Erasmus Darwin (1731 – 1802)

First the new actions of the excited sense,
Urged by appulses from without, commence;
With these exertions pain, or pleasure, springs,
And forms perceptions of external things.
Thus, when illuminated by the solar beams,
Yon waving woods, green lawns, and sparkling streams,
In one bright point by rays converging lie
Planed on the moving tablet of the eye;
The mind obeys the silver goads of light,
And irritation moves the nerves of sight.

The lines above are from Erasmus Darwin’s *The Temple of Nature* (Canto III 55 – 64) published in 1803, the year after his death. This poem presents his astute speculations about the origins of life and its evolution; the four Cantos consider the production of life, its reproduction, the progress of mind, and the forces of good and evil. Darwin’s reputation was high during his life, but diminished in the century that followed, being eclipsed by the impact of his grandson, Charles. It is being restored now, due in no small measure to the research and writing of Desmond King-Hele. He has written two biographies of Erasmus Darwin (King-Hele 1977, 1999), has edited his letters (King-Hele 1981), has assessed his poetry (King-Hele 1986), and is about to reprint the *Life of Erasmus Darwin* written by Charles (King-Hele 2002).

Figure 1. Portrait of Erasmus Darwin superimposed on one of the paving stones in the garden at Erasmus Darwin House, Lichfield. Other paving stones mark his contributions as a scientist, inventor, evolutionist, humanitarian, and poet.
Erasmus Darwin (figure 1) was born at Elston, near Newark, Nottinghamshire on 12 December 1731. At the age of nine he went to Chesterfield School, proceeding to St John's College, Cambridge in 1750. He studied medicine at Edinburgh University for two years from 1754, and practiced as a physician at Lichfield from 1756 to 1781. His house, close by Lichfield Cathedral, has been restored and reflects many aspects of his rich and rewarding life. Darwin built a successful practice at Lichfield, but his interests were not confined to medicine. He formed friendships with major engines of the industrial revolution, like James Brindley, Matthew Boulton, James Watt, Josiah Wedgwood, and Joseph Priestley. From around 1765 onwards they met on the nearest Monday to the new moon; the group later became the Lunar Society of Birmingham. The final twenty one years of his life were spent practicing medicine at Derby. It was during this period that his fame as a poet and his authority as a physician were firmly established. Darwin's epic poem on vegetable life, *The Botanic Garden* was published in two parts in 1789 and 1791, and the two volumes of *Zoonomia*, dealing with animal life, appeared in 1794 and 1796. Robert Darwin, the father of Charles, was the third son of his first marriage. His wife, Mary, died in 1770 and he married Elizabeth Pole in 1781. Erasmus Darwin died on 18 April 1802 at his home, Breadsall Priory. A conference in commemoration of the bicentenary of his death was held at Lichfield in April this year, and it brought together those who acknowledged his many inventions and the advances he made in medicine, geology, meteorology, botany, zoology, educational theory, poetry, and vision.

It is the last of these that is of most interest to readers of *Perception*, and the lines above signal the links between Darwin’s poetry and his science. The latter received its most mature expression in *Zoonomia*, a massive text with lofty aims. He commenced: “The purpose of the following pages is an endeavour to reduce the facts belonging to ANIMAL LIFE into classes, orders, genera, and species; and by comparing them with each other, to unravel the theory of diseases” (1794, page 1). The theory was based on assessing the excess or deficiency of sensation, irritation, volition, or association. The sections of *Zoonomia* concerned with vision embraced the dimension of motion. One was entitled “The motions of the retina demonstrated by experiment” and the other was on “Vertigo”. *Zoonomia* itself has an interesting history. The first volume was published in 1794, with the second edition of it in 1796; the first edition of the second volume appeared in that year, too (figure 2). Volume 1 contained Darwin's survey of organic life, and volume 2 presented his classification of diseases. The third edition was published in four volumes in 1801. Some significant changes in the sections on vision were made over the three editions, as will be indicated below.

Prior to the publication of *Zoonomia*, Darwin (1778) had written an article on squinting, and he had established an enduring interest in afterimages. In a letter to Benjamin Franklin, in January 1774, he noted that “I have another very curious Paper containing experiments on the Colours seen in the closed Eye after having gazed some Time on luminous Objects, which is not quite transcribed, but which I will send you, if you think it is likely to be acceptable to the [Royal] Society at this Time, but will otherwise let it lie by me another year” (Willcox 1978, page 25). This paper was not published under his name but was, perhaps, expressed indirectly through the article by his son, Robert Waring Darwin (1766–1848), on ocular spectra (R Darwin 1786). This article was reprinted in its entirety as Section XL of *Zoonomia*, and large parts of the section on “Motions of the retina” were derived from it. Robert's son, Charles Darwin (1809–1882), suggested that rather more than a little help was provided by Erasmus to Robert in both the article and the dissertation on which it was based. In his *Life of Erasmus Darwin* Charles wrote of the article that “I believe he was largely aided in writing it by his father” (C Darwin 1887, page 84). In the footnote to the reprint of Franklin’s letter Willcox (1978) suggests that they collaborated on it.
The language of the article bears a close similarity to that in which Erasmus cloaks diseases in *Zoonomia*. We cannot determine the extent to which it corresponds to Robert’s later publications, because there were none! The article described positive and negative afterimages in both their achromatic and chromatic aspects, the fragmentation of patterned afterimages, and the variation in the apparent size of the afterimage with the distance of the surface on which it is projected. A simple “tadpole” demonstration was described in which a black shape was fixated for some time and then projected on to white paper; a negative afterimage could be seen, and it appeared whiter than the paper itself. The interpretation of this effect was essentially in terms of differential retinal adaptation. The visibility of afterimages could be revived by intermittent stimulation (moving the hand in front of the eyes), and it was noted that there can be a latency before the afterimage is initially visible.

Erasmus Darwin commenced the section on motions of the retina: “BEFORE the great variety of animal motions can be duly arranged into natural classes and orders, it is necessary to smooth the way to this yet unconquered field of science, by removing some obstacles which thwart our passage. I. To demonstrate that the retina and other immediate organs of sense possess a power of motion, and that these motions constitute our ideas.” (1794, page 14). The power of motion was demonstrated principally via ocular spectra (afterimages), and the section has hand-coloured plates of single and concentric circles. His theory of space perception was essentially Berkeleyian, with the emphasis on learning through tactile and muscular exploration. This sentiment is expressed many times in *The Temple of Nature*. 

Figure 2. Volumes 1 and 2 of Erasmus Darwin’s *Zoonomia*. The second edition of volume 1 was published in 1796, as was the first edition of volume 2. The latter is described as volume 2 on the title pages, but as Part 2 thereafter; it contained “A catalogue of diseases distributed into natural classes according to their proximate causes, with their subsequent orders, genera, and species, and with their methods of cure”.

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There are many allusions to the senses in Darwin’s poem, and they build upon sections in *Zoonomia*. For example, he stated that “it is not the presence of the light and sound, but the motions of the organ, that are immediately necessary to constitute the perception or idea of light and sound” (1794, page 21). In the context of eye movements, he drew attention to the instability of the eyes during attempts at steady fixation, and the apparent motion that occurs when a peripheral afterimage is pursued. It was in this connection that Darwin discussed visual vertigo. When the body is rotated several times and then stops, the body seems to be rotating in the opposite direction, as does the visual world. Erasmus Darwin described the effect in the section on “Vertigo”. He listed other conditions that could induce dizziness like looking downwards from a high tower, unusual body motion (as at sea), and drunkenness.

Darwin returned to interpret visual vertigo in some “Additional observations on VERTIGO”, which were appended to the forty chapters in volume I. The addition was required because his theory (that visual motion was due to ocular pursuit of peripheral afterimages) had been attacked by William Charles Wells (1757–1817) in his book on binocular single vision (Wells 1792). Wells provided experimental evidence (from observing afterimages) that the eyes moved in slow and fast phases (nystagmus) following rotation, and the visual motion was observed during the slow phases (see Wade 2002). Darwin countered:

“After revolving with your eyes open till you become vertiginous, as soon as you cease to revolve, not only the circum-ambient objects appear to circulate around you in a direction contrary to that, in which you have been turning, but you are liable to roll your eyes forwards and backwards; as is well observed, and ingeniously demonstrated by Dr. Wells in a late publication on vision. The same occurs, if you revolve your head with your eyes closed, and open them immediately at the time of your ceasing to turn; and even during the whole time of revolving, as may be felt by your hand pressed lightly on your closed eyelids. To these movements of the eyes, of which he supposes the observer to be unconscious, Dr. Wells ascribes the apparent circumgyration of objects on ceasing to revolve. The cause of thus turning our eyes forwards, and then back again, after our body is at rest, depends, I imagine, on the same circumstance, which induces us to follow the indistinct spectra, which are formed on one side of the center of the retina, when we observe them apparently on clouds ... and then not being able to gain more distinct vision of them, we turn our eyes back, and again and again pursue the flying shade ....

Doctor Wells imagines, that no spectra can be gained in the eye, if a person revolves with his eyelids closed, and thinks this is a sufficient argument against the opinion, that the apparent progression of the spectra of light or colours in the eye can cause the apparent retrogression of objects in the vertigo above described; but it is certain, when any person revolves in a light room with his eyes closed, that he nevertheless perceives differences of light both in quantity and colour through his eyelids, as he turns round; and readily gains spectra of those differences. And these spectra are not very different except in vividness from those, which he acquires, when he revolves with unclosed eyes, since if he then revolves very rapidly the colours and forms of surrounding objects are as it were mixed in his eye.” (1794, pages 571 and 573)

That is, afterimages could still be formed with the eyes closed and they would be in the peripheral parts of the retina. There is a tendency to pursue but never to locate a peripheral afterimage even when it is very weak. Darwin then provided what he considered to be crucial evidence that eye and visual motions were not related. He denied the occurrence of ocular torsion or rolling of the eyes and so he conducted an ingenious experiment:

“in which the rolling of the eyes does not take place at all after revolving, and yet the vertigo is more distressing than in the situations above mentioned. If any one looks steadily at a spot in the ceiling over his head, or indeed at his own finger held up high over his head, and in that situation turns round till he becomes giddy; and then stops, and looks horizontally; he now finds, that the apparent rotation of objects is from above downwards, or from below upwards; that is, the apparent circulation of objects is now
vertical instead of horizontal, making part of a circle round the axis of the eye; and this
without any rolling of his eyeballs. The reason of there being no rolling of the eyeballs
perceived after this experiment, is, because the images of objects are formed in rotation
round the axis of the eye, and not from one side to the other of the axis of it; so that,
as the eyeball has not the power to turn in its socket round its own axis, it cannot follow
the apparent motions of these evanescent spectra, either before or after the body is at
rest.” (1794, page 572)

Thus, Darwin considered that if ocular torsion was not possible then rotary motion
could not be associated with it! Accordingly, Darwin dismissed the correlation between
eye movements and visual motion for all forms of postrotational vertigo. He did not
modify his position even when Wells (1794a, 1794b) presented experimental evidence
that the eyes did undergo torsional nystagmus under the conditions described by Darwin.

Darwin’s objections to Wells’s observations were not changed in the second edition
of volume 1 (Darwin 1796a), but there were some informative additions to the section
on “Vertigo”. These concerned the dizziness that can be induced visually:

“Thus in a room hung with a paper, which is coloured with similar small black lozenges
or rhomboids, many people become dizzy; for when they fall, the next and the next
lozenge succeeds upon the eye; which they mistake for the first, and are not aware, that
they have any apparent motion. But if you fix a sheet of paper, or draw any other figure,
in the midst of these lozenges, the charm ceases, and no dizziness is perceptible .... Thus
some people become dizzy at the sight of a whirling wheel, or by gazing on the fluctua-
tions of a river, if no steady objects are at the same time within the sphere of distinct
vision.” (1796a, pages 232–233)

This last description comes very close to describing a visual motion aftereffect. Although
motion aftereffects had been described by Aristotle and Lucretius, they remained unre-
reported until Purkinje (1820) rediscovered them. It is of interest to note that Purkinje’s
account was also in an article on vertigo, and it is Purkinje who is usually credited
with establishing the connection between the direction of visual vertigo and the orien-
tation of the head during rotation.

In the third edition of Zoonomia, Darwin (1801a) incorporated his assessment of
Wells’s experiments in the section on “Vertigo”, and accepted that there could be several
causes of apparent visual motion following body rotation, but that it was mainly a
“deception of imagination”. However, Darwin’s greatest contribution to subsequent
research on posture and vertigo was his invention of the human centrifuge. This was
described and illustrated in volume 4 of the third edition (Darwin 1801b). He called
the device a rotative couch; he did not, however, construct one or perform experiments
with it. The proposed function of the rotative couch was to increase pressure on the
brain. He described it thus:

“Another experiment I have frequently wished to try, which cannot be done in private
practice, and which I therefore recommend to some hospital physician; and that is,
to endeavour to still the violent actions of the heart and arteries, after due evacuations
by venesection and cathartics, by gently compressing the brain. This might be done by
suspending a bed, so as to whirl the patient round with his head most distant from the
centre of rotation, as if he lay on a mill-stone ... For this purpose a perpendicular shaft
armed with iron gudgeons might have one end pass into the floor, and the other into
a beam in the ceiling, with a horizontal arm, to which a small bed may be readily
suspended. By thus whirling the patient with increasing velocity sleep might be produced,
and probably the violence of the actions of the heart and arteries might be diminished
in inflammatory fevers.” (1801b, pages 436–437)

Detailed engineering drawings were made by Darwin’s friend, James Watt (1736 – 1819),
and are shown in figure 3. It is clear that Darwin’s device was not stimulated by his
concern with vertigo; rather it was driven by his theory of disease, in which any means
of inducing sleep was considered efficacious. Indeed, it was a conversation with his
engineer friend—James Brindley (1716–1772)—that led to the invention of the rotative couch:

“Another way of procuring sleep mechanically was related to me by Mr. Brindley, the famous canal engineer, who was brought up to the business of a mill-wright; he told me that he had more than once seen the experiment of a man extending himself across the large stone of a corn-mill, and that by gradually letting the stone whirl, the man fell asleep, before the stone had gained its full velocity, and he supposed would have died without pain by the continuance or increase of the motion. In this case the centrifugal motion of the head and feet must accumulate the blood in both those extremities of the body, and thus compress the brain.” (1801b, page 314)

The basis for Darwin’s invention of the rotating chair or bed might have been idiosyncratic but its subsequent application has been widespread, and it has provided the foundation on which much vestibular research has progressed (see White 1964).

Darwin was alert to the advances made over a vast scientific spectrum. For example, he was amongst the first to apply galvanic (electrical) stimulation to the senses. He reported an experiment by Volta in which current from lead and silver in connection, when delivered to different parts of the tongue, resulted in “a saline or acidulous taste is perceived, as of a fluid like a stream of electricity passing from one of them to the other. This new application of the sense of taste deserves further investigation, as it may acquaint us with new properties of matter” (1794, page 120). This was elaborated upon in the “Additions” to volume 1; if silver and zinc are applied to the tongue they can produce taste or a flash of light. In 1800 Darwin described using a “galvanic pillar” (after Volta’s pile) to stimulate the eyes at up to 100 discharges a minute, producing flashes (see King-Hele 1999).

The dependence of perception on motion was stressed by both Berkeley and Darwin. In Zoonomia Darwin stated “Thus when a tree is the object of sight, a part of the retina resembling a flat branching tree is stimulated by various shades of colours; but it is by suggestion, that the gibbosity of the tree, and the moss, that fringes its trunk, appears before us. These are ideas of suggestion, which we feel or attend to,
associated with the motions of the retina” (1794, page 117). They also shared a distrust of geometrical interpretations of vision, based on the retinal image:

“If our recollection or imagination be not a repetition of animal movements, I ask, in my turn, What is it? You tell me it consists of images or pictures of things. Where is this extensive canvas hung up? or where are numerous receptacles in which those are deposited? or to what else in the animal system have they any similitude? That pleasing picture of objects, represented in miniature on the retina of the eye, seems to have given rise to this illusive oratory! It was forgot that this representation belongs rather to the laws of light, than to those of life; and may with equal elegance be seen in the camera obscura as in the eye; and that the picture vanishes for ever, when the object is withdrawn.” (1794, page 29)

Despite criticising this “illusive oratory”, Darwin adopted similar allusive devises in his poetic view of nature. The Temple of Nature was the publisher’s rather than Darwin’s title for the evolutionary and revolutionary poem; Darwin had called it The Origin of Society. The poem has copious notes and footnotes on all the topics contained within it, explaining the terms used and justifying the positions adopted. Accordingly, it is appropriate to finish, as we began, with a verse from The Temple of Nature. This one (Canto III 131—144) also intones the power of the hand (the tangent organ) in framing the form of vision, as well as commenting on the wonders of the magic lantern.

Slow could the tangent organ wander o’er  
The rock-built mountain and the winding shore;  
No apt ideas could the pigmy mite,  
Or embroyon emmet, to the touch excite.  
But as each mass the solar ray reflects,  
The eye’s clear glass the transient beams collects;  
Bends to their focal point the rays that swerve,  
And paints the living image on the nerve.  
So in some village-barn, or festive hall,  
The spheric lens illumes the whiten’d wall;  
O’er the bright field successive figures fleet,  
And motley shadows dance along the sheet.  
Symbol of solid forms is colour’d light,  
And the mute language of the touch is sight.

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