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Dr Erasmus Darwin's Management of Consumption: Cul-de-sacs and Prescient Insights

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Abstract

Erasmus Darwin (1731-1802) was one of the most significant intellectuals of eighteenth-century England. His talents were diverse, ranging from the invention of a copying machine and canal lifts to poetry that influenced Keats, Shelley, and Byron.

This paper however explores how Darwin, a very well-respected physician used his intellectual capacities to manage pulmonary consumption, through reference to letters to his friend James Watt about Jessie Watt's respiratory complaints, and correspondence with Thomas Beddoes, a pioneer of pneumatic medicine. These sources together with his publication *Zoonomia* provide an opportunity to examine in detail the reasoning behind Darwin's treatment suggestions.

This paper first gives a brief overview of the history of tuberculosis and medical understanding and treatment of consumption up to the late eighteenth century. A description follows of Darwin's ideas about the causes and pathology of pulmonary consumption. These explain his complex reasons for advising rotational motion, and his use of the foxglove and opium. The paper then describes his interest in pneumatic medicine and discussions with Thomas Beddoes about the therapeutic benefits of hypoxia in consumptives.

Despite Darwin having an inquiring, logical mind, his efforts at treating consumption failed. Reasons for this failure are discussed which, apart from a lack of evidence for germ theory, include a medical world that was struggling to assert its professionalism and to create evidence-based theories, as we enjoy in western medicine today. Lack of a dominant intellectual medical model and the failure to cure patients encouraged physicians to think creatively.

Key words

Erasmus Darwin, Thomas Beddoes, James Watt, Pulmonary consumption, Addictive drugs, Rotative swing, Pneumatic therapy

Introduction

Erasmus Darwin (1731-1802), Figure 1, was one of the most significant intellectuals of eighteenth-century England. Although it is probably true to say that Erasmus Darwin's achievements have been eclipsed by his much more famous grandson, the naturalist Charles Darwin (1809-82), this is to do him an injustice. Not only did he lay down the principles of evolution by natural selection in *Zoonomia or, The Laws of Organic Life*,[1] a two-volume compendium about life, physiology and disease, but he was also a creative inventor, responsible for a speaking machine, a horizontal windmill that Wedgwood used initially to grind colours in his pottery factory, new carriage designs, a copying machine, and a canal lift to name but a few.

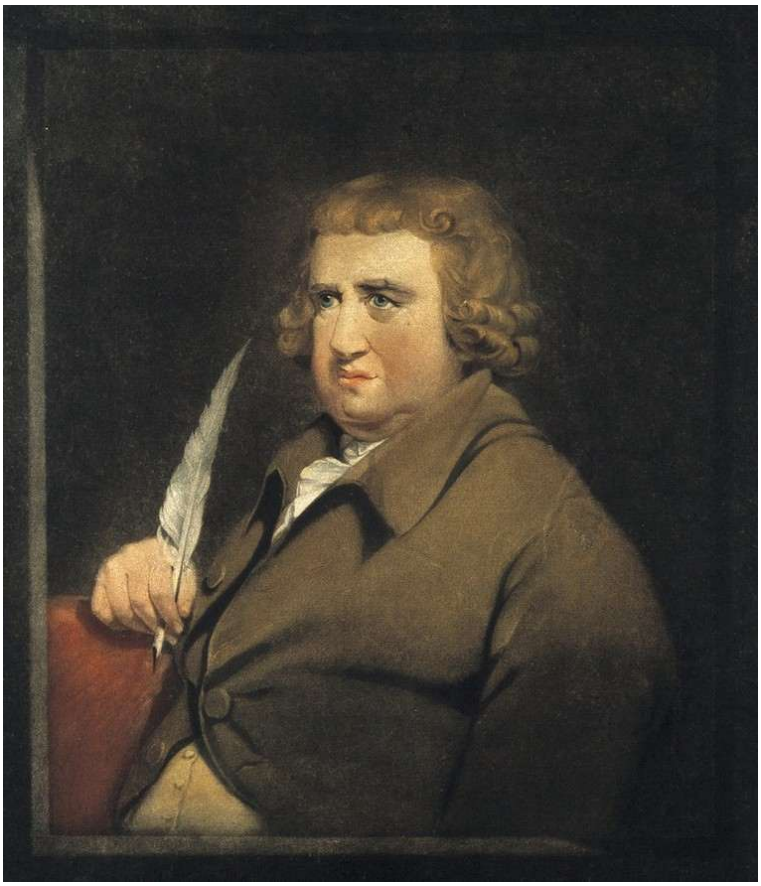

Figure 1. Erasmus Darwin. Colour mezzotint by J. R. Smith, 1797, after J. Wright. Wellcome Collection. Reference: 2381i. Public Domain Mark.

Together with others Erasmus Darwin established the intellectually fertile Birmingham Lunar Society, a group of men from different disciplines who met monthly when the moon was full to illuminate their travels. He formed close friendships with,

[1] Darwin E. *Zoonomia; or, the Laws of Organic Life*, *Vol. 1 & 2*. London: Printed for J. Johnson; 1794 & 1796. Later editions created volumes or parts 3 and 4 which simply contained the latter content of the 1796 text.

for example: Matthew Boulton (1728-1809), a leading manufacturer in Birmingham; James Watt (1736-1819) of steam engine fame; James Keir (1735-1820), pioneer of the chemical industry; Josiah Wedgwood (1730-95), the ceramic pioneer; and Thomas Beddoes (1760-1808), pioneer of pneumatic medicine. They all appreciated his enthusiasm and engagement with their projects and together they facilitated the Industrial Revolution in England.[2] In addition, he was a highly regarded and progressive jobbing physician who preferred travelling long journeys to visit his patients than accept the post of royal physician to George III.

Given their friendship, it is not surprising that in 1793 James Watt consulted Erasmus about his fourteen-year-old daughter Jessie who had suffered from a disorder of her lungs for some years. Her diagnosis was pulmonary consumption, a disease which was so rampant amongst the young in the eighteenth century that it was labelled 'the robber of youth' or, due to its characteristic pallor, 'the white plague'. The mortality rate in Europe around 1800 was about 900 per 100,000 inhabitants each year.[3]

Thanks to Darwin's practice of conducting consultations through correspondence, we have records of his treatment advice. These letters have been previously carefully collated with comments,[4] but have not been analysed in conjunction with his two-volume *Zoonomia*, which includes a *Materia Medica*, to clarify his understanding of the pathology of tuberculosis (TB) and thereby explain why he chose certain treatments for those of his patients with the disease.

To put Darwin's ideas on the causes, pathology and treatment of pulmonary consumption into its historical and contemporaneous context, this author first gives a brief overview of the history of TB followed by medical understanding and treatment approaches from antiquity, with an emphasis on standard eighteenth-century medical practice. Darwin's epistolary consultations with the Watt family are then described in detail. Their content, together with letters to Thomas Beddoes and his publication *Zoonomia,* are further explored to help understand his views about the causes of consumption and the reasoning for his treatment suggestions.

These sources are helpful because Beddoes was a pioneer of the therapeutic possibilities of atmospheric air and established a Pneumatic Institute in Bristol. He also co-authored a publication in two parts with James Watt in 1794, and in a revised edition of 1795, that discussed the medical uses of atmospheric airs and proposed an apparatus that could efficiently deliver them.[5] Darwin encouraged Beddoes in his research and together they developed the idea that a low oxygen environment might slow down or even treat pulmonary consumption. Further, Darwin directed Watt to Beddoes for advice on Jessie's treatment.

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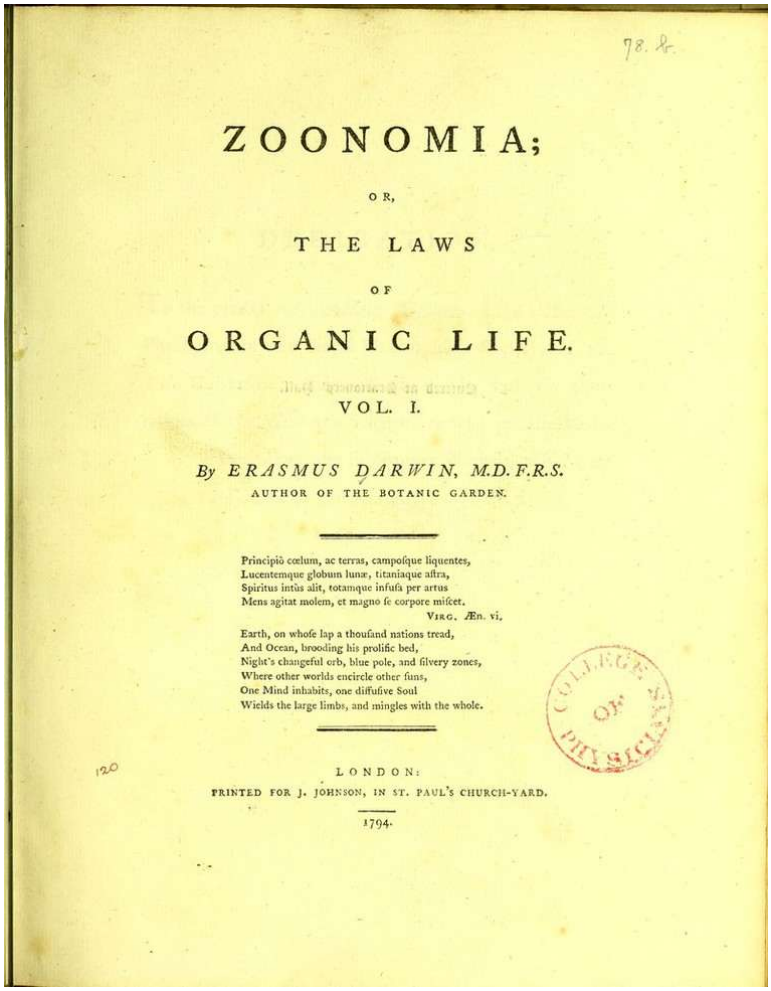
[2] King-Hele D. *Doctor of Revolution: The Life and Genius of Erasmus Darwin*. London: Faber & Faber; 1977. p13.

[3] Barberis I, Bragazzi NL, Galluzzo L, Martini M. The history of tuberculosis: from the first historical records to the isolation of Koch's bacillus. *Journal of Preventive Medicine and Hygiene.* 2017; 58(1): E9–E12.

[4] King-Hele D. *The Letters of Erasmus Darwin*. Cambridge: Cambridge University Press; 1981.

[5] Beddoes T, Watt J. *Considerations on the medicinal use of factitious airs and on the manner of obtaining them in large quantities. In two parts.* Bristol: Printed by Bulgin and Rosser, for J. Johnson and H. Murray; 1794; *Considerations on the medicinal use and on the production of factitious airs*. Second Edition. Bristol: Printed by Bulgin and Rosser, for J. Johnson; 1795.



ZOONOMIA;

OR,

THE LAWS

OF

ORGANIC LIFE.

VOL. I.

By ERASMUS DARWIN, M.D. F.R.S.

AUTHOR OF THE BOTANIC GARDEN.

Principiò cœlum, ac terras, camposque liquentes,
Lucentemque globum lunæ, titaniaque astra,
Spiritus intùs alit, totamque infusa per artus
Mens agitat molem, et magno se corpore miscet.
VIRG. Æn. vi.

Earth, on whose lap a thousand nations tread,
And Ocean, brooding his prolific bed,
Night's changeful orb, blue pole, and silvery zones,
Where other worlds encircle other suns,
One Mind inhabits, one diffusive Soul
Wields the large limbs, and mingles with the whole.

LONDON:

PRINTED FOR J. JOHNSON, IN ST. PAUL'S CHURCH-YARD.

1794.

Figure 2. Title page of *Zoonomia* by Erasmus Darwin, 1794. Wellcome Collection. Public Domain Mark. https://wellcomecollection.org/works/jma5fbp6

Volume I of *Zoonomia*, published in 1794 (Figure 2), took Darwin over twenty years to write. It was meant to be a classification system of all organic life in which he divided bodily action into four classes: Irritation, Sensation, Volition and Association. It includes several essays on a wide variety of subjects, including the liver, circulation, sleep and instinct. Volume II, published two years later, focused on classification of diseases. The *Materia Medica* at the end was intended to classify 'all substances which may contribute to health'. It is here that he gives treatment plans for a variety of diseases and complaints, including consumption.

An overview of the history of TB to the late eighteenth century: theories and management

The cause of TB, *Mycobacterium tuberculosis*, has affected humans for thousands of years. During the first millennium it spread to western Europe from the Far East,

becoming endemic by the Middle Ages.[6] Its spread increased during the eighteenth and nineteenth centuries as country folk flocked to cities for work where they often lived in overcrowded and poorly ventilated homes, favourable to the spread of the disease. The cause was not known and a subject for disagreement since antiquity regarding whether it was a hereditary condition or spread by an invisible agent. It was not until 1869 that Jean-Antoine Villemin (1827-92) proved that it was contagious, by injecting tuberculous matter from human cadavers into laboratory rabbits, which then became infected.[7] Fourteen years later Robert Koch (1843-1910) confirmed the germ theory of spread through identifying the bacillus using more sophisticated laboratory techniques and establishing its infectivity.

By the time Darwin was practising in the last decades of the eighteenth century, there had been some progress in establishing the basic pathology of phthisis,[8] and differentiation of different types of consumption, although this was contested, even diagnosis using the new percussion method invented by Leopold Auenbrugger (1722-1809) in 1761.[9] Disagreement about aetiology continued. Italy, Spain and France leaned towards an infectious cause, thereby applying in the seventeenth- and eighteenth-century public health measures like isolation and quarantine. Northern European countries tended to favour a hereditary cause or a cancer.[10] Significantly, progress in effective treatments was strikingly absent.

What could an eighteenth-century physician therefore do to manage the consumptive patient? The answer is that he relied on Hippocratic-Galenic medicine that taught the importance in the first instance of paying attention to the non-naturals, that is the atmosphere, exercise, sleep, diet, excretions and emotions. The mainstays of treatment in classical medicine therefore included diet, a change of air to drier lighter climates, sea voyages to induce vomiting, gentle exercise and bloodletting if the individual was spitting blood, since haemoptysis (coughing up blood) was thought to occur to counter-balance an excess of blood that was overheating the body.

The rationale for bloodletting arose from a humoral theory of disease that asserted that the body, which was composed of four humours, blood, phlegm, black bile and yellow bile, lapsed into illness when these were not in the correct balance. Each of the humours was also characterised by a pair of qualities such as hot and wet, or cold and dry. Management of illness thus focused on reestablishing balance, often through diet or

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[6] Bynum H. *Spitting Blood: The History of Tuberculosis.* Oxford: Oxford University Press; 2012.

[7] Barnes DS. *The Making of a Social Disease: Tuberculosis in Nineteenth-century France.* Berkeley CA: University of California Press; 1995. p.41.

[8] The term *consumption* was used as a lay term for phthisis in the 17th and 18th centuries, and both terms were used until the mid-19th century when the term *tuberculosis* was coined by Johann Lukas Schönlein and later used by Hermann Brehmer, Jean Antoine Villemin and Robert Koch. See: Frith J. History of Tuberculosis. Part 1 – Phthisis, consumption and the White Plague. *Journal of Military and Veterans' Health*. 2014; 22(2): 29-35.

[9] Daniel TM. (2000). *Pioneers of Medicine and Their Impact on Tuberculosis*. Rochester NY: University of Rochester Press; 2000. p.45.

[10] Sabbatani S. Historical insights into tuberculosis. Girolamo Fracastoro's intuition on the transmission of tuberculosis and his opponents. History of an idea [Article in Italian]. *Infezioni in Medicina.* 2004; 12(4): 284–291.

allopathy, that is exposure to an opposite quality. This is why a cooling diet was advised during the spring when it was thought that people were prone to having too much hot and wet blood; alternatively, bloodletting was undertaken to remove excess blood.

Despite advances in anatomical and physiological knowledge, the medicine of antiquity was deeply embedded in medical practice of the eighteenth and indeed, much of the nineteenth century. Although other medical models had emerged, such as iatrochemistry, mechanical medicine and nerve theory, they were often syncretized with classical medicine. Consequently, the physician's primary focus when managing consumption would be to help nature's healing power through rest, fresh air, a nutritious diet and moderate exercise. Bloodletting might be used to manage a fever in the more robust patient and blistering to draw toxic humors away from the lungs. Medication such as opium was a mainstay of many treatments, used to calm and sedate.

Medical advice in antiquity for consumption had included sea voyages which continued to be advised on the basis that sea air must be good. However, in the eighteenth century some physicians argued that the therapeutic factor was not merely exposure to sea air but sea sickness severe enough to cause vomiting because the violent motion quickly expelled uncomfortable mucus and purulent material. This led to a practice of prescribing mild emetics since not everyone had the means to afford a sea voyage.

Erasmus Darwin's correspondence with James Watt

These letters between Darwin and Watt start on 13 December 1793 and conclude on 11 June 1794, just after Jessie died.[11] Darwin clearly visited the Watt family to examine her on a few occasions, but actual details are not available. The first letter expresses Darwin's pleasure to hear that Jessie is continuing to get stronger and is no longer suffering with 'affectations of her lungs, and side' which had been bothering her in varying degrees for so long. He assumes that the medication he had prescribed, namely chalybeate (a medicine containing salts of iron) and laudanum, both in small quantities, had helped and advises its continuation for three months or longer until the weather becomes warmer. Further advice follows.

First, not to overheat her with a flannel next to the skin since this overstimulates cutaneous blood vessels thereby wasting 'the general quantity of animal power similar to what happens in scarlet fever'. Better to put a flannel on the outside of the shift and not to use one during warmer months. Jessie should use the winter cold air like a cold bath and go out three or four times each day for a few minutes at a time. She should keep busy with activities that help her to alter her posture during the cold season such as dancing, swinging, shuttlecock and fetching what she needs rather than have it brought to her. Best of all she should play Taw (marbles) because it keeps the joints supple, or exercise by bell ringing because it imitates swinging by the hands but on no account exercise with the lead weights (dumb bells) since they compress the intervertebral cartilages which stunts growth in young people.

[11] King-Hele. *The Letters*, 1981 (Note 4). p.228-261.

Jessie's health presumably declined rapidly since the next letter is dated just under three weeks later, on 1 January 1794. Perhaps Darwin is responding to a request for more explicit advice on how to manage Jessie's fever because he immediately launches into instructions to keep cool those parts of the body that are too hot while simultaneously warming up those parts that are too cool.

Thus in 'eruptive fevers', by which he probably means fever accompanied by a rash, he advises wrapping cold feet in flannel and exposing the face and bosom to the cold air. He next explains that ulcers are the basic pathology of consumption and the aim of treatment is to dry them up either by using foxglove, other emetics or a circular swinging, 'so as to be intoxicated and sickish as in a ship'. Darwin then recommends 'a zi [sic] of tincture of foxglove twice a day to be increased to two drams' and that Jessie should swing horizontally for half an hour or longer four to six times a day until she experiences vertigo and feels sick.

He is surprisingly discursive in the next part of the letter, outlining other possible interventions that he thinks may help. These include opium drops, five to ten twice a day to facilitate absorption, and tincture of bark if 'hysterical symptoms' recur (see below). Should a putrid fever develop, then yeast or mixed 'common air and fix'd air [carbon dioxide]' because of their antiseptic qualities. It is in this letter that he first mentions Dr Beddoes, pointing out that he endorses the use of air mixtures in such cases.

In the following two months, according to a letter from Jessie's mother, the young patient had lost weight, become weaker and was suffering with pains in her head and sides. Darwin replies that this is because she is not eating enough and reiterates the importance of nourishment and moderate outdoor exercise. He advises creating a small blister on her side or back for the pain, explaining that this stimulates digestion and 'the energy of the whole system'. The advice is based on a belief in 'consent of parts', which assumes a nervous sympathy between organs. Presumably he recommends further medicines since he tells her that they can be dispensed by their usual Birmingham apothecary-surgeon, who will give directions on how to take them.

The next letter from Darwin dated 25 April reveals that Jessie is no better. James Watt, clutching at straws perhaps, has presumably raised the question of whether a journey to the south coast might help. Erasmus supports the idea while reiterating that her lung complaint, amenorrhea and the 'symptoms term'd hysterical' are due to weakness, all of which is the result of lack of proper nourishment. At this point he compares Jessie with another patient in Tamworth, Miss Wilson, with similar symptoms occasioned by lack of nourishment. Advice follows on how to stimulate the digestive process and a regretful comment that medical science is not forward enough to use blood transfusion. This was an intervention that had intrigued him, but he had not felt it yet safe to try.

He tells Watt that he has seen the benefits of just a half-grain opium pill twice a day, increasing to a one grain-pill after a few weeks, insisting that the opium must be given 'in a very small pill [and] uniformly persisted in'. If fits occur or are threatened, thirty drops of a mixture of castor and laudanum to be given in addition to usual opium pills, repeated thirty minutes later if the symptoms have not stopped. As for diet, he recommends 'flesh meat' and small beer twice a day, but he mandates that Jessie's own wishes and taste should be primarily followed. So, if she prefers spring herbs, wine, and

water rather than small beer, she must have that. Finally, she should keep her stays loose, lie down for an hour after dinner and go to bed early.

It is likely that Darwin visited Jessie soon after when he gave further advice, since his letter of 25 May notes that 'antimonials for inflammatory symptoms' had not been very successful. He concentrates on discussing the benefits and adverse effects of emetics. If James Powder, a popular eighteenth-century fever powder containing antimony oxide and calcium phosphate, had brought no relief then ipecacuanha for three to five mornings. Best of all 'whirling circularly and horizontally' once or twice a day to induce seasickness. He maintains that even if vomiting does not occur, the motion 'cur[es] self -spreading ulcers'. If this does not work then foxglove, even though it can be harsh, for which he gives a dose schedule. He asks to be informed in the next few days of Jessie's response.

This letter ends with another reference to Thomas Beddoes, on this occasion his experience that acid applications may help to heal scrofulous ulcers, that is open sores on the neck. Darwin speculates that if this is the case, then pulmonic ulcers might heal through exposure to carbonic acid and atmospheric gas in equal parts or even 'oxygene gas [oxygen] at one quarter of its normal tension to atmospheric air'. He thinks this latter combination far better than that of azote (nitrogen) or hydrogen which some foreign researchers have tried. There again, he muses, the proportions might need to be different for different types of consumption. He ends by urging Watt to talk this over with Beddoes.

The next letter written only a week later seems uncharacteristically weary possibly because the Watt family have decided that emetics and swinging are too harsh for their daughter. What does a physician do when a patient refuses their advice? Darwin's response is to repeat his views and rationale for suggesting foxglove and circular swinging. He even suggests alternative emetics such as 'the scilla', a popular drug made from the bulb of a sea-onion. He adds that powder of bark and/or fix'd air might be given a trial. Watt has questioned whether a suffusion of warm water would help. Darwin doubts it. A week later, Darwin resignedly responds to probably a desperate letter from James Watt asking for further suggestions. He can only reiterate his previous advice on the swing, 'the most manageable and least dangerous'.

The inevitable then occurred. How does a doctor and friend console a grieving parent? Unlike all Darwin's other letters which are addressed 'Dear Sir', he begins this one, dated 11 June, with 'My dear friend' and continues 'There is nothing I can say to console you, which your own strength of mind has not already suggested …'. He tells his friend that Mrs Darwin has been grieving on behalf of them and how poignant his own grief is at the loss of such a 'beautiful [and] amiable character'. He quotes a letter between Cicero and Sulpicius that prompts him to comment 'we are all mortal; and as we are necessitated to bear our evils, we should bear them with fortitude'.

However, three weeks later there is another letter to his friend whom he praises for having decided that he must focus on a new project. This turned out to be a joint project with Thomas Beddoes to develop apparatus that could extract or mix airs reliably. Darwin even asks him to send him his newly designed apparatus saying that he had an asthmatic patient with whom he wished to try. The letter ends asking to be remembered to Mrs Watt.

Causes, pathological changes and classification according to Erasmus Darwin

There are three main sources that help to reveal Darwin's views about the causes, pathology and classification of consumption: *Zoonomia*, his correspondence with James Watt, and a letter he wrote to Thomas Beddoes, dated 17 January 1793,[12] in which he congratulates him on a treatise, *A Letter to Erasmus Darwin*, proposing a new method of treating pulmonary consumption.[13] This correspondence took place about eighteen months before Jessie's death, and eleven months before Darwin's first letter to Watt where he gave advice about treatment of her condition.

Darwin's letter of January 1793 reveals that he thought consumption could be caused by both hereditary predisposition and infection. He observed that relatives of those who had the disease succumb 'by hereditary predisposition' while 'nearest friends [do so] by contagion'. Yet, he seemed to favour an infectious model given that having classified consumption into two distinct types, he wrote that both were infectious to people who slept with a consumptive in the last stage of the disease. He supported this with clinical observations of spouses who developed the disease after the death of their partner. Like some of his medical predecessors, he speculated about the role of microorganisms but lacking any firm evidence, fell short of concluding they were the vector of infection.[14]

Darwin proposed that one type of pulmonary consumption begun between the ages of 17 and 27 years with 'mild haemoptoe' (haemoptysis); this was generally hereditary and free of the appearance of scrofula.[15] The other type did not start with haemoptoe, occurred at any time in life and was characterised by the appearance of scrofula in current relatives or earlier generation relatives. He added that younger patients with haemoptoe often have dark eyes and large pupils whereas those with the other type of consumption are light eyed with large pupils. The enlarged pupil size was due to an 'inirritability of the eye', a reflection of an 'inirritability of the whole system', or what we might now term lassitude or sluggishness. He added that haemoptoe is more likely in 'inirritible or weak people' and to occur during sleep because the respiratory system is not as responsive as it is during waking hours.

Like many other physicians, Darwin used the term ulcers to describe the basic pathology of the lungs but his interpretation of how they were formed differed from most of his contemporaries. He thought that they developed when bronchial veins ruptured leading to stagnation of blood in the air vessels of the lungs. Because they are continuously exposed to air, they are unable to heal easily. He bases this view on the observation that large skin or superficial abscesses can exist for weeks without causing a fever if they are not exposed to air, but once they are fever develops. Therefore, opening the abscesses with a seton, a thin thread through the skin to maintain an opening for discharge of pus, is a good idea because this method minimises the exposure to air.

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[12] King-Hele. *The Letters*, 1981 (Note 4).

[13] Beddoes T. *A Letter to Erasmus Darwin, M.D. on a new method of treating pulmonary consumption, and some other diseases hitherto found incurable.* Bristol: Printed by Bulgin and Rosser; 1793.

[14] Darwin. *Zoonomia, Vol. 2*, 1796 (Note 1). Part III, *Materia Medica*.

[15] Scrofula refers to lymph gland enlargement in the neck, usually associated with tuberculosis, but can be the result of atypical mycobacteria.

He points out that a similar approach of reducing contact with air occurs in attempts to heal a compound fracture. He admits in his letter to Beddoes that he is unsure what part of air is so damaging, whether it is an excessive amount of oxygene or azotic air (nitrogen) and hopes that Beddoes' experiments will decide the matter: 'Go on, dear Sir, save the young and fair of the rising generation from premature death; and rescue the science of medicine from its greatest opprobrium'.[16]

In Volume II of *Zoonomia,* the section *Materia Medica* provides more insights into Darwin's views about 'irritability' and ulcer healing. His classification system divides drug and food interventions into five categories based on different actions.[17] Again, he makes the fundamental point that an ulcer will not heal until absorption of fluid from it exceeds secretion of fluid into it. He further explains that ulcers in any part of the body spread due to 'saline aqueous acrimonious fluid' that is secreted into them. Normally this fluid is immediately reabsorbed. When it is not, the ulcer proliferates. Whereas external ulcers can be treated with lead salts or a dry application of powdered bark (probably Peruvian bark, or cinchona) to encourage absorption of the secreted fluid, lung ulcers require different drugs to encourage re-absorption.

The rationale behind Darwin's therapeutic advice

Darwin discussed the benefits of many drugs in his letters to James Watt. The ones he considered particularly effective for treating his daughter and strongly advised were opium and the foxglove.

Opium

Opium has been used medicinally for millennia and its use in ancient societies is well documented.[18] The influential physician and clinical teacher, Professor Herman Boerhaave of Leiden (1668-1738) used diacodium, a syrup of poppies to facilitate sleep in his consumptive patients.[19] By the eighteenth century it was a staple of most physicians' drug options, so it is hardly surprising that Darwin also prescribed it. In fact, he recommended Jessie take opium on several occasions, usually in pill form rather than as liquid laudanum. Characteristically, he tried to develop a theory of its mechanism in consumption, concluding that it facilitated re-absorption of the 'saline acrimony' and thereby helped ulcers to heal. Its action, he thought, was in two stages. Initially it promoted secretion which encouraged fibres to be deposited that thickened the matter, filling the ulcers with 'granulations of flesh'. Once this happened other medicines could be given that encouraged absorption only, such as Peruvian bark taken internally.

Darwin classified opium as belonging to the category of *Incitantia*, a Latin word meaning to hasten or accelerate. The action of foods or drugs in this category increased 'the exertion of all the irritative motions'. There was another reason to prescribe it.

[16] King-Hele. *The Letters*, 1981 (Note 4). Letter 93C. p.230.
[17] Darwin. *Zoonomia, Vol. 2,* 1796 (Note 14).
[18] Stefano GB, Pilonis N, Ptacek R, Kream RM. Reciprocal Evolution of Opiate Science from Medical and Cultural Perspectives**.** *Medical Science Monitor.* 2017; 23: 2890–96.
[19] Bynum. *Spitting Blood*, 2012 (Note 6). p.66.

Jessie had developed nervous pains in her sides and episodes of fits that Darwin refers to as 'hysterical symptoms'. From the late nineteenth century to the present time, the term hysterical has implied a psychological mechanism as the cause of symptoms. This was not Darwin's view. On the contrary, he thought that hysterical disease was physically rooted and presented 'inverted' symptoms which differed according to location. His examples may help us understand what he meant: borborygmi (gurgling sounds from gas and fluid movement in the intestines) were the result of inverted motions in the intestines and globus hystericus (the feeling of a lump in the throat) the result of retrograde peristalsis in the oesophagus.

In one of his letters to Watt, dated 25 April, Darwin states that Jessie's hysterical symptoms are the result of a poorly functioning digestive system, and the consequent poor nourishment had led to her 'debility'. This framework of understanding gives him a logical reason to prescribe opium for her hysterical symptoms, namely exploiting opium's *Incitantian* property of 'hastening' to stimulate the digestive system, thereby encouraging Jessie to eat more and gain strength. Notably, he was meticulous about the dosing schedule because he understood the addictive potential of opium and the development of a rebound 'debility' once it was stopped. His approach is along the lines of start low and increase slow, a maxim held to this day. Thus, he recommends half-grain opium pills twice a day increasing slowly to one-grain pills after a few weeks. He is insistent that the opium is given 'in a very small pill [and] uniformly persisted in'.

Darwin considered the following to also fall into the category of *Incintatia*: alcohol, many other drugs recognized as poisons and 'passions of the mind, as joy and love … [and the external] application of heat, electricity, ether, essential oils, and exercise'.[20]

Foxglove (digitalis)

By the time Erasmus Darwin was treating Jessie, he was convinced by the foxglove's ability to remove fluid: 'Nothing equals it for the purpose of absorbing water from the cellular membrane in the *anasarca pulmonum* [generalized lung oedema]*'*.[21] Modern medicine explains its action quite differently.[22] He goes on to say how astonished people are to see their limbs empty and their breathing improved when they suffer with dropsy (congestive heart failure) a condition that leads to swollen limbs from oedema and difficulty in breathing.

The foxglove was mentioned by Nicholas Culpeper in *The English Physician*, a popular herbal medicine guide of 1652, for a variety of conditions that included wounds, epilepsy and the King's Evil (scrofula).[23] Over a century later Dr William Withering (1741-99) discovered that it was an effective therapeutic agent in dropsy. In 1785 he

[20] Darwin. *Zoonomia, Vol. 1,* 1794 (Note 1). xx1x. 5.2.
[21] Darwin. *Zoonomia, Vol. 2,* 1796 (Note 14).
[22] Digitalis's effect is through strengthening the force of contraction of the heart which improves cardiac output. In addition, it slows down heart rate. Improved heart function can then reduce the pressure in the pulmonary veins and capillaries which can help to reduce fluid in the lungs. The underlying cause of fluid in the lungs is frequently heart failure.
[23] Culpeper N. *The English Physician*. London: Printed by William Bentley; 1652. p.97–98. From the medieval period, scrofula was called the King's Evil because it was thought that monarchs could heal it through their royal touch.

published *An Account of the Foxglove and some of its Medical Uses* which describes how he was prompted to explore its therapeutic effects on hearing of a local Shropshire woman who was well known for having a cure for dropsy.[24] He quickly determined that the therapeutic ingredient must be the foxglove and explored its potential by using it in varying doses on patients he treated *pro bono* at the hospital in Birmingham where he worked. He had moved to Birmingham from Stafford in 1775 at the suggestion of Erasmus Darwin, when his friend and fellow Lunar Society member Dr Small died; Withering was also invited to take up Dr Small's place in the Society.

As Withering explains in *An Account* he was initially very careful about dosage, aware that severe vomiting was a side effect which could further debilitate the patient. Thus, when Darwin asked for his opinion on one of his own patients with dropsy, Withering was at first most reluctant to suggest the use of digitalis. However, he succumbed with Darwin's encouragement, and it proved such a success that Withering later took over the entire care of the patient. This case is one of many described in *An Account* but is significant because Darwin attributed the discovery of the therapeutic effects of the foxglove in dropsy to his medically trained son Charles, born in 1758 who had died in 1778 of a septic infection acquired during a dissection.

Charles had been an excellent student whose essay on the difference between mucus and pus won him the Gold Medal of the Aesculapian Society of Edinburgh. After his death Erasmus edited his essay and combined it with his thesis on the lymphatics, adding in a section containing nine case histories involving the use of the foxglove; the first of these was the one for which he had asked Withering's opinion in 1776. The entire text was published in 1780 and failed to acknowledge Withering's work.[25] In January 1785 Darwin presented a paper to the Royal College of Physicians titled 'An Account of the Successful Use of Foxglove in Some Dropsies and In Pulmonary Consumption' which was subsequently published in *Medical Transactions*.[26] Here he gives a detailed dosing regimen for 'consumptions and scrophulous ulcers', and recommends omission for one to two days if unacceptable nausea occurs or the patient is too debilitated. Yet again he makes no reference to Withering. Justifiably, when Withering's *An Account* came out in the same year, it was highly praised and sealed his reputation.[27]

It is hard to be sure which of the two physicians first used digitalis in pulmonary consumption, but it is likely to be neither if *An Account* is a true representation of events. Withering says there that in 1783 he used it 'in particularly severe cases of consumption' having heard about common people in the West of England taking it for *phthisis pulmonalis,* although he admits he had not found it very effective. He also recalls coming across a note in the *Parkinson's Herbal* two years previously written by an apothecary surgeon of high repute, Mr Sanders, whom he quotes: 'Consumptives are cured infallibly

[24] Withering W. *An Account of the Foxglove and Some of Its Medical Uses: with Practical Remarks on Dropsy and Other Diseases*. Birmingham: Printed by M. Swinney; 1785.
[25] Darwin C. *Experiments establishing a criterion between mucaginous and purulent matter.* Lichfield: printed for J. Jackson, T. Cadell in London and W. Creech, Edinburgh; 1780. Published posthumously with a foreword by Erasmus Darwin, his father.
[26] Darwin E. An Account of the Successful Use of Foxglove in Some Dropsies and in Pulmonary Consumption*. Medical Transactions.* 1785; 3: 255- 286.
[27] Littler WA Withering, Darwin and digitalis. *QJM: An International Journal of Medicine*. 2019; 112: 887-890.

by weak decoctions of foxglove leaves in water, or water and wine, and drank … It has done great wonders … begin sparingly … for it is of a vomiting nature'.[28]

All this suggests that the use of foxglove in managing consumption was known in folk medicine and had reached the attention of other medical practitioners before it did Withering.

Undoubtedly, Darwin's behaviour towards Withering was not what now we would consider as professional. It is hard to explain it given that in so many other respects he was regarded by his contemporaries as a generous and humble friend and colleague. However, unlike Withering, Darwin did make efforts to explain the mechanism by which digitalis might be effective in managing consumption. In *Zoonomia* he categorises it as belonging to those botanicals that act by inverting the natural motions, the *Invertentia* and hence causes vomiting. His letters to Watt advise that it was a stronger emetic than ipecacuanha and that it was his preferred emetic. He believed emetics were useful because they promoted re-absorption of acrimonious fluid in the lung ulcers, thereby stopping or delaying their spread. His faith in the therapeutic effect of vomiting is further illustrated by his enthusiasm for the rotative swing or couch.

The rotative swing/couch

Darwin conceived of a mechanical apparatus as a safer alternative to medication to induce vomiting: '… the rotating swing is most manageable, least dangerous and most efficacious of all means hitherto essayed in pulmonary ulcers and where absorption from the lungs is indicated'.[29] The following quote describes the process:

> ... the patient should be placed in a chair suspended from the ceiling by two parallel cords in contact with each other, the chair should then be forcibly revolved 20 or 40 times one way, and suffered to return spontaneously; which induces a degree of sickness in most adult people, and is well worth an exact and pertinacious trial, for an hour or two, three or four times a day for a month.[30]

Darwin firmly believed that vomiting and sea sickness were effective treatments for consumption, but he did not agree with the reasons given by classical and contemporary scholars. A well respected colleague, Dr Thomas Reid (1739-1802), wrote at length on the subject in a publication in 1785, *An essay on the nature and cause of the phthisis or consumption of the lungs,*[31] where he points out that sea voyages were recommended by ancient writers like Celsus and Pliny as well moderns such as Boerhaave, Richard Mead (1673-1754), William Cullen (1710-90), Robert Whytt (1714-66) and John Gilchrist (1759-1841). Reid rejected the idea that the therapeutic effect was due to exposure to sea air, which was the contemporary view. Rather the effect was essentially a mechanical one where 'straining violently till pure bile is pumped into the stomach and discharged

[28] Withering. *An Account of the Foxglove,* 1785 (Note 24). p.9.
[29] King-Hele. *The Letters*, 1981 (Note 4). Letter 94H. p.249.
[30] Darwin E. *Zoonomia, Vol. 2,* 1796 (Note 1), p.292.
[31] Reid T. *An essay on the nature and cause of the phthisis or consumption of the lungs*. London: T Cadel; 1785.

… [was key because] bilious obstructions [are] removed, the digestive faculties restored, good chyle ... produced …'.

Darwin held a different explanation of the changes that occur on vomiting. As referred to above, his basic hypothesis was that vomiting induced re-absorption of any fluids in the lung ulcers thereby limiting their proliferation. Further, he explained that vomiting produces a 'torpor [in the stomach that] by association [makes] the motions of the arteries and heart weaker'. Through 'reverse sympathy … sensorial power accumulates in the pulmonary system that leads to an increased re-absorption of the fluids there'. [32] Darwin went on to say that a weaker circulation, brought on by vomiting, had the added advantage of reducing or stopping haemoptysis.

The notion of sympathy between nerves was a commonly held view at this time. Indeed, anything that related to nerve theory was quite fashionable in medical discourse in the later eighteenth century. Robert Whytt was a leading figure on nervous physiology and President of the Royal College of Physicians of Edinburgh for three years from 1763. In a major publication on 'nervous, hypochondriac, or hysteric' diseases he wrote about a 'sympathy between the stomach and other parts of the body' that was mediated by the nerves.[33] This is why, he tells us, opiates in the stomach can quieten a cough. However, in contrast to Darwin, he does not refer to a *reverse* sympathy between the stomach and lungs. Whytt's views about how emetics could improve a consumptive's symptoms also differ from those of Darwin. In common with Reid, he favoured a mechanical explanation, adding that mucus and purulent material in the lungs are forced out during vomiting. This he felt was a more patient-friendly method of discharge than constant coughing and moreover, once the vomiting stopped, it allowed the 'lungs to rest'.

Darwin's letters to Watt repeatedly advised that Jessie undertake circular swinging. He makes it clear more than once that this is a more effective method than administering ipecacuanha or the foxglove, and less harsh. It is not clear why he preferred this to the more horizontal motion produced by a children's playground swing. Presumably he considered it a more effective method, especially when the process entailed rotatory swinging in a chair two to three hours a day to make her 'vertiginous and sickish'. It may not be therefore surprising if her parents did not follow Darwin's instructions. In the second volume of *Zoonomia*, Darwin provided the specifications for a rotative apparatus and credited Dr James Smyth (1741-1821), physician to the King, for his essay on swinging in pulmonary consumption as an earlier advocate, although unlike Darwin he simply thought that regular swinging led to a palliative sedation. Smyth concludes his essay with the following:

> … as the sedative power of motion, to which we have ascribed the efficacy of sailing and swinging, is a principle hitherto unknown, I have been at some pains fully to establish it; and am convinced in my own mind, that when conducted with skill and integrity, it will not only be found useful in the cure of pulmonary

[32] Darwin. *Zoonomia, Vol. 2,* 1796 (Note 14). Class 1.1.1.4.

[33] Whytt R. *Observations on the nature, causes, and cure, of those disorders, which have been commonly called nervous, hypochondriac, or hysteric.* Edinburgh: printed for T. Becket, and P. du Hondt, London and J. Balfour, Edinburgh; 1765.

complaints, but may probably be employed with advantage in a variety of other cases.[34]

Darwin believed that swinging could also diminish fever through forcing blood from the brain to other parts of the body, and that this was achievable by the patient lying on a bed with her head at a distance from the centre of motion. Following Jessie's death, James Watt took Darwin's advice to distract himself with a project. One of these, as is related in the next section, was to collaborate with Beddoes on his pneumatic apparatus. Another was to design 'a movable rotative couch' based on Darwin's specifications. Over a year later in November 1795, Beddoes contacted Watt, asking if he could have the couch constructed to enable him to treat his patient Mrs Kerr who was suffering with consumption. Darwin was delighted and subsequently wrote to Watt to request a copy of his design for inclusion in the next edition of *Zoonomia* (Figure 3).

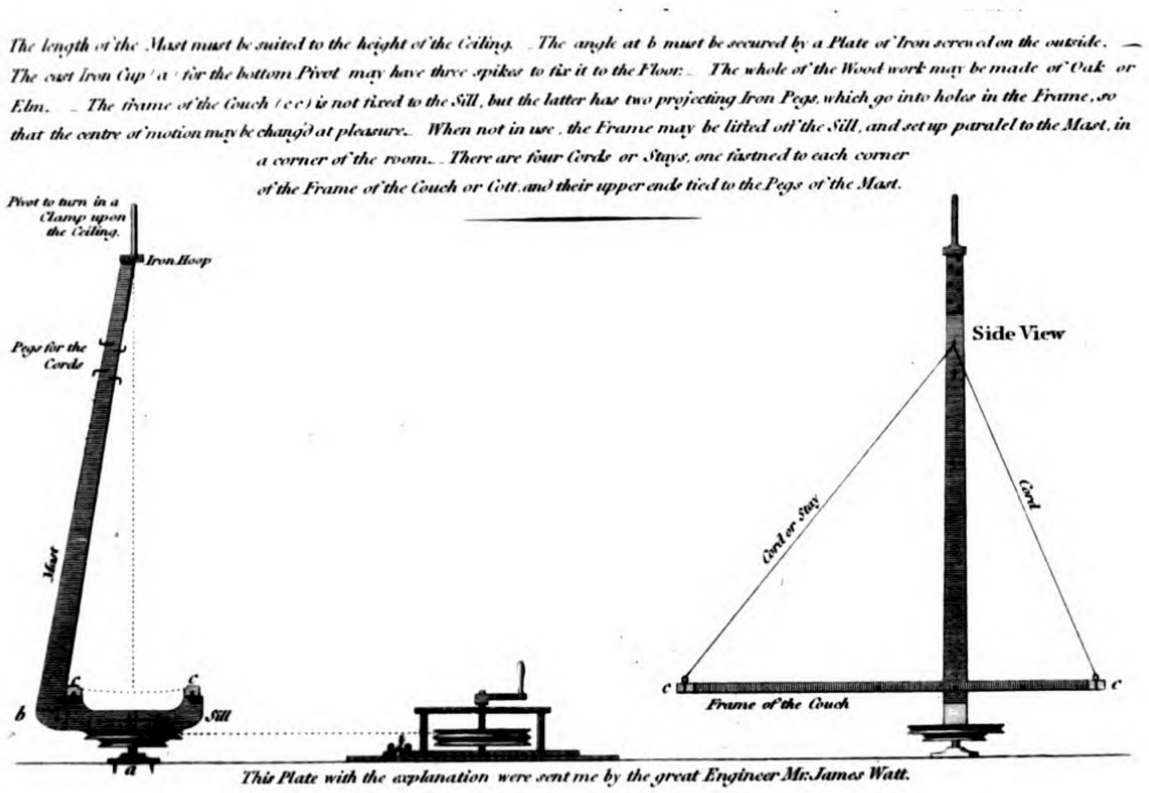

Figure 3. Prototype of a rotative swing by James Watt. Darwin E. *Zoonomia, or the laws of organic life. Vol. IV*, Third Edition. London: printed for J. Johnson; 1801. After p.436. https://dbooks.bodleian.ox.ac.uk/books/PDFs/600054995.pdf

[34] Smyth JC. *An account of the effects of swinging, employed as a remedy in the pulmonary consumption and hectic fever.* London: printed for J. Johnson; 1787.

Beddoes thought that 'some form of motion' would be beneficial for Mrs Kerr. The apparatus was ready within two months and initially helpful, especially when the swinging was slow, in that her flushing and chills largely stopped, and her sleep improved. Beddoes' scientific skepticism is revealed with a comment that he could not be sure these benefits were the result of the swinging couch, though he had not changed her diet or medicine. After first trying out the couch he made some adjustments, which he described to Watt in a letter on 12 January 1796. Notably he added 'side pieces perpend[r] for the sake of more swinging …', presumably to prevent her falling out of the apparatus. To his credit he also tried out the couch himself, remarking 'the whole sensation is to me highly disagreeable'. Sadly, Mrs Kerr died a few months later.[35]

The rotative swing marked the beginning of the therapeutic use of centrifugation.[36] The idea was soon taken up by specialist doctors of insanity, Joseph Mason Cox (1763-1818) of Fishponds Asylum near Bristol and William Hallaran (1765-1825), superintendent at Cork Lunatic Asylum. Cox had a rotative swing made for his asylum in Bristol where initially he used it to induce sleep or quieten disturbed patients. He regarded it more effective than opium. In *Practical Observations on Insanity*, he referred to its use in case study reports and advocated it as a cure for a variety of mental illnesses.[37] There was a robust, although erroneous, rationale behind his regard for this treatment that drew from the views of physician and philosopher John Locke (1632-1704) on the causes and treatments of insanity as well as contemporary Brunonian theory.[38] The basic idea was that stimulation of the brain could recalibrate the reasoning faculties restoring them to normal. The practice was not confined to Britain. For example, in Germany the physician Ernst Horn (1774-1848) introduced rotational therapy at the Charité Hospital in Berlin and in Italy, Vincenzo Chiarugi (1759-1820), a pioneering moral therapist, used rocking to calm maniacal patients. But, the rotative swing's visceral unpleasantness, together with the reports of it being used as a means of control and punishment, turned public opinion against it such that by the 1830s it was no longer employed.

Pneumatic medicine: Beddoes, Darwin and Watt

As noted above, Darwin was well acquainted with Beddoes' work and urged him to continue with his experiments in pneumatic medicine in his reply to Beddoes' *A Letter* of 1793 which in effect was a short treatise. In *A Letter* Beddoes displays his interest in using therapeutic airs to treat consumption, citing the observations of a Dr Percival, possibly English occupational health physician and medical ethicist Thomas Percival (1740-1804), that carbonic acid air alleviated its symptoms. He goes on to say that

[35] Stansfield DA, Stansfield RG. Dr Thomas Beddoes and James Watt: preparatory work 1794-96 for the Bristol Pneumatic Institute. *Medical History.* 1986; 30: 276-302.
[36] White WJA. *History of the Centrifuge in Aerospace Medicine*. Santa Monica CA: Douglas Aircraft Co; 1964.
[37] Cox JM. *Practical Observations on Insanity.* London: Baldwin; 1804.
[38] Dickson S. Rotation therapy for maniacs, melancholics and idiots: theory, practice and perception in European medical and literary case histories. *History of Psychiatry.* 2018; 29(1): 22-37.

although Dr Fourcroy (1755-1809) had described twenty cases where inspiration of oxygene air aggravated symptoms, his work was unimpressive because it was merely based on 'random trials, guided by no fixed principle'. This might sound arrogant, but Beddoes was knowledgeable about recent developments in gas chemistry. In the 1780s he had visited Antoine Lavoisier (1743-94) in Paris who had discovered oxygen in 1778 and hydrogen in 1783, and the role that oxygen plays in combustion. He was familiar with the research of Joseph Priestley (1733-1804), particularly his independent discovery of dephlogisticated air (oxygen) in 1774 and his experiments that showed hydrogen and carbonic acid to be potentially injurious to health. Further he had taught the principles of gas chemistry at Oxford University.

In *A Letter* Beddoes expresses his intention to design apparatus that could reliably extract azote (nitrogen gas), hydrogen, carbonic acid gas and oxygene. He hopes to mix these airs with one another and atmospheric air in different proportions with the aim of discovering correct mixtures to treat not only consumption but various other diseases. He refers at length to one patient, a consumptive young man, whom he had treated initially successfully with mixed air that greatly eased his symptoms of dyspnoea, expectoration and pain, although he ultimately died. Beddoes also describes his experiences of self-experimentation, of breathing pure oxygen over many weeks, taken up to five minutes at a time and no longer than an hour per day. Amongst the beneficial effects were an improvement in his complexion that prompts him to suggest with a degree of mirth that oxygen had the potential to become a household cosmetic item. Unfortunately, he soon discovered the disadvantage of too much oxygen through becoming very ill for some weeks.[39]

Darwin did not employ pneumatic therapy in Jessie Watt's case probably because Beddoes' work was still at an early stage and his pneumatic apparatus was undeveloped. A letter of 9 June 1794 from Watt to his friend Bishop reveals that Beddoes was approached for help in Jessie's last days:

> I sent for Dr. Darwin who gave little hopes but prescribed for the fever and other urgent symptoms. I then had Dr. Beddoes who attended her daily for a week but also seemed to think the case desperate. She breathed fixt air from effervescing mixtures placed near her and sometimes inhaled it mixt with atmosphere, but without other apparent effect than its being grateful to her. The violence and fever the hystericks and her great weakness prevented our trying the effect of other airs and some attractive medicines.[40]

Beddoes at this stage did not have the funds to develop his apparatus. After Jessie died Watt decided to throw himself into a project which was to support Beddoes' ideas for pneumatic apparatus and the establishment of a Pneumatic Institute. As a result, by August 1794, two months after Jessie's death, Darwin received newly designed apparatus by Watt and Beddoes that led him to write a long enthusiastic letter recommending various improvements. In the next three years Watt and Beddoes

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[39] Beddoes. *A Letter to Erasmus Darwin,* 1793 (Note 13).

[40] Robinson E, McKie D (eds). *Partners in Science. Letters of James Watt and Joseph Black.* Cambridge MA: Harvard University Press; 1970. 9 June 1794. Letter 144. p.203.

collaborated on optimising the breathing apparatus, publishing their work,[41] and developing the Institute, which Darwin and various friends as well as Beddoes had financed. Beddoes' vision of the Pneumatic Institute was that it should concurrently undertake research and treatment of patients with the hope that it would establish the therapeutic efficacy of gases in a variety of conditions, although foremost in pulmonary consumption. Although there was substantial interest in this project amongst many physicians in England who had trialed gases, there was also a lot of opposition from 'physicians who are almost as inveterate against me as they were against the discoveries of the circulation of the blood' according to a letter from Beddoes to Watt. Thanks to his friends and Watt's considerable influence he was able to overcome this and open the establishment in 1799.[42]

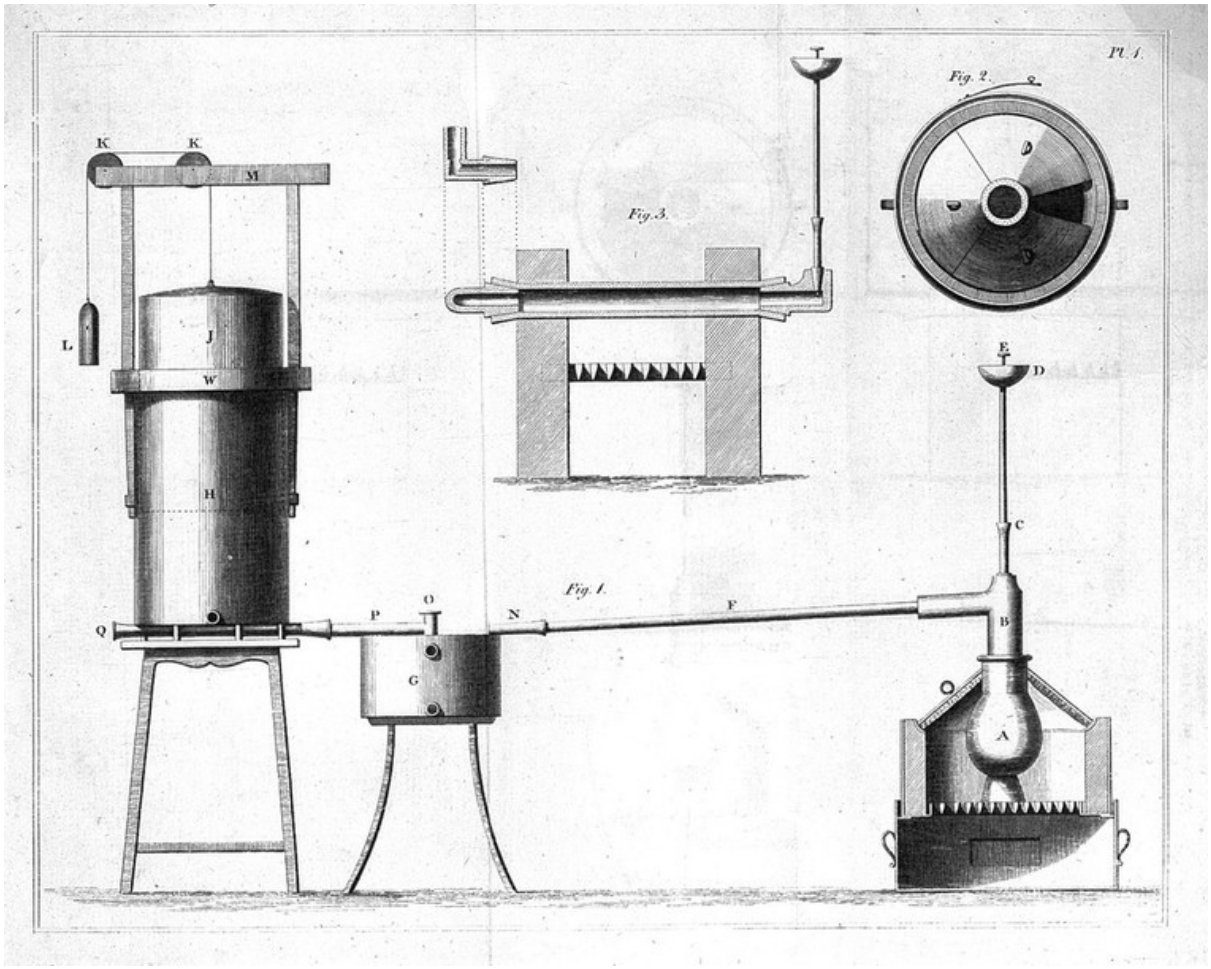

Figure 4. Watt's design of pneumatic apparatus. From: Beddoes, Watt. *Considerations*, 1794 (Note 5). Plate 1. Source: Wellcome Collection. Public Domain Mark.

A theme in Beddoes' work was the notion that a high oxygen environment could be a cause of consumption and worsen the prognosis. This was possibly prompted by an

[41] Beddoes, Watt. *Considerations*. Second Edition. 1795 (Note 5).
[42] Stansfield, Stansfield. Dr Thomas Beddoes, 1986 (Note 31).

early observation that the cheeks of consumptives were characteristically a florid crimson colour which he attributed to excess oxygen in the blood.[43] Darwin was interested in the idea that a high oxygen environment was detrimental as revealed by a letter to Beddoes where he relates how he had urged a patient's father 'to try a lower atmosphere' on his consumptive son.[44] We do not know if the father tried this out.

Darwin was also intrigued by Beddoes' observation that consumptive symptoms remitted during pregnancy. Both men concluded that this was due to hypoxia. This concept was revived in the mid-nineteenth century when Hermann Brehmer (1826-89) published his medical thesis in 1853, *On the laws concerning the initiation and progression of pulmonary tuberculosis*. However, his rationale was different. Having noted from postmortems that consumptive victims had small hearts relative to their lung size he reasoned that hypoxic conditions would encourage the heart to grow larger thereby increasing the overall strength of the sufferer. It is likely that he was influenced by his friend, the naturalist Alexander von Humboldt (1769-1859), who told him that TB rarely occurred among high altitude residents of the Himalayas and other mountainous locations. Brehmer subsequently opened the first high altitude sanitorium for treatment of TB at Gorbersdorf, which was situated in the Sudeten mountains at a height of 600 meters.[45]

Other sanatoria were established up to World War I, most notably in the resort of Davos, which was modelled on Brehmer's.[46] One popular measure in these sanitoria was to insist on bed rest such that the patient lay flat. Unbeknown to their physicians that may have worked because gravity dependent distribution of pulmonary blood flow in the upright position creates high oxygen tension in the apices of the lungs, which favours growth of tubercles; lying flat therefore would reduce multiplication.[47]

Discussion

The letters between Erasmus Darwin and his friend James Watt about his daughter's consumption reveal Darwin as a conscientious and compassionate physician. These together with his ambitious and successful publications further reveal him as an interdisciplinary, imaginative and logical thinker. So why were his ideas about consumption and its treatment so fallacious? The obvious answer is the lack of evidence for microorganisms, although Darwin flirted with the concept and realised that microscopy might lead to new insights in the future. However, the germ theory of disease transmission was not to be proven until the development of microbiology and bacteriology in the second half of the nineteenth century. To understand better Darwin's

[43] Bynum. *Spitting Blood*, 2012 (Note 6). p73.
[44] King-Hele. *The Letters*, 1981 (Note 4). Letter 94C. p.242.
[45] Daniel TM. Hermann Brehmer and the origins of tuberculosis sanatoria. *International Journal of Tuberculosis and Lung Disease*. 2011; 15(2): 161–162.
[46] Murray JF, Schraufnagel DE, Hopewell PC. Treatment of Tuberculosis. A Historical Perspective. *Annals of the American Thoracic Society.* 2015; 12(12): 1749-59.
[47] Murray JF. Bill Dock and the location of pulmonary tuberculosis: how bed rest might have helped consumption. *American Journal of Respiratory and Critical Care Medicine*. 2003; 168(9): 1029-33.

failures requires a proper appreciation of the entire medical landscape of the late eighteenth century and the dynamics of his relationship with the Watt family.

Despite improved understanding of human anatomy and physiology there was still no unequivocally dominant medical model that explained disease. It may appear that Hippocratic theory that spoke of humoral imbalance, the healing power of Nature and the importance of regimen, was such, but clearly practising physicians for some centuries had become increasingly dissatisfied with the shortcomings of the model and the lack of effective treatments for many diseases, particularly consumption. Consequently, many alternative theories developed, although ancient medical interventions were incorporated rather than abandoned.

Another characteristic of the eighteenth-century scientific world was a lack of what we would recognise today as published good quality peer-reviewed journals to promote dissemination of medical findings, scrutiny and discourse. In England, the earliest one, which has continued to the present day, was *Philosophical Transactions of the Royal Society,* established two years after the Royal Society of London (1663) was created; this journal was devoted to the study of natural philosophy (science) and included medicine but did not have a thorough system of reviewing papers prior to publication, until a committee was established in 1831-32 which included a medical member.[48]

Many other medical journals were established in eighteenth-century Britain, either by individuals or collectively by medical societies but for the most part they were ephemeral, and they lacked any concept of rigorous peer review, which only developed in the mid-nineteenth century. Significantly, Darwin's concern to keep up to date is revealed by a letter to his son Robert in which he said he wanted to 'read all the new medical journals which come out'.[49]

Darwin was clearly highly conscientious but in the case of Jessie, he was treating the daughter of his great friend; moreover, he and his wife were friendly with the whole Watt family. This may have prompted him to recommend the latest potentially beneficial treatments available even when it meant admitting to his deficiencies and referring Jessie to Beddoes. Significantly, although he was well aware of the likely prognosis, he maintained an optimistic tone in most of his letters which reveals his recognition of the therapeutic power of instilling hope.

Darwin and Beddoes' view that consumptive symptoms remitted during pregnancy because of hypoxia was speculative. It is now recognised that pregnancy is a state of profound bodily change and immunological complexity. Conceivably an attenuated immunological response in the pregnant woman could result in a reduced granulomatous response in those with TB and thus reduce symptoms. But generally, pregnant females are more susceptible to infection, so it might be expected that consumptive symptoms would worsen rather than improve.[50]

This author speculates that a different explanation for apparent remission might be that of a late uterus pressing on the lungs. This leads to a situation like an intentionally collapsed lung, a popular treatment in the twentieth century designed to 'rest the lung', which may have helped due to induction of hypoxia. Some *in vitro* studies have shown

[48] Marta MM. A brief history of the evolution of the medical research article**.** *Medicine and Pharmacy Reports*. 2015; 88(4): 567–570.
[49] King-Hele. *The Letters*, 1981 (Note 4). 92C. p.221.
[50] Personal communication: Dr William Dibb, Consultant Microbiologist.

that *M. tuberculosis* much prefers an aerobic atmosphere, that is one containing oxygen, although most mycobacteria are facultative anaerobes. The evidence *in vivo* is less clear but evidence from studies of oxygen administered at reduced atmospheric pressure shows that low oxygen pressures inhibit *M. tuberculosis* bacilli from surviving and multiplying.[51]

Considering Darwin both as the compassionate doctor and friend as well as an intellectual working in the medical world described above, helps us to put his theories and treatments into context. Today, orthodox western medical practice is grounded in an evidence-based medical paradigm. There are competitors from 'alternative' medicines and the traditions of the non-western world, such as Homeopathy, Chinese Traditional medicine, and Ayurvedic medicine but none of these, arguably, can compete with western orthodox dominance.

In the eighteenth century no one intellectual model had such dominance. Further, statistically reviewed clinical data were in the foothills of development, opportunities for robust medical debate in person or print were limited, and medical technology was not advanced. Understanding this in the context of a doctor trying to save the fourteen-year-old daughter of a close friend helps to explain how a man of such extraordinary ability could proceed down blind alleys.

[51] Murray JF. Tuberculosis and high altitude. Worth a try in extensively drug-resistant tuberculosis? *American Journal of Respiratory and Critical Care Medicine.* 2014; 189(4): 390-393.

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