

# A NOTE ON THEORIES OF RESPIRATION AND MUSCULAR ACTION IN ENGLAND c.1660

by

J. A. BENNETT\*

IN 1647 CHRISTOPHER WREN, then fifteen years old, stayed for a time at the home of the physician, Royalist, and friend of William Harvey, Sir Charles Scarborough. The evidence for this comes from two letters written by Wren, one to his father, the other to the mathematician William Oughtred. Both letters were printed in *Parentalia*.<sup>1</sup> From them we know that Scarborough treated Wren for an illness, that he encouraged Wren's interest in mathematics, and that Wren spent some time "greatly enjoying the society of the famous Physician".<sup>2</sup> That Wren was under Scarborough's care may be partly explained by a friendship between Scarborough and Wren's brother-in-law William Holder, perhaps established at Cambridge through Seth Ward.<sup>3</sup> It is possible also that the society Wren encountered in 1647 was greatly enhanced by the fact that about that time Scarborough's home was becoming a meeting-place for Royalist scholars in London.<sup>4</sup>

So much for the evidence; the standard account of this period in Wren's life goes much further. *Parentalia* says that Wren assisted Scarborough in his work on the human muscles, and that he made pasteboard models of muscles to illustrate Scarborough's lectures at Surgeons' Hall.<sup>5</sup> All the secondary accounts date this work to about 1647, and certainly to before Wren became a student at Wadham College, Oxford, about 1649. *Parentalia* does not actually say that it was done before Wren went to Wadham, but the position of one of the two references in the narrative account by Christopher Wren jr. does give this impression.<sup>6</sup>

The picture of Wren "employed by Sir C. Scarborough, M.D., as a demonstrator",<sup>7</sup>

\*J. A. Bennett, M.A., Ph.D., 13 Sleaford Street, Cambridge CB1 2PW.

<sup>1</sup> Christopher Wren jr., *Parentalia: or, memoirs of the family of the Wrens*, London, S. Wren, 1750 (hereafter cited as *Parentalia*), pp. 185–186; there are translations in Lena Milman, *Sir Christopher Wren*, London, Duckworth, 1908, pp. 19–22.

<sup>2</sup> *Ibid.*, p. 19.

<sup>3</sup> John Aubrey, *Brief Lives*, chiefly of contemporaries, edited by Andrew Clark, Oxford, Clarendon Press, 1898, vol. 1, p. 405; vol. 2, p. 285. For some later evidence of their friendship, see *The diary of Robert Hooke (1672–1680)*, edited by Henry W. Robinson and Walter Adams, London, Taylor & Francis, 1935, pp. 104, 386, and see note 25 below.

<sup>4</sup> Walter Pope, *Life of Seth Ward*, London, Keblewhite, 1697, pp. 18–19, 117. It is not known for certain when Scarborough left Oxford for London, though it was some time between June 1646 and January 1648, see *Dictionary of national biography* article on Scarborough. As Pope suggests, it was probably shortly after the surrender of Oxford in June 1646.

<sup>5</sup> *Parentalia*, pp. 187, 238.

<sup>6</sup> *Ibid.*, p. 187.

<sup>7</sup> W. Douglas Caröe, *Tom Tower*, Christ Church, Oxford, Oxford, Clarendon Press, 1923, p. 10.

or “chosen by Dr. Charles Scarborough as his assistant”,<sup>8</sup> for his lectures at Surgeons’ Hall has become established without further question.<sup>9</sup> R. G. Frank *jr.* has recently pointed to an interesting reference of 1662 to a “wodden man” which Scarburgh used in his lectures to demonstrate the motions of muscles, adding that the model was made by Wren, “who had worked as a demonstrator for Scarborough before going up to Wadham”.<sup>10</sup> Now *Parentalia* can be misleading and does not always respect the highest standards of scholarship.<sup>11</sup> The biographical material it contains is particularly suspect. It is certainly dangerous to read into the narrative more than is actually there; indeed a wiser policy is to scrutinize even Christopher *jr.*’s definite claims, and ask what evidence he had for making them.

## I

*Parentalia* was written and revised over an extended period, from at least 1719 onwards.<sup>12</sup> In his earliest drafts Christopher *jr.* refers both to a treatise on the motions of muscles, and to pasteboard models. Thus he says, “He [Wren] Composed a Treatise of the Motions explaining the whole Anatomy by Models form’d in Pastboards”,<sup>13</sup> and, “At the desire of Sr. C. Scarborough he Discours’d larg’ly on the Motions of the Muscles, Explaining the Anatomy by Models form’d in Pastboards”.<sup>14</sup> When he settled down to write a complete transcript in 1728, Christopher *jr.* did not refer to this work in connexion with the 1647 episode, but included only the second of the two *Parentalia* references (as it was eventually printed on p. 238). Here he says that the models were presented to Scarburgh and were destroyed in the Great Fire, but he makes no mention of Scarburgh’s lectures. He originally followed this with a spurious claim that Wren had written the *De ratione motus musculorum* of William Croone, which was published anonymously in 1664.<sup>15</sup>

At two later dates Christopher *jr.* inserted further relevant passages into his transcript. We can say which insertion was made first, since only one appears in the fair copy now at All Souls College, Oxford, which was made in 1734, or shortly afterwards.<sup>16</sup> Here Christopher *jr.* adds to the passage mentioned above material he had found in Samuel Knight’s *Life of Dr. John Colet* (London, 1724), concerning Scarburgh and his lectures on muscles at Surgeons’ Hall. He embellishes this himself, and is now prepared, tentatively, to link Wren’s models with Scarburgh’s lectures. As yet, however, the link is not very explicit: “In this New Improvement of Anatomy, He

<sup>8</sup> Robert T. Gunther, *Early science in Oxford*, Oxford, 1920–1967, vol. 3, pp. 96–97.

<sup>9</sup> For some more recent examples, see William C. Gibson, ‘The medical interests of Christopher Wren’, in William C. Gibson and Ladislao Reti, *Some aspects of seventeenth-century medicine and science*, Los Angeles, University of California Press, 1969, p. 26; Tibor Doby, ‘Sir Christopher Wren and medicine’, *Episteme*, 1973, 7: 83–106, see p. 86.

<sup>10</sup> Robert G. Frank *jr.*, ‘The John Ward diaries: mirror of seventeenth-century science and medicine’, *J. Hist. Med.*, 1974, 29: 147–179, see pp. 159–160.

<sup>11</sup> For a discussion of this question, see J. A. Bennett, ‘A study of *Parentalia*, with two unpublished letters of Sir Christopher Wren’, *Ann. Sci.*, 1973, 30: 129–147.

<sup>12</sup> *Ibid.*, p. 130.

<sup>13</sup> British Museum MS. Add. 25,071, f. 32v.

<sup>14</sup> *Ibid.*, f. 38v. For an analysis of the manuscripts relating to the composition of *Parentalia*, see Bennett, *op. cit.*, note 11 above.

<sup>15</sup> Royal Society MS. 249, f. 272v; see Bennett, *op. cit.*, note 11 above, p. 141.

<sup>16</sup> See *ibid.*, pp. 130–131.

*A note on theories of respiration and muscular action in England c. 1660*

had great Assistance from Sr. Chr: Wren, who for His use, with much Skill and Exactness, Formed Models of the Muscles, in Pastboards, for the readier Explanation of their Parts, and Functions . . .”<sup>17</sup> Christopher *jr* repeats that the models were destroyed in the Great Fire, but is now prepared to add: “probably in the Repository at Surgeons=Hall”.

The claim that Wren had written *De ratione motus musculorum* was deleted before *Parentalia* was printed, and the whole of the first inserted passage was (probably accidentally) omitted. However, some time after the fair copy was made, Christopher *jr*. rearranged this material to some extent and inserted it again, at an earlier place in his narrative, that is, following the account of Wren’s early stay with Scarborough.<sup>18</sup> Here it was eventually printed. We now read, not that Wren simply presented his models to Scarborough, but that they were purposefully made for his lectures:

Mr. Christopher Wren was an Assistant to the said Dr. Scarborough, in anatomical Preparations and Experiments, especially upon the Muscles of human Bodies, during their Studies at Oxford and elsewhere; and particularly he explained by Models formed on Pasteboards, the *Anatomical Administration of all the Muscles of an human Body, as they naturally rise in Dissection, &c.*<sup>19</sup> for the Use of Dr. Scarborough’s celebrated Lectures in the publick Theatre in Surgeon’s-Hall . . .<sup>20</sup>

What conclusions can we draw from the genesis of this passage in *Parentalia*? In the first place, we can say that the accepted pre-Wadham dating is definitely wrong. Clearly the position of the passage in Christopher *jr.*’s narrative is not important; it is a late addition to the text, containing material that had previously been inserted elsewhere. In fact, if we look at his very early drafts, the work with Scarborough is associated with a later period in Wren’s career:

Anatomy also and Physick was Part of his Studies, in which he made so happy and early a Progress, as in the Year 1663, to be an Assistant to the great Physician Dr. Willis in his Noble Work of the Anatomy of the Brain; and to be Consulted on many occasions by Sr. Charles Scarborough; and, his Fellow Collegiate at All-Souls, Sr. Tho: Millington. At the desire of Sr. C. Scarborough he Discours’d larg’ly on the Motions of the Muscles, Explaining the Anatomy by Models form’d in Pastboards.<sup>21</sup>

As far as the pre-Wadham dating is concerned, the fact that Scarborough was elected Reader at Surgeons’ Hall only in October 1649<sup>22</sup> could have been used to obviate our examination of the *Parentalia* text, but this has been valuable in other ways.

For example, did Wren at any time make models to illustrate Scarborough’s lectures, or

<sup>17</sup> Royal Society MS. 249, f. 270; cf. All Souls MS. 313, pp. 381–382.

<sup>18</sup> Royal Society MS. 249, f. 208; note also *ibid.*, f. 218, and omission at All Souls MS. 313, pp. 248–249.

<sup>19</sup> If we trace the genesis of the various parts of this passage back through Christopher *jr.*’s earlier draft, Samuel Knight, *Life of Dr. J. Colet*, London, Downing, 1724, pp. 409–410, Anthony à Wood, *Athenae Oxonienses*, London, Knaplock, Midwinter & Tomson, 1721, vol. 2, *Fasti Oxonienses*, p. 56, and Charles Goodall, *The Royal College of Physicians of London*, London, Kettilby, 1684, *An historical account of the College’s proceedings against empiricks and unlicenced practisers*, ‘The Epistle Dedicatory’, it becomes clear just how misleading *Parentalia* can be. The words in italics, for example, come from the title of a small handbook on dissection by William Molins, published before Scarborough’s lectures had begun.

<sup>20</sup> *Parentalia*, p. 187; cf. Royal Society MS. 249, f. 208.

<sup>21</sup> British Museum MS. Add. 25,071, f. 38v. Note that even in his final version Christopher *jr.* refers to work done at Oxford.

<sup>22</sup> See the *Dictionary of national biography* article on Scarborough.

become associated with the lectures in any way? We have seen that these possibilities occurred to Christopher *jr.* only as the *Parentalia* text developed, and it looks very much as though they were based on surmise, rather than on direct evidence. Did Wren make models of muscles at all, albeit not purposefully for the lectures? Here we seem to be on firmer ground. As we shall see, there is independent evidence of Wren's interest in the motion of muscles, and Christopher *jr.* refers to models in his very early drafts. In his earliest reference he also cites his evidence: "There is extant only the first draught of a Letter to Sr. Charles relating to the Arm, wherein is some hint of the Pastboards".<sup>23</sup> Without this letter it is difficult to judge its significance. Having seen Christopher *jr.*'s ability to base definite claims on very little evidence, particularly with regard to Wren's supposed authorship of *De ratione motus musculorum*,<sup>24</sup> the only safe course is to regard the case for the models as inconclusive.

On the positive side, we know that Wren maintained contact with Scarburgh long after the early period under his care. After Wren became Professor of Astronomy at Gresham College in 1657, he and Scarburgh were both giving public lectures in London,<sup>25</sup> and both joined in the regular meetings of a group of "mathematical friends".<sup>26</sup> Although an original Fellow, Scarburgh took little part in the early meetings of the Royal Society, but he and Wren were associated with the Longitude Commission of 1672, and the Mathematical School at Christ's Hospital. Hooke's *Diary* gives evidence of their continued friendship.<sup>27</sup> There is every reason to suppose that, when Wren became interested in the action of muscles, he benefited in some way from Scarburgh's expert knowledge of the subject. Although he was not clear about Scarburgh's role, Christopher *jr.* consistently maintained that he had some link with Wren's work on muscles.

Wren definitely did not act as a demonstrator for Scarburgh before going to Wadham. At a later date he did become interested in muscular action and may well have made models, as he often did, to illustrate his ideas, though even this is not known with certainty. We can probably assume that he would have discussed mutual interests with his friend Scarburgh, who was an authority in the field. They may even have collaborated together, and Scarburgh may have come into possession of models made by Wren. However it seems doubtful that Wren assisted directly at Scarburgh's lectures, or that he made models purposefully to illustrate them. We need more definite evidence on these questions before repeating the standard account.

A later date for Wren's concern with muscular action, and in particular for the treatise consistently referred to by Christopher *jr.*, has an interest that goes beyond that of a simple biographical fact. It brings us closer to the period in the early 1660s when Oxford was a centre for research and new ideas in physiology, and when Wren's associates there included Boyle, Willis and Lower. Further evidence confirms

<sup>23</sup> British Museum MS. Add. 25,071, f. 32v (note also *ibid.*, f. 100v); cf. *Parentalia*, p. 238 (and *ibid.*, p. 243).

<sup>24</sup> Bennett, *op. cit.*, note 11 above, p. 141.

<sup>25</sup> It is interesting that William Holder knew something of the anatomy lectures given by Scarburgh in 1660, see William Holder, *A supplement to the Philosophical Transactions of July, 1670*, London, Brome, 1678, p. 5.

<sup>26</sup> Robert Vaughan (ed.), *The Protectorate of Oliver Cromwell*, London, Colburn, 1838, vol. 2, pp. 478–479.

<sup>27</sup> Hooke, *op. cit.*, note 3 above, pp. 104, 249, 386.

*A note on theories of respiration and muscular action in England c. 1660*

that this was indeed the context for his work. Just as some of his other medical interests had important theoretical significances—intravenous injection for the theory of circulation, splenectomy for Galenic physiology<sup>28</sup>—Wren played a role in a wide-ranging theoretical debate that embraced muscular action, respiration and even meteorology. The evidence for this must be pieced together from a variety of sources.

First, what might Wren have derived from discussions or collaborations with Scarburgh? Scarburgh was greatly interested in mathematics and, according to Dr. Charles Goodall, this was reflected in a mechanical approach to anatomy. Goodall says that Scarburgh “. . . was the first who introduced Geometrical and Mechanical Speculations into Anatomy, and applied them as well in all his learned conversation, as more particularly in his famous Lectures upon the Muscles of Humane Bodies for 16 or 17 years together in the publick Theatre at Surgeons-Hall . . .”<sup>29</sup>

Through Scarburgh, Wren may well have become familiar with the mechanics of muscular action. A complete account, however, would need to explain the origin of the mechanical force. As Wren himself pointed out in an address to the Royal Society, probably delivered at the beginning of 1662,<sup>30</sup> a mechanical account must be comple-

<sup>28</sup> See Charles Webster, ‘The Helmontian George Thomson and William Harvey: the revival and application of splenectomy to physiological research’, *Med. Hist.*, 1971, 15: 154–167; note p. 41. Webster is probably correct in suggesting that it was Scarburgh who introduced Wren to the splenectomy experiment. In a note, written in his copy of Bacon’s *Sylva sylvarum*, Wren’s father, Dean Christopher Wren, refers to a successful splenectomy performed by Scarburgh on a dog, see Bodleian Library, T. 11. 20 Th., *New Atlantis*, p. 35. The note cannot be precisely dated, but other of the annotations in this volume date from 1656 to 1658, the year of Dean Wren’s death.

<sup>29</sup> Goodall, loc. cit., note 19 above.

<sup>30</sup> The address is printed at *Parentalia*, pp. 221–224, but the date is not given. Wren opens by saying, “We begin a new Year, and therefore may pause a little, and look back on what we have done, and consider what we may do”, *ibid.*, p. 221. Much of the address is concerned with his proposal that the Society should begin to compile an “History of Seasons”, which he thought “fit to be propos’d now at the Beginning of the Year”, *ibid.*, p. 222. Observations would be made in different parts of the country over a long period. The history involved, in part, an extensive meteorological record, and Wren referred to a way of observing wind-direction that had been successfully used at Oxford. He also hinted at some more unusual ideas: “I might seem to promise too much, should I say, an Engine may be fram’d, which if you visit your Chamber but one half Hour in the Day, shall tell you how many Changes of Wind have been in your Absence, though there were Twenty, and at what Hour every Change happen’d, and whether it were soft, stiff, or vehement.” Temperature could similarly be recorded: “Neither shall the Thermometer need a constant Observance, for after the same Method may that be made to be its own Register”, *ibid.*, p. 224. Wren concluded by saying: “Many other Things I might suggest of this Nature, which if the Design be once begun, I shall most willingly submit, upon Occasion, to the Judgment of the Society”, *ibid.*, p. 224. Clearly the address was written before Wren submitted his design for a weather-clock to the Society. There was, in fact, a Royal Society meeting on 1 January 1661/2, when, according to the minutes, “Mr. Croune was desired to write to Dr. Power, to observe the weather at Hallifax: Dr. Wren to draw up a scheme for a weather-cock, against the next meeting: and Mr. Powle to observe the weather at home, and to give account thereof at his conveniency”, Thomas Birch, *A history of the Royal Society of London*, London, Millar, 1756–1757, vol. 1, p. 68. At the following meeting, “Dr. Wren brought in a scheme for a weather clock”, *ibid.*, p. 68. On 2 September 1663 Wilkins reminded the Society of “their former consideration of making a history of the weather, in order to build thereupon an art of prognosticating the changes thereof” (cf. Wren at *Parentalia*, p. 223), and it was decided to write to Wren “to send to the society a scheme of his weather-engine, formerly proposed”, Birch, *op. cit.*, vol. 1, p. 300. Wren eventually sent a design, which was registered by the Society on 9 December 1663, see *ibid.*, pp. 304, 305, 337, 341; Royal Society MS. EL. W. 3 no. 4, and RB. vol. 2 (original), pp. 321–322.



mented by a chemical explanation:

. . . in the Body of a Man, if we consider it only mechanically, we may indeed learn the Fabrick and Action of the organical Parts, but without Chymistry, we shall be at a Loss to know, what Blood, Spirits and Humours are, from the due Temper of which (as of the Spring in the Barrel Wheel) the Motions of all the Parts depend.<sup>31</sup>

Wren's emphasis on the necessity of a chemical explanation reflects the contemporary iatrochemical doctrines of his associates at Oxford. Familiar components of the traditional physiology—"Blood, Spirits and Humours"—must be understood afresh in chemical terms. For Wren, as for Boyle, the techniques of the chemists were tools essential to the development of both physiology and the corpuscular mechanical philosophy:

Mechanical Philosophy only teaches us what probably may be done in Nature by the Motion and Figures of the little Particles of Things, but Chymistry helps to determine what is actually done by the Motions of those invisible Parts of Liquors, Spirits, and Fumes; and oftentimes gives Light enough to contradict mechanical Hypotheses, that otherwise seem well grounded.<sup>32</sup>

It is worth noting, incidentally, that similar ideas appear in connexion with Wren's early work in microscopy: here too was a technique for placing the corpuscular philosophy on a sound empirical basis.<sup>33</sup>

At a Royal Society meeting on 8 March 1664/5, John Wilkins proposed an experiment "of Dr. Wren's suggestion".<sup>34</sup> If a "fermenting liquor" were placed in a jar connected to an empty bladder, the "air" being generated could be collected in the bladder and, if the apparatus were fitted with a tap, could be retained there. During the following weeks a series of experiments grew from this suggestion.<sup>35</sup> At the first of them, on 15 March, nitric acid was poured on to powdered oyster shells, and "the exhalation caused by the corrosion of the shells by the aquafortis, in a very little time blew up the bladder . . . so as to swell it with air very plump". Whereupon "Dr. Wren made use of this experiment to explain the motion of the muscles by explosion".<sup>36</sup> This is our first clue to Wren's ideas on the chemical source of muscular

<sup>31</sup> *Parentalia*, p. 221.

<sup>32</sup> *Ibid.* Cf. Wilkins: "By CHYMICAL OPERATIONS are meant such kinds of works as tend to the changing of bodies, with respect to the Position and Figure of their minuter parts", John Wilkins, *An essay towards a real character and a philosophical language*, London, Gellibrand & Martyn, 1668, p. 248. Wren attended Peter Stahl's chemistry classes at Oxford, see Andrew Clark (ed.), *The life and times of Anthony Wood*, Oxford, Oxford Historical Society, 1891–1895, vol. 1, p. 290, 472–473; G. H. Turnbull, 'Peter Stahl, the first public teacher of chemistry at Oxford', *Ann. Sci.*, 1953, 9: 265–270.

<sup>33</sup> *Parentalia*, pp. 204–205. Cf. Matthew Wren, *Monarchy asserted; or, the state of monarchicall and popular government*, Oxford, Bowman, 1659, preface; Henry Power, *Experimental philosophy, in three books*, London, Martin & Allestry, 1664, p. 82; Robert Hooke, *Micrographia: or some physiological descriptions of minute bodies*, London, Martyn & Allestry, 1665, preface; and note Laurens Laudan, 'The clock metaphor and probabilism: the impact of Descartes on English methodological thought, 1650–65', *Ann. Sci.*, 1966, 22: 73–103.

<sup>34</sup> Birch, *op. cit.*, note 30 above, vol. 2, p. 20.

<sup>35</sup> See *ibid.*, pp. 22–23, 25–26, 27, 29, 31; *Oeuvres complètes de Christiaan Huygens*, The Hague, Martinus Nijhoff, 1880–1950, vol. 5, p. 320. Note that Boyle later said that he had frequently done experiments of this kind, Birch, *op. cit.*, note 30 above, vol. 3, p. 84.

<sup>36</sup> *Ibid.*, vol. 2, p. 22.

*A note on theories of respiration and muscular action in England c. 1660*

action. Wilkins himself had previously devised experiments to demonstrate the mechanical force generated by inflating a bladder.<sup>37</sup>

Many had suggested that muscles contract because they are inflated by spirits passing along the nerves. In his *De ratione motus musculorum* of 1664 Croone put forward the idea that this inflation is caused by a chemical reaction between a nervous juice and the blood: “. . . not one is such a novice in Chemistry as not to know how great a commotion and agitation of the particles is accustomed to occur from different liquors mixed with each other . . .”.<sup>38</sup> In the same year Willis published his *Cerebri anatome*, where he also suggests a chemical explanation of muscular action in which a reaction between arterial blood and animal spirits produces an expansive force “like the explosion of Gun-powder”.<sup>39</sup> The blood contributes a vital, activating ingredient to the explosive reaction:

. . . whenas the arterious Juyce joyns more plentifully with the nervous flowing within the sanguineous parts, it may be well thought, that it also lays upon the Spirits brought thither with it, as it were some nitrosulphureous particles, and intimately fixes them on them; and so, by reason of this Copula, highly flatuous and apt to be rarified, the Spirits themselves become there more active, so that in every motive endeavour, whereby the Muscle is suddenly intumified, they, as if inkindled, are exploded.<sup>40</sup>

Willis repeats his explanation in comparing the action of the heart with that of a muscle:

And not much unlike in the Muscles, as in the Heart, is the business performed; the Spirits inhabiting their Fibres, receive a sulphureous Copula and apt for explosion, from the blood there more plentifully flowing than about the Membranes, with which being endued, as often as they receive from the Nerve as it were the fiery inkindling or the match, the instinct of the motion to be performed, they being excited, and striking off their Copula, very much inflate or blow up the Muscle, and intumifize it for performing or compassing the motive endeavour.<sup>41</sup>

Wren, of course, had taken part in the dissections and discussions that prepared the way for *Cerebri anatome*, and had drawn most of the illustrations in the book.<sup>42</sup>

## II

The function of respiration was a directly related problem; essential to Willis's muscular explosions were the “nitrosulphureous particles” carried by the arterial blood. John Mayow, who became a Fellow of All Souls in 1660 and therefore was probably in contact with Wren, developed a theory (first published in 1668) in which

<sup>37</sup> Ibid., vol. 1, p. 36.

<sup>38</sup> Quoted in L. G. Wilson, ‘William Croone's theory of muscular contraction’, *Notes Rec. R. Soc. Lond.*, 1961, 16: 158–178, see p. 162.

<sup>39</sup> Thomas Willis, *Dr. Willis's practice of physick, being the whole works of that renowned and famous physician*, translated by S. Pordage, London, Dring, Harper & Leigh, 1684, *The anatomy of the brain*, p. 105. A useful survey can be found in Raymond Hierons and Alfred Meyer, ‘Willis's place in the history of muscle physiology’, *Proc. R. Soc. Med.*, 1964, 57: 687–692.

<sup>40</sup> Willis, op. cit., note 39 above, p. 105.

<sup>41</sup> Ibid., p. 111.

<sup>42</sup> See *ibid.*, preface; *The life and works of the Honourable Robert Boyle*, edited by Thomas Birch, London, Rivington, 1772, vol. 6, pp. 462–466, 487.

nitrous particles, a vital constituent of the air, were carried by the arterial blood to the muscles, and there exploded on contact with the animal spirits. The same particles were also essential to combustion. Through the interest that Mayow's ideas have generated among historians, it has become clear that his work was part of a more general discussion, and that similar references to a "nitro-aerial spirit" can be found in the records of many natural philosophers.<sup>43</sup> These include, among Wren's associates, Willis, Lower, Boyle, Hooke and Ralph Bathurst.

Wren also was concerned with respiration and the notion that the air had a vital constituent. His interest seems to have focused on the possibility of actually demonstrating this, using what Sprat described as "Instruments of Respiration, and for straining the breath from fuliginous vapours, to try whether the same breath so purify'd will serve again".<sup>44</sup> Wren went at least as far as a written description of such an instrument,<sup>45</sup> though it seems unlikely that it was ever constructed. However in July 1663 he thought that a demonstration of this kind would provide suitable entertainment for the king's proposed visit to the Royal Society, and accordingly wrote to William Brouncker as follows:

It would be no unpleasing spectacle to see a man live without new Aire, as long as you please. A description of ye vessel for cooling and percolating ye Aire at once I formerly showed ye Society, and left with Mr Boyle. I suppose it worth putting in practice. You will at least learne thus much from it; if<sup>46</sup> something else in Aire is requisite for life, yn yt it should be coole only, and free from ye fuliginous vapors and moisture, it was infected wth in expiraõn; for all these will in probability be separated in ye circulation of ye breath in ye Engine. If Nitrous fumes be found requisite (as I suspect) wayes may phaps be found to supply yt too, by placing some benigne Chymicall Spirits, yt by fuming may impregnate ye Aire wthin ye vessell.<sup>47</sup>

In its contemporary context this reference to a vital nitrous component suggests a link between Wren's ideas on respiration and on muscular action. The link is confirmed by a later reference. On 17 December 1677 Hooke recorded that Wren ". . . told me of his paper Mr. Boyle had not returnd him, about the fabric of the muscles . . .",<sup>48</sup> and on 9 February 1677/8 Wren "Spake of his Theory of Respiration, muscular motion, &c., deliverd to Mr. Boyle . . .".<sup>49</sup> Since Wren said in 1663 that

<sup>43</sup> See, for example, T. S. Patterson, 'John Mayow in contemporary setting', *Isis*, 1931, 15: 47–96, 504–546; Henry Guerlac, 'John Mayow and the aerial nitre', *Actes du Septième Congrès International d'Histoire des Sciences*, Paris, Académie Internationale d'Histoire des Sciences, 1953, pp. 332–349; Henry Guerlac, 'The poets' nitre', *Isis*, 1954, 45: 243–255; J. R. Partington, 'The life and work of John Mayow (1641–1679)', *Isis*, 1956, 47: 217–230, 405–417; Allen G. Debus, 'The Paracelsian aerial niter', *Isis*, 1964, 55: 43–61. Note also Douglas McKie, 'Fire and the Flamma Vitalis: Boyle, Hooke and Mayow', in E. Ashworth Underwood (ed.), *Science, medicine and history*, London, Oxford University Press, 1953, vol. 1, pp. 469–488; Kenneth Dewhurst, *John Locke (1632–1704), physician and philosopher. A medical biography*, London, Wellcome Historical Medical Library, 1963, pp. 12–15.

<sup>44</sup> Thomas Sprat, *The history of the Royal Society of London*, London, Martyn & Allestry, 1667, p. 316; note also *ibid.*, p. 218.

<sup>45</sup> *Parentalia*, p. 243.

<sup>46</sup> The letter is quoted from a copy by Oldenburg, since this source is the closest available to Wren's original. Where Oldenburg reads "if" here, both *Parentalia*, p. 226, and a copy by Abraham Hill at British Museum MS. Sloane 2903, f. 105, have "that".

<sup>47</sup> Royal Society MS. EL. W. 3 no. 3.

<sup>48</sup> Hooke, *op. cit.*, note 3 above, p. 334.

<sup>49</sup> *Ibid.*, p. 344. On 6 February 1689/90 Wren and Hooke discussed "theory of Niter air flame", see Gunther, *op. cit.*, note 8 above, vol. 10, p. 185.



### *A note on theories of respiration and muscular action in England c. 1660*

Boyle had his account of a device for purifying the air, since he specified the importance of a nitrous element at the same time, and since he explained “the motion of muscles by explosion” early in 1665, it seems likely that this theory dates from the early 1660s and that Wren’s ideas developed alongside those of his friends at Oxford. Boyle was doing relevant experiments during this period. Willis, Lower and Wren carried on anatomical work together, and the *Cerebri anatome* contains relevant ideas, which Willis developed in later publications. Lower postulated a nitro-aerial spirit and muscular explosion in his *De corde* of 1669.

It is interesting that in April 1678, only a few months after Hooke and Wren had been discussing Wren’s earlier theories, Hooke proposed an explanation of muscular action at a meeting of the Royal Society, with Wren in the chair. When he had finished, “. . . an occasion was taken, to discourse of the causes of the motion of the muscles; and how far the air taken in by the lungs might contribute towards muscular motion. And it was thought, that it was of great necessity for that very purpose.”<sup>50</sup> On the question of muscular action, Wren’s ideas had not substantially changed: “Sir Christopher Wren supposed, that the swelling and shrinking might proceed from a fermentative motion arising from the mixture of two heterogeneous fluids.”<sup>51</sup>

We can probably uncover one of the sources of Wren’s interest in respiration. Guerlac has pointed out that the story of Cornelius Drebbel’s submarine, whose occupants were revived by breathing an aerial substance prepared from saltpetre, provided support for the theory of a vital nitro-aerial spirit, and that Boyle published a detailed account of this in 1660.<sup>52</sup> Wilkins had already devoted a chapter of his *Mathematicall magick* (1648) to “the possibility of framing an Ark for submarine navigations”, where he mentions Drebbel’s attempts and discusses “the greatest difficulty of all . . . how the air may be supplied for respiration”.<sup>53</sup> This book had a great influence on Wren in the 1650s and a catalogue of his early work, which probably reflects his interests during this period, includes not only “Strainer of the Breath, to make the same Air serve in Respiration”, but also “Ways of submarine Navigation” and “To stay long under Water”.<sup>54</sup> It seems possible that Wren first approached the subject of respiration through this specific problem, that he became acquainted with the mechanics of muscular action through his association with Scarburgh, and that, in discussions with his friends in the early 1660s, he contributed to the development of theories linking respiration and muscular action. These discussions involved the contemporary notion of a vital nitro-aerial spirit.

### III

Another aspect of Wren’s work during this period, which again runs parallel to similar interests among his friends, carries the thread of related ideas still further.

<sup>50</sup> Birch, *op. cit.*, note 30 above, vol. 3, p. 402.

<sup>51</sup> *Ibid.*, p. 403. Note Hooke, *op. cit.*, note 3 above, p. 355.

<sup>52</sup> Guerlac (1953), *op. cit.*, note 43 above, p. 339. Note also Boyle at Birch, *op. cit.*, note 30 above, vol. 2, p. 287.

<sup>53</sup> *The mathematical and philosophical works of John Wilkins*, London, Vernor & Hood, 1802, vol. 2, pp. 188–194.

<sup>54</sup> *Parentalia*, p. 198.

If part of the air is so vital to life, then the atmosphere must be studied as an important variable in the health of man. Already in 1657 Wren had suggested to the “rational philosophical Enquirer into Medicine” that a correlative study of dissections, epidemics, the weather and other natural phenomena would yield “a true Astrology to be found by the enquiring Philosopher, which would be of admiral Use to Physick”.<sup>55</sup> He returned to this theme in his 1662 address to the Royal Society, where he stressed the importance of chemistry to physiology. The programme was now better organized, perhaps because its theoretical rationale—the role of the air in the health of man—had been formulated more clearly: “. . . there is another Part of Physiology, which concerns us as near as the Breath of our Nostrils, and I know not any Thing wherein we may more oblige Posterity, than that which I would now propose.”<sup>56</sup>

What Wren proposed was an “History of Seasons”, divided into two parts. The first, “A meteorological History”, consisted of five sub-histories, in which were recorded the changing qualities of the air, such as its motion (winds), heat, cold, moisture, or refraction as observed with astronomical instruments. This would be correlated with “A History of Things depending upon Alteration of the Air and Seasons”—a record of crops and cattle, wines (though, as a foreign import, this belonged rather among the independent variables), fish, fowl, insects and venomous creatures, and

Above all, the Physicians of our Society should be desir'd to give us a good Account of the epidemical Diseases of the Year; Histories of any new Disease that shall happen; Changes of the old; Difference of Operations in Medicine according to the Weather and Seasons, both inwardly, and in Wounds: and to this should be added, a due Consideration of the weekly and annual Bills of Mortality in London.<sup>57</sup>

Wren's work in meteorology, which was largely concerned with the design of instruments, such as a rain-gauge and a thermometer, both self-registering, and his famous weather-clock, is correctly understood in the context of a broad medical philosophy. Associates who were also interested in meteorology, such as Boyle and Hooke, seem to have held similar ideas, and to have supported a miasmatic theory of epidemics. Boyle thought that epidemics resulted from a chemical imbalance in the atmosphere, caused by effluvia which originated in mineral deposits in the earth.<sup>58</sup>

#### IV

It seems clear that in the first half of the 1660s Wren played at least a supporting role in some exciting developments in theoretical physiology. The sparse record of his work adds a little to our understanding of a network of related ideas, which involved both a number of natural philosophers and a wide range of their interests.

We can perhaps derive a final point of interest from Wren. A familiar account of

<sup>55</sup> *Ibid.*, pp. 202–203.

<sup>56</sup> *Ibid.*, p. 222.

<sup>57</sup> *Ibid.*, pp. 222–223. Cf. Sprat, *op. cit.*, note 44 above, pp. 312–313.

<sup>58</sup> See Kenneth Dewhurst, ‘Locke's contribution to Boyle's researches on air and on human blood’, *Notes Rec. R. Soc. Lond.*, 1962, 17: 198–206; Dewhurst, *op. cit.*, note 43 above, pp. 17–19; Kenneth D. Keele, ‘The Sydenham-Boyle theory of morbid particles’, *Med. Hist.*, 1974, 18: 240–248.

*A note on theories of respiration and muscular action in England c. 1660*

the discovery of variations in the height of a stationary barometer begins with Wren's suggestion to Boyle that barometric observations would test the Cartesian theory that tides were due to pressure exerted by the moon.<sup>59</sup> The test naturally gave a negative result. Much later, in November 1679, the Royal Society discussed the question of "whence the alteration of the gravity of the air proceeds", and "Sir Christopher Wren was of the opinion, that it proceeded most of all from the impregnating of the air by nitrous salts, which were continually raised up into it."<sup>60</sup> We cannot know whether this was an opinion of long standing, though it may well have been, but it is at least interesting to think that Wren saw the vital nitro-aerial spirit being replenished in nature, and barometric readings as the immediate concern of the physician.

<sup>59</sup> See *The posthumous works of Robert Hooke*, edited by Richard Waller, London, R. Waller, 1705, 'The life of Dr. Robert Hooke', pp. vii-viii; Boyle, *op. cit.*, note 42 above, vol. 1, p. 41; Birch, *op. cit.*, note 30 above, vol. 3, p. 464; W. E. Knowles Middleton, 'A footnote to the history of the barometer', *Notes Rec. R. Soc. Lond.*, 1965, 20: 145-151, see p. 145.

<sup>60</sup> Birch, *op. cit.*, note 30 above, vol. 3, p. 509.