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Charles Bell's seeing hand: Teaching anatomy to the senses in Britain, 1750–1840

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Abstract
Charles Bell's Bridgewater Treatise on the hand should be read as elaborating philosophies of pedagogy and the senses, and as fitting with Bell's work on the nervous system. In *The Hand*, Bell argues that sensory reception must be coupled with muscular action to establish true knowledge, elevating the 'doing' hand to epistemological parity with the long-superior 'seeing' eye. Knowledge in anatomy was typically couched in terms to do with sight and depiction; but according to Bell, anatomy simply could not teach the sort of feeling that one would encounter inside a living body. Instead, anatomy taught students to map the parts so that their fingers, moving through a surgical field, could 'see' and therefore could know and could act. This elevation of the status of the hand also had social implications that fit with Bell's reformist politics.

Keywords
Charles Bell, Bridgewater Treatises, Pedagogy, Anatomy, Touch, Vision, the Senses.

Charles Bell's Bridgewater Treatise on the hand is well known to historians as an exemplar of natural theology in the 1830s.[1] But the book also reflects Enlightenment philosophy of mind, relationships between manual and cognitive labor, and a pedagogical philosophy, all of which were as important to the author as the straightforward natural theological arguments contained within it.[2] Historians who have written about Bell's anatomy have tended not to discuss Bell's Bridgewater Treatise on the hand, while those (few) who have discussed his work popularizing science (the framework through which the Bridgewater Treatise is often contextualized) have seen that as separate from his scientific inquiries and discoveries.[3] Using Bell's *The Hand, Its Mechanism and Vital Endowments as Evincing Design*,[4] I argue here that the work represented a pedagogical program.

A surgeon-anatomist, Sir Charles Bell was an enlightenment philosopher living in an age of reform. He was an ambitious surgeon and anatomist, an aspiring natural philosopher, an artist, a reluctant vivisectionist and defender of priority for a discovery of the

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separate roots of motor and sensory nerves against the challenges of the Frenchman François Magendie.[5] He was also a pedagogue and through his pedagogy we can find unity in what has often been seen as disparate work. His pedagogy was rooted in a philosophy of the senses that was born in Enlightenment Edinburgh and was closely tied to Bell's work on the nervous system. Through that philosophy, students were taught to visualize using the hand; they were taught that vision was necessarily combined with the action of the will through the eye's analogous organ, the hand, in order for one to knowingly see. The implications of that philosophy of the senses, however—a philosophy that focused on the hand and eye and on the relationships between feeling, seeing and knowing—were also social and political. Bell's philosophy of learning was reformist in nature.

Charles Bell, who was eventually knighted for his work on the nervous system, was nonetheless always striving to situate himself among natural philosophers. Thus, as a surgeon without the distinctions that classical learning might have bestowed upon him, he was eager to improve the epistemological standing of the hand and of embodied knowledge—even his most philosophical writings are those of a man whose work was largely manual and yet whose field, surgery, had long been assigned low status within the world of medicine because it was work of the hands. It is important to recognize the call for epistemological parity between hand and eye in his Bridgewater Treatise in order to understand Bell better. His Bridgewater Treatise also presents an opportunity, however, for insight into the tactile in the history of science. Despite much recent work on the role of the senses in science and its history, what has been done has focused primarily on sound/hearing, smell and vision, with comparatively little attention focused on touch.[6] Surgery and anatomy present very good (perhaps uniquely good) opportunities to expand that work and to investigate the role of touch in the history of science.[7] Charles Bell's writing, the writing of a philosopher-surgeon, gives voice to that neglected sense.

Pedagogy, reform and Bell's Bridgewater Treatise on the Hand

The Georgian London that formed the backdrop for Bell's Bridgewater Treatise was one embroiled in reform. The Great Reform Act of 1832 (just one year before Bell's treatise was published) has caused historians to define the surrounding decades (as early as 1780 and late as 1860) as the 'Great Age of Reform'.[8] A variety of medical reform movements existed in the early nineteenth century alongside reform movements of other sorts, including those that were political in nature.[9] Adrian Desmond's 'radical reformers' in his *The Politics of Evolution* were medical men who imported Continental life sciences such as morphology and experimental physiology, as well as philosophical materialism, into London University's classrooms; as a consequence, Desmond's work has defined those reformers for other historians since its publication.[10] But those radical reformers had conservative counterparts who were also interested in reform. These 'conservative reformers' employed a rhetoric of tradition in their calls for reform and argued for incremental changes, particularly in educational requirements and licensing laws, and small modifications and the improvement of a system already in place, rather than revolutionary overhaul of medical institutions.

Many medical reformers tapped into a rhetoric that was available from the political sphere, but the medical reform movement also had its own issues and politics that

diverged from national politics.[11] Conservative medical reformers emphasized practical skills and systematic education, and had some immediate success in shaping what constituted medical science and medical education in Britain. Pedagogy became the center of British medical improvement and the site at which medicine and science were integrated. London reformers developed particular ways of defining British medicine and its strengths and argued for restructuring and improvement in ways that complemented those definitions. Still, despite their reliance on British tradition, these conservative reformers had real ambitions for moderate reform through education.[12]

Amidst such foment and calls for reform and revolution, Charles Bell built his career and his anatomical research around pedagogy, developing a teaching career as a way of publicizing his discoveries on the nerves and of earning a living. He ran a private anatomy school in London, only to leave it for other pedagogical ventures, first contributing to the founding of London University and later the Middlesex Hospital School. He wrote textbooks for students of art, anatomy and surgery, and his primary occupation was always that of a teacher.[13] But in looking for Bell's pedagogical philosophy, I am going to focus here on a book of Bell's that is not usually considered a pedagogical text—his Bridgewater Treatise on the hand, for it is here that we find clearly expressed some of the fundamental notions underlying and motivating his pedagogical thinking and practice.

In 1829, Francis Egerton, the eighth Earl of Bridgewater, died, leaving behind in his will a sum of money to be made available to the President of the Royal Society of London for a specific purpose: to commission someone to 'write, print, and publish, one thousand copies of a work On the Power, Wisdom, and Goodness of God, as manifested in the Creation; illustrating such work by all reasonable arguments, as, for instance, the variety and formation of God's creatures in the animal, vegetable, and mineral kingdoms'.[14] The President of the Royal Society at the time, Davies Gilbert, Esq., together with the Archbishop of Canterbury and the Bishop of London, worked to appoint eight gentlemen to write separate Treatises on the different branches of the subject. Bridgewater Treatises became scientific best-sellers of the nineteenth century in large part because they presented accessible, safe general science. They succeeded as scientific teaching texts that did not threaten religious authority, rather than as examples of demonstrative natural theology or formal apologetics.[15] As such, they stand beside a host of attempts to educate an increasingly large and therefore powerful working and middle class populace in science and rational thought. The popularity of Bell's volume is evidenced by its nine editions published within four decades.[16] Nonetheless, Bell's treatise on the hand has been little examined by historians, who have long treated its natural theological and popularizing purposes as straightforward, uninteresting and not integral to Bell's other, more scientific endeavors.[17] Such a popularizing mission might well appear to be the sole or principal way of understanding Bell's *The Hand* as a text with social implications, but to view it that way is to frame the book as separate from Bell's other pursuits in anatomy and medical education. It was not separate.

The Hand is not a particularly theological work, nor one that is obviously simplified for a popular audience. It is not even clearly and consistently about the human hand. Instead, Bell establishes a 'definition of the hand', with the second chapter bearing exactly that title, in which he asserts: 'We ought to define the Hand as belonging exclusively to Man—corresponding in its sensibility and motion to the endowments of his Mind'.[18] In fact, for Bell the 'hand' is defined as much by structure as by function: his

treatise discusses a broad range of different organs that exist in the locations of hand-like appendages. He begins to contextualize by talking about monkeys, whose hands function like those of humans, but who also use their hands for climbing. From there he draws up a list that relies sometimes on structural similarity (of bones, or sometimes of muscles) and sometimes on functional similarity, the common thread being simply that he is interested in the extremities of animals. The bones of the hand, he says, 'so truly admirable in man, are recognized in the fin of the whale, in the paddle of the turtle, and in the wing of the bird; we see the corresponding bones, perfectly suited to their purpose in the paw of the lion, or the bear; and equally fitted for motion in the hoof of the horse or in the foot of the camel; or adjusted for climbing or digging, in the long-clawed feet of the sloth or bear'.[19] He draws that group together by saying that he means to examine 'the bones and muscles, which in different animals are suited to particular purposes so combined in the Hand…'[20] His view of the subject is expansive, for he writes that it would be a mistake to look 'at a part only, instead of embracing a comprehensive system; where by slight, hardly perceptible changes and gradations in the forms, the analogous bones were adjusted to every condition of animal existence'.[21] Thus, in this treatise purportedly about the human hand, one can identify a rather Cuvierian argument about the extremities of a wide range of animals and the ways in which those extremities are suited both to the animals' bodies in which they are found and to the environments in which those bodies live.[22]

The Hand, Its Mechanism and Vital Endowments, as Evincing Design appears at the outset to be a fairly detailed and technical description of comparative anatomy—not just of hands, but of extremities—paws, and even the 'feelers, tentacles, and suckers' of fish that serve as instruments of sensation and locomotion. The book is full of pictures (Figures 1 and 2), and of words that act like pictures, with the last section of the book even called 'additional illustrations' (by which Bell means examples, not pictures). It is largely composed of technical, descriptive natural history and comparative anatomy, but the descriptive character was no accident: description was among the first stages of learning, according to Bell and to many of his contemporaries who were also interested in learning through sensation. This was itself a book about learning and about teaching.[23]

Bell's *The Hand*, rather than being a straightforward piece of natural theology, elaborated the pedagogical philosophy of a British anatomist and surgeon in a way that makes the book a central part of Bell's work, both on systematizing the reform of medical and surgical education, and on the nervous system. That pedagogical philosophy was grounded in the senses and in their interrelationship: direct experience—visual and tactile experience of the sort described in *The Hand*—provided the basis of all learning.

While the idea of sense-based learning was common, the eyes had long been privileged in a way that Bell aimed to subvert. Bell's philosophy of the senses is captured in a short passage from a chapter titled 'Of the Muscular Sense', in which Bell writes: 'When treating of the senses, and showing how one organ profits by the exercise of the other, and how each is indebted to that of touch, I was led to observe that the sensibility of the skin is the most dependent of all on the exercise of another quality. Without a sense of muscular action…touch could hardly be an inlet to knowledge at all.'[24] When discussing the senses, we now tend to connect a particular anatomical part or parts to particular kinds of sensation. But according to Bell, the various senses, which were thought to be the foundation of all knowledge, could hardly 'know' unless they could act. Touch could not be the inlet

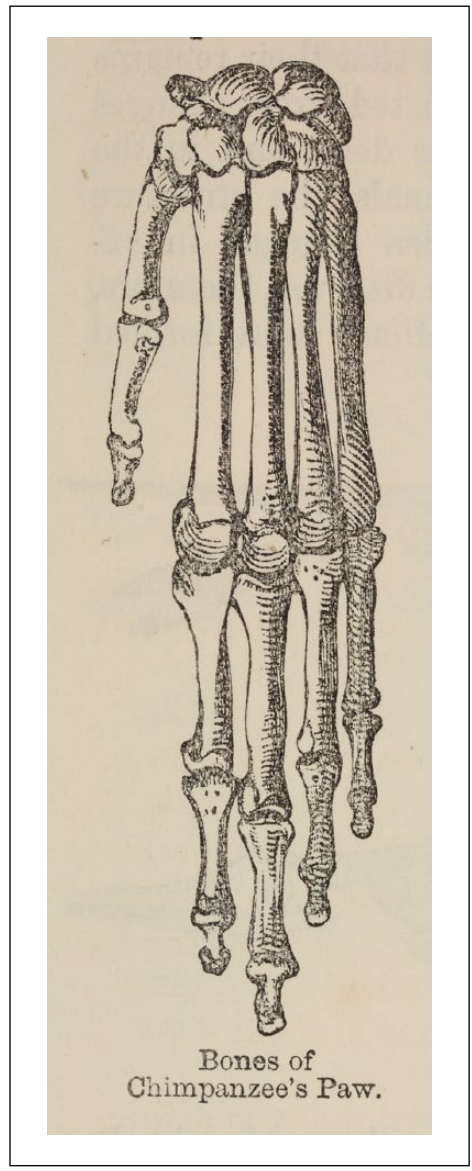

Figure 1. Images of the various 'hands' Bell discusses in his Bridgewater Treatise range from that of the chimpanzee, as shown here, to the foot of a camel and 'suckers and feelers' of fish. Charles Bell, *The Hand, Its Mechanism and Vital Endowments as Evincing Design*. London: William Pickering, 1833, p. 87. Photograph courtesy of James Voelkel of the Chemical Heritage Foundation.

to knowledge without muscular action; how, then, could vision create knowledge other than through a different, active organ? Eyes and hands had to be paired so that the eye, and vision, could be an inlet to knowledge through action. This philosophy of the senses

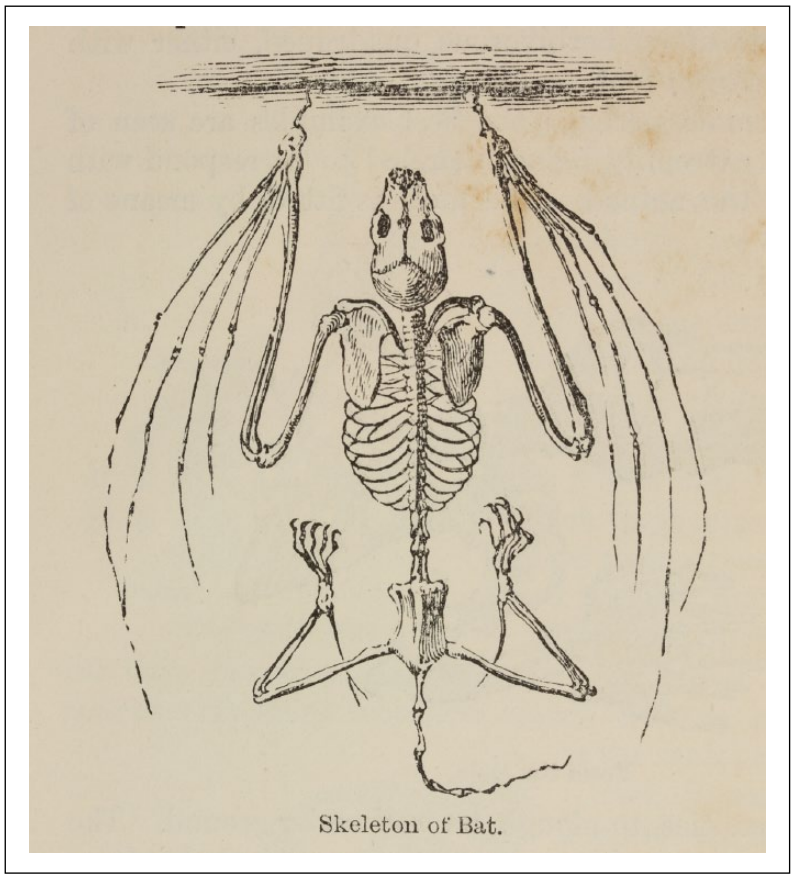

Figure 2. The bat pictured here is contrasted with the skeleton of a mole in Bell's text as evidence of the suitedness of animals' forms to their particular environments (in this case, the bat's delicate bones perfectly suited to a life in the air, while the mole's more robust frame was appropriate to a life spent burrowing underground). Ibid, p. 61. Photograph courtesy of James Voelkel of the Chemical Heritage Foundation.

provides us with a way of understanding why a treatise on the hand should talk a great deal about the eye; why Bell immediately establishes his subject as hands, defined functionally, in the context of systems of organs within which they act; and why Bell's Bridgewater Treatise on the hand ends with a chapter titled 'Comparison of the Eye with the Hand'.

The eye and hand were similar organs, trained analogously, allowing the surgeon's or artist's hands to see, and therefore to know, which meant to act. Such haptically embodied vision is rooted in Bell's pedagogical system, a system that was itself grounded in sensation and in objects, but that was meant to train surgeons. That system privileged vision as the most significant sensory impulse for building knowledge at the same time that it valued the hand as a necessary expression and extension of the eye in building knowledge and as a vehicle for expressing the will through action.

Seeing, learning, and *The Hand*

Bell's pedagogical philosophy addressed a theme that abounded in the early nineteenth century—the relationship between sensory perception and learning. The relation was found in the much-publicized work of contemporary educational philosophers, as well as in the practices of private anatomy teachers in London who built museums and anatomy theaters, and in the works of the so-called Common Sense philosophers of Edinburgh, among whom Bell was schooled and with whom he socialized.[25] Bell combined these different strains in the medical classroom, and they came together in his Bridgewater Treatise.

Bell grew up in Edinburgh at a time when Moral Philosophy had significant standing—when it was taken to be at the core of Edinburgh's Enlightenment. His father an Episcopalian minister, Bell was born into a relatively modest household, but their financial situation worsened when Bell's father died when Charles was only five years old. There was no money for an extensive formal education for Charles or his brothers, but each found his place in a tight-knit intellectual society.[26]

In an 1872 profile of Charles Bell and review of his 'Letters and Discoveries', the *Edinburgh Review* wrote of Charles and his brother George Joseph's early education that 'there were three men occupying chairs of public instruction in Scotland during Charles Bell's early manhood, who, although they had no direct influence on his career, were yet so instrumental in moulding the modes of thought of the society to which he belonged… that this sketch would be imperfect without some mention of them…'.[27] Those three were John Millar, John Playfair, and Dugald Stewart. The review notes too that Edinburgh's circles at the time were narrow, bringing together 'a very brilliant intellectual assembly',[28] which included George's young friends Walter Scott, Francis Jeffrey, and Henry Brougham, as well as University men like Joseph Black, Alexander Monro Secundus, and William Cullen. All were heirs to the great thinkers of the generation immediately prior—Adam Smith, Thomas Reid, Adam Ferguson, and William Robertson.[29]

Bell referred admiringly to Dugald Stewart in his letters to George even after he had moved to London, asking in a typical passage from 1808, 'Could you not get Dugald Stewart, or Playfair, to look at my manuscript of the Brain?'[30] It is not so much that Bell directly adopted the philosophy of Stewart or of any of the other luminaries of the Scottish Enlightenment, but rather that Bell inhabited a social and intellectual world in which questions about learning and the ways in which the mind worked were of central concern; he clearly held in high regard people for whom the answers to such questions involved sensory experience developed into general laws and orders of nature.

Jennifer Tannoch-Bland has said of Stewart: 'He offered an image of himself as an explicator of systems, an educator'.[31] The system to which he most concertedly applied himself was that of mental philosophy, 'embark[ing] on the construction of a methodologically grounded model for a science of mind' that would answer the 'charge that mental philosophy was not scientific because it was non-experimental by questioning the distinction between experiment and observation'.[32] According to Stewart himself, at the foundation of natural philosophy, 'how far soever we may carry our simplifications, we must ultimately make the appeal to facts for which we have the evidence of our senses…'.[33] Those facts could be accumulated and analogized, expanded through abstraction and induction. Stewart explained how this development of knowledge could be seen through the ways in which language was formed, making reference to another

Scottish philosopher, Adam Smith, whose pupil he was, and whose biographical memoir he wrote in 1793—a further indication of the small intellectual community whose members were so often in dialogue with each other, and which had produced Bell. The first step, wrote Stewart, 'would be the assignation of particular names to denote particular objects… Afterwards, as the experience of men enlarged, these names would be gradually applied to other objects resembling the first… objects come at last to be classified and referred to their proper genera and species.'[34] Bell's pedagogical philosophy reflects similar themes and explanatory mechanisms. Like Stewart, Bell describes the accumulation of sensory experience, the proper linguistic description of sensations and objects, and ultimately the relationships of objects to each other.

Similar ideas had appeared in the work of the Swiss pedagogue Johann Pestalozzi, being mentioned in publications in English as early as 1803 when the *Philosophical Magazine's* 'Proceedings of Learned Societies' wrote of the Academy of Sciences at Berlin that there was a paper read 'On Pestalozzi's method of teaching, by professor Fischer'.[35] While there is no mention of Pestalozzi in Bell's letters, Bell read widely, and Pestalozzi's work was popular and relatively well-known. A fuller account of his life and teaching methods was printed in *The Athenaeum* in 1807,[36] and Pestalozzi's annual address to members of his school, which appealed for funds for his educational institute, was printed in English in 1818 as 'The Address of Pestalozzi to the British public soliciting them to aid by subscriptions his plan of preparing schoolmasters and mistresses for the people, that mankind may in time receive the first principles of intellectual instruction from their Mothers'.[37] But what became one of the most widely cited British accounts of Pestalozzi and his methods came from Charles Mayo, whose lecture on Pestalozzi's life and methods, delivered at the Royal Institution in 1826, received wide notice in periodicals. In that lecture, later printed in its entirety, Mayo said of Pestalozzi's philosophy: 'The cultivation of the higher intellectual faculties of reasoning, taste, &c. is preceded by the careful development of just observation and clear intellectual conception. For this purpose, real objects are presented to the examination of the younger pupils; the physical senses are trained to accurate perception, and the understanding is gradually led to generalize and classify the notices it receives through them.'[38] Like Adam Smith, Pestalozzi conceived of the formation of knowledge in terms of the accumulation of experience and then generalization and classification. Mayo then described the objects of education in Pestalozzi's system, saying that the first 'must be to lead a child to observe with accuracy; the second, to express with correctness the result of his observation. The practice of embodying in language the conceptions we form gives permanence to the impressions; and the habit of expressing ourselves with the utmost precision of which we are capable mainly assists the faculty of thinking with accuracy, and remembering with fidelity.'[39] Bell's pedagogical project was clearly one whose themes and explanatory mechanisms resonated with broad philosophical concerns of the day that had their likely roots in somewhat earlier Scottish philosophy and its Lockean preoccupations.

Written relatively late in Bell's career, *The Hand* should be seen as a mature articulation of a pedagogical philosophy. By contextualizing it in that way, we can see *The Hand* as central to the rest of Bell's work, rather than as an isolated and idiosyncratic side project. Bell was explicit concerning his preoccupations with popularizing missions more generally, and this suggests the need for precisely such recontextualization. Two

years prior to the publication of *The Hand*, seeming to worry about redundancies in publications of the Society for the Diffusion of Useful Knowledge (SDUK),[40] he wrote of the planned Bridgewater Treatises that 'the encyclopaedists are all writing the same stuff. And here are eight men more to wear the subject to the bone—all the same work'.[41] Bell's concern about copying work or revisiting subjects that had already been addressed, 'wearing them to the bone,' or reducing their complexity unjustly, suggests that he saw his presentation of the anatomy of the hand as something other than a recapitulation for a popular audience of work that had been done elsewhere. His contribution, then, came in the elaboration and application to medical teaching of a pedagogical philosophy in which books served as secondary to objects and knowledge through books was developed first by description of experience and second by arrangement into a system of such descriptions.[42] It was a pedagogical philosophy that drew upon, synthesized, and expanded the work of others. The description Tannoch-Bland gives of Stewart as 'explicator of systems, an educator'[43] could as easily be applied to Bell.

The system of learning described in Bell's Bridgewater Treatise was a developmental and sensory one. For Bell, learning began with simple exposure to objects in the world: 'In the early stages of life, before our minds have the full power of comprehension, the objects around us serve but to excite and exercise the outward senses…'.[44] Sensory apparatus, however, were undisciplined, and had to be trained to perceive well. Eyes had to be physically taught to see, for example, as Bell wrote: 'This faculty of searching for the object is slowly acquired in the child; and, in truth, the motions of the eye are made perfect, like those of the hand, by slow degrees'.[45] In addition to the conditioning of motion, impressions had to be prepared, so that men knew how to look for, rather than at, Nature. In time, perceptions ordered and compared, made systematic. Bell regarded the hand, the subject of his text, as a challenge to the anatomy teacher (one could assume all the more so in a text for a general audience)—lots of little bones to account for in a rather ordinary-seeming appendage. 'The demonstration to the anatomical student of the muscles of the human hand and arm, becomes the test of his master's perfection as a teacher. Nothing is more uninteresting, tedious, and difficult to attend to, than the demonstration of the muscles of the arm, when they are taken successively, as they present themselves.'[46] The good teacher's secret, it seems, was to take these muscles as a part of a system, a system with an intelligible order, one that coupled form and function. In Bell's own words, 'when they are taught with lucid arrangement, according to the motions performed by them, it is positively agreeable to find how much interest may be given to the subject'.[47]

Training of the senses, then, was accomplished both through the conditioning of the will controlling muscular action, and through the accumulation and comparison of sensation. In a crucial passage, Bell argued: 'In both organs [the hand and eye] there is a compound operation:—the impression on the nerve, of sense is accompanied with an effort of the will, to accommodate the muscular action to it'.[48] Sensation, then, could only provide knowledge when coupled with muscular action.

When the senses had been trained through conditioning and their impressions compared, that sensory knowledge was enrolled in the representation of anatomy through the artistic or surgical action of the will. And once the will and the body were trained, then reason and philosophy could be developed, for, according to Bell, 'in the maturity of reason, philosophy should present…things to us anew, with this difference, that the mind

may contemplate them: that mind which is now strengthened by experience to comprehend them, and to entertain a grateful sense of them'.[49] Sensory experience, then, was followed by training of the senses and the will, training was followed by definition and description, and finally definition and description were followed by reason and truth.

A look at the table of contents for *The Hand* finds this pedagogical philosophy reflected in the chapter headings: 'Chapter II. Definition Of The Hand', 'Chapter III. The Comparative Anatomy of the Hand', 'Chapter X. The Hand Not the Source of Ingenuity or Contrivance, Nor Consequently of Man's Superiority'. Chapters progress from description, to comparison, to reasoning and philosophizing from that comparison. The topics of the first two chapters listed are rather self-evident, whereas Chapter X is an example of the kinds of deductions that can be made from comparison. Bell uses it as an opportunity to discuss the suitability of an animal's characters to each other and to that animal's environment—in the case of man, his hand is suited to his mind, much as it is to his other organs:

> The hand is not a thing appended… a thousand intricate relations must be established throughout the body in connection with it—such as nerves of motion and nerves of sensation: and there must be an original part of the composition of the brain, which shall have relation to these new parts, before they can be put in activity. But even with all this superadded organization the hand would lie inactive, unless there were created a propensity to put it into action.[50]

Such knowledge, such deductions and philosophizing, could only come, in both the text and in teaching, after sensation, description, and comparison.

Pedagogy and practice

By taking note of its pedagogical philosophy, we can begin to place Bell's Bridgewater Treatise squarely within the context of his other work and practices. For example, *The Hand* describes teaching based on the sorts of sensory experiences that Bell systematized in the displays that populated his classroom.

Bell's classroom was filled with objects that fitted with his understanding of learning. Visual experience of dead bodies—dissections conducted at the front of a classroom, chalk drawings and diagrams, grand and detailed engravings, wax casts, and jarred specimens collected to capture all varieties, with multiple specimens of each organ—taught students to know anatomy.[51] These displays were deliberately arranged and each taught a different kind of seeing, functioning as a system. Together they laid the foundation for the education of a surgeon, by a man whose pedagogical philosophy was based in sensory experience. A series of organs would be arranged in jars on shelves, interspersed with engravings and books, wax models and casts, and a catalogue defining each object, organized to promote the sort of comparison and ordering that Bell advocated in *The Hand*. Within the system of displays, each organ would be exhibited by a series of specimens that represented the range and variety of normal anatomy and pathological anatomy that deviated from normal in predictable ways. The ordering carried with it all the various stages of learning: sensory experience, definition of the parts, comparison, and reason, the inferred philosophical truth being much like that of *The Hand*—that Nature is knowable and has an order.

But while the sensory experience of Bell's classroom system was visual, the end goal of learning for the surgeon or artist was not seeing—it was acting. The hand had to be trained to see in an obscure, messy body cavity. And as the passage from Bell at the beginning of this article suggested, one could not truly know by the senses without the coordinated and attendant muscular action that embodied the force of the will. Bell therefore took a fairly common philosophy of object learning and developed from it a kind of knowing and informed action by connecting the hand and eye as coordinated, analogous organs, the hand serving as a sort of extension of the eye. He did so in a way that addressed epistemological questions generated in the Enlightenment, and that bears a certain relationship to his work on the nerves.

Bell's work echoed Locke's famous philosophical exploration of Molyneux's Problem, about the interrelationship between the senses. Locke wrote in *An Essay Concerning Human Understanding* (1690): 'Suppose a man born blind, and now an adult, taught by his touch to distinguish between a cube and a sphere of the same metal. Suppose then the cube and sphere were placed on the same table and the blind man made to see: query, whether by his sight before he touched them, could he distinguish and tell which was the globe and which the cube?'[52] The real issue at stake is the commensurability of visual and tactile categories. Bell's answer is that they are commensurable, but only through the action of the body. Senses played a primary role but had to be trained in an interrelated fashion and, more importantly, senses that took in impressions of the world had to be paired with the action of the will—with agency.

The hand and the eye were complementary sensory organs, governed by the will and muscular action. They required similar training, each attaining better functioning with age and practice. In the end, they knew the world in the same way. Bell wrote as much in *The Hand*: 'The faculty of searching for the object is slowly acquired in the child; and, in truth, the motions of the eye are made perfect, like those of the hand, by slow degrees. In both organs there is a compound operation:—the impression on the nerve of sense, is accompanied with an effort of the will, to accommodate the muscular action to it'.[53] Knowledge, according to Bell, could not be developed from the senses without the effort of the will and muscular action. It was a point that was picked up quite clearly by at least one reader. The reviewer of the book for the *London Medical Gazette* latched onto the idea explicitly: 'Contemplating the hand as an organ of the senses, gives the author an opportunity to enter upon several novel and important views relating to the general sensibilities of the body. We must not omit to recommend to the attention of our readers the disquisition upon the sense of muscular action, as connected with the organ of touch.'[54]

Discussions of the hand, and particularly of the hand and eye, allowed Bell to elaborate upon the conjoined roles of received sensation and muscular action in the development of knowledge. It was a natural and yet innovative step for a man who considered his primary contribution to medical science to have been the development of a sort of system of circulation of the nerves, whereby nervous impulses made their way from sensing extremity to brain via one path and then back out from brain to muscular organ by another. Exposure to objects was necessarily paired, according to Bell, with the training of the will to exert muscular action, and it is in this pairing of sense and will that the influence of Bell's work on the nerves on his Bridgewater Treatise can be found.

Bell's ideas about the hand and eye, their symmetrical and analogous relationship whereby the eye relays information to the brain that is simultaneously acted upon through

the hand, fits quite neatly within what he considered his most significant work—that on the nervous system. Bell began his work on the nerves as a way of understanding the brain, the seat of knowledge, tracing the brain outward through its extensions. Its result, ultimately, was a sort of circulatory system of the nerves, and Bell always considered that system's novelty and contribution to be its elegance and its symmetry. As Amédée Pichot, a contemporary of Bell's, wrote in his biography of Bell:

> all the nerves had the same properties, and contributed equally to the double object of transmitting *sensation* to the brain, and reciprocally *will* and *motion* to the muscles. Force of will proceeds from within to without, or as a centrifugal force. But when a sensation takes place, since the effect must be produced by the impression made on the extremity of the nerve expanded under the epidermis, and transmitted by the nerve itself to the sensorium, it is also evident that this second force is a nervous current which proceeds from the circumference to the centre, or a centripetal force.[55]

Sensation and motion were paired in sheaths of nerves, much as they were in the development of knowledge about the world. True knowledge could only be developed with both.

Seeing (and smelling and other senses exercised in a receptive sort of way) was necessarily followed by doing (exerting 'the will' and 'motion,' in Bell's terms) in a compound process of creating knowledge—in the case of anatomy, by dissecting, by creating displays, and ultimately by performing surgery. In his textbook *Institutes of Surgery* (1838), Bell argued for such a compound style of sensory learning using the construction of visual displays to teach students the manual dexterity and hand-eye coordination they would need as surgeons.

The student of surgery, wrote Bell, '[c]ommencing under an anatomical Teacher… and having a general idea of the system of animal bodies, should undertake dissection early. This he must do to acquire an intimate knowledge of structure and a dexterous hand; and this is so necessary, that he should be in the anatomical rooms during the greater part of his attendance on the winter classes.'[56] This advice highlights the sensory input necessary to Bell's pedagogical program as well as the manual skill required. He followed this recommendation with another that built on it, suggesting ways for developing the exercise of 'the will' and 'motion' through muscular action. 'It is essential that he [the student] should practise some mechanical exercise, that he may acquire an accordance between the eye and the hand. My brother put me to drawing, modelling, and etching, with this view; but perhaps the best exercise of all is the art of anatomical preparation,—a very different matter from that exercise of the scalpel with which students are generally satisfied.'[57]

It was not enough, in Bell's idea of a surgical education, to simply learn a few techniques of surgery from an older surgeon—rote handwork. There was a whole program for training the senses to perceive properly and the hand to act in coordination with that vision. In Bell's scheme, the eyes observed, returning sensation to the mind; and the mind sent the 'force of the will' to the hands, hands that embodied true knowledge and acted for the eye. Thus Bell wrote in his Bridgewater Treatise, 'we have to show how much the sense of vision depends on the Hand, and how strict the analogy is between these two organs'.[58] Elsewhere in the Treatise, he described the hand as an extension of the mind: 'Our argument, in the early part of the volume, has shown man, by the power

of the hand (as the ready instrument of the mind) accommodated to every condition through which his destinies promise to be accomplished'.[59] Vision, then, depended on the hand; the hand was the instrument of the mind; hands and eyes were analogous organs; and knowledge could only be built on the complete, compound action of the nervous system, perceiving and exercising the force of the will.

Coordinated efforts of the hand and eye, of muscle and sensation, were necessary for the surgeon, whom Bell taught to use his hands through the practice of art, much as they were for the artist, whom Bell taught to see through the practice of dissection.[60] Combination, sympathy, and symmetry were important in Bell's ideas about embodied learning. As he said in an 1833 lecture on esophagotomy, 'There are certain sensibilities situated in different parts of the body…that are given for the purpose of drawing into combination or sympathy a variety of muscles, some of which may, perhaps, be placed in distant parts of the body, but the combination of which is necessary to the performance of a certain act'.[61] Surgery required such coordination—total sensory knowledge created through muscular action and force of the will much as it was through vision. As Bell told his students,

> you must know the parts perfectly well, and look upon them in every aspect; and you must also perform the operation upon the dead body. But if you operate upon the dead body, and then come to operate upon the living one…you will be very apt indeed to be thrown out, and to lose your presence of mind, for you will be astonished at the difference. You operate on a dead body, with the parts in a state of perfect relaxation; whereas, in actual practice, you find your finger and your instruments engaged in a deep wound, where the parts are spasmodically contracted; and hence arises a difficulty in ascertaining the extent of your incision. I cannot express to you otherwise the difference which there is in the living body, as contrasted with the relaxed condition of the parts, and the facility with which you cut into the bladder in the dead.[62]

What Bell describes in this passage is the need for surgeons to be able to 'see' with their hands—to see without viewing. He framed expertise in that way because anatomizing a dead body could not teach one to feel as one would feel in a living body: the sensation of touch alone, taught and cultivated through anatomy, could never be a young surgeon's guide. Similarly, learning through vision alone would not suffice, as a surgeon practicing on a living, injured or ill body would never have visual access to a whole living body, as an anatomist might when dissecting. The senses had to act in cooperation. The eyes could not act alone in developing knowledge and the hands could not act on the sense of touch developed through dissection. Instead, in this decisive disjunction of pathological anatomy from live surgery, hands were taught to see through Bell's symmetrically developed knowledge of hand and eye, of perception and action.

Surgery required the touch of a *seeing, knowing* hand. In 1764, the Scottish philosopher Thomas Reid had written that 'the Evidence of reason is called *seeing*, not *feeling, smelling*, or *tasting*. Yet, we are wont to express the manner of the divine knowledge by *seeing*, as that kind of knowledge which is most perfect in us.'[63] For Bell, the tactile practices of anatomy taught vision, the primary source of knowing in late-Enlightenment Britain. Classroom instruction in anatomy was built around a system of *visual* displays—around demonstrations of dissection, jarred specimens, chalkboard illustrations, paintings, etc.[64]

And knowledge in anatomy was couched in terms to do with sight and depiction;[65] anatomy simply could not teach the sort of feeling that one would encounter inside a living body. Instead, it taught students to map the parts so that their fingers, moving through a surgical field, could 'see' and therefore could know and could act.

Reid had also written: 'It is not therefore without reason, that the faculty of seeing is looked upon, not only as more noble than the other senses, but as having something in it of a nature superior to sensation'.[66] The eye trumps the hand in nobility and as the true inlet to knowledge. Reid then invokes Locke's blind man, asking how a man born blind might develop knowledge about what Reid himself terms the 'visual language' of Nature. His answer seems to be an invocation of 'the mind's eye,' but Reid circumscribes its power, saying that vision developed in the mind is never one of discovery: 'We have seen how far a blind man may go in the knowledge of the appearances which things make to the eye. As to the things which are suggested by them, or inferred from them; although he could never discover of them himself, yet he may understand them perfectly by the information of others.'[67] By subverting the primacy of the visual, or rather by reorienting it so that vision could be located in the hand, Bell not only argued for overturning long-held philosophical tenets about the ranking and significance of the senses, but, perhaps equally importantly, produced a philosophical argument that, in a veiled way, supported a platform of social and professional reform.[68] It is by tying his argument about hand and eye to Bell's politics that we can begin to appreciate just how well *The Hand* was integrated into his other pursuits, how epistemological and social reform were bound together.

Epistemological and social reform in the pairing of hand and eye

Bell was always striving for legitimacy, despite acute and painful awareness of his impoverished background and lack of proper training in natural history.[69] He had been trained as surgeon at a time when surgeons occupied a relatively low rank in the British medical world. He was an instructor at a time when a teaching position alone guaranteed neither fortune nor respectability, as salaries came from student enrollment and not from universities themselves, so one could be a rather unsuccessful and impoverished university lecturer. Charles Bell asked his brother for money in letters long after Charles had moved to London. Still, teaching when done well seemed a noble calling, and when a lecturer was popular, he could establish his reputation through students and word of mouth. Toward the end of his life, Bell wrote his brother often about his professional standing, saying, for example:

> I have seen enough to satisfy me of what the world can offer a man—I mean this great world; and were you to look back to my letters, you would find the opinion uniformly expressed that the place of a professor who fills his place is the most respectable in life. My hands are better for operation than any I have seen at work; but an operating surgeon's life has no equivalent reward in this world… I must be the teacher and consulting surgeon to be happy.[70]

An operating surgeon had little standing or respectability in London, and was hardly seen as a man of learning. Historians of science and medicine have attributed surgeons' low

standing to the physicality of their work—it was craft, labor of the hands, messy.[71] There was no long tradition of Latinate works in surgery as there was in medicine or anatomy. But perhaps as importantly, surgery was work that was denied the sure epistemological footing of those sciences developed through the eye and mind—through texts, but also through vision and witnessing.[72] One did not attain knowledge of nature—did not *see* nature—by feeling around inside an oozing, living body through a tiny incision to visualize the body's obscured interior. In just this contrastive sense, then, it was a politically as well as an epistemologically radical move to insist that the hand could *see*.

One way to support a reformist reading of Bell's argument on behalf of the hand is to examine Bell's Bridgewater Treatise in the context of others of his arguments for reform. While conservative reformers like Bell extolled the virtues of a British medical education, they also recognized a need to improve elements of that education. Their proposals for reform often came in the form of institutional change. Sir Charles Bell testified twice about unjust promotions within hospitals before the 1834 Select Committee of the House of Commons, which was appointed at the instigation of Thomas Wakley 'to inquire into and consider of the laws, Regulations and Usages regarding the EDUCATION and PRACTICE of the various Branches of the MEDICAL PROFESSION, in the United Kingdom'. He was called to give this testimony because of a pamphlet that he had written in November of 1824, entitled, 'A Letter to the Governors of the Middlesex Hospital, from the Junior Surgeon'. The letter, of which Bell had 500 copies printed, was a response to the promotion of a young physician who was well connected at the College of Physicians instead of the assumed favorite and more well-seasoned candidate. This pamphlet reveals a strong critic of the hierarchy in British medicine, but also Bell's deeper concern for the structure of British medical education.[73] Bell summarized his position in the following passage:

> I advocate this principle, that the situation of Physician or Surgeon to an hospital, should be a reward for professional merit. It is unhappily conceived, on the other hand, that young Physicians should be introduced to hospitals—that they may there learn their profession, and be prepared for private practice; and that whenever their private patients promise them a livelihood, they should leave the hospital to the next candidate for the notice of the town… In the course of a few months a young gentleman is a Student, a Member of the College, Physician to an Hospital, and Teacher of Medicine. It would be well if he were to proceed at this rate; but a few private patients withdraw him from his public duties, and he is influenced by that notion which prevails so extensively in London, that to be otherwise employed than moving about in a chariot, is to declare his incapacity.[74]

Bell objected specifically to the promotion of the junior fellow and to the use of hospital positions not as rewards for those who had done well as practitioners and as an end in themselves, but instead as springboards for young, well-connected members of the medical field. However, his testimony also indicates a broader concern with the social standing of medical men, and reveals a concern with tying professional experience and standing to scientific contributions. His testimony actively engaged in reform politics. But it was important to Bell, who had been embroiled in a very public priority dispute with François Magendie, and whose reform politics were decidedly anti-French, that his institutional reform and its philosophical basis had nothing to do with revolutionary moves in France to unite medical and surgical training.

Shortly before his testimony to Parliament, Bell's reformist pedagogy had found expression in his work developing a new London University program of medical education. It was a project of great significance to Bell and resulted in London's first university. And while it became the project of other pedagogues with other politics not long after its founding, forcing Bell's resignation, it too demonstrates Bell's interest in reform.

The Diploma of Master of Medicine and Surgery at London University united medical professions that had been legally separate (surgeons and physicians could not practice each others' trades), and that occupied distinctly different places in the medical hierarchy. Pedagogically they were different as well, with medicine full of theory and surgery taught by apprenticeship. The certification program at London University that was meant to bridge all of those forms of separation required that students acquire certificates of honor in classes on the 'practice of medicine, anatomy, physiology, surgery, midwifery and diseases of women and children, materia medica, botany, chemistry, and anatomical demonstrations and dissections as well as attending the medical practice of a hospital containing at least 100 beds for 12 months; and surgical practice in an hospital meeting the same requirements'.[75]

By teaching medicine and surgery side by side to all of its students, London University's council was catering to a group of general practitioners who were becoming more and more prevalent in London and the provinces. Although men within London were forbidden by the corporations from crossing disciplines (surgeons could not practice medicine, and apothecaries could choose to dispense drugs or medical advice, but not both), in practice most men outside of London were apothecaries and operated as 'general practitioners'. The course offerings of London University were built around the interests of apothecaries and surgeons who planned to work as general practitioners. But there is no question that such reform also helped to elevate the place of the surgeon by insisting on the importance of the work he did with his hands, rather than just acknowledging the realities of practice and contributing to its improvement.

In his *Institutes of Surgery* of 1838 Bell laid out a plan of instruction, recommending that students have a background in natural philosophy before beginning their study of medical subjects; that they begin with anatomy, practicing dissection frequently; that they then add some form of mechanical exercise such as drawing or anatomical preparation; that they dissect always with reference to the living body, of which they should acquire a knowledge in the hospital, where they should observe the body and how much the natural constitution can bear; and that they also acquire a knowledge of the medical treatment of disease for the many times when they will need to treat surgical diseases[76] medically. Finally, Bell says, 'clinical instruction is the last and best stage of this laborious course of study: and to maintain his spirits and perseverance during it, the student must look to the noble consequences, the power which knowledge places in his hands'.[77] Both medicine and surgery would be improved through such a systematic training, grounded in anatomy and in hospital training. Knowledge was placed in the surgeon's hands.

Conclusion

Examining Bell's life allows a glimpse of what he might have thought his treatise on the hand could accomplish. In 1839, six years after the publication of his Bridgewater Treatise, Bell reflected on his own early school education in the margins of a biography of him in

Pettigrew's *Medical Portrait Gallery*: 'Anything demonstrative or mechanical, or tending to Natural Philosophy, I comprehended better than my companions; but the memory of verses or Latin rules, without intellectual comprehension of some principles, I was almost incapable of. This incapacity depressed me, and it was only when in professional education [that] I found subjects more suited to my capacities.'[78] Bell found the traditional pursuits of a schoolboy's education, those of memorizing verses or learning Latin grammar, difficult, describing his skills as residing in that which was *demonstrative* (shown to the eye) or *mechanical* (produced by the hand). Again, the hand and eye are paired, and this time in Bell's description of that at which he himself excelled. The learning of the hand and eye was best developed, as Bell says, in his professional education.

It is clear from his letters that Bell was sensitive about such things. His wife later recollected: 'He often regretted that he had not what he called "an education …. [H]e had only the common rudiments of the commonest branches given to him. All the rest he acquired for himself, and took great pains, as he advanced in age, to make up for his fancied deficiencies.'[79] He tried, in his last years, to learn French and Italian, and he wrote in the margins of that 1839 biography of himself, 'Memory should be cultivated. It bestows great advantages. Mine was ever deficient. I could not, and cannot, venture on a quotation either in conversation or in a public discourse.'[80] His bemoaned deficiencies would be overcome by the development and acknowledgement of a different kind of knowledge, one that was embodied by hand and eye and that was described as seeing.

Bell's most significant scientific work, his discovery of a 'circulation' in the motor and sensory nerves, bringing motor impulses from the brain to the extremities and sensations from the extremities back to the brain, seems to have informed or at least resonated with his ideas about sensory learning and the necessity for the eye to be coupled with the hand— sensation paired with the exercise of muscles and the force of the will. This pedagogical and epistemological stance had social ramifications, and when one understands Bell to have been a reformer, it is possible to read his work on the hand and eye as validating a kind of knowledge produced by the surgeon or anatomist, as insisting on the significance of the hand. Uniting two forms of manual work, Bell wrote of visual artists that they needed to dissect with their hands to learn to see, and that only in doing so could they elevate their work to the status of philosophy or a liberal art:

> the study [of anatomy] is necessarily one of great importance; it does not teach him to use his pencil, but it teaches him to observe nature, to see forms in their minute varieties, which, but for the principles here elucidated, would pass unnoticed—to catch expressions so evanescent that they must escape him, did he not know their sources. It is this reducing of things to their principles which elevates his art into a connection with philosophy, and which gives it the character of a liberal art.[81]

The study of nature—always, according to Bell,[82] to be conducted actively through hands-on dissection—literally taught artists how to see, how to comprehend the 'principles' of nature.

The Hand, then, becomes a central text in understanding the work of a pedagogue and surgeon-reformer, an aspiring gentlemen and anatomist natural philosopher, who was working in the shadow of the Scottish Enlightenment, teaching people to know by seeing with their hands. According to *The Hand*: 'If a man contemplate the common objects

around him—if he observe the connection between the qualities of things external and the exercise of his senses, between the senses so excited, and the condition of his mind, he will perceive that he is in the centre of a magnificent system, and that the strictest relation is established between the intellectual capacities and the material world'.[83] That material world was known through sensory perception and material interaction performed symmetrically and simultaneously.

The sort of magnificent system Bell describes, known through a circulation of nervous impulses to and from the brain and extremities, permitted a surgeon's hand that was educated to be a knowing one; a seeing one. Thus Charles Bell began his Introductory Remarks at the Opening of London University in 1829 with the words: 'I am known only by the work of my hands'.[84]

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Notes

1. For more on the Bridgewater Treatises, including Bell's, as examples of Natural Theology, see Jonathan Topham, 'Science and Popular Education in the 1830s: The Role of the "Bridgewater Treatises"', *British Journal for the History of Science*, 25 (1992), pp. 397–430; Jonathan Topham, 'Beyond the "Common Context": The Production and Reading of the Bridgewater Treatises', *Isis* 89 (1998), pp. 233–62; James A. Secord, *Victorian Sensation: the Extraordinary Publication, Reception, and Secret Authorship of Vestiges of the Natural History of Creation* (Chicago: University of Chicago Press, 2000); Matthew Eddy, 'Nineteenth-Century Natural Theology', in John Hedley Brooke, Russell Manning, and Fraser Watts (eds.) *Oxford Handbook of Natural Theology* (Oxford: Oxford University Press, 2013), pp. 101–17. Each of these works treats the Bridgewater Treatises, among them Bell's, as a group, situating them beside each other and not among the other works of their individual authors. Nonetheless these few works suggest how well known the Bridgewater Treatises were generally, as would cursory investigations of Darwin, who is often situated in a British context shaped by natural theology. This article attempts to investigate Bell's Bridgewater Treatise, a work of natural theology, in a somewhat different way, by situating it alongside Bell's other and not explicitly natural theological works, rather than other Bridgewater Treatises or works of natural theology.
2. Steven Shapin and Barry Barnes offer useful insight into the relationship between thought and practice, reason and sensation in their article 'Head and Hand: Rhetorical Resources in British Pedagogical Writing, 1770–1850', *Oxford Review of Education*, 2 (1976), pp. 231–54. In it, they describe the world Bell inhabited—late Enlightenment Britain—demonstrating the dichotomies posed in pedagogical texts between the reasoned learning of the upper classes and the unthinking sensual and manual learning of the lower orders. Such context is important to understanding the reformist nature of Bell's supposedly conservative natural theological treatise.

3. Take, for example, two primary works on Bell's life and discovery, neither of which accords 'The Hand' significance as a piece of innovative research: Gordon Gordon-Taylor and E.W. Walls, *Sir Charles Bell, His Life and Times* (Edinburgh: E. & S. Livingstone, 1958); Paul F. Cranefield and Charles Bell, *The Way In and the Way Out: François Magendie, Charles Bell, and the Roots of the Spinal Nerves: with a facsimile of Charles Bell's annotated copy of his Ideas of a new anatomy of the brain* (Mount Kisco: Futura Publishing Company, 1974).
4. Charles Bell, *The Hand, Its Mechanism and Vital Endowments as Evincing Design* (London: William Pickering, 1833).
5. For more on Bell, see a relatively brief article by L.S. Jacyna, 'Bell, Sir Charles (1774–1842)', *Oxford Dictionary of National Biography* (Oxford: Oxford University Press, 2004); online edn, Jan 2008 [http://www.oxforddnb.com/view/article/1999, accessed 12 November 2013], as well as Carin Berkowitz, 'Medical Science as Pedagogy in Early Nineteenth-Century Britain: Charles Bell and the Politics of London Medical Reform' (unpublished PhD Thesis, Cornell University, 2010); Cranefield and Bell, *The Way In and the Way Out*; Gordon-Taylor and Walls, *Sir Charles Bell, His Life and Times*; Ludmilla Jordanova, 'The Representation of the Human Body: Art and Medicine in the Work of Charles Bell', in Brian Allen (ed.) *Towards a Modern Art World* (New Haven, CT: Yale University Press, 1995), pp. 79–94; Irving Loudon, 'Sir Charles Bell and the Anatomy of Expression', *British Medical Journal*, 285 (1982), pp. 1794–6; Pauline Mazumdar, 'Anatomy, Physiology and Surgery: Physiology Teaching in Early Nineteenth-Century London', *Canadian Bulletin of Medical History*, 4 (1987), pp. 119–43. Nineteenth century biographies include Alexander Shaw, *Narrative of the Discoveries of Sir Charles Bell in the Nervous System* (London: Longman, 1839); Alexander Shaw, *An Account of Discoveries of Sir Charles Bell in the Nervous System* (London: J. Murray, 1860); Amédée Pichot, *The Life and Labours of Sir Charles Bell* (London: R. Bentley, 1860); 'Letters and Discoveries of Sir Charles Bell', *The Edinburgh Review*, 136 (1872), pp. 394–429.
6. The close examination of visualization in the history of science has a long history: Matthew Eddy, *Seeing the Enlightenment: Learning to Order and Value Visual Culture* (Chicago: University of Chicago Press, forthcoming); Ludmilla Jordanova, 'Medicine and Genres of Display', in L. Cooke and P. Wollen (eds.), *Visual Display: Culture Beyond Appearances* (Seattle, WA: Bay Press, 1995), pp. 202–17; Martin Kemp and Marina Wallace, *Spectacular Bodies: the Art and Science of the Human Body from Leonardo to Now* (London, Los Angeles: University of California Press, 2000); Alex Soojung-Kim Pang, 'Visual Representation and Post-constructivist History of Science', *Historical Studies in the Physical and Biological Sciences* 27(1997), pp. 139–70; Martin Rudwick, 'The Emergence Of A Visual Language For Geological Science 1760–1840', *History of Science* 14 (1976), pp. 149–94; Norton Wise, 'Making Visible', *Isis*, 97 (2006), pp. 75–82; Lorraine Daston and Peter Galison, *Objectivity* (Cambridge, Mass.: MIT Press, 2007)), but to that history recent work on the senses more broadly, particularly on taste, hearing, and smell, has been added. Among others, see Julia Kursell, Alexandra Hui, Myles W. Jackson (eds.), *Music, Sound, and the Laboratory from 1750–1980*, *Osiris* 28 (Chicago: University of Chicago Press, 2013); Lissa Roberts, 'The Death of the Sensuous Chemist', *Studies in the History and Philosophy of Science* 26 (1995), pp. 503–29; Evan Ragland, 'Chymistry and Taste in the Seventeenth Century: Franciscus Dele Boë Sylvius as a Chymical Physician Between Galenism and Cartesianism', *Ambix*, 59 (2012), pp. 1–21; Domenico Bertoloni Meli, 'The Color of Blood: Between Sensory Experience and Epistemic Significance', in Lorraine Daston and Elizabeth Lunbeck (eds.), *Histories of Scientific Observation* (Chicago: University of Chicago Press, 2011), pp. 117–34; Steven Shapin, 'The Sciences of Subjectivity', *Social Studies of Science*, 42 (2012), pp. 170–84.

7. I've found little in the history of science on the role of touch, though Mark Paterson has written about the sense broadly in Mark Paterson, *The Senses of Touch: Haptics, Affects, and Technologies* (Oxford; New York: Berg, 2007). And Eve Keller makes touch central to her argument about gender and the role of male midwives in early-modern England in Eve Keller, 'The Subject of Touch: Medical Authority in Early Modern Midwifery', in Elizabeth D. Harvey (ed.), *Sensible Flesh: On Touch in Early Modern Culture* (Philadelphia, PA: University of Pennsylvania Press, 2003), pp. 62–80. Notable recent work on touch in science studies includes Rachel Prentice, 'The Anatomy of a Surgical Simulation: Materializing Bodies in the Machine', *Social Studies of Science* 35 (2005) pp. 867–94; Rachel Prentice, 'Drilling Surgeons: The Social Lessons in Embodied Surgical Learning', *Science, Technology, and Human Values*, 32 (2007), pp. 534–53.
8. Arthur Burns and Joanna Innes, *Rethinking the Age of Reform: Britain 1780–1850* (Cambridge, UK: Cambridge University Press, 2003). See particularly the Introduction by Innes and Burns, and Chapter 2, by Joanna Innes, '"Reform" in English public life: the fortunes of a word'.
9. The Reform Act of 1832, the first great reform act and one that expanded the franchise, was debated and passed while medical reforms described in this chapter were being debated and enacted. Adrian J. Desmond, *The Politics of Evolution: Morphology, Medicine, and Reform in Radical London* (Chicago: University of Chicago Press, 1989); Ian Burney, 'Medicine in the Age of Reform', in Arthur Burns and Joanna Innes (eds), *Rethinking the Age of Reform: Britain 1780–1850* (Cambridge, UK: Cambridge University Press, 2003), pp. 163–81; Eric J. Evans, *Britain Before the Reform Act: Politics and Society 1815–1832* (London; New York: Longman, 1989).
10. Desmond, *The Politics of Evolution*.
11. Burney, 'Medicine in the Age of Reform'; Roger French and Andrew Wear, *British Medicine in an Age of Reform* (London; New York: Routledge, 1991); John Harley Warner, 'The Idea of Science in English Medicine: The 'Decline of Science' and the Rhetoric of Reform, 1815–1845', in Roger French and Andrew Wear (eds.), *British Medicine in an Age of Reform* (New York: Routledge, 1991), pp. 136–64; Berkowitz, 'Medical Science as Pedagogy in Early Nineteenth-Century Britain'.
12. Berkowitz, 'Medical Science as Pedagogy in Early Nineteenth-Century Britain.'
13. Gordon-Taylor and Walls, *Sir Charles Bell, His Life and Times*.
14. Bell, *The Hand, Its Mechanism and Vital Endowments as Evincing Design*, v.
15. Topham, 'Science and Popular Education in the 1830s: The Role of the "Bridgewater Treatises"'; Topham, 'Beyond the "Common Context"'; Jonathan Topham, 'Scientific Publishing and the Reading of Science in Nineteenth-Century Britain: A Historiographical Survey and Guide to Sources', *Studies in the History and Philosophy of Science*, 31 (2000), pp. 559–612.
16. The 1874 edition, the ninth, was published with an introduction by Alexander Shaw, Bell's student, brother-in-law, and friend, alongside an account of Bell's discoveries.
17. Gordon-Taylor and Walls set the tone when they proclaimed *The Hand* a natural project for its devout Christian and creationist author. Gordon-Taylor and Walls, *Sir Charles Bell, His Life and Times*, 163–5.
18. Bell, *The Hand, Its Mechanism and Vital Endowments as Evincing Design*, 12.
19. Ibid., pp. 15–16.
20. Ibid., p. 16.
21. Ibid., p. 15.
22. For more on Cuvierian anatomy, see Toby A. Appel, *The Cuvier-Geoffroy Debate: French Biology in the Decades before Darwin* (New York: Oxford University Press, 1987); Dorinda

Outram, *Georges Cuvier: Vocation, Science, and Authority in Post-Revolutionary France* (Manchester: Manchester University Press, 1984).

23. Sensation, particularly in relation to pedagogy, has been the subject of several interesting and recent pieces of which a few examples are listed here. Melanie Keene has looked at objects and object lessons in teaching children in her unpublished PhD thesis, 'Object Lessons: Sensory Science Education, 1830–1870' (Cambridge: University of Cambridge, 2009). Matthew Eddy has written about the visual practices of note-taking: Eddy, *Seeing the Enlightenment*. Lissa Roberts' article on the sensuous chemist contains an examination of the senses and science and is still among the best. For sensory perception in an alchemical context, see J.R.R. Christie, 'The Paracelsian Body', in Ole Grell *(*ed.) *Paracelsus. The Man and His Reputation, His Ideas and Their Transformation* (Leiden: Brill, 1998), Chapter 12. In addition, knowledge, the senses, and pedagogy are the subject of Shapin and Barnes' article 'Head and Hand'.
24. Bell, *The Hand, Its Mechanism and Vital Endowments as Evincing Design*, p. 193.
25. Berkowitz, 'Medical Science as Pedagogy in Early Nineteenth-Century'.
26. George became a well-regarded lawyer and a good friend to Francis Jeffrey, Henry Brougham, the Horners, and others who became leaders among the Edinburgh Whigs in the 1830s. Charles was adopted into George's social circles, and Jeffrey and Brougham in particular provided patronage and support for the rest of his life. 'Letters and Discoveries of Sir Charles Bell', pp. 394–408.
27. Ibid., p. 406.
28. Ibid.
29. Thinking was by no means uniform, of course, among these men. But close-knit circles of philosophically and naturally philosophically minded men seem to have produced common themes of inquiry across disciplines and generations. For a very good overview of the Scottish Enlightenment, see Alexander Broadie, (ed.) *The Cambridge Companion to the Scottish Enlightenment* (Cambridge: Cambridge University Press, 2003). Chapters 2 ('Religion and Rational Theology', by M.A. Stewart), 3 ('The Human Mind and its Powers', by Alexander Broadie), and 5 ('Science in the Scottish Enlightenment', by Paul Wood) are particularly instructive on topics covered in this article.
30. Charles Bell, *Letters of Sir Charles Bell, Selected from his Correspondence with his Brother George Joseph Bell* (London: J. Murray, 1870), p. 128 (5 August 1808).
31. Jennifer Tannoch-Bland, 'Dugald Stewart on Intellectual Character', *British Journal for the History of Science*, 30 (1997), pp. 307–20: 311.
32. Ibid., p. 308.
33. Dugald Stewart, *Elements of the Philosophy of the Human Mind*, The Collected Works of Dugald Stewart Vol. IV (Edinburgh: Thomas Constable and Co., 1854), p. 212 (originally published in 1827).
34. Ibid., p. 24. Smith's essay on 'Considerations concerning the first formation of languages,' and its relation to 'The principles which lead and direct philosophical enquiries' is examined in J.R.R. Christie, 'Adam Smith's Metaphysics of Language', in Geoffrey N. Cantor, Andrew E. Benjamin, J.R.R. Christie (eds.), *The Figural and the Literal: Problems of Language in the History of Science and Philosophy, 1630-1800* (Manchester, UK: Manchester University Press, 1987).
35. Editor, 'XLIX. Proceedings of Learned Societies: the Academy of Sciences at Berlin', *The Philosophical Magazine: Comprehending the Various Branches of Science, Liberal and Fine Arts, Agriculture, Manufactures, and Commerce*, 18 (1804), p. 281.
36. H.R., 'Some Account of Pestalozzi and His Method of Instruction', *The Athenaeum*, 2 (1807), pp. 331–2.

37. John Alfred Green, *The Educational Ideas of Pestalozzi* (New York: Greenwood Press, 1969), p. 220.
38. Charles Mayo, *A Memoir of Pestalozzi: Being the Substance of a Lecture Delivered at the Royal Institution, Albemarle Street, May, 1826* (London: J.A. Hessey, 1828), p. 27.
39. Ibid., p. 16.
40. Secord, *Victorian Sensation*, Chapter 2.
41. Bell, *Letters of Sir Charles Bell*, 320 (3 September 1831).
42. Berkowitz, 'Medical Science as Pedagogy in Early Nineteenth-Century Britain'; Carin Berkowitz, 'Systems of Display: the Making of Anatomical Knowledge in Enlightenment Britain', *BJHS*, 46 (2013), pp. 359–87.
43. Tannoch-Bland, 'Dugald Stewart on Intellectual Character', p. 311.
44. Bell, *The Hand, Its Mechanism and Vital Endowments as Evincing Design*, p. 8.
45. Ibid., p. 252.
46. Ibid., p. 116.
47. Ibid.
48. Ibid., p. 252.
49. Ibid., p. 9.
50. Ibid., p. 160.
51. Berkowitz, 'Systems of Display'.
52. John Locke, *An Essay Concerning Human Understanding* (London: Printed by Eliz. Holt for Thomas Bassett 1690), Book 2, Chapter 9. It was a problem taken up by other surgeons before Bell as well. William Cheselden, also a London surgeon, addressed it, for example in 'An Account of some Observations made by a young Gentleman, who was born blind, or lost his Sight so early, that he had no Remembrance of ever having seen, and was couch'd between 13 and 14 Years of Age', *Philosophical Transactions*, 402 (1728) pp. 447–50. Cheselden applied what might be seen as the first experimental evidence to the problem when he treated a congenitally blind boy whose sight was restored when his cataracts were removed. The boy did not know shapes and could not distinguish things by sight.
53. Bell, *The Hand, Its Mechanism and Vital Endowments as Evincing Design*, p. 252.
54. Anonymous, 'Charles Bell's Bridgewater Treatise', *London Medical Gazette*, 13 (1833) p. 257.
55. Pichot, *The Life and Labours of Sir Charles Bell*, pp. 91–2. [emphasis added]
56. Charles Bell, *Institutes of Surgery; Arranged in the Order of the Lectures Delivered in the University of Edinburgh*, 2 volumes (Edinburgh: Black, 1838), p. xx.
57. Ibid.
58. Bell, *The Hand, its Mechanism and Vital Endowments as Evincing Design*, p. 245.
59. Ibid., p. 279.
60. Carin Berkowitz, 'The Beauty of Anatomy: Visual Displays and Surgical Education in Early-Nineteenth-Century London', *Bulletin of the History of Medicine*, 85 (2011) pp. 248–71.
61. Charles Bell, 'Clinical Lecture on Esophagotomy', *London Medical Gazette*, 11 (1833) p. 538.
62. Charles Bell, 'Clinical Lecture on Lithotomy', *London Medical Gazette*, 11 (1833) p. 686.
63. Thomas Reid, *An Inquiry into the Human Mind: on the Principles of Common Sense*, 3rd edition (London: T. Cadell and T. Longman, London; A. Kincaid and J. Bell, Edinburgh, 1769), pp. 122–23.
64. Carin Berkowitz, 'Systems of Display'.
65. To know was 'to see', which is why anatomy was so often taught through demonstration and discoveries were presented in visual terms, often in illustrations themselves. This was true from the sixteenth century on: see Sachiko Kusukawa, *Picturing the Book of Nature: Image, Text, and Argument in Sixteenth-Century Human Anatomy and Medical Botany* (Chicago; London: University of Chicago Press, 2012).

66. Reid, *An Inquiry into the Human Mind*, p. 122.
67. Ibid., p. 126.
68. Here it is worth returning to Shapin and Barnes and their article on the head and hand. They quote a passage from 'The Consequences of a Scientific Education to the Working Classes of this Country pointed out, and the theories of Mr Brougham on that subject confuted; in a letter to the Marquess of Lansdown. By a Country Gentleman' (1826) that encapsulates nicely their argument that work of the head and the hand were separated and ranked in pedagogical texts: 'It may easily be shown that practice and theory seldom unite in the same individual; that the occupation of the practitioner requires all his time and thoughts to fulfil the wishes of eye or hand: whilst the theorist reasons within himself, and throws himself on his mind. Theoretical excellence must have reason for its soil, which mechanics have not.' Shapin and Barnes, 'Head and Hand: Rhetorical Resources in British Pedagogical Writing, 1770–1850', p. 232. It was exactly this sort of pervasive tradition, even among Bell's friends and patrons (like Henry Brougham), that helps to illuminate the kind of reform Bell sought and that makes his claims for the epistemological status of the hand all the more radical. In literature on contemporary training in surgery, Rachel Prentice shows that the place of head and hand in creating knowledge and teaching surgeons is still being debated and worked out. Prentice, 'The Anatomy of a Surgical Simulation'; Prentice, 'Drilling Surgeons'.
69. He wrote to his brother George, for example, 'I wish I could persuade you to dip a little into natural history and structure. How much I regret that I did not make myself acquainted with natural history'. Bell, *Letters of Sir Charles Bell*, p. 252 (15 December 1815).
70. Ibid., p. 348 (8 December 1835).
71. Roy Porter, *Blood and Guts: A Short History of Medicine* (New York: W.W. Norton, 2003): p. 115.
72. Chapter Two, for example, of perhaps the most famous book on virtual witnessing, *Leviathan and the Air Pump*, is titled 'Seeing and Believing'. Steven Shapin and Simon Schaffer, *Leviathan and the Air-Pump: Hobbes, Boyle, and the Experimental Life* (Princeton, NJ: Princeton University Press, 1985).
73. Richard Hunt and Ida Macalpine, 'A Privately Printed Pamphlet by Sir Charles Bell on the Principles Involved in Appointments to the London Hospitals', *Annals of the Royal College of Surgeons of England*, 30 (1962), p. 261. They write of the pamphlet on p. 258, 'As Bell has not so far been credited with an active interest in reforms of the medical profession, we tried to find a copy of his pamphlet in the London libraries to study it, but were unsuccessful […] at last we found it listed in W.B. Taylor's *Catalogue of the Library of the Society of Apothecaries*, 1913, listed anonymously under Middlesex Hospital as number 4 of 13 pamphlets'. Copies of this Catalogue had been auctioned off and they were able to get hold of one through correspondence with a collector, so their article remains the only real source of this letter by Bell.
74. Ibid.
75. Leonard Horner, 'University of London, Medical Diploma', *London Medical Gazette*, 6, 1830.
76. By surgical diseases, Bell meant things like gallstones that could be treated operatively, and often were, but that might be treated medically instead.
77. Bell, *Institutes of Surgery; Arranged in the Order of the Lectures Delivered in the University of Edinburgh*, pp. xix–xxii.
78. Bell, *Letters of Sir Charles Bell*, p. 13.
79. Ibid., note to p. 13.
80. Ibid., p. 13.
81. Charles Bell, *Essays on the Anatomy of Expression in Painting* (London: Longman, Hurst, Rees, and Orme, 1806), pp 184–85.

82. For more on this—a tradition of teaching artists anatomy through dissection—see Berkowitz, 'The Beauty of Anatomy'; also Frederick Cummings, 'B.R. Haydon and His School', *Journal of the Warburg and Courtauld Institutes*, 26(3/4) 1963 on Bell's student, the artist Benjamin Haydon.
83. Bell, *The Hand, Its Mechanism and Vital Endowments as Evincing Design*, p. 33.
84. Charles Bell, 'London University – Mr. Bell's Introductory Lecture', *London Medical Gazette*, 5, 1830, p. 18.