiatry* 19: 275–296.

Cheung, Tobias. 2010. Omni Fibra Ex Fibra: Fibre Oeconomies in Bonnet's and Diderot's models of organic order. *Early Science and Medicine* 15: 66–104.

Clarke, Edwin. 1968. The doctrine of the hollow nerve in the seventeenth and eighteenth centuries. In *Medicine, Science and culture: Historical essays in honour of Owsei Temkin*, ed. Lloyd G. Stevenson and Robert P. Multhauf, 123–131. Baltimore: Johns Hopkins University Press.

Clucas, Stephen. 1991. Poetic atomism in seventeenth-century England: Henry More, Thomas Traherne and 'scientific imagination'. *Renaissance Studies* 5: 327–340.

Cole, F.J. 1921. The history of anatomical injections. In *Studies in the history and method of science*, vol. 2, ed. Charles Singer, 285–343. Oxford: Clarendon Press.

Cole, F.J. 1951. History of micro-dissection. *Proceedings of the Royal Society of London. Series B, Biological Sciences* 138: 159–187.

Colman, William. 1970. Mechanical philosophy and hypothetical physiology. In *The Annus mirabilis of Sir I. Newton*, ed. Robert Palter, 322–332. Cambridge, MA: MIT Press.

Colman, William. 1971. *Biology in the nineteenth century: Problems of form, functions, and transformation*. New York: Wiley.

Connor, Steven. 2004. *The book of skin*. Ithaca: Cornell University Press.

Cross, Stephen J. 1981. John Hunter, the animal economy, and late eighteenth-century physiological discourse. *Studies in History of Biology* 5: 1–110.

Cunningham, Andrew. 1990. Medicine to calm the mind: Boerhaave's medical system, and why it was adopted in Edinburgh. In *The medical enlightenment of the eighteenth century*, ed. Andrew Cunningham and Roger French, 40–66. Cambridge: Cambridge University Press.

Cunningham, Andrew, and Roger French (eds.). 1990. *The medical enlightenment of the eighteenth century*. Cambridge: Cambridge University Press.

Darnton, Robert. 1968. *Mesmerism and the end of the Enlightenment in France*. Cambridge, MA: Harvard University Press.

Dawson, Virginia P. 1987. *Nature's Enigma: The problem of the polyp in the letters of Bonnet, Trembley and Réaumur*. Philadelphia: American Philosophical Society.

Deleuze, Gilles. 1993. *The fold: Leibniz and the Baroque*. Foreword and Trans. Tom Conley. Minneapolis: University of Minnesota Press.

Deutsch, Helen, and Felicity Nusbaum (eds.). 2000. *"Defects": Engendering the modern body*. Ann Arbor: University of Michigan Press.

Doig, A., J. Press, S. Ferguson, I.A. Milne, and R. Passmore (eds.). 1993. *William Cullen and the eighteenth century medical world*. Edinburgh: Edinburgh University Press.

Emerton, E. Norma. 1984. *The scientific reinterpretation of form*. Ithaca: Cornell University Press.

Finney, Gretchen. 1971. Fear of exercising the lungs related to iatro-mechanics 1675–1750. *Bulletin of the History of Medicine* 45: 341–366.

Fletcher, Anthony. 1995. *Gender, sex and subordination in England 1500–1800*. New Haven: Yale University Press.

Fournier, Marian. 1996. *The fabric of life: Microscopy in the seventeenth century*. Baltimore: Johns Hopkins University Press.

Fox, Christopher. 1982. Locke and the Scriblerians: The discussion of identity in early eighteenth century England. *Eighteenth Century Studies* 16: 1–25.

Frank Jr., Robert G. 1980. *Harvey and the Oxford physiologists: A study of scientific ideas*. Berkeley: University of California Press.

Freeman, R.B. 1962. Illustrations of insect anatomy from the beginning to the time of Cuvier. *Medical and Biological Illustration* 12: 174–183.

French, R.K. 1969. *Robert Whytt, the soul, and medicine*. London: Wellcome Institute of History of Medicine.

Gibbons, Brian J. 1998. Mysticism and mechanism: The religious context of George Cheyne's representation of the body and its ills. *British Journal for Eighteenth-Century Studies* 21: 1–23.

Giglioni, Guido. 1997. The machines of the body and the operations of the soul in Marcello Malpighi's Anatomy. In *Marcello Malpighi, anatomist and physician*, ed. Domenico Bertoloni Meli, 149–174. Firenze: Loe S. Olschki.

Giglioni, Guido. 2008. What ever happened to Francis Glisson?: Albrecht Haller and the fate of eighteenth-century irritability. *Science in Context* 21: 465–492.

Gillespie, Neale C. 1987. Natural history, natural theology, and social order: John Ray and the 'Newtonian ideology'. *Journal of the History of Biology* 20: 1–49.

Gouk, Penelope. 2000. Music, melancholy, and medical spirits in early modern thought. In *Music as medicine: The history of music therapy since antiquity*, ed. Peregrine Horden, 173–194. Aldershot: Ashgate.

Gouk, Penelope. 2014. Music and the nervous system in eighteenth-century British medical thought. In *Music and the nerves, 1700–1900*, ed. James Kennaway, 44–71. Basingstoke: Palgrave.

Guerrini, Anita. 2000. *Obesity and depression in the Enlightenment: The life and times of George Cheyne*. Norman: University of Oklahoma Press.

Guerrini, Anita. 2002. The burden of procreation: Women and preformation in the works of George Garden and George Cheyne. In *Science and medicine in the Scottish Enlightenment*, ed. Charles W.J. Wither and Paul Wood, 172–190. East Linto: Tuckwell Press.

Haigh, Elizabeth L. 1976. Vitalism, the soul, and sensibility: The physiology of Theophile Bordeu. *Journal of the History of Medicine* 31: 30–41.

Hall, Thomas S. 1969. *History of general physiology, 600 B.C. to A.D. 1900,* 2 vols. Chicago: University of Chicago Press.

Hankins, Thomas L., and Robert J. Silverman. 1995. *Instruments and the imagination*. Princeton: Princeton University Press.

Harbison, Robert. 2000. *Reflections on Baroque*. London: Reaktion Books.

Harris, Henry. 1999. *The birth of the cell*. New Haven: Yale University Press.

Henry, John. 1997. *The scientific revolution and the origins of modern science*. London: Macmillan.

Hoff, Hebbel E. 1942. The history of the refractory period: A neglected contribution of Felice Fontana. *Yale Journal of Biology and Medicine* 14: 735–772.

Hollander, Anne. 2002. *Fabric of vision: Dress and drapery in painting*. London: National Gallery.

Hook, Judith. 1976. *The Baroque age in England*. London: Thames and Hudson.

Howard-Jones, N. 1951. John Quincy, M.D.[d.1722], apothecary and iatrophyscial writer. *Journal of the History of Medicine* 6: 149–175.

Hunter, Michael. 1992. *Science and society in Restoration England*. 1981. Reprint. Aldershot: Gregg Revivals.

Ilie, Paul. 1995. *The age of Minerva, vol. 2: Cognitive discontinuities in eighteenth-century thought: From body to mind in physiology and arts*. Philadelphia: University of Pennsylvania Press.

Ishizuka, Hisao. 2006. Enlightening the fibre-woven body: William Blake and eighteenth-century fibre medicine. *Literature and Medicine* 25: 72–92.

Ishizuka, Hisao. 2009. Untying the web of Urizen: William Blake, nervous medicine, and the culture of feeling. In *Liberating medicine, 1720–1835*, ed. Tristanne Connolly and Steve Clark, 97–108. London: Pickering and Chatto.

Jacyna, L.S. 1984. The romantic programme and the reception of cell theory in Britain. *Journal of the History of Biology* 17: 13–48.

Jacyna, L.S. 1990. Romantic thought and the origins of cell theory. In *Romanticism and the Sciences*, ed. Andrew Cunningham and Nicholas Jardine, 161–168. Cambridge: Cambridge University Press.

Jacyna, L.S. 1995. Animal spirits and eighteenth-century British medicine. In *The comparison between concepts of life-breath in East and West*, ed. Yosio Kawakita, Shizu Sakai, and Yasuo Otsuka, 139–161. Tokyo: Ishiyaku EuroAmerica, Inc. Publishers.

James, R.R. 1932. William Briggs, M.D. (1650–1704). *British Journal of Ophthalmology* 16: 360–368.

Jaynes, Julian. 1970. The problem of animate motion in the seventeenth century. *Journal of the History of Ideas* 31: 219–234.

Jones, William Powell. 1966. *The rhetoric of science: A study of scientific ideas and imagery in eighteenth-century English poetry*. London: RKP.

Kargon, Robert Hugh. 1966. *Atomism in England*. Oxford: Clarendon Press.

Kassler, Jamie C. 1995. *Inner music: Hobbes, Hooke, and North on internal character*. London: Athlone.

Kassler, Jamie C. 1998. Restraining the passions: Hydropneumatics and hierarchy in the philosophy of Thomas Willis. In *The soft underbelly of reason: The passions in the seventeenth century*, ed. Stephen Gaukroger, 147–164. London/New York: Routledge.

Kassler, Jamie C. 2000. On the stretch: Hobbes, mechanics and the shaking palsy. In *1543 and all that*, ed. G. Freeland and A. Corones, 151–187. Dordrecht: Kluwer Academic Publishers.

Kemp, Martin, and Marina Wallace. 2000. *Spectacular bodies: The art and science of the human body form Leonardo to now*. Berkeley: University of California Press.

Kennaway, James. 2012. *Bad vibrations: The history of the idea of music as a cause of disease*. Farnham: Ashgate.

King, Lester S. 1958. *The medical world of the eighteenth century*. Chicago: University of Chicago Press.

King, Lester S. 1964. Stahl and Hoffmann: A study in eighteenth century animism. *Journal of the History of Medicine* 19: 118–130.

King, Lester S. 1970. *The road to medical Enlightenment 1650–1695*. London: Macdonald.

King, Lester S. 1978. *The philosophy of medicine: The early eighteenth century*. Cambridge, MA: Harvard University Press.

King-Hele, Desmond. 1977. *Doctor of revolution: The life and genius of Erasmus Darwin*. London: Faber.

Kooijmans, Luuc. 2011. *Death defied: The anatomy lessons of Frederik Ruysch*. Trans. Diane Webb. Leiden/Boston: Brill.

Kuriyama, Shigehisa. 1999. *The expressiveness of the body and the divergence of Greek and Chinese medicine*. New York: Zone Books.

Laqueur, Thomas. 1990. *Making sex: Body and gender from the Greeks to Freud*. Cambridge, MA: Harvard University Press.

Lawrence, Christopher. 1979. The nervous system and society in the Scottish Enlightenment. In *Natural order: Historical studies of scientific culture*, ed. Barry Barnes and Steven Shapin, 19–40. London: Sage.

Lawrence, Christopher. 1985. Ornate physicians and learned artisans: Edinburgh medical men, 1726–1776. In *William Hunter and the eighteenth-century medical world*, ed. W.F. Bynum and Roy Porter, 153–176. Cambridge: Cambridge University Press.

Le Fanu, William. 1972. The lost half-century in English medicine, 1700–1750. *Bulletin of the History of Medicine* 46: 319–348.

Lesky, Erna. 1970. Structure and function in Gall. *Bulletin of the History of Medicine* 44: 297–314.

Lindeboom, G.A. 1970. Boerhaave's concept of basic structure of the body. *Clio Medica* 5: 203–208.

Lindeboom, G.A. 1982. Leeuwenhoek and the problem of sexual reproduction. In ed. L.C. Palm, 129–153.

Lindemann, Mary. 1999. *Medicine and society in early modern Europe*. Cambridge: Cambridge University Press.

Long, A.A. 1996. *Stoic studies*. Cambridge: Cambridge University Press.

Lonie, Ian M. 1981. Hippocrates the iatromechanist. *Medical History* 25: 113–150.

Martin, John Rupert. 1977. *Baroque*. Oxford: Westview Press.

Martin, Raymond, and John Barresi. 2000. *Naturalization of the soul: Self and personal identity in the eighteenth century*. London: Routledge.

Mayr, Otto. 1986. *Authority, liberty, and automatic machinery in early modern Europe*. Baltimore: Johns Hopkins University Press.

McNeill, Maureen. 1987. *Under the banner of science: Erasmus Darwin and his age*. Manchester: Manchester University Press.

Meli, Domenico Bertoloni. 2011. *Mechanism, experiment, disease: Marcello Malpighi and seventeenth-century anatomy*. Baltimore: Johns Hopkins University Press.

Melsen, Andrew G. Van. 1960. *From atomos to atom: The history of the concept of atom*. 1952. New York: Harper & Brothers.

Mintz, Samuel I. 1996. *The hunting of Leviathan*. 1962. Reprint. Bristol: Thoemmes Press.

Moravia, Sergio. 1975. From *homme machine* to *homme sensible*: Changing eighteenth-century models of man. *Journal of the History of Ideas* 39: 45–60.

Mullan, John. 1988. *Sentiment and sociability: The language of feeling in the eighteenth century*. Oxford: Clarendon Press.

Ogborn, Miles. 1998. *Spaces of modernity: London's geographies 1680–1780*. London: Guilford Press.

Pagel, Walter. 1967. *William Harvey's biological ideas: Selected aspects and historical background*. New York: Hafner.

Palm, L.C., and H.A.M. Snelders (eds.). 1982. *Antoni van Leeuwenhoek 1632–1723*. Amsterdam: Rodopi.

Paster, Gail Kern. 1997. Nervous tension: Networks of blood and spirit in the early modern body. In *The body in parts: Fantasies of corporeality in early modern Europe*, ed. David Hillman and Carla Mazzio, 107–125. London: Routledge.

Pickstone, John V. 1973. Globules and coagula: Concepts of tissue formation in the early nineteenth century. *Journal of the History of Medicine* 28: 336–356.

Pinto-Correia, Clara. 1997. *The ovary of eve: Egg and sperm and preformation*. Chicago: University of Chicago Press.

Porter, Roy. 1989. Erasmus Darwin: Doctor of revolution? In *History, humanity, and evolution*, ed. James R. Moore, 39–70. Cambridge: Cambridge University Press.

Porter, Roy (ed.). 1995a. *Medicine in the Enlightenment*. Amsterdam: Rodopi.

Porter, Roy. 1995b. The eighteenth century. In *The Western medical tradition: 800 BC to AD 1800,* eds. Lawrence I. Conrad, Michael Neve, Vivian Nutton, Roy Porter, and Andrew Wear, 393–394. Cambridge: Cambridge University Press.

Porter, Roy. 2000. *The creation of the modern world: The untold story of the British Enlightenment*. New York: Norton.

Porter, Roy. 2003. *Flesh in the age of reason: The modern foundations of body and soul*. New York: Norton.

Porter, Roy, and Marie Mulvey Roberts (eds.). 1996. *Pleasure in the eighteenth century*. Basingstoke: Macmillan.

Pyle, Andrew. 2006. Malebranche on animal generation: Preexistence and the microscope. In *The problem of animal generation in early modern philosophy*, ed. Justin E. Smith, 194–214. Cambridge: Cambridge University Press.

Rather, L.J. 1969. Some relations between eighteen-century fibre theory and nineteenth-century cell theory. *Clio Medica* 4: 191-02.

Reill, Peter Hanns. 2005. *Vitalizing nature in the Enlightenment*. California: University of California Press.

Rendell, J.R. 1910. Swedenborg on the cerebral cortex as the seat of psychological activity. In *Transactions of the international Swedenborg congress, held in connection with the celebration of the Swedenborg's centenary*, 56–70. London: Swedenborg Society.

Rifkin, Benjamin A., Michael J. Ackerman, and Judith Folkenberg. 2006. *Human anatomy: From the Renaissance to the digital age*. New York: Abrams.

Risse, Guenter B. 1992. Medicine in the age of Enlightenment. In *Medicine in society: Historical essays*, ed. Andrew Wear, 149–196. Cambridge: Cambridge University Press.

Rist, J.M. 1969. *Stoic philosophy*. Cambridge: Cambridge University Press.

Roach, Joseph R. 1985. *The player's passion: Studies in the science of acting*. Ann Arbor: University of Michigan Press.

Roberts, K.B., and J.D.W. Tomlinson. 1992. *The fabric of the body: European traditions of anatomical illustration*. Oxford: Clarendon Press.

Roger, Jacques. 1997. *The life sciences in eighteenth-century French thought*. ed. Keith R. Benson. Trans. Robert Ellrich. Stanford: Stanford University Press.

Rogers, John. 1996. *The matter of revolution: Science, poetry, & politics in the age of Milton*. Ithaca: Cornell University Press.

Rousseau, G.S. 1989. Discourse of the nerve. In *Literature and science as modes of expression*, ed. Frederick Amrine, 29–60. Boston: Kluwer Academic Publisher.

Rousseau, G.S. (ed.). 1990. *The language of psyche: Mind and body in Enlightenment thought*. Berkeley: University of California Press.

Rousseau, G.S. 1991a. Nerves, spirits, and fibres: Towards an anthropology of sensibility. In idem, *Enlightenment crossings: Pre- and post- modern discourses, anthropological*, 122–141. Manchester: Manchester University Press.

Rousseau, G.S. 1991b. Towards a semiotics of the nerves: The social history of language in a new key. In *Language, self and society: A social history of language*, ed. Peter Burke and Roy Porter, 213–275. London: Polity.

Rousseau, G.S. 1993. Medicine and the muses: An approach to literature and medicine. In *Literature and medicine during the eighteenth century*, ed. Marie Mulvey Roberts and Roy Porter, 23–57. London: Routledge.

Rousseau, G.S. 2004. *Nervous acts: Essays on literature, culture and sensibility*. Basingstoke: Palgrave.

Rousseau, G.S. 2005. Temperament and the long shadow of nerves in the eighteenth century. In *Brain, mind and medicine: Essays in eighteenth century neuroscience*, ed. Harry Whitaker, C.U.M. Smith, and Stanley Finger, 353–369. New York: Springer.

Rousseau, G.S. 2006. A sympathy of parts: Nervous science and Scottish society. In *Anatomy acts: How to know ourselves*, ed. Andrew Patrizio and Dawn Kemp, 17–30. Edinburgh: Birlinn.

Rousseau, G.S. 2007. 'Brainomania': Brain, mind and soul in the long eighteenth century. *British Journal for the Eighteenth-Century Studies* 30: 161–191.

Ruestow, Edward G. 1980. The rise of the doctrine of vascular secretion in the Netherlands. *Journal of the History of Medicine* 35: 265–287.

Ruestow, Edward G. 1996. *The microscope in the Dutch Republic: The shaping of discovery*. Cambridge: Cambridge University Press.

Sant, Ann Jessie Van. 1993. *Eighteenth-century sensibility and the novel: The senses in social context*. Cambridge: Cambridge University Press.

Sarafianos, Aris. 2008. The contractility of Burke's sublime and heterodoxies in medicine and art. *Journal of the History of Ideas* 69: 23–48.

Schiebinger, Londa. 1989. *The mind has no sex?: Women in the origins of modern science*. Cambridge, MA: Harvard University Press.

Schoenfeldt, Michael. 1997. Fables of the belly in early modern England. In *The body in parts: Fantasies of corporeality in early modern Europe*, ed. David Hillman and Carla Mazzio, 243–261. London: Routledge.

Schuette, Marie. 1963. *The art of embroidery*. London: Thames and Hudson.

Sherrington, C.S. 1919. Note on the history of the word 'tonus' as a physiological term. In *Contribution to medical and biological research*, vol. 1, 261–268. New York: Hoeve.

Siena, Kevin. 2010. Pliable bodies: the moral biology of health and diseases. In *The cultural history of the human body in the Enlightenment*, ed. Carole Reeves, 33–52. Oxford: Berg.

Smith, C.U.M. 1987. David Hartley's Newtonian neurophysiology. *Journal of the History of the Behavioral Sciences* 23: 123–136.

Smith, C.U.M. 2005. All from fibres: Erasmus Darwin's evolutionary psychobiology. In *The genius of Erasmus Darwin*, ed. C.U.M. Smith and Robert Arnott, 133–144. Aldershot: Ashgate.

Smith, Roger. 1973. The background of physiological psychology in natural philosophy. *History of Science* 11: 75–123.

Snelders, H.A.M. 1982. Antoni van Leeuwenhoek's mechanistic view of the world. In *Antoni van Leeuwenhoek 1632–1723*, ed. L.C. Palm and H.A.M. Snelders, 57–78. Amsterdam: Rodopi.

Solmsen, Friedrich. 1950. Tissues and the soul: Philosophical contributions to physiology. *Philosophical Review* 59: 435–468.

Stafford, Barbara Maria. 1991. *The body criticism: Imagining the unseen in enlightenment art and medicine*. Cambridge, MA: MIT Press.

Steedman, Carolyn. 1995. *Strange dislocations: Childhood and the idea of human interiority, 1780–1930*. London: Virago.

Steinke, Hubert. 2005. *Irritating experiments: Haller's concept and the European controversy on irritability and sensibility, 1750–1790*. Amsterdam: Rodopi.

Stenn, Frederick. 1941. Giorgio Baglivi. *Annals of Medical History* 3: 183–194.

Stepan, Nancy. 1982. *The idea of race in science: Great Britain, 1800–1960*. London: Macmillan.

Stolberg, Michael. 2011. *Experiencing illness and the sick body in early modern Europe*. Basingstoke: Palgrave.

Stott, Rosalie. 1987. Health and virtue: Or how to keep out of harm's way. Lectures on pathology and therapeutics by William Cullen c.1770. *Medical History* 31: 123–142.

Taki, Koji. 1996. The cosmos of the cloth. In idem, *Yokubono Shujigaku* [The rhetoric of desire]. Tokyo: Seidosha.

Taylor, D.W. 1988. Discourses on the human physiology by Alexander Monro *primus* (1697–1767). *Medical History* 32: 65–81.

Temkin, Owsei. 1964. The classical roots of Glisson's doctrine of irritation. *Bulletin of the History of Medicine* 38: 297–328.

Thiel, Udo. 1998. Locke and eighteenth-century materialist conceptions of personal identity. *Locke Newsletter* 29: 59–83.

Thiel, Udo. 2011. *The early modern subject: Self-consciousness and personal identity from Descartes to Hume*. Oxford: Oxford University Press.

Thomson, John. 1859. An account of the life, lectures, and writings of William Cullen, 2 vols. Edinburgh.

Trower, Shelley. 2012. *Senses of vibration: A history of the pleasure and pain of sound*. New York: Continuum.

Uglow, Jenny. 2002. *The lunar men: The friends who made the future, 1730–1810*. London: Faber and Faber.

Vickers, Neil. 2004. *Coleridge and the doctors, 1795–1806*. Oxford: Oxford University Press.

Vidal, Fernando. 2002. Brains, bodies, selves, and science: Anthropologies of identity and the resurrection of the body. *Critical Inquiry* 28: 930–974.

Vigarello, Georges. 1988. *Concepts of cleanliness: Changing attitudes in France since the Middle Ages*. Trans. Jean Birrell. Cambridge: Cambridge University Press.

Vila, Anne C. 1998. *Enlightenment and pathology: Sensibility in the literature and medicine of eighteenth-century France*. Baltimore: Johns Hopkins University Press.

Wade, Nicholas J. 1999. *A natural history of vision*. Cambridge, MA: MIT Press.

Wahrman, Dror. 2004. *The making of the modern self: Identity and culture in eighteenth-century England*. New Haven: Yale University Press.

Walker, D.P. 1958. *Spiritual and demonic magic from Ficino to Campanella*. London: Warburg Institute.

Walker, D.P. 1985. Medical spirits in philosophy and theology from Ficino to Newton. In *Music, spirit, and language in the Renaissance*, ed. Penelope Gouk, 287–300. London: Variorum Reprints.

Wardle, Patricia. 1970. *Guide to English embroidery*. London: Her Majesty's Stationary Office.

Webster, Charles. 1965. The discovery of Boyle's law, and the concept of the elasticity of air in the seventeenth century. *Archive for History of Exact Sciences* 2: 441–502.

Wellman, Kathleen. 1992. *La Mettrie: Medicine, philosophy, and Enlightenment*. Durham: Duke University Press.

Wetmore, Alex. 2009. Sympathy machines: Men of feeling and the automaton. *Eighteenth Century Studies* 43: 37–54.

Williams, Elizabeth A. 2003. *A cultural history of medical vitalism in Enlightenment Montpellier*. Burlington: Ashgate.

Wilson, J. Walter. 1947. Dutrochet and the cell theory. *Isis* 37: 14–21.

Wilson, Catherine. 1995. *The invisible world: Early modern philosophy and the invention of the microscope*. Princeton: Princeton University Press.

Wright, John P. 1990. Metaphysics and physiology: Mind, body, and the animal economy in eighteenth-century Scotland. In *Studies in philosophy and Scottish Enlightenment*, ed. M. A. Stewart, 251–302. Oxford: Oxford University Press.

Yolton, John. 1983. *Thinking matter: Materialism in eighteenth-century Britain*. Minneapolis: University of Minnesota Press.

Index

Note: Page numbers followed by “n” refers to notes.

H. Ishizuka, *Fiber, Medicine, and Culture in the British Enlightenment*, DOI 10.1057/978-1-349-93268-9