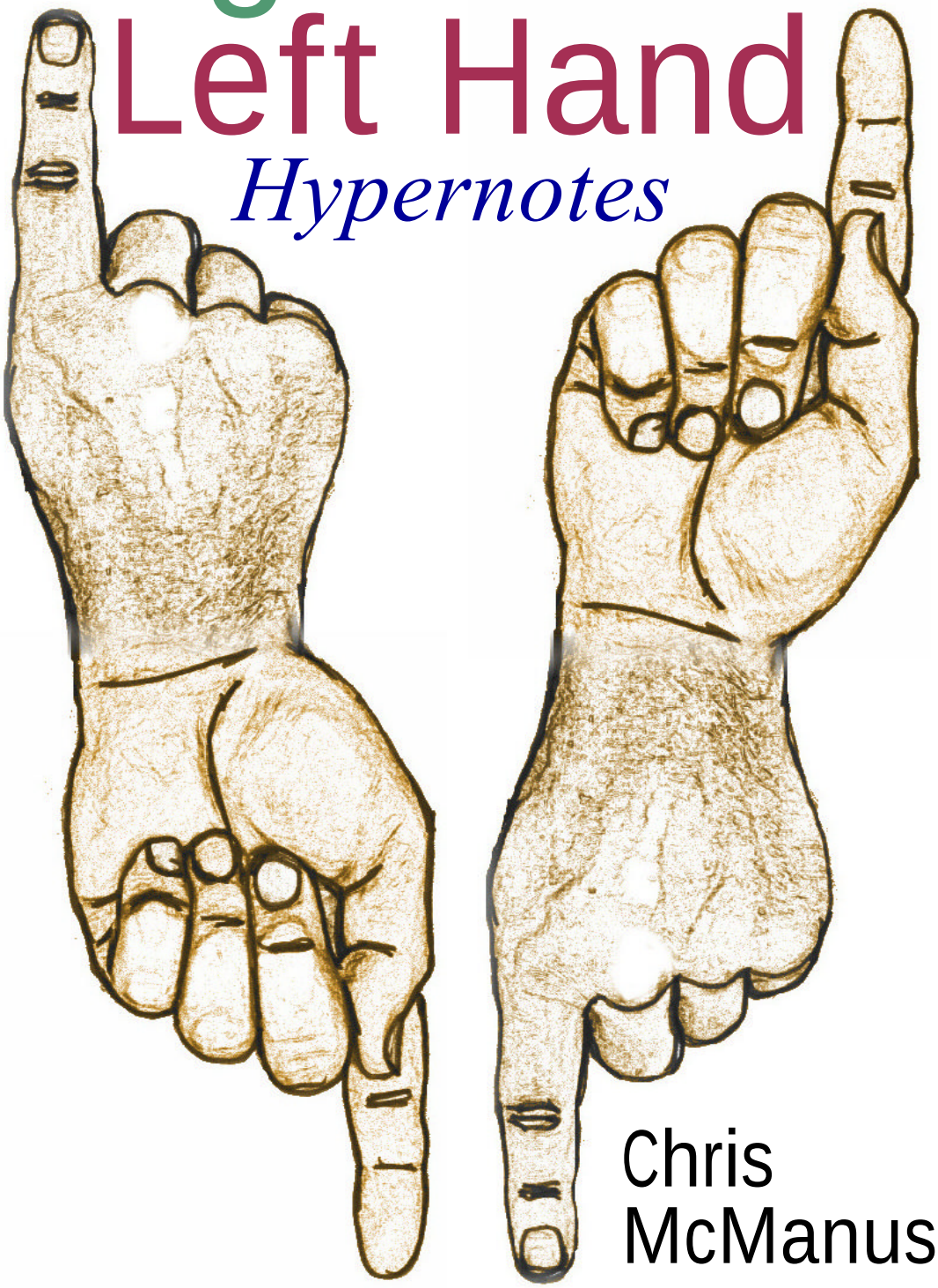
Right Hand Left Hand

Hypernotes



Chris McManus

Introduction

"... permit me to disclose my name,
My calling, and the business I pursue.
I am a scholar, christen'd Lateral,
Truth-speaker, dweller on the open way.
Much have I read in books, and more in men,
Far have I wander'd, deeply have I weighed
The words and ways of pilgrims passing by".

In writing *Right hand, left hand* I encountered far more material than I could begin to include in the book or its endnotes. As an academic researcher into laterality I found them interesting, and I therefore felt it possible that others with my own particular enthusiasms might also find them useful. The internet is the perfect place for such ruminations and reflections since they are readily available to those who are interested but do not impose at all on those who find their detail of little matter. As an example of the things I found while preparing the book, and also as an epigraph to these details, I cite a curious piece of verse published in 1888 by Robert Buchanan (1841-1901), a Victorian poet who would now be almost entirely forgotten[1] were it not for the vitriol of his pseudonymous attack, as 'Thomas Matiland', on Rossetti and Swinburne, which made Ezra Pound subsequently refer to "foetid Buchanan"[2]. Rossetti at the time wrote a twelve-page reply, which was never published but has subsequently been rediscovered (Freeman, 2001), and includes a particularly angry but undistinguished limerick which was to be on its title page[3]. In his epic poem, *The city of dream* (Buchanan, 1901), which is some 7000 lines long[4], and is dedicated "To the sainted spirit of John Bunyan" there is a character by the curious name of Lateral, a scholar[5], who presents to the pilgrim as a stranger. It is a strange piece of verse, moving in its way[6], and it fits well for its present purpose.

---

[1] Buchanan must have been appreciated in his time or it would not have been thought worth publishing the two very lengthy volumes of his complete works (Buchanan, 1901). He does however seem to have slipped into the third division of nineteenth century poets. A critical appraisal of his work published in the year of his death (Stodert-Walker, 1901) says that, "Mr. Buchanan's significance lies then in the fact that he has used, as a subject for poetry, the great truths science has taught...". That may be so, but it hardly makes the generally turgid verse any the more readable, and seems only to be yet a further argument that science and poetry simply do not mix.

[2] In *Yeux glauques* of *Hugh Selwyn Mauberley (1920)*.

[3] "As a critic, the poet Buchanan
Thinks the Pseudo worth two of the Anon --
Into Maitland he's slunk;
Yet what gift of the skunk
Guides the shuddering nose to Buchanan?"

[4] I confess to having read only a tiny fraction of the entire work, only discovering this section of the text through a computer database.

[5] Buchanan thinks little of Lateral it must be said, linking together, "Literal and Lateral (the drones!) / [who] Interpret the dry letter of the book". Lateral is later described as as a "Blind human mole / Dull burrower in the darkness".

[6] At times I find sections of the poem are strangely evocative of aspects of T S Eliot, and in particular of parts of *Murder in the Cathedral*.

Chapter 1: Hypernotes

☞WWW☜ 1:1

Situs inversus refers to a complete mirror reversal of the organs of the body. Heterotaxy is now being used again in the scientific literature, referring to an anomalous positioning of the viscera relative to one another (Anderson, Webb, & Brown, 1998). In his classic paper, Layton (1976a) showed that in mice with *situs inversus* there was also an increased tendency for the blood vessels of the abdomen to show atypical patterns of drainage, a heterotaxy. The confusion over the naming of the various abnormal syndromes has been referred to as 'nosologia ambiguus' (Casey & Hackett, 2000).

☞WWW☜ 1:2

Details of Watson's life are in his obituary (Anonymous, 1882) and his entry in *Munk's Roll* (Munk, 1878). Although *Munk's Roll* usually consists of obituaries, in the case of Watson the entry was published during his life-time. The description of Watson as Nestor was subsequently adopted in the *British Medical Journal* obituary, and in a brief notice a week earlier (Anonymous, 1882). The phrase eventually became a medical cliche, as for instance when Hughlings Jackson was called 'the Nestor of English neurology' (Critchley & Critchley, 1998 p.136). The description of Watson is clearly older though, being used in the *British Medical Journal*'s review of the 5th edition of the textbook, in October 1871: "With the age of Nestor, Sir Thomas Watson has retained and even improved upon the silver-tongued eloquence in which he was alike wont to clothe his wise and careful judgements" (p.467).

Watson has been described as a "forerunner of Semmelweiss", who was to show the role of hospital-acquired cross-infection in puerperal fever (Györgyei, 1976). The specific comment on surgical gloves reads, "In these days of ready invention, a glove, I think, might be devised which should be impervious to fluids, and yet so thin and pliant as not to interfere materially with the delicate sense of touch required in these manipulations."

When made a baronet, Watson adopted the beautifully elegant motto, **Παθηματα, Μαθηματα**, (Pathemata, Mathemata) *Sufferings are lessons*; it would be an excellent motto for medicine in general.

T H Huxley made his comments about Watson in a Presidential Address to the Royal Society on 30th Nov 1883.

Richmond, who painted Watson's portrait, and earlier in his career had painted Charles Darwin and his wife Emma at the time of their marriage, provides an interesting link with Osbert Sitwell's *Left hand, right hand*, since it was Richmond's son who painted a portrait of Sitwell's mother. Clearly artistic talent did not in this case run in the family, since, as Sitwell puts it, "Sir William Blake Richmond ... was the second son of George Richmond, the charming portraitist, whose profession, but not whose gifts, he seems to have inherited" (Sitwell, 1945).

As well as Richmond's painted portrait of Watson, there is also a drawing and several photographs of Watson in the collection of the Wellcome Museum in London.

☞WWW☜ 1:3

Although nowadays referred to as the Royal College of Physicians, the origins of the 'Royal' are obscure, not being used in the original charter of 1518, and first used in a letter from Charles II only in 1674. It was not used consistently until the 1850s (Payne, 1960), and was referred to simply as the College of Physicians in the article discussed here.

Watson would have presented the heart of John Reid at a meeting in what was then the relatively new College of Physicians building in Pall Mall East, the college having moved there from the City of London in 1825[7]. A photograph of the building can be found in Cook (1992a).

I had hoped that the specimen of John Reid's heart might still exist, but enquiries at King's and several other London medical museums have not succeeded in identifying it. I am however particularly grateful to Mr Jim MacIntyre for his help in trying to trace the specimen.

Sir Astley Paston Cooper was born in 1768, was made a Fellow of the Royal Society in 1802, and died in 1841. In 1830 he published his superbly illustrated account of *Diseases of the Testis*, and a few years later in 1840 followed the equally exquisite monograph *On the Anatomy of the Breast*.

It should be noted that the evidence that "Dr Watson", the author of the paper in the *London Medical Gazette*, is the same as Sir Thomas Watson is circumstantial but overwhelmingly compelling. *Munk's Role* (Munk, 1878), the biographical record of Fellows of the Royal College of Physicians has no other appropriately qualified Dr Watson living at the right time, Sir Thomas was associated with both the Middlesex Hospital and King's College, he was clearly active in the College, and later in life would rapidly include references to Broca's discoveries into his textbook of medicine. It is also the case that the pages of the *London Medical Gazette* in the 1830s and 1840s are full or papers by Watson, including the lectures that would later form the *Lectures on the principles and practice of physic.* The presumption that Dr Watson and Sir Thomas Watson are one and the same seem inescapable.

☞WWW☜ 1:4

Watson made his comment about stethoscopes in the fourth edition of his textbook of medicine, published in 1857, 20 years after John Reid had died; see East (1957 p.38). The stethoscope had actually caught on remarkably quickly. Laennec published his *Traité de l'auscultation médiate* in 1819, and within five years the newly published *Lancet* had an article nearly thirty pages in length, ostensibly a review of Forbes' book on the stethoscope (Forbes, 1824), but in reality a 'how to do it' manual (Anonymous, 1834). It must also be said that in the 1843 edition of his textbook, Watson does devote several pages to the use of the stethoscope.

[7] The College moved to its present site in Regent's Park in 1964

Although it is clear even from the first edition of Watson's vast encyclopaedic textbook of medicine that he was an excellent physician, particularly one who put great emphasis upon the history and pathological examination, he is less obviously a *scientist* in the way he describes his material. That is not meant to be critical of him. Medicine and science are, at their extremes, very different modes of cognition and discourse, and Watson is clearly mainly at the medical end. I think I am entitled to say this having backgrounds in both medicine and science.

The idea of the physician as scientist, and particularly as scientist collecting data from patients to test a diagnostic or therapeutic hypothesis, is a nineteenth century invention. before that even examination of the patient was rare. In a footnote to his edition of *Middlemarch* (Eliot, 1965), W. J. Harvey specifically notes how advanced Lydgate was in 1830 to be using a stethoscope, and quotes from Newman's *The evolution of medical education in the Nineteenth Century:* "it is little short of astonishing to notice how completely physical examination was disregarded. The old physicians took most careful histories, and paid the greatest attention to what the patient told them about the structural abnormalities they were experiencing. They looked at the facies and the tongue, observed the appearance of shed blood, of urine, and of faeces, in that order of interest, but they hardly ever examined the patient at all.".

That the location of the heart could be determined in life had actually been demonstrated twelve years before Watson described the case of John Reid. Bryan (1824) described the case of Agnes Cavanagh, for whom although in life "no suspicion was entertained that there was anything peculiar in her conformation", but was subsequently shown at post mortem to have *situs inversus*. As a result, the chest of her still living father was examined, and his heart was clearly in the normal place, "the pulsations of the heart being sensible at the left side of the thorax". Bryan also noted that his patient was right-handed: "The *placement extraordinaire* of her viscera did not lead to any unusual symptom, not even to a preference for using the left hand"

☞WWW☜ 1:6

I first became aware of the HG Wells' *The Plattner Story* through Richard Gregory's *Mirrors in Mind* (1998). Subsequently I found it referred to in Cook (1914). It is dated as 1896 and printed in *Thirty strange stories* of 1897. It can be found on the internet at www.mtroyal.ab.ca/programs /arts/english/gaslight/plattner.htm.

Torgersen (1950a) does note that only 25/715 (3.5%) of the brothers and sisters of the patients with *situs inversus* were left-handed, and in their 320 parents, 17 (5.3%) were left-handed. It is therefore possible that there is a slightly raised incidence of left-handedness in individuals with *situs inversus*; however as Torgersen himself notes, the handedness of siblings and parents was not ascertained directly, but only from the patients themselves, and it is possible that they were not always accurate. Nevertheless what is clear is that the incidence of left-handedness is very much lower than the 90-95% which would be predicted if the brain were also mirror-imaged. The results are also compatible with other studies (Cockayne, 1938; Gordon, 1998). A modern study is however definitely needed.

☞WWW☜ 1:7

The point about the cross-cultural studies had also been made three years earlier by Sir Charles Bell (1834a)

Corballis and Beale (1983 pp.94-5) give only two examples of populations where it is reputably claimed that there is an excess of left-handers over right: the claim in the Eclogues of Stobaeus, of about 600 AD, that "those on the south-west ... for the most part fight with the left hand" (cited by Wilson, 1891); and John H Tooke's *Diversions of Purley, 1786-1805,* which claimed "I remember to have read in a voyage of Da Gama's to Kalekut ... that the people of Melinda ... were all left handed..." (cited by Wile, 1934).

☞WWW☜ 1:8

Although 'racemic' is now used to mean a mixture of equal proportions of right and left forms, its original uses refers to the acid coming from grapes, the Latin *racemus* meaning a bunch of grapes (Nicolle, 1962 p.25).

Pasteur did have one lucky break in carrying out this study – the conditions were cool enough. Isaac Asimov, himself once a lecturer in biochemistry to medical students, describes how below 28°C racemic acid crystallises, as Pasteur found, into two different types of crystal, but above that temperature a more complex single type of crystal is formed containing both (+) and (-) molecules (Asimov, 1976 p.57).

In the later experiments, Pasteur actually showed that non-optically active racemic acid became optically active if a mould was allowed to grow on it. The mould, probably *Penicillium glaucum*, consumed the (+) tartaric acid, leaving behind the (-) tartaric acid, which then was optically active (Mason, 1989 p.184).

☞WWW☜ 1:10

After serving in a regiment of Hussars, Dax studied first in Toulouse and then entered the medical school at Montpellier on the 19th day of Pluviôse in the year III (7th Feb 1795), and on the 10th day of Thermidor, year VII (28th July 1799), "le citoyen Dax" presented his thesis for the degree of doctor of medicine, having spent many of the worst years of the French Revolution as a student (Mouret, 1959 p.48; Ravoire, 1933 pp.8-9). Dax died on 3rd June 1837. In Sommières there is a small commemorative plaque on the wall of the building where the Doctors Dax lived and held their surgeries (see Critchley (1979 pp.72-82) for a photograph and brief history). Nowhere have I ever come across photographs of either Dax *père* or *fils*. Since Professor Lauren Harris is also unaware of any portraits, it seems likely that they do not exist.

Dax's paper was published in 1865 (Dax, 1865a; for a translation see Joynt and Benton 1964a). Dax's 1836 paper is usually said to have been read (Finger & Roe, 1999a). There are though some sources which suggest it was never even actually read at the Congress (Critchley, 1979; Joynt and Benton, 1964; see Finger, 1994, p.391). Although Dax *fils* did not have his own copy of the paper, a hand-written copy did turn up in the papers of a former Dean of the medical school at Montpellier , and Gustave published it. That the manuscript copy was genuine seems to be supported by the eventual emergence of a manuscript in the

hand-writing of Marc Dax, a fact described in a paper in 1879. The only slight confusion seems to be whether the manuscript was found by "a friend of Gustav Dax among the papers of his own deceased father" (Schiller, 1979a) or by Caizergues "dans les papiers de son grand-père, ancien doyen de la Faculté" (Hécaen & Dubois, 1969a), who died in 1850 (Ravoire, 1933 p.21).

Dax claimed to have seen 40 patients, all with damage to the left side. In addition his son Gustave collected a total of 87 aphasic patients, 16 of his own and the rest from the literature, all of whom had left hemisphere damage (Dax, 1865b). If we take Broca's estimate that nineteen out of twenty aphasic patients have a left-sided lesion (Broca, 1865 p.111), then the probability of after seeing 40 patients that at least one of them will have a right-sided lesion is about 87%; with 87 patients the probability rises to 98.8%; and with the grand total of 127 patients to 99.85%. The suspicion must therefore be that there has been some selection of cases.

☞WWW☜ 1:11

Although originally in the Musée Dupuytren, the brains were removed in 1940 after the walls of the museum collapsed (Signoret et al., 1984). Although long thought lost, Schiller (1979a) in his monograph on Broca, describes in 1962 finding the brains of Leborgne and Lélong in the basement of the École de Médecine in Paris: "with the help of friendly attendants and a flashlight I have been allowed to take a specimen ... up into the light of day from its dusty shelf in the basement ... where it had rested since 1940". Although then again thought lost, in 1979 Signoret e*t al* again searched the basement, once again found the brains, and this time removed the brain of Leborgne from its glass pot for the first time, photographed, and also looked at it with computerised tomography (CT) (Castaigne et al., 1980; Signoret et al, 1984) . The scans confirm that the damage was entirely restricted to Broca's area, and that Wernicke's area was unaffected. Photographs of the brain of Lélong were also published by Quercy (1943). For a partial translation of Broca (1861) see Eling (1994a).

Leborgne's name is an intriguing one: **borgne** in French is an adjective meaning one-eyed, and **le borgne** is a modern slang term for the penis (presumably in much the same way as Australian slang, at least as popularised by Barry McKenzie, uses 'one-eyed trouser snake'). Of greater interest in the context of laterality is that Dumézil (1974a), in a hypothesis that is still controversial, noted the mythic overlap in Indo-European between a one-eyed hero and a one-armed hero (who needless to say had lost the right arm), and in his title he refers to 'Le Borgne' and 'Le Manchot' (the one-armed, one-handed, presumably from **manche** for an empty sleeve). There is no mention of Broca or Leborgne in his essay

☞WWW☜ 1:12

The quote is from Schiller (1979a p.192). For a full translation of Broca (1865), reprinted in Hécaen and Dubois (1969a), see Berker *et al* (1986a).

Finger and Roe (1999a) have emphasised that it is commonly suggested that Broca discovered cerebral dominance in 1861, when he published the cases of Tan and Leborgne, although Broca himself was "inclined to attribute to coincidence" that the first two cases were on the left. It was not until 1863 that Broca first tentatively proposed that the left hemisphere was dominant, at a meeting on April 2nd, 1863. Since Gustave Dax had submitted both his

father's manuscript and a lengthy manuscript of his own to the *Académie de Médicine*, where they were received on March 23rd, 1863, just nine days before Broca's presentation, it was almost inevitable that controversy over the question of priority would continue. Whether priority should go to Dax for his finding, whether Broca and Dax were co-discoverers independently, or even whether Broca may have published in a hurry because he had had some prior, privileged (and, by implication, improper) sight of Dax *fils'* manuscript still is not clear. In the absence of any new information it is unlikely ever to go away entirely. What *is* clear is that it was Broca who realised the philosophical and neurophysiological importance of this finding, and that without Broca, Dax would probably have remained well nigh unknown in perpetuity, yet another "flower born to blush unseen / And waste its sweetness on the desert air" (Thomas Gray).

☞WWW☜ 1:13

The quality of Watson's textbook is a commonplace in the medical literature of the time. Harvey Cushing, the biographer of Sir William Osler, described how "Watson's justly celebrated 'Practice' ... had successfully held the field against all rivals, and there were many" (Cushing, 1925 I: p.339). A contemporary reviewing the fifth edition of 1871, although critical of the scientific content, could still praise, "its fluency and beauty of language [which] make it as delightful to read as a standard novel" (Anonymous., 1872), and Watson as a result had been called 'The Cicero of English medicine' (Smithers, 1979 p.94). The young Osler, whose own *Principles and practice of medicine*, was to play the same role for the next two generations of students, wrote an obituary of Watson whom he described as "wearing the white flower of a blameless life" (Osler, 1883). Later he included Watson's book as one of several English textbooks which "furnished Anglican pap to the sucklings, as well as strong meat to the full grown" (Osler, 1939).

The pre-eminence of Watson's textbook has often made me wonder if it is a coincidence that Sherlock Holmes' faithful assistant was Dr ***Watson***. There is little doubt that Holmes himself was modelled by Sir Arthur Conan Doyle on Dr Joseph Bell, a charismatic teacher of Doyle's at the Edinburgh Medical School. Hesketh Pearson suggested that Watson was based on Conan Doyle himself (Pearson, 1943), and Stashower (2000 p.76) raises the possibility that Dr James Watson of Portsmouth or Dr Patrick Heron Watson of Edinburgh were models, at least for the name. Doyle thought long and hard about Holmes' name (trying Sherringford Holmes and Sherrington Hope before arriving at Sherlock Holmes), and also considered Ormond Sacker before settling on Dr John Watson: Holmes "must have a commonplace comrade as a foil. ... A drab quiet name for this unostentatious man, Watson would do" it has been suggested (Michael Coren, 1995 pp.49-50). That may be, but the name of Watson may still not have been chosen at random. Given that Watson is the perfect foil for Holmes, is his mirror-image in every respect, it would make sense to name him after a textbook, a book no doubt just referred to as 'Watson' by Victorian medical students – and seeming to be the opposite of everything represented by the charismatic Dr Joseph Bell. Watson entered the Edinburgh medical school in 1876 just five years after Watson had published the fifth edition of his textbook, a time when the book was already seen as rather dated and old-fashioned (Anonymous., 1872)– rather like Holmes' Watson in fact. And writing textbooks is, like dictionary-making, and also perhaps writing short stories, is merely a task for "harmless drudges".

The quotations by Watson are from his textbook (Watson, 1871vol 1, p.494). The first edition of his textbook has examples of cases of language loss after left hemisphere damage. The still bear reprinting, mainly because the detail in these old case histories, with its insights into the daily life of the 1830s, has such a remarkable charm compared with the dry, tedious, scientific accounts in the modern medical literature, which are packed with pounds of biochemistry and not an ounce of humanity. In the first case the patient, despite being treated by trephination, died on 10th February 1834 and Watson clearly describes the post-mortem findings of what would now be called a chronic sub-dural haematoma.:

> "In the year 1833, during Christmas time, the coachman of a lady living in my neighbourhood fell, being intoxicated, into a cellar or area, struck in his fall one side of his head, and tore up the scalp over a considerable space. ... In the early part of February, 1834, he had a shivering fit, which was followed by convulsions of the right side of the body, and subsequently by paralysis of the right arm and leg, and by stupor from which he could easily be roused. he would put out his tongue when desired to do so; but to every question he answered 'yes'." (Watson, 1843 vol 1, p.364).

In the second case, reported at more length, there is also a post mortem with clear signs of an intracerebral abscess, perhaps secondary to an infected embolism:

> "I received, on the 3rd of September, a note, written in a remarkably clear and neat hand, desiring that I would call upon the writer, as he had had a severe attack of apoplexy a day or two before. .... I found a stout, active gentleman, apparently in perfect health, and declaring that he felt so. He showed me, however, a paper written by a surgeon ... [saying that on the 30th of August the patient had been unconscious from an apoplectic attack, and had been bled]. My patient spoke of going down to his country-house, where he had, he said, 'a good deal of shooting to do'. I dissuaded him from this, and enjoined perfect quiet for at least a fortnight to come. The next day, after a long and imprudent conversation with a friend, he suddenly lost the thread of his discourse, and could not recover it. Then he became confused, and misapplied words. I asked him how he felt. He answered, 'No quite right', and this he repeated very many times, abbreviating it first into 'not right' and at length in 'n'ight'. Wishing to mention 'camphor', he called it 'pamphlet'.... On the 5th it was evident that his right arm and leg were weak in comparison with the others... By slow degrees the weakness degenerated into complete palsy, and the right side of the face became motionless. ... and so, on the morning of the 15th of September, he died. We examined his head the next day. [There were] .... two ounces of pus, which was situated in the upper part of the left hemisphere of the cerebrum. .... In the centre of this cavity was a small, fibrous, tough mass of a dull red colour; the coagulum, doubtless, of blood effused on the 30th of August. In front of the abscess the brain *seemed* natural, but its consistence was that of liquid custard." Watson, T. *Lectures on the principles and practice of Physic,* 1 edn, London: Jon W Parker, 1843 vol 1, p.499Watson, 1843 vol 1, p.499.

Hughlings Jackson (1874a), who wrote extensively on neurology, also said, "To locate the damage which destroys speech and to locate speech are two different things", a principle that has long been recognised and as often ignored in neurology and neuropsychology.

☞WWW☜ 1:15

Watson's argument was already an old one when he put it forward, Sir Charles Bell (1834a) having criticised a similar argument, that the blood supply to the arms and hands is asymmetric, as "a cause altogether unequal to the effect". Bell goes on to demolish the argument further by pointing out the most people are right-footed also but there is no difference in blood supply to the legs. It is more than possible that Bell and Watson had discussed the matter since Watson was brought in by Bell to be the Professor of Medicine at the Middlesex Hospital (Gordon-Taylor & Walls, 1958).

Although Watson restricts his argument to handedness, it should also be the case that people with *situs inversus* should also be right hemisphere language dominant. Regrettably even nowadays there have been only a few very limited studies of language dominance in

situs inversus, and they are barely sufficient to base a judgement (Kennedy et al., 1999; Tanaka et al., 1999; Woods, 1986). Overall the presumption is that language, like handedness, is the same in *situs inversus* as in the normal *situs solitus*.

There are other problems still with Watson's anatomical theory, ones which came from facts which Broca and most other workers in the second half of the nineteenth century had not yet appreciated. Everyone assumed initially that even though there was a gross asymmetry of language in the brain, that some vestiges of symmetry could be restored (at least in a mathematical sense), if *left* handers tended to have language in the *right* cerebral hemisphere. It took a good half century or it to be generally accepted, but the majority of left-handers, like the majority of right-handers, actually have language in the left hemisphere. And that is something that Watson's anatomical theory also would not be able to explain.

Chapter 2: Hypernotes

☞WWW☜ 2:1

Hertz and his companions now lie side by side in the military cemetery at Haudiomont, Meuse, near Verdun.

☞WWW☜ 2:3

Mary Douglas in her introduction to the 1990 translation of Mauss' *The gift*, paraphrases the theory as, "A gift that does nothing to enhance solidarity is a contradiction" (Mauss, 1990). Mauss also mentioned on one occasion the origin of the use of the left and the right hands in a comment that was both fully Durkheimian and Hertzian: "In order to know why [a Moslem] makes this gesture and not another, neither the physiology not the psychology of motor dissymmetry in man are sufficient; it is necessary to know the traditions that impose it" (1936, cited by Parkin (1996 p.61)).

☞WWW☜ 2:4

Certainly Durkheim and his school have been influential. Lévi-Strauss described how few people have been able to read Mauss's *Essay on the Gift* without feeling "a beating heart, a seething brain, and the spirit invaded by any indefinable but imperious certitude of being present at a decisive event in scientific evolution" (Firth, 1975).

Not all anthropologists have been totally sympathetic to all aspects of Durkheim and his group. The distinguished Oxford anthropologist Evans-Pritchard was not happy with appeals by the Durkheimians to a collective consciousness which emphasised differences between the sacred and the profane, which Evans-Pritchard described as "a polarity which I find to be almost equally vague and ill-defined". Although it is tempting to sympathise with this view – and the sacred and profane are not of much immediate relevance in the everyday lives of many people at the beginning of the twenty-first century – one should not dismiss the concept immediately. It is a bit like our ideas about the thought of Sigmund Freud, who was theorising at almost much the same time. When I teach modern students about Freud they invariably complain that Freud seems to see sex in everything, and that much of the symbolism and its interpretation seems to be laughable. Partly that it because they are forgetting the way that sexual innuendo permeates almost all of our modern life, often to the point of obsession (and one only has to think about many adverts, such as the one for a car in which a woman purrs that 'size does matter'). The modern counter-point to the late nineteenth century Viennese attitudes to sex, which Freud was analysing, is found in our fear of death. Few people except professionals witness it, and we are all living longer than ever before in a world that is safer and healthier than at any time in history, and yet people go to immense lengths to avoid death, to reduce the risk of it, and will often not talk or even think about death. Likewise, although much of the modern world is secular, in Durkheimian Paris, religion was still of central importance in a way which our modern agnostic and atheistic

world has almost forgotten[8]; so it is not surprising perhaps that it permeated Durkheim's theorising. In the modern world the sacred has not in fact disappeared, but it has instead re-emerged in the guise of the worship of art, of nature, or, in some cases, of science.

☞WWW☜ 2:5

The quotation by Sir Raymond Firth was inadvertently not cited in the book proper. It was made in a review of Needham's *Right and Left* (Firth, 1975). Firth died in February 2002 at the age of 101.

Sperber (1975a) has pointed out that the handshake has what might be called its own 'myths of origin', stories we have invented to make sense of our behaviour, "one shows that one is not armed; by extending the right hand, one makes it impossible to hit the other"; etc...

The quotation from *Madame Bovary* can be found in Part 2, chapter 6.

The traditional approach to anthropology, of trying to study only 'primitive' societies, poses an inevitable problem for anthropology, as Evans-Pritchard emphasised (Hertz, 1960 p.24). Modern societies are homogenising rapidly, and true cultural independence is now rarely possible. In many cases anthropologists can only resort to studying the field notes of their predecessors, and that intellectual capital is limited and will one day be exhausted. The researcher is also left one (or even several) steps removed from the reality and impact of the phenomena and beliefs themselves.

As an example of how modern anthropologists will study almost any aspect of society, and perhaps need to do so, I particularly relish the story by Joan Cassell, an American anthropologist, who described an event in an operating theatre:

> "...I snatched a mask, entered the operating room, and moved next to the anaesthesiologist... The surgeon has just opened the patient. The room was silent as he concentrated on the procedure. Later, however, when the tricky part was over, he looked up and caught my eye. 'Who are you?' he inquired in a commanding tone. This was his territory and I was obviously an interloper. "I'm Joan Cassell – I'm an anthropologist studying surgeons". ... "What's an anthropologist doing studying surgeons?" he ... demanded. With absolutely no conscious volition on my part, I heard my voice responding, "'Well there were no other primitives left" (Cassell, 1998 p.10).

☞WWW☜ 2:6

Hertz was in London from October 1904 to July 1905, when he and his wife stayed at lodgings in Highgate, and again in July and August 1906, and once more in the autumn on 1910 (Parkin, 1996). In many ways Hertz's paper anticipated a more influential paper by W.H.R. Rivers, the anthropologist and psychiatrist who subsequently became famous as the principle character in Pat Barker's award-winning novel, *The Ghost Road* (Slobodin, 1997 p.167).

On the necessarily social nature of death, Hertz (1960 pp.27,77) wrote:

> "where a human being is concerned, the physiological phenomena are not the whole of death. To the organic event is added a complex mass of beliefs, emotions and activities... Death does not confine itself to ending the visible bodily life of an individual; it also destroys the social being grafted upon the physical individual".

[8] It is well demonstrated in a visit to the cemetery at Montparnasse where Durkheim is buried (although regrettably the inscription on his own grave is almost illegible).

☞WWW☜ 2:7

Although Durkheim does not mention Hertz in his *The elementary forms of religious life* of 1912 (Durkheim, 1995), he does in the introduction discuss the problem of the representation of space:

> "To have a spatial ordering of things is to be able to situate them differently: to place some on the right, pothers on the left, these above, these below... [S]pace would not be itself if ... it was not divided and differentiated. But where do these divisions that are essential to space come from? It itself it has no right, no left, no high, no low, ... All these distinctions evidently arise from the fact that different affective colorings have been assigned to regions. And since all men of the same civilisation conceive of space in the sa me manner, it is evidently necessary that these affective colorings and the distinctions that arise from them also be held in common – which implies almost necessarily that they are of social origin." (p.11)

Despite the apparent conclusion that the meaning of space must be socially constructed, the phrase "almost necessarily" allows an alternative interpretation, mentioned in a footnote, that, "all individuals, by virtue of their organo-psychic constitution, are affected in the same manner by the different parts of space". Durkheim rejects the notion because "the divisions of space vary among societies – proof that they are not based exclusively in the inborn nature of man", although probably Hertz would have disagreed, at least for the meaning of right and left.

☞WWW☜ 2:8

In part the Kurgans were building on pre-existing symbolisms already being used in the Neolithic cultures of Europe whereby, for instance, burial mounds had their high end to the east, and with individual burial chambers to the right of the passageway facing east (Kraig, 1978 p.164).

This sort of pattern is far from restricted to Indo-European burials. For instance in east Africa, the A-Kamba place the corpse of a man on his right side and the corpse of a woman on her left side; likewise, the Acholi bury the corpse of a man on the right side of the door, and of a woman on the left side of the door (Wieschoff, 1938 p.61).

The argument that one has to look at the entire *set* of symbolisms is a bit like analysing style in music. Given a single tune, it is difficult to make anything of it in stylistic terms. But once one has heard a couple of tunes, all of which say they are 'the blues', it is obvious that there is a clear set of rules of which all the different exemplars are valid cases, but that, for instance, nursery rhymes are not. 'The blues' is not any one tune but the commonality of rules of the entire set.

☞WWW☜ 2:9[9]

In *The Rime of the Ancient Mariner*, Samuel Taylor Coleridge describes how, as the Mariner sails south:

[9] **☞WWW☜** was inadvertently omitted from the notes in the book.

"The sun came up upon the left,
Out of the sea came he!
And he shone bright, and on the right
Went down into the sea."

Subsequently, when "the good south wind still blew behind", "The sun now rose upon the right..../ and on the left / Went down into the sea".

☞WWW☜ 2:11

Clocks do indeed go in the same direction as the sun, but that is not necessarily the reason that clocks do go clockwise, as can be seen in chapter 12.

Even though it was auspicious for omens to go to the right, there is a problem that it is not at all clear which direction that actually was in Ancient Greece (Braunlich, 1936).

Despite port being passed clockwise, there is also the seeming contradiction that it is also passed to one's *left*:

"The most widely-known tradition is that of *passing the port.* British naval officers meticulously passed the port from "port to port" – that is clockwise. Traditionally, the decanter of port is placed in front of the host who then serves the guest to his right and then passes the decanter to the guest on his left. The port is then passed to the left all the way back to the host" (www.intowine.com).

The ambiguity arises because at dinner one sits on the outside of a circle looking in, whereas looking at the sun, one stands at the centre of a circle looking out. Right and left and hence reversed. The difference results in much confusion of interpretation. The phrase Catharpin fashion was, according to Cook (1914) used in a dictionary of slang of 1690. I have been unable to find it anywhere else.

Although at the opening of the Vienna Opera Ball it is traditional for the waltz to be danced anti-clockwise, that is in part to exclude those who have not practised this more difficult step. Those selected to take part have to arrive in Vienna a week beforehand in order to rehearse the anti-clockwise waltz.

Blake-Coleman 1982a found that of 216 16th and 17th century machines, 62% of 102 hand-turned prime movers rotated clockwise, as did 58% of 114 water, wind, horse, and other movers. However in 83% of cases the final motion was clockwise.

The full text of Richard Serra's comments is:

"*Interviewer:* "Given the precarious nature of the walk through the corridor, have you any preference as to whether people go round it clockwise or anticlockwise?
"*Serra*: "The passage is equally narrow on both sides of the opening into the inner ellipse, so it shouldn't really matter whether one walks in one direction or the other. I feel that it is less destabilising to walk the passage clockwise. But that might just be my preference, although I think it's a natural impulse to walk to the right" (Sylvester, 1999).

A similar phenomenon is also seen in the Millennium Dome in Britain, which on 1st January 2000 opened to great fanfare. However by the end of January it was apparent that attendance was insufficient to make it financially viable, and an expert was brought in from Disneyland

to give it a make over and make it more attractive. Amongst the changes implemented was converting the circulation of people around the exhibits from anti-clockwise to clockwise.

☞WWW☜ 2:13

In a letter to his future biographer, Ernest Jones (Paskauskas, 1993 p.31). Jones in a reply about two months later even suggests that early masturbation might determine right and left handedness:

> "Might early auto-erotic practices not determine which was to be [the] later skillful hand, in some cases right, in others left. Probably this is quite foolish, but if you think there might be anything in it I should be glad to know" (p.35).

There is no indication of what Freud thought of this idea.

The apparently simple symbolism of the Gogo is actually more subtle and complex here, one correspondent telling Rigby (1966a), "this left hand is clever in one way, and the right is foolish...".

The Chinese method of diagnosing the sex of a child is, of course, the opposite way around from that which might be expected in the Western tradition. Granet (1973a), who cites the example, points out that in many senses 'left' in Chinese tradition is the *honourable* side, and that is does not have the solely negative connotations found elsewhere; this is however only "a certain pre-eminence... but this pre-eminence is only occasional" (p.57). It might also be worried, given the general inability of scientists to predict sex antenatally before the era of ultrasound and amniocentesis, that the system was doomed to obvious failure. The cop-out which saves any wrong diagnosis is that if a fetus moves towards the right it belongs on the right – in other words, it can be on the left but demonstrate by the subtlest of movements that it should have been on the right.

There is an interesting parallel in both the Kaguru and in the Shakespeare quote, although the details are very wrong, to modern research on 'genomic imprinting' which finds that some fetal organs depend almost entirely on genes from the mother and others almost entirely on genes from the father.

☞WWW☜ 2:14

For Anaxagoras' theory that male children come from the right testicle, see Aristotle, *De Gen. An.*, 763, b.31 (Peck, 1953 p.373).Leophanes suggested this was true for humans (Peck, 1953 765.a.25 p.383), and Pliny suggested it was the case for sheep (Rackham, 1983 VIII: LXXII, p.133). Pliny also suggested that in oxen, the sex of offspring could be determined : "It is said that if the bulls after coupling go away towards the right hand side the offspring will be males, and if towards the left, females" (VIII: LXX, p.125).

The quotation by Mrs Ida Ellis is from Pearsall (1971 p.303). Mrs Ellis also continues with an interestingly scientific further prediction, a potential refutation, and finally a non-scientific device which 'saves' the theory:

> "men who have only one testicle can only beget one gender, but sometimes they do not descend, remaining in the body, in which case a child of either gender may appear".

Experimental proof that the right testicle in animals did not produce males was provided by King (1911), and Copeman (1919); see also Crew (1952).

For the theories of Empedocles, see Aristotle, *De Gen. An.*, 763 b.31 (although Aristotle also reported cases which contradicted the theory, *De Gen. An.* 765 a.18). A modern version of the theory suggested that males came from the right ovary and females from the left ovary (Dawson, 1909), although experimental evidence refutes that theory (Doncaster & Marshall, 1910; King, 1909; King, 1911). For more details on ancient theories of sex determination see McManus (1979f, Chapter 12), and for left and right in general in the Greek world see Lloyd (1966b).

☞WWW☜ 2:15[10]

The Purum are located at 24' 26" N, 94' 0" E. (Das, 1945). They were studied by Tarakchandra Das and his students on four separate field trips between 1931 and 1936, when they numbered only 303 individuals. By the time Das's detailed monograph was ready for publication in 1941 there was a severe shortage of paper because of the war, and it could not be published until 1945. By then the fate of the Purums was very unclear. In his Preface, Das says,

> "The four villages of the Purums were situated very near Palel which was the scene of severe fighting between the allies and the Japanese on several occasions. How the poor Purums fared in this struggle for domination I am unable to state at present. If they had not retired to some safe place in the interior of the hills before the appearance of the Japanese on this front they must have gone out of existence" (p. viiDas, 1945 p. vii).

Although his own war-time experience made Needham concur with Das's gloomy prognosis, Needham (1958 p.98) reported that in October 1956 the Purums had returned and rebuilt their villages.

It is worth stating that although Das does not comment on it himself, the Purum are almost certainly mostly right-handed, as far as one can tell from the photographs in the book, where only the right hand is seen carrying out skilled activities. We are also told that the women usually wear a single piece of cloth, knotted below the left arm pit, suggesting right-handedness (p.98). It should also be said that they were a pre-literate society, although elementary reading and writing had recently been introduced at elementary schools.

Needham has been extremely influential in regenerating interest in Hertz, not only by translating Hertz's essays on death and on the right hand (Hertz, 1960), but also by editing an influential book of readings on the symbolism of the right and left hands (Needham, 1973), and by his own structural analyses of the two hands (Needham, 1979).

☞WWW☜ 2:17

The Toraja are interesting in that there is an explicit anthropological mention that "The Toraja have also reflected upon how it has come about that men do everything with their right hand" (Wieschoff, 1938 p.75); the answer is, needless to say, symbolic and to do with life and death.

---

[10] **☞WWW☜** was inadvertently omitted from the notes in the book.

☞WWW☜ 2:18

Needham 1979 p.52. put the problem very forcefully, and I have merely paraphrased his comments:

> "It is not necessary that the house should be divided into a right half and a left half, or that wife-givers should assigned to the right and wife-takers to the left. It is not necessary that wife-givers should be considered superior to wife-takers, any more than it is necessary that right should be regarded as superior to left".(Needham, 1979 p.52).

Although it does seem as though right-left symbolism does take the same form everywhere, it is also necessary to be reassured that we are not simply ignoring the 'negative' cases, the ones which might not fit the theory. Are there in fact any situations in which left is superior to right? One possible case was the Mugwe, a religious dignitary amongst the Meru of Kenya, for whom the *left* hand is sacred. A detailed analysis by Needham (1960a), suggests that this still fits within a standard scheme, mainly because left and right and left also relates to sacred and profane; as a result, since the right hand is used for everyday activities, at which it is more proficient, the left hand is then left for the sacred.

☞WWW☜ 2:19

Sir Thomas Browne also mentions that the Egyptians thought there was a nerve running directly from the heart to the ring finger: "But how weak anatomists they were, which were so good embalmers...".

Although the term 'morganatic' seems to be in popular use as a description of a marriage in which one partner has previously been divorced, the proper description is of a marriage between a man of high social status and a woman of lower social status where the wife shall not be entitled to the dignities nor the possessions of her husband. The *Concise Oxford Dictionary* has at the etymology, "French *morganatique* or German *morganatisch* from medieval Latin *matrimonium ad morganaticam* 'marriage with a morning gift', the husband's gift to the wife after consummation being his only obligation in such a marriage".

☞WWW☜ 2:20

Fabbro (1994b) has identified 151 verses in the Old Testament and 49 in the New Testament referring to right and left. The vast majority of the references are to the right rather than the left.

Detailed statistics on the portrayal of right and left can be found in McManus (1979f, chapter 13). Although the Madonna and Child paintings show the pattern I have described at the beginning at the end of the 13th century, by the sixteenth century the pattern has changed entirely, probably due to theological considerations resulting from the Cult of the Virgin Mary.

McManus, 1979f; Sattler, 2000.

Paradise Lost, V: 689; V: 726: VI: 79. Fowler (1971a) traces these references back to *Isaiah,* 14, xiii. Milton does associate the use of the left rib with the warmth and blood of the heart (*Paradise Lost* IV: 484). In 1608, Andrew Willett in his *Hexapla* commented, "It is a

superficial question out of what side of Adam, Eve was taken ... It is resolved by most out of the left because Adam's heart lay there; but these are frivolous and needlesse matters".

☞WWW☜ 2:21

Psalm 118, v. 16. There are parallels with an Akkadian creation epic, "[Marduk] lifted the mace, grasped it in his right hand". Plessner (1970a) emphasises that the values attached to right and left in the Old Testament are similar to those elsewhere in world literature. The earliest reference, *Genesis* 48: 15, "and Israel stretched out his right hand and laid it upon Ephraim's head ... and his left hand upon Manasseh's head", implies a preference for the right over the left. Because all of the Old Testament uses of 'left' are geographical', whereas 'right' is only once used geographically (*II Kings* 12: 10), and 'right' is often used instead of 'hand' or 'side', then wherever 'the hand' is referred to, Plessner says it should always be regarded as referring to the right hand.

For left and right in the Talmud see Anonymous., 1916 X:419

On putting on shoes, see Wile, I. S. *Handedness: Right and left,* Boston: Lothrop, Lee and Shepard, 1934 p.218 Wile, 1934 p.218. There is a strong parallel with an Islamic tradition,

> "Allah's Apostle said, 'If you want to put on your shoes, put on the right shoe first; and if you want to take them off, take the left one first. Let the right shoe be the first to be put on and the last to be taken off.'" *Sahih Bukhari, Volume 7, Book 72, Number 747:* (http://www.usc.edu/dept/MSA/fundamentals/hadithsunnah/bukhari/072.sbt.html)

☞WWW☜ 2:22

It is said that a part of the propaganda against the Shah of Iran which was put out by the Ayatollah Khomeni when he was in exile in Paris was that the Shah must have been cursed by Allah because his first-born son was a left-hander (www.ausport.gov.au/fulltext/1998/sportsf/sf980227.htm). Nevertheless modern Islam does seem more tolerant: at http:/islam.org/dialogue/Q325.htm, the answers to which are provided by *Arab News* in Jeddah, it is clear that other attitudes are also prevalent. The question reads, "I am a 12 year old student, and I am left-handed. People have often reminded me not to eat or write with my left hand, because people who do so will not go to heaven; they will go to hell. ... I will be grateful for your advice".

☞WWW☜ 2:25

Davidson emphasises that such left-right differences are rarely simple, and cites an analysis of the Pierre Bourdieu as an example (Bourdieu, 1990). Bourdieu had also cited examples of the interpretation of left and right in his earlier book (Bourdieu, 1977). Bourdieu died in February 2002.

In the second quotation, Davidson is careful to say "probably, anticlockwise" since it is not at all clear which direction the Greeks were referring to when they said "to the right" (Braunlich, 1936).

☞WWW☜ 2:27

Bismarck actually wrote about his dream in a letter to Kaiser Wilhelm I on Dec 18th, 1881, in reply to a letter from the Kaiser describing a dream of his own. The dream is discussed by Freud in his *Interpretation of Dreams*, where he talks about the analyses of Sachs and Stekel, who concluded that in dreams 'left' stands for what is wrong, forbidden and sinful (Freud, 1976 pp.475-503). The dream is discussed in the fifth edition of *The interpretation of dreams*. Butler, A. J. *Bismarck: The man and the statesman; being the reflections and reminiscences of Otto Prince von Bismarck,* London: Smith, Elder and Co, 1898vol II, p.210Butler, 1898vol II, p.210.

In *The interpretation of dreams*, Freud quotes from Stekel:

> "in dreams 'left' stands for what is wrong, forbidden and sinful ... [It] might very well be applied to masturbation carried out in in childhood in the face of prohibition. ... The fact that seizing the rod was a forbidden and rebellious act was no longer indicated except symbolically by the 'left' hand which performed it."
> "...'right' and 'left' in dreams have an ethical sense. 'The right-hand path always means the path of righteousness and the left-hand one that of crime. Thus 'left' may represent homosexuality, incest or perversion, and 'right' may represent marriage..."

Domhoff (1968a) also follows Erich Fromm in seeing "the Left way" as being essentially that of Marxism.

☞WWW☜ 2:29

Needham has expressed very well how remarkable it is that right-left symbolism is the same the world over:

> "It is very remarkable that civilisations most distant from each other in time and space should have constructed practically identical dual classifications, composed of such standard oppositions as right/left, male/female, strong/weak, superior/inferior, light/dark, and so on" Needham, 1979 p.32.)

And Hertz also expressed it in his typically forceful style:

> "[F]rom one end to the other of the world of humanity, in the sacred places where the worshipper meets his god, in the cursed places where devilish pacts are made, on the throne as well as in the witness-box, on the battlefield and in the peaceful workroom of the weaver, everywhere one unchangeable law governs the functions of the two hands. ... The supremacy of the right hand..." (Hertz, 1960 p.109-110)

☞WWW☜ 2:30

Hertz's views can be summarised in a series of quotations from his essay on the right hand:

> "we are right-handed because we are left-brained";
>
> "[there] is no reason for dogmatically denying the action of the physical factor";
>
> "in spite of the forcible and sometimes cruel pressures which society exerts from their childhood on people who are left-handed, they retain all their lives an instinctive preference for the use of the left hand";
>
> "Organic asymmetry in man is at once a fact and an ideal";

> "The preponderance of the right hand is obligatory, imposed by coercion, and guaranteed by sanctions: contrarily, a veritable prohibition weighs on the left hand and paralyses it."

Parkin (1996 p.64) has a powerful and telling comparison, which shows the force of the ideology underlying right and left:

> "handedness is a problem of the same order as incest – a cardinal attribute of human populations, yet subject to varying degrees of representation and contradiction cross-culturally, existing wholly within neither nature nor society, but belonging partly to both and thus linking them".

☞WWW☜ 2:31

A nice literary example of dualism is found in Janette Winterson's *Gut symmetries*:

> *"*our ... world of dualities and oppositional pairs: Black/white, good/evil, male/female, conscious/unconscious, Heaven/Hell, predatory/prey" (Winterson, 1997 pp.4-5)

Hertz was talking about dualism when he described the human mind's "innate capacity to differentiate".(Parkin, 1996 p.61). Although I have presented the account of Hertz and dual symbolic classification as if it is totally accepted within anthropology, that is not entirely the case. In particular Louis Dumont (1979b), and his student Tcherkézoff (1983a; 1987a), have strongly criticised the theory – indeed Dumont simply said of the view of Hertz, "It is wholly mistaken" (1980 p.220). The nature of the argument is, to say the least, subtle. Needham 1987b devotes many pages to them, pages which he describes himself as "very taxing" and "somewhat tedious". Needham's account of Dumont shows his despair at trying to understand quite what the theory is saying, and with the barbs that only an Oxford academic can wield with such devastating accuracy, Needham describes Dumont's style as, "assertive yet recondite, abrupt in pronouncement yet enigmatic in implication" and notes "The degree of fervour ... that marks his argument ... especially [in] those parts that are hardest to make out". I confess I find a similar problem, although Parkin (1996 pp.845-86) is somewhat more sympathetic, emphasising the key point that Dumont does not believe that the two items in an oppositional pair are symmetric or equivalent, but instead there is a hierarchy, one being dominant to the other. Critics of Hertz have also questioned whether it is empirically correct that *all* cultures favour the right over the left, and although occasional examples have been found where left does seem to be symbolically preferred (again, see Parkin for a good review), the very scarcity of the few counter-instances can hardly overwhelm the vast mass of evidence in favour of Hertz's position.

Anthropologists have their own version of the old dualist joke: "... there are two kinds of people in the world – those who divide everything into two and those who don't" (Needham, 1987b p.6).

The psychologist George Kelly, who died in an air-crash in 1966, founded personal construct psychology around the central idea that human thought is determined by the way in which the world is classified into polar opposites (Bannister & Fransella, 1971; Kelly, 1955). Studies since then have provided clear evidence for the psychological importance of the way the world is categorised, with, for instance,.organisms divided into 'animals' and 'plants', trees divided into 'evergreen' and 'deciduous', and animals into those which are or are not 'birds'. The benefits are two fold. As well as being economical of cognitive effort, such classifications often also reflect the way the world actually is organised and has evolved – biologically, birds really are a separate category of animals, 'organisms with feathers' which

are all descended from an early avian ancestor with feathers (Rosch, 1978, Palmer, 1978). Cognitive categorisation also occurs in what is known as 'categorical perception' (Harnad, 1987). Speech sounds generated by a computerised speech synthesiser can be made to vary physically along a continuum, but we typically only hear two or three categories. And likewise, the million or so discriminable colours between pure red and pure yellow are described only with by a very small number of colour categories, 'red', 'yellow', or 'orange' (Berlin & Kay, 1969). The categories of speech sounds and colour are probably hard-wired into the structure of our brains. Classification and categorisation is "a very basic cognitive activity.

☞WWW☜ 2:32

Hertz actually says:

> "Powers which maintain and increase life, which give health, social pre-eminence, courage in war and skill in work, all reside in the sacred principle. Contrarily the profane ... and the impure are essentially weakening and deadly: the baleful influences which oppress, diminish and harm individuals come from this side. So on the one side there is the pole of strength, good and life; while on the other there is the pole of weakness, evil and death. Or, if a more recent terminology is preferred, on one side gods, on the other demons".

And as Hertz says, how could man's body escape this polarity which applies to everything else? Indeed he goes so far as to say that "If organic asymmetry had not existed, *it would have had to be invented*".

Subsequently Lévi-Strauss was to make a similar argument, "argu[ing] that binary classification is a fundamental property of human mental processes" (Hallpike, 1979 p.224), although, as Hallpike puts it, "Exactly what Lévi-Strauss means ... is, as usual, thoroughly elusive" (p.224).

☞WWW☜ 2:33

Hertz actually says,

> "The religious necessities which make the pre-eminence of one of the hands inevitable do not determine which of them will be preferred. How is it that the sacred side should invariably be the right and the profane the left?".
> "The slight physiological advantages possessed by the right hand are merely the occasion of a qualitative differentiation of which the cause lies beyond the individual, in the constitution of the collective consciousness. An almost insignificant bodily asymmetry is enough to turn in one direction and the other contrary representations which are already completely formed".

The application of a little effort to produce a large effect by invoking the powers of a much larger system is also the principle of many sports. A skier who turns on the top of a mogul takes advantage of the system being poised on the edge of chaos, at a moment when a tiny input produces a large output. Likewise a tiny force correctly applied at just the right moment will make a child fly high on a swing.

Hertz does not in his essay try to address the question of the origins of dualism and polarity, although he does comment that it is "one of the profoundest questions which the science of comparative religion and sociology in general have to solve". He is right.

☞WWW☜ 2:34

The disagreement about symbols is part of a wider malaise, Dan Sperber, commenting that, "The fact is that there is very little agreement amongst anthropologists about anything" (Sperber, 1996 p.15)[11]. Sperber's assertion is readily supported by the strong attack on his ideas by Foster 1995a, despite her having included a long essay by him in a previous volume she had edited (Sperber, 1980). I realise of course that it is also nothing but folly for a psychologist such as myself to step into an arena where even anthropologists themselves seem to find little agreement.

☞WWW☜ 2:36

Sperber is not alone amongst anthropologists in suggesting that symbolism is a natural part of the human mind, Needham for instance saying that, "the symbolic opposition of right and left, and a dualistic categorization of phenomena of which this opposition is paradigmatic, are so common as to seem natural proclivities of the human mind". (Needham, 1960a p.123).

Sperber says of his proposed mechanism,

> "I clarify my hypothesis: the conceptual mechanism never works in vain; when a conceptual representation fails to establish the relevance of its object, it becomes itself the object of a second representation. ... [T]he symbolic mechanism is the '*bricoleur* of the mind'. It starts from the principle that waste-products of the conceptual industry deserve to be saved because something can always be made of them.. ... A representation is symbolic precisely to the extent that it is not entirely explicable, that is to say, expressible by semantic means". (Sperber, 1975a p.113).

☞WWW☜ 2:38

One thinks here of a phrase of Ernest Gellner's, that "if a native says something sensible it is primitive technology, but if it sounds very odd then it is symbolic" (cited by Boyer (1996a)). Our own view of the world seems so very familiar and so very normal that even professional anthropologists can find it deceptive and impose their own view upon other people's behaviours.

☞WWW☜ 2:39

This chapter originally had a far longer and more expository account of symbolism; one in fact that was too long for the book. It may however be of interest to some readers, and it is therefore included here.

"Symbolism" is a term that many people, as we have already suggested, find exceedingly off-putting, particularly in the context of science. So let us have a brief look at it, and try and see what is known and thought about it, particularly in relation to left and right. The philosopher, A.N. Whitehead, who perhaps nowadays is best remembered for his comment that Western philosophy was 'a series of footnotes to Plato', in 1927 devoted a whole book to

[11] Sperber is not alone, Luhrmann (2001), in a review of the work of Geertz, comments, "Most anthropologists admire his work immensely, but tumble over themlseves to explain all that is wrong with it. (This creates an alarming prospect for a reviewer: to admire is to lack critical edge, to criticise is to lack respect. Alas.)".

symbolism (Whitehead, 1927). He acknowledged immediately that symbolism was now very much less fashionable than it used to be:

> "during the mediaeval period in Europe symbolism seemed to dominate men's imaginations. Architecture was symbolical, ceremonial was symbolical, heraldry was symbolical. With the Reformation a reaction set in. Men tried to dispense with symbols as 'fond things, vainly invented', and concentrated on their direct apprehension of the ultimate facts ... [H]ard-headed men want[ed] facts and not symbols. .... [T]he symbolic elements in life have a tendency to run wild, like the vegetation in a tropical forest. The life of humanity can easily be overwhelmed by its symbolic accessories... "

And yet, despite all of these provisoes he goes on to say, "symbolism is no mere idle fancy or corrupt degeneration: it is inherent in the very texture of human life". More recently the anthropologist Rodney Needham simply described symbolism as "a primary and ineradicable proclivity of thought and imagination" (Needham, 1979 p.70). And indeed once one looks, symbolism pops up everywhere in one form or another. Recently I bought a jar of baby food which was described as containing "Country Chicken"; but what is the force of that word 'country'? Replace it with its opposite, 'Urban Chicken', and it immediately becomes obvious that 'country' is meaningless in any strict sense. So its value must be entirely symbolic, somehow telling us that this chicken is healthy, fresh, natural, and so on. And of course in being 'natural' another series of symbolic associations will occur, just as if the food is also 'organic' or 'green'. There may be technical meanings which are legalistically correct – and no doubt the chicken did live in the countryside at some time (and there are few chickens living in cities nowadays) – but that is not why it is being described that way.

At one level it is indisputable that symbols are important. If you have got this far in this book then you will already have looked at tens of thousands of little black scribbles, arranged on the page in rows which, if scanned from left to right and top to bottom, and combined using the rules we call 'English', will have told you many things and, hopefully, will have made sense to you. But let us just go back a moment. "Made sense". Let us just look at that second word. 'sense'. Or 'SENSE'. Or, even, '**Sense**'. That little black sinuous squiggle at the beginning that we call an 'S' can take many shapes and sizes, but still with an E, an N, an S and another E it becomes 'sense'. But what is that? And why does it mean 'sense' when the letters are in that order but not another? Ultimately all such little squiggles are simply symbols; and likewise their combinations are also only squiggles. Writing down such symbols has a strange effect. It doesn't actually bring SENSE (or sensibility for that matter) into being in any way. So why should it seem reasonable to say that "SENSE" has a meaning whereas it does not seem reasonable to attach a meaning to "the right hand is sacred"? Although it seems strange to say it, these squiggles that we call letters ultimately have a meaning because we *believe* in them doing so, and because of social conventions. So why is it sensible to believe in some sorts of symbols and not in others?

Although symbolism is at the very heart of anthropology it is extremely difficult to find any universally accepted theory to account for it. Indeed Dan Sperber, an anthropologist who is very influenced by modern psychological theories, has commented, "The fact is that there is very little agreement amongst anthropologists about anything" (Sperber, 1996 p.15); the semiotician Umberto Eco has also almost despaired, "a symbol can be everything and nothing" (Eco, 1984 p.131), with as many definitions as there are authors. He does cite approvingly Todorov's identification of symbols, "with the whole gamut of indirect and even of direct meanings: connotations, presuppositions, implications, implicatures, figures of speech, intended meaning, and so on." (p.137).

One of the clearest expositions on symbolism is that of Edmund Leach, who devoted a short, elegant book to the topic (Leach, 1976). Although anthropologists and semiologists like to distinguish symbols, signals, signs and natural indices, I will here use the term 'symbols' for all of them. Central to Leach's ideas are not only that symbols are arbitrary (and that is obvious even for the letters of the alphabet or the sounds in spoken language), but that they have no meaning of themselves, only acquiring meaning *in relation to other symbols*. At its most minimal this is apparent even in the binary numeric code which is used by computers: a 1 cannot mean anything unless the system knows also that the 1 is not a 0. Symbols therefore arise from our sense of difference. If objects are not discriminable then they cannot be symbolic. The meaning which is carried by symbols arises from the patterns and relationships that are found between them, so that the binary number '1101' means 'thirteen' because of the particular pattern of the 1s and 0s[12]. Any other pattern, say, '1011' would not mean thirteen but would mean something else, in this case 'eleven'. Although the symbols are entirely arbitrary, these binary numbers and the words in English which correspond to them, have very clear and precise rules concerning their meaning and their manipulation. '1101' minus '1011' can only be '10' in the binary system, just as in English language arithmetic, thirteen minus eleven can only be two. Symbols can therefore be manipulated in a form of algebra, which can be very precise in the case of mathematics. However it is not just mathematical symbols which can be manipulated in such ways — any symbols can. However it is essential that the rules used are appropriate. If for instance we thought that '1101' and '1011' were in the decimal system, then '1101' minus '1011' would be '90' and not '10'. And likewise the series of 1s and 0s inside my computer which correspond to the manuscript of this book are only meaningful when read into a word processing program; read them into a graphics package or a spreadsheet program and meaningless garbage will be the result. It is knowing the appropriate rules and bounds of symbols which makes their use complicated. Leach shows how very readily one can slide across between different sets of rules and in so doing obtain metaphors, such as 'The lion is the king of the beasts'. There are two very different sets of rules here. 'The lion is a beast' is valid in describing the natural world of animals, whereas 'The king is the most powerful man in the state' is a description of a social system. Although there is a sense in which a lion is the most powerful animal in the jungle, it is only metaphorically true to say that the lion is the king of the jungle, because it is combining one statement from one system and one from another. Nevertheless there is a sense in which the metaphor has some truth about it, and that can be seen because most people have little trouble in understanding what the phrase means. That there is truth of some sort in the phrase becomes apparent when we substitute some other social description. Perhaps, "The lion is the lawyer of the jungle", "the lion is the street cleaner of the jungle', or 'the lion is the disc jockey of the jungle'. These phrases do not only seem absurd, there is a sense in which also they seem *false* or untrue. If pushed, for instance, we would probably argue that some other species is the street cleaner of the jungle – ants, perhaps. Metaphor is not therefore entirely arbitrary, but it has its own internal logic[13]. What species might be the 'disc jockey of the jungle' I will leave the reader to think about.

---

[12] In binary notation, the left-most number is the number of ones, the next the number of twos, the third the number of fours, the fourth the number of eights, and so on. 1101 is therefore 1 one, 1 four and 1 eight, making thirteen altogether. 1011 in contrast represents 8+2+1=11.

[13] Often though these relationships are obscure, even to insiders within the system. Nevertheless Leach, emphasises that even though, "Very often the symbolic equations will be highly obscure but, regardless of whether the devotees understand the system or not, there will always be method in their madness" (Leach, 1976 p.39). It is the role of careful anthropological or semiological or critical analysis to find those links.

Leach's view of symbolism emphasises the importance of difference in the definition of symbols, but does not say what particular symbols can or should be used. Although in principle almost anything could be a symbol, if one surveys symbols across historical times and widely different cultures it is quite clear that the frequently used ones are surprisingly restricted in their origins. The most potent and important symbols used in our language, in our myths, and even in those objects of twenty-first century fantasy, advertisements, all come from very obvious origins.

> "Symbols are rooted in the common biological nature of man – male and female, birth, death, mating, menstruation, pregnancy, suckling, sickness, elimination, and so forth; in the physical structure of the universe – the seasons, the waxing and waning of the moon, drought and flood, and in the local environment. The same social conflicts within men and between men, such as ambivalent attitudes towards incest, parental authority, and birth and death, are repeatedly represented... ".(Wilson (1971 p.5), cited in Foster (1961a)

If you are not immediately convinced of this then it is in part because modern ways of life divorce us from their underlying processes[14]. Think however about the ways that advertisers try and create images for computers or cars or any other modern technology. Either the old, old symbols are somehow attached to the cars or computers themselves or they are attached to the people using the cars or computers. Sex and the fear of death lie at the basis of so many advertisements. As TS Eliot put it,

> "Birth, and copulation, and death
> That's all the facts when you come to brass tacks"

Sir Edmund Leach also saw the structure of the human body as being ideal for generating symbols, and in particular for generating opposites:

> "the human body is imperfectly symmetrical. Taking the navel as centre, the arms 'match' the legs, the genitals 'match' the head, the left side 'matches' the right side. But these paired dyads are contrasted, not identical; I cannot put a right-handed glove on my left hand. The upper and lower parts of the body, the right and left side are thus specially suited for the representation of related but contrary ideas – e.g. *good/bad*; and so indeed it is..." (Leach, 1976 p.48)

It is not surprising therefore that the right and left hands were ripe for being used symbolically[15]. Now also it is more obvious why it is the right hand that is good and the left hand that is evil. As simple anatomical descriptions of body parts, the terms right and left are neutral. However as descriptions of differences in skill and power, the right hand is, for most people, the stronger and more proficient. Applying symbolic algebra metaphorically means that if 'good' is to be applied to one hand and 'evil' to the other then it can only be the right hand that is good and the left hand that is bad. In the words of the psalmist, it is the right hand that does not forget her cunning.

---

[14] "Our way of life has largely excluded manifestations of the natural world from official consciousness, with the result that symbols function for us as metaphors and illustrations, not at potent entities in their own right which are parts of a total representative system" (Hallpike, 1979 p.144).

[15] Needham (1987b p.213) points out that it is not entirely obvious that the right and left *hands* should be so particularly favoured in symbolic terms, since "...we also possess two feet, two ears, and two nostrils, yet these are not commonly singled out as pairs in the way that hands are. Even our two eyes which are of such physical and social importance, are not usually adopted as emblems of opposition. Swedenborg did so ... but this is an idiosyncratic idea...".

To a psychologist such as myself, the problem with symbols is that they are so often misinterpreted by non-psychologists and they are so often ignored by psychologists. Probably it is the former that is responsible for the latter. Popular books on psychology love to try and tell us 'the hidden meaning of...', and then will follow a list of symbols and their meaning. Dream about this and it means that; behave that way and reveal a secret message about the true self. Always there is some sense in which a particular symbol has a particular meaning, often supported by the phrase, 'the hidden *language* of ...', with the impression that all is required for the language of the symbols to be translated into English. The anthropologist Dan Sperber has strongly contested such a view, and his argument is clear enough. "The argument may be summarised in this way: *if symbols had a meaning, it would be obvious enough*" (Sperber, 1975a p.93, my emphasis).[16] In other words, symbols don't *have* meaning, we *give them* meaning. And in so doing, much of what can happen is idiosyncratic and personal to the individual themself, with dreams perhaps being the most extreme example of all. Dreams may be interpretable with the help of a psychoanalyst who knows their client well, but the interpretation will bear no relationship to that of another client with the identical dream.

Sperber views symbols as an inevitable part of the functioning of the human mind.[17] Always the mind is struggling to make conceptual sense of the world, but it is not always the case that such sense can be found. But minds don't stop working at that point. Instead the symbolic system takes over, collecting, storing and putting together into patterns in the hope that one day, somehow, meaning will emerge[18]. In trying to store such miscellaneous material, each mind will approach it differently. Sometimes there are features which are nigh on universal, and everyone will do it the same (perhaps, say, information about day and night, or men and women). Other aspects are more specific to people from particular cultures or belief systems (for instance, consider the modern meaning of Christmas to someone not from a Western culture); and finally there are parts of the symbolism which are completely individual, so that those of one person bears little resemblance to those of any other (one can imagine this by thinking about trying to find someone else's bank statements or whatever in their home filing system)[19]. The filing system on my desk or in my computer has an internal system, I place things in particular places, in relation to one another, but there is little common in the way I will do it or in the way you will do it. Individuals sharing a culture will agree on certain aspects of the way they do things (and doctors, for instance, mostly keep their clinical

---

[16] Sperber says also, "Symbolicity is therefore not a property either of objects, or of acts, or of utterances, but of conceptual representations that describe or interpret them." (p.112).

[17] He is not alone amongst anthropologists, Needham for instance saying that, "the symbolic opposition of right and left, and a dualistic categorization of phenomena of which this opposition is paradigmatic, are so common as to seem natural proclivities of the human mind". (Needham, 1960a p.123).

[18] "I clarify my hypothesis: the conceptual mechanism never works in vain; when a conceptual representation fails to establish the relevance of its object, it becomes itself the object of a second representation. ... [T]he symbolic mechanism is the '*bricoleur* of the mind'. It starts from the principle that waste-products of the conceptual industry deserve to be saved because something can always be made of them.. ... A representation is symbolic precisely to the extent that it is not entirely explicable, that is to say, expressible by semantic means". (Sperber, 1975a p.113).

[19] Sperber, for instance, in talking about myths, Sperber says that there is, "No meaning in universal myths, but broadly, a universal focalisation, a cultural evocational field, and an individual evocation" (Sperber, 1975a p.140).

notes in a very standard format precisely so other doctors can quickly make sense of them). And occasionally aspects of the way we organise the world are universal – there are no societies for instance which do not organise their lives in terms of the year and the cycle of the seasons. Often we know that things are being done correctly without being able to say *why* they are being done in a particular way, or what the underlying rules are.

Sperber describes several examples of left-right symbolisms which work in precisely such ways. Observing the Dorze in the Sudan, where he was doing fieldwork, he noticed a ceremony in which,

> "Along comes a group of dignitaries who ... undertake a circling of the market place in an anticlockwise direction. I enquire: the tour cannot be done in the other direction. Why? It is the custom. But then? One turns in the direction of the sun. How is that? Well, from right to left." [20]

Like so many aspects of symbolism and social organisation, explanation breaks down, although the system is clear enough to those who are doing it. And outsiders can also learn to classify in the same way[21]. We are no better. Sperber, who is French himself, also mentions two lateral symbolisms in the *code de politesse*, the handshake and the use of a knife and fork, which have been "inflicted on each of us from infancy". He points out that the handshake has what might be called its own 'myths of origin', stories we have invented to make sense of our behaviour, "one shows that one is not armed; by extending the right hand, one makes it impossible to hit the other". As far as using a knife and fork is concerned, again there are half-hearted explanations and justifications, but these are very superficial, often merely saying that "... it is polite to ... hold one's knife in the right hand", without explaining why it is polite and what politeness means. Although there are rules underlying these behaviours, and these are acquired through learning, there is rarely explicit teaching, and there is no explanation of for instance, "the fact that when finished eating one puts the knife and fork together parallel towards the right rather than towards the left" ("pp.21-22").

---

[20] Even ignoring the fact that anticlockwise and from right to left are saying precisely the same thing, Sperber also points out that given the latitude of the Sudan, "... there are no more reasons, between the Tropic of Cancer and the Equator, for thinking that the sun turns from right to left rather than from left to right" Sperber, 1975a p.3.

[21] Sperber points out that, "... up-down, cold-hot, feminine-masculine, right-left, nature-culture, etc. As in the case of Freudian symbolism, we are still at the level of a trivial party game. However many societies do play this game, dividing things without laterality in left and right ..., and things without verticality into up and down. Thus the Dorze divide the whole universe into cold and hot and into senior and junior, following principles I must have internalised intuitively since – I repeatedly tested this – I apply them as they do, without being able yet to make them explicit" (Sperber, 1975a p.59).

Chapter 3: Hypernotes

☞WWW☜ 3:1

TH Huxley, born 4th May 1825 and died 29th June 1895. Desmond, 1994

On Saturday 30th June 1860, at the British Association meeting in Oxford, in front of a crowd of 700 people, Huxley had effectively destroyed Samuel Wilberforce, the Bishop of Oxford with the celebrated put-down which has become an iconic moment for modern science:

> "If ... the question is put to me would I rather have a miserable ape for a grandfather or a man highly endowed by nature and possessed of great means of influence ... who employs these faculties ... for the mere purpose of introducing ridicule into a grave scientific discussion, I unhesitatingly affirm my preference for the ape" (9578).

In *The long revolution* (1961b), Raymond Williams says that "Huxley was a public educator, in the full sense..." – that is, he provided education rather than mere instruction. Huxley did recognise the dangers of attempting to popularise science:

> "it must be admitted that the popularisation of science, whether by lecture or essay, has its drawbacks. Success in this department has its perils for those who succeed. The 'people who fail' take their revenge ... by ignoring all the rest of a man's work and glibly labelling him a mere populariser."

Huxley's educational philosophy saw a key role for lectures ("[their] object is, in the first place, to awaken the attention and excite the enthusiasm of the student"). The content was also crucial, "commenc[ing] with the familiar facts of the scholar's daily experience", the lecturer "should lead the beginner, step by step, to remoter objects and to the less readily comprehensible relations of things." But it was not only content that made the lectures and books so popular. It was also the elegant, witty, seemingly effortless prose, the emphasis upon argument and process rather than mere description, and the fact that it was being done by one of the very great scientists of the age himself. The words were far from the remote pronouncements so typically handed down from the ivory towers. Such fluency did not come easily: "I found that the task of putting the truths learned in the field , the laboratory and the museum, into language which, without bating a jot of scientific accuracy, shall be generally intelligible, taxed such scientific and literary faculty as I possessed to the uttermost...".

A fine example of Huxley's popular lecturing style is found in his lecture entitled *On a piece of chalk* (Huxley, 1967), delivered to a group of working men at the meeting of the British Association in Norwich, in 1868. It begins by considering the chalk which lay beneath the city of Norwich itself, and soon encompassed a vast mass of geology, geography and biology. In an interesting link with the theme of the present book, it was that same meeting at

Norwich at which Broca and Hughlings Jackson both read papers on the lateralisation of language in the brain (Critchley & Critchley, 1998 pp. 93-4).

☞WWW☜ 3:2

The sub-title of *Physiography* was 'An introduction to the study of nature'. The last lines of the book returns the reader whence they had started:

> "... the spectacle of the ebb and flow of the tide, under London Bridge, from which we started, proves to be a symbol of the working of forces which extend from planet to planet, and from star to star, throughout the universe" (Huxley, 1877 p.377)

The book is available on the internet at ??????.

☞WWW☜ 3:3

A brief search on the Internet for 'Left Bank' finds hardly a city in the world that does not seem to have a restaurant called 'The Left Bank', and there are also innumerable presses, book shops and other places of left-of-centre intellectual activity with the same name. Ultimately almost all can probably trace their pedigree to Henri Murger's *La Vie de Bohème*, which formed the basis for Puccini's *La Bohème*.

☞WWW☜ 3:4

Quite why Huxley was so far out on this topic is an interesting question. It certainly was not due to Huxley being unaware of Kant – and in fact he not only mentions Kant in the introduction to the *Physiography*, but had also in January 1870 published a letter in *Nature* on Kant's ideas about the nature of space. Neither is it because he could not read German – he had been reading German since childhood, took German philosophical works with him on the *Rattlesnake*, and earned money later in life by translating scientific books from German. Two possibilities remain. One is that Kant's 1768 comments on right and left were less well known in the late nineteenth century than they are today, but that seems unlikely given that Kant refers to the problems of left and right again in 1770, in 1783 and in 1786. The other possibility is simply that Huxley didn't write the passage, and perhaps didn't even read the passage very closely. Huxley's capacity for overwork and taking on too many projects was legion. In his review in *Nature* in January 1878, Judd refers to the role that his friend, a Mr Rudler, had played as "editor", and that "To this cause we may attribute the small number of inaccuracies in either fact or expression which a careful perusal of the work has revealed". A charitable explanation therefore is that this is simply not Huxley's own work.

☞WWW☜ 3:5

The method does require that midday is defined in a strict sense, when the sun is highest in the sky, and not the mid-day as indicated on clocks which nowadays are synchronised within different time-zones. Until the mid-nineteenth century this was the only meaning of noon everywhere, but the problems of co-ordinating railway timetables meant that our modern time-zones were created (Landes, 2000 pp.304-5).

☞WWW☜ 3:6

Although the reversals were first proposed in 1906 by Benard Brunhes, they were first properly described in the 1950s when it was found that rock on the ocean floor had alternating

bands of iron oxides pointed north and south. The magnetic field seems to have reversed about 170 times over the past 100 million years – about every 600,000 years; see Lowrie & Alvarez, 1981. The next reversal is predicted within the next two thousand years or so. (geography.about.com/education/scilife/ geography/library/weekly/aa032299.htm; www.amsci.org/amsci/articles/96articles/Fuller.html).

As well as the Earth's magnetic core shifting, it is also possible that the entire planet has become unstable and undergone major shifts in position, with the North Pole at times ending up at the equator (Irion, 2001).

☞WWW☜ 3:7

The pattern of the stars in the night sky will change for at least two different reasons. Firstly, the earth is itself changing its position relative to the stars. As Hipparchus of Nicaea realised in the 2nd century BC, the positions of the stars at the equinoxes are therefore slightly different every year. This is now known as the 'precession of the equinoxes' and takes about 26,000 years to go through one full cycle. For its effect on the position of the Pole Star when the pyramids were being built, see Spence (2000a) Secondly, the stars are themselves moving (so-called, proper motion), as was first recognised by Sir James Halley (1656-1742) in 1718 when he compared the positions of the stars Sirius, Arcturus and Aldebaran with the positions reported by Ptolemy (died ca. 180 AD) in his *Almagest*. Although small, over eons these proper motions would result in the positions of the stars becoming increasingly different from their present positions.

☞WWW☜ 3:8

Mullins (1999b) concluded that no other planet in the Solar System was likely to provide a better home for the chap with the long white beard and the reindeers than did Earth. The recent appearance of open water at the North Pole as a result of global warming may mean that opinion needs to be revised.

For a discussion of why Venus is the only retrograde planet see Correia and Laskar (2001a).

☞WWW☜ 3:9

There are complicated theories to do with the English in the 15th century buying port wine from Portugal, where they docked at *O Porto,* loading the red wine on the larboard side. www.whittsflying.com/Page5History.htm.

☞WWW☜ 3:10

For the reader who wants a detailed analysis of almost anything to do with spirals and their nature, the best starting place is *The curves of life* (1914) by Sir Theodore Cook (1867-1928), which is still in print. A brief biographical account of Cook can be found in Kemp (1995b).

The screw is only one example of the subtle and sophisticated engineering in everyday objects that we take for granted, objects such as the pencil, the subject of a superb biography by Henry Petroski (1989a), or the table fork or the paper clip, also described by Petroski

(1994c). Rybczynski(2000b)'s account of the screw is in a similar vein, although a minor disappointment is that there is no discussion of when screws became right handed. Rybczynski has several engravings of early machines with wood screws, but they are extremely difficult to interpret because they may have been reversed during the printing process (e.g. the left-handed screw on p.60). The sole exception is the drawing on p.90, from c1475-1500, where it is clear that the wood screw in the lower half has a left-hand thread, and being a drawing the image is not reversed.

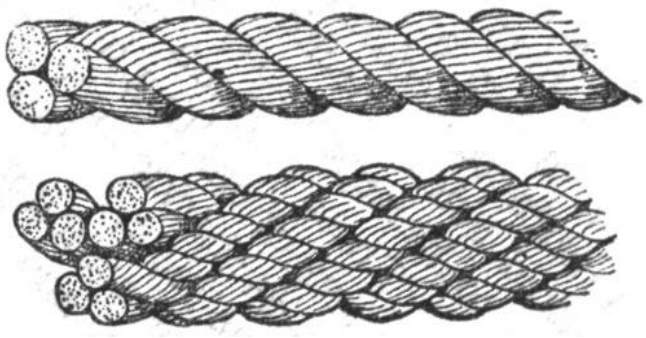
Any cyclist who has tried to take their bicycle as baggage on an international flight will have encountered left hand screws. Airlines like to pretend that they encourage cyclists, but in reality they invent a wealth of minor inconveniences which are designed to deter all but the most determined. One neat device, at check-in, is for them to say, "You must remove the pedals". What the purpose of this is difficult to see – the bicycle hardly takes up any less room because of it. When asked to do remove the pedals, most people start by removing the right pedal, which is difficult enough since one usually doesn't have the appropriate tools, and it has sometimes been tightened by cycling thousands of miles on it. But the real problem comes with the left pedal. One can strain and strain and nothing seems to happen. That is because it has a *left hand* thread, and turning in the conventional way is tightening not loosening it. Another nice trick by airlines is to say that the bike must be packed in a cardboard box "of the type available at any bicycle dealer". Great; it sounds so easy. It isn't much help, though, if one has just cycled over the Rockies or the Alps, and at midnight on a Saturday is trying to catch the flight home; cycling over mountains is not that easy, and even the keenest touring cyclists usually prefer not also to take a cardboard box bigger than the bike itself over the mountain passes.

Cook (1914 p.241-2) claims coffin screws, "that fortunately rare variety", also had left-hand threads; I think I can vouch from my days as a hospital porter, where I was required to help undertakers remove bodies from the mortuary, that this did not apply in 1969. Cook also claims that "the screws of watches made in India [and other oriental countries]" had left-hand threads. I know of no evidence on this matter, although presumably there must be a definitive answer.

☞WWW☜ 3:12

Ropes are described in terms of whether they have a clockwise twist, which is also known as a right-hand lay, or a 'Z' twist, or an anticlockwise, left-hand, or 'S' twist. Strictly, a single right-hand twist produces a *yarn*; several yarns are given a left-hand twist to form a *strand*; and several strands are given a right-hand twist when then are laid into a *rope.* If a rope has three strands it is known as a *hawser*, being *hawser-laid.* The top diagram below shows a right-hand twisted rope, with the left-hand twisted strands also visible. *Cable-laid ropes* can be either right or left-handed but are more usually left-hand, and are made by laying together three ropes, with a left-hand twist as in the lower diagram. Ropes only bed down properly if alternate layers are twisted to right and to left. When being coiled on the deck of a ship, right-hand ropes will only lie properly if coiled clockwise ('with the sun' as it is said), and left-hand ropes if coiled anti-clockwise. Interestingly, when plants such as honey-suckle grow over themselves, then the individual strands are left-handed, and the rope so formed is *also* left-handed (Cook, 1914). Of course unlike rope-making, the product is not being selected for its strength.

(Top) A right-hand lay rope consisting of three left-hand strands, each of which would be made up of right-hand lay yarns. (bottom). A left-hand lay cable comprised of three right-hand lay ropes.



The convention for naming ropes has not always been as universal as it should have been. An anonymous pamphlet (Anonymous., 1878 p.12) described one expensive failure which resulted:

> "The first Atlantic cable that was laid [in 1857] failed through a similar mistake. The *Niagara*'s half was made in Liverpool, and the *Agamemnon*'s half in London. It was only discovered, when too late, that the ropes were half right lay and half left. They tried to obviate the difficulty by covering the mid-ocean splice with a wooden shoot, or casing, but it only passed one message or so, and all that money was thrown into the sea...".

The reasons for the error are given in more detail elsewhere (Blake-Coleman, 1982a p.161). Ironically, one of the consultants on the exercise was the already distinguished physicist, William Thomson, later to be Lord Kelvin, who was subsequently the first to use the term 'chirality'.

The naming of right-hand spirals by botanists perhaps reflects the sort of twist a plant would make if it were growing upwards in the northern hemisphere and following the sun around which, as was seen in figure 2 of chapter 2, would mean a clockwise turn, and hence a left-hand spiral in the sense of left-hand screw thread.

I will not take the opportunity to quote the entire words of Flanders and Swann's *Misalliance*, although they would bear it. They can be found in Gardner (1990a).

The twisting of thread is apparently also the basis of the distinction between jeans made by Levi Strauss and by Lee, Hugo Williams (2001b)telling us that,

> "There is a gentleman's agreement among jean manufacturers that Levi's use a 'left-hand twill', while Lee jeans use a right. ... The toughest is left-hand for some reason; Levi's got first-choice because they were there first".

☞WWW☜ 3:13

Cook (1914 pp.341-379) proposed that the rare form of *Voluta vespertilio*, seen in figure 3, was the model which Leonardo may have used to design the spiral staircase of the Château at Blois in the Loire.

☞WWW☜ 3:14

Clark (1973b) has pointed out that left and right differ from other place words. If we say "Mary is in front of the house" or "Mary is at the top of the house" the location is clearly relative to the house, whereas "Mary is to the right of the house" usually means to the right with respect to us, the viewer, and not from the house's point of view.

☞WWW☜ 3:15[22]

An alternative method for actors to indicate right and left is to refer to 'prompt' and 'opposite prompt' (or 'off prompt'). It is a seemingly unambiguous system except that the prompter normally sits on the actors' left in the UK but the actors' right in the US. Corballis and Beale (1976 p.156) say that that French actors traditionally always had a courtyard, *cour,* to one side of the stage and a garden, *jardin*, to the other. Actors remembered which was which by punning *cour*, with *coeur*, the heart, on which side the courtyard would be found.

For an example of the disputes than can occur when proper right and proper left are not taken into account, see the article by Steven M. Wight (dobc.unipv.it/scrineum/scrineum.htm).

For reasons that I have never seen explained, and as Gardner (1990a) has pointed out, striped men's ties in Britain follow the pattern of the bend sinister, whereas those in America follow the pattern of the bend dexter. One presumes that this can have nothing to do with supposed legitimacy.

☞WWW☜ 3:16

The river Pregel which flowed through Königsberg had two islands, which were connected to each other and the two banks by seven bridges. The question was whether it was possible walk over every bridge without recrossing any of them. The great Euler proved in 1735 that it was impossible.

☞WWW☜ 3:17[23]

A recent view of the old argument about the difference between the absolute and relative views of space, and physicists' arguments about the problems of how one can have acceleration without a frame to measure it, and hence the idea of an 'ether' which pervades all space, has been updated in quantum mechanics with the proposal that the vacumm itself has structure (see Davies (2001c).

☞WWW☜ 3:18

Kant's collected works total 5651 pages, of which about half is critical apparatus.

I am not sure I know of any earlier reference than Kant which treats the universality of right-handedness as of crucial importance for understanding the nature of handedness and

---

[22] **☞WWW☜** was inadvertently omitted from the notes in the book.

[23] **☞WWW☜** was inadvertently omitted from the notes in the book.

humanity, although there are undoubtedly earlier references which talk about right and left handedness (e.g. Plato and Aristotle).

The translation from Kant is taken from Van Cleve and Frederick (1991 p.30). There is an important distinction from the Cambridge edition (Walford & Meerbote, 1992) which says "all the peoples of the world are right-handed (apart from a few exceptions which ... do not upset the universality of the regular natural order)". The implication in the latter is that there are some races, tribes or groups who *do* mostly write with the left hand. This distinction would be important in laterality research. Although the original German (Buchenau, 1922) is still somewhat ambiguous, it seems clear from the lines that follow that it is individual people who are the exceptions, rather than individual groups of people, as in the translation of Kerford and Walford (1968b).

☞WWW☜ 3:20

The railway track need not be straight as such, but it should not have any points used for changing tracks. It does not matter if the ends join up, in a circle, although the track should stay flat. It does not matter even if the track is on a Möbius strip, which is still one-dimensional.

☞WWW☜ 3:21

In his brief comment, Wittgenstein pointed out that, "A right hand glove could be put on the left hand, if it could be turned round in four-dimensional space". The philosopher Jonathan Bennett describes this remark as "mathematically sound but entirely unhelpful" (Bennett, 1970, reprinted in Van Cleve & Frederick, 1991 p.107).

In his *The Plattner story*, referred to elsewhere in this book, H G Wells puts very clearly the issue of rotation through a fourth dimension:

> "There is no way of taking a man and moving him about *in space*, as ordinary people understand space, that will result in our changing his sides. Whatever you do, his right is still his right, his left his left. You can do that with a perfectly thin and flat thing, of course. If you were to cut a figure out of paper, any figure with a right and left side, you could change its sides simply by lifting it up and turning it over. But with a solid it is different. Mathematical theorists tell us that the only way in which the right and left sides of a solid body can be changed is by taking that body clean out of space as we know it,--taking it out of ordinary existence, that is, and turning it somewhere outside space. This is a little abstruse, no doubt, but any one with any knowledge of mathematical theory will assure the reader of its truth. To put the thing in technical language, the curious inversion of Plattner's right and left sides is proof that he has moved out of our space into what is called the Fourth Dimension, and that he has returned again to our world."

Philosophers object though that a mirror whilst producing the effect of rotating through a fourth dimension does not do it as a *continuous* transformation, unlike a rotation in a higher space. There are no intermediate positions which the mirror produces (one cannot stop halfway, for instance, unlike the case of picking up the triangle in figure 10).

☞WWW☜ 3:23

HG Wells clearly understood the mathematical situation for in *The Plattner Story* he says, "There is no way of taking a man and moving him about *in space*, as ordinary people understand space, that will result in our changing his sides. Whatever you do, his right is still

his right, his left his left. You can do that with a perfectly thin and flat thing, of course. If you were to cut a figure out of paper, any figure with a right and left side, you could change its sides simply by lifting it up and turning it over. But with a solid it is different."

There are only three spatial dimensions at the macroscopic level at which our hands exist. If there are ten dimensions at a microscopic level, as superstring theories demand, that would have no consequence for Kant's argument (Van Cleve, 1987).

A completely mirror-reversed person would starve to death, none of their enzymes being able to metabolise the L-amino acids and the D-sugars of which most food is composed. If the person were truly completely mirror-reversed they would also be made of anti-matter (Avalos et al., 1998 p.2393), rather than matter, with interestingly explosive consequences on their return.

There is an argument that in order to reject Kant's argument it is not necessary to have a *real* fourth spatial dimension in which the object could be rotated. But that itself is a difficult argument, since if there were a fourth virtual dimension in which three-dimensional objects could be rotated, then as the philosopher James Van Cleve has pointed out, Kant would merely have had to consider instead not a three-dimensional hand but a four-dimensional 'left' hand. That could be rotated into four-dimensional 'right' hand by rotating it into a fifth dimension. But then Kant would merely have to propose a five-dimensional 'left' hand, to which the critic would invoke a sixth-dimensional rotation; and so on, for ever. The argument is what is called an 'infinite regress'. However far it goes, the critic has problems with it, and Kant can always stay one step ahead (Van Cleve, 1987; reprinted in Van Cleve & Frederick, 1991 p.216.

☞WWW☜ 3:24

A recent book devoted to Kant's ideas on right and left, starts out, "Some ordinary facts about the world we live in can be readily explained by other ordinary facts. ... One ordinary fact that is not readily explainable in terms of other ordinary facts is the difference between left and right hands. ... [I]t is not obvious what facts about the world might explain the difference, or even, perhaps, what the difference is. Exactly what is it, after all, that makes a hand left and not right?" (Frederick, 1991).

Kant's different positions on the nature of space have meant that philosophers have tended to select those parts of Kant's arguments that they find attractive. For instance, Bertrand Russell could claim, "these cases ... show, as Kant intended them to show, the essential relativity of space" (Russell, 1896).

One dominant position now in the philosophy of right and left is that Kant's original ideas were correct. The philosopher Graham Nerlich, in an article that "significantly changed the focus of the debate about Kant's argument" (Frederick, 1991) acknowledges that "Kant himself had second and even third thoughts about his argument. My aim is to show that his first ideas were almost entirely correct about the whole of the issue" (Nerlich, 1973, reprinted in Van Cleve & Frederick, 1991).

☞WWW☜ 3:25

Project Ozma was a search for radio messages from extra-terrestrials, started in 1960 at the Green Bank radio observatory in West Virginia. Frank Drake, who created the name, based it on the 'humanoid' ruler in the Oz books. (see Gardner, Gardner, 1990a). Although Gardner does not acknowledge him, Borel (1960b) seems to have presented the essential problem earlier, and done it in the context of communicating in Morse code with an extra-terrestrial on a cloud-covered planet, at a great distance, in an unknown direction, (Bennett, 1970, reprinted in Van Cleve & Frederick, 1991).

One of the founding fathers of modern psychology, William James (1842-1910), also made the same point about the impossibility of describing left and right using verbal labels, and of the need for direct comparison:

> "If we take a cube and label one side *top,* another *bottom*, a third *front,* and a fourth *back*, there remains no form of words by which we can describe to another person which of the remaining sides is *right* and which *left*. We can only point and say *here* is right and *there* is left, just as we should say *this* is red and *that* blue" (James, 1890vol II, p.150).

Richard Feynman also presented the problem in the lectures he was giving at Caltech in about 1960, and which were published in 1963 (Feynman, Leighton, & Sands, 1963 p.52-8).Typically though he added several layers of physical sophisitication on top of it. Feynman is trying to tell the Martian how to build a model of a human being. Height can be specified in universals, such as "we are 17,000,000,000 hydrogen atoms high", but the problem arises when the Martian is told, " 'Now put the heart on the left side'. He says, 'Duhhh — the left side?'". In typical Feynman fashion the story continues with the insight that the Martian, despite having left and right specified in terms of cobalt-60, could still get everything back to front if Martians happened to be made of anti-matter. An explosive end is possible, the fantasy continuing,

> "What would happen when, after much conversation back and forth, we each have taught the other to make space ships and we meet halfway in empty space? We have instructed each other on our traditions, and so forth, and the two of us come rushing out to shake hands. Well, if he puts out his left hand, watch out!" (p.52-11).

Chapter 4: Hypernotes

☞WWW☜ 4:1

The story is told by Fritsch (1968c), who attributes it to the German psychologist Kurt Elze, who in 1924 invented the term ‘right-left-blindness’ (Elze, 1924; Elze, 1926).

In *Paradise Lost*, IV: 785, Milton describes the army of Cherubim, “Half wheeling to the shield, half to the spear” (Fowler, 1971a).

☞WWW☜ 4:2

Care has however to be taken when people are declared to have right-left confusion. For instance, Fritsch (1968c p.54) mentions that the physicist Helmholtz was described as being “‘right-left blind’ to a very high degree”, whereas Benton (1959 p.58) is sceptical, emphasising only that Helmholtz described himself as having difficulty discriminating right and left when a child.

Freud described his difficulty in a letter to Wilhelm Fliess, Jan 4th, 1898 (Freud, 1985). Although 'right' and 'write' sound the same in English, the trick does not work quite as well in German, where *rechts* (right) and *schreiben* (to write) aren’t pronounced in the same way; nevertheless, as Freud found, the method solved his problem.

☞WWW☜ 4:3

Even navigation in cities is not easy. As an eighteen-year old taking my driving test, the examiner told me to turn left at the next junction. I immediately moved into the middle of the road and turned right; this being England, he smiled and said he’d thought he would start with something easy, but I’d now shown him I could do one of the more complicated manoeuvres.

☞WWW☜ 4:5

The best simple introduction to Proto-Indo-European is Crystal (1987c). For a more detailed and technical but highly accessible description of the details of how it is reconstructed, as well as examples of many of the wide range of scripts and languages, see Beekes (1995c). My own introduction, many years ago, to proto-Indo-European was through Anthony Burgess’s elegant little book called *Language made plain* (1964b) .

☞WWW☜ 4:6

As an example of another law, Brugmann's Law says that a long *a* in Sanskrit will become an *o* in Greek. There were exceptions, of course, but these also were rule-bound. August Leskien, a scholar of the Slavic languages, emphasised the 'regularity of the sound laws', whereby sounds in one language are modified in a regular systematic fashion to become different sounds in other languages. Collinge (1985a) has an account of all the various sound laws in Indo-European languages.

The concept of systematic change in languages is in some ways very similar to that of change in genetics by mutation and selection. New words appear quite spontaneously, and of the existing words, some are more successful and are used more often, so survive better. Speciation also occurs simply by geographical separation, just as sub-species and then species of animals and plants occur by physical separation coupled with genetic drift and selection for a slightly different ecological niche. The important difference between genes and language is that genes only spread *vertically* (i.e. from parent to child) whereas linguistic components can spread *horizontally* (just as viruses spread horizontally – I can 'infect' you with a cold or a new word which you then spread further yourself). Ultimately words and other parts of language are ideas, and in some sense the concept of a 'meme' fits well with them (see Blackmore 1999c).

☞WWW☜ 4:7

Germanic and East Germanic, like Proto-Indo-European, are themselves languages without any written records, and therefore they have been reconstructed from their descendants.

Renfrew (1987d) has a good account of the romantic stories of Hittite and Tocharian. Examples of the scripts can be found in Beekes (1995c).

One of the great successes of the reconstruction of Proto-Indo-European was the hypothesis put forward by the great Swiss linguist, Ferdinand de Saussure (1857-1913) that some of the anomalies of reconstruction could be got round if one suggested the existence of extra consonants which are not present in present-day Indo-European languages. It was a brave claim indeed, and Saussure referred to these additional consonants as 'laryngeals', by analogy with similar sounds in modern Semitic languages which are produced at the very back of the throat. The theory was dramatically vindicated when in 1927 it was shown that Hittite indeed had sounds in precisely the right form. The laryngeals are indicated by the symbol **H** in the reconstructions below.

As well as nouns describing the objects and ideas of the proto-Indo-European world, verbs describing the things that they did, numbers for counting, pronouns for referring to each other, and so on, the proto-Indo-European vocabulary also contained adjectives, very many of which are paired. As examples we have:

good	***wesu-/*su-**	***t'us-**	bad
high, top	***$b^herĝ^h$-**	***nī-**	low, bottom
wide, flat	***p^h(e)l-H-/-t^h**	***Han$ĝ^h$-u-**	narrow
full	***$p^hl̥$H-(no-)**	***wāst^ho-**	empty, devastated
large	***meƙ'H-**	***d^heb^h-**	small
thick, solid	***b^heng^h-**	***t^hen-**	thin
long	***t'elH(n)g^ho-**	***mre$ĝ^h$u-**	short
heavy	***k'o(e)r-u**	***leg^{h}o-**	light
new	***newo-**	***wet^{h}o-**	old
white, light-coloured	***alb^{h}o-**	***mel-**	black, dark

Even a brief glance at these words suggests things with which we are very familiar (even if as Esperanto sometimes seems, it is familiar but incomprehensible). Some words look extremely close to English itself (***newo-** for **new**, or ***t^hen-** for **thin**), and others have resonances in English because we have words that are related to them (***alb^{h}o-** and **albinism**, ***mel-** with **melanin**, ***meƙ'H-** with the prefix **macro**, and ***b^{h}erĝ^h-** with the German **berg** for a mountain).

It is almost tempting at this point to wonder whether one could understand proto-Indo-European if it were spoken. The answer on theoretical grounds is almost certainly no, since we know that modern English speakers have difficulty in making sense even of the Middle English in which Chaucer wrote *The Canterbury Tales*, and that the Old English in which *Beowulf* was written is almost incomprehensible to the modern ear. For those though who would like to find out for themselves, they should watch out for a film released in 1981 called *Quest for Fire*. Films about pre-historic times are not normally renowned for their attention to scientific detail (one thinks of *One million years BC* in which Raquel Welch wears a fur bikini and is chased by a dinosaur, despite dinosaurs having been extinct for 64 million years). *Quest for Fire* though is different in one interesting respect. The script was written by the novelist Anthony Burgess, who, as well as writing books such as *A clockwork orange*, was also a gifted amateur linguist[24]. He therefore wrote the script entirely in proto-Indo-European[25]. I once saw the film in Heidelberg on the grounds that I wouldn't have been able to understand the dialogue in any of the other films being shown in the cinema, but with *Quest for Fire* I knew I would be as baffled as everyone else in the cinema.

[24] His most ambitious achievement was the seemingly impossible task of translating James Joyce's *Finnegans Wake* into Italian.

[25] It must be said, from memory, that there were other aspects of the film which did not show the same attention to verisimilitude. Fire had probably been discovered long before proto-Indo-European had been spoken, and there was little indication of the village, agriculturalist life around which the vocabulary of proto-Indo-European seems to centre. And it seems unlikely that sex from the front rather than the rear was discovered so late in human evolution, although it made good cinema. According to *Halliwell's Film Guide*, *Quest for Fire* is set eighty thousand years ago. That is long before Proto-Indo-European would have been in use, and even sixty thousand years or more before Nostratic. It is however probably within the range during which modern humans were probably using a sophisticated language equivalent to that in use today.

☞WWW☜ 4:9

These are the reconstructions of, respectively, Buck, p.865 (Buck, 1949), Gamkrelidze and Ivanov, p.686 (Gamkrelidze & Ivanov, 1995), and Delamarre (1984) (Delamarre, 1984a). Delamarre (1984a) does reconstruct *laiwos / *sewyos / *skaiwos, but he is an exception.

☞WWW☜ 4:10

With characteristic honesty, Hertz acknowledges in a footnote that the idea had already been suggested in 1906 by Meillet. Gamkrelidze and Ivanov, who do not cite Hertz, also seem unaware of Hertz's other major theoretical point, that physiology can do nothing to explain the symbolic pre-eminence of the right hand, suggesting, "This association of right with the favourable, good and positive, and left with the unfavorable, bad, and negative, can be regarded as a semantic universal of language. It is of course based on the typical differential physiological capacity of the human right and left hands."

☞WWW☜ 4:11

See Hamilton & Deese, 1971. Clark (1973b) points out that in the pairs *long*-**short**, *far*-**near**, *tall*-**short**, *high*-**low**, *deep*-**shallow**, *wide*-**narrow**, *broad*-**narrow**, *thick*-**thin**, the first member (in italics) is unmarked, and the second (in bold), is marked.

The marking often involves *-w^{e}/o- in the Germanic languages, in pairs such as 'west' and 'east', or 'winter' as opposed to 'summer' (Mallory & Adams, 1997 p.349; Markey, 1982 p.189).

☞WWW☜ 4:13

The word Nostratic comes from the Latin *nostratis*, meaning "our countryman', a rather ethnocentric term which has since been criticised. For an introduction to Nostratic see Ross (1991a), for a critical review of the concept see Salmons and Joseph (1998a), and for a dictionary of Nostratic see Dolgopolsky (1998b). It is unlikely that Nostratic will have a reconstructable word for left, since none exists in Proto-Indo-European, but it is possible one will exist for right.

☞WWW☜ 4:14

The originals of the postage stamp and the dollar bill look like this:

The photograph of Hale-Bopp was taken by Howard Taylor, at Chandler's Ford in Hampshire, UK, and was downloaded from the InterNet (http://www.jpl.nasa.gov/comet/taylor1.html), where many other images of the comet can also be found. The comet actually looked like this:

☞WWW☜ 4:15

The study of Hale-Bopp also found a small difference between right and left handers, 57% of 189 left-handers getting the right-left orientation correct compared with 65% of 190 right-handers (Martin & Jones, 1999).

☞WWW☜ 4:16

Novelists are not always exact about the precise timing of their observations. In Italo Calvino's *Il visconte dimezzato* (*The cloven viscount*), the nurse says, "Can't you tell left from right any more? And yet you learnt when you were five...".

Winnie-the-Pooh has been used extensively as the theme for the elegant book on symmetry by Rosen (1975b).

☞WWW☜ 4:17

The ages quoted are based on the study of Elkind (1961c). It is conventional to quote the age at which a task can be completed as that at which 75% of children do it correctly. Similar results are found in the study of Dellatolas *et al* (1998c).

☞WWW☜ 4:18

Piaget (1928 pp.202-3) comments that, "One of the most striking things one finds about the child under 7-8, is his extreme assurance on all subjects. ... 'I know!' – such is the only proof that is used for a long time in childish logic. True, the child is always asking questions, but up to the age of 7-8 a large number of the questions are rhetorical: the child knows his own answer..."

☞WWW☜ 4:20

Perhaps the most extreme case of left-right confusion is described in the book of *Jonah (4:11)*, where we are told about "Nineveh, that great city, wherein are more than six score thousand persons [120,000] that cannot discern between their right hand and their left hand".

Biblical scholars (Sasson, 1990; Wade, 1925) seem to regard it as having a metaphorical rather than literal meaning. One possibility is that it refers to young children, who are incapable of distinguishing their right and left hands, and that would be compatible with the population of 120,000, since the total population of Nineveh at its peak has been estimated at 300,000 (Sasson, 1990 p.311). An alternative explanation is that it refers to some form of mental or, more likely, moral handicap, but that does not seem compatible with the overall context. Perhaps the best explanation is that of Sasson who suggests it is a description of the sheer size of Nineveh, vast by Biblical standards, and, "so teeming with life that Ninevites do not know who their neighbours are" (Sasson, 1990 p.315), not knowing who lives to their right or left sides.

Although there have been concerns that women may merely *report* more often that they have problems with left and right (Williams, Standen, & Ricciardelli, 1993), there is experimental evidence that women actually do carry out left-right discrimination tasks less quickly than men (although not less accurately) (Snyder, 1991). Interestingly it does however seem that in children, girls and boys do not show any difference in distinguishing right and left (Benton, 1959 p.34), and it is not clear at what age the difference emerges.

☞WWW☜ 4:21

In the experiment proper, subjects were presented with four sets like that shown in the figure, containing a total of 80 hands. Control subjects who reported no problems at all with distinguishing right and left in everyday life took 38 seconds to say whether the hands pointed up or down, 61 seconds to say whether they pointed to right or left, and 142 seconds to say whether they were right or left hands. Subjects reporting right-left confusion took 43, 70 and 178 seconds for the same tasks (Brandt & Mackavey, 1981)

☞WWW☜ 4:22

The account is describing experiments 4 and 6 of Sholl and Egeth (1981). Essentially similar results have been found by Maki (1979c). The question has been controversial with the study of Farrell (1979d) finding a suggestion of perceptual differences between right and left, although the results do not seem to replicate.

☞WWW☜ 4:24

Mach (1838-1916) , who said, “the distinction between right and left depends upon an asymmetry”, was both a Professor of Physics at the University of Prague and a Professor of Philosophy at the University of Vienna. He is probably best known now for his work on the shock waves travelling ahead of fast moving objects, and the measurement now known as the Mach number, of the ratio of the velocity to the speed of sound. He was also a successful populariser of science whose *Popular Scientific Lectures* (Mach, 1910) are still an interesting and entertaining read. His introduction to the *Lectures* sets the task well for the modern populariser: “[The author] must select ... easy subjects, and restrict themselves to the exposition of the simplest and the most essential poits. Nevertheless, by an appropriate choice of the matter, the *charm* and the *poetry* of research can be conveyed by them. ... such lectures can exercise a favorable influence by showing the substantial sameness of scientific and everyday thought. The public, in this way, loses its shyness towards scientific questions...”.

☞WWW☜ 4:27

Gerstmann published his first case report in 1924, and described two more cases in 1927, but it was only when he published further cases in 1930 that right-left disorientation was included as a key part of the syndrome.

Although Gerstmann was the first to describe the association of his tetrad of symptoms, the first description of neurological patients with confusion of right and left was made four decades earlier by Obersteiner (1882) who described “a peculiar sensory disorder”, which he called *allochiria.* Many papers were published on the symptom over the next quarter of a century, often only confusing the situation. Much clarification came with the work of Ernest Jones, the future biographer of Freud, who emphasised that many cases were hysterical in origin, and that, in a very modern phrase, the condition “is primarily a disturbance of the sense of right- or left-handedness”, “a mental defect of the specific feeling of ‘sidedness’ ” (Jones, 1907).

Occasional cases do occur in the right hemisphere, in at least one case of which the patient was left handed (Moore et al., 1991). The precise location of the lesion In Gerstmann’s syndrome is still not exactly clear; Dehaene *et al* (1998d) have placed it “in the vicinity of the intra-parietal sulcus”, deep in the parietal lobe.

Finger agnosia is an extremely difficult symptom for which to gain any sense of empathy. Kinsbourne and Warrington (1962a) suggested that, "The fingers were treated by the patients, in some respects, as if they were an undifferentiated mass". Imagine perhaps that they have been permanently stuck together with superglue or sticking plaster, or, in contrast, imagine trying to have a properly *separate* feeling for each of the bones in your wrist or the body of your foot.

The Oscar Wilde quote comes from Critchley (1966 p.184). I have not been able to find the original source.

☞WWW☜ 4:29

Galton said that “The pattern or ‘form’ in which the numerals are seen is by no means the same in different persons, but assumes the most grotesque variety of shapes, which run in all sorts of angles, bends, curves and zigzags...”

The number form is taken from Spalding and Zangwill (1959). The patient was a 24 year-old solider, wounded in October 1944, with a problem of calculation and damage to the angular gyrus on the left side. He attributed his mathematical problems to the loss of his number form which had occurred as a result of the shrapnel wound.

The numbering of the fingers does differ in different countries, and I am using English nomenclature which does not count the thumb, so that the first finger is the index finger, the third the ring finger and the fourth the little finger or pinkie.

The relationship between numbers and left and right is shown in a fascinatingly elegant experiment by Dehaene. In his experiment subjects looked at a number flashed on a screen and had to say whether it was odd or even by pressing with their left hand if it was even, and with their right hand if it was odd. The unexpected result was that for small numbers, people were faster with their left hand, whereas for bigger numbers they were faster with their right hand. The implication of what has been called SNARC ('spatial-numerical association of response codes') is that for most people numbers are indeed laid out mentally from left to right[26]. The neat twist on this experiment is that it was also carried out with a group of Iranian students, who had been taught to read and write from right to left. The pattern of results was similar except that they were faster with the *right* hand for the smaller numbers and the *left* hand for the larger numbers[27]. It seems that the way we organise numbers from left to right inside our heads is in part related to whether we write from left to right or vice-versa (Butterworth, 1999).

☞WWW☜ 4:30

An influential theory of vision distinguishes between two separate streams in the brain, a ventral stream "coding for perception", which ends in the infero-temporal cortex and is concerned with form perception, and a dorsal stream "coding for action", which ends in the posterior parietal cortex and is mainly concerned with action (Milner & Goodale, 1995). It would seem that action needs to know about the right and left of objects, whereas form can to a large extent ignore it. That is supported by the almost paradoxical result that monkeys with damage to the infero-temporal cortex are relatively *better* than control monkeys at distinguishing mirror-images (Gaffan, Harrison, & Gaffan, 1986; Milner & Goodale, 1995 p.152). JBA, a patient who also had bilateral parietal lesions, could only distinguish an object from its mirror image if she *couldn't* name the object (Warrington & Davidoff, 2000) RJ's lesion is parietal and might therefore be expected to impair his awareness of right and left but leave perception of objects intact.

☞WWW☜ 4:31

Wood Jones, 1941; Wood Jones, 1949. Wood Jones' classic textbook on the hand, one of the few medical textbooks from the 1940s still on the open shelf in my medical school library, was written during the first World War, "in the intervals of military service and air raids", and the second edition during the second World War, "during the intervals between routine duties and air-raid signals". Wartime probably provides all the experience a hand surgeon could ever require.

Right-handed neutrinos were mentioned by Quinn and Witherell (1998e); the correction was published on p.6 of the January 1999 issue. In an article published in 1958 Abdus Salam,

---

[26] Dehaene, S., Bossini, S. & Giraux, P. *Journal of Experimental Psychology: General* 122: 371-96, 1993 Dehaene, Bossini, & Giraux, 1993. A similar effect was *not* found for letters of the alphabet.

[27] There is a potential confusion here to do with what in the West are called 'arabic numerals', i.e. 1,2,3,etc.. Numbers in the Arabic language are written in what is known as the 'east Arabic' system, with ١٢٣٤٥٦٧٨٩ representing respectively the digits one though nine. However, although Arabic in general is written from right to left, the place system of the numbers is written, as in Western scripts, from left to right. As a result, ١٢٣ represents the number one hundred and twenty three (123) and not three hundred and twenty one (321).

who was one of the first theoreticians to understand the neutrino, had written, "right-polarized neutrinos exist but left polarized neutrinos do not", which seems also to be an error (Salam, 1958 p.103). It must be said though that although Salam was one of the first to realise that neutrinos explained the failure of conservation of parity, the equations themselves could not say whether neutrinos were right or left handed, that being a matter to be resolved by experiment (Fraser, 2000 pp.132-135).

Dr Tom Schneider, of the Laboratory of Computational and Experimental Biology at the National Cancer Institute in Maryland, has his left-handed DNA site at www.lecb.ncifcrf.gov/~toms/LeftHanded.DNA.html. The site repays a visit, being beautifully illustrated with lots of hyperlinks. Particularly interesting are the journals and companies which refuse to allow their errors to be reproduced. For those who would like an up-to-date example then the back cover of the issue of *Science* for 25th Jan 2002 shows a nice example of left-handed DNA.

Although most DNA has what is called a B structure, DNA can spontaneously form a true left-handed spiral known as Z-DNA (Wang et al., 1979). Recently it has been discovered that there are enzymes that bind to Z-DNA specifically meaning it must have a role, albeit one that is not understood, in normal cell metabolism (Schwartz et al., 1999).

An intriguing historical example where commercial examples do not seemed to have cared about right and left is the one discussed by Stephen Jay Gould in his essay "Left snails and right minds (1997 pp.202-217). He had noticed that in an early book on conchology, by Nehemiah Grew in 1681, the dextral snails were all illustrated back to front (as also was the unusual inverted, sinistral, snail, which was shown the ordinary way round). At first Gould like many of us assumed it was incompetence or carelessness, but then he found a series of other examples from this time period which were also illustrated in the same way. He wonders whether it might be a convention (just as astronomers usually print their pictures upside down, because that is the way they look through their telescopes), but then comes down on a psychological theory: "the conceptual world of pre-eighteenth-century zoology must have accorded little importance to the orientation of a shell". An alternative is that engravers found it difficult to reverse images and the default was to allow *all* of them to be reversed unless there were strong reasons why it mattered which way round they were (as with lettering). And since most organisms are symmetric anyway, it would be impossible in general to tell.

Time is no guarantee that such left-right errors will be picked up. The 1997 re-issue of Watson's *The Double Helix*, was published by Weidenfeld and Nicolson, and it was reprinted in paperback in 1999 by Penguin Books, and although the cover shows a different picture of DNA it is also back to front. Perhaps at this point I should also say that since Weidenfeld and Nicolson are also publishing this book I will be extremely careful in doing my checking. Nevertheless I will be amazed if some chirality gremlin doesn't creep into the works.

The error in *Nature* occurred in the caption of an illustration on p.737, 15th June 2000. See Porter (2000c), who also points out plenty of left-handed DNA being illustrated in other articles on functional genomics in the same issue. Likewise *Scientific American* managed to illustrate an article celebrating the sequencing of the human genome managed with several examples of left-handed DNA. I have stopped counting the number of advertisers or popular newspapers that show left-handed DNA. It is more interesting though when one finds the

error in substantive scientific articles in substantive scientific journals, and, almost as this book goes to press I notice yet another in *Nature* (Downward, 2001 figure 1).

After all this discussion about how confusing right and left can be, you might ask how I, a psychologist, cope with it. Needless to say I am no better than anyone else. Like Freud I use various motor mnemonics to remember which side is which. Certainly I seem incapable of knowing which is a right hand spiral without making tiny screwdriver-like movements with my right hand. When all else fails, though, I have an infallible method. They were bought for me by Barbara Bulman-Fleming, a dear friend who is also a laterality researcher – a pair of socks, one of which has the word 'right' in a dozen or more languages and the other has the word 'left' in the same Babel. I sometimes wear them when giving popular lectures on handedness and lateralisation. The only problem, of course, is knowing which one goes on which foot....

Chapter 4 was originally meant to end with our translation of a charming poem by the Austrian poet, Ernst Jandl. However due to seemingly insuperable copyright problems, it was eventually omitted from the book. Here however is the poem, firstly in the original German (Jandl, 1997 p.74), and then in our translation[28]. There is also a published translation by Anselm Hollo (Jandl, 2000).

lichtung

manche meinen
lechts und rinks
kann man nicht
velwechsern.
werch ein illtum!

dilection

some think
reft and light
cannot be
at arr mislead.
they ale misred!

[28] Translated (©) by Christine Pleines and Chris McManus.

Chapter 5: Hypernotes

☞WWW☜ 5:1

Act II, Scene II of *Siegfried*, in the English translation by Andrew Porter, performed by the English National Opera. The libretto here is quoted from the complete recording in August 1973, conducted by Sir Reginald Goodall at the London Coliseum (EMI SLS875, OC 191 02473-02477).

Wagner himself does not specify that the heart is on the left, and he may only, for instance, have meant that the heart was in the chest. The original words, with a very literal translation, are:

"Doch heiße mich das: hat der Wurm ein Herz?	"Tell me this: has the dragon a heart?"
"Ein grimmiges, hartes Herz!	"A grim, hard heart!"
"Das sitzt ihm doch wo es jedem schlägt, trag' es Mann oder Thier?	"That must be in the same place as it beats for everyone, be they man or beast?"
"Gewiß, Knabe, da führt's auch der Wurm;" (Wagner, 1888):	"Certainly, ..., that's where the dragon has it as well..."

A detail to remember in speculating about the heart of Fafner the dragon is that earlier in the ring cycle Fafner is one of the two giants who steal the gold, and that Fafner uses the magical Tarnhelm to transform himself into Fafner the dragon to guard the stolen hoard. It is probable therefore that his internal organs will correspond quite closely to the internal organs of the giant Fafner, and therefore the heart will be on the left.

☞WWW☜ 5:2

The typical Western forms of dragon are found, for instance, in Carpaccio's paintings of the life of St George in the Scuola di San Giorgio degli Schiavoni in Venice, and in Raphael's drawing in the Uffizi (Altmann, 1992i p.42), but also in innumerable books for children, and one can be seen, for instance, on the cover of J.K. Rowling's *Harry Potter and the Goblet of Fire*. Portrayals of dragons go back to the earliest recorded civilisations and seem to be world-wide in their distribution. The determining feature is the inclusion of body parts from several or many different animals, as in an early Sumerian dragon with the claws and wings of an eagle and the hind legs of a lion (Elliot Smith, 1919 p.79, figure 1). An ancient Chinese

description of a dragon describes its “nine resemblances” – “His horns resemble those of a stag, his head that of a camel, his eyes those of a demon, his neck that of a snake his belly that of a clam, his scales those of a carp, his claws those of an eagle, his soles those of a tiger, his ears those of a cow” (Elliot Smith, 1919 p.81).

☞WWW☜ 5:3

In *Beowulf*, the eponymous hero, Beowulf, fights the dragon Grendel bare-handed and mortally wounds him by ripping off his arm and shoulder, which are carried back to the great hall, Heorot, and put on display. While Grendel fled to his den to die, “his right hand [*swīðre hand*] stayed behind him in Heorot,/ evidence of his miserable overthrow/ as he dived into murk on the mere-bottom” (Heaney, 1999 p.67).

I could not resist including the illustration of the Burroughs-Wellcome advert in this book, the writing of which was supported by a prize from the Wellcome Trust, whose wealth mainly has come from sales of that and a wealth of other drugs. It therefore seems an appropriate tribute to include the illustration. However when I originally found the picture of the painting, I was somewhat suspicious of it, as can be seen by my comment about the Valentine's heart. Subsequently I found the wonderful monograph by Vinken (1999d) entitled *The shape of the heart* which asks precisely where, when, and why modern icons of the heart, such as ♡❤ ♥, are 'heart-shaped' when the real human heart looks nothing like it. The brief answers would seem to be, 'in Northern Italy', 'at the beginning of the fourteenth century', and 'as the result of an error in understanding Aristotle'. The palaeolithic cave painting in the advertisement is actually at Pindal in Spain, where it was discovered by the French *abbe* Henri Breuil. In his original account he thought that the mark was the animal's ear, and in his 1911 report he describes how “a large, more or less heart-shaped mark ... represents the ear flap”. Apparently a group of elephant hunters then suggested to him that the mark was the heart, principally because of a painting of another elephant, in Southern France, where the beast is being shot with three arrows above the left shoulder, where the heart would be. Subsequent workers have been sceptical that the mark is heart-shaped, or is indeed any particular shape, the whole thing being too vague to have a clear contour. As yet I have been unable to track down the elephant with the three arrows in the left shoulder, but this might just possibly be very slight evidence that indeed prehistoric man knew the heart was on the left side.

☞WWW☜ 5:4

The scarlet tree was the title of the second volume of Sitwell’s autobiography (Sitwell, 1946), from which the quotation is taken. The dust jacket of the first edition shows a beautiful representation of the vascular tree. Ziegler (1999j p.309) says that Sitwell commented that the title refers to the 'singing blood in the young veins' – although the figure on the dust jacket undoubtedly shows the arteries...

.

☞WWW☜ 5:5

Although I have talked about the human body, most of these asymmetries can be found in other vertebrates as well, albeit sometimes in modified form. I remember once, in Andhra Pradesh in India, dissecting a cobra that had been caught in the hospital compound and being amazed at how even in this seemingly so symmetric an organism, the liver was as asymmetric as in humans, albeit being very much longer and thinner.

A potential confusion in thinking about the asymmetry of the body is that anatomists also talk about the right and left sides of the heart. The right ventricle is smaller and pumps blood at relatively low pressure to the lungs, whereas the left ventricle is much larger and pumps blood at higher pressure, through the aorta, to the rest of the body. Although the right ventricle happens to be closer to the right side of the body, it has not developed from the right side. Both ventricles actually develop in the embryo from a single tube, one from the front end of the tube and the other from the rear end. and it is of no real consequence that the larger of the two happens to be called the left ventricle. It might have made more sense and been less confusing if one were called the first and the other the second ventricle, reflecting the order in which blood passes through them. See Larsen (1998 p.105).

The asymmetry of the testicles is not only of size and height. The venous drainage of the right testicle goes directly into the inferior vena cava, whereas that of the left testicle enters into the left renal vein. The difference in size of the testicles is also reflected in the ovaries of women, and in both males and females the asymmetry is present at an extremely early stage of embryonic development, so early that the fetus can only be sexed by looking at the chromosomes (Mittwoch & Kirk, 1975) but nevertheless there is an asymmetry of the rudiments of the gonads.

Varicocoele in one large series was on the left side in all of 136 cases (Oster, 1971). Because of the different venous drainage of the right and left testicle, there can be reflux of blood back down the left testicular vein which can cause the varicocoele. The infertility is probably due to the increased blood flow raising the temperature of the scrotum and preventing spermatogenesis. Removal of the varicocoele often restores fertility. Very occasionally varicocoele occurs on the right hand side and it is then said always to be associated with situs inversus (Server et al., 1998).

☞WWW☜ 5:7

Although I comment mention "organisms such as sea-squirts, which are more primitive than vertebrates", it must be emphasised that this is merely short hand, since modern sea-squirts are neither our ancestors nor, in a strict sense, are more primitive than us, having been in existence for precisely the same amount of time (Gee, 2000). The loose terminology is however useful for a simple description.

Although having an internal skeleton solves the problem of oxygen diffusion, eventually even having an internal skeleton results in difficulties principally because, as Haldane pointed out, the strength of supporting leg bones grows as length squared (L^2), whereas the weight of the body grows as length cubed (L^3). The eventual result is disaster, the legs having to become ever larger, more massive and yet heavier in order to support the vast weight of the

body. The exception is large sea animals, such as whales, in which the massive body weight is supported by the buoyancy of water rather than by the skeleton as such.

A video of the blood flowing through the heart, showing the spiral movement, and models of the action of a symmetric and an asymmetric heart can be seen at www.nature.com (Kilner et al., 2000).

☞WWW☜ 5:8

There are also other very exciting fossils coming out of China at present which will almost certainly help to clarify the origins of the vertebrates (Chen, Huang, & Li, 1999).

The literature on the evolution of vertebrates of exceedingly technical and very confusing. An excellent and relatively accessible account can be found in Gee (1996b).

In writing this entire section I am uncomfortably aware that Dick Jefferies, like any good scientist, is continually revising his views on the basis of new evidence. Some of his published ideas are therefore no longer entirely his strict beliefs (although he does suggest that it would not be sensible for me to revise the text on the basis of as yet unpublished opinions). Here, in an e-mail of 16th November 2000, are Dick's current thoughts, for which I am exceedingly grateful:

> "Your account of dexiothetism is fine except for a change of opinion on my part which you could not have known about. Namely, I have recently decided, on sequence evidence, that the correct basic cladogram for the deuterostomes is probably ((hemichordates + echinoderms) chordates) rather than (hemichordates (echinoderms + chordates)). This means that the group Dexiothetica (=echinoderms + chordates) is paraphyletic and ought to be forgotten. There are several implications from this:
>
> > 1) I believe that dexiothetism certainly occurred, but that present-day hemichordates have lost almost all of the resulting asymmetries;
> >
> > 2) Cephalodiscus no longer seems to be very primitive and the bilaterally symmetrical "Cephalodiscus-like ancestor" is no longer closely related to Cephalodiscus - indeed, the sequence evidence implies that the latest common ancestor of extant hemichordates would have been a worm-like enteropneust, not a pterobranch resembling Cephalodiscus:
> >
> > 3) lurking among the fossils which I placed in the stem group of the echinoderms in a paper that I co-authored in 1996 (Jefferies, Brown & Daley. Acta Zoologica. 77, 101-122) must be members of the stem-group of the hemichordates as well as stem-group Ambulacraria (hemichordates + echinoderms) and true stem-group echinoderms - I think I know which fossils were the stem-group hemichordates but at present it is only a hunch:
> >
> > 4) the calcitic skeleton, restricted among extant forms to the echinoderms, has thus been lost four times among the deuterostomes, not three times as I formerly believed".

I am also aware that other researchers are reconsidering some parts of the theory (David et al., 2000). When deep experts disagree there is little the rest of us can do except sit and watch with fascination and await a new consensus. Until that arrives we can merely speculate on the implications of the ideas which are already floating around.

☞WWW☜ 5:9

This account is mainly based on that in Gee (1996b p.10). Recent molecular analyses suggests that a group called the Acoela are the most primitive Bilateria (Ruiz-Trillo et al., 1999).

☞WWW☜ 5:10

Dick Jefferies is undoubtedly a scholar's idea of a scholar. I once met him at his office in the Natural History Museum, and spent several hours looking at specimens. At one point I asked him how many examples were known altogether of a particular species: "Oh, about half a dozen. They are all on the window sill over there!". Dick is unashamedly a cladist in his interpretation of both living and fossil forms (Gee, 2000 pp.74-76), and approvingly cites Hennig's dictum that " 'Das Kriterium der Wahrheit ist Vereinbarkeit' – the criterion of truth is coherence (of results)" (Jefferies, 1986 p.15).

☞WWW☜ 5:11

Gee (1996b pp.201-286) provides a good critical account of the strengths and possible weaknesses of Jefferies' theory. Even if it is not correct in all its details, and few scientific theories are ever correct in all their details, Jefferies' theory is quite the best that we have at present, and it provides a serious and realistic attempt to create the sort of theory that is needed. Jefferies (1986 p.vii) particularly emphasises that it was Torsten Gislén who first proposed, seventy years earlier, that chordates arose from the calcichordates, but his ideas were almost totally ignored during his lifetime (Gislén, 1930).

Jefferies has commented about the reconstruction of the movements of *Rhenocystis,* this is "palaeopsychology", observing the recorded behaviour of organisms long, long dead. There is something extremely moving[29] about seeing the fossilised tracks or footprints of animals. One only has to think of the human footprints at Laetoli (Hay & Leakey, 1982) or the recently discovered dinosaur tracks in Greenland (Gatesy et al., 1999).

☞WWW☜ 5:12

Gee (1996b) states very clearly what our response should be to such ideas:

> "...no idea, however odd, should ever fail simply because the reader finds it outrageous. Strangeness and novelty, after all, are attributes to be welcomed by science, for the oddball notion of today might be the orthodoxy of tomorrow. ... Even the most *outré* idea deserves serious consideration, and if it is found to fail, it will be by the standards of scientific investigation..."

Popularising science, writing interestingly, and also being accurate are extremely difficult things to reconcile. As a marvellously witty description of Jefferies' theory which is wrong in almost every substantial respect I cannot resist quoting from an article in *The Times* of 1993:

> "...one academic theory aired in recent years traces the starboard tendency to one of man's less successful Jurassic ancestors, a sea-bed dwelling creature with a rudimentary left ear in its anus, causing it to lie permanently on its side in order to listen for the approach of predators and grab passing lemon sole with its right paw" (Hamilton, 1993).

There is some support for Jefferies' conjecture from work in developmental embryology, where there is a similarity between the cascade of signalling molecules which specify left and right and those which specify dorsal and ventral (Whitman & Mercola, 2001f).

---

[29] It is a beautifully ambiguous term, the emotion of motion.

☞WWW☜ 5:13

Richard Dawkins (1997 pp.204-210) considers the theoretical advantages of symmetry in more detail. That organisms do indeed tend to evolve symmetry when there is selection for speed is shown in an intriguing study in which robots were jointly selected both for the efficiency of their neural networks and for the body forms to which the networks were connected (Lipson & Pollack, 2000).

Well, dragons are mostly four limbed (and indeed in some from the 13th and 14th centuries they *are* four-limbed, "bipedal and winged and saurian in shape", as it has been put (Hebron, 1985 p.3). However mythology (and the cover of *Harry Potter and the Goblet of Fire*) often shows dragons that have four legs and two wings, and that is not a vertebrate pattern, which is invariably tetrapod in its primitive form. The same problem has been pointed out with many conventional representations of angels, where there are two arms, two legs, and a pair of wings on the back, which does not fit the vertebrate pattern. But then, angels probably didn't evolve either.

☞WWW☜ 5:14

This can be seen easily in any flatfish from a fishmonger. If it is held vertically upright then the basic body layout is the same as any other fish, with the exception that the eyes are in the wrong place, both being on one side. In particular the mouth can be seen now to have two lips, an upper and a lower, in an arrangement like that of any other fish.

The twisting of the flatfish's eye involves a number of re-arrangements, and in particular the nerves from the eyes to the brain, which normally cross at the topic chiasm, get an additional twist in them (Policansky, 1982).

Although the selective advantages of being a flatfish flat on the seabed seem clear enough, the mechanism by which flatfish attained this outcome is less than clear. In particular, how did the eye migration mechanism develop? And as with so many things in biology, surely it would have been a disaster to have the eye move only part of the way. So what were the intermediate states, and how were they advantageous?

☞WWW☜ 5:15

It is possible by transplanting tissue between embryos or applying beads to the embryo which been soaked in growth factor, to produce an additional limb which is the mirror-image of one already present on the same side, or to produce 'mirror polydactyly' in which there are extra fingers on an arm, with two thumbs in the middle, two index fingers beside them, and two middle fingers on the outside. See Larsen (1998 p.225) for illustrations of some of the defects. None of these cases, though, involve novel mechanisms as far as the mechanism of right and left determination is concerned.

It is intriguing that, rather like Conan Doyle's dog that didn't bark in the night, it is much easier in biology to ask what does occur and why, rather than to ask why certain problems do not arise and to ask why not. But each can be equally informative in theoretical terms. It is the absence of certain types of defect that is so instructive in this case.

☞WWW☜ 5:16

Although it sounds far more trivial, one of the problems of conditions such as cebocephaly is that, unlike cyclops in which the defects are so gross that the fetus usually dies, the less severely defects of cebocephaly are usually compatible with life. Larsen (1998 p.267) has a picture of a child with the problem. One dreads to imagine the stigmatisation suffered by such a child; it is reminiscent of the opening lines of Goffman's *Stigma*, with its quotation from the novel, *Miss Lonelyhearts*, by Nathanael West: "...I would like to have boyfriends like the other girls and go out on Saturday nites, but no boy will take me because I was born without a nose – although I am a good dancer and have a nice shape and my father buys me pretty clothes" (Goffman, 1963). Although there are many causes for these rare syndromes, some genetic, one cause which is to a large extent avoidable is fetal alcohol syndrome due to excess maternal drinking.

Developmental biologists who discover new molecules are entitled to call them what they like. Although at the time when *Sonic hedgehog* was named it probably seemed clever and trendy, already it merely looks rather silly, and in a few decades it will be in as dead a language as the Latin and Greek names about which students presently complain. For a list of *Drosophila* genes, such as *heartless*, or *dumb*, or *ken and barbie*, along with their etymologies, see www.flynome.com.

'Knockout mice' (Chiang et al., 1996) in which particular genes of importance in development are targeted and removed have transformed our understanding of the role of particular genes in embryology. Newer techniques are also allowing genes to be knocked out just for short periods in development, so that effects later in development can be observed, or for genes to be knocked out and then degraded or altered versions 'knocked-in', to find out how which parts of the gene are of particular importance.

The establishment of the mid-line is in part controlled by *slit* (Harris & Holt, 1999). One effect of particular neurobiological interest is in directing nerves to their proper destination. In the brain it is essential that some nerve fibres cross over to the other side, whereas there are others that must stay on the side on which they start. And if fibres do cross the midline it is crucial that those same nerve fibres stay on that other side, rather than crossing back over the midline. The whole process is controlled by the product of a gene called *slit* (Harris & Holt, 1999).

Failure to establish a midline is probably also in part responsible for errors of lateralisation in conjoined twins (Burdine & Schier, 2000), in which monozygotic twins fail to separate properly.

☞WWW☜ 5:18

The names of the condition are almost as confused as the body parts, isomerism defect also being known also as Ivemark syndrome (Ivemark, 1955), situs ambiguus, visceral heterotaxy, laterality sequence, isomerism sequence, and asplenia/polysplenia syndrome (Burn, 1991). There are also the conditions known as the heterotaxias, in which *some* organs are reversed and others are not. This is not quite the same as isomerism but can be equally problematic, with the typical difficulty being in the connections of the heart, so that heart failure often results.

The causes of isomerism defect are not known, but there is evidence that left isomerism runs in families (Arnold, Bixler, & Girod, 1983) and is associated with diabetes in the mother (Splitt et al., 1999). That raises the interesting possibility that right and left isomerism have different underlying aetiologies.

In isomerism defect the problem is once again probably to do with the midline, keeping those things which are the left's on the left and those things which are the right's on the right. In fact when one looks carefully at individuals with isomerism defects they often also have developmental malformations of the midline itself (Goldstein, Ticho, & Fishman, 1998, Izraeli et al., 1999; Ticho, Goldstein, & Van Praagh, 2000). The same situation is also found in other animals, such as mice, zebrafish and the frog, *Xenopus*. The importance of the midline may not be merely in maintaining a physical midline barrier between the right and left halves but in actively suppressing right-expressing genes on the left and vice-versa (Izraeli et al, 1999 p.693). Analogies involving driving and motor cars seem to come naturally when trying to think about such problems, and a recent elegant one criticises an overly simplistic view of early embryos as being like "the tranquil lanes of a rural area", and suggests they are more like "the tangled network of highways around Los Angeles". And something is needed to control such traffic:

> "If we look at ... the region either side of the midline, we see heavy traffic in all directions. Heart precursors migrate towards the midline; neural-crest cells migrate away from the dorsal neural tube; germline cells move towards the posterior gonadal ridge; and muscle precursors migrate from next to the midline towards the sides of the embryo to form slow muscle cells. Many [molecules] are required to direct this cellular traffic" (Driever, 2000 p.142).

It reminds me of those trunk roads which existed when I was a child. Instead of being like motorways, with several lanes in each direction, separated by a clear crash barrier to stop anything going from one side to the other, there were instead just three lanes, one in each direction, and a middle lane, officially called the 'overtaking lane', but known to everyone as the 'suicide lane' because of the disastrous crashes that occurred at regular intervals, throwing debris to left and right of the road. The absence of a clearly demarcated midline is not a good idea.

☞WWW☜ 5:19

Robert Burns, *To a Mouse* (1786).

For many paired organs there are actually slight directional asymmetries, consistent population level differences between the two sides as well, but I am ignoring these for present purposes. However in general the right arm is slightly longer than the left arm (Latimer & Lowrance, 1965; Ludwig, 1932 p.263), the left leg is slightly longer than the right leg (Latimer & Lowrance, 1965), and so on.

Although I have described fluctuating asymmetry in terms of the simple difference in size of the two sides, it is more accurate to calculate the relative difference, using some formula such as (R-L)/(R+L) to take differences in overall size into account. A child and an adult can then have the same relative difference despite having very different sizes overall. If there are consistent directional asymmetries, then the best measure of fluctuating asymmetry is the standard deviation of the difference score, after adjustment for overall size differences (Palmer & Strobeck, 1986). For superb reviews of the whole question of the measurement of

fluctuating asymmetry and its subtleties, see Palmer and Strobeck (2001d) and Palmer (2000d).

☞WWW☜ 5:20

The development of the two sides, based on the instructions in the genes, is not like two guided missiles, aimed at the same target, and with error correcting software so that if either missile starts to move slightly off target then its trajectory will be altered to correct the problem. The cells forming the two incisors or the two arms or the two legs are instead like ballistic rockets: they are pointed in the right direction, given their instructions, launched and then there is nothing anybody can do to determine exactly where they land. Should a storm blow one of them around *en route* then the rocket ends up somewhere other than where it was intended. The question is not whether both rockets will hit the target but rather how far apart will they be when they land, for it is nigh on impossible that they should hit at precisely the same place.

Fluctuating asymmetry is ultimately due to chance alone. This form of chance must be contrasted with the sort of chance or random variation that is typically included in statistical analyses which is due either to measurement error or sampling variation, both of which can in principle be measured, accounted for and potentially eliminated. The chance variation in fluctuating asymmetry is a different sort, and in its final form it has been described as 'deep chance', a form of noise implicit in the Brownian motion of particles, and ultimately in the randomness of quantum fluctuations themselves.

Although the direction of asymmetry in individuals varies randomly from generation to generation, it fluctuates, it is also the case that fluctuating asymmetry in the sense of the extent of variance shown is probably heritable (MØller & Swaddle, 1997a pp.113-119; Whitlock, 1996), although of course the direction of such variability is still not heritable. If your parents are very asymmetric then you are more likely to be asymmetric, but which way round the asymmetry will be is random.

I have presented a fairly conventional view of fluctuating asymmetry. There are however a number of problems in its interpretation, particularly as an indicator of genetic fitness; see amongst others, MØller & Pomiankowski, 1993; Bjorksten, Fowler, & Pomiankowski, 2002; David et al., 1998; Bjorksten et al., 2000; David et al., 1999.

☞WWW☜ 5:21

Genes often do not have the effect in different contexts. This is most obvious in the completely inbred mice which are so much used in laboratory research. All are identical to one another and often a gene can have a particular effect in them. However that same gene when introduced into another inbred strain will have a completely different effect. Geneticists refer to this as an effect of the 'genetic background'.

On a technical note it must be emphasised again that instability, environmental disruptions, or whatever, do not alter the mean or the location of the distribution of left-right differences, which must stay at zero, but instead it increases the variance, and so more individuals will have larger right-left differences, although still precisely half will have right larger than left and half have left larger than right. In practice one also measures several or many characters at the

same time and combines them statistically, and the individual characters can have different directions. That also allows the measurement of variation within the organism as well as between. It should also be emphasised that fluctuating asymmetry is a measure that applies to individual traits within an organism, whereas developmental stability applies to the organism as a whole, with important theoretical implications for the distribution of measures of asymmetry (Gangestad & Thornhill, 1999).

Although I have discussed the topic of fluctuating asymmetry / developmental instability as if it is well accepted by all those in the field, there are undoubtedly many theoretical problems associated with the area, some to do with measurement, and others to do with problems of replication (Palmer, 2000d).

☞WWW☜ 5:23

Sitwell continues, "But radiance is a better word to match her quality, I think, than beauty, and a certain sad radiance still clung to her". There is a painting of Lady Sitwell as a girl in the original edition of *Left hand, right hand!* (Sitwell, 1945, and a rather poor profile photograph in *The Sitwells* (National Portrait Gallery, 1994 p.31), in which the characteristic Sitwell nose is just about visible.

Data on the relationship between fluctuating asymmetry and sexual selection and breeding success, as well as other biological parameters, can be found on the web-site which accompanies Møller and Swaddle (1997a), www.oup.co.uk/MS-asymmetry/. There is some evidence that birds with slightly asymmetric wings and tail-feathers are less good at flying, although that of course may reflect aerodynamic problems themselves, rather than developmental stability as such (MØller & Swaddle, 1997a pp.159-172).

For a marvellous semi-spoof on the whole issue of sexual selection and fluctuating asymmetry, see Palmer and Hammond (2000e).

☞WWW☜ 5:24

Embryology was even more difficult for the founders in its early, heroic stages. The survival of operated embryos was poor, and since there were no facilities for culturing organisms out of their natural season, amphibian embryos were only available for a short time between April and early July: "the pressure to continue operating throughout waking hours during the season cost the Nature-loving Spemann dearly, in foregoing spring over some forty years" (Horder & Weindling, 1986 p.193).

Embryologists use a number of terms to describe the fertilised egg of different species at different stages. For simplicity I have used embryo throughout.

☞WWW☜ 5:25

When in 1886-7 Hans Spemann had "a touch of tuberculosis" and spent the winter in a Swiss health resort, high in the mountains, a copy of Weismann's later book (1892) was the only scientific work he took with him: "I found here a theory of heredity and development elaborated with uncommon perspicacity to its ultimate consequences. ... This stimulated experimental work of my own" (Hamburger, 1988 p.9). In thinking about Weismann and

Roux it is important to remember that at thetime no one had the faintest idea what the genetic material might be, and how it might be organised. Neither had Mendelian genetics yet been rediscovered.

Viktor Hamburger, who perhaps should have received the Nobel Prize for experimental embryology in 1986, and who was publishing on the history of the subject almost until his death, died on 12th June 2001, just short of his 101st birthday.

Reflection suggests that things could not possibly be as simple as the mosaic theory suggested. Although always couched in terms of right and left halves, in the absence of anything defining front-back and top-bottom, then right and left could not even be determined. In fact Roux did also find embryos in which the back or the front of the embryo was missing, although textbooks tend to concentrate on the left-right situation.

According to Spemann, the problem of Roux's experiment seems to be that although one of the cells was no longer alive, "effects of a more simple and purely mechanical kind might have issued from it" (p.21). Spemann actually uses the term "vital" rather than alive, and he puts it in quotations. Only when his autobiography was published posthumously in 1943 did it become apparent that Spemann was a vitalist, believing that "all parts of an organism possess an element of consciousness" (Hamburger, 1999 p.242). Driesch's experiment used the sea urchin, which is an echinoderm and therefore one of the most closely related of all the living invertebrates to the chordates. Subsequent experiments showed that the same result was found in frogs. It was also shown that if one used Roux's hot-needle technique and then removed the dead cell then the organism developed normally (Spemann, 1938 pp.24-25).

The result of Roux's experiment was not really explained until many years later, when the Nieuwkoop centre was identified, and it became apparent that the plane of cleavage had already passed through it, and that the remaining live cell did not 'know' that the other cell was dead (Wolpert et al., 1998 p. 67).

☞WWW☜ 5:26

Spemann received the Nobel Prize in 1935, three years before Hitler instituted national prizes for the arts and sciences and banned Germans from accepting the Nobel Prize (Horder & Weindling, 1986). The Prize was awarded for the discovery of the 'organizer', a region of the early embryo which acted as a sort of 'master switch' for development. Transplantation of the organizer from one embryo to another would result in the development of two head regions. Although the crucial experiment was carried out with Hilde Mangold, the prize was awarded to Spemann alone since Mangold, who was then 26 years old, had died of burns in September 1924 after a gasoline heater exploded in her kitchen (Hamburger, 1988 p.173). There have recently been suggestions that the key organiser experiment had also been performed earlier, in 1909, by an American zoologist, Ethel Browne, and that Spemann was aware of those results (Lenhoff, 1991). The name of the organiser has itself been controversial, and Spemann himself referred to it on occasions as the 'leader' or the 'Führer', and he seems to have used the term in a metaphorical sense in a political context (Horder & Weindling, 1986).

Reviewing these and other experiments a few years later Huxley and de Beer (1934 pp.75-77) also note how double-headed monsters also occur spontaneously in trout, both in the wild and in hatcheries, and that the right hand member shows situs inversus on about half of occasions. Over the years the explanations of the difference between the right and the left embryo have been many and varied. As Oppenheimer (1974bpp. 871-2) says, "The interpretations have varied according to their times: asymmetrical microstructure, intrinsic bending tendency, material deficiency, asymmetric induction, localised asymmetry factor, left dominance in a left-right physiological gradient, physiological determination, reversal by regulatory movements, reversal as a result of developmental arrest, and many others have been called upon as explanatory".

☞WWW☜ 5:27[30]

The British Association meeting in Toronto in 1897 was the second of its meetings to be held abroad; the first one in 1884 in Montreal was more of a social than a scientific success, being described as "the longest and most lavish 'picnic' in the Association's history" (Worboys, 1981 p.175).

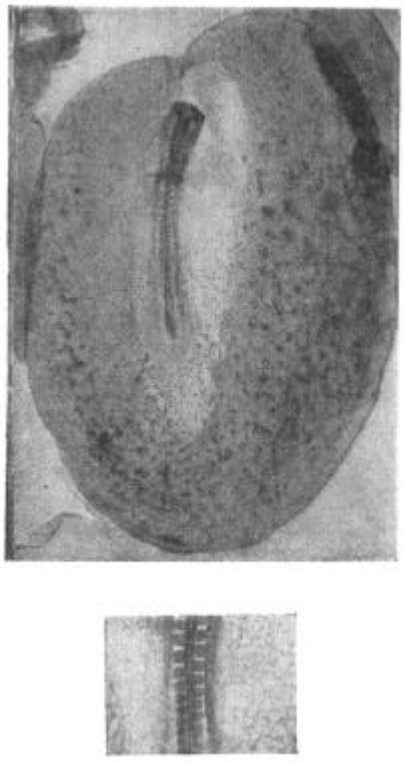
Tantamount seems to be an amalgam of several figures. Naomi Mitchison (1965 p.53), the novelist and sister of JBS Haldane, the physiologist, claimed that Tantamount was based on her father, John Scott Haldane, himself a physiologist who was notorious for his eccentricities. The opportunity would have been there, as Aldous Huxley and the Haldanes were close friends. The parallels are also fairly close, Haldane having a private laboratory in his own house, working in his laboratories to all hours, seeming to be as unworldly as it is possible to be, and in later life becoming more interested in the non-material, spiritual aspects of science (Clark, 1968a). However Haldane himself disliked experimenting on animals, preferring to experiment on himself (and his children). Furthermore Haldane was never interested in embryology. Onto Haldane's personality seems therefore to have been grafted Julian Huxley's own experimental interests and methods, as Deery (1996 p.34) seems to imply (although JBS Haldane seems to have been confused with JS Haldane). Tantamount also has overtones of the heterodox ideas of Bastian 1913a, who rejected Pasteur's experiments on spontaneous generation, work Aldous Huxley may well have been aware of, his grandfather, Thomas Henry, attacking it in 1870 (Bastian, 1913a p.8), and Aldous does cite Bastian's other work in *Point Counter Point*. Finally, there is a strong hint of Sir Michael Foster (1836-1907), the Cambridge physiologist, who gave the Presidential Address to the Physiology section at the meeting in Toronto in 1897. He mentioned Du Bois Reymond, who had died since the previous Canadian meeting, in a rather barbed comment: "who, if he laboured in a narrow path, set a brilliant example of the way in which exact physical analysis may be applied to the physiology of living beings, and in other ways had a powerful influence of the progress of physiology", and he also discussed the development of "the new physiological chemistry" (which would have included the role of osmosis), and singled out the work of Emil Fischer who was at that time sorting out the absolute structure of chiral molecules. Finally, in a remarkable last passage, referring in part to the anti-vivisectionists, and reminiscent of the scientific evangelism of Tantamount, he described how, "We physiologists are sorely tempted towards self-righteousness, for we enjoy that blessedness which comes when men revile you and persecute you and say all manner of evil against you

[30] **☞WWW☜** was inadvertently omitted from the notes in the book.

falsely". It seems difficult to believe that Aldous Huxley had not browsed through the proceedings of the Toronto meeting, and did not know Foster, who gained the Chair of Physiology at Cambridge on the basis of T H Huxley's advice (Geison, 1978).

☞WWW☜ 5:28

In the year he died, Aldous Huxley, in response to CP Snow's *The two cultures*, published a little book about the relations of science and literate which he contrasted in terms of pairs of opposites: "Public and private. Objective and subjective. The world of concepts and the multitudinous abyss of immediate experience. The simplified, jargonized purity of scientific discourse and the magical, many-meaninged purity of literature" (Huxley, 1963 p.36). One is crying out to be on the right and one on the left... Huxley worries about the paradox that "the poetry of this most scientific of centuries should be ... less concerned with science than was the poetry of times in which science was relatively unimportant...". In part it is, he says, because "'Popular science' is a new art form, partaking simultaneously of the text book and the *reportage*, the philosophical essay and the sociological forecast".



*The elements of experimental embryology (*Huxley & de Beer, 1934) has been described as "coming at the high point of optimism with regard to the prospects for a chemical identification of the organiser" (Horder & Weindling, 1986 p.226).

Art was clearly imitating Life rather directly in the experiments Huxley described in *Point Counter Point*, because Huxley and de Beer's book has a whole section devoted to the question of how temperature gradients affect the development of embryos (Tazelaar, 1929,Tazelaar, Huxley, & De Beer, 1930). As well as descriptions of experiments on newts and frogs, there is a photograph of a chick embryo, published originally in 1928, the same year as *Point Counter Point*, in which the higher temperature on the left hand side has not only meant that the whole embryo is curved, but also on that side there are more somites, the precursors of the vertebrae which make up the backbone (figure 14). Although such experiments were technically ingenious, and though they did occasionally seem to shift the position of the midline of the organism (Huxley & de Beer, 1934 p.342), ultimately they did little to resolve the problem of why the heart was usually on the left and occasionally was on the right.

☞WWW☜ 5:29

There were of course exceptions, and some useful, solid work did occur. Oppenheimer (1974b) reviews the work in particular of von Woellwarth ("a sort of intellectual grandson of Spemann"), and von Kraft (who has recently published in English an overview of three decades of studies – see Von Kraft, 1999). See also Wehrmaker (1969b).

The key theoretical papers which influenced both psychologists and embryologists were by Michael Morgan, one of my PhD supervisors, who is now at City University in London (and who is the winner of the 2001 Wellcome Trust Prize to write a popular science book) , and Michael Corballis who is at the University of Auckland in New Zealand. The 1978 papers (Corballis & Morgan, 1978, Morgan & Corballis, 1978) referred to Layton's work, and the reply to commentaries (Morgan, 1978) also mentioned Afzelius's study. The papers of Morgan and Corballis also mention, amongst others, the work of Wilhelmi, Harrison and Von Woellwarth.

☞WWW☜ 5:30

There had also been an earlier report of a similar mutation causing situs inversus but the strain was weak and died out (Tihen, Charles, & Sippel, 1948).

Although Layton (1976b) refers to the defect as being "situs inversus viscerum", there is a suggestion that many of these animals do not have pure situs inversus, but a high proportion have some heterotaxia, with some organs being mirror-reversed and others being in their normal location (Brown & Wolpert, 1990). Layton himself reported some heterotaxias of the heart and of the venous system in a subsequent paper (Layton, 1978). In this respect the mice may be different from the majority of humans with situs inversus who do not show heterotaxia.

In the twelve years since the original paper was published (Layton, 1976b), the mice had gone through 32 generations, equivalent to about eight or nine centuries of human breeding. One can see why the mouse is such a favourite animal for genetic research.

It is also possible to tell *in utero* whether a mouse embryo has situs inversus since a normal mice coils in a right-handed direction, whereas a mouse with situs inversus has a left-hand coil (Layton, 1976b, Figure 1).

At a single genetic locus, such as *iv*, an individual will have two copies of the gene, one from each parent. The normal gene (allele), which is called the 'wild' type and occurs in the common field or house mouse, is conventionally shown as +. If a mouse has received the same gene from each of its parents, either two + or two *iv* genes, it is said to be homozygous, and its genotype is either +/+ or *iv/iv*. If instead it has received different genes from the two parents, it is said to be heterozygous and has a genotype *+/iv*. The only mice which show situs inversus are those with the *iv/iv* genotype.

An important theoretical possibility that had to be ruled out in explaining the 50% incidence of situs inversus in the homozygous *iv/iv* mouse was that the gene had what is called *partial penetrance*, meaning that other factors were also important in determining on which side the heart would be placed. That explanation was however excluded by Layton taking mice which were all *iv/iv* and interbreeding them (so all their offspring had also to be *iv/iv*). He then looked at whether the proportion of offspring with situs inversus related to whether or not the parents had situs inversus. It did not. Whether both parents had their heart on the left, both had their heart on the right, or one had the one on one side and one on the other, in each case exactly a half of the offspring had their heart on the right and a half on the left.

☞WWW☜ 5:31

Although the syndrome is known as Kartagener's syndrome after the Swiss paediatrician who described four cases in his 1933 paper (Kartagener, 1933), Kartagener was not actually the first person to describe the condition, Siewert describing it in 1904 (Siewert, 1904). History seems to have had its revenge on Kartagener because there seems to be utter confusion as to how to describe his name, researchers varying between Kar-ta-*gay*-ner and Kar-*taj*-en-er. And in recent years, 'primary ciliary dyskinesia' has more frequently been used (Parraudeau et al., 1994).

It is not clear from this particular patient's case history whether the patient himself was aware of his situs inversus, and although it is implied that he was infertile, it is not stated whether he had any children or had tried unsuccessfully to have any. That he continued to smoke at such a level with such symptoms suggests this was the first time he had been diagnosed as having Kartagener's syndrome (Parraudeau et al, 1994). Although it is unusual for the condition to be diagnosed in mid-life, there is a report in the literature of a patient not diagnosed until the age of 75 (Gomez-de-Terreros-Caro et al., 1999).

Not all male patients with Kartagener's syndrome are infertile, and in some cases the sperm do seem to have some mobility, albeit not normal. It is for that reason the syndrome is now called primary ciliary dyskinesia, meaning impaired movement, rather than immotile cilia syndrome, which implies a complete lack of movement. These patients are probably also fertile if intracytoplasmic sperm injection techniques are used for getting the sperm into the egg.

☞WWW☜ 5:33

In a review nearly a quarter of a century later, Afzelius (1999e) quotes his earlier view that the cilia "have a certain position and a fixed beat direction and that their beating somehow is instrumental in determining the visceral situs". He acknowledges though that a crucial problem was that normal 9+2 cilia beat back and forth in a whip-like motion, and hence there would still have to be something that orientated them to left and right of the organism.. The same theoretical problem does not occur with the inherently chiral monocilia.

☞WWW☜ 5:34

The drug acetazolamide is a carbonic anhydrase inhibitor, and is used among other things for the treatment of glaucoma, as a weak diuretic and an anti-convulsant, and for preventing acute mountain sickness.

Brown and Wolpert's key theoretical paper began, "The development of handed asymmetry is a deep and neglected problem" (Brown & Wolpert, 1990).

In their theoretical model, Brown and Wolpert wrote, in a phrase that might be seen as prescient: "...we propose an interaction between the oriented F molecule and the polarity of the cells with respect to the midline. For example, if the F molecule caused transport of some other molecules in the direction of its 'arms' ... then the transport would be towards the midline on the left side and away from it on the right side" (Brown & Wolpert, 1990 p.3).

There have been two important integrative meetings subsequent to the Ciba meeting in 1991, one in the Banbury Centre at Cold Spring Harbor in November 1997, and then at the Juan March Foundation in Madrid in April 2001 (Wright, 2001).

☞WWW☜ 5:35

There is an inevitable problem in writing about left and right, and in particular of presenting pictures of left and right; does one place the left of an object to the left (for verbal consistency) or to the right (as it looks when one faces it, just as when we look face to face at another person their left hand is on our right). Biologists have not been consistent[31], and that is reflected in the diagrams and pictures in this chapter. Partly it reflects the facts that dissections are usually carried out from the ventral rather than the dorsal surface, so that left and right seem to be reversed[32]. And likewise microscope slides produced on a microtome are usually, in effect, reversed because of the way the blocks are sliced. However many microscope images are nowadays digitised, and so it is easy to 'flip' the image so that left and right are to the left and right of the viewer. Although I considered being consistent in this chapter, in practice there seemed to be no easy way to do it sensibly, and I have therefore left the images as they were presented in the originals.

☞WWW☜ 5:36

Although the bulging of the heart tube is the most visible sign of the asymmetry of the developing heart, there is a slight asymmetry of Hensen's node visible before the heart tube is present (Cooke, 1995).

For a superb review of the various signalling molecules that have been implicated in left-right asymmetry, see Mercola and Levin (2001e).

☞WWW☜ 5:37

The classic example in biology of correlation not proving causation is that in the countries of northern Europe there is a high correlation between the numbers of storks and the birth rate. This does not however prove that the babies are brought by the storks, but merely shows that the times of year when births are highest and the times of year when storks migrate are themselves similar.

Although the story as presented about *Sonic hedgehog* seems straightforward, it has since become very complex, not least because *Sonic hedgehog* seems to behave differently in different species; for instance mice with *Sonic hedgehog* knocked out do not seem to have an increased rate of situs inversus. The explanation of these problems probably involves homologous cascades in different organisms, with a wide range of intermediary substances (Esteban et al., 1999, Capdevila et al., 2000, Levin et al., 1997, Ryan et al., 1998).

---

[31] And neither have anthropologists, Needham commenting that he found it necessary to standardise the tables in his *Right and left* (1973 p.xxxv).

[32] However a developing chick embryo viewed with the egg shell removed, is seen from the dorsal surface.

The number of molecules involved in signalling left and right seems to increase every day. In September 2000 Michael Levin's web-site described 24 genes that are asymmetrically expressed in embryos, and a further seven that although expressed symmetrically are involved in left-right asymmetry (134.174.168.95/ ~mlevin/lr_asymm.shtml). Whitman and Mercola (2001f) have since provided a useful diagram comparing the processes in chick, mouse, *Xenopus* and zebrafish. Why there should be such variability between species in what would one would have thought to be a heavily conserved process is still a mystery. However it is an accepted principle in developmental biology that the early stages of development are often very variable, being particularly dependent on the ways and places in which fertilisation occurs, and, in mammals, on the geometry and nature of implantation. Subsequent stages during early organogenesis are then much more similar ('conserved'). In laterality this is known as the 'left-right phylotypic stage' (Yost, 2001), and seems to focus on the roles of the nodal-related proteins and *Pitx2*. Later organogenesis can then once more become much more variable as a result of the different organisations and forms required by different species.

☞WWW☜ 5:38[33]

In a subsequent paper it was found that left-right dynein was expressed in the node, just where *Sonic hedgehog* and similar substances would later be found to be expressed asymmetrically. But the problem was that it was present in equal amounts on the left and the right sides (Supp et al., 1999). The analysis of the *iv* mouse has been much improved by analysing the *lrd* mouse which has the gene for left-right dynein knocked out specifically, and unlike the *iv/iv* mouse this produces normal litter sizes and is generally more robust. A variant of the *lrd* mouse has also been produced which has, amongst other things, a neomycin gene inserted into the region near the gene. This had the entirely unexpected effect of producing about 70% of mice with *situs inversus*, thereby parallelling the reversal found in the *inv* mouse. One possibility, still to be investigated, is that the cilia in the *lrd-neo* mice also beat less efficiently, slowing transport across the node.

☞WWW☜ 5:39

A video of the beating monocilia can be seen at http://www.molecule.org/cgi/content/full/4/4/459. The original paper by Nonaka *et al* (Nonaka et al., 1998) erroneously described the rotation as anti-clockwise, the error arising due to the high speed of rotation of the cilia and aliasing on a relatively low speed video recorder (see subsequent Erratum in *Cell*).

It had previously been generally thought that monocilia were immotile and mainly had a sensory role, providing a bridge between the environment of the cell, and the inside (e.g. Cohen & Meininger, 1987). Monocilia or primary cilia also occur widely, for reasons unknown, in any cell in culture which is provided with a limited food supply and becomes quiescent.

Embryologists, with the exception of Afzelius, had generally ignored the possibility that cilia might have an important role to play in directing development. One exception was Twitty

[33] **☞WWW☜** was inadvertently omitted from the notes in the book.

(1928a), who carried out experiments in the laboratory of Ros Harrison on transplanting cilia. In his intellectual autobiography he suggests:

> "Altogether the ciliary project was a rewarding and entertaining initiation into experimental biology. I suspect that embryologists will find it profitable to return to these organelles when methods become available for effectively attacking phenomena of cellular polarity at the molecular level". (Twitty, 1966 p.19).

☞WWW☜ 5:40

Brueckner and her team at first could not replicate the finding that the normal monocilia rotated, and only succeeded when they found exactly the right microscope: "They're there. It's real", she eventually said Ainsworth, 2000. A video of normal and *iv* cells can be found at http://genome.chmcc.org/cilia/ Supp, Potter, & Brueckner, 2000. At a meeting in June 2001 Hirokawa described his iconoclastic finding of the beating monocilia and showed a slide with a picture of Galileo and his famous quotation, "But still it moves..."...

☞WWW☜ 5:41

The *inv* mouse was presented at a meeting at Cold Spring Harbor in 1992, and the paper was published the next year (Yokoyama et al., 1993), when Nigel Brown and Tony Lander described it as "one of those rare and remarkable papers announcing the completely unexpected" (Brown & Lander, 1993).The gene, also called the *inversin* gene, has been cloned (Mochizuki et al., 1998), and has been found to produce disruption of hepatobiliary system, which may account for the known association of situs inversus with biliary atresia (Mazziotti et al., 1999).

Although *iv* and *inv* look very similar when printed, *inv* is pronounced like the first syllable of '*inv*ersion', whereas *iv* is pronounced as "eye-vee".

The idea that the proportion of anomalous types cannot rise above 50% is related to a concept, which I have called Morgan's principle (McManus, 1979f, McManus, 1984, McManus, 1985a). Based on the papers of Michael Morgan (Morgan, 1977, Corballis & Morgan, 1978, Morgan & Corballis, 1978), it says that paired alleles cannot produce enantiomorphic phenotypes – "genetic models of asymmetry should be asymmetrical", as Morgan (1978) puts it. It is therefore highly unlikely that if one allele makes something be on the left then the other will make it produce the mirror image phenotype on the right.

☞WWW☜ 5:42

It was not completely impossible that the *inv* monocilia rotated in the opposite direction since it had long been known that bacterial flagellae, based on the protein flagellin, are capable of rotating both clockwise and anti-clockwise. A tiny change in the conformation of the protein alters the flagella from a right-handed to a left-handed helix (Berg, 1991; Samatey et al., 2001).

The flow in the *inv* mouse is clearly abnormal. Normally a bead starting at the right hand side would reach the midline within about three seconds and get to the left edge within five seconds. The movement in the *inv* mouse is not nearly so good, and half the beads had not reached the left edge after ten seconds. There was also a suggestion of turbulence in the node with beads circling around, rather than making their normal almost straight line path to the other side. Why though should the flow be turbulent and slow? In fact there is another

question lurking here which some readers may already have worried about. Why even in the normal mouse should a rotating motion of the propellers send the beads from right to left and not vice versa. After all if you stir the water in your bath on one side it goes one way, but it comes back down the other side the other way. How can the flow go consistently in only one direction? Hirokawa suggested that the one way traffic took place not only because of the action of the rotating monocilia. What was important was that the node is not a simple circular depression, but is actually shaped like a triangle pointing towards the front of the organism. Although on their own or in a circular depression the cilia would produce equal rightward and leftward flows, the effect of being in a triangular pit is to mean that the rightward flow pass forwards, towards the top of the triangle, where its force would tend to be dissipated[34]. The result is then a leftward flow overall. Because the node is smaller and has a rather longer, thinner shape in the *inv* mouse, the normal leftward flow is disrupted and slows down.

As well as the abnormal nodal shape, it has also been suggested that the phase relationship between the turning of the *inv* monocilia may be disrupted, although it is very difficult to tell because they are turning so fast and they are so difficult to see easily (Okada et al., 1999 p. 462).

☞WWW☜ 5:43

Okada *et al* actually propose several models, but I concentrate here entirely on what they call the 'delayed activation' model (Okada et al, 1999 p.466).

Although it may sound a bit *ad hoc* for the molecule firstly to be activated and then to be deactivated, such processes are completely standard in biology. Many hormones are stored and transported as inactive pro-hormones, and only start working when something is snipped off one end. Likewise almost immediately after many neurotransmitters are released, enzymes start mopping them up in order to 'turn off' the response. Okada e*t al* (1999 p.467) point out that *Sonic hedgehog* autocatalyses its own activation (Lee et al., 1994).

☞WWW☜ 5:44

I have enormous admiration for the work of Hirokawa's team. Having followed this confused literature for thirty years and having been unable to see how the system could ever be made sense of in terms of biology, Hirokawa's work undoubtedly has the breath of genius. Not only does it provide plausible explanations of almost all of the major phenomena that required explanation, but it also feels like real biology. So much of what is nowadays called biological research is actually nothing but manipulating strings of DNA base pairs within computers. The key thing that Hirokawa and his colleagues did was actually to look down the microscope very, very carefully, and reconcile what they saw with the sophisticated biochemical and genetic techniques they were also using. Like all good research the nodal flow theory raises many questions of detail, and no doubt other researchers will dot the *i*s and

[34] Of course if some fluid flows left then other must flow right to compensate, but it is not necessarily the sort of flow that will be adequate for carrying objects from one side to the other. Rain eventually evaporates as water vapour and comes down again as rain, but one does not carry an umbrella to avoid the flow due to the evaporation.

cross a few *t*s, but the basic formulation seems unlikely to be disproven[35]. And even if it should prove to be wrong, it has raised more interesting questions and looked in new ways at what were thought to be well understood processes than could have imagined even five years ago.

A tricky problem for the nodal theory remains the difficult question of whether nodal flow is important in species other than the mouse, and there much confusion still reigns (Burdine & Schier, 2000), and other mechanisms have been proposed, such as the role of gap junctions in *Xenopus* (Levin & Mercola, 1998). It has also been suggested that the principle role of nodal cilia is not to generate asymmetry *de novo*, but instead is to amplify a pre-existing asymmetry is some species (Wagner & Yost, 2000). For the purposes of the present exposition I am not particularly worried as to whether the mechanism is the same in all species, as I am impressed by the remarkable finding that an entirely different mechanism from any that had been previously conceived could be responsible, even if only in one species. That alone makes the whole approach worthwhile, and it provides a beautiful story of how science progresses.

It would however be nice to have some more experimental demonstration that nodal flow was indeed important. Afzelius (Afzelius, 1999e) has suggested raising embryos in a viscous solution, to reduce the flows, and Wolpert has suggested using a jet of water to disrupt the flows (Ainsworth, 2000). Perhaps such experiments will have been done by the time this book is published, although they will be technically difficult.

The whole topic of molecular motors has been given new impetus recently by synthetic molecular motors being created chemically. Because the molecules of which they are made are chiral they rotate in a particular direction (Davis, 1999). Indeed, if the molecules were achiral then the motor would probably not be able to rotate at all.

[35] For undoubtedly the cilia do move. It is of course possible, though, that there is something still further upstream which is the main breaker of symmetry. There does also remain the problem of what happens in other species such as the chick, where there are a few very sparse monocilia in a different place, and which are unlikely to produce a flow, and in the frog and zebra fish where no cilia have yet been demonstrated. It is possible that the nodal cilia are only of importance in mammals (and it is important that they have been demonstrated in humans).

Chapter 6: Hypernotes

☞WWW☜ 6:1

Jonathan Miller has pointed out how very strange it is that Alice, despite being so keenly observant of almost everything in the looking glass-room, has failed to notice the one thing which would tell her that it was indeed only a mirror reflection, the image of her mirror-reversed self in the other room (Miller, 1998 p.120).

Martin Gardner (1990a p.124) comments that "Lewis Carroll could hardly have been aware of how profound a question his Alice was raising". I wonder if this is so. *Through the looking glass* was published in 1871. Pasteur's work on tartaric acid was published in the 1840s, and by 1874 Van't Hoff had published his theory of stereochemistry. In 1860 Pasteur had even speculated what would happen if the world was inverted left-right:

> "Perhaps a new world would be presented to us. Who could foresee the organisation of living beings, if the cellulose, which is right, should become left, if the left albumen of the blood should become right? There are here mysteries..." (Meister, 1965 p.113)

Given Pasteur's immense popularity during his life time it is at least possible that Carroll read this or similar comments. Heilbronner and Dunitz (1993 pp.85-6) also point out that a close friend of Carroll was the chemist Algernon G V Harcourt, also a Fellow of Christ Church, and who would probably have been aware of recent work by Wislicenus on stereoisomers of lactic acid, which is obtained from the fermentation of milk.

☞WWW☜ 6:2

A peptide consists of two or more amino acids joined together. Oligopeptides have been defined (Scott & Eagleson, 1983 pp. 437-438) as those with 10 or fewer amino acids, polypeptides with more than 10 amino acids, and proteins as those with more than about 100 or so amino acids. It is all a bit biologically arbitrary and I have tended, rather loosely, generically to call them all proteins, but I sometimes use the term peptides where it seems more appropriate.

Although it is a commonplace, particularly after the Human Genome Project, to regard DNA as the key 'molecule of life', it is really the proteins, with their rich diversity of form which create all the tissues of life. DNA has an important role mainly because it can specify the complicated sequences of those proteins in a replicable form. If one had to put a bet on whether it would be easier to create life without DNA or life without proteins, then there seems little doubt that the DNA is less important.

☞WWW☜ 6:3

The simplest and smallest of the amino-acids, glycine, is an exception in not coming in enantiomeric forms, since the R group is a hydrogen, meaning there are two hydrogen atoms on the carbon atom and hence the molecule is not chiral.

Although I talk about D- and L-amino acids, there is a technical issue here which I have slid over, preferring for simplicity to use D- and L- throughout the main text. Since the time of Pasteur, isomers have been called D- (dextro-rotatory) or L- (laevo-rotatory) according to whether they rotate polarised light to right or left. Sometimes they are referred to as (+) and (-), or d- and l- with the same meaning. A fundamentally different form of nomenclature looks at the precise, absolute layout of the various chemical groups around the carbon atom which is the chiral centre of the molecule, and the two types are referred to as R- (rectus) and S- (sinister), from the Latin for right and left. There is no necessary correlation between being D- and being R-, or between being L- and being S-, and all possible combinations can occur, for instance in the amino-acids, where all are S- in the absolute sense but a few rotate polarised light to the right (Tucker, 2000). Pasteur himself realised the difference between absolute chemical structure and rotation of polarised light when he showed that what we should strictly call R-tartaric acid rotated light to the right (D) when dissolved in water but to the left (L) when dissolved in hydrochloric acid (Nicolle, 1962 p.28). A chiral centre is defined according to the atomic mass of the four substituents attached to the carbon atom.. Looking at the carbon atom from the side opposite to the substituent of lowest atomic mass, if the remaining three substituents decrease in mass clockwise then the chiral centre is R, anticlockwise and it is S (Lamzin, Dauter, & Wilson, 1995 p.830).

☞WWW☜ 6:4

In his definition, Kelvin continues: “Two equal and similar right hands are homochirally similar. Equal and similar right and left hands are heterochirally similar or 'allochirally' similar (but heterochirally is better). These are also called 'enantiomorphs', after a usage introduced, I believe, by German writers. Any chiral object and its image in a plane mirror are heterochirally similar” (Kelvin, 1904). Although Kelvin’s definition still stands for static objects, it does not cope well with moving objects, and a more recent definition says, “True chirality is exhibited by systems existing in two distinct enantiomeric states that are interconnected by space inversion, but not by time reversal combined with any proper spatial rotation” (Barron, 1996 p.165).

☞WWW☜ 6:5

Auden's Quant asks his image about Looking-Glass world:

> “My deuce, my double, my dear image
> Is it lively there, that land of glass
> Where song is a grimace, sound logic
> A suite of gestures?” (Mendelson, 1976; The Age of Anxiety, p.346).

Martin Gardner (1990a p.124) pointed out that although the alcohol will taste the same, the many congeners which give the interesting flavours to most alcoholic drinks are probably chiral, and the drink would probably not therefore taste the same.

The error about D- and L-limonene occurs frequently on the Internet, both in educational sites, see www.americanhistory.si.edu/ hosc/molecule/04exp.htm and www.chem.swin.edu.au/courses/swin/stereo/enan.html. The source for this common error is probably Gardner (1990a p.123), who says "It was recently discovered that the differences in the smell of oranges and lemons is caused by differences between right and left forms of limonene". Although earlier in the same paragraph Gardner talks about an article in *Scientific American* on the topic (Amoore, Johnston, Jr., & Rubin, 1964), the paper mentioned actually does not discuss orange and lemon specifically, although it does say some stereoisomers smell different, but without specific examples. The error is surprisingly prevalent (e.g. Hegstrom & Kondepudi, 1990b), and I confess to being responsible for it creeping into an article in *Wellcome News* (Fricker, 1999).

The analogy of a lock and key to describe how enzymes interact with their substrates was first used by Emil Fischer in 1894 (Mason, 1989 p.186).

Many complex biological molecules on which smell depends come in more than two forms. Although it is usual to think of chiral molecules as just L and D, that is only the case if there is a single carbon atom which has four different groups attached to it. If a molecule has two such carbon atoms then two chiral forms can occur at each carbon, giving four different forms, and so on.

There is an interesting variant on the question of symmetry in the keys for Yale locks. Most such keys for front doors require the key to be put into the lock the correct way up. Car door keys, in contrast, are now often made so that they can be put in either way up, to save awkward fumbling in the dark or the cold. However both sorts are still chiral, and their mirror images would not work.

☞WWW☜ 6:6

Although D-thyroxine has been reported to be effective in suppressing normal thyroid activity (Bantle et al., 1984), there seems a problem with all such studies in that commercially available D-thyroxine is contaminated with several percent of L-thyroxine, which is of course active (Young-WF et al., 1984). This may explain the claim made by Gardner (1990a pp.123-4) that D-thyroxine reduces cholesterol.

☞WWW☜ 6:8

One can appreciate the scale of the advances in synthetic chemistry by looking at the journal *Tetrahedron*, which gets it name from the spatial layout of the carbon atom's four bonds. In 1990 a new section was started, *Tetrahedron: Asymmetry*, devoted to the synthesis of stereoisomers; already its densely packed pages fill one and a half shelves of my university's library.

For more about the award of the 2001 Nobel Prize in Chemistry see Adam (2001g) and the Nobel Prize website (www.nobel.se/chemistry/laureates/2001/public.html). For recent advances in chiral synthesis see Gómez and Waymouth (2002a).

☞WWW☜ 6:9

The problem of thalidomide's racemisation has been forcefully put in several places (Wnendt & Zwingenberger, 1997,Winter & Frankus, 1992), and there seems little doubt that thalidomide racemises *in vivo* very quickly (Eriksson et al., 1995; Eriksson et al., 1998). There are many examples of the mythology about thalidomide, for instance by Dr. Philip Emeagwali at www.inventors.about.com/ library/weekly/aa111097.htm, by Professor Michael Chong at www.adm.uwaterloo.ca/ infonews/release/1997/ 186%20New%20ways%20to%20make% 20molecules,%20November%2024,%201997.html, at www.bgsm.edu/graduate/asymmetry.html, by Hegstrom and Kondepudi (1990b) and by de Silva (1995d). The Internet does however have more accurate versions of the story, as for instance at the American Medical Association web-site www.ama-assn.org/special/ hiv/newsline/briefing/thalido.htm. There are also suggestions that the rapid racemisation may be avoidable in chemically modified forms of the drug.

The story of the different clinical effects of the two forms of thalidomide is cited by MacDermott *et al* (1996 p.1442), who quoted a paper by Blaschke *et al* (1979e) as showing that while L- and D- forms are both hypnotic, only the L-form was teratogenic. The Blaschke *et al* (1979e) paper does not in fact discuss the hypnotic effect at all, but does find a clear teratogenic effect of L-thalidomide but not D-thalidomide. Early studies had wondered whether some of the toxic effects of thalidomide might be due to its breakdown products "containing amino acid residues of the unnatural D-series" (Fabro et al., 1965). A subsequent paper (Fabro, Smith, & Williams, 1967) however found no differences between L- and D-thalidomide in hypnotic or teratogenic effect (although mysteriously the racemate was of very different toxicity to the pure enantiomers (Knightley et al., 1979 pp.14-20 & 264), and there is now some scepticism that thalidomide is chiral in its effects (Winter & Frankus, 1992). More recent work suggests that more chirally stable homologues of thalidomide are teratogenic only in the L-form (Wnendt et al., 1996, Schmahl et al., 1996, Heger et al., 1994). There is also some support for D-thalidomide being more hypnotic than L-thalidomide (Hoglund, Eriksson, & Bjorkman, 1998).

Although it is generally assumed that thalidomide has been banned and is never used, in fact it is being used under very strictly controlled conditions for the treatment of certain severe immune problems, such as erythema nodosum leprosum in leprosy, and Behçet's disease. It seems that both the D- and L-forms of thalidomide analogues have the immunomodulating activity, with the L-form being slightly more effective (Wnendt et al, 1996). Thalidomide has recently been licensed by the US Food and Drug Administration, under very strict conditions, for treating a range of otherwise untreatable conditions (Horton, 2001).

☞WWW☜ 6:10

The twenty amino acids are glycine, alanine, valine, leucine, isoleucine, methionine, phenylalanine, tyrosine, tryptophan, serine, proline, threonine, cysteine, asparagine, glutamine, lysine, histidine, arginine, aspartate, and glutamate (Nelson & Cox, 2000). Some amino-acids are specified by more than one combination of three bases in the triplet code. There is also evidence that occasionally the stop codon, UGA, in bacteria and in mammals, can specify a twenty-first amino acid, selenocysteine (Atkins & Gesteland, 2000). A recent advance has also shown that in *E. coli* it is possible to create a novel transfer RNA which reads the codon UAG, which is normally a nonsense codon, and instead incorporate a novel,

non-canonical amino acid, *O*-methyl-L-tyrosine into the proteins produced (Böck, 2001; Wang et al., 2001). An interesting speculation is whether such technologies might one day allow D-amino acids to be incorporated into proteins.

The fact that the sugars we consume and of which we are composed are mostly in the D-form has made some people wonder about the L-sugars, and in particular to speculate that they may be useful precisely because they are *not* metabolised. If they cannot be metabolised it must also be the case that neither can they be converted into fat, the fate of excess sugar. Since L-glucose also tastes as sweet as ordinary D-glucose, some people have argued that it would be the perfect food additive – sweetening without fattening. It is a nice idea, but nature is not fooled that easily. The L-glucose may well not be metabolised but it has to go somewhere. It is a small molecule and therefore will be absorbed through the wall of the bowel, much is then removed in the liver, and the rest then circulates in the blood before being excreted by the kidneys. And in the sort of quantities that are involved in a typical Western diet, that is a lot of sugar to excrete, and it would almost certainly have bad effects on the kidneys and bladder, with stones and infections being real possibilities amongst others (Clemmit, 1991; Gram, 1986a).

☞WWW☜ 6:11

There are good reasons other than purely curiosity, for looking at D-proteins, one of which is that they can help in working out three-dimensional protein structures, which is always difficult, not least because all the standard methods of X-ray crystallography suffer from the 'phase problem'. Using crystals composed of a racemic mixture of the D- and L-protein reduces the number of possible phases from a very large number down to two, since the system has symmetry restored to it (Lamzin, Dauter, & Wilson, 1995, Petsko, 1992).

The D-protease (Milton, Milton, & Kent, 1992) was not the first D-protein to be synthesised, but it was the first to have a chiral substrate (Petsko, 1992).

There is a theoretical concern that since the D-protease is constructed from matter, rather than from anti-matter as should a true, complete enantiomer, then it ought to be less efficient or in some other way different from the L-form due to the asymmetry of the weak interaction. However theoretical calculations suggest that the protein would have to be bigger by about ten orders of magnitude (i.e. 10^{10}) before an effect would show (Brewster & Laskowski, 1992).

☞WWW☜ 6:12

Spontaneous racemisation of amino acids is one of the main reasons why it has in the past been difficult to get an accurate measurement of the extent to which D-amino acids occur naturally, since early techniques for breaking down proteins into the amino acids of which they were made up, also produced racemisation.

Although it is probable that all amino acids can spontaneously racemise, it seems that aspartic acid is particularly vulnerable, being the predominant D-amino acid found in red blood cell proteins, where it arises either by direct racemisation of L-aspartic acid, or by deamidation of L-asparagine (Ingrosso & Perna, 1998).

It has been estimated that D-Aspartate accumulates in the lens of the eye at a rate of 0.14% per year. The technique of measuring aspartic acid in the lens has allowed estimates of the age of bowhead whales, some of which appear to be over two hundred years old (George & et al, 2000). The amino acid clock does seem to be influenced by temperature, and as a result it has also been used to estimate temperature (Miller, Magee, & Jull, 1997). There are some minor problems with the dating from Ötzi, which the authors describe (Lubec, Weninger, & Anderson, 1994), because an Egyptian mummy, also 5200 years old, has only 24% D-amino acid. It is not clear whether it is Ötzi or the mummy which is anomalous. Nevertheless the general principle of the method is still clear enough.

☞WWW☜ 6:13

The essential amino acids in humans are leucine, iso-leucine, lysine, phenylalanine, methionine, cysteine, threonine, tryptophan, valine.

Proteases work by breaking the bond between one amino acid and the next, which is of the form -CO-NH-. By splitting a water molecule, H_2O into H- and -OH, and adding the -OH to the -CO- to form -COOH, and the H- to the -NH- to form NH_2-, the bond is broken. Since water is added the process is known as hydrolysis. A detailed account of the mechanisms can be found in Zubay (1998f).

The L-lactose and other L-sugars in the Looking-glass milk would also not be absorbed, and would probably contribute to diarrhoea, mostly by an osmotic effect which causes water to be sucked into the bowel.

☞WWW☜ 6:15

To give an example of D-amino acids in foods, unpasteurised raw milk has about 1.5% D-amino acids, whereas the proportion rises to 2.1% in powdered milk, 3.2% in evaporated milk, and 4.9% in infant formula milk (Man & Bada, 1987 p.214). The proportion of D-amino acids is particularly high in food cooked at high temperature with alkali, such as corn chips and tortillas (Man & Bada, 1987). It is also probable that irradiated food has a higher proportion of D-amino acids.

The rats kept in a germ-free environment actually have lower levels of D-amino acid oxidase and, by inference, of D-amino acids (Bender, 1985).

Sir Hans Krebs (1900-1981) who discovered D-amino acid oxidase, received the Nobel Prize in Physiology or Medicine in 1953.

Free D-amino acids can be found in human blood, and the levels are higher in the elderly, and in those with kidney disease, suggesting that the D-amino acid oxidase in the kidney may be impaired (Nagata et al., 1987). The effects of ageing are probably a secondary consequence of impaired kidney function.

D-amino acid oxidase is intriguing for another reason, because the active site into which the D-amino acid binds is the precise mirror image of the binding site of another enzyme called flavocytochrome b_2 (Mattevi et al., 1996). Producing a binding site which is the mirror-image

of another is a peculiarly difficult problem if one cannot simply substitute all the L-amino acids with D-amino acids, and it is intriguing that evolution has managed to achieve this task.

☞WWW☜ 6:17

The need for all these elaborate defensive and aggressive measures comes from one of the great truths of Life, the Universe and Everything. Life is a very dangerous, fragile, vulnerable business. One mistake and any organism ends up as part of some other organism, having been eaten. Very small organisms are particularly vulnerable, being merely thin-skinned bags of a delicious and nutritious soup of fats, carbohydrates and proteins. Rule number one is therefore to avoid being eaten, and organisms have developed a myriad of ways to achieve that aim. Rule number two is pretty similar: avoid being infected, which actually is only being eaten, but this time slowly from within, rather than quickly from without. Almost all organisms, however simple, therefore have a myriad of methods of making themselves unpalatable or inedible, or for killing invaders. All will deter predators.

By one of those coincidences for which history is renowned, in 1928, the same year that Fleming discovered penicillin, another very distinct sort of antibiotic was discovered by Rogers – it is called nisin, is licensed as a food additive in the United States, and has probably been used informally by humans to preserve food since the beginnings of recorded time. It was the first of a class of antibiotics known, rather confusingly, as the lantibiotics — and, No, that 'l' is not a typo. They are called lantibiotics because they all contain the very strange amino acid lanthionine (Hansen, 1993), which consists of two alanine molecules joined together by an atom of sulphur, Ala-S-Ala.; and not surprisingly, since they are included here they all contain a hefty dose of D-amino acids as well. The second lantibiotic, subtilin was not discovered until 1948, after which there was a long gap until suddenly a dozen were identified at the end of the 1980s. To see what is so different about the lantibiotics, we need to think about how an organism might go about producing a conventional antibiotic. The problem is that these more traditional antibiotics contain unusual, if not distinctly bizarre, amino acids, and therefore they cannot be produced by ribosomes which simply read off the instructions from the genetic code in the DNA. Two types of solution are possible. One is to ignore the DNA and instead to set up a specific multi-enzyme complex which acts as a one-off production line for the antibiotic. (Of course the enzymes themselves are coded for in the DNA and produced by ribosomes in the usual way, but that is very different from the way in which the lantibiotics are produced). A one-off production line works but it is not easy to modify the system effectively and quickly. Worse still from a human perspective, if we want new antibiotics to replace old, ineffective ones rendered useless by acquired resistance, we can only go off searching for yet more different, yet more unusual organisms in the hope that they will provide some novel antibiotic substances. The alternative way of producing an antibiotic, the way of the lantibiotics, is to encode them in the DNA as a sequence of base pairs which the ribosomes can translate into a peptide, albeit one containing the standard, boring set of twenty L-amino acids. That peptide can, however, then be acted upon by a series of enzymes in what is called post-translational modification, replacing some of the amino acids with more exotic ones, and making some of the L-amino acids into D-amino acids. The advantages of this for the organism are enormous. Firstly, most of the assembly process merely uses the existing ribosomal machinery. And secondly, a small change in the genetic code, the very stuff of which evolution is made, can produce small changes in the lantibiotic, so that natural selection can readily fine tune the lantibiotic for changes occurring in the organism's environment or predators. That also is the advantage for humans as well,

since we can use artificial selection and the methods of genetic engineering to create changes in the lantibiotics to make them suitable for our needs, rather than the needs of the bacteria. They may well be the future for new antibiotics, which cannot forever go on being found using the old methods, which relied heavily on chance

Another novel approach to producing antibiotics, the creation of nanotubes which pierce the bacterial cell wall, thereby releasing the cell contents, also relies on using D-amino acids, which both resist protease action and also, when paired with L-amino acids, produce a symmetric tubular molecule (Gura, 2000).

☞WWW☜ 6:18

In 1992, fifty-seven years after he entered the University of Pavia as a student, Erspamer published a full-length review of the opioid peptides he had discovered (Erspamer, 1992).

Erspamer's personal feelings are rarely expressed in academic papers, but their very scarcity makes them all the more affecting. Science and scholarship are not carried out in an emotional vacuum, and as Freud said, all behaviours, however seemingly simple, are always over-determined, with many and complex motivations, often with their hidden defense mechanisms. Whilst reading around in preparation for this book, I came across the second edition of George Dumézil's *Mitra-Varuna.* Its introduction, written, in January 1947, also ends on a note of almost unbearable sadness, which so echoed that of Marcel Mauss' description of Durkheim's decimated research group (see chapter 2), that I feel I must quote it, 'lest we forget':

> "I shall always retain a particular fondness in my heart for the year 1938-39; but it is a memory peopled by ghosts. ... Every Thursday in the lecture hall [in Paris], beside Roger Caillois, Lucien Gerschel and Elisabeth Raucq, I would greet our gracious colleague Marie-Louise Sjoestedt, whose pupil in turn I became on Wednesdays when she taught me Welsh and Irish; she was not to survive France's first misfortunes. Pintelon, an assistant professor at the University of Ghent, was destined to perish in uniform while on guard in Belgium, even before the invasion. Deborah Lifschitz, from the Musée de l'Homme, so kind hearted and intelligent, was doomed to the horrors of Auschwitz. Other young faces were destined for other ordeals...". Dumézil, 1988.

☞WWW☜ 6:19

The title of the 1999 paper, "What peptides these deltorphins be", (Lazarus et al., 1999), is said by the authors to be a paraphrase of "What fools these mortals be", which is attributed to Seneca, although it is also an exact Shakespearean quote, from *A Midsummer Night's dream* (Act 3, scene 2).

☞WWW☜ 6:21

The dermorphins act on the μ (mu) opioid receptors, and the deltorphins on the δ (delta) receptors. As yet no amphibian peptides have been found that act on the κ (kappa) opioid receptors.

Since the deltorphins are active after injection into veins, passing across the blood-brain behaviour, these could well be the designer drugs of the future. Instead of heroin and morphine originating in fields full of poppies in hot, tropical countries, after which they are harvested, purified, and then transported halfway around the world, illegally crossing multiple

frontiers, before ending up on the streets of our cities, such drugs could be created by anyone with the basic laboratory facilities to synthesise a peptide consisting of seven amino acids, the only technical difficulty being the inclusion of the D-amino acids. And much, much smaller quantities than heroin and morphine would be required. It is a frightening prospect, but, at always, Pandora's box contains many things, and the lid can never be put back on. It is worth remembering that humans have always searched hard for psychoactive drugs – and it is a pretty strange thing, when one thinks about it, to smoke or inject the processed juice of a ripe poppy.

☞WWW☜ 6:22

A problem for most ordinary biochemical techniques is that they do not distinguish D- and L-amino acids. Indeed once the sequence of dermorphin was discovered a peptide was synthesised and found to be completely inactive, and only after careful checking did it emerge D-alanine rather than L-alanine was needed. The moral is that no amount of scanning through the genomic data banks, or looking at protein digests or using mass spectroscopy will reveal whether D-amino acids are important in proteins. The only check is to build the protein from scratch and see if it works. If it doesn't then a D-amino acid could be lurking (Scaloni, Simmaco, & Bossa, 1998).

There are also D-amino acids in proteins in *Mytilus edulis* (Volkmann & Heck, 1998 p.83), the bivalve mollusc, *Mytilus edulis,* (Volkmann & Heck, 1998), the African giant snail, *Achatina fulica*, the snail, *Helix pomatia* (Yasuda-Kamatani, 1998), the crayfishes, *Procambarus clarkii* and *Procambarus bouvieri* and the lobster, *Homarus americanus* (Huberman & Aguilar, 1998).

A photograph and other information about *Conus* can be found at www.ncrr.nih.gov/newspub/mar97rpt/snail.htm.

The witches in *Macbeth* would have recognised the essential recipe for finding D-amino acids, with "poisoned entrails" and "toad['s] ...sweltered venom", "eye of newt, and toe of frog", and "adder's fork, and blind-worm's sting". D-amino acids do seem to be disproportionately involved in nasty, toxic substances for which the modern pharmaceutical industry can find all sorts of interesting uses. But then most of the effective drugs are simply poisons used in small enough doses to be helpful. If drugs could not poison at high doses then they probably would not have any useful physiological effect in conventional doses. Finding effective drugs has never been easy, and doctors and pharmacologists have looked in unlikely places – William Withering found digitalis in the foxglove, atropine comes from the deadly nightshade, aspirin came from the bark of the willow tree, and of course penicillin comes from a mould. The vast majority of such finds have been from plants or fungi, and very few have come from animals, the most obvious exception being curare, the muscle relaxant which also came from frogs. That situation is however changing, and animals are now being looked at systematically. Dr David Newman of the National Cancer Institute in America put it very nicely indeed: "If you are fat, fleshy, brightly coloured and slow moving, I want to see you. There's something in you, on you, or travelling with you that stops you from being eaten" (Gratzer, 2000). That description fits the snails well, and also the many frogs and toads of the Amazon basin which are typically brightly coloured. In the biological warfare that constitutes the fight for survival between hungry species, "the creature with the best chemistry set wins"(Gratzer, 2000). D-amino acids are yet another variant in that

chemistry set, and while one's enemies are not using them then they are a very powerful weapon, particularly when used to make venoms which are potent poisons acting quickly on an enemy's brain to paralyse or convulse them. It is not of course easy using such potent weapons. They have to be produced, they have to be stored, and when used they have to be replaced, a process often taking days or weeks and leaving the animal vulnerable. There is also the problem of making sure that you do not inadvertently poison yourself or your nearest and dearest. Perhaps that is why relatively few species have developed these intricate forms of defence.

☞WWW☜ 6:23

There is something seemingly rather arbitrary about which of anything we call right or left. Is there then any deep sense in which amino acids are L and sugars are D? Yes, is the answer. The German chemist, Emil Fischer in the 1880s worked out the structural (as opposed to the optical) chirality of the amino acids and sugars. He started with the simplest chiral organic molecule, glyceraldehyde, which has -H, -CHO, –OH and -CH2-OH attached to its central carbon atom. He called one version D-glyceraldehyde, according to the organisation of the groups around the central carbon atom, and then worked out whether all of the other organic compounds, including amino acids were structurally the same or reversed with respect to the carbon atom. The sugars were the same structure as the D-glyceraldehyde and the amino acids were the opposite, and hence were the L-forms.

There is another argument lurking beneath the surface of homochirality which asks whether there is any advantage to building systems entirely from asymmetric components (rather than from symmetric ones). Evidence from computer simulations of complex autonomous replicators suggests that they are easier to build with less complex rules if the replicators are themselves symmetric (Sipper & Reggia, 2001).

☞WWW☜ 6:24

The geneticist JBS Haldane put both the question and the answer very clearly:

> "[A biochemist who] finds the same quite complex molecules in all plants and animals, can hardly doubt their common origin. There may be some reason in the chemical nature of things why all living creatures must contain glucose. But there appears to be no reason, other than common ancestry, why they should all contain dextrorotatory glucose, and none of them its mirror image". (Haldane, 1932 p.146).

In other words, as Leslie Orgel said, "the earth could equally well have been populated by D-organisms"(Orgel, 1973 p.167). Similarly, Murray Gell-Mann, the Nobel prize-winning theoretical physicist, suggested that "the biochemical left-right asymmetry is a frozen characteristic of the ancestor of all surviving terrestrial life, and ... it could just as well have turned out the other way". It is nothing but a "frozen accident" (Gell-Mann, 1995 p.229)

The Encyclopaedia Britannica article also comments that, "Whether left- or right-handed activity was adopted was probably purely a matter of chance...". And likewise Martin Gardner (1990a p.150) comments that "Whichever handedness predominated might gain a competitive advantage simply by virtue of its larger numbers". It must though be said that Gardner is somewhat out of date, even in his revised edition of 1990, since he still says that the Murchison meteorite has a racemic mixture of amino acids.

The form of the argument is not new, and is exactly akin to that proposed by Einstein when asked why there are more electrons than positrons in the universe: “The electrons got there first” – in other words, once both were in existence, each would start to annihilate the other until which ever had a slight excess would dominate our universe. More modern explanations of the excess of matter over anti-matter reflect the CPT (charge-parity-time symmetries) (Adair, 1988; Close, 2000f; Quinn & Witherell, 1998e).

☞WWW☜ 6:25

Darwin talks about the warm pond in a letter to Joseph Hooker in 1871. Darwin continues by saying that “a protein compound was chemically formed, ready to undergo still more complex changes”, unlike in the present day when “such matter would be instantly devoured, or absorbed, which would not have been the case before living creatures were formed”.

The experiments of Miller on the early atmosphere are important and well known, not least because amino acids were produced in the test-tube simulations. What is essential to realise for present purposes is that the experiments only ever produced a 50:50 mixture of L and D forms. That point has been taken up by fundamentalist groups (e.g. www.yfiles.com/origin.html) to suggest it is evidence for an *ur*-biochemist: “The solution is simple, yet it has profound implications. To separate the two amino acid forms requires the introduction of *biochemical expertise* or *know-how*, which is the very antithesis of chance! However, biochemical expertise or know-how comes *only* from a mind” – the mind of God, in other words. Those criticism of the early experiments may well be valid, but they do of course ignore the subsequent half century or so of research.

Symmetry breaking in the possible conditions of the early earth continues to be a problem that excites many scientists, both physicists and chemists as well as biologists. As a result it is common for researchers to speculate that novel chiral mechanisms may be relevant to the origins of life on earth. An example is the finding that in some cases stirring a solution clockwise or anticlockwise can result in oppositely handed chiral products from reagents which are themselves achiral (Ribó et al., 2001). Although undoubtedly surprising and potentially of great interest for those trying to synthesise chiral pharmaceuticals and other chemicals, it is difficult to see how stirring could really be "a serious candidate for chiral selection in prebiotic stages of evolution" (Feringa, 2001) unless it is proposed that there were large consistently stirred pools of fluid on the early earth, which hardly seems likely, even given the existence of the Coriolis forces.

☞WWW☜ 6:27

It writing about physics, I am uncomfortably aware that I am a biological scientist by training, and my knowledge of physics, in particular particle physics, is that of an amateur. That is why I am not talking about the topic at length here. There are plenty of excellent books by those who do know what they are talking about, and anyone interested should look, for instance, at Martin Gardner’s classic *The ambidextrous universe* (1990a), or Frank Close’s more recent *Lucifer’s legacy* (2000f)

Wigner, a Hungarian physicist, who won the Nobel Prize in 1963, showed in 1927 that right-left symmetry and the conservation of parity are formally equivalent. For a selection of his writings see Wigner (1967).

Patrick Blackett (1897-1974) had himself been awarded the Nobel Prize for Physics in 1948, for his work on cloud chambers and its use for finding the positron.

The Wu experiment was actually a collaborative effort, and the usual convention of the time would have been to list the authors in alphabetical order, unless one author were the originator of the idea, when they should go first. Wu (1912-1997) was indeed the originator of the idea, but protocol was also that unless the originator suggested changing the order then alphabetical precedent should stand. Wu did not suggest it, and it would have been unseemly for the other authors to do so, and so the (male) authors suggested that Wu should appear first on the grounds that she was the only woman. As Kurti and Sutton (1997b) comment, whether this is an early example of affirmative action or sexism is not clear. While on the topic, I have never been clear why Wu, a Professor at Columbia University in New York should so often be referred to as "Madam [or Madame] Wu"; that I suspect *is* sexism. For further background to the experiment see Hargittai and Hargittai (2000 pp.201-204).

As well as the Wu experiment on beta decay (Wu et al., 1957), there was also a second experiment on meson decay (Garwin, Lederman, & Weinrich, 1957) which also showed the same failure of conservation of parity, and within months there were dozens of others. Photographs of the original apparatus for the meson experiment can be found in Morrison (1957a), including, amidst the vast piles of equipment, the key carbon block, "supported by a brick and coffee can". Perhaps one of the most intriguing of the spin-offs from the parity experiments were the results, described Blackett in a 1958 lecture (1959 p.302) of a much earlier experiment, published in 1928, forty years previously, which had also shown that beta particles were not scattered equally to left and right (the rediscovery of the paper was made by Grodzins (Bernstein, 1962b p.88). The authors of that earlier experiment concluded that their results could come from "some asymmetry in the electron itself" (Cox, McIlwraith, & Kurrelmeyer, 1928 p.547), but since there was no theoretical framework for explaining the finding, the result was almost totally ignored: "I cannot remember ever having read or heard of Cox's work", as Blackett said, despite his close involvement with the field. Salam (1958) also pointed out that all the key evidence for the non-conservation of parity existed on photographic plates dating back at least a decade before the Wu experiment.

☞WWW☜ 6:28

Yang called himself Frank after his hero, Benjamin Franklin, whereas Lee is known as "T.D." (Regis, 1998 p.142).

Pauli, who won the Nobel Prize in 1945, is quoted by Salam (1958), who emphasises that 'the *not* is heavily underscored' by Pauli. Gleick (1994 p.334) emphasises how quickly, despite the strength with which the theoreticians had believed in parity, there was "a revisionists' purgatory in the making: theorists from Dirac to Gell-Man [were] 'busy explaining that they personally had never thought parity was anything special' ".

☞WWW☜ 6:29

Almost immediately after the Wu experiment it was announced that μ mesons were even more strongly handed (Garwin, Lederman, & Weinrich, 1957). Subsequently it was found that all three types of neutrino are strongly left-handed, perhaps the most extreme example of failure of conservation of parity.

An electron is left-handed in precisely the same sense as a screw or a spiral is left-handed (Hegstrom & Kondepudi, 1990b). Imagine the electron rotating, like the earth around its north-south axis, and that the particle is itself also moving due north. A point on the surface of the particle will then form a left-handed helix and so the electron is left-handed, tracing out the same path as a left-handed corkscrew.

In a typical gambit from a theoretician, Pauli subsequently turned around completely the problem of failure of conservation of parity, and said, "I am shocked not by the fact that the Lord prefers the left hand as by the fact that he still appears to be left-handed symmetric when he expresses himself strongly. In short, the actual problem how seems to be the question: Why are strong interactions right-and-left symmetric?"(Gardner, 1990a p.218).

Bernstein (1962b) gives an excellent in-depth journalistic account of the response of the world of physics to the stunning discovery. Within three months of the experiment, *Scientific American* had published a detailed account of it and its implications (Morrison, 1957a).

Sadly it would seem that the Nobel Prize also split apart the very successful partnership of Lee and Yang, the relationship eventually foundering in part over that occasional but trivial source of intense irritation to scientists who collaborate on research papers – the order of names on the paper. This was apparently particularly intense for the *New Yorker* article (Bernstein, 1962b), and one suspects the final title, "A question of parity" is deeply ironic. Eventually things deteriorated so much that Lee and Yang, or perhaps that should be Yang and Lee, each published books describing entirely different histories of their collaborative papers (Regis, 1998).

The precise extent of charge-parity violation is still controversial and problematic, a report in May 2001 estimating the key parameter particularly accurately and finding it to be outside the range expected by the standard model (Chen, 2001).

☞WWW☜ 6:30

Many years later Salam himself proposed a mechanism for the excess of L-amino acids which involved a Bose condensation at temperatures close to absolute zero, as might occur in the depths of space (Salam, 1991; Salam, 1992). However empirical testing suggests that the mechanism probably does not occur (Figureau, Duval, & Boukenter, 1995).

The quote about one-eye giants (Salam, 1958) is interesting, because as has been seen in a previous chapter, Dumézil (1974a) had suggested that actually several early one-eyed heroes were indeed asymmetric.

There is a suggestion from a survey of 7563 galaxies that there is a 4.6% excess of left-handed galaxies (Mason, 1991 p.283). I have not however been able to trace this claim back to its source.

☞WWW☜ 6:31

Cline (1996 p.269) put it nicely:"Over the past 20 years, many experiments have been carried out [on the chemical effects of the weak interaction] ... However it appears that nearly every positive effect that was observed has turned out to be incorrect. In table 3 [of the Cline paper] we list some [few] experimental results that are not yet refuted or in direct conflict with previous null effects".

☞WWW☜ 6:32

The theory also explains something else which is otherwise rather mystifying. Although life is formed from L-amino acids it is made of D-sugars. Why is it not L-amino acids and L-sugars? The theory of the weak interaction neatly explains this, because although L-amino acids are more stable than D-amino acids, it is D-sugars which are more stable than L-sugars. So organisms are formed of the most stable amino acids and the most stable sugars (MacDermott, 1996 p.250). This is actually quite a triumph for the weak interaction theory since, as Bonner 1998g has pointed out, hardly any one has ever succeeded in explaining why there might be an excess of D-sugars.

☞WWW☜ 6:35

Although it is often presumed that the insides of meteorites must get very, very hot, there is evidence in at least one case that the interior may not even have been heated above 40˚C (Weiss et al., 2000).

An account of the Murchison meteorite can be found in *The Times*, 30th September 1969, p.8h.

Other factors which exclude the possibility of contamination are that amino acids such as serine, threonine, tyrosine, phenylalanine, and methionine, which are common on earth, have not been detected in the Murchison meteorite (Engel & Nagy, 1982), and the proportions of the ^{13}carbon and ^{15}nitrogen isotopes are both higher than on Earth (Engel & Macko, 1997; Engel, Macko, & Silfer, 1990).

Several authors have quoted the early result on the 50:50 mixture of L- and D-amino acids and assumed that it means the meteoritic amino acids could not have come from contamination (Orgel, 1973, Gardner, 1990a). Interestingly, exactly the same argument was also used for the Murray meteorite, which fell in Kentucky on 20th September 1950 (Lawless et al., 1971), and was subsequently shown to have non-racemic mixtures of non-terrestrial amino acids (Pizzarello & Cronin, 2000).

The entire Tagish Lake meteorite is estimated as weighting about 200,000 kilograms. The fragments recovered are described as “lumps of crumbly rock with scorched, pitted surfaces -- [they] resemble partly used charcoal briquettes: black, porous, fairly light and still smelling of sulfur” (www.spacescience.com/headlines/y2000/ast16mar_1.htm.). Early reports on its

chemical analyses suggest that the organic content is relatively low, and as yet there are no published reports on whether the amino acids are D- or L- (Hiroi, Zolensky, & Pieters, 2001,Pizzarello et al., 2001). A problem of analysing the meteorite seems to be that the owner has not yet parted with the relatively substantial samples which are needed for proper chemical analysis.

Although in this and the following sections I talk only of amino-acids as possibly having come from meteorites, it has also been demonstrated recently that the Murchison and Murray meteorites also contain sugar-related compounds that might also have had a role to play in initiating life on the early Earth (Cooper et al., 2001). As yet there seems to have been no analysis of whether the sugars are L- or D-, which would be of great interest.

☞WWW☜ 6:36

Curie's principle (1894) is the corollary of the statement by Francis Robert Japp in 1898, that "only asymmetry begets asymmetry" (Barrett et al., 1987).

For information on circularly polarized light see Bouchiat and Pottier (1984b), and also acept.la.asu.edu/PiN/rdg/polarize/polarize.shtml. Despite the problems of replicating so many effects which claim to affect D- and L-amino acids differently, Cline (1996 p.269) says, "Th[e] observation that circularly polarised light destroys L and D isomers selectively ... is now well established ... and there is no doubt that this effect is real".

The most recent neutron star in our galaxy is the Crab pulsar, which exploded as a supernova on 4th July 1054 AD (Oort, 1957). The oldest supernova that we are aware of exploded about 20 million years ago. Within the Milky Way there are probably about 30,000 neutron stars which are sufficiently active to produce an enantiomeric excess in dust passing near by (within 1 parsec, about 3.25 light years) (Greenberg, 1996 p.201).

☞WWW☜ 6:37

This section is based strongly on the paper by Bonner (1998g). An important part of the evidence that amino acids in meteorites have indeed formed in the cold dark reaches of inter-galactic space is provided by their high proportion of deuterium, an isotope of hydrogen (Epstein et al., 1987).

Although inter-galactic space is likely to be extremely cold, that does not necessarily mean that water is frozen into ice so hard that no chemical reactions can take place. So-called 'amorphous ice' can form in such conditions, and it has many of the properties of liquid water, and could well be a good place for organic compounds to form (Blake & Jenniskens, 2001).

☞WWW☜ 6:38

"Bucket loads" actually massively understates the amount of material that comets may have deposited on Earth. Halley's comet alone is one third organic material by mass, and about 3% of the organic material in carbonaceous chondrites is amino acids. In a paper of which Carl Sagan was a co-author (Chyba et al., 1990), it is estimated that between 10^6 and 10^7 kgms of organic material from impacting meteorites would have arrived on early Earth each year, of which about 1% would have been amino acids. To put this in perspective, the total mass of

biological material on Earth is about $6x10^{14}$ kgms, so that, even in the most extreme case, if *all* of this had come from meteorites it would have taken between 60 and 600 million years, very much less than the time that life has been on Earth.

On the problems of amino acids occurring spontaneously in the environment of the early Earth, Dyson (1999 p.17) points out that although Miller's classic experiments of 1953 synthesised amino acids in a simulation of the early atmosphere which was 'reducing', there is no evidence that the early atmosphere actually was reducing.

☞WWW☜ 6:39

Although Gould's argument is principally about the bacteria in the vernacular sense, it is clear from his evidence that it is a serious possibility that the archaea outweigh all other organisms on the planet (Gould, 1997).

☞WWW☜ 6:40

The idea that meteorites laden with L-amino acids were the origins of life on Earth is a nice one that is at least supported by the very solid evidence of large amounts of L-amino acids in meteorites. While there is no doubt that those meteorites do have the L-amino acids, there is rather more doubt about quite where they came from and why. The trouble with the theory of circularly polarised light is that circularly polarised light is not that common in the universe, although it can undoubtedly be found (and a recent report describes it in the Orion OMC-1 star-formation region (Bailey et al., 1998), and earlier work found polarised light around the Crab nebula (Oort, 1957)). An alternative possibility has been raised in a recent suggestion as to where homochirality came from. Pasteur himself, influenced by what it now seems was a complete misunderstanding of Faraday's work on the 'handedness' of magnetic fields, had thought that magnetic fields might induce crystals to grow one particular way (Barron, 2000; Lord Kelvin had however pointed out that "the magnetic rotation has neither left-handed nor right-handed quality, that is to say, no chirality"). A modern variant of the experiment has however worked, using what is known as the magnetochiral effect, in which light is adsorbed slightly differently by chiral molecules if the light is parallel to a magnetic field than if it is going in the opposite direction. The crucial thing about this is that the light does not have to be polarised – any old ordinary light will do. An experiment by Geert Rikken and Ernst Raupach (2000g), at the Max Planck Institute in Grenoble, found that when a racemic mixture of chiral molecules was placed in a strong magnetic field, with light going parallel to the field, then one enantiomorph of the chiral molecule tends to predominate. The effect is however small, only about one part in a thousand. Nevertheless it has much more scope for explaining the excess of L-amino acids than circularly polarised light, mainly because magnetic fields and light are everywhere, whereas circularly polarised light is rare. Having said that, the sort of magnetic fields found on earth seem too small to be able to produce the effect, particularly since most of the sunlight is at right angles to them, rather than parallel. It therefore seems probable, just as with the circularly polarised light theory, that the largest effects must be found in space, perhaps again near a neutron star.

The Hubble Space Telescope in October 1996 identified a neutron star relatively close to Earth. Although its precise distance is not known it lies in front of a molecular could about 400 light-years away, and hence must be closer than that. Its diameter has been estimated at 28 kilometres, and its extreme temperature (about 650,000°C) means it has to be a neutron star. It is not however a pulsar, emitting neither radio waves nor light, and so presumably is not rotating (www.seds.org/Maps/Const/Add/coronoaaustra_add.html).

Chapter 7: Hypernotes

☞WWW☜ 7:2

I find the biography of Darwin by Bowlby (1990c) to be especially satisfactory, perhaps because it seems to be so particularly interested in the psychology of Darwin the man as an individual and unusual human being, in contrast to much modern historical analysis and biography which attempts only to embed Darwin in a social world of which he was indeed a part, but sometimes only a rather distant part.

Nicknames and pet names were clearly very much in order in the Darwin family since later we are told, "Our little boy is a noble fat little fellow & my father has christened him Sir Tunberry Clumsy" (Burkhardt & Smith, 1986 p.279).

☞WWW☜ 7:3

Regrettably Darwin actually doesn't confirm that the result of the repeated experiment was the same as the first time, but that is the natural interpretation (Burkhardt & Smith, 1988 pp 415).

☞WWW☜ 7:4

Often Darwin had to be goaded into print by some other worker writing on a related topic, as indeed he even had to in 1859 with *The origin of species* itself, when Alfred Russel Wallace came up with precisely the same idea, albeit one that was far less thoroughly worked out and documented than the details Darwin would provide. Darwin would not have been comfortable in the modern world of 'publish or perish', of research accountability, and the need to produce papers regularly and frequently to demonstrate one's ability. But then he had a large private income, mostly from the proceeds of the Wedgewood pottery, and had no need for such worldly concerns.

The paper by Taine (1877), which makes no mention of handedness, was published in the April 1877 issue of the journal, and so Darwin must have rushed to prepare his paper and get it into print in the next issue of the quarterly journal, in July 1877 (Darwin, 1877). It has been commented that the "Biographical Sketch" might seem "rather cool, clinical, and possibly even exploitative", whereas a reading of the diaries themselves gives a very different impression of a Darwin who is "gentle, loving, and playful" (Keegan & Gruber, 1985 p.129). It is possible that Taine met Darwin, since he was an Anglophile, who] visited London and wrote a book about the England (Paxman, 1999 pp.190,213,229).

☞WWW☜ 7:6

There is an intriguing footnote in the transcription of Charles Darwin's diaries which refers to some strange, unsophisticated handwriting which is attributed to Emma Darwin having injured her thumb and "writing with her left hand following some injury to the thumb of her right hand" (Burkhardt & Smith, 1988 p.433). This seems incompatible with Darwin's clear statement that she was left-handed. Either the editor had forgotten that she was left-handed, and meant merely that she was writing with her non-dominant hand, or Emma was indeed naturally left-handed but had nonetheless been taught to write with her right hand, as was sometimes the case in the nineteenth century. Emma's daughter, Helen Titchfield does describe her mother's handwriting as being "like herself, firm, calm, and transparently clear. She did not write quickly, but with an even steady pace..." (Litchfield, 1915 vol I, p.62). That the writing was slow may mean it was written by a left-hander forced to use her right hand. Correspondence from Dr Sarah Wilmot, Associate Editor of the Darwin Correspondence Project, 11/4/2000, confirms that Emma was merely presumed to be right-handed, rather than it being confirmed.

☞WWW☜ 7:7

For scientific use, questionnaires typically have many more questions (up to about sixty), covering a range of different topics, and they are answered on a three or more usually a five-point scale (from 'Always right', through 'Usually right', 'Either', 'Usually left' to 'Always left'). In practice the results obtained are essentially similar to those at Waltham Forest. A minor problem at Waltham Forest was that some children ticked both right *and* left. I have counted those who ticked left only in computing the results, and have changed the instructions slightly in the present questionnaire. In the past I have not been convinced that lengthy questionnaires contribute much more than do brief questionnaires (McManus, 1979f Chapter 2), particularly for assessing direction of handedness, which is assessed almost perfectly by writing hand, as long as there is no history of having been forced to change hands. Longer handedness questionnaires do though have the advantage of attaining a distribution of scores which is more bimodal normal than J-shaped (McManus, 1979f; McManus, 1996). I am not convinced that questionnaires properly differentiate different 'types' of handedness, and certainly not the large numbers of sub-types that have been proposed by Annett (1970b). Even the differentiation of 'skilled' and 'unskilled, or 'fine' and 'coarse' movements proposed by several workers (Healey, Liederman, & Geschwind, 1986; Liederman & Healey, 1986; Steenhuis & Bryden, 1989) is, I suspect, merely due to the individual J-shaped distributions on each item effectively resulting in binary measures which give rise in factor analysis to difficulty factors (Maxwell, 1977,Bernstein & Teng, 1989). I think the sole exception to such criticisms is the finding that writing and throwing are separate, for which there is good external validation (Peters & Servos, 1989b).

I am extremely grateful to the Vestry House Museum for permission here, and elsewhere, to quote from their exhibition, '*A sinister way of life? The story of left-handedness'*, 13th August - 16th November 1996, and to Nigel Sadler, then Keeper of the Museum, for permission to quote from his unpublished notes and files (Sadler, 1996a). The questionnaire was distributed to children aged 6 to 15 in a number of schools in Waltham Forest. The graphs are based on 1238 males and 1654 females. There was no difference in incidence between the older and the younger participants, and to a good approximation the distribution is typical of that obtained with adult subjects.

Of the 2892 children in total, 285 (9.9%) were left-handed, scoring 5 or more on the scale. The numbers scoring 0 through to 10 were 1800, 515, 161, 80, 51, 36, 27, 36, 41, 62, 83. Of the 1238 males, 143 (11.6%) were left-handed, compared with 142 (8.6%) of the 1654 females. The difference is statistically significant (Chi-square = 7.01, 1 df, p=.008).

☞WWW☜ 7:8

Handedness researchers typically distinguish *direction* of hand preference, whether the right or the left hand is used preferentially, from *degree* of preference, the extent to which the dominant hand is preferred to the non-dominant hand (McManus, 1996). The definition of 'strong' or 'weak' preference is more arbitrary, and in the present account I have chosen 0 or 10 as a description of 'strong' as it makes the account easier.

The idea that people can be ambidextrous is an old one, and I am grateful to Michael Peters for pointing out to me one of the oldest known references to ambidexterity, in Homer's *Iliad*, where, during the fight with Achilles: "the warrior Asteropaeus hurled with both spears at once, since he was ambidextrous [περιδεξιόs]" (Murray & Wyatt, 1999 21:162-3). As Michael says, since Asteropaeus lost then clearly ambidexterity is not all it is cracked up to be. A somewhat later reference from Greece, this time early Classical, is the poet Archilochos who was said to have been ambidextrous[36]. Probably four or five hundred years older, perhaps contemporary with Homer, is the description in the Bible of a group of Benjamites who may be seen as ambidextrous: "They carried bows and could sling stones or shoot arrows with the left hand or the right." *(1 Chronicles 12: 2).*

The tapping task shown was developed by Tapley and Bryden (Tapley & Bryden, 1985); examples of the test in use can be found in Van Horn (1992b) and in McManus *et al* (1993a). It is probably one of the best tasks for showing which hand is more skilled at the very fine repetitive movements which are typical of those involved in writing. I have yet to see anyone who approaches being described as ambidextrous on this task. My views on ambidexterity are rather like those of Gilbert and Sullivan in *Iolanthe* on politics:

> "...Nature always does contrive
> That every boy and every gal,
> That's born into the world alive,
> Is either a little Liberal,
> Or else a little Conservative!"

So it is that for hand skill, everyone leans to some extent either a little to the left or a little to the right.

A formal meta-analysis of the incidence of left-handedness in one hundred different studies can be found in the unpublished paper of Seddon and McManus (1991b), a copy of which is available as a PDF file at www.righthandlefthand.com. A summary of the results can be seen in figure 1 of McManus (1991c).

---

[36] Although the translation of the fragments by Davenport (1964c) does not contain any reference to his ambidexterity, it does have a charming version of a fragment that was referred to by Plutarch:

> "Fortune is like a wife:
> Fire in her right hand,
> Water in her left".

☞WWW☜ 7:9

The unpublished meta-analysis I carried out with Dr Beatrice Seddon (Seddon & McManus, 1991b – see above; see also McManus, 1991c figure 3) – found the sex difference to be constant across many societies and historical periods. It is perhaps the most important constant factor which has to be explained in the origin of handedness. Although when conditions are more common in males (e.g. haemophilia or colour blindness) it is due to the gene responsible being carried on the X chromosome, the 5:4 ratio is incompatible with any simple hypothesis such as that of Jones and Martin (2000h), who predicted a ratio of 1.61 males left-handers for every female left-hander. It might however reflect a modifier gene on the X chromosome (McManus and Bryden, 1992c).

☞WWW☜ 7:10

Although in an early study of ours we were unable to find any evidence for left-handedness being more common in male homosexuals (Marchant-Haycox, McManus, & Wilson, 1991), a meta-analysis of twenty such studies suggests there is an overall effect (Lalumière, Blanchard, & Zucker, 2000i), our study failing to find an effect because it was too small. In male homosexuals the overall odds ratio for left-handedness was 1.34, meaning that if 10% of male heterosexuals are left-handed then about 13% of male homosexuals will be left-handed. The effect was stronger and in the same direction in female homosexuals, with an odds ratio of 1.91, i.e. if 10% of female heterosexuals are left-handed then about 17.5% of female homosexuals will be left-handed. In interpreting the result it is worth noting that the effect size is smaller in more recent studies, raising the possibility of some methodological artefact or bias in the earlier studies, a phenomenon that has also been found in other meta-analysis (Van Horn & McManus, 1992).

Lalumière *et al* (2000i) have reported five separate studies in which transsexuals have a higher incidence of left-handedness.

In the 1980s Norman Geschwind proposed a very influential and still highly cited theory in which testosterone levels during early fetal life influenced very many aspects of development (Geschwind & Galaburda, 1987). The theory is difficult to pin down precisely (McManus & Bryden, 1991). At least one key highly counter-intuitive prediction which initiated the theory, that left-handers suffer more from allergic disorders (Geschwind & Behan, 1982), seems to have been falsified by a mass of data (Bryden, McManus, & Bulman-Fleming, 1994a). That does not however mean that fetal testosterone levels cannot be involved in handedness in relation to homosexuality, gender identity and other related conditions. Although there is some suggestion that cerebral lateralisation in adults is related to testosterone levels (Moffat & Hampson, 1996; Moffat & Hampson, 2000) or to the use of drugs which might have altered testosterone levels *in utero* (Smith & Hines, 1998), what is properly required are studies in which fetal testosterone levels have been measured directly, as at amniocentesis. Such studies are rare, and tend not to find the expected results (Grimshaw, Bryden, & Finegan, 1995). For other aspects of sex differences and lateralisation see Kimura (1999f).

☞WWW☜ 7:11

For the record I should say that I score zero on the questionnaire given earlier. However I clearly have other lacunae of left-handedness, and can, for instance, play badminton equally badly with either my right or my left hand. Such inconsistencies of handedness are far from unusual. To cite two examples amongst sporting personalities, the right-handed tennis player, Ivan Lendl, now plays golf left-handed. Likewise the cricketer David Gower, renowned in his time for his elegant left-handed batting style, is actually right-handed on a standard handedness questionnaire (Harris, 1985).

☞WWW☜ 7:12

For the original research on inconsistent left-handers, see Peters (1987e), Peters and Servos (1989b) and Peters (1990d). Estimates of the incidence of inconsistent right-handedness are reported by McManus *et al* (1999g).

Havelock Ellis, who was born in 1859, himself attributed the difference between writing and throwing to an innate left-handedness, saying, “Although I am right-handed except in the single action of throwing a stone or ball, I am inclined to think that congenitally I may be left-handed, and that my right-handedness is the artificial result of training, the spontaneous tendency only showing itself in the untrained act of throwing.” (p.85). He also attributed his bad hand writing to the same factor: “I was, I believe, naturally left-handed; I have never been able to throw a ball with my right hand, and though I have never written with my left hand, my right-handed use of the pen was always the despair of my teachers” (p.84). The hand-writing was so bad that his headmaster, “would ask me if I wrote with the kitchen poker, and sometimes remark that I seemed to keep a tame spider to race over the page” (p.55) (Ellis, 1967).

☞WWW☜ 7:13

The terms used to define handedness have been confusing since at least the beginning of this century (Jones, 1909). My least favourite term in use is 'non-right hander', a term particularly in vogue in the 1970s and 1980s, which seems to have been popular because it seemed to make fewer judgements about what was and was not a left-hander. In practice it seems to solve nothing but merely provides the user with a veneer of pseudo-scientific precision. Its major problem is that almost any meaning can be attached to it, and there are several studies in which anyone who does not score zero on a questionnaire such as that in figure 2, is described as a 'non-right-hander'. The serious practical problem is that it gives the incompetent or unscrupulous researcher a choice of a wealth of measures, some or other of which may attain statistical significance due to chance alone. 'Non-right-handed' typically also confounds direction and degree of lateralisation.

☞WWW☜ 7:14

In the study of Porac and Coren (Porac & Coren, 1981 pp.32-49), 13% of right handers and 63% of left handers were left footed. For a recent critical review of the measurement of footedness see Gabbard and Hart (2000j).

The earliest reference to footedness seems to be in Thucydides' *History of the Peloponnesian War* (Warner, 1972 III, 22) in which a group of besieged Plataean soldiers attempted to escape from their city:

> "...they waited for a stormy night with wind and rain and no moon, and then they slipped out of the city... They were lightly armed and only wore shoes on the left foot, to stop them slipping in the mud".

Based on the analysis of Carey *et al* (2000k) of 216 top international players in the France '98 competition, 80% of whom used the right foot most of the time, a figure similar to that in the population as a whole (Porac & Coren, 1981).

It is a mathematical necessity that if 10% of people are left-handed and 20% are left-footed, then at least 10% of right-handers must be left-footed even if handedness and footedness are associated as strongly as possible. If handedness and footedness showed no association at all then 20% of right-handers would be left-footed. In practice the proportion of left-footed right-handers is closer to 10% than 20%, showing that handedness and footedness are correlated quite substantially.

☞WWW☜ 7:15

It may be that the sudden near universal popularity for mobile phones may make ear preference of rather greater interest for academic research. One recent piece of work on a slightly different task suggests that sales telephone operators who use the left ear differ in personality from those who prefer to use the right ear (Jackson, Furnham, & Miller, 2001).

Hugo Williams, in a piece in the TLS (Williams, 1994) has a nice description of the use of the hands in telephoning:

> "With my right hand out of action, I notice that no one dials a telephone number with their left hand. They pick up the phone with their right, swap over to dial, then swap back again to speak, the way the French swap their fork over after they have cut up their meat. People don't trust their left hand to per-form such an intimate task as dialling, any more than they trust their left hand to perform adequately in bed, unless it be for some mild perversion of habitude. If one hand ever had cause to be jealous of the other, it is surely the underprivileged left of the pushy, over-confident right."

An intriguing aspect of eye dominance is that very many people do not even realise that it exists. Indeed when carrying out the sighting task they often realise for the first time that in pointing at a distant object only one eye can be aligned with the pointing finger, so that the other eye has a different view of the scene, which means that there are two images of fingers, one of which is ignored by the brain. In the same way, eye dominance also seems to have been noticed relatively late in human history, the first proper description of it being due to Giovanni Battista della Porta (1593; see Wade (1998h for a translation), although Wade make a strong suggestion that Aristotle was aware of the phenomenon.

In sport there are some suggestions that cross-laterals, those with the dominant hand and the dominant eye on opposite sides, are less good at tasks such as putting in golf (Steinberg, Frehlich, & Tennant, 1995), target shooting with a rifle (Lucas, 1946, Sheeran, 1985) or archery (Christina et al., 1981), although there seems to be no effect on free-throw shooting in basketball (Shick, 1977).

From the point of view of trying to understand why people are lateralised, an intriguing question is why there is eye dominance at all. The two eyes are generally symmetric, as is

much of the brain to which they are connected, so why should one eye be preferred to the other? Although it is often suggested that people might prefer to look with the eye which sees better, the one with higher visual acuity, in fact there seems to be no association at all between having higher acuity in one eye and it being dominant (Porac & Coren, 1976). One possible explanation of eye dominance is that it has nothing at all to do with seeing as such, with visual perception, and is instead related to the way that we move our eyes. Moving the two eyes exactly together is quite a difficult task, and in most people one eye tends to move first to look at an object and the other then follows[37]. In a recent piece of research my colleagues and I found, somewhat to our surprise, that eye dominance relates rather more closely to the hand one throws with than the hand one writes with (McManus et al., 1999g). Why might that be? Although we don't normally think of it in such a way, there is little real difference in principle between throwing a ball with one's hand and moving one's eyes. In the case of eye movements, the ball being thrown is the eye-ball and it is being thrown within the eye socket, but otherwise the task is similar. It is then less surprising that there should be an association between the dominant eye and the hand used for throwing in general.

☞WWW☜ 7:16

About 56% of people chew more on the right side, and they are more likely to be right handed (Hoogmartens & Caubergh, 1987).

Although I know of no formal evidence on it, hand clasping seems to be pretty well constant in individuals across the life-span.

☞WWW☜ 7:17

Like hand-clasping, arm-folding seems to be completely constant across the life-span of individuals. A nice example can be seen in photographs of Picasso across his life-span, in many of which he likes to stand staring straight at the camera with his arms folded, always in the same way with the left wrist on top.

Picasso also provides a good example of another laterality, leg-crossing. Most people sit in a chair with one leg crossed over the other, and for most people this tends to be with right leg over the left, at least at first until the legs begin to ache when people will cross the other way. Leg-crossing seems to be constant through life, and there are pictures of Picasso taken in 1939, 1948, 1952, 1954 and 1957, in each of which he sits with the left leg crossed over the right. Leg-crossing is statistically related to handedness (Reiss, 1994) and should not be confused with the 'palthi' style in India of sitting cross-legged on the ground, where the palms of the feet point upwards (Chaurasia, 1976).

The study of ear wiggling also found that men are more able to wiggle their ears than women (Code, 1995).

---

[37] An interesting result of this is that the egocentre, that feeling of quite where is the 'I' which is us, and which seems to be somewhere an inch or two behind and between our two eyes is slightly more towards the side of the dominant eye – the right in most people (Barbeito, 1981). Although traditionally it has been presumed that both eyes are moved by a single control system in the brain, that no longer seems to be the case, each eye being controlled separately (Zhou & King, 1998).

☞WWW☜ 7:18

Although the direction of handedness seems to be fixed by about two years of age, the degree of handedness continues to increase throughout childhood (McManus et al., 1988). There is also some evidence that degree of handedness continues to increase even into late adulthood. Porac(1993b) found that elderly people become particularly strongly handed on tasks such as picking up a full glass of water, an explanation of which is that both hands are beginning to become weak or to tremor. In a young adult either hand has a sufficient reserve of skill in each hand to be able to cope with some tremor, whereas in the elderly that is not the case, and since the non-dominant hand has less reserve, so there is a shift towards using the dominant hand.

☞WWW☜ 7:19

For examples of fetuses sucking their thumb see http://pregnancy.about.com/health/pregnancy/library/ultrasounds/blusindex.htm where there are images from 11 weeks of gestation onwards.

Of 274 fetuses in the study of Hepper *et al* (1991d), 22 (8%) sucked the left thumb, with the proportion being the same in the fetuses aged 15-21 weeks as in more mature fetuses. There was little change in the side of thumb sucking when the same fetus was observed three weeks later, suggesting the measure is reliable within an individual fetus.

Hepper has recently, in an as yet unpublished study (Hepper, Personal communication, 2001) , followed up the right and left thumb sucking children at the age of five and found a high correlation between side of the thumb sucking and eventual handedness, confirming that fetal thumb-sucking is indeed a valid measure of handedness.

In the later study of Hepper e*t al* (1998i) there were 63 fetuses which showed more movements on one side or the other. A further 9 fetuses showed equal movement on the left and the right.

☞WWW☜ 7:20

For a forceful modern statement of the case that handedness is due to a social rather than genetic factors see Provins (1997c); however strongly stated though, I am afraid that I do not find the argument convincing.

The figures in the table are based on 63,250 children of two right-handers, 8,933 children of one right and one left-hander, 417 children of two left-handers (McManus & Bryden, 1992c). The paper also gives details of how there are subtle inter-relationships between handedness, the sex of the child and, in RxL parents, the sex of the parent who is left-handed. There is a tendency for left-handed mothers to be a little more likely to have left-handed children than left-handed fathers, although the possibility has been raised that this may only reflect uncertain paternity in the case of some fathers.

In the scientific literature it is more common to use odds ratios rather than the risk ratios I have cited in the text. However when the proportion of an event is relatively low, as it is in left-handedness, then the odds ratios and risk ratios are fairly similar numerically. Risk ratios

are also much easier for people to understand, and I have therefore used them in the book. For the family data the risk ratio for a left-handed child when one parent is right and one is left-handed is 2.05 times, being 19.5% divided by 9.5%. The odds ratio is slightly higher at 2.307, and takes into account the probabilities of having a right-handed child. Specifically the odds of having a left-hander are calculated as:

$$\frac{P(Left \mid RxL) \times P(Right \mid RxR)}{P(Right \mid RxL) \times P(Left \mid RxR)} = \frac{.195 \times .905}{.095 \times .805} = 2.307$$

Likewise the risk ratio for two left-handed parents compared with two right-handed parents is 2.75 times, whereas the odds ratio is 3.365 times.

The data showing that half of all left-handers have no left-hander in the family were collected as part of the National Childhood Encephalopathy study (Madge et al., 1993, McManus, 1995a). In part the lack of left-handed relatives reflects the relatively small number of children in modern families which make it very difficult to see the ways that even strongly genetic characteristics are inherited. If Darwin had only two children instead of ten then even with a one in five chance of each child being left-handed he could well have ended up with only right-handed children. Nevertheless, Ogle (1871) asked 57 left-handers about their relatives and even in the late nineteenth century only 27 (47%) knew of a left-handed relative (first cousin or closer); even so, Ogle concluded that left-handedness was “an hereditary affection” (see Harris, 2000 p.150).

☞WWW☜ 7:21

Aristotle (Armstrong, 1935 1194.b.32) continues, “If in general and at most times left retains the familiar character of left, and right of right, the distinction is natural one”. Strictly, Aristotle is saying that handedness is congenital, rather than inherited, but in this case that can really only mean it was in some sense inherited.

Sir Charles Bell (Bell, 1834a p.142)says, “That the preference for the right hand is not the result of education, we may learn from those who by constitution have a superiority on the left. They find a difficulty in accommodating themselves to the modes of society: and although not only the precepts of parents, but every thing they see and handle, conduce to make them choose the right hand, yet, will they rather use the left ...". The same argument was later put forward by Broca (see Harris, 1991 p.9) and by Hertz (1960 p.91).

Although I do not think Amar Klar (1996c) was the first person to put forward the data showing that grandparents have an influence on the handedness of children, Klar certainly made the point clearly and forcibly. Klar's data are not entirely convincing though as he has to rely on data from Rife (1940) as a control group, which is less than satisfactory. I therefore present here previously unpublished data from the two surveys of Cambridge undergraduates described by McManus (1985a), and called ICM1(propositi) and ICM2 (propositi). In each case the analysis looks at all individuals in the family (i.e. propositi and siblings), and is restricted to families in which both parents are right-handed.

	ICM2-propositi		ICM1-propositi	
	Grandparents both right-handed	One or more left-handed grandparents	Grandparents both right-handed	One or more left-handed grandparents
Right-handed	688	119	2166	156
Left-handed	80	22	285	43
Per cent left-handed (Total)	**10.42%** (768)	**15.60%** (141)	**11.63%** (2451)	**21.61%** (199)

In both studies the proportion of left-handed offspring is higher if there is a grandparent who is left-handed, than if all grandparents are right-handed (ICM1: Chi-square = 16.90, 1 df, p<.001), ICM2: Chi-square = 3.216, 1 df, p=.073), the combined result being highly significant (chi-square = 20.12, 2 df, p<<.001).

☞WWW☜ 7:22

Although I have presented the argument in its strong form, whereby *all* left-handedness is pathological, the argument also applies in a weaker form in which a minority of people have a genetic or other tendency to be left-handed – unilateral cerebral trauma which is as likely to occur in the right as the left hemisphere will still result in an increased rate of left-handedness. The argument was first put forward by Satz (1972); see also Satz, Baymur, & Van der Vlugt, 1979, Silva & Satz, 1979, and Soper & Satz, 1984.

☞WWW☜ 7:23

Before finding out about the National Child Development Study, I spent several fruitless months trying to test the idea by obtaining data from the maternity hospital where as a medical student I had done my obstetrics. Despite the hospital having a sophisticated computer system which would have allowed babies to be followed up at the age of five years, when their handedness would be known, permission was refused on what was called 'ethical grounds'. It was argued that even by writing from the maternity hospital and asking if a child was left-handed, I might be implying, if they were, that the child's obstetric care had been sub-standard, and clearly that would have to be unethical. Although ethical committees in medical research have helped prevent much of the scandalous maltreatment of patients in scientific research that were reported so vividly by Pappworth (8478 /d) in his book *Human guinea pigs*, they also seem to provide an opportunity for people with a host of other less acceptable motivations to prevent research which, for what ever reason, they would prefer not to be done. The vagaries of ethical committees are well seen in the fact that the same research project can be accepted by many ethical committees as satisfactory whereas they are rejected by other committees as unethical (Alberti, 2000). Something has to be wrong.

The ESRC's Research Data Archive at the University of Essex is now the UK Data Archive (www.data-archive.ac.uk).

Although the total sample in the NCDS was over 16,000, information on handedness and/or both complications were only available for the still very substantial sample of over 11,000 individuals. For full details see McManus (1981 Chapter 3).

The NCDS data also showed something else which I have subsequently undermine very many other theories which suggest that handedness might somehow be environmental in whatever form. Epidemiologists have found in general that there are few stressors or noxious events which do not occur more frequently in individuals from the lower social classes (IV and V in the British Registrar-General's system) than in the higher social classes (I and II). And yet in the NCDS it is very clear that there is simply no association between left-handedness and social class (McManus, 1981), producing serious problems for many possible environmental hypotheses about the origin of left-handedness.

Despite my general scepticism that pathological left-handedness can explain all or even a large number of cases of left-handedness, it nevertheless is still possible that pathological factors account for a small minority of cases of left-handedness. The elegant analysis of Bishop (1984c) suggests that perhaps one in twenty left-handers (*i.e.* about one in two hundred of the population as a whole) may be left-handed as a result of pathological factors.

☞WWW☜ 7:24

Given what I was saying earlier about the difficulty of deciding whether children at this age are right or left handed, it might be that I simply wrong in saying one is right handed and the other left-handed. Franziska is very consistent in her use of the left hand, transferring spoons and other things from the right to the left hand. Anna however is somewhat more variable. Of course by the time the book is published we should know for certain...

There has always been fascination, even at the lay level, in the difference of handedness of identical twin pairs. As a recent example, consider the question in *The Guardian*'s *Notes and Queries* section, where someone asked, “I have identical four-year old twin girls, but one seems to be left- while the other is right-handed. Can anyone explain this?”. As always in such columns, willingness to reply and knowledge bear little correlation, and the first reply was breathtaking for its ignorance and its ability dogmatically to impart potentially devastating information at a distance: “One will have her heart on the right-hand side of her chest (known as a 'cardiodexter'). All other asymmetries are likewise reversed.” (Brimicombe, 2000). One doesn't get much more wrong than that. Fortunately John Galloway wrote in a few weeks later with an accurate answer.

In our review of handedness in twins (McManus & Bryden, 1992c) we found that of 2,900 pairs of identical twins, 75.3% were R-R, 3.0% were L-L, and 21.7% were R-L. For 2589 pairs of non-identical twins, 75.4% were R-R, 2.0% were L-L, and 22.6% were R-L. Although the proportions of identical twins may look very similar to those expected by chance (a binomial distribution), this is not actually the case for identical twins, there only being .901 of the R-L cases expected as a result of chance. For non-identical twins the proportions are much more similar to chance expectation, .993 of expected R-L pairs. It should be noted that these figures are calculated separately for each study and then averaged, rather than being calculated on data aggregated across all studies (McManus & Bryden, 1992c). A recent meta-analysis of 28 studies of handedness in twins, with a total of 9,969 pairs, has confirmed that identical twin

pairs are more likely to be concordant (L-L or R-R) than are non-identical twin pairs (Sicotte, Woods, & Mazziotta, 1999k). The same meta-analysis also found a small but significant increased rate of left-handedness in twins compared with singletons, although the effect was identical in size in identical and non-identical twins.

A recent study has looked at a large number of twins and found some evidence that in discordant monozygotic twins the left-handed twin tends to be the first-born twin (James & Orlebeke, 2002). The mechanism for such a finding is still not clear, although it does not seem to be due to the first-born twin also being the heavier.

☞WWW☜ 7:26

My account of the genetics of handedness is written entirely from a personal point of view and I have, for obvious reasons, concentrated on my own genetic model (McManus, 1979f, McManus, 1984, McManus, 1985a). This is the point to say that there is one major alternative, the model of Marian Annett, which has been described in several places. The present model is Annett's third, the two earlier models (Annett, 1964, Annett, 1978) both failing for various reasons. The current model, in which the RS gene is additive, was first described by Annett and Kilshaw (1983b). For recent reviews see the papers by Annett (1995e, 1996d, 1998j), and her recent book (Annett, 2002b). This is not the place to go into my criticisms of the model, but an account of the various differences between us can be found in several places (McManus, 1985b, McManus, 1991c, McManus & Bryden, 1992c, McManus, Shergill, & Bryden, 1993a), and will also appear in a review in *Cortex* by me of the 2002 book.

☞WWW☜ 7:27

Essentially the calculations for twins are those of a binomial in which the probability of being left-handed is 0, 0.25 and 0.5 for the DD, DC and CC genotypes. As a result 0, 3/8 or 1/2 of the pairs are discordant. However *DD*, *DC*, and *CC* are not equally common in the population. If 10% of people are left-handed then 20% of the gene-pool must consist of *C* alleles and 80% of D alleles. Therefore at 64% of people are *DD*, 32% are *DC* and 4% are *CC*. Therefore amongst monozygotic twins, 83.0% of pairs will both be right-handed, 3.0% will both be left-handed, and 14.0% will be discordant, one being right-handed and the other left-handed.

On a similar basis, if 10% of the population is left-handed then left-handedness will occur in 7.8% of the children of two right-handed parents, 18.9% of the children of one right and one left-handed parent, and 30.0% of the children of two left-handed parents.

☞WWW☜ 7:28

There are several people who have thought seriously about the issue of finding the genes responsible for handedness, and a recent review has emphasised the low power of many of the approaches (Van Agtmael, Forrest, & Williamson, 2001). Amar Klar (1996c) and Tim Crow (1998k) have also looked in detail for the gene, although my personal feeling is that they are limited by either the wrong genetic model in Klar's case, or searching primarily on the X chromosome in Crow's case. Part of the problem in searching for a gene, at least if additive models such as my own and Annett's are correct, is the relatively low power of conventional family studies (Van Agtmael, Forrest, & Williamson, 2001). Over the years I have tried with

colleagues to get research funding to look for the gene for left-handedness, and invariably the grant has been turned down because expert referees who are geneticists say, *ex cathedra*, that it is obvious that handedness must be cultural rather than genetic. Such are the problems of peer review by peers who are not experts in the field.

☞WWW☜ 7:30

A similar phenomenon to that found in autism (McManus et al., 1992,Cornish & McManus, 1996) has also been found in fragile-X syndrome, in which the symptoms often show a similarity to those found in autism (Cornish, Pigram, & Shaw, 1997).

Studies of apraxia (see chapter 8), in which patients lose the ability to make skilled movements with both hands after damage to one half of the brain, typically the left, usually assume that whatever is responsible for praxis, that is skilled motor actions, is also responsible for handedness. That assumption is however becoming less likely with the identification of several right-handed patients in whom there is damage to the *right* hemisphere and yet they show a loss of skill with the right hand (Rapscak, Gonzalez-Rothi, & Heilman, 1987, Marchetti & Della Sala, 1997, Raymer et al., 1999). The implication is that something to do with hand *preference* is in the left hemisphere (or, at least, is controlling the right side of the body), whereas something to do specifically with *skilled* hand movements is in the right hemisphere. Since these patients describe themselves as right-handed and use the right hand preferentially for skilled activities, it seems that preference has to be prior to skill. Detailed analyses of brain activity during movements of the right hand, the left hand, and both hands in a bimanual task, suggest that the supplementary motor cortex is specifically involved in the bimanual tasks, and is in the left hemisphere in right-handers (Jäncke et al., 2000). The few anomalous cases described above may well be individuals in whom the supplementary motor cortex is in the right hemisphere, impairing certain skilled actions, but the mechanism for preference still allows the right hand to be dominant; the prediction would be that they are the DC or CC genotype.

☞WWW☜ 7:31

This is the case of Pieroccini (1903), reported by Hécaen and de Ajuriaguerra (1964d) who do not give any further reference. I also am sure that about twenty years ago I also saw a similar phenomenon reported in children with arm defects due to thalidomide but am unable any longer to find the reference.

Peters, M. (E-mail communication, 2000). I am grateful to Michael and Anne Peters for telling me this anecdote and allowing me to repeat it here. A not dissimilar case is that described by Brugger *et al* (2000l) in which a woman born without forelimbs nevertheless ate using a ring attached to her right upper arm, steered an electric wheelchair with her right upper arm, and in general could be described as 'right-handed'.

If handedness is primarily a preference rather than a skill difference then other stories can also be told about its possible neural origins. For instance, one of the great ignored areas of the brain is the cerebellum, the 'little brain', found at the back of the head below the cerebral hemispheres and presumed in most introductory textbooks not to do much of any great intellectual sophistication. That may be, but in recent years it has begun to be rehabilitated as it has become apparent that the cerebellum has as many neurones as the cerebral cortex, and

that damage to it can affect a range of high level functions. So certain were researchers at one time that the cerebellum did little of interest that they did not even bother to include it in the field of view looked at by PET scanners. Occasionally, usually due to luck more than anything else, the cerebellum was included in the images and to the horror of many researchers it was found to be active in complex cognitive tasks, a finding that has since been replicated in better machines which could visualise the cerebellum properly. Why should this matter for handedness? Mainly because there are strong suggestions that one of the areas which is abnormal in autism is the cerebellum, and that abnormalities of the cerebellum are associated with atypical handedness (McManus & Cornish, 1997).

☞WWW☜ 7:32

The asymmetries are in the nigrostriatal system, of which the substantia nigra is in the brain stem, but the corpus striatum is not. The direction of rotation is towards the side opposite to that with the higher dopamine level (Glick, 1983). An intriguing finding is that although Glick assumed originally that there was a 50:50 mixture of right and left turning animals, a review of over 600 rats who had taken part in a number of studies found that 55% turned to the right, a significant difference from 50% (p.18).

☞WWW☜ 7:33

In the studies (Schaeffer, 1928; see Ludwig (1932 pp.327-330.), 57% of people turned to the right and 43% to the left, the size of the circles being surprisingly small, a diameter of about 18 metres when walking or swimming, and about 50 metres when driving. Ludwig speculates that one side is somewhat stronger than the other, and that the difference is accentuated as the person becomes tired, when walking or swimming (but not driving), accounting for the ever tightening spiral. Schaeffer (1931) also carried out studies of protozoa and found that in the majority of cases they spiralled to the right.Bracha et al., 1987. Slight turning tendencies can also be recognised in subjects wearing a backpack attached to a set of detectors, and suggest that slight noises to one side, or carrying a heavy object on one side can cause veering (Millar, 1999). A similar tendency of right handers to turn to the right can be seen in the stepping test used by Previc and Saucedo (Previc & Saucedo, 1992).

Although it is possible that turning tendencies might underlie handedness, there is the potential problem that when reaching out with the right hand the turn is anti-clockwise, whereas the spontaneous direction for turning for right-handers is clockwise. The difficulty is not however insurmountable, and may reflect differences in the shoulder girdle and the pelvic girdle in their role in balance and movement.

☞WWW☜ 7:34

Lauren Harris, in an imaginative and scholarly reconstruction of Darwin's possible thinking, concludes that Darwin would probably have followed Ogle and Ferrier in being sympathetic to Broca's finding (Harris, 2000 pp.157-160).

Chapter 8: Hypernotes

☞WWW☜ 8:1

There are three pictures side by side in Debré (1998l), and in each Pasteur's left hand lies in the identical position, presumably placed there not by Pasteur himself but by a helper.

☞WWW☜ 8:3

Mach described the fit as ‘apoplectic’ (Mach, 1914 p.175), although probably little weight should be put on that, any more than the description of Pasteur’s stroke as a ‘haemorrhage’ – diagnostic methods were far from sophisticated at the time, and is still difficult clinically without the help of a CT scanner. Both Mach and Pasteur are typical in their description of the absence of any pain or other awareness inside the head while the brain damage was occurring. Neurosurgeons routinely cut and manipulate the exposed brain of conscious patients without it being anaesthetised and without the patients being aware of it.

Mach had extremely limited recovery of his right hand: “Over the flexors of this hand I have acquired a very slight control, but over the extensors none at all” Mach, 1914 p.176.

☞WWW☜ 8:4

Although Scott himself said he was born on August 15th, 1771, a recent biographer has suggested that he was actually born in 1770 (Anderson, 1976c). I have used Scott's own date here.

Watson's presence on the boat journey to Scotland is described in his own obituary (Anonymous, 1882), and also by Scott's biographers (Sutherland, 1995 p.354), although in one he is erroneously called James Watson, presumably a confusion with Captain James Watson, R.N (Johnson, 1970 p.1267). Watson, apparently nicknamed 'the physician of the novelists' (MacNulty, 1933) seems to keep appearing throughout the present book, rather like Woody Allen's *Zelig*, often where the action is but never quite seeming to be part of the big plot. Although some authors have apparently suggested that Watson continued to Abbotsford with Scott, that does not seem to be the case (MacNulty, 1933) and he returned to London after Scott was safely arrived at Leith (Lockhart, 1896 p.751).

Anderson (1976c) has speculated that Scott may had been disease of the right internal carotid artery, which would in part account for the fluctuating course of the illness. On a tiny but important detail, it is worth nothing that Scott was right handed, a portrait sketch by Sir Edwin Landseer in the National Portrait Gallery showing Scott writing with his right hand.

The full post-mortem report for Scott can be found in MacNalty (MacNulty, 1933).

Illiterate patients also have the same patterns on dichotic testing (Castro & Morais, 1987); see also Lecours *et al* (1988a). The question of illiteracy and aphasia was raised by Macdonald Critchley in 1956 (Lecours, 1980 p.600), although Eduard Weber (1806-1871) was apparently the first to ask about the issue (Coppens, Parente, & Lecours, 1998 p.191).

The full Hippocratic text, from *The Coan prognosis*, is, "When a convulsion is attended by prolonged aphasia, it is a bad sign; if such aphasia be short-lived, it is associated either with paralysis of the tongue, or of the arm and right side of the body. The trouble is ended by the sudden passage of a large quantity of urine at one time"(Chadwick & Mann, 1950 p.248). The last sentence about the large quantity of urine seems utterly mysterious from a modern point of view and must make one wonder how much trust can be placed in the first sentence. Hippocrates also described a case history of a pregnant woman with a fever (*Epidemics I, Case XIII*: Howard & Hatfield, 1987, p.8):

> "Pain in the neck and in the head and in the region of the right collar-bone. Quickly she lost her power of speech, the right arm was paralysed, with a convulsion after the manner of a stroke... Fourth day. Her speech was recovered but was indistinct...".

Case of language loss and right-sided motor problems were described as early as 1830, for instance the patient Robert Delany, described by Osborne (1834b),

> "... admitted into Sir Patrick Dun's Hospital, 2nd March 1830, with paralysis of the right and leg, in consequence of an apoplectic seizure, which took place above a month previously. He shewed by his actions, that he perfectly comprehended every thing that was said to him. When asked a question, he always endeavoured to give an answer, but could only say *bon te utt* and a few other monosyllables, but no words of more syllables."

Goethe's *Wilhelm Meister* (Carlyle, 1874) was translated in 1824 by Thomas Carlyle, who would later publish his own evolutionary theory of the origin of right-handedness (the 'shield theory' – see chapter 10). Goethe's description, to some extent like that of Jeanette Winterson, has the detail which suggests the account is based on a strong carefully observed personal experience. It has a careful description of the problems of aphasia for patients and their relatives:

> "We had to guess at everything that he required; for he never could pronounce the word that he intended. There were times when this was dreadfully afflicting to us; he would require expressly to be left alone with me; with earnest gestures, he would signify that eery one should go away; and when we saw ourselves alone, he could not speak the word he meant. His impatience mounted to the highest pitch: his situation touched me to the inmost heart. Thus much seemed certain: he had something which he wished to tell me, which especially concerned my interest. What longing did I feel to know it! At other times I could discover all things in his eyes: but now it was n vain. Even his eyes no longer spoke. Only this was clear; he wanted nothing, he desired nothing; he was striving to discover something to me, which unhappily I did not learn. His malady revisited him; he grew entirely inactive, incapable of motion, and a short time afterwards he died."

Charles Dickens has also been claimed to have noticed the association of language dominance and right sided paralysis. A brief article in the *British Medical Journal* after the author's death, "he anticipated the clinical researches of M. Dax, Broca and Hughlings Jackson, in the connection of right hemiplegia with aphasia (*vide Dombey and Son*, for the last illness of Mrs. Skewton)." (Anonymous, 1870a). The story was also repeated in a biography that Dickens had anticipated "connection of right hemiplegia with asphasia [*sic*]"

(Anonymous, 1870b). However while in chapter 37 Mrs Skewton was undoubtedly paralysed, and at times unable to talk, and when the use of her right hand returned, she was able to write, there is no clear description of this being a hemiplegia, rather than a bilateral paralysis, and the final illness in chapter 41 makes no mention of lateralised symptoms.

☞WWW☜ 8:7

The problem of how many patients would be needed to discover the association is straightforward. Think about the fact that three-quarters of the cases of speech loss have their brain damage on the left side. If language showed no particular association with one side or other of the brain then one would expect 50% to have damage on the left side[38]. How many cases would one need to be confident that the true proportion was indeed 75% and not 50%? It is a bit like those problems so beloved of statistics teachers. I have two coins. One is fair, so that heads and tails are equally likely. The other is biassed, and I have doctored it so that three-quarters of the time it comes down heads. I take one coin from my pocket and toss it. Which is it? It comes down heads. Which coin is it likely to be? Who can say? I toss it again, and again after that, and each time it comes down heads. On the fourth time it comes down tails. Three heads out of four tosses. Does that mean it must be the biassed coin? Hardly. If I toss an ordinary, fair, unbiassed coin four times then on a quarter of occasions I will get three heads and on one in sixteen times I will even get four heads. Using what in statistics is known as a 'power calculation', then in order to be 90% certain of finding evidence that the coin is biassed or not one would need to toss it about 40 times[39].

At some point in a statistical calculation the evidence forces one to reject what statisticians call the null hypothesis. I am always reminded of that scene at the beginning of Tom Stoppard's *Rosencrantz and Guildenstern are dead*, when, despite the fact that normally, "a coin showed heads about as often as it showed tails", that morning, "Ninety-two coins spun consecutively have come down heads ninety-two consecutive times"; something was clearly wrong, different, untoward. The probability of a fair coin showing ninety-two consecutive heads is 2.02×10^{-28}. Guildenstern comments, "A weaker man might be moved to re-examine his faith, if nothing else at least in the law of probability".

Statistical analysis does make one wonder about the work of Dax, who reported forty patients, *not one* of whom had brain damage on the right side. It is all a little suspiciously too good, and reminds one of R.A. Fisher's comment that the 3:1 ratios reported by Gregor Mendel in his famous studies on pea-plants were far too good to be true (see Pilgrim, 1986). In comparison, Broca was extremely cautious, commenting after finding that eight cases all had left sided lesions, "I do not dare to draw any conclusion from this and am waiting for new data" (Schiller, 1979a p.194).

---

[38] Throughout these calculations the assumption is made that right and left sided brain damage is equally likely. To a first approximation it is – see for instance Table 21 of McManus (1985a).

[39] Calculated using *Statpower*, two-tailed, one-sample test of a proportion, null hypothesis P=.5, alternative hypothesis P=.75, alpha=.05, power=.9. The actual N required is 39.

☞WWW☜ 8:8

The case was reported by Dr Prevost, the Head Physician from the Geneva Hospital, at a meeting of the Physical and Natural History Society in London on Jan 20th, 1876 (Anonymous., 1876). Prevost had been in London in 1868 when he saw an aphasic patient with Hughlings Jackson and advised Jackson to ask if the patient was left-handed. – see Jackson(1868).

Broca himself introduced "the special name", 'aphemie' in his 1861 paper; the term aphemia was first used in English in 1864. The modern French term 'aphasie' was introduced by Trousseau in 1865, since 'aphemie' in Greek meant 'infamy', "which was clearly inappropriate", and after consulting a Greek Hellenist he introduced the term 'aphasie' (Hécaen & Dubois, 1969a p.193); the term 'aphasia' was first used in English in 1867 (Schiller, 1979a pp, 178, 200). As Schiller points out, the term 'Broca's aphasia' is a "bastard term".

☞WWW☜ 8:9

Although this syndrome is typically called Wernicke's aphasia, and Wernicke did indeed produce a good description in 1874 (see Eggert, 1977), a few years earlier Bastian (1869) had described what has been called Jargon Aphasia, and is essentially the same condition (Christman & Buckingham, 1991).

The paper by Osborne (1834b) is full of fascinating details about the patient. The lesion was probably in the left half of the brain since "when he put out his tongue, it was protruded towards the right".

Osborne's case also appeared in Aldous Huxley's *Point counter point* (1996 p.391):

> "Philip was dining alone. In front of his plate half a bottle of claret and the water jug propped up an open volume. ... The book was Bastian's *On the brain*. ... Halfway through the fish, he came upon the case of the Irishman who had suffered from paraphasia ... The physician had asked the patient to read aloud a paragraph from the statutes of Trinity College, Dublin. ... Marvellous! Philip said to himself ... What style! What majestic beauty! The richness and sonority of the opening phrase! 'An the bee-what in the tee-mother of the trothodoodoo' ".

The book was actually entitled *The brain as an organ of mind* 1880. Neither Bastian nor Huxley copy the original exactly, as is shown in the misattribution of the statutes, and other minor errors (McManus, 2001a).

☞WWW☜ 8:10

Crampton (1833a, 1833b) recognises that although many of the words used are erroneous, they are often not random: "Sometimes (as in the last instance) one could trace the association of ideas through which he was led to the misnomer: stirabout and buttermilk being associated in the mind of every man of his class in this country; but in the greater number of instances, no such association could be traced..."(p.209).

☞WWW☜ 8:11

For good reviews of the different types of aphasia types see Damasio (1992d) and Code (1991e).

The study of Indefrey *et al* (1998a), was unpublished but reported by Hagoort *et al* (1999h).

There is far from universal agreement on the precise localisation of Broca's area, Broca himself describing what is now called Brodmann's area 44, with other workers describing areas 44 and 45, or 44, 45 and 47 (Uylings et al., 1999). The area responsible for grammatical analysis seems to overlap a part of area 45.

☞WWW☜ 8:13

The emphasis in the quotation from Jackson (1874a) is present in the original. Jackson particularly attributes the recognition of objects to the posterior part of the right hemisphere as opposed to linguistic functions which are in the anterior part of the left hemisphere. Later in 1876 he also describes the right hemisphere as the seat of “visual ideation” or “imperception” (1876).

☞WWW☜ 8:14

There is also a left-hemisphere (or more precisely, a verbal or symbolic) way of solving the problem as well. Since a cube is three-dimensional and the sides are at right-angles to one another, that is they are orthogonal, then each dimension must have two sides, one at each end, and hence there must be three times two equals six sides altogether. A corner is at the intersection of all three dimensions, and the three lines making the corner can each come either from a positive or a negative direction. There are eight possible combinations of three positives and negatives and hence eight corners. And so on. The nice thing about the verbal approach is that is generalised very easily to a four-dimensional cube, a hypercube; or even one with five, six or however many dimensions. Not many people can visualise them.

☞WWW☜ 8:15

An excellent introduction to the problems of agnosia can be found in the detailed case history of 'John' by Humphreys and Riddoch (1987f). 'To see but not to see' is a superb summary of the problem.

The picture of Einstein is difficult to see in part because it is printed upside down, a feature I have exploited here to reduce the risk that the reader sees the portrait too quickly. There are probably specialised centres in the brain for face perception, some in the right hemisphere. One of the very interesting problems of face perception is why it is so difficult to see faces upside down (Bruce & Young, 1998 pp.158-160).

☞WWW☜ 8:16

I particularly relish Dr P's comment that “It would contain its contents” (Sacks, 1985 p.13). One could imagine Philip in *Point counterpoint* waxing lyrical over the phrase. In a footnote Sacks also explains that, “Later, by accident, he got it on, and exclaimed, 'My God, it's a glove!'”. The case history also makes it clear that Dr P shows left side neglect.

☞WWW☜ 8:17

Inability to dress herself properly was one of the symptoms reported in Hughlings Jackson's 1876) early case of right hemisphere damage. See the historical review by Hécaen and Albert (1978 pp.106-7) for a discussion of whether dressing apraxia is a separate syndrome in its own right.

☞WWW☜ 8:18

That the musical quality of speech is affected differently by the two hemispheres can be seen on Wada testing, where anaesthetisation of the left hemisphere prevents a patient from speaking although they can still sing (and can even sing the words of songs which they are unable to speak, Gordon & Bogen, 1974). Conversely the ability to sing though is removed after anaesthetisation of the right hemisphere, although words can still be spoken normally.

☞WWW☜ 8:20

An additional intriguing aspect of these drawings is that pre-operatively P.S. has drawn the cube as most right-handers would do, so that the front of the cube is to the left-hand side, with the back sloping away to the right. Post-operatively though the drawing by the left hand now seems to be mirror-reversed, the front surface of the cube being to the right of the drawing, with the other sides sloping away to the left. It is a mirror-image in other words, which is what one might expect the left hand to do.

One does not even need to damage the entire corpus callosum to find the pattern of deficit seen in P.S. Heilman *et al* (1984d) described a similar result in a patient with a localised area of damage to the callosum due to an aneurysm of the anterior communicating artery (see Watson *et al* (1985c) for details of the lesion).

☞WWW☜ 8:21

The fourteen right-handed patients were receiving ECT as part of the treatment of manic-depression or schizophrenia. Although the authors comment that this may have meant the answers they gave were not typical of normal thought, they do emphasise that in the control condition all of the subjects answered the questions properly in a logical fashion (Deglin & Kinsbourne, 1996).

☞WWW☜ 8:23

For further details on Dickens see my recent paper in *The Lancet* (McManus, 2001b).

One possible diagnosis for Dickens' heart disease is atrial fibrillation, which would be helped by the digitalis he was prescribed, and can also be responsible for small emboli which can affect brain functioning if they block the circulation.

Watson was undoubtedly one of the premier neurologists of the day, the fifth edition of his textbook of 1871 showing he was well up to date on recent work, particularly in its copious citation of the works of Hughlings Jackson then only just gaining his reputation. Jackson was

later to repay the compliment, in his 1878 paper referring to Watson as one of those who had particularly contributed to the study of aphasia, and particularly referring to a case in which Watson clearly distinguished automatic and propositional speech (Jackson, 1878). Given Jackson's love of the novels of Charles Dickens (Critchley & Critchley, 1998 p.176), and his interest in neuro-ophthalmology, it is surely one of the great lost opportunities in neurology, that Watson did not ask Jackson to see Dickens, when perhaps he might have described his symptoms of neglect.

☞WWW☜ 8:24

The first, very brief, mention of neglect was by Hughlings Jackson (1876, Halligan & Marshall, 1993), who at that time was a young neurologist with an interest in ophthalmology, working in London (Critchley & Critchley, 1998).

Neglect dyslexia was itself hardly studied until about two decades ago, Ellis *et al* (1993 p.233) pointing out that until the mid-1980s almost all accounts of neglect dyslexia treated it as just being part of neglect in general.

A rarer error that can occur in neglect dyslexia is that letters are added, as in LOVE being read as GLOVE (Behrmann, 1994d).

An interesting question for interpreting Charles Dickens' symptoms as neglect dyslexia is that most patients with neglect dyslexia do not seem to have insight into their problem, whereas Dickens clearly did, or he could not have described it so accurately to Forster. However it is clear that most patients do have some awareness of what the proper length of the word should be, and adjust their incorrect readings to take that into account. Dickens was however describing a problem in reading the names of shops, that is, proper names, and for these it is probable that from long experience he would have known what they should be. To give a modern example, if one regularly walks past a shop and then one day sees it is called BLOOMSBURYS rather than SAINSBURYS or PIEBALDS rather than McDONALDS, despite the logos, the layout, and the things sold all being the same as usual, then something may well strike one as odd.

☞WWW☜ 8:25

Whether neglect dyslexia and the more common generalised visuo-spatial neglect are separate, dissociable conditions, or whether neglect dyslexia usually also involves generalised neglect is not at all clear at present (Behrmann, 1994d).

The details of Fellini's illness are described by Chandler (1996e), and by Cantagallo and Della Sala (1998m), who had permission from Fellini's sister and the Fellini Foundation to report the clinical details of the case. That Fellini had both coronary artery disease and cerebro-vascular disease is perhaps not surprising given the strength of his family history:

> "Heart trouble and strokes run in my family. My mother's brother had a stroke and couldn't speak. My father's brother, my own brother, Riccardo -- all of them died of these problems...".Chandler, 1996e p.365

The cerebral lesion, at the junction of the temporal and the parietal lobes, was probably due to a thrombosis of a branch of the middle cerebral artery.

☞WWW☜ 8:26

Neglect seems to occur much more frequently after right brain damage than left (Bowen, McKenna, & Tallis, 1999). The situation is though complicated by the fact that within a few days of a stroke neglect is very common (60-70%) in both right and left brain damaged patients (Stone et al., 1991), but that neglect following left brain damage rapidly resolves, resulting in what Ian Robertson has called 'The paradox of neglect' (Robertson, 1993). Occasional examples of right-sided neglect do seem to occur particularly in left-handed patients (e.g. Caramazza & Hillis, 1990).

Although traditionally neglect has been described in terms of visual neglect, there is recent work suggesting that there is also neglect of the left side of auditory space, which is also associated with right parietal lesions (Bellman, Meuli, & Clarke, 2001; Marshall, 2001).

☞WWW☜ 8:27

The meaning of 'Vai a menga' is less than clear, and the translation by Cantagallo and Della Salla (1998m) of 'Forget it!' is perhaps too polite. 'Menga' is not a word in Italian, and one possible explanation is that Fellini was trying to write 'Vai a ramengo' – Go to hell! – and that his left neglect meant that he omitted to write the first two letters of 'ramengo'. Why he also put an 'a' on the end instead of an 'o' is not clear but may be a carryover from 'meta'. Interestingly 'ramengo' probably comes from 'ramingo', to wander, which is precisely what the half-way mark has done.

☞WWW☜ 8:28

In a famous description of patients neglected one half of space in memory, two patients who lived in Milan were asked to imagine they were standing in the Piazza del Duomo, on the side directly opposite the Cathedral, the Duomo. Asked what buildings could be seen, they named only those down the right hand side of the Piazza. When next asked to imagine they were standing on the steps of the Duomo looking out at the Piazza they then correctly described all the buildings down what was then the right hand side; in other words the ones neglected previously (Bisiach & Luzzatti, 1978).

☞WWW☜ 8:30

The division in neglect is often not precisely at the middle, and more detailed studies suggest that there is a gradient of neglect which gets more severe the further one moves into the left half of the object. For an example see Behrmann 1994d.

That the problem in neglect is one of attention and not merely one of sensation is seen from the phenomenon of extinction. If a simple object is placed on the right hand side it can be seen, and likewise if an object is placed just on the left-hand side it can be seen. But if the two are presented at the same time then the patient only reports seeing the one on the right, the left-hand one being neglected. This provides a simple bedside test, the doctor asking the patient to close their eyes and say when they feel their hands being touched. When the right hand is touched the patient reports it, as they do when the left hand is touched. However when both are touched at the same time, only the touch on the right hand is reported.

The stroke of the 59 year old patient was a large lesion in the right temporo-parietal area, and had occurred two years previously (Marshall & Halligan, 1993).

☞WWW☜ 8:31

I had hoped to include in the book the four very fine self-portraits by Anton Räderscheidt, who had a right-sided stroke with neglect, and in which not only can the neglect be seen but also visible is his recovery over a period of many months. They can be seen in colour in Wurtz (1982b). Unfortunately the copyright holders would not allow them to be reproduced in monochrome. Other examples of neglect in artists, in addition to Räderscheidt and Greenshields (Halligan & Marshall, 1997), are Lovis Corinth (Parkin, 1996 Cover illustration), and several who have not been named but for whom detailed analyses have been carried out (Marsh & Philwin, 1987, Schnider et al., 1993, Vigouroux, Bonnefoi, & Khalil, 1990).

☞WWW☜ 8:32

Anosognosia was apparently first described by Seneca the younger, the first century AD Roman philosopher, in a letter:

> "You know that Harpastes, my wife's fatuous companion, has remained in my home as an inherited burden ... This foolish woman has suddenly lost her sight. Incredible as it might appear, what I am going to tell you is true: She does not know she is blind. Therefore, again and again she asks her guardian to take her elsewhere. She claims that my home is dark." (Prigatano, 1996 p.81).

Anosognosia is surprisingly frequent, being found in 15% of a series of patients with a first stroke (Ghika et al., 1999), and 30% of patients with right hemisphere strokes (Stone, Halligan, & Greenwood, 1993)..

In quoting Fellini's description of his left arm I have changed "asparagi" to "asparagus", which reads slightly better.

Although Dickens did not have a strict anosognosia, not having a hemiplegia, there is nevertheless a strong case that he showed denial of a whole range of bodily symptoms McManus, 2001b.

The Romanian patient had several other symptoms of parietal lobe disorder, including a left-sided neglect (Façon, Wertheim, & Mestes, 1960).

Although it has been conventional for nearly a hundred years to regard neglect as a symptom of parietal lobe disorder, it was only in 2001 that it was realised that was not the case. Many patients with neglect show visual field disorders, and that seems to have misled researchers. Patients with a pure neglect and no field disorder have lesions adjacent to the parietal lobe, in the right superior temporal cortex, whereas those with field disorders do indeed show parietal lobe lesions, probably due to damage to the underlying optic radiation (Graziano, 2001; Karnath, Ferber, & Himmelbach, 2001). Although an extremely interesting result which in particular resolves the problem of reconciling human data with experimental lesion studies in monkeys, in practice it gives little serious difficulty in regarding the parietal

lobe as the seat of these disorders since the area is immediately contiguous to the parietal lobe and many patients have quite large lesions (Fellini for instance being one).

☞WWW☜ 8:34

The lateralisation of olfaction is made more complicated because the flow of the right and left nostrils tends to alternate over a cycle of several hours, first one nostril and then the other taking in more air. The nostril with the greater flow rate is more sensitive to odorants of different sorption (Sobel et al., 1999). Intriguingly there is a long tradition in Yoga of breathing in specifically through one nostril or the other in order to achieve different meditative states (Gore, 1991), and a suggestion that breathing through just one nostril can enhance right or left hemispheric modes of processing (Morris, 1998).

The precise nature of the deficit in Gourmand Syndrome (Regard & Landis, 1997), is controversial, perhaps having obsessional features, or being related to a failure of impulse control (Regard & Landis, 1998) or to a heightened drive associated with hypomania (Cockrell, 1998).

A recurrent finding in the literature on the lateralisation of music is that musicians and non-musicians differ in the hemispheres they use for tasks, difficult melodies being recognised more easily in the right hemisphere of non-musicians but the left hemisphere of experienced musicians (Messerli et al., 1995), suggesting that there is a sense in which training literally helps in recognising the 'language' of music, a left hemisphere process. See also Damásio and Damásio (1977a), Bever (1974c), Fabbro *et al* (1990e), and Piro (1993c).

Rhythm is probably related to speech dominance rather than handedness (Ibbotson & Morton, 1981).

The situation for absolute pitch may be more complicated than was originally thought (Zatorre et al., 1998).

Although 'wine, women and song' always quoted in English with 'women' in the plural, the phrase is attributed to the Protestant theologian, Martin Luther, as “Wein, Weib und Gesang”, wine, *woman* and song; “Who loves not woman, wine, and song / Remains a fool his whole life long”.

In the study of sexual arousal in a scanner (Stoléru et al., 1999), we are told that the films were “tasteful with good actors” (Day, 1999), as one might hope in Paris, and that "a curtain was installed around the tomograph to ensure that the subject's privacy would be respected". For those who feel think that is all a bit too near the bone for a scientific study, such virtual sex is still far removed from the real thing which was managed by some intrepid Dutch researchers. Sex in a scanner was not easy as scanners are pretty small, being designed for single occupancy, and so the subjects were chosen to have "a small to average weight/height index”. (Schultz et al., 1999). The advent on the market of Viagra (sildenafil) was also a contributor to success as it allowed the men to maintain an erection long enough for the scanner to capture the image.

☞WWW☜ 8:35

In figure 14, it might be worried that the left hand side is more salient because in the West we are used to reading from left to right, and so our eyes tend to go to the left hand side of the page. It is a nice idea but probably wrong. Nicholls tested it by looking at a group of Hebrew students who read from right to left and he found exactly the same effect as in Western students who read from left to right (Nicholls & Bradshaw, 1999).

Although it is true that in complete pictures the balance point is to the left, it is somewhat disconcerting that in a more formal experimental setup that objects appear perceptually 'heavier' on the right hand side of the midline (McManus, Edmondson, & Rodger, 1985).

There is an interesting tendency for right-handers to prefer to sit on the right hand side of cinemas, presumably so that they attend better to the screen. The effect is also present in left-handers but somewhat reduced, although still in the same direction, suggesting that cerebral lateralisation is the cause (Karev, 2000).

Of almost 1000 people who were asked about figure 15, Jaynes (1976d p.120) says that about 80% of the right-handers chose the bottom face. However only 45% of an unknown proportion of left-handers (presumably about 10%) also did so, suggesting that a greater proportion of left-handers have reversed cerebral dominance for perceiving emotion. The faces are also reproduced by Paul (Paul, 1990 p.105) where the pictures have been modified and the statistics slightly altered as well. A more formal test has been produced by Levy *et al* (1983c); see also Harris and Snyder (1992e). It is possible that some of the effect may reflect scanning habits derived from language, one study suggesting that readers of Hebrew, Arabic and Urdu showed no tendency to choose the left-hand half, although neither did they tend to choose the right hand half, suggesting that perhaps both scanning and hemispheric specialisation are important (Eviatar, 1997). Another study found a somewhat different result, with readers of Urdu having a reversed pattern compared with readers of Hindi (Sakhuja et al., 2001).

☞WWW☜ 8:36

Although the crucial experiments are usually attributed to Kimura (1961d) and Bryden (1962c), earlier work was also done by Cherry (1953) and Broadbent (1954). For an excellent overview of dichotic listening see Bryden (1982c). It is commonly presumed that only dichotic techniques can reveal hemispheric effects. However there have been many monaural studies which have also found ear differences (Henry, 1979; Henry, 1983).

Dichotic listening tests have been bedevilled since their introduction by the fact that the subjects are aware of hearing different words on the two ears, and therefore they can choose to attend preferentially to one ear or the other. Kinsbourne (1975c) has argued that the laterality effects are principally the result of a swing in attention, activation of the left hemisphere in expectation of hearing words sending attention to the right side of space. That theory is probably rejected by the very elegant experiment of Bulman-Fleming and Bryden (1994e) in which right and left hemisphere effects are obtained simultaneously. Fused dichotic words also avoid the problem since although different stimuli are presented to the two ears they are so closely matched in time that the subject hears only a single word which perceptually is in the centre of the head; nevertheless the words on the right ear are heard

preferentially (Wexler & Halwes, 1983), and there is a close correlation with Wada testing for language dominance (Zatorre, 1989, Fernandes & Smith, 2000).

☞WWW☜ 8:38

Broca himself was aware of the theoretical possibility that there were some people who had language in the right hemisphere (and a left hemiplegia), and he acknowledged that,

> "Just as there are left-handers in whom the inherent pre-dominance of the motor activity of the right hemisphere confers a natural and irreversible pre-dominance to the activity of the left hand, so in the same way it is conceivable that there may be a certain number of people in whom the inherent predominance of the convolutions of the right hemisphere will reverse the order of the phenomena I have just described." (Broca, 1865; translation Hécaen & Piercy, 1956).

The sliding between handedness and right hemispheric language makes it look as if Broca is suggesting that the two are associated. However as Eling (1984e) has emphasised, that was not his meaning. Broca continuing,

> "But I don't want to conclude but there must be any agreement between these two categories of exception; because it doesn't seem necessary to me that the motor part and the intellectual part of each hemisphere must be associated, one with the other..." (my translation).

The emphasis in the quotation from Hughlings Jackson (1866) is in the original.

This idea that left-handers are the converse of right-handers has been variously called the mirror-reversal principle, the conjunction principle and Broca's rule (Harris, 1980, Harris, 1991). I have also used the term Dax's law (McManus, 1979f p.6.9;McManus, 1983), dating it back to Ogle (Ogle, 1871); the term was also used by Critchley (1964e). Quite who first enunciated the principle is not clear, although I think it is clear that neither of the Dax's was responsible. Although Broca has generally been cleared of the specific charge (Harris, 1991), there is little doubt that he was very sympathetic to the basic concept. Certainly the idea was common by 1866 and became the established norm for many years after (Harris, 1991).

☞WWW☜ 8:39

William James (James, 1890 vol I: p.39) was actually referring to the damage found in cases of aphasia, but I have substituted 'language' since that is what was to be inferred from the statement.

If one looks at the pattern of cases reported during the eighty or so years after Broca then it is clear that for a long while people were only publishing cases which fitted the scenario that the only patients with right hemisphere language were left-handers; See figure 6.1 in McManus (1979f) .

☞WWW☜ 8:40

Luria (1970c) was published in Russian in 1947 and not translated until 1970. The concept of latent sinistrality was however also invoked by Russell Brain, one of the leading British neurologists (Brain, 1945), and was clearly extant in the world scientific literature before that.

I criticised Luria's concept of left-handedness in a long, historical paper (McManus, 1983). I found great difficulty in getting the article published, one referee describing it as a character assassination. I was fortunate that Marcel Kinsbourne was exceedingly helpful in eventually getting it into print, and I continue to remain indebted to him for that assistance.

To my knowledge no formal evidence has ever been put forward that the signs of latent left handedness predicted crossed handedness and language dominance. I am reminded when thinking about latent left-handedness of the Freudian concept of latent homosexuality, and the old psychoanalytic joke about the only question is whether a client is homosexual or a latent homosexual, since no other category exists. Latent homosexuality and latent left-handedness were themselves explicitly linked by Fliess (Freud, 1985 p.296).

☞WWW☜ 8:43

To spell out the calculations precisely, the proportions of the four combinations of handedness and language, RL, RR, LR and LL will be 1:0:0:0 for DD, .5625:.1875: .1875:.0625 for DC and .25:.25:.25:.25 for CC. If 10% of the population is left-handed then .64 of the population are DD, .32 are DC and .04 are CC. The proportions of RL, RR, LR and LL are then .83:.07:.07:.03, making 7.77% of right-handers and 30.0% of left-handers have language in the right hemisphere.

☞WWW☜ 8:44

Despite the absolute numbers varying quite considerably according to the techniques used to assess the proportion of right and left language dominance, what was much more impressive was that the relationship between the proportion of right-handed language in right-handers and the proportion in left-handers was much more constant. That suggested that the differences between the different methods of assessment were more to do with definition and measurement error than they were to do with fundamental discrepancies (McManus, 1979f,McManus, 1985a).

Although I do not not discuss it in the book, there are probably systematic differences resulting from the study of patients with acute rather than chronic lesions, and that these may well result from many of the patients with chronic lesions no longer being aphasic due to recovery. That can be modelled by a simple extension whereby there are two language centres, which either can be both in the left hemisphere, both in the right hemisphere, or one in each hemisphere. Disruption of either centre by a stroke results in an acute aphasia. However if one centre remains intact, due to it being in the other hemisphere, then recovery can occur. The result is that the incidence of aphasia in chronic patients is far lower than in acute patients. For further details see McManus (1985a).

☞WWW☜ 8:45

Gardner was a forerunner of Wada, developing a slightly different technique, the injection of the local anaesthetic procaine directly into the brain itself; the technique though never really caught on (Harris & Snyder, 1997).

☞WWW☜ 8:46

Although I have implied that the carotid artery provides the blood supply to one hemisphere, to be more precise it is the internal carotid artery which supplies the anterior and middle cerebral arteries, which provide blood to the frontal, temporal and parietal lobes of the brain. The blood to the posterior cerebral arteries mostly comes from the vertebral arteries which are not affected by the Wada technique.

Although injection using a large needle directly ntot he carotid artery is a crude technique it was still being carried out while I was a house surgeon on a neurosurgical unit in the UK in 1975. Patients would be sent off to the X-ray unit and radiologists would stab away at their necks with a distressingly long needle until eventually they managed to put some dye and then some amytal into the carotid artery on that side. And then they would start on the other side. Nowadays a long, thin flexible catheter in inserted into the femoral artery, and then guided up into the internal carotid artery with X-ray monitoring.

Wada eventually became a neurosurgeon at the University of British Columbia in Vancouver, Canada becoming his adopted country.

☞WWW☜ 8:48

Despite its problems, the Wada test have provided many neuropsychological insights when used in patients about to undergo neurosurgery, as for instance in the demonstration that amytal produces a temporary unilateral neglect after injection into the right hemisphere but not the left hemisphere (Spiers et al., 1990), or that anosognosia occurs after right-sided injection (Carpenter et al., 1995). Wada himself had also noticed that patients reported left-right disorientation after left-sided injections (Snyder & Harris, 1997 p.25).

☞WWW☜ 8:49

The technology used in the new method of assessing language dominance had been in use in fetal medicine units for a while; I'd even seen it in action myself a year or so before I read of its use in understanding lateralisation, but still the idea did occur to me. The method was used in the fetal medicine unit to assess the blood flow through the brains of my daughters, who were still then *in utero*. Identical twins often suffer from the problem known as Identical Twin Transfusion Syndrome, in which the blood vessels of the two twins become interconnected in the placenta. Because the twins are genetically identical the blood vessels interconnect with abandon, and, if things go badly, the arteries of one twin can get connected to the veins of the other. The result is a chronic haemorrhage from one twin to the other. One becomes severely anaemic and becomes the smaller, while the gets all the blood from its co-twin, and becomes plethoric, bloated and big. Neither benefits either twin. The smaller twin suffers from starvation, whereas the blood in the larger twin can become so thick and viscous because of the red blood cells continually being added to it that it can slow down and even clot, with disastrous consequences. Ultrasound Doppler scanning allows one to measure the rate of flow off the blood in the middle cerebral artery of the fetus and check if it is moving quickly enough. In severe cases it flows slowly or even, during one phase of the cardiac cycle, it flows backwards. Fortunately neither was the case with my daughters.

Knecht's technique (Knecht et al., 2000) is highly reproducible (Knecht et al., 1998a) and also correlates well with the Wada test (Knecht et al., 1998b). Interestingly the proportion of right hemisphere dominant right-handed males (8/77 = 10.4%) was somewhat higher than that of right hemisphere dominant right-handed females (6/111=5.4%). Although the difference is not statistically significant, it is nevertheless much what might be expected.

Based on the figures given in Knecht et al (2000m)[40], The 95% confidence for the proportion of right-handers with right-hemisphere language dominance is 2.7% - 9.1%. For the left-handers the 95% confidence interval is 16.2% to 31.3%.

An important paper was also published in 1999 which used functional MRI (fMRI) to assess language dominance in individual normal right and left-handers (Pujol et al., 1999). Of 50 right-handers, 1 (2%) showed right-hemisphere activation, and of 50 left-handers, 9 (18%) showed bilateral or right hemisphere activation[41]. The 95% confidence intervals for right-handers are 0 to 5.9%, and for left-handers are 7.4 to 28.6%.

Knecht and his colleagues have also used their method to look at correlates between atypical language dominance (i.e. right-sided) and other aspects of behaviour (Knecht et al., 2001), such as linguistic ability, academic achievement, or artistic talent, although some of their measures, as of artistic ability, were somewhat limited in their power to detect such effects.

[40] Numbers derived from the table in figure 3, with the group with laterality coefficients between -25 and +25 equally divided between right and left-handers.

[41] Numbers based on the data in figure 2 on p.1039, right hemisphere dominance being based on a language laterality index of ≤ 0.

Chapter 9: Hypernotes

☞WWW☜ 9:1

Whether Ehud was actually a natural left-hander is very unclear, the original Hebrew having the sense of "a man with his right hand drawn up, contracted by accident or disease" (Moore, 1895 p.93), "of a kind that would seriously diminish the capability of a fighting man and make him seem to be harmless" (Soggin, 1987 p.50). Having said that, the same commentators also point out that the same term is used later for the 700 left-handers in the army who were said to be particularly skilled.

The date of 1200 BC is very approximate. The *Encyclopaedia Judaica* comments, "Insufficient chronological evidence makes it difficult for the historian to reconstruct the dates of the events recounted in Judges. ... No less vague is the background of the deliverance story of Ehud son of Gera and the period in which it took place" (Anonymous., 1971 8:583). The same source points out also that the events described later in *Judges* 20: 14-15, probably occurred earlier chronologically than those described in *Judges* 3: 15-22.

Sir Thomas Browne commented on the strangeness of "draw[ing] examples of the left from the sons of the right hand, as we read of seven thousand in the army of the Benjamites" (Wilkin, 1852 vol I, p.393). Cook (1914 p.262) says something similar. The comments arise from Benjamin, *Ben Yamin*, literally meaning "Son of the right hand", although it also means "sons of the south", and probably refers more to the geographical origin of the tribe than their handedness (Boling, 1975 p.86; 9599 /ft " pp.247-8"}).

Cook (1914 p.243) pointed out that the passage does not say that the 700 are the only left-handers. It is also not clear whether the 700 are a part of the 26,000 or are in addition to them. The New English Bible which I quote in the main text abbreviates the episode. A fuller translation is "twenty six thousand men bearing arms, without including the inhabitants of Gibeah, and they amounted to seven hundred picked fighters. Of all this company, seven hundred were picked fighters, [left-handed]" (Soggin, 1987 p.291). When discussing the number seven hundred, Moore long ago suggested "[The] identity of number and phrase is suspicious" (Moore, 1895 p.429). To make matters worse, there are other versions of Judges that have 25,000 or 23,000 instead of 26,000 (Lias, 1902 p.196), and the Jewish historian Flavius Josephus in *The antiquities of the Jews*, written at the end of the first century AD, said, "The Benjamites' army was twenty five thousand and six hundred; *five hundred* of which were excellent at slinging stones with their left hands (my emphasis; Whiston, 1906 V.2.10(156)). The highest and lowest possible estimates then give 3.04% (700/23000) and 1.87% (500/26700). Probably not too much faith should be put in the precise percentage.

☞WWW☜ 9:2

Classical writing is replete with examples demonstrating that most people were right-handed. I'll restrict myself here to just two, taken from that early scientific treatise, *On the nature of the universe*, written in Latin about 80 BC by Lucretius (Latham & Godwin, 1994), who, in a description originating in Homer's *Odyssey*, describes an opulent household with "golden images of youths ... holding flaming torches in their right hands to illumine banquets" (p.38), and how, "The bronze statues by the city gates show their right hands worn thin by the touch of travellers who have greeted them in passing"(p.18). Clearly right-handedness is the norm.

Montaigne referred to the habit of cutting off the thumbs of prisoners, although he seems to refer to both thumbs: "Some person whose name I no longer remember, having won a battle at sea, ordered the thumbs of all his vanquished enemies to be cut off, to render them incapable of fighting or rowing" (Trechmann, 1935 I:140).

☞WWW☜ 9:3

Darwin corresponded with Ogle on the origins of handedness, receiving a letter from him on 25th Feb 1871, and replying to him on 25th Dec 1871, Christmas Day, when he sent him a copy of his notes on the handedness of his son William. Ogle was made Assistant Physician at St. George's Hospital in 1869 but resigned in 1872 on the grounds of ill-health. He subsequently went on and became Superintendent of Statistics, being responsible for the censuses of 1881 and 1891, and also translated some of the works of Aristotle. Despite his "ill-health" he died in 1912 at the age of 85 (Anonymous, 1912).

An exception to the belief that left-handedness was at about the same rate as in the book of *Judges* was Shaw (1878) who thought "the proportion of left-handed in the tribe of Benjamin seems to have been *greater* than at the present day" (my emphasis). He presumably had not read Ogle's paper since he also adds that "we have no reliable statistics ... either among ancients or moderns".

Harris (1990f) provides a comprehensive review of early studies of the rate of left-handedness. An early review by Beeley (1918) of seven different studies found a median incidence of 4%, the same value as is cited in an article in Scientific American in March, 1910 (Huber, 1910 p.261).

☞WWW☜ 9:4

See also chapter 7 on sex differences. Although in the data of Gilbert and Wysocki (1992f) it looks as if the difference between the sexes increases over the years, that is not actually the case. Proportionately the excess of left-handed males remains the same over almost the entire range, as can be seen if the ordinate is plotted logarithmically. For the entire data, there are 29% more left-handed men than there are left-handed women, which is entirely compatible with other studies (McManus, 1991c).

☞WWW☜ 9:7

For simplicity in the Euchiria, Lowgenia and Hipressia calculations I have merged together cases where one parent is right-handed and the other left-handed, with those few in which both are left-handed. It makes no difference to the conclusions.

The calculations are properly carried out using odds ratios rather than the risk ratios I have quoted here. However risk ratios are easier to describe, and I have therefore used them here (as in chapter 7). The rate of left-handed children when a parent is left-handed, 19.5%, is 2.5 times the rate when both parents are right-handed, 7.8%. However the odds of two right-handed parents having a left-handed child are 7.8%:92.2% = .0846, whereas the odds of a left-handed child when one parent is left-handed is 19.5%:80.5% = 2422. The odds ratio for a left-handed parent having a left-handed child in comparison with two right-handed parents is .2422/.0846 = 2.86 times. .

The mathematically convenient fact that the rate of the C allele is exactly twice the proportion of left-handers occurs because the genetic model is additive. It is not generally true of genetic models, and specifically is not the case when genes are recessive or dominant.

The reason for the apparently counter-intuitive result in Lowgenia, that a lower gene frequency results in a higher odds ratio, is because as the proportion of C alleles falls, so the likelihood that a right-handed parent will be carrying a *C* allele also falls. In the extreme case when *C* is close to zero, right-handers almost completely breed true, having hardly any left-handed offspring, whereas two left-handers still have to carry C alleles. The result is that as the frequency of *C* falls so the odds ratio gets higher and higher.

In the Hipressian calculations it is assumed that the left handers who change their handedness are a random 50% of all left-handers, irrespective of parental handedness, etc., and occurs in both the parents and the offspring.

It might seem surprising that left-handed parents in Hipressia are less likely to have left-handed children than in Lowgenia, particularly since left-handers in Hipressia are indeed exactly what they seem to be, left-handers. However Lowgenia is not the proper place to compare them with, because Lowgenia has a lower rate of C genes. The appropriate comparison is with Euchiria, and the 9.9% in Hipressia is comparable with Euchiria's 19.5% once it is taken into account that half of the genetic left-handers in Hipressia are forced to become right-handers.

☞WWW☜ 9:8

The data for Japan and the United Arab Emirates are in preparation at present. The data for Ivory Coast and Sudan can be found in De Agostini e*t al* (1997d), although an analysis of them using the present methods is currently in preparation. Maharaj Singh has also recently published further data showing a much lower incidence of left-handedness in India compared with France (Singh, Manjary, & Dellatolas, 2001).

The method described here is only illustrative. In the full analysis it is possible to assess the extent to which any particular combination of incidence of left handedness and odds ratio of handedness in families results from the joint effects of social pressure and differences in gene

frequency. In all the countries, including the West, there is always a small effect of social pressure, but it is of the same size everywhere (and might reflect measurement error). The differences between countries are however almost entirely accounted for by differences in gene frequency.

Another piece of evidence that supports the idea that differences in incidence of left-handedness between countries are genetic is that emigrants from Asia to the West continue to have low rates of left handedness after they have arrived in the West. For instance in the data of Gilbert and Wysocki, only 6.1% of the Asian respondents (about 10,500 in number) wrote with their left hand, compared with 9.5% of the White respondents. Since all were US residents that suggests that living in a society with a more relaxed attitude has not changed the incidence of left handedness. A similar result, with rather more control over the sample, is found in two large UK studies of applicants to medical school (McManus et al., 1995; McManus, Richards, & Maitlis, 1989). In a 1986 survey, of 355 UK nationals whose ethnic origin was from the Indian sub-continent, 8.7% were left-handed, compared with 12.0% of 1447 White applicants. Similarly, for a 1991 survey, of 1119 UK nationals whose ethnic origin was from the Indian sub-continent, 8.0% were left-handed, compared with 10.9% of 3455 White applicants. The effect is statistically significant, and there was no difference between the Indian group born in the UK and those born outside the UK. Likewise in a very large sample of 152,000 applicants to US medical schools, 13.1% of whites were left-handed, compared with 9.2% of Asian Indians, 6.3% of Vietnamese, 5.4% of Korean and 5.3% of Chinese (Halpern, Haviland, & Killian, 1998o).

A recent review of handedness in Japan and the Far east can be found in Iwasaki (2000n) who cites several additional studies in Japanese which confirm the basic finding that the incidence of left-handedness is far lower in Japan. See also Ida e*t al* (Ida, Mandal, & Bryden, 2000).

☞WWW☜ 9:9

In the study of Chamberlain (1928b) it is assumed that the students were eighteen when they entered university, and hence would have been born in 1909. Some would be somewhat older than that, perhaps by ten years or so. The siblings were as likely to be ten or more years older or younger, meaning that the majority of individuals would have been born between 1900 and 1920.

In the study of Gilbert and Wysocki study (1992f), the rate of left-handedn in those born before 1920 was 3.9%.

The family data for children born before 1939 are based on the studies of Ramaley (1913b, Chamberlain (1928b), Rife (1940), Merrell (1957b), and the grandparental and parental data of McManus (1985a); see McManus and Bryden (1992c). In some cases the data were published long after 1939, but refer to data from parents or grandparents who would have been born before 1939.

The full data for the risk ratios in the family studies are as follows. For those born before 1939, there were 13923 offspring, 7.27% of whom were left-handed. In the 12753 offspring of two right-handers, 6.1% were left-handed, compared with 20.1% of the 1170 offspring in which one parent was left-handed, giving a risk ratio of 3.29. For those born after 1955, there

were 21085 offspring, 13.3% of whom were left-handed. In the 21085 offspring of two right-handers, 11.9% were left-handed, compared with 19.5% of the 3741 offspring in which one parent was left-handed, giving a risk ratio of 1.64. Those born between 1940 and 1954 were midway between the other two groups, both in their incidence of left handedness and odds ratio. There were 37592 offspring, 10.8% of whom were left-handed. In the 33153 offspring of two right-handers, 9.6% were left-handed, compared with 20.0% of the 4439 offspring in which one parent was left-handed, giving a risk ratio of 2.08.

☞WWW☜ 9:10

It has often been regarded as a problem that many family studies of handedness include all of the children in a family, not least because it means that the significance tests can be affected because the offspring are not independent. However it is an advantage from the present point of view as it means one can calculate the average number of children in a family. It should though be noted that one cannot calculate the standard deviation of the number of children, and therefore it is not straightforward to carry out significance tests on the differences..

☞WWW☜ 9:11

It is worth remembering that indirect social pressure requires the right-handed majority to be able to recognise which individuals in their society are left-handed. That means, therefore, that in Hipressia those left-handers who have changed to being right-handers, and can pass fully as right-handers, will *not* be under indirect social pressure and will continue to spread their genes for left-handedness. Direct and indirect social pressure can therefore work in entirely opposite directions, one requiring the absence of the other.

☞WWW☜ 9:12

Left-handers leave their mark in other ways as well. In the Geometric phase of early Greek pottery, from about 1000-700 BC, it was common to paint circles and semi-circles on to the pot. Right-handers prefer to draw and paint circles and semi-circles in a clockwise decoration (Alter, 1989; Van Sommers, 1984), whereas left-handers tend to go the other way. In the National Archaeological Museum and other museums in Athens I found twenty-eight such circles where one could tell if the circle were drawn clockwise or anticlockwise. Twenty-six were clockwise, and two anti-clockwise, suggesting that about seven percent of the craftsmen might have been left-handed.

Another possible indication of handedness is given in early pre-Dynastic pots from Egypt, which are often decorated with painted spirals, which start at the centre and spiralling outwards. So far in the 12 examples I have looked at in the Petrie Museum at University College London, all are clockwise. The numbers are as yet, however, too small to be able to draw any useful conclusions.

☞WWW☜ 9:13

The radiocarbon dating of Ötzi gives a figure of between 3350 and 3100 BC (Spindler, 1996).

It seems probable though unproven that Ötzi was right-handed. The pieces of cord he was carrying may well have been made by him himself, since they are such relatively trivial pieces

of equipment requiring little skill to make. That is particularly true of the bowstring, made from twisted animal sinew, the raw materials of which were also found with Ötzi (Spindler, 1996 p.250).There is also evidence that Ötzi may have died because of the consequences of a serious injury, eight weeks or so before death, which damaged the right shoulder and broke several ribs on the right. He probably died lying on his left side, perhaps because of pain in the right shoulder. Damage to the right shoulder of a right hander would have been particularly disastrous in the dangerous conditions of the High Alps, and might have been responsible for his death (Zur Nedden et al., 1994). Recent work has also suggested that Ötzi has an arrow-head deep in his left shoulder, which almost certainly contributed to his death, showing evidence of heavy bleeding and possible damage to the brachial plexus (Holden, 2001).

☞WWW☜ 9:14

The figure of 5% comes from the fact that of 13 boring implements studied by microwear analysis, the direction of turning was clockwise in 21, anticlockwise in 3, and could not be determined in 7 (Cahen, Keeley, & Van Noten, 1979 p. 681). However the three counter-clockwise implements all came from the same core, and were probably all made and used by the same person. There are therefore probably 1 left-hander and 21 right-handers in the sample, giving 4.54% left-handedness, or about 5%.

☞WWW☜ 9:15

It should be said that there is no shortage of studies claiming to estimate the proportion of right and left handers, some studies dating back to the last century (for a review see e.g. Cunningham, 1902). However many use methods which are, to say the least, dubious, and often rely on subjective assessments of the best hand in which a stone tool might be used (e.g. Posnansky, 1959). In other cases attempts have been made to assess handedness from skeletal remains, either of the skull or arm bones, but there is sufficient noise in the data to make any precise estimate of the incidence of left handedness difficult to interpret; see Steele (2000o) for a detailed review.

☞WWW☜ 9:17

There is evidence of earlier stone tools, made about two and a half million years ago (Roche et al., 1999; Semaw et al., 1997), although as yet there is no analysis of whether they are right or left handed.

☞WWW☜ 9:18

There actually seems to be no work on the inheritance of pawedness in cats, and so I have taken a little poetic license here. However there certainly is extensive work on pawedness in mice (Collins, 1968; Collins, 1969; Collins, 1977; Collins, 1985), and it seems extremely likely that the same conclusions apply in cats. I have therefore taken a chance in what I said.

In this book I make a strong claim that handedness, in the sense of a 90:10 mixture, is a peculiarly human phenomenon. Not all workers agree with that, and a recent strongly argued case has been made by Rogers (2000p), and while I accept that there are large numbers of motor and sensory asymmetries in other animals, I am yet to be convinced that these are

phylogenetically related, being so diffuse in form and seemingly non-functional, that, *pace* Rogers, I am still willing to follow Corballis (1991f), as quoted by Rogers, that "right handedness and cerebral asymmetry are unique to humans".

☞WWW☜ 9:19

Annett (1991g) also found that almost exactly half of a group of captive gorillas were right handed. Amongst the New World monkeys there is also evidence that although individuals re highly lateralised, there is a 50:50 mixture of right and left handers on various tasks (Laska, 1998; Laska & Tutsch, 2000).

The estimate of sixty per cent of chimpanzees being right-handed is based on the unbiased task of Hopkins et al (2000q), in which of 169 chimpanzees, 97 out of 169 (57.4%) showed some shift towards the right hand.

The ultimate test of whether the laterality of chimpanzees is similar or different to that in humans will come with the identification of the relatively small percentage of genes which shows differences between humans and chimpanzees, a process that should soon be completed (Fujiyama et al., 2002).

An area of research related to that of handedness in the great apes, is that of brain asymmetry in the great apes, claims being made that, for instance, Broca's area shows the same anatomical asymmetries as it does in humans (Cantalupo & Hopkins, 2001). Although that may be so, it is also the case that ape and human brains are embedded in a body which has a myriad of ancient asymmetries, notably of the viscera. Anatomical asymmetries may therefore only reflect visceral *situs,* rather than being an indicator of functional brain asymmetry. That is supported by studies of humans with *situs inversus*, who show reversed anatomical asymmetry for the frontal and occipital petalias(Kennedy et al, 1999), but do *not* show reversed functional asymmetry, most individuals being right handed (Cockayne, 1938,Torgersen, 1950a,Gordon, 1998), and having left language dominance as shown by dichotic listening (Tanaka et al, 1999) and by fMRI (Kennedy et al, 1999), the same direction of asymmetries as is found in humans with *situs solitus*, whose viscera are lateralised normally, with the heart on the left. In the absence of direct evidence of the great ape anatomical asymmetry being associated with functional asymmetries of cognitive or linguistic processing, the most parsimonious explanation for their asymmetry is that it reflects the location of the heart, which in humans and the great apes is on the left side[42].

☞WWW☜ 9:22[43]

The list of behavioural asymmetries could be extended far further. A recent one which attracted much attention is the asymmetric use of tapering leaves as tools by New Calendonian Crows (Hunt, Corballis, & Gray, 2001).

---

[42] The contents of this paragraph were submitted to *Nature* as a letter immediately after the publication of the paper by Cantalupo and Hopkins. *Nature* however has a self-image of infallibility, and therefore almost never publishes criticism of any paper it has ever published. This was no exception. If it is infallible and beyond criticism in the judgements of its editors and referees then it is the only scientific journal in the world to be such.

[43] **☞WWW☜** was inadvertently omitted from the notes in the book.

As well as behavioural asymmetries, there are also occasional examples of anatomical asymmetries within the brain of non-human species, perhaps the most investigated being the habenular nucleus in the brain stem of a range of species, most notably the frog (Morgan, O'Donnell, & Oliver, 1973), which is typically double on the left and single on the right, although the pattern varies in other species, and the phylogeny is still somewhat obscure (Concha & Wilson, 2001). A finding of particular interest is that the asymmetry of the habenula is determined by the Nodal signalling pathway, and that if this is knocked out then the system does not become symmetric but instead becomes randomised, showing a 50:50 mixture of right and left (Concha et al., 2000). The functions of the habenulae are somewhat unclear, although they have been implicated in many functions (Sutherland, 1982), and in humans act as a major determinant of 5-HT levels in the brain (Morris et al., 1999)

☞WWW☜ 9:23

As well as in *The Origin of Species* Peckham, 1959 p.250-3, Darwin also mentions the flatfish in *The variation of animals and plants under domestication* (Darwin, 1905), where he comments that:

> "Many animals have the right and left sides of their body unequally developed: this is well known to be the case with the flatfish. In most flatfishes the left is the blind side but in some it is the right: though in both cases reversed or 'wrong' fishes are occasionally developed; and in *Platessa flesus* the right or left side is indifferenbtly the upper one."

☞WWW☜ 9:24[44]

Although there are many catalogues of the myriad of miscellaneous asymmetries found in animals, there are few serious attempts at putting them into order. A wise and thoughtful exception is that of Rich Palmer (1996f).

☞WWW☜ 9:25

Termite fishing, as well as fishing for ants with sticks, are part of chimpanzee cultures, being found in some chimpanzee communities such as Gombe, where both are present, or sometimes only one is present, as in the Mahale K-group, who fish for termites but not for ants, or in other communities neither is present (Whiten & Boesch, 2001).

☞WWW☜ 9:26

Aristotle describes the hand as "an instrument that represents many instruments" in *De partibus animalium* (Peck, 1937 687.a), and Galen subsequently developed the theme in *De usu partium*:

> "[It is] of all instruments the most variously serviceable. So too it is spear and sword, and whatsoever other weapon or instrument you please; for all these can it be from its power of grasping and holding them all. For though the hand is no one particular instrument, it is the instrument for all instruments because it is formed by Nature to receive them all...". (Rowe, 1999 p.5).

[44] ☞WWW☜ was inadvertently omitted from the notes in the book.

☞WWW☜ 9:27

Sidney's shepherd tries to warn Man:

> "Deme it no gloire to swell in tyrannie.
> Thou are of blood; joy not to see things bleede:
> Thou fearest death; thinke they are loth to die."

The picture of the hands of primates (Schultz, 1969) also includes *Tupaia*, the tree shrew, which is nowadays not generally thought to be a primate (Fragaszy, 1998).

It is sometimes so easy to forget how important our hands are to us, for there is barely a thing we could do in our complex technological world without them. So deeply are we immersed in our use of them that we are like the old Chinese proverb, "The last person to notice the water is the fish". I was about to write about the events of yesterday, and to reflect on the amazing uses of these flesh-covered bony excrescences, derived ultimately from the fins of some prehistoric fish, when I realised that I couldn't even type those words into my word-processor, or use its touch-pad, or for that matter, write those words with a pen or pencil, without my hands to help me. With my word-processor I might just have got away with one finger, or even one toe, but some of the other activities I saw during that day would have been well beyond me. Perhaps most stunning was the evening in the local jazz club watching a quintet who were playing innovative free jazz. Watching those hands racing across the piano keyboard, playing complex chordal structures, watching the subtle rhythms of the percussionist, or the flying fingers of the clarinettist, saxophonist or double bassist, made it irresistible to speculate on why humans can do all of this and even animals such as the chimpanzee cannot. Part of the mistake is to look only at the hand itself. It is of course on the end of an arm of almost equal subtlety and important. The wide range of movement of the ball and socket joint of the shoulder, the hinge joint of the elbow, and the ability of the lower arm to rotate. And of course each of those players, be it the percussionist, the bass player, the pianist, or the clarinettist and saxophonist, were all doing *different* things with each hand. It is a remarkable ability. More remarkable still, at least from the perspective of an ape or a monkey, was that the bass player and wind players were each standing on their two legs, leaving the hands free to carry out these complex activities[45]. Earlier in the day we had watched our two daughters, then eleven-months old, crawling around, trying, only half successfully, also to carry a toy in one hand at the same time. They were also just realising that it was possible, if only for a few moments, to stand upright on their legs. So it is not only hands that are important, but also legs. Unless we are bipedal, there is little point in having sophisticated hands, as all they do is rest on the ground. Inevitably the evolution of tool using hands and a body that can stand on two legs are intimately connected.

☞WWW☜ 9:29

The symbol ☞WWW☜ was included in the book in error.

[45]Darwin (1874b)is credited with being one of the first to notice that, "In throwing a stone or spear ... a man must stand firmly on his feet".

☞WWW☜ 9:29

Although it is tempting to see the hand of *Australopithecus* as a direct ancestor of the human hand, there are some problems in interpreting the wrist bones, which perhaps suggest knuckle-walking took place (Richmond & Strait, 2000).

Although it is not stated explicitly in the text another important aspect of being able to throw and being highly dextrous with the hands is that one needs to be bipedal. One cannot walk on four legs and throw at the same time. Manual dexterity and bipedalism must also, therefore, have co-evolved.

☞WWW☜ 9:30

It is possible that Neanderthal was somewhat less dextrous than *Homo sapiens* (Musgrave, 1971), although most modern authorities do not seem to support that position (Aiello & Dean, 1990 pp.392-4).

☞WWW☜ 9:33

The role of clock speed in determining what a computer can do and can do well is often neglected. A similar analogy probably applies also to brains. There is little doubt that human brains have increased in size dramatically, and presumably that is because increased computing power is needed for the new ecological niche in which the early hominids were living. It doesn't matter what that computing power was need for, and there have been many, many speculations, from language, through tool usage, throwing, and gossip.What does matter is that there are relatively few ways in which the brain computer can be made more powerful, given the biological equivalent of more mega-flops. How does one get a more powerful brain?

Our brains are exceedingly complicated neuronal machines which process information. Although in many ways the analogy of computers for our brains is overly strained and sometimes absurdly wrong, there are nevertheless many lessons that can be learned about the possible evolution of the brain by looking at the ways that computers have changed over the past half century. To the ordinary user of a computer they seem to look different every half decade or so. Where now people use a mouse to click and point at multicoloured displays in Windows, it was a decade ago that they were typing command lines into DOS with monochrome monitors. A decade before that they would take a pile of punched cards to a central computer facility and twenty-four hours later receive a pile of line-printer output with those oh so prestigious holes down the side. And a decade before that the computer was programmed either by flicking switches or feeding in paper tape with 5, 7 or 8 rows of holes. And ten years yet further back Alan Turing could only program one of the prototype computers in Manchester by typing in numbers to the base 32, using the numbers one to nine and then the letters A to V, a system he found perfectly natural and which he could never understand that other people found difficult. But these are all surface features. Deep down there is little that has really changed in the way computers work. My students always tell me that SPSS for Windows is so much better than the old DOS version and then are surprised when I show them that all the fancy coloured front end does is to generate a string of

commands which are identical to the ones we used to type in the DOS version[46]. The languages we program in, be they FORTRAN, BASIC, C or whatever, are essentially all dialects of the very early languages such as ALGOL. They have a few more elegant features but there is nothing in them which would not be recognised by the people who developed the original languages. And the chips at the centre of the computer are still doing the same as they ever used to do, those things which Turing said any universal computing machine; taking numbers expressed in binary form, moving them from one place to another and performing operations such as addition and multiplication on them. They may now do it for 16, 32 , 64 or even 128 bits at a time, but again nothing deep down has really changed. So why have computers got so much more powerful over the last half century. There is really only one thing that accounts for it – speed. The early home computers were felt to go like the wind with their 1 MHz 6502 CPUs, whereas now the newspapers advertise Pentium computers which run at 1 Gigahertz – a thousand times faster. And why do computers go so much faster then they used to? Mainly because the people who designed firstly printed circuits with transistors, and then integrated circuits, managed to make them smaller and smaller, as they developed ever new photolithographic techniques for laying circuits in silicon, etching them with harder and harder UV light of ever shorter wave-length, and looking towards X-ray lithography for the next generation of chips[47]. Those same technologies also meant that memory could also grow and grow, so that now a word-processor program will take up more hard disk than the entire storage available thirty years ago on a university mainframe. The result of all that speed and all that memory is that the old programming methods can do things such as re-drawing the graphics on my screen at a speed that now makes it *feel* as if it instantaneous. The result is that I now can do things with my computer which I could not do before in real time. I could in principle have done them, but it would have been slow, and a video-game where one waits an hour for the screen to re-draw is not a game. How much of all this change is due to better programs, more elegant algorithms, new programming languages? Almost none. It is speed and ever smaller memory that makes computers work better and better[48].

Does this tell us anything about the ways that the brain might have evolved? Probably, yes, a lot. Some things about brains and nervous systems have hardly changed since nerve cells were invented. All nerves have myelin sheaths and sodium-potassium pumps to keep high levels of potassium inside the cell so that electrical impulses can be conducted, and all chemical transmission at synapses is much the same in principle from worm to man. Of course the details might be slightly different, a novel neurotransmitter here, an inhibitor there, but there is as much novelty as in the central processor of most computers. Brains also are pretty much the same. Networks of cells, the neurones, in layers, interconnected with short, medium and long-range connections to one another, and with occasional large bundles of fibres, nerves, sending the output to some other part of the brain. Look for a single big idea in the way the neurones are connected and there is only one in the game, lateral inhibition. But it was discovered in *Limulus*, the horse-shoe crab, an invertebrate that seems hardly to have changed in a hundred million years and yet is a perfectly adequate model for the process in

[46]These can be seen in the syntax window in SPSS for Windows.

[47]For a brief history of integrated circuits, and a graphic illustration of Moore's Law see Mullins (2000r).

[48]And it has been argued that one of the great tragedies of the memory and processing revolution is that it has been squandered in massively inefficient software which proliferates to fill whatever space can be provided for it.

human brains. Of course I exaggerate a little for rhetorical effect, but there are few really big new ideas out there in brain evolution. Except for a couple of exceptions, and they are little to do with how nerves work and even less to do with what the nerves are actually doing. They are the same as in computers. Build them big, build them fast, and miniaturise as much as possible. Make neurones smaller, and allow them to be more interconnected, that is how the richness of the networks increases, and then allow the brain to be even larger, so that even more neurones can be fitted in, and then the same old programs, the same old methods of nervous transmission, the same old synapses, the same old programs if one likes, may well be able to do things which are interestingly new, radically new, like walking or talking of fantasising.

If one wants a very practical example of how speed and memory can do things which are fundamentally different, one only has to look at an article in *New Scientist* in which a radically new wheelchair was being designed for the disabled (Daviss, 2000). Most wheelchairs have four wheels because that means they are stable and can sit still on the ground. The trouble is they are not very good at doing much else, such as going up kerbs or stairs. Re-arrange the four wheels so that in effect the wheel-chair is standing upright on just two of them, put in some powerful motors and some position sensors which are connected to three powerful Pentium computers and then, like balancing a broomstick on one's palm by continually moving it around, suddenly, almost miraculously, the wheelchair is stable on two wheels, it can climb kerbs, go up stairs and even go across deep sand without falling over. None of the technology is really new except the powerful computers which are running it; and what is new about them is that they are fast. But it couldn't be done without them. And suddenly it is liberating, novel, exciting. There is no reason why a bigger, faster brain with more memory couldn't account for many of the changes that have occurred in the evolution of the human brain.

As a view of brain evolution, the emphasis on size and speed has all sorts of advantages, of which the main one is that evolution can only work by changing genes, and genes can only produce proteins, and those proteins can only produce cells that are slightly differently shaped, or are connected in different ways or are packed in somewhat different fashions. They cannot possibly work at high conceptual levels. It seems almost impossible that a gene could in any serious way be responsible for syntax or counting or reading or any of the high level mental skills that so concern psychologists. Those things are going to have to emerge, somehow, as epiphenomena from altering the tiny details of the way that neurones are connected. Some forms of connection, some forms of inhibition, some recurrent networks, some forms of mutual inhibition may be better for certain mental tasks, just as some forms of memory organisation are better for processing music files or images or acting as servers on computers. But changing the basic design is as unlikely as the computer industry deciding to use ultraviolet photolithography to produce silicon chips with little nano-balls on nano-wires that work in the same way as an ultra-miniaturised abacus[49]. It ain't possible. Evolution can only build on what it has, not what might be desirable. And what it has are neurones, with chemical transmitters which are connected in particular ways during a few months of fetal life. That is what genes can alter and is the raw material on which evolution of the brain has to depend.

[49]The exception could well be quantum computers, although that seems a long way off as yet.

☞WWW☜ 9:35

Calvin points out that timing can be increased also by having arrays of timing processors which work in parallel. The result can be a far greater increase in accuracy than the ten to fifteen per cent difference which seems to apply to the left hemisphere in the Nicholls task. Calvin (1982d) cites the nice example of how on its 1831 voyage the *Beagle* had 22 chronometers to make the measurement of longitude more precise than any single chronometer would allow.

☞WWW☜ 9:39

I have simplified the story here somewhat. In a more detailed account elsewhere (McManus, 1999) I have suggested, following Maynard-Smith and Szathmáry (Maynard Smith & Szathmáry, 1995), that the genes underlying language evolved in two separate stages, and so the *C** gene mutated into a *D** gene, which allowed only proto-language, which would still have benefited proto-humans over their competitors. Subsequently the *D** gene mutated into the modern *D* gene which allowed full syntax, and which may, following Bickerton (Bickerton, 1996a; Bickerton, 1996b), have evolved from the development of a novel piece of neurological circuitry, the fronto-cerebellar circuitry. That has also sorts of explanatory advantages, not least the fact that the cerebellum is being more and more realised to be intimately involved in precise timing, one of the quintessential aspects of language and in particular spoken language, and it also accounts for the otherwise mystifying neurological patients with cerebellar lesions and an impairment of syntax (Silveri, Leggio, & Molinari, 1994). The modern *C* gene is then proposed to have evolved out of the modern *D* gene, making the evolutionary sequence *C** ➜*D** ➜ *D* ➜ *C.*

Recent work (Howard, 2001; Rao & Wu, 2001) has suggested the possibility that the human brain has evolved some novel circuitry which is not found in the chimpanzee brain, involving a pathway from the telencephalon to the dorsal thalamus. Such pathways must be controlled by genes, which have not yet been found, and may well be responsible for some aspects of language and the other cognitive abilities which differentiate humans and apes.

Nichols (1999i; Adler, 2000) in her controversial analysis of grammatical structures in languages suggests that "there is no evidence that human language in general has changed since the earliest stage recoverable by the method used here. There is simply diversity, distributed geographically" (p.277). Since her methods typically seem to date this diversity from between 50,000 years ago (when the Australasian languages separated; p.228) and about 100,000 years ago (p.27), that might suggest the *D* gene mutated at about that time, humans having only proto-language during the long period of cultural stasis before that.

☞WWW☜ 9:40

The dynamics of the fixing of one gene when there are two in the gene pool with identical fitness is well shown by Cavalli-Sforza and Bodmer (Cavalli-Sforza & Bodmer, 1971). It occurs because any population is necessarily finite in size (and in practice is usually small in terms of the effective population size), with the result that binomial sampling fluctuations occur, meaning that slowly one gene begins to predominate over the other in its proportion in the population. That would be a random walk except that the walk is occurring between two

absorbing barriers at 0% and 100%. Once the proportion reaches either of those values, which it must do given sufficient time, then there is no way back, and one gene is fixed, whereas the other is eliminated from the gene pool.

☞WWW☜ 9:41

A real problem for genetics is that the advantage of a heterozygote need have nothing to do with the ostensible function of the gene, since genes often have multiple functions, and the balance can occur due to two seemingly unrelated processes. It is therefore possible that people with the *DC* genotype can also run faster, can metabolise food more efficiently, or any of a host of factors which might mean that the have more offspring and hence are fitter. In the absence of any evidence for such processes I have chosen in this book to ask the question which is neuropsychologically most interesting, of what might be an advantage resulting from the effects of the *DC* genotype upon neural organisation itself. As a possible example, it seems to be the case that left-handers overall are somewhat less likely to suffer from left-handers or ulcers. Whether it is handedness *per se* which is the cause of that association, or the association is more specifically with the DC or CC genotype, is still not clear.

☞WWW☜ 9:42

Theories that some people have different brains from others typically invoke pathological factors, as in Satz's theory of pathological left-handedness (Satz, 1972; Satz, Baymur, & Van der Vlugt, 1979; Soper & Satz, 1984), or in Coren and Searleman's rare-trait marker model (Coren & Searleman, 1990). In each of these cases some factor, either unilateral trauma, or a process akin to fluctuating asymmetry, pushes modules from one hemisphere to another. In effect that can 'randomise' a complex system, and it can be seen as being akin to a phenocopy of the effects produced by the DC or CC genotype.

Finch and Kirkwood (2000s) have summarised the neglected role of randomness in biology: "Chance is omnipresent in living systems, being at once the source both of creative novelty in evolution and of corruption and decay" (p.4). The positive advantages of randomness are seen well in the benefits that are brought to sensory systems by the introduction of noise, so-called 'stochastic resonance' (Ferster, 1996; Wiesenfeld & Moss, 1995).

A rare example of randomness being expressed in organisms at the biochemical level is seen in the worm *Caenorhabditis elegans*, which has two structurally and functionally identical AWC neurons involved in olfaction, but there is a receptor, STR-2, which is randomly expressed in either the right or the left neuron but never in both. The asymmetry seems to be essential for the proper working of the system since mutants which are symmetric have defects (Wes & Bargmann, 2001). The formal analogy to the CC genotype proposed for handedness is also a close one in several ways, not least the fact that a neural substrate can be expressed randomly on one side or the other but not both.

☞WWW☜ 9:43

The same principles of organisation and randomness can be seen in large social organisations, particularly where a slight rearrangement of an otherwise well functioning system can sometimes benefit the overall workings of the system. A large organisation in which

everyone does the same job in perpetuity is doomed to die through stasis. But equally, continual and massive reorganisations are unlikely to be beneficial. A little change though might shift an organisation from being good to being extremely good, and hence becoming very successful at a particular task, as a new alignment of individuals and skills becomes a powerful problem-solving force.

☞WWW☜ 9:45

The precise numbers of anomalous individuals given that there are a dozen modules can readily be calculated from the binomial distribution, as shown below:

Number of anomalous modules	*DD*	*DC*	*CC*
0	100%	3.17%	0.02%
1	0%	12.67%	.29%
2	0%	23.23%	1.61%
3	0%	25.81%	5.37%
4	0%	19.36%	12.08%
5	0%	10.32%	19.34%
6	0%	4.01%	22.56%
7	0%	1.15%	19.34%
8	0%	0.24%	12.08%
9	0%	0.04%	5.37%
10	0%	0.0035%	1.61%
11	0%	0.0002%	0.29%
12	0%	0.000006%	0.02%

In DC individuals with twelve modules and a 0.25 probability of any one being lateralised atypically, then 26% of individuals will have three atypical modules, 23% will have two atypical modules, 13% will have only one atypical module, and 3% will have no atypical modules. Overall then 65% will have three or less atypical modules. Only 5% of DC individuals will have six or more atypically located modules, compared with 61% of CC individuals.

Chapter 10: Hypernotes

☞WWW☜ 10:1

A few lines after describing reading Carlyle's *Chartism*, (LeQuesne, 1982 p.57), Emma Darwin mentions that "The baby [William, met already in chapter 7] performed his first smile today, a great event...". Carlyle's essay on 'Chartism' is still in print (Shelston, 1971).

There was clearly some ambivalence in Charles Darwin's own views on Carlyle, since in February 1838 in a letter to Emma he had said that "I feel particularly well towards him", and in January 1839 that "Carlyle is the best worth listening to of any man I know". Forty years later he took the opportunity to abuse Carlyle in his *Autobiography* (Darwin & Huxley, 1974 pp 66-7):

> "Carlyle sneered at almost everyone: one day in my house, he called Grote's *History* 'a fetid quagmire, with nothing spiritual about it'. I always thought until his *Reminiscences* appeared, that his sneers were partly jokes, but this now seems rather doubtful. His expression was that of a depressed, almost despondent, yet benevolent man; and it is notorious how heartily he laughed. ... His mind seemed to me a very narrow one; even if all branches of science, which he despised, are excluded. ... As far as I could judge, I never met a man with a mind so ill adapted for scientific research."

Even Carlyle's biographer, Froude, said that the 'Occasional discourse on the Nigger Question' of 1849 gave 'universal offence'. Darwin in his *Autobiography* put it simply: "his views about slavery were revolting".

The success or otherwise of the Carlyle's marriage has always been controversial, although even contemporaries were aware of its weaknesses, Samuel Butler for instance having remarked that it was "very good of God to let Carlyle and Mrs Carlyle marry one another, and so make only two people miserable instead of four" (Ashton, 2002).

As an old man Carlyle was undoubtedly not particularly likeable. As a young man, T H Huxley had read and admired Carlyle deeply, and his style probably influenced Huxley's. The curmudgeonly old Carlyle, a man " nearly always desperately unhappy ... permanently soured by ill-luck", as the then Eric Blair described him Orwell, 1970 p.57), is well shown in an incident when,

> "...near the end of Carlyle's life, [T H] Huxley saw him walking slowly and alone down the opposite side of the street, and touched by his solitary appearance, crossed over and spoke to him. The old man looked, and merely remarking, 'You're Huxley, aren't you? The man that says we are all descended from monkeys', went on his way" (Michell, 1913).

In 1867, Carlyle's photograph had been taken by the pioneer photographer, Julia Margaret Cameron, and he was already looking the gaunt, unwell man who could not allow himself to respond to Huxley's hand of friendship.

☞WWW☜ 10:2

Although Carlyle's *Reminiscences* seemed to be published with unseemly haste, just weeks after his death, the author had agreed with Froude that they could be published ten years after they were written, and that happened to coincide with Carlyle's death (Heffer, 1995 p.371).

The description of the tremor in Froude's biography (Froude, 1885 p.390) uses the word 'ateral', which is not in the *Oxford English Dictionary* as such, although it does have "attery", defined as venomous, mixed with gall, malignant, or purulent. Parkinson's disease, the 'shaking palsy', was first described by James Parkinson in 1817. Although in Carlyle's case it was the dominant, right, hand that was affected, in general Parkinson's disease does not seem to be any more likely to affect the dominant than the non-dominant side (Reynolds & Locke, 1971).

☞WWW☜ 10:3

This was one of the worst periods of Carlyle's life. Two days later on 17th June 1871 he wrote that, "for ten days past I have been in such a [bad] state of health as I ever knew in my life" (Heffer, 1995 p.369). The passage from Carlyle's Journal has been quoted by Barsley (1966c), who mis-quotes it, instead of having 'windy' having 'wintery', which would be unlikely in June.

☞WWW☜ 10:4

Whether in 1871 Carlyle could have seen men mowing within walking distance of his house in Cheyne Row, is not clear. The time of year was certainly right for hay-making. Whether there were still fields nearby was another matter. A decade or two earlier there almost undoubtedly were, but by 1871 London was rapidly encroaching on Chelsea (Glanville, 1972). Earlier in his life, in the summer of 1845, he had taken long rides as far as Harrow, Kew and Acton, and had watched the harvesting (Heffer, 1995 p.244), and in 1840 he is described as "when taking himself out for walks went over Battersea Bridge and into the country..." (Heffer, 1995 p.210), and in May 1841 he took his walks, "westwads, into the fields past Fulham" (Heffer, 1995 p.213).

☞WWW☜ 10:5

"For a left-hander, eating a meal at a counter can be hazardous; he tends to put his elbow into his left-sided neighbor's soup or sandwich"(http://www.baylorhealth.com/ proceedings/ 12_4/12_4_flatt.htm). Petroski (1994c p.3) comments, "We manipulate knife, fork and spoon as automatically as we do our fingers, and we seem to become conscious of our silverware only when right- and left-handers cross elbows at a dinner party".

☞WWW☜ 10:6

Petroski (1994c pp.15-18) suggests the habit of using a knife in the right hand and a fork in the left, which is probably seventeenth or eighteenth century, evolved from an earlier habit of eating with two knifes, which was itself an improvement on eating with only one knife, which invariably meant dirty, greasy, and sometimes burned, fingers. The American style of using a knife and fork, what Emily Post in the 'Blue Book of Social Usage' in the 1920s called 'zigzagging', using the fork in the left hand for cutting, and then transferring it to the right hand for eating, may have arisen from an early colonial habit of eating with a knife and spoon.

The example of dealing cards at a bridge table is given by Cook (1914 p.165).

☞WWW☜ 10:7

For reviews of the writing systems of the world see Diringher (Diringer & Regensburger, 1968d), Daniels (1996g), and Coulmas (1996h). There are probably some other minority writing systems which have evolved independently, such as the Mayan and other scripts of central America (Mayan is written from left to right), and the rongorongo of Easter Island, which also is written from left to right.

Pictographs are still with us, and many 'international' signs such as ✂, ✆, ✈, ☺, ♬, ☞, ⏯ and ⏭ are frequently used (and also are frequently asymmetric; the symbol ⏯ on a tape deck or video machine does depend on one knowing that the tape goes from left to right, an assumption derived ultimately from reading left to right).

The problems of a pictographic language such as Chinese or Japanese are several fold. One is that a Chinese or Japanese character gives no indication of how it is to be pronounced. One hears stories of Japanese businessmen who present their cards to one another but still do not know how to greet each other out loud, because the signs do not say how to speak the name. Another problem is with dictionaries, since there is no obvious order in which to place the signs (unlike our alphabet which comes in an agreed order); in Japanese the solution seems to be to count the number of strokes in the sign, say six, and then search systematically through all the six-stroke signs. It is not an efficient method. Finally, of course, Japanese and Chinese type-writers are notoriously complex, with thousands of keys. The development even of a telegraph system is very complex (and that is said to be why the Japanese instead invented the fax machine). Certainly it is difficult to see how a modern computer could have been developed which used only pictographs.

The very early history of writing continues to be confused and confusing (Lawler, 2001), and new archaeological remains have the potential for overturning many established findings (although dating is not always as clear as it might be).

☞WWW☜ 10:9

The problem of the direction of the ductus is clearly put by Ronald Stroud (1989c): "If the Greeks had learned to write their own language in their own alphabet as early as 1100 BC, ... why do we have to wait over three hundred years for the first tangible evidence of such an achievement ?". See also Stroud 1989c p.116. The standard account has been described clearly by Jeffrey (1990g p.43). The theory tends to argue that any inscription which is from

right-to-left must either have been archaic or an atavistic hangover, which is, though, a self-fulfilling theory.

An interesting but somewhat speculative theory to account for the change in the ductus is that of John Skoyles, who suggests that Ancient Greeks read with their right hemisphere, whereas there was a shift over the next half millennium, and Classical Greeks read with their left hemisphere. The result was that right-to-left reading was initially easier, but that later left-to-right reading became advantaged (Skoyles, 1985d; Skoyles, 1988c). The theory clearly has some conceptual overlap with that of Jaynes (1976d), who also argued that cerebral dominance in the Classical Greek mind had evolved in comparison with earlier peoples, and that consciousness in its modern form was the result.

One of the longest examples of a boustrophedon inscription is the Code of Gortyna, discovered in Crete. It dates from the 5th century BC, and is the oldest law code in Europe. For an illustration see Farnoux (1996 pp.24-5). Joyce's comment about boustrophedon can be found in *Finnegans Wake* Joyce, 1975 p.18; see O'Shea (1994f), who also describes Joyce's 'boustrophedonic writing', palindromic at times, with its reversals of order: “But by writing thithaways end to end and turning, turning and end to end hithaways writing” (Joyce, 1975).

Naveh (1988b) has argued that early Greek would have also contained elements of Hebrew and Aramaic scripts, which were written from right to left..

☞WWW☜ 10:10

There is a third method of writing in boustrophedon, at least in principle, which I have never seen discussed, but would involve reversing the order of the words, but not the letters within words on each retrograde line. Or to put the same thing self-referentially:

There is a third method, in principle at least, of
seen never have I which ,boustrophedon in writing
discussed, but would involve reversing the order
on ,words within letters the not but ,words the of
the even-numbered lines which are written retrograde.

In deciding whether letters are, or not symmetric, one has to be careful of the font one is using, because serifs can make letters asymmetric which otherwise might seem symmetric (e.g.’i’) but to a first approximation, only ‘i’,’l’,’o’,’v’,’w’ and ‘x’ are symmetric; as for instance in the sans serif font Ariel, e.g. 'i', 'l', 'o', 'v', 'w', and 'x' .

☞WWW☜ 10:12

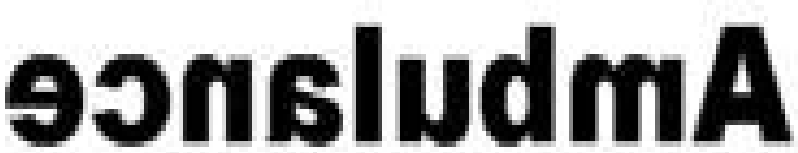
A Unix/Linux program for printing in boustrophedon can be found at www.vis.colostate.edu/ ~traevoli/. The program will also produce false boustrophedon if requested, and the retrograde lines can be printed in a different colour to help separate them visually.

The Frere system was developed in 1840, and on the return sweep, from right-to-left, the characters were mirror-image reversed; Moon produced his system a decade or so later, and

the characters on the right-to-left sweep were not mirror-imaged. The method of printing we now call braille, which was invented by Louis Braille (1809-1852) in France in 1829, was only introduced into Britain in about 1870. (www.braille.org/ papers/ lorimer/ chap3.html).

The real problem for boustrophedon is its status in ancient Greek. Is there clear evidence that the script evolved from right-to-left, through boustrophedon, to left-to-right? Anne Jeffrey argued the case most forcefully that there was not. Firstly she argues that there is no proper evidence that archaic Greek was ever written consistently from right-to-left. Individual lines do occur, but they are hardly evidence for a systematic usage of this type of writing. It is as if a Martian came to England, and concluded that English could be written in either direction because sometimes one saw signs such as figure 2:

Figure 2: Inscription on the front of an ambulance.



Although this sign does occur, on the front of ambulances, so that drivers who are being followed by an ambulance can more quickly read the word in their rear-view mirrors, it is hardly typical of modern English script (perhaps the sole exception being the television monitors which are used in the auto-cue systems for announcers produce continuous retrograde, mirror-imaged text, so that the text is the correct way round when reflected in a half-silvered mirror placed between the camera and the announcer).. Jeffrey argues that most retrograde script in archaic Greece was also similar, typically being used in situations where the geometry constrained the way the writing could be put. Many retrograde inscriptions are on walls, over doorways, on pots, or in other places where it makes little sense to write left-to-right. A related practice still occurs in English when poetry is being printed – if a word or two will not fit in to a line, the words are printed at the extreme right hand edge of the page, and not back at the left-hand edge. Jeffrey argued that instead of going through a phase of retrograde writing, Greek writers went straight into boustrophedon: “from the beginning, when more than one line was required, they used instinctively the boustrophedon system” (Jeffrey, 1990g p.45). It must be said that whatever else it is, boustrophedon hardly seems the “instinctive” way of doing anything – except, perhaps, ploughing a field. That the Greeks did use it though seems indisputable (and they would hardly have had a word for it otherwise).

Whatever the precise details of quite how archaic Greek writing evolved, much has been made of the fact that it did so. The last dying throes of boustrophedon were just disappearing at the beginning of the Golden Age of Greece, when classical Greek civilisation set up so many of the institutions and ideas that the Western intellectual tradition takes for granted. Some how it is presumed that being able to write from left-to-right had something to do with it. Jeffery herself puts it down to the majority of the population being right-handed, although most people were probably right-handed long before that time. Writing from left-to-right is “the easiest way to write” for a right-hander, and the majority of the Greek population, as today, would have been right-handed. The important thing about the boustrophedon of archaic Greece was that it allowed writers to try out both right-to-left and left-to-right, when it

would then have become breathtakingly obvious that left-to-right was easier. And somehow the rest is history. It is, I fear, a difficult theory to sustain.

☞WWW☜ 10:13

Inevitably the historical chart over-simplifies many issues, and is itself derived from secondary sources, since I am not an expert, or even an amateur, in any of the highly specialised areas involved. My starting point was the extremely useful figure on p.61 of Healey (1990 p.61), which I have amended and extended on the basis of information in Coulmas (1996h), Diringer (1968d), and Daniels and Bright (1996g). Connections between scripts mean that the characters of the scripts themselves show a relationship, rather than that there is a relationship in the languages represented. The difference is important: Urdu is essentially an Arabic script which is being used to represent the Hindu language; and linear B represents the Greek language although the script bears no relation to Greek. Where scripts are shown without any connections it is because their origin is not known, or I do not know it. Needless to say the chart makes no attempt at completeness. I have chosen to omit Chinese and the scripts derived from it, mainly because their direction is principally vertical, albeit with columns that typically go from right to left.

For scripts which have not been deciphered it can be extremely difficult to know whether they are written from right or left or left to right. An excellent account of the difficulties is shown for the enigmatic Phaistos Disk, probably produced in Minoan Crete about 1700 BC (Balistier, 2000).

☞WWW☜ 10:14

Since early scripts are often quite indeterminate in their direction, so that scribes must have had practice writing in both directions, then according to the theory of Jeffrey (1990g) the scribes should rapidly have settled down on left-to-right as being the most natural direction for the right-handers who undoubtedly were the majority of the population in the region (see chapter 9).

Without any direct experience I would have thought that right-handed writing on papyrus would be more difficult if pushing the pen from right-to-left, when it would tend to catch in the fibres of the papyrus, rather than pulling it from left-to-right. But no doubt Herodotus would have agreed with me.

Skoyles (1984f; 1985d; 1988c; see also www.users.globalnet.co.uk/ ~skoyles/right1.htm.) suggests that Ugaritic, which was a cuneiform, alphabetic script derived from Proto-Sinaitic/Proto-Canaanite, was written consistently from left-to-right. Likewise Old Persian cuneiform is also written from left to right (Testen, 1996). It is a nice theory, but the problem is that other early cuneiform scripts, albeit syllabic, such as Hittite and Akkadian, have the same problem of smudging the wet clay, but are not written consistently from left-to-right (Walker, 1990) . Following Jeffrey's argument, one would have thought that these early writers, having tried it both ways, would rapidly have realised that left-to-right was better. That they did not suggests that smudging was not the main process driving direction of writing. And to add to the problems, proto-Elamite, also cuneiform, seems generally to have been written from right to left (Englund, 1996). A more detailed analysis creates even more problems for the 'smudging' theory. On a typical cuneiform tablet the writing starts in the

top left hand corner, and follows down the left-hand side in a column, in which the symbols go from left to right. Then, just like a newspaper the text starts again at the top, slightly to the right, and follows down column, and so on, until the right-hand edge is reached. What then happens is interesting; the tablet is turned over (at the bottom edge though, and not the side), and the writing then continues in another column in which the characters read from left to right, *which starts on the right hand side* (Powell, 1981 p.424-5). The next column is then *to the left* of the previous one, and so on, until the left-hand edge is reached. What is clear, here, is that although the individual rows in the columns are written from left to right, the columns on the reverse side of the tablet are written *from right to left.* If smudging were a problem then this would surely not be the way in which it was chosen to write the reverse side.

I am grateful to Professor Marvin Powell of Northern Illinois University for his comment that a left-handed cuneiform writer would have been almost inconceivable in the ancient world.

☞WWW☜ 10:15

Hewes' own conclusion was: "The [quantitative] pre-eminence of left-right scripts, numerically and geographically, is due to a combination of historical, economic and religious factors altogether unrelated to the laterality aspects of the matter" (Hewes, 1949 p.3239). Corballis and Beale (1976 p.107) come to a similar conclusion when they talk about "further doubt whether there is a truly natural direction in which to write".

Gould (1989d) in describing contingency, says, "the final result is dependent, or contingent, upon everything that came before – the unerasable and determining signature of history". He emphasises that contingency is not randomness (Gould, 1989d p.283). It may look like it from the outside, because we are not privy to the details of the decisions made, but to those inside the process there is a clear causal chain which is dependent upon a myriad of tiny but influential events and decisions. To the external viewer or the statistician although much of that gets described as 'noise', it is not actually, but rather is unexplained variation, which is a very different thing indeed.

Some readers may find explanations invoking contingency as in some way unsatisfactory – and perhaps claim that they are not even real explanations. Gould addresses this problem head on:

> "I have ... slipped into the rhetoric of inferiority — ... that historical explanations may be less interesting.. . No ... apologies need to be made. Historical explanations are endlessly fascinating in themselves, in many ways more intriguing to the human psyche than the inexorable consequences of nature's laws. ... With contingency we are drawn in; we become involved; we share the pain of triumph or tragedy." (p.284).

☞WWW☜ 10:16

In the past there was certainly not consistency in the United States, and for instance, driving was on the left of the inter-state National Road built in 1806 until at least 1848 (de Luna, 1993).

A modern way of talking about 'custom' is to describe it in terms of memes. As Susan Blackmore (1999c p.7) has put it, "So, for example, whenever you drive on the left (or the right!)... you are dealing in memes".

The traffic rules were more complicated in Goethe's Rome, because there were people who ignored or were excused the traffic rules, just like the members of the Politburo in the old Soviet Union who were said to ignore all red traffic lights. In Rome, Goethe tells us, "Ambassadors have the right to drive in either direction down the middle of the street". (Goethe, 1970 p.448).

The gridlock in eighteenth century Paris was followed by another recognisably modern phenomenon which followed: "The result was road rage. In one particularly nasty incident at the Places des Victoires in 1766, a furious nobleman leaped out of his carriage, drew his sword, and buried it in the belly of the horse attached to the carriage blocking his. He was the Marquis de Sade." (Darnton, 1999).

☞WWW☜ 10:17

A physical model of the process of streaming when particles have their own intrinsic powers of movement, due to Helbing *et al*, is described by Buchanan (2000t).

Although lawyers have rarely looked at the legitimacy of governments imposing a rule of the road, Adams (1996i) has published a devastatingly satirical piece on the mythical country of Idd, which drove on the right originally, but where immigrants with different belief systems started driving on the left. A pragmatic compromise was reached for a while in which liberal Iddians and recent immigrants were allowed to drive on the left between 1 a.m. and 5 a.m. in secluded areas. Further compromises were then reached in which most Iddians drove on the left but some were 'exempt' because of their historic belief systems and were allowed to drive on the right. The inevitable outcome was carnage on the roads. Adams chilling conclusion is that, "only pragmatism or utilitarianism can be the basis of law once a dominant morality evaporates, and neither philosophy is compelling enough of a justification for most to defend the rule of law against dogmatic idealists ... [W]ithout consensus about fundamental values, democracy collapses, regardless of what judicial and legislative countermeasures are taken. It happened in Idd and it will happen in the United States".

In Nabokov's *Lolita* it was driving on that "queer mirror side" which was also Humboldt's inevitable downfall, because it simply could not be ignored, particularly once he drove into town (Nabokov, 1995 p.306).

☞WWW☜ 10:19

Feldman (1987 p.238) put it clearly, and also showed another misapprehension about Britain: "Why do the English [sic] drive on the left and just about everybody else on the right?".

In preparing the maps and writing this section I am indebted to two excellent web sites: www.travel-library.com/ general/driving/drive_which_side.html, and www.mmailbase.ac.uk/lists/ int-boundaries/1999-09/0000.html, both of which draw heavily on Kincaid (1986b p.198). The percentages are for the early 1980s by Kincaid who also estimates 23% of the road mileage, 18% of motor vehicles, 34% of territories and 30% of independent territories were then driving on the left.

☞WWW☜ 10:20

The fact that the Maritimes followed Britain does beg the question of why, and for how long, Britain has driven on the left. Kincaid (1986b p.11) says he was unable to find out anything about ancient driving habits. An intriguing exception has recently been found in Roman Britain. The Romans excavated a large quarry at Blunsdon Ridge near Swindon in Wiltshire. The old road is still visible, and the ruts on the left hand side of the road are far deeper than those on the right, presumably due to the far heavier carts leaving than entering the quarry. In this little corner of the Roman Empire, driving was on the left (Kennedy, 1999).

☞WWW☜ 10:21

Intriguingly the 1904 Baedeker guide to Italy only talks about cyclists. The idea of travelling by motor car appears in the 1913 guide.

A typical example of the question about driving on the right or left was in New Scientist's *The last word* for 23rd October 1999, which can be found on their web-site, www.last-word.com.

☞WWW☜ 10:22

Although the change in the rule of the road in Austria is declared as being 'overnight' in some accounts, in fact the *Anschluss* was on 12th March 1938, the proclamation was issued on 18th August, and the changeover occurred at 00:00 on Monday 19th September (Kincaid, 1986b p.50).

☞WWW☜ 10:23

There seems to be some confusion over quite when Myanmar (Burma) changed this side of driving, since although Honour (1995f) refers to it as 'recent', Kincaid (1986b p.52) suggests it was probably in 1970.

☞WWW☜ 10:25

This was not an easy map to produce, and it is heavily dependent on that of Kincaid (1986b pp.196-7). The borders are the same modern borders as those shown on the map for 2000, despite some having changed in the interim. Nevertheless it should give a good idea of the amount of change over the past century. The year 1919 was chosen by Kincaid (1986b p.198) because it was probably the one in which the largest number of people drove on the left, about 33.7% of the world's land area of 52.4 million square miles. An interesting thought is that if none of the countries shown in the 1919 map had changed their rule of the road, then given current population sizes, about 64% of the world's population would presently drive on the left. That figure is however very influenced by China, which contributes about 20% of the world's population. Excluding it, then about 54% would drive on the left.

☞WWW☜ 10:26

Ising glasses were developed by the mathematical physicist Ernst Ising (1900-1998), who for understanding magnets (www.bradley.edu/las/phy/ising.html; www.swin.edu.au /chem/complex/vp/vp06/vp06.html). In a magnet each little domain can be considered as

being a tiny magnet in its own right, each with its own north and south pole (Stein, 1989). To start with, in an unmagnetised piece of iron, they point in all directions at random. As the iron is magnetised so the individual domains come to be aligned one with another. The crucial feature from our point of view is that each little domain is also influenced by those around it. To be a little domain facing north is difficult when all around are facing south. A little push and you too will face south as well. This is actually a good model for social and economic interactions as well (Arthur, 1990i). For an interactive model of a two-dimensional Ising model see bartok.ucsc.edu/peter/java/ising/ising.html.

For a description of Conway's game Life see Holland (1998n). There are also close links to neural networks (see www-perg.phast.umass.edu/perspective/NeuralNetworks/NeuralNetworksEssay.html).

☞WWW☜ 10:27

This property of the world can be easily visualised if one takes the map, rolls it up in a tube, and then twists the tube around in a circle until the ends join. The final product looks like the sort of doughnut that has a ring in the middle. Whenever one goes off one edge of the map one comes straight back on to the opposite side. Not having any edges makes many calculations of this sort much easier and more elegant. Of course in the real world edges are problematic precisely because they are different and interesting.

☞WWW☜ 10:28

Left-right symbolism is, needless to say, strongly developed in *Chirenia*; so it is not surprising that heads is right and tails left, or white is right and black is left. However the Chirenese had to resort to tossing a coin to decide whether to drive on the right or left because the Dextralist party argued that driving on the right side of the road was clearly better because the car was on the right, whereas the Sinistralists argued that driving on the left was self-evidently better because it meant that the driver was in the right-hand side of the car. Civil war was eventually avoided only because of a strong Federal president who showed that coin-tossing was the only fair way to resolve the impasse.

Lest it be thought that I have carefully chosen this example to give a 'good' result, I should say that it was in fact the first one I tested. The only thing I did do was shift the output so that the black blob was nicely centred. I also ran a further 50 replications. In none of them did white or black completely dominate the situation (i.e. fixation of white or black, with 0% or 100% white). The average final percentage of white was, not surprisingly, very close to 50% (48.2%), but the distribution was, again unsurprisingly, much wider (standard deviation = 20.8; range =8 to 96) than was the starting distribution (mean white = 49.4%; standard deviation = 5.7; range= 36 - 62). A stable configuration appeared in an average of 5.7 cycles (SD 1.9; range= 3-14), and in 88% of cases there were two separate areas; in the remainder there were three (an area was defined as single if one could drive from any cell in it to any other while staying on the same side of the road).

Perhaps the most surprising thing about the Chirenia simulation is that in the 50 replications the smaller, minority area represented an average of 32.3% (SD 10.8) of the total area, which is remarkably close to the 33.8% of the world's population who currently drive on the left. Although at first the fact there are always two or more areas might also seem surprising, it

comes about because of the criterion of a *clear majority* of neighbouring regions going the opposite way. Any particular region is surrounded by eight other regions, and hence four can drive on the right, four on the left and the situation will be stable, neither right nor left attaining a majority amongst the neighbours.

Whether the Chirenian simulation is a good model for predicting the real world does depend in part on the continued existence of right and left hand drive cars. Should monopolistic multinational car manufacturing companies decide autocratically to rationalise production and only produce left-hand drive cars then that might put additional pressure on countries that drive on the left. Having said that, the existence of places such as Cyprus and the US Virgin Islands where most people drive on the left in left hand drive cars suggests that there may still be stability.

An interesting pressure on the minority of countries that drive on the left occurred, as in Britain, with DaimlerChrysler's Smart car, which when it was introduced into the UK came only in a left-hand drive version, as in the rest of Europe. At first that might have seemed to be a sign that manufacturers would prefer to produce only left-hand drive cars, thereby putting pressure on countries driving on the left to drive on the right. The ease with which drivers adapted to a left-hand drive car while driving on the left might also have decoupled the side of the road for driving and the side of the steering wheel. However in October 2001 DaimlerChrysler announced that it would be producing a right-hand drive version for sale on the British market (*The Guardian*, October 15th, p.21).

☞WWW☜ 10:29

Gould (1908) puts forward a lengthy and complex case that right-eyedness is the predominant reason for driving on the right being the natural way. But he wrote extensively on eyedness, arguing that it was a neglected aspect of behaviour and the basis of all sorts of pathologies (e.g. Gould, 1904).

Whether early cars were all built with their accelerator on the right and clutch on the left would be worth following up. Just as early clocks were not all built to go clockwise (see chapter 12), so it is possible that early cars, particularly those built individually by left-handed enthusiasts, might be reversed.

☞WWW☜ 10:30

Leeming (1969c) is cited by Kincaid (1986b pp.25-7) as finding that countries which drive on the left have a lower accident rate than those that drive on the right. The effect is large, the order of about a third, but does not seem to have been studied any further. However the statistics presented by Leeming are relatively limited and very selective. Kincaid speculates that any effect if present could be due to the driver's right eye being closer to the oncoming traffic. I analysed numbers of road accidents for the 62 countries reported in the *Economist* book of world statistics for 1985-88 (The Economist, 1990) in relation to log total population, log area of the country, log miles of road and log number of vehicles, as reported by Kincaid (1986b) for the year 1982 or thereabouts. The log of the number killed per annum was very significantly related to population size and number of vehicles. The 15 countries driving on the left had a very slightly lower rate of accidents (0.25%), but the very small effect was nowhere near statistical significance. A similar negative result was found for the number of

injuries per annum. It can be concluded that accident rates do not differ in relation to driving on the right or the left.

☞WWW☜ 10:31

The situation for pedestrians seems in general to be one of mild anarchy (Kincaid, 1986b pp.37-9), and although attempts have been made over the years to impose a rule of the road it generally has had all the success of herding cats. In the narrow medieval streets of Siena I have seen an old sign, probably nineteenth century, saying 'Pedoni a sinistra', although there was little evidence of note being taken note of it. One of the rare exceptions which is observed, at least by Londoners who get very annoyed with tourists who do not understand it, is the habit of standing on the right and overtaking on the left on the escalators on the Underground. Occasionally claims are made that pedestrians naturally 'drive on the right', be they American or British (Mestel, 1998), but it is doubtful that there is any universality.

As far as horses are concerned, Kincaid (1986b p.3) mentions that the practice of leading a horse with the right hand from the left side "appears to be universal". Charles Darwin also mentioned "the difficulty of getting on a horse on the left side ... because [the human] leg is right handed" (Barrett et al, 1987 p.533). Xenophon in his *Art of horsemanship* gave instructions on getting on an off a horse which presumed most people were right footed (Gould, 1908 p.35), and likewise Bell (1834a p.143) comments that "The horseman puts the left foot in the stirrup and springs from the right".

The 'rule of the road' seems to be universally applied for ships, as far as I am aware, and specifies precisely who has right of way and how ships should manoeuvre in a myriad of complex situations.

Hamer (1986c) discusses trains, as also does Kincaid (1986b p.39-41). Gould (1908) has a good account of the confused situation in America at the beginning of the twentieth century. Although railways largely follow the same habit as roads, the most prominent exception is in France, where trains run on the left, probably because the first railways were built by a British engineer, Thomas Brassey. The trains in Alsace Lorraine, which was annexed by Germany in 1870, were built by German engineers and run on the right, and at the pre-1919 border there are flyovers (*saut de mouton*, sheep's jumps) to swap the trains from one side to the other.

Aeroplanes, despite their external symmetry, show a number of internal asymmetries, of which the most obvious are that the captain always sits on the left, and passengers always board from the left at international airports. Most of these asymmetries seem to arise from early aeroplanes being 'mounted' in much the same way as a horse, from the left, and from the right-handedness of the pilot, who wishes to have the centrally placed joystick in his right hand. To confuse matters, helicopter pilots are seated on the right side of the flight deck (see discussion in *New Scientist*, 'The last word', 22nd April 2000).

I heard about the Monster Raving Loony Party's manifesto from Steve Jones, but have unable to find it anywhere in writing. However a glance at the Monster Raving Loony Party's manifesto for the 1997 general election (freespace.virgin.net/ raving.loony/sutchmanif.htm), written by the late Screaming Lord Sutch, will confirm that the transport policy shares a coherent philosophy with the party's other policies.

☞WWW☜ 10:33

The full entry in Carlyle's journal on the universality of right-handedness reads:

> "It is curious to consider the institution of the right hand among universal mankind; probably the very oldest human institution that exists, indispensable to all human co-operation whatsoever. I wonder if there is any people barbarous enough not to have this distinction of hands; no human Cosmos possible to be even begun without it. Oldest Hebrews, &c writing from right to left, are as familiar with the world-old institution as we. How old? Old!." Froude, 1885 vol II, pp. 407-8

Pye-Smith starts out by rejecting any direct effect of the heart upon handedness, since "by an examination of the chest in left-handed persons it may readily be seen that most of them at least have their hearts in the right place". He then carries on:

> "If a hundred of our ambidextrous ancestors made the step in civilisation of inventing a shield, we may suppose that half would carry it on the right arm and fight with the left, the other half on the left and fight with the right. The latter would certainly, in the long run, escape mortal wounds better than the former, and thus a race of men who fought with the right hand would gradually be developed by a process of natural selection. Such a race would naturally use the right hand also when they discovered how to draw and to write...". Pye-Smith, 1871

Pye-Smith (1840-1914) who published his paper in the middle of 1871, at much the same time as when, on June 15th 1871, Carlyle went out for that morning walk, had a distinguished career, going on to become FRCP, FRS, and Vice-Chancellor of the University of London. After taking a degree in Classics at University College London in 1858, he went on to take his medical degree at Guy's in 1863, and then to study in Paris under Trousseau, Berlin under Virchow, and Vienna under Hebra. T H Huxley is said to have described him as "the best educated young man in London". Given the overlapping of the social circles of the Huxleys, the Darwins and the Carlyles it seems at least feasible that Pye-Smith and Carlyle both talked about the shield theory. It is also more than possible that the idea was generally in the air, since more than a decade earlier, "C.H.P." (1856) had commented that "the possible protection afforded by the unemployed left hand to the side where the most important organ of the body is placed, has also been, perhaps fancifully, assumed as a final cause of [right-handedness]". The comment is interesting in that it occurs before the publication of Darwin's *Origin of Species*, which has been presumed to trigger the 'shield' theory.

Although there is no direct evidence that Darwin himself ever considered the shield theory, we do know that it in August 1878 he was in correspondence with A.L. Adams who mentions to him a theory that deer have larger left antlers than right, "possibly for protection of [the] heart". As far as I am aware, Darwin's reply does not exist.

☞WWW☜ 10:35

There is no doubt that left-handed batters are particularly common in baseball, 31% of major league players (excluding pitchers) batting left-handed, compared with 9% of high-school players. In addition 12% of major league players batted with either hand (switch-hitters) compared with 2% of high-school players. Whether the asymmetry of the game itself can entirely account for the effect is not clear as there is a suggestion that professionals who bat left *and throw left* have higher batting averages than those who bat left and throw right, whereas of course both should be equally advantaged by tactical advantages and being closer to first base (McLean & Churczak, 1982).

A film of Babe Ruth, the left-hander, can be seen at www.baseballhistorian.com/html/babe_ruth.htm, where the advantage of the left-hander can be clearly seen as Ruth runs towards first base.

I have heard it suggested that golf courses are organised asymmetrically, the greens tending to favour right-handers. That would certainly be compatible with claims that only one golfer playing left-handed has won a major[50] (Billings, 1994), and that there is a dearth of left-handed golfers at top levels of the game (Aggleton & Wood, 1990h).

It has also been claimed that horses themselves are not symmetric, about 75% preferring to lead with the left fore foot (Gray, 1989); see also www.horseshoes.com/advice/egray1/eqnasmdx.htm.. Greyhounds suffer a far higher rate of fractures of the right navicular bone in the ankle, as a result of the extra stress put on it because it is on the outside of the curve (Johnson et al., 2000). Whether human athletes have the same problem is not clear. There is however no doubt that bone re-modelling does occur in humans once the loading of the two legs is not symmetric, as for instance after a stroke on one side (JØrgensen et al., 2000).

Sometimes although left-handedness is not explicitly forbidden, it is sometimes discouraged. For instance in the Shotokan style of karate there seem to be almost no masters who are left-handed because the 27 basic forms are themselves intrinsically right-handed (Layton, 1993). In diving, although there are no specific rules about direction, Coren has described how left-handers some times score less well because their anti-clockwise spirals look less slick to judges used to the more common clockwise spirals of right-handers (www.ausport.gov.au/fulltext/1998/sportsf/sf980227.htm).

☞WWW☜ 10:36

Wood and Aggleton (1989e) looked at 167 goalkeepers, 9.6% of whom were left-handed. Aggleton and Wood (1990h) also found that amongst 100 professional darts players only 3.8% were left-handed, slightly less than expected.

Amongst top ten-pin bowlers, Aggleton and Wood (1990h) found that of 131 males and 213 females, 9.9% and 6.6% were left-handed. Although ten-pin bowling seems symmetric (as long as the holes in the ball are appropriate for a left or right-hander) there is an argument that because most bowlers are right-handed then the lanes become subtlely worn in the typical curving path of a right-hander, then this provides a slight advantage for a left-hander who can find a 'sweet spot' on the left hand side of the lane. The argument of course can also be reversed to say that right-handers typically throw in a track left by their fellow right-handers.

There is a suggestion that left-handers may more often be clumsy or dyspractic (Gordon & McKinlay, 1980 p.6, Gubbay, 1975 table 4.37). Sir Cyril Burt attracted much bad press from left-handers for his description in the 1930s of their motor abilities: "They squint, they stammer, they shuffle and shamble. They flounder about like seals out of water, awkward in the house and clumsy in their games. They are fumblers and bunglers at whatever they do..." (Burt, 1961 p.287). He was however describing a sub-group whom he called “the ambi-

[50]Bob Charles in the 1963 Open Championship.

sinistral", a sub-group for whom there seems to be good statistical evidence. Dorothy Bishop has shown that amongst left-handers there is a group in whom performance in the non-dominant hand, the right hand, is much worse than is performance by right-handers using their non-dominant hand, the left (Bishop, 1980,Bishop, 1990). Since many skilled tasks involve co-ordinating the right and left hands this probably means that left-handers are more likely to be found in a group of clumsy (dyspractic) individuals.

☞WWW☜ 10:37

Although in the past tennis has been a symmetric sport, Neale Fraser, a champion from the 1950s (www.ausport.gov.au/fulltext/1998/sportsf/sf980227.htm) points out that that is not quite the case now:

> "But the biggest advantage I think has only come about since the advent of the tie-break. In the tie-break, ... after the first point when you change serves, the service person starts in the second court all the time, and that's the left-hander's most favoured side. Conversely, when the right-hander is playing and has to serve, he is serving into the second court which is not his favoured side. So I think the tie-break favours the left-hander."

In 1998 it was claimed that 19% of men and 11% of women on the international tennis circuit were left-handed, compared with 12% of men and 8% of men in the population in general. (www.ausport.gov.au/fulltext/1998/sportsf/sf980227.htm). However Wood and Aggleton (1989e) in their survey could find no consistent excess of left-handers, and before 1954 questions were asked as to why left-handers in tennis were so rare (Buss, 1995). Taking all of the results together there probably is an excess of left-handed tennis players (Raymond et al., 1996j). There does however seem no doubt that there is an excess of top table tennis players who are left-handed (Raymond et al, 1996j), and a similar excess may also be found in badminton (Raymond et al, 1996j).

The advantage in competitive sports is perhaps not restricted to top level players. Alison Brace of Walthamstow, described for instance:

> "As a teenager I played a lot of badminton. I found being left handed an advantage as it was often off-putting for my opponents. They would play what they thought was my backhand and would be surprised when I could return the short so easily". (Vestry House exhibition, see Sadler, 1996b).

In baseball there has been a continual evolutionary battle between right and left-handed pitchers and hitters which has been well-documented due to the quality of the historical statistics available (Flanagan, 1998,Goldstein & Young, 1996). In cricket there have been seven separate occasions in which the England test team no less than five of the eleven players have been left-handed (Anonymous., 1993). The Australian test team from 1877 to 1998 is said to have had 17% of its bowlers and 20% of its batsmen left-handed (www.ausport.gov.au /fulltext/1998/sportsf/sf980227.htm). However Wood and Aggleton (1989e) could not find an excess of left-handers amongst batsmen, only amongst bowlers, although Raymond *et al* suggest there is also an excess of left-handed batsmen (1996j) and not batsmen.

The tactical advantages of the left-hander were recognised long before the advent of modern sport and were particularly apparent in that most obvious substitute for lethal battle, fencing[51]. In 1747, Captain John Godfrey clearly stated how left-handers were advantaged:

> "I cannot help taking notice that the left-handed Man has the advantage over the right-handed, upon an equal footing ... in both Small and Back-Sword. I would rather contend with the right-handed Man with more judgement, than the other with less". Cited by Harris (1990f p.204).

Similar, in July 1892 the Italian master fencer Eugenio Pini, from Livorno, fought the French Master Pini. A report of the time showed the problems that Pini faced:

> "Rue, the Parisian fencer, is a left-handed man, who fences with much steadiness and calm, and many of Pini's favourite attacks were rendered useless owing to this peculiarity of left-handedness. It is generally admitted that the Cav. Pini is superior to any French fencer". (users.townsqr.com/ale/gugler.htm).

Pini himself had a rather eccentric but very effective style, which was described in *The Graphic* of 2 July 1892:

> "The position taken up by the Cav. Pini is a very curious one. He leans forward with his head low, his right foot well in front of him, and his left hand hanging loosely near his shoulder. On guard, he holds his foil nearly upright, and his attack is marvellously rapid and dashing. He is at all points at once, his blade flashes round his adversaries and threaten in every position, so that the artist has endeavored to give some idea of the rapidity of his play by marking in dotted lines the quivering of his foil."

The reasons for the advantage of left-handed fencers were apparent even before the first World War, Theodore Cook putting it very straightforwardly: "left-handed fencers ... have far more opportunity of practising against right-handed men than we have of getting used to them" (Cook, 1914 p.243).

☞WWW☜ 10:38

If the incidence of dyadic fighting has decreased over historical time then one would expect the incidence of left-handedness to have come down, whereas the incidence actually seems to have been mostly constant with some increase in the incidence of left-handedness. The size of any frequency-dependent selection will also depend on the number of fights, the proportion of left-handers, and the proportion of fights which result in the victor rather than the loser successfully having offspring. The effect could be very small overall, although given a large enough length of time that is no objection to such a theory as small effects can still become fixed.

Even if the advantages of fighting from the unexpected or the stronger side perhaps haven't influenced the evolution of left-handers, is it possible that they have determined other historical moments? The Battle of Hastings in 1066 is a defining moment in English history which every British school child is supposed to know about[52]. What has left and right got to do with it? One of the mysteries is quite how so few English, who were outnumbered three to

---

[51] Since in part this book has been inspired by Osbert Sitwell's *Left Hand, Right Hand!*, I feel I must emphasise here that Sitwell himself learned to fence, in Italy, and with the left hand at that (see also chapter 11).

[52] Actually only 64% of a representative sample of British adults aged 25-34 knew what happened in 1066, with the proportion rising to between 73 and 78% of those aged over 45 (Anonymous, 2000a).

one by the Normans, managed to fight so effectively and for so long. A possible solution is that the Normans approached the English line diagonally and from the left. The result was the English axemen could brace their right foot, and swing the axe forcefully to the left, their stronger side (Wheeler, 1988 p.134)[53]. Although it didn't change the outcome in that case, on such left-right differences the course of history might sometimes have flowed.

☞WWW☜ 10:40

Brodie also comments that "We know that some individuals are left-handed, but the proportion of them is very small, and I am not aware that there has ever been a left-handed nation." (Brodie, 1862). He actually attributes the low proportion of left handers to their general difficulty in co-operating with others, and therefore anticipates Carlyle's comments on the mowers. Brodie (1783-1862) was a very distinguished surgeon, being not only President of the Royal College of Surgeons, but also of the Royal Society, the first surgeon to be so. He was the Royal Society's youngest winner of the Copley Medal at the age of 26, but for researches on the role of the brain in maintaining body temperature and the action of the heart which have since been described as having an "impact out of all proportion to their theoretical importance" (Goodfield, 1970). He is remembered now only for the eponymous Brodie's abscess, an increasingly rare form of chronic osteomyelitis.

Potentially it is not only left-handed surgeons who are disadvantaged in medical practice. Traditionally patients in bed are examined with the doctor standing on the patient's right, a position which is convenient for a group of right handers but inconveniences the left-hander in their midst, and could be seen as discriminatory (Roper, 1999).

The idea that left-handers are rare amongst surgeons, is denied by Hugh Dudley who was Professor of Surgery at St. Mary's for many years, although his comments about 'accommodation' suggest there is potentially a real problem:

> "I have known many surgeons who are left-handed and some of them are at the top of their field. True, they may have difficulty in relating to a predominantly right-handed team but my experience is that the assistants and, most importantly, the scrub nurse ... are always prepared to modify their approach to accommodate someone who is skilled but contrary as far as their handedness is concerned." Dudley, 1995.

In good Hippocratic tradition, Dudley also comments that "I am ambidextrous.... This has great advantages for a surgeon though it can cause confusion in assistants. Nevertheless I found it useful throughout my professional career and did not think that it gave rise to difficulties with my team."

☞WWW☜ 10:41

Although Hendrix usually played with the guitar strung conventionally for a left-hander (i.e. the bass strings at the top), he was known on occasion to pick up a right-hander's guitar, turn it over, and improvise on it, despite the bass strings now being at the bottom. In playing

[53] Of course the Normans would also have the English on *their* left side, with the same advantage to right-handers, and so the argument depends critically on the advantage of the static English over the advancing Normans, who were also moving up hill. Whether the size of the effect is large in practice is an interesting question.

the guitar upside down, albeit restrung, he did have to use the tremolo arm in a very atypical position.

Chaplin not only played the violin left-handed in *Limelight* (1952), but did so also in *The Vagabond* (1916). In his autobiography, Chaplin describes how, "As I played left-handed, my violin was strung left-handed with the bass bar and sounding post reversed. I had great ambitions to be a concert artist..." (and he practised four to six hours a day) (Chaplin, 1964 p.131).

Barsley (1966c p.142) says that James Barton, who used to play violin left-handed with the Allegri Quartet, suggested there were aesthetic and practical advantages in having one of the violins in a string quartet playing left-handed since the two violinists face inwards towards the other players.

Oldfield (1969d) also says he has never seen a left-handed string player in an orchestra. Occasionally though musicians do play instruments 'the wrong way round'. A very unusual example is Reinhard Goebel, who gave up being Konzertmeister of Musica Antiqua Köln in 1990 at the age of 38 as the result of a paralysis of the left arm, due to focal dystonia ((www.eubo.org.uk/ebo_biogs.htm; greentea.unl.edu/shop/text/nyt.txt). He subsequently re-learned the violin left-handed, and is once again conducting, although now from the second violin's desk, presumably to prevent violent confrontations with the bows of the other violins.

As well as studying the handedness of instrumentalists, the research also looked at ten leading choirs and a similar slight excess of left handers was found (Aggleton, Kentridge, & Good, 1994). An elegant feature of the study was the use of an age and sex matched control for each musician from a study of the general population (Ellis, Ellis, & Marshall, 1988). An earlier study by Oldfield (1969d) of students in two university schools of music also found a slight but non-significant excess of left-handers amongst musicians.

☞WWW☜ 10:42

As with all usages of right and left there seems to be an arbitrary component in the description of the National Assembly – is it left and right from the point of view of the members themselves or from the perspective of the Speaker or the King. Parkin (1996 p.69) cites Dumont's description, that the "traditional social order was expressed by seating which proceed downwards from the king ... [so that] the first two estates took the right side of the chamber, leaving the negatively valued left side to their social inferiors, the third estate, who rapidly became associated with radicalism. The upshot was that the right, originally standing for innovation and newness, became the side of political conservatism and stability, while the left, originally 'caring, reproductive' became the side of revolution and chaos".

The OED cites James' *Will to believe* as the first usage of left wing in which he says, "In theology subjectivism develops as its 'left wing' antinomianism"; also while discussing Hegelian gnosticism James says "... it would certainly develop its left wing here as there and produce a reaction of disgust". A more recognisable usage is by Bodley in 1898, "...the Socialists, who now compose the Radical left wing".

☞WWW☜ 10:43

Studies of attitudes towards social, political, moral and ethical issues tend to find that two dimensions are better for descriptive purposes. One dimension is the usual left (radical) versus right (conservative), whereas the other dimension has been called toughminded - tenderminded. Tenderminded people have their political beliefs but are little inclined to impose them on other people, whereas toughminded people are willing to do what is necessary, often against opposition, to impose their views. Since the far right and the far left both tend to be toughminded it has been said that the political spectrum may be better viewed not as a line but as a horseshoe or even as a circle, the two extremes becoming so similar that they almost join up once more (Eysenck, 1954).

☞WWW☜ 10:44

The spectrum of colours does also provide a quasi-spatial dimension, of wavelength, and it has also been used for describing politics with red at the radical end and blue at the conservative. It has the advantage of leaving a host of other terms and colours for other political positions (pink, green, etc.).

☞WWW☜ 10:45

According to Domhoff (1968a p.594), the ones who sat on the right, "were identified with the King-Father and his rightist values. They were part of the fatherhood - the ruling class. On the other hand, the capitalists and dissident intellectuals were on the left – a brotherly grouping espousing brotherhood and mother-derived values – because they were at that time the rebellious young upstarts who had not developed an identification with the patriarchal trappings of the French monarchy". The favoured ones also sit to the right hand of God in the Bible, and in a range of African cultures it is common for the favoured one to sit to the right hand side of the leader (Wieschoff, 1938).

Although in general in southern India each caste tended to be either right-handed or left-handed (Beck, 1970; Brimnes, 1999), an intriguing exception is the Mālas, the 'untouchables', amongst whom there are both right and left-handed sections (Nicholson, 1926).

☞WWW☜ 10:46

These ideas on the relationship between cerebral functioning and the difference between left and right political groups were first proposed in an unpublished manuscript by Tucker (1985e). The work on seating patterns and personality is by the Gurs (Gur, Sackheim, & Gur, 1976; Gur & Gur, 1975).

☞WWW☜ 10:47

Figures in the original article were to one decimal place (Mair, 2000). Clearly many difficult judgements have had to be made in constructing this table but one presumes that they are precisely those for which a Professor of Comparative Politics is best suited, and that there would be reasonable agreement if other experts carried out the same task. For our purpose the important thing is that the original author did not know that they would be used for the present analysis, in particular for the relative numerical proportions of right and left.

☞WWW☜ 10:48

Pollyanna explains the game in more detail in the book. The idea, "was to just find something about everything to be glad about – not matter what twas". For instance, a friend complains that there is not much to be glad about when you had hoped to be given a doll as a present and in fact had received a pair of crutches. Pollyanna replies, "why, just be glad because you don't need 'em!".

My feeling is that Pollyanna is little known outside of the US, although an internet search suggests that being 'Pollyanna-ish' is a common phrase there. The concept is much older though, and in European thought it is less an uplifting if unctuously saccharine moral tale for children than the ironic and hard-hitting attack of Voltaire's *Candide* on the church. In modern British thought the concept is now most likely to invoke the Candidean scene at the end of *Monty Python's Life of Brian* in which the crucified criminals sing, "Always look on the bright side of life". Or alternatively the Skip James song recorded by Cream, the majority of whose lyrics consist of "I'm so glad, I'm so glad, I'm glad, I'm glad, I'm glad" – a sentence that seems to be parsable in surprisingly many ways.

☞WWW☜ 10: 50

Claude Shannon, who was born in 1916, died on 24th February, 2001.

Mathematically if an event has a probability, p, then the information received from that individual event is $log_2 (1/p)$. The average information, H, from a series of such events is $p.log_2 (1/p)$. The maximum information can be calculated by differentiating H with respect to p, and setting dH/dp=0. The maximum information occurs when $p=1/e$ = .3678. There is also a theory that the proportion is close to the Golden Section (0.6180: 0.3820), which has been invoked in many different contexts (McManus, 1980; McManus & Weatherby, 1997), although separating the predictions is not easy – see Tuohy and Stradling (1987g).

It might be worried that the calculation above only considers one of the possibilities, the one with probability p. In practice there is a second alternative event, that not-p occurs; that it is not raining in other words, which occurs with probability $(1-p)$. If so then the *total* information is $p.log_2 (1/p^-)+ (1-p).log_2 (1-p)^{-1}$ and the maximum information then does indeed occur when $p=.5$. Berlyne (1971b), following Frank, emphasises that $p.log_2 (1/p)$ is the "strikingness" or "penetrance" of each individual contribution to the total information, and is the proper measure. To be told in the desert that it is not raining is hardly a useful outcome.

☞WWW☜ 10:51

Carlyle's thought was much more subtle than the simplistic labels of 'proto-fascist' which were subsequently applied to it (Heffer, 1995 pp. 19-25).

Carlyle would also have been wary of the need for statistics for looking at many of the issues raised in this chapter, and indeed in the book as a whole. In his essay on *Chartism* he recognises that mere numbers alone, mindless counting, do not give knowledge:

> "Statistics is a science which ought to be honourable, the basis of many most important sciences; but it is not to be carried on by steam, this science, any more than others are; a wise head is requisite for carrying it on.."

As someone who teaches and uses statistics extensively, I can only agree profoundly with the statement.

Chapter 11: Hypernotes

☞WWW☜ 11:1

Sitwell devoted the final chapter of *Left hand, Right Hand!* to the Sargent painting. Modern critical opinion is much more appreciative of Sargent's talent both as a portraitist (Kilmurray & Ormond, 1998) and in other genres, and the recent Tate Gallery Exhibition (Oct 1998 - Jan 1999) seemed to show precisely how in his portraits Sargent was looking through the surface vanities to the personality behind the facade.

Although the painting is also clearly meant to be a statement about their unity as a family, later in life Edith was said to be "white with fury and contempt that my father held me in what he thought was a tender paternal embrace", since tenderness was rare from either parent (Bradford, 1995 p.19).

☞WWW☜ 11:2

I do not think Sitwell's left-handedness is mentioned in the biography by Ziegler (1999j).

The autobiography was published in five volumes under the collective name *Left Hand, Right Hand!* (Sitwell, 1945). The first volume was originally called *The cruel month*, but now seems never to be known by that name but instead by the collective name. The other four volumes are, in order, *The scarlet tree*, *Great morning*, *Laughter in the next room*, and *Noble essences*. Even Sitwell's biographer, while suggesting that "this Blenheim among autobiographies has survived remarkably well", comments how "the social assumptions occasionally jar, the mannerisms grate" (Ziegler, 1999j p.313).

In quoting from Orwell's review of the third volume of Sitwell's biography I have not perhaps been entirely fair since even Orwell concludes his review by saying that, "although the range they cover is narrow, [these volumes] must be among the best autobiographies of our time" (Orwell, 1970 p.505).

☞WWW☜ 11:3

Sitwell later used the cricketing incident as one of the few true parts of his *Who's Who* entry, the majority of which was totally frivolous. Many of the successive entries over the years can be found in the end papers of the first edition of *Laughter in the next room*.

Lord Dawson was to be called in once more by Sitwell, in less satisfactory circumstances, in July 1940 when Sitwell was looking for a medical certificate that his health would not allow him to take on any arduous government work. Dawson acquiesced, although it would seem with serious doubts (Ziegler, 1999j p.246).

Examples of Sitwell's handwriting can be found in the end papers of the first edition of *Nobles Essences*, and in the catalogue published by the National Portrait Gallery (1994 p.180).

Darwin commented in his notebooks that "...handwriting said to be heredetary [sic]. shows well what minute details of structure heredetary" (Barrett et al, 1987 p.420 E.89).

☞WWW☜ 11:6

There is mention in a Parliamentary debate of 22nd July 1998 of a seven-year old left-handed child in Worcestershire who was forced to write with the right hand.

I should probably state at this point that I am and always have been right-handed myself. My mother is, however, left-handed and when I was a child she was, to our knowledge, the only left-hander in the family[54]. She tells me that she has hardly ever noticed any problems at all of being left-handed, and indeed she seems to cope with almost all aspects of the right-handed world without trouble. One memory of childhood, though, is her left-handed dress-making scissors – it was intriguing how they were almost impossible for a right-handed child to use.

As a right-hander researching and writing about left-handedness I am uncomfortably aware of the comment made by Diane Paul (1990 p.49), that,

> "One of the biggest problems through decades of handedness research has been that well-meaning, right-handed researchers do not fully comprehend the workings of a left-hander's mind."

☞WWW☜ 11:12

The authors of the article on the negative refractive index, as well as the editors of *Science*, are clearly doubtful about the usage of the term since they actually say, " these materials were termed 'left-handed' (LHM)", the scare quotes showing their own doubts. They were right to be worried. If they had taken any other contentious description, say calling them 'female materials' or 'gay materials' or 'black materials' then the pejorative nature and the inappropriateness of the description would have been apparent. It should be emphasised that left and right in a physical sense have nothing to do with the nature of the phenomenon itself. According to Mullins (Mullins, 2001) the name comes from the fact that instead of the usual right-hand law for an electromagnetic material one has to use a left-hand law, a perhaps half-justifiable reason.

The etymology of the left-handed hummingbird is not entirely clear, and it is also a possibility that left-handed means 'from the north' (Kelley, 1992)Kelley, 1992.

[54] One of my daughters is however left-handed.

Although the use of 'left-handed' to mean homosexual is often quoted as being from the 1920s onwards, it was clearly in use before that, Rubert Brooke for instance writing a letter in 1910 to Lytton Strachey about the attractions of Lulworth Cove for a holiday, which included, "a fishing village, which had a beautiful left-handed boy in it two years ago" (Jones, 1999, p.123).

☞WWW☜ 11:12

The lithograph of *The potato eaters* was actually produced before the much more well-known painting (of which there are actually three versions, as well as an oil sketch (De la Faille, 1970). Van Gogh wrote in a letter to Theo in which he enclosed some copies of the lithograph, “I should like to make, with a few alterations, a definite picture of the sketch I painted in the Cottage” (Anonymous., 1958 vol II, p.364).

Van Gogh was not the only young artist to make the same mistake. Picasso’s first engraving as drawn on the plate showed a picador holding a pike in his right hand, but the pike was in the left hand in the final print. Picasso wittily finessed the problem by titling his engraving *El Zurdo (The Left-hander)* (Richardson, 1991 p.137).

Although for dramatic effect I have based the description in the text on *The potato eaters*, the original paper in which the effect was described showed a crayon drawing in what was ostensibly a memory experiment. The drawing showed eight children at a party, seven of whom held something in their left hand. Left-handers were significantly more likely to notice the handedness of the children when asked (Etaugh & Brausam, 1978), and spontaneously to use left-handedness in describing the picture (Etaugh & Fredman, 1980), where it was noticed by 50% of the 14 left-handers but only 1 of the 14 right-handers ($p<.05$).

☞WWW☜ 11:13

I have been studying right and left for thirty years and still consciously have to make an effort to check the handedness of people I am talking to, rather than it being immediately obvious to me. But then, as mentioned earlier, I am a right-hander.

☞WWW☜ 11:14

Of 245 right-handed students, 1 (0.4%) mentioned their handedness compared with 3 (7.5%) of 40 left-handed students ($p<.01$). Of the 1288 right-handed school-children, 6 (0.6%) mentioned handedness, compared with 3 (1.9%) of the 159 left-handed school-children ($p<.05$) (McGuire & McGuire, 1980) .

☞WWW☜ 11:15

Dieth, who had become interested in English dialects while Lecturer in German at Aberdeen from 1922-27, died prematurely, before the English Dialect Survey was completed. Orton became Professor of English Language and Medieval Literature in Leeds, and published basic analyses of the surveys. Orton died in 1975 before the dictionary itself was published, although he was active until the last in analysing the data and prepared much of it for publication. Upton and his colleagues (Upton & Widdowson, 1996) at the Institute of Dialect and Folk Life Studies in Leeds have continued to publish further detailed analyses.

Upton has since suggested that the decline in the number of terms has been even more rapid in the last third of the twentieth century. After noting the 80 or more terms once in use for left-handedness, he says, “When I ask my English students these days, they are hard put to come up with three or four” (*The Observer (London)*, 31.10.99, p.14).

☞WWW☜ 11:16

I have been unable to find out anything about the origins of the term 'cotmer-handed'. It is not mentioned in the Oxford English Dictionary.

In 1974 there was a major re-organisation of local government in England and Wales, with a changing in many of the county boundaries. The maps presented in this book are drawn on the post-1974 boundaries, but the data in the dictionary are reported on pre-1974 boundaries. Occasionally this might produce minor inaccuracies of little consequence.

☞WWW☜ 11:17

Runciman (1997e) says that in the days before floodlighting, the baseball diamond always faced east, in order that the setting sun would not prevent the batter seeing the ball. Left-handed batters would then face south and hence were known as southpaws. A variant specifically refers to the old West Side Chicago ballpark (www.baylorhealth.com/ proceeedings/ 12_4/12_4_flatt.htm). The OED gives the first baseball usage as 1891 in the Chicago Herald of 24th July (“the new south-paw came to town yesterday”), and the term was only first used specifically to refer to a left-handed boxer in 1942. However the OED has a usage in 1848 meaning a punch with the left hand.

The term ‘north-handed’ probably derives from a person who is facing east towards the rising sun having their left hand to the north (Mayhew, 1895).

☞WWW☜ 11:18

A major methodological difference from the English Dialect Survey is that the Linguistic Survey of Scotland (Mather & Speitel, 1975) was carried out by a postal questionnaire, rather than by direct interview.

☞WWW☜ 11:20

The problem with scissors has been described previously by Coren (1992 p.267), and in almost every book by left-handers for left-handers. Clarke (1993 p.22) specifically mentions that, "It is not enough to re-mould the handles [of scissors] so that either hand can be inserted." Sadler (1997f) also comments on the need for the blades to be forced together slightly.

Although it might seem self-evident that left-handers would prefer left-handed scissors, that is not necessarily the case as the consumer magazine *Which?* found when it tested a range of left-handed equipment (Anonymous, 2000b). Part of the explanation as they say is that left-handers are already used to using right-handed scissors (and in my own research I have been surprised by the fact that in a large group of over 900 applicants to medical school who were tested for manual dexterity there were no systematic differences between right and

left-handers in the speed of usage of scissors, all of which were right-handed). In the *Which?* test there were however other tools which were preferred by left-handers, particularly striking being the left-handed garden secateurs, where people said, "you can see where the blade is cutting".

☞WWW☜ 11:21

Carlyle's words on tool-making are actually those of Professor Teufelsdröckh in *Sartor resartus*.

The sum total of Chwast's comments on handedness are as follows (Chwast, 1985):

"*Has your left-handedness influenced your work in any way?* I've always been left-handed. Although my mother would deny it, she tried to get me to use my right hand more often, because it was considered a handicap -- and evidence of my being a little odd. However, being odd gave me a terrific excuse for being an artist. ...
One last question. You treat your right hand like a second child, and your left hand like royalty. Does your right hand serve any useful purpose? Well, yes. I use my right hand to hold my head up at the correct distance from my drawing table. I couldn't work any other way."

☞WWW☜ 11:22

The survey of schools was carried out in 1996 by Nigel Sadler as a part of the Vestry House Museum exhibition, *A sinister way of life? The story of left-handedness*, 13th August - 16th November 1996. The questionnaire was sent to 86 schools in the Waltham Forest area, of which 27 replied. It is more than probable that those which did not reply had even less provision for left-handers. A brief synopsis of the results follows:

Equipment/training	*Provide*	*Do not provide*	*No answer*
Scissors	**22**	**5**	**-**
Books on LH for Pupils	**2**	**25**	**-**
Books on LH for Teachers	**4**	**23**	**-**
Teachers been on specific training	**1**	**26**	**-**
Are the teachers aware of the following:			
Specialist LH bookshops	**2**	**24**	**1**
Specialist LH shops	**14**	**12**	**1**
Specialist LH equipment	**25**	**0**	**2**
The number of LH pupils in the school	**9**	**16**	**2**
Relationship between LH and learning disabilities	**10**	**14**	**3**
Do you sit LH together	**1**	**20**	**6**
Do you sit LH on the left side of right-handers	**5**	**17**	**5**

The House of Commons debate was entirely stimulated by a single left-handed MP, Peter Luff, who has helped to keep the issue on the agenda for several years. The debate was full of rather twee jokes about the rights of lefties and the like. For connoisseur's of New Labour policies there was however one fine moment when the Minister commented,

"I wondered briefly whether the Government's search for a third way might be relevant to this debate but – after 30 seconds – decided that, of all policy spheres, perhaps only left-handedness does not offer a third way. It really is a debate about left and right, and perhaps about achieving equal rights".

☞WWW☜ 11:24

Jack Fincher (1977b), himself a left-hander, has gently mocked the ineffectuality of pressure groups for left-handers, describing how, "the National League for Left-handers -- all 123 men and women strong -- has been moved to suggest such militant stratagems of social protest to the rightful status quo as offering your left hand to shake, or putting stamps on the left side of letters of avoid cancellation (as if the Post Office didn't have its hands full already)". Likewise, "Something called The Association for the Protection of the Rights of Left-handers" now exists ... and campaigns for the allowable use of the left hand in taking oaths and saluting... ".

Theodore Dalrymple is a pseudonym. I once knew well the “young and learnèd doctor ... [for] we turned o’er many books together”. An intellectual iconoclast of brilliance, he might at times be likened, in his own words, to “Daniels come to judgment (as Antonio exclaims...in *The Merchant of Venice*)” (9816 /ft " p.44").

☞WWW☜ 11:25

The logic of Rawls' argument was apparent even in the nineteenth century when Ireland (1880 p.214) commented that, “A left-handed child forced to write with his right hand through fear of punishment, is very much in the same condition as a right handed one who should be forced to hold his pen in his left”.

☞WWW☜ 11:26

As I emphasised in chapter 9, the advantage is not strictly associated with being left-handed but with having one copy of the *C* gene. That raises some interesting challenges for those who wish to play at eugenics. Once the gene is identified it would be straightforward to select individuals of the *DC* rather than the *CC* type, but from then on the outcome is not dependent on genes but on the random processes of fluctuating asymmetry. A quarter of the *DC* individuals will be left-handed, but no genetic test could identify them, and it seems unlikely at present that any anatomically based scan of the developing fetus could identify what is essentially a functional asymmetry. Likewise the theory of cerebral variation says that DC individuals will often be wired up differently from one another but it cannot say for any individual whether the combination will be advantageous or deleterious. That is dependent on chance and chance alone, and is unknowable and unpredictable in a deep sense. It is rather satisfying really that those who wish to control everything would find that they would still have to play a lottery with their eugenics[55].

[55] It is even more interesting than that, since the choice would be between the certainty of a *DD* individual, with their standard brain organisation, or the various unpredictable alternatives of a *DC* individual which will, on aggregate benefit the individual, but in some cases would be disadvantageous.

Chapter 12: Hypernotes

☞WWW☜ 12:1

Browne's *Religio Medici* was a success even before it was published. Having been written between 1634 and 1636 it circulated in several manuscript copies, and was only published properly after two pirated editions came out in 1642.

The term 'Vulgar' in the popular title of the *Pseudodoxia epidemica...* is used in the old sense of 'In common or general use'.

☞WWW☜ 12:2

The phrase "enumeration of many unconnected particulars" comes from Dr Johnson's biography of Browne (see p.xvi of the Wilkin edition).

Joubert's *Popular errors* is criticised by Browne (see de Rocher, 1989 p. xvi at the very beginning of the *Vulgar errors*. "Laurentius Joubertus, by the same title [*Popular errors*], led our expectation into thoughts of great relief; whereby notwithstanding, we reaped no advantage, it answering scarce at all the promise of the inscription" (Wilkin, 1852 vol I, p.4). Although the Popular errors proposed to answer many questions, Joubert's plans were greater than the reality, and while we have an outline of the final thirty books in six parts, only the first five were actually published. Unfortunately the question on the use of the left hand was raised but, as far as I can tell, never answered.

On reading the scientific notebooks of Darwin Barrett et al, 1987 I have been struck by how much Darwin himself was a part of the tradition of cataloguing popular beliefs, and then asking whether or not they may find any form of support. The notebooks are a marvellous mixture of careful observation, natural history and theoretical speculations and insights, coupled with the writing down of 'vulgar errors' of all sorts; thus we find several comments from Darwin's hairdresser (a Mr Willis of Great Marlborough Street, it would seem), who talked to Darwin about the fact that black hair is stronger than other colours (p.338) and of the breeding habits of dogs (p.385). There are also the beliefs of Darwin's father ("My father has somewhere heard (Hunter?) that pulse of new born babies of labouring classes are [sic] slower than those of gentlefolks"; p.530), of his father's friends ("My father says on authority of M^{r} Wynne that bitch's offspring is affected by previous marriages with impure

breed"). There are also accounts of pure Lamarckism ("A cat had its tail cut off at Shrewsbury & its kittens (in number 3) had all short tails"; p.525), and other miscellaneous but probably untrue facts ("I have read paper somewhere on horse being insane at the sight of anything scarlet" p.523). Darwin had read the *Religio Medici* only relatively recently (p.550 of notebook M) , and might therefore also have read the *Vulgar Errors* in the newly published 1836 edition of the complete works by Wilkins.

☞WWW☜ 12:3

The Royal Society was founded in 1660, and itself was somewhat credulous in its early days Bennett, 1962 p.17 . Browne's son Edward was elected FRS in 1668, at the age of 23.

Joseph Needham called Browne "the father of the static aspect of physico-chemical embryology" (Needham, 1934 vol 1, p.112), and describes the significance of Browne's experiments on eggs as being "quite overlooked", particularly in his willingness to put any disputed point "to the test of 'ocular aspection' " (Needham, 1931vol 1, p.137).

☞WWW☜ 12:4

Often unsophisticated philosophers and practitioners of science pretend that science is only based upon evidence and experiment (and the modern quasi-religion of 'evidence-based medicine' particularly makes a fetish of it). In practice good scientists reject many experimental studies in advance because logic and reason mean they are unlikely to be successful, and topics of study are chosen (and given particular credence) because earlier authorities have particularly vouched for them as important, and such authorities are especially likely to be believed until strong evidence makes it necessary to reject them.

☞WWW☜ 12:5

The explanation of the badger's legs is given as a footnote in Wilkin's edition of the *Works* 1852.

☞WWW☜ 12:6

Ulisse Aldrovandi[56] (1522-1605) was an Italian naturalist, who according to Gould Gould, 1997 p.210, "wrote the great compendia that pulled together all available knowledge about animals – ancient and modern, story and observation, myth and reality, human use and natural occurrence".

In his edition of the *Works*, Wilkin (1852) reprints a long series of marginal comments from the copy of the *Vulgar Errors* owned by Dr Christopher Wren, the Dean of St. Paul's and the father of the great architect. On the question of lobsters he writes, "This never happens [i.e. one is longer than the other], but when one is by chance wrung off, when they are young, by a bigger lobster, which growing out againe, can never reach the greatnes of the other: the fisherman finde this continually to be true..."

[56] Aldrovandus in the *Vulgar errors*.

In discussing the movement of animals, Browne describes to movement of most animals as "*per diametrum*", that is, on the diagonal, moving a front leg and the opposite side rear leg at the same time (although that in fact is not how most animals do move, see Stewart and Golubitsky (1992g). As a result he does concede that it might just about make sense to have legs of the same length as it were across the diagonal, but that there could be no sense in having legs on one side of different length to those on the other side.

As a medical student I had a friend who claimed to have had a goldfish which had a stroke and perpetually swam in a circle. Fortunately this wasn't too limiting in the bowl in which it lived. He also claimed it was a happy coincidence that the stroke was on the correct side, or it would have perpetually swum into the side of the bowl; a moment's reflection however shows that whichever side was paralysed, the fish soon have settled down into a stable circular motion.

Richard Dawkins makes the argument for symmetry in the external form of animals using the same argument: "any major departure from left/right mirror symmetry may result in the animal going round in circles when it should be pursuing the shortest distance between two points" (Dawkins, 1997 p.208-9).

☞WWW☜ 12:7

A variant of the myth, which is clearly a variant of the shield theory, but has several original aspects, can be found in the web-site (www.scican.net/~ptjones/left.html) on left-handedness written by Tracy Jones, herself a left-hander:

> "In the bronze age, it was believed left-handed soldiers were martyrs; this was because they couldn't possibly survive warfare, since their shield couldn't be held over their heart in battle (of course, we now know the heart is more centrally located)".

☞WWW☜ 12:8

The respondents answered by pointing at a diagram in which, it must be said, the areas to the left and right are extremely small, so that the heart would be far too lateralised. The authors of the survey clearly had not thought very hard about their question since they had to admit that *none* of the areas was uniquely correct for a subsequent question about the position of the gall-bladder! The sample size overall was 299, and groups AB, C1, C2 and DE was 40,58, 74 and 125 (Edinburgh International Science Festival, 1993).

SHOW CARD B

Q2 Looking at this picture could you point out to me where you think the following parts of the body are? (PROMPT IF NECESSARY: I am interested in your thoughts even if you are not at all certain) READ OUT LIST OF PARTS OF THE BODY AND WRITE IN LETTER NEAREST TO POINT INDICATED BY RESPONDENT

Funny bone .....

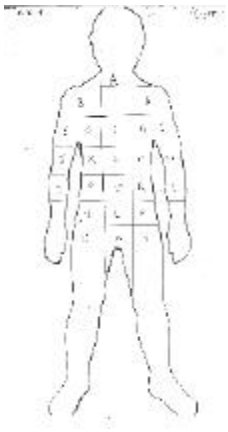
Heart .....

Appendix .....

Spleen .....

Thyroid .....

Gall bladder .....



☞WWW☜ 12:9

In the end Sir Thomas Browne does recognise that really the heart is on the left, for after making several provisoes he then comments “And in these considerations must Aristotle be salved, when he affirmeth the heart of man is placed on the left side”. And to disagree with Aristotle, one of the greatest biologists of all time, is probably more than Browne could ultimately stomach.

The position of the heart was very well summarised by the anatomist Galen:

> “[the heart] lies rather towards the left, since its tip unlike its base, does not lie precisely midway between the right and the left of the thorax. It is not stretched from head to tip precisely in the median line, but it bends slightly, as I have mentioned, towards the left” (Vinken, 1999d p.76).

☞WWW☜ 12:11

In his original description of the pain in 1772, William Heberden (1710-1801) said he chose the name angina pectoris for “the seat of it, and the sense of strangling and anxiety, with which it is attended” (Leibowitz, 1970 p.87).

William Heberden described the pain as “sometimes situated in the upper part, sometimes in the middle, sometimes at the bottom of the os sterni, and often more inclined to the left than the right side. It likewise very frequently extends from the breast to the middle of the left arm”. The Oxford Textbook of Medicine gives a more modern view that the “squeezing, crushing, gripping, band-like, choking, throttling, or ...vice-like [pain]... is typically central and symmetrical”.

Although the pain of angina and myocardial ischaemia is typically central, it can be “sometimes slightly to the left but not 'inframammary' (Henderson, 1996). I have been struggling ever since starting to write this book to find a paper, published I think in the 1970s, which asked why it was that some patients with undoubted myocardial ischaemia did indeed have pain on the left side. The conclusion was that the pain was more to the left in those patients who were most neurotic. It is an intriguing idea, and I wish I could trace the research study which looked at it.

Atypical chest pain, "is characterised by a unilateral left submammary pain, sometimes sharp in quality, which radiates up to the left shoulder and left axilla. It does not bear a close relation to effort and may be sharp in quality. It is asymmetrical and often localised to a small area in the left chest. These symptoms are rarely anginal in quality” (Swanton, 1996).

The nerves which bring sensations from deep inside our bodies are much less precisely localised than those from nearer the surface. The result is that many deep internal pains are central to start with, and only become localised as the disease begins to affect the surface of the body – an example is the pain of appendicitis, where a good diagnostician will look for a history of a severe pain in the *centre* of the abdomen which then moves after a few hours to the *right* lower corner of the abdomen.

Even if the pain after angina or a heart attack is central, that does not mean the control mechanisms are. There seems little doubt that the actions of the heart, speeding up and slowing down, are controlled far more by the right hemisphere than the left, perhaps suggesting why strong emotional responses can indeed result in heart problems (Wittling, 1995, Wittling et al., 1998).

☞WWW☜ 12:12

The heart is a little to the left is by William Sloane Coffin, "a leading activist preacher", and I merely saw it advertised in the *New York Review of Books*, where its title leapt out. From the advertiser's blurb the books seems primarily to be concerned with left and right as a metaphor for the struggle between the religious right and the libertarian left.

☞WWW☜ 12:13

Hair whorling has often been suggested to be related to twinning (Lauterbach, 1925; Newman, Freeman, & Holzinger, 1966); there are also suggestions that in singletons that the side of the hair whorl is related to right and left handedness (de Zarate & de Zarate, 1991; Friedman, Golomb, & Mora, 1952). For an exceptionally lax definition of mirror-imaging see Golbin *et al* (1993d). Facial and dental mirror-imaging have been reported by Townsend *et al* (1986d). The term has also been applied to differences in cerebral organisation (Sommer et al., 1999). It is possible that ectodermal mirror-imaging does occur, but it seems nothing to do with handedness. An example of what has been called "chiral twins, the rarest kind" is the physicist and science fiction novelist, Gregory Benford, and his brother Jim (Mercola & Levin, 2001e: "Greg is right-handed whereas Jim is left-handed, they have birth marks on opposite cheeks, and their peppered gray hair spirals in opposite directions".

The theory of mirror imaging in twins was probably first enunciated clearly by Newman (1111 pp.185-189).

A comparison of identical twins with a common placenta, amnion and chorion, a common placenta and chorion but separate amnions, or separate amnion, chorion and placentas finds no difference in the rate of left-handedness or of 'mirror-imaging', suggesting that discordance in identical twins is nothing to do with the process of splitting, and hence with mirror-imaging (Carlier et al., 1996; Derom et al., 1996).

The meta-analysis of Sicotte *et al* (1999k) found no evidence at all for a higher rate of left-handedness in identical than non-identical twins. They did finder a higher rate of concordance (R-R and L-L pairs), but that can still occur even though the rate of left-handedness is the same in the two types of twin.

Strictly the meta-analysis of handedness in MZ and DZ twins is only the end of the line for the mirror-imaging theory of handedness. It is possible that mirror-imaging occurs for situs, for teeth, hair whorls, or whatever, but no study has ever produced any convincing statistics. The only solid epidemiological data on situs inversus could find no association with twinning rates (Torgersen, 1950a). However until someone who believes in mirror-imaging produces some convincing statistics then it seems difficult to believe in it, particularly since it makes little biological sense, except in the very unusual case of conjoined twins (Levin et al., 1996).

☞WWW☜ 12:14

Aristotle's ideas can be found in Peck (1953, 717.a.34, 788.a.10). The theory that the testicles act as weights explains castration as working because the removal of the weights closes the internal ducts. That a castrated bull may fertilise a female for a few days after castration was attributed to a delay in the ducts closing off (instead of to the inevitable storage of semen in the seminal vesicles for a few days or weeks). An identical theory was also held by Giles of Rome (Hewson, 1975 p.91). The role of the seminal vesicles was correctly appreciated by Sir Thomas Browne (Wilkin, 1852, Vulgar Errors IV, v). Aristotle's theory was part of a broader theory of right and left in biological systems, and he proposed that it was the right side which initiated movement (*De Inc. An.*, 705.b.14; 705.b.30; 706.b.5), which was warmer and less watery than the left (*De Part. An.*, 493.b.19.), and also the stronger (*Hist. An.*, 493.b.19.) For more details see McManus (1979f).

☞WWW☜ 12:15

The 2001 articles in The Observer and The Guardian were based on an article by Ellis and Engh (2000u), published several months earlier in the previous year. Although widely reported as showing that left-handers die earlier than right-handers, in fact the overall difference between right and left-handers was non-significant (p.562). The differences only emerged when individuals were classified on a five-point scale from 'extremely right-handed', though 'generally right-handed', 'Ambidextrous', 'generally left-handed' and 'extremely left-handed', the difference in age at death being entirely restricted to the 'generally left-handed' group. Since however this is not a self-rating but a description by a relative, its validity must be somewhat in doubt. Unfortunately the study also, despite having data on the age of *living* relatives, chose only to describe dead ones, thereby suffering from the usual statistical artefact.

Coren and Halpern (1988d) found statistical significance only when they used a rather peculiar test called the Kolmogorov-Smirnov test. However a conventional analysis of their data using a standard t-test finds no difference at all in the average age at death.

The California study (Halpern & Coren, 1991). was carried out by phoning the relatives of people in California who were known to have died recently and asking them about the deceased person's handedness.

The problems of death cohorts is surprisingly common in the medical literature, and can be found in a range of situations, as for instance in claims that women doctors die younger than male doctors (McManus, 1995b) or that anaesthetists die younger than other doctors (McManus, 1997a). Both cases are actually due to the fact that in general women doctors or anaesthetists are on average younger than other doctors (McManus, 1997b), women only having entered medical school in large numbers relatively recently, and anaesthetics being a young speciality.

There are several large scale studies of populations which have assessed the Coren-Halpern hypothesis, and in all of them there is either no evidence at all for a decreased longevity of left-handers (Ellis et al., 1998a; Ellis et al., 1998b; Fudin et al., 1993; Hugdahl et al., 1993;

Marks & Williamson, 1991; Stellman, Muscat, & Wynder, 1993; Wolf, D'Agostino, & Cobb, 1991) or else there is some evidence but it is at a different age or otherwise does not replicate the findings of Coren and Halpern (Aggleton, Kentridge, & Neave, 1993). For a critical review of the literature see Harris (Harris, 1993a; Harris, 1993b), and a reply by Halpen and Coren (Halpern & Coren, 1993).

☞WWW☜ 12:18

The meta-analysis of the immune data is quite technical, and readers are referred to the original analysis (Bryden, McManus, & Bulman-Fleming, 1994a). Although there was a very small positive association overall (odds ratio = 1.06, $p<.05$) that did not take into account the likely effects of publication bias which would have resulted in more positive than negative results being published. A more detailed analysis also found that although three conditions did seem to show significant positive associations ('Allergies', 'Asthma', 'Ulcerative colitis / Crohn's disease'), there were also two conditions which showed significant negative associations ('Arthritis', 'myasthenia gravis'). On balance the conclusion has to be that there is no overall support for a simple version of the Geschwind theory. See however the many commentaries on our paper in *Brain and Cogntion*, and our replies (Bryden, McManus, & Bulman-Fleming, 1994b; Bryden, McManus, & Bulman-Fleming, 1995).

☞WWW☜ 12:19

A variant on the theory of Neanderthal's being left-handed is that they were ambidextrous (de Kay, 1994g pp.28-32), although the provenance suggests this is probably another myth caught in the process of creation.

Stan Gooch's theory still has its followers, as seen for instance in an article in *The Times* in 2001 (Howard, 2001).

☞WWW☜ 12:23

The claim is often made that Mensa members are more likely to be left-handed (e.g. Clarke (1993 p.3) and Perelle & Ehrman (1993e)).

The original research on handedness and intelligence was published in the *Mensa Research Journal* (see Perelle & Ehrman, 1982) and found 20% of members were "non-righthanders". A replication (Storfer, 1995) found that 11.4% of male and 10.5% of female members were left-handed, which does not differ from population estimates. The possibility that left-handers may have different patterns of intellectual ability has been put forward particularly by Benbow (1986e), although a subsequent review of the field by O'Boyle and Benbow (1990 p.364) concluded that,

> "the findings ... have a distinctly piece-meal flavour to them ... To is, it seemed that for each piece of data confirming a relationship between hand preference and a corresponding ability or talent, there appeared to be at least one other result that ... failed to replicate the original finding ...[or] postulated some new ... variable to moderate the connection ... or ... flatly contradicted the notion that any such relationship existed".

Peters (1992h) came to a similar conclusion. The most recent large study to be thrown into the melting pot on this issue is that of Halpern e*t al* (1998o) who looked at 174,000 applicants to US medical schools and found the left-handers had a higher verbal reasoning score (but not

higher scores on writing, biological or physical sciences). They also found that left-handers were more likely to be accepted at medical school, a phenomenon I have never found any evidence for in our UK studies (McManus et al, 1995; McManus & Richards, 1984; McManus, Richards, & Maitlis, 1989).

The two large scale population studies of handedness and intelligence are by Hardyck *et al* (1976e), and McManus and Mascie-Taylor (1983d). see also McManus *et al* (1993a).

There is no doubt that at the very bottom end of the distribution of intellectual ability left-handedness is associated with serious mental retardation (Pipe, 1990). The causal relation is probably that the disruption of early brain development both causes impaired cerebral functioning and an increased rate of left-handedness due to pathological factors. In other words these individuals are not of low intellectual ability *because* they are left-handed. It is a similar process to that by which almost any biological stressor causes an increased incidence of *situs inversus* (Wehrmaker, 1969b).

☞WWW☜ 12:24

The results of the survey of dot.com directors is unlikely to be statistically significant since there were only 101 directors in the survey overall (Cassy, 2000).

The finding of an increased rate of left-handers in architects (Peterson & Lansky, 1974) was also found in another relatively small study (Gotestam, 1990); however it failed to replicate in the larger study of Wood and Aggleton (1991h).

☞WWW☜ 12:26

I looked at seventeen different web-sites devoted to handedness that I found via www.google.com, using the search terms "famous left handers". Only one artist was included on all of the lists, Leonardo. All but one site included Picasso in its list. Although lists often claimed things such as "Left-handed dominance is very common among artists, particularly painters", a total of only fifteen artists was actually mentioned on any of the lists. Given the hundreds, probably thousands, of separate artists to be found in any decent art library, it is probably more correct to follow the list which admits, "There are not many left-handed artists, but several are world famous" (www.baylorhealth.com/proceedings/12_4/12_4_flatt.htm). That said, several on this list certainly do not fit my concept of "world famous". The artists named are:

Leonardo	17
Picasso	16
Michelangelo	14
Raphael	10
Paul Klee	8
Holbein	7
Escher	5
Durer	2
Ronald Searle	2
Sebastiano del Piombo	2
Raoul Dufy	1
Edwin Landseer	1
LeRoy Neiman	1
Milton Caniff	1
Bill Maudlin	1

I have not attempted to check all of these, but I should say that there is clear photographic evidence that Paul Klee painted with his left hand (Güse, 1991; Klee, 1970; Lanchner, 1987), and that I am not convinced from the hatch marks in the drawings of Sebastiano del Piombo that he was left-handed (Hirst, 1981).

Picasso is also included on web-sites about handedness produced by academics where he is included in the lists of famous left-handers (e.g. www.indiana.edu/~primate/left.html, and duke.usask.ca/~elias/left/famous.htm).

Popular books for left-handers also claim that Picasso was left-handed (Paul, 1990 p.14; Langford, 1984 p.100; Fincher, 1977b p.27; Lindsay, 1980 p.5), and the idea is also repeated in books for teachers on teaching the left-handed (Clarke, 1993 p.3; Paul 1993f has photographs of both Picasso and Einstein on its cover). Picasso features also in scholarly books produced by academics, as for instance in Richard Gregory's *Mirrors in mind* (Gregory, 1998q), in an article by the psychiatrist Pierre Flor-Henry who cites Picasso as one of the many geniuses who are left-handed (Flor-Henry, 1991 p.416), by Csikszentmihalyi (1998p), who mentions Picasso as being left-handed, and by Stan Coren who mentions Picasso's left-handedness on at least two occasions (Halpern & Coren, 1990, Coren, 1992 p.52).

"No artist has been photographed as abundantly and as often as Picasso". (Bernadac, 1991). Photographs of Picasso carrying out the various activities can be found in a range of books: Baldassari, 1997; Bernadac, 1991; Bozo et al., 1986; Daix, 1993; Duncan, 1958; Duncan, 1996; Jardot, 1959; Penrose, 1971; Rubin, 1980:

In his studio in Clichy, 1901, Bozo et al, 1986 p.273.
Self-portrait with a palette, in oils, palette in left hand, 1906, Rubin, 1980 p.79
Painting Guernica, 1937, Bozo et al, 1986 p.289
In studio in Antibes, 1946, Bozo et al, 1986 p.294

Filming of *le mystere Picasso* by Clouzot, 1955, Bozo et al, 1986 p.301; see also Penrose, 1971 fig 224
Writing signature, Antibes, 1957, Penrose, 1971 fig 219
Drawing in sketchbook, 1957, Duncan, 1958
Cutting out clay pattern of fish, 1957, Duncan, 1958
Painting on ceramic dish, 1957, Duncan, 1958
Shooting revolver, 1957, Duncan, 1958
Painting on sculpture, 1957, Duncan, 1958
Holding skipping rope, 1957, Duncan, 1958
Scratching on slides, 1967, Baldassari, 1997

In passing it is also worth noting for the record that we also have photographs showing that Picasso was also right-eye dominant (Duncan, 1958), but that he crossed his left arm over his right arm (e.g. Bernadac, 1991), and crossed his left leg over his right. Arm-folding in general does not correlate with handedness and is not a marker of left-handedness (McManus & Mascie-Taylor, 1979).

☞WWW☜ 12:27

In *Drawing with the right side of the brain*, Picasso's ability is of course attributed to his being left-handed and hence using the right side of the brain to draw. Picasso is also quoted on p.74 (Edwards, 1989) as saying "Painting is a lie that tells the truth". That is probably so. But that Picasso was a left-hander is a lie with no truth.

☞WWW☜ 12:28

Interestingly although Picasso is included in the de Kay's later *The natural superiority of the left-hander* of 1979, he is not included in *The world's greatest left-handers* of 1985 (de Kay, 1994g).

Many photographs can be found of Bob Dylan playing guitar right-handed (Sandson, Wen, & LeMay, 1992), and there is also a photograph of him playing table tennis backstage, with the bat held clearly in his right hand (Gross & Alexander, 1978).

☞WWW☜ 12:29

There are several books with pictures of Einstein writing at a blackboard using his right hand or writing on a note pad with his right hand. In one book there is a picture of him writing with his left hand at a blackboard but all of the writing is in mirror image, and the same picture occurs in other books with normal writing. Witelson *et al* (1999l) suggest that "There is evidence to suggest that Einstein was not consistently right-handed", and cite Winokur (1984g). However in that book the only activity Einstein does with his left hand is to hold his pipe, a non-skilled activity, like holding a cigarette, that many right-handers do with their left-hand. In the three pictures in which he is writing he uses the right hand, he stands in front of a blackboard in one picture holding chalk in his right hand, and in the two pictures of him lighting his pipe the match is held in the right hand. The Winokur book does show that Einstein clasped his hands with his left thumb on top, but that is irrelevant to his handedness since hand-clasping is unrelated to handedness (McManus & Mascie-Taylor, 1979).

One of the few books to note that there is precious little evidence that Einstein was left-handed is Rutledge and Donley (1992 p.30), who accept that most of the evidence is very indirect, usually being based on claims that Einstein learned to read and write at a late age. They do claim that Einstein was left-eye dominant, there apparently being photographs of him looking through telescopes and microscopes with his left eye, but since 20% of right-handers are left-eye dominant, that is hardly compelling evidence for left-handedness. Either way, it didn't stop his publishers putting Einstein along with Benjamin Franklin and the usual suspects on the cover of the book.

☞WWW☜ 12:30

I have looked in the earlier popular books on handedness and the only one in which I can find a reference to Franklin is Wile 1934 pp. 356-7, who quotes the *Petition* in its entirety but makes no suggestion that Franklin was left-handed.

References to Franklin's left-handed are found, once again, by de Kay 1994g in *The Natural Superiority of the Left-hander* (1979), and in *The world's greatest left-handers* (1985), where he spins an elaborate story about Franklin's left-handedness helping him as a printer because he could read mirror-script more easily. An academic who claims Franklin is left-handed is Coren (1992 p.280). A recent occurrence of a left-handed Franklin is on the cover of *The left-handers 2001 desk calendar*, which offers "365 days of left-handed legends, lore and more" – but mostly legends, it would seem..

Not all authors do claim that Franklin was left-handed, and in particular Barsley. wrote, "The American genius Benjamin Franklin was *not* himself a left-hander" (my emphasis), but gives no reasons for saying it, although his books are generally well-researched. Barsley argues that the *Petition of the left hand* was "a serious attempt to recommend ambidextrality to the teaching profession" (Barsley, 1970 p.85; Barsley, 1966c p.129). It is however more than possible that Franklin simply liked a practical joke. Certainly the *Petition of the left hand* was not Franklin's first of its genre, for eleven years earlier in 1768 he published in *The Tatler* a *Petition of the letter Z* (Bigelow, 1887vol IV), addressed to the Censor-General , taking up the case of the letter Z, which is "of as high extraction and has as good an estate as any other letter of the Alphabet", and pointing out that "there is therefore no reason why he should be treated as he is, with disrespect...". The Petition ends with a prayer, unsuccessful, "that the Alphabet may by your censorial authority be reversed...".

It should also be said that I can find no reference to Franklin being left-handed in Clark's biography (Clark, 1983), and it seems unlikely that he would have omitted it if there were solid evidence to support it.

The portrait of Franklin by Chambertin was painted while Franklin was in London in 1762. Chambertin had "a reputation for accurate likenesses". A very popular mezzotint was also made from the portrait by Edward Fisher, and it also shows Franklin as right-handed (and the artist must therefore have reversed the portrait during its production; Labaree et al., 1966 p.xv). Franklin himself commented on the Chambertin portrait (Van Doren, 1939 p.431), and if it were inaccurate it is unlikely it would have been reproduced and distributed by the Franklin family.

Lindsay's later book, *Left is right: the survival guide for living lefty in a right-handed world* (1996k), which looks like a different book but actually bears an uncanny overlap with the earlier *The left-handed book* (1980), repeats the old stories about Franklin being left-handed but this time does *not* show the Chambertin portrait. Perhaps a covert admission that the original was in error?

☞WWW☜ 12:34

The modern popularity of the question probably stems to a large part from David Feldman's book called *Why do clocks run clockwise? and other imponderables* (Feldman, 1987). The answer is a mere eight lines long and tells the standard story about sundials. It is attributed to Henry Fried, an American horologist, but I have not been able to find where it was published. A much earlier comment on the problem is due to Mach (1914 p.338) who comments in a footnote that, "By the direction in which its hands move the watch proclaims its descent from the sundial and its discovery in the northern hemisphere".

The answer quoted by the New Scientist reader was submitted to *New Scientist's Last Word* column by Mike Thomson of Cardiff (*New Scientist*, 24th April 1999). He is far from alone in proposing this explanation of the clockwise direction of clocks.

☞WWW☜ 12:35

Although it is generally assumed that early clocks were mostly large public clocks, Landes (2000 p.83) points out that some horologists think that small domestic clocks would also have been made but that it is only the larger clocks which have survived.

Details of the Queens' College sundial can be found at www.quns.cam.ac.uk/Queens/Misc/Dial.htm, and in Scarr (1988e). Should you still doubt that vertical sundials go anti-clockwise then you can get an interactive view of the new vertical sundial in Foundress Court of Pembroke College, Cambridge. (www.uk.research.att.com/sundial). If the British weather allows you then two observations an hour or two apart should easily show the movement of the shadow.

☞WWW☜ 12:36

In his *Italian Journey* in September 1786, Goethe (1970pp. 59-61) describes the complex calculations he went through to use the *hora italica*, which is more confusing than it seems at first sight, since the hour of sunset varies throughout the year, and hence midnight is not at a fixed numerical time.

A further unusual feature of Uccello's clock is that the numerals on the left-hand side, such as XVIII are upside down. Nowadays they would be one way up on the right hand side and the other way up on the left hand side, so that both seemed approximately upright when viewed from a normal position. This may reflect the fact that some early clocks did not have a fixed dial and rotating hands, but instead a fixed hand or pointer and a rotating dial. If Uccello had been copying such a dial then it would make sense for all the numbers to be in the same relation to the one before, so that they were the correct way up as they went past the pointer. However even if the dial in the Botticelli clock did rotate in such a fashion, there is of course no way the one painted in fresco on the wall of the cathedral could do so. An

additional problem of interpretation, as Christine Pleines pointed out to me, is that even though the numbers on a rotating dial are ordered in an anti-clockwise direction, the dial itself would in fact rotate clockwise.

I cannot help noting that I found an illustration of Ucello's clock on an Australian web-site (www.uq.net.au/iacobus/uccello/clock.html) devoted to the artist. However it had been mirror reversed, so that the clock went clockwise. I can only presume that the person setting up the site thought that the anti-clockwise image had itself been inadvertently reversed and corrected the supposed error.

☞WWW☜ 12:37

The church of Ognissanti was damaged by flooding in the 1960s and as a result Botticello's fresco has been moved to the convent next door. For a detailed picture of the clock see Bo and Mandel (1978 Plate XXV). Lightbown (1989 p.76) points out that the time on the clock is exactly sunset, which is corroborated by the angle of the golden light in the scene.

Illustrations of all of the types of clock mentioned can be found in Simoni (1965).

☞WWW☜ 12:38

For details of the process of lock-in see the articles by Arthur (1990i, 1989f, 1988f). Arthur explicitly uses the example of Uccello's clock:

> "When Paolo Uccello designed the clock in 1443, a convention for clockfaces had not emerged. Competing designs were subject to increasing returns: the more clockfaces of one kind were built, the more people became used to reading them. Hence it was more likely that future clockfaces would be of the same kind. After 1550, 'clockwise' designs displaying only 12 hours had crowded out other designs." Arthur, 1990i p.82.

No references are given to support this claim. The claim about stabilisation by 1550 is probably correct for the clockwise direction, but not for clocks with 12 hours displayed (Simoni, 1965).

It has often been noted that with regard to video-tape formats, BetaMax was undoubtedly superior technically to VHS, but VHS won hands down. Victory does not always go to the best. In the long run both however will inevitably be replaced by DVD.

The problem for the ants is that the pheromone trail laid down is too permanent (Bonabeau, Dorigo, & Theraulaz, 2000). As a result computer algorithms for numerical optimisation which simulate the process lay a virtual pheromone trail which 'evaporates' to prevent the system getting stuck in early solutions.

☞WWW☜ 12:39

The date of the earliest clock is still not clear, but Landes (2000 p.9) cites the paper by Thorndike (1941a) which suggests that a mechanical clock was in existence by 1271. It would seem that this early clock was conceived to have a wheel that would rotate once in twenty four hours ("between sunrise and sunrise"), rather than our current system of rotating in twelve hours, and hence twice very day. The system of having twelve hours on a clock or

watch is, the more one thinks of it, extremely strange, and if it were not that we are all totally immersed in it almost from birth, it would surely cry out for an explanation.

☞WWW☜ 12:40

Although not reported in the original paper (Price & Gilden, 2000), the authors also found the interesting result that the bias was identical in right and left-handers (D M Gilden, personal communication, 2000).

☞WWW☜ 12:41

I have based most of this account on the very clear descriptions provided by Martin Gardner (1990a) in his book *The Ambidextrous Universe* and by Richard Gregory (1998q) in his book *Mirrors in Mind*. I find myself entirely convinced by Gardner's account. Gardner however regards an earlier account of Gregory's as "confusing" (p.22) of revised edition), and Gregory is equally critical of Gardner (Gregory, 1998q pp. 98-99). My personal view is that Gardner is correct about the nature of the *optical* problem, whereas Gregory understands that there is also a *psychological* problem which he accounts for satisfactorily. Maddox (1991i) has also stressed the separation of physics and psychology, of "the reflection of light in mirrors and what observers construe of the images they see".

I have purposely been a little vague when talking about buttons on clothes as there is a bizarre difference between men's and women's clothes. Buttons on men's clother are held in the right hand, while the 'hole' is held in the left hand; for women it is the opposite. Quite why this is so has been speculated on many times. The most prevalent theory says that buttons are easier for right handers to do up if they hold the fiddly little bit, the button, in their more skilled hand, the right – again the principle that the left hand *holds* while the right hand *does*. That women's clothes are the other way around is said to be that in Victorian times the majority of women with large numbers of buttons would have someone to dress them, and therefore the design was reversed. Whether there is historical evidence for this I am not clear, and neither whether it shows any cross-cultural uniformity. It would benefit from systematic research.

For a recent cultural history of mirrors, their origins and their meanings see Melchior-Bonnet (2001h).

☞WWW☜ 12:43

Notice that the image in the mirror is not a real image, since it could not be projected onto a screen. Instead it is a virtual image, one that *looks* as if it exists. It occurs because the divergent rays of light are focussed onto the retina of the eye by the lens in the eye. When light entering the eye has actually bounced off several objects then the brain cannot tell where it is has truly come from and instead simply 'projects' its origin back to where it would have come from if it had always been travelling in a straight line. The dotted lines in the figure show the backward projections of the lines of light entering the eye, behind the mirror, from where they seem to come.

☞WWW☜ 12:45

The mirror problem also shows the difficulty in trying to describe the world relative to ourselves. As we saw earlier, left and right look different from the point of view of different people – and hence the audience's left and right in a theatre is not the same as the actor's 'stage right' and 'stage left'. The actors have turned around through 180 degrees relative to the audience so that you can see them and they can see you – for otherwise the play would be a bit difficult to understand. But left and right as descriptions can then be very confusing.

☞WWW☜ 12:46

Although two simple mirrors at right angles is the easiest way to make such a mirror, any curved *concave* mirror (i.e. one that is bent inwards upon itself) has the same property, as was recognised by both Plato and Lucretius.

A further variant of this situation is seen in the 'mirror' that we can produce by pointing a video-camera at our self and then looking at our image on a monitor screen. This system behaves exactly like the double mirror system. When we wave our right hand at the figure on the TV screen that figure waves their right hand back at us. What has happened here is that in order to see ourselves on the monitor we have had to rotate the camera through 180 degrees relative to ourselves – the camera's right hand side is on our lefthand side, and so on. So the system has done a double reversal and everything seems back to normal[57].

☞WWW☜ 12:48

The three-mirror situation is intriguing. If you look directly at just one wall, front and back will be reversed and the image will be mirror-reversed. If you now look directly into the join of the walls, front-back and right-left are reversed, and the result is an image in the correct orientation. If you now look into the corner of the room where all three mirrors meet at right angles, you will again see a mirror-image reversal; one mirror reverses front-back, a second right-left and the third top-bottom, resulting in a mirror-image object (which is also upside down).

[57] There is actually a series of reversals here, because the lens of the camera reverses left and right (but also top and bottom), and the monitor has also been turned around from the direction of the camera.

Chapter 13: Hypernotes

☞WWW☜ 13:2

This account is principally based on that of Sadler (1997f). He also points out in the same article that Bart Simpson is shown left-handed most of the time; "He might just be left-handed to fit in with the stereotype that left-handers have a rebellious nature" (p.148).

Whether Henson was left-handed is unclear, at least one web-site saying his left-handedness is a myth, albeit one that is often quoted (http://www.qsulis.demon.co.uk /Website_Louise_Gold/The_Muppet_Show.htm).

Although most Muppets are left-handed because they were controlled by right-handed puppeteers, it seems that the Muppets controlled by the left-handed puppeteer Louise Gold were right-handed. (www-cs-students.stanford.edu/~csilvers/muppet-faq.html).

Before anyone asks, I agree that this theory of puppetry ought to mean that *all* puppets, and not just Muppets, should be left-handed. And so it should. Whether it does I have no idea. I leave it to some interested reader to publish the definitive study. One might also ask a) whether film makers might also sometimes reverse the images on film or video (see the comment on *Titanic*), and b) whether most of the time right handers are too insensitive to notice this excess of left-handers (see the comment on Van Gogh's *Potato Eaters*, in chapter 11).

The sophisticated cognitive and motor skills have been little discussed by neurologists or psychologists, an insightful exception being the account of Wilson (1998 Chapter 4). There is however no mention of the differences in usage between right and left hands. By way of compensation there is a lovely account of how the Greek name for a puppet was *neurospastos*, a name with several uncanny neurological similarities. The modern word 'neuron' in fact derives from the Greek word for a cord or fibres, which were also the strings that moved the puppet.

☞WWW☜ 13:4

I have also seen it claimed that Julius Caesar was left-handed (Lindsay, 1996k p.11). However the same source also claims (p.40) that Caesar decreed that the alphabet would go from left to right, a suggestion which is undoubtedly false.

The evidence concerning Commodus' left-handedness is made slightly less clear by Cassius Dio also saying, "Having killed an ostrich and cut off its head, he came up to where we were sitting, holdiing the head in his left hand and in his right hand raising aloft his blood sword" (Cary, 1927 vol IX, pp. 114-115, Book LXIII).

☞WWW☜ 13:5

Gladiator was released May 2000 with Commodus played by Joaquin Phoenix.

At the time of his death Billy the Kid was found with his six-shooter by his right hand and a butcher's knife at his left (Utley, 2000 p.194). Although right-handed, there is no doubt that Billy's gunsmanship was exceptional with both hands. Frank Coe described how he practised continually and, "could take two six-shooters, loaded and cocked, one in each hand ... and twirl one in one direction and the other in the other direction, at the same time" (ibid, pp.32-33). The picture of Billy the Kid posed an interesting problem for *The Guardian* newspaper which has a strong editorial policy of not left-right reversing pictures merely for aesthetic effect. The problem is that the "left-handed" Billy is the true version of the photograph, whereas the "right-handed" Billy is the true version of Billy himself (Mayes, 2001). The problem of tin-type pictures in reversing the image is mentioned by H G Wells in *The Plattner story*, where in one early picture Plattner does seem reversed, but:

> "The photograph of Gottfried at fourteen seems to contradict these facts, but that is because it is one of those cheap "Gem" photographs that were then in vogue, taken direct upon metal, and therefore reversing things just as a looking-glass would."

From the details given in *The Plattner story* it would seem that this picture of Gottfried must have been taken in about 1884, much the same time as Billy the Kid was also being photographed.

Michael Ondaatje's *The collected works of Billy the Kid* (1989g), subtitled "Left handed poems", was first published in 1970, a decade and a half before the definitive right-handed photograph of Billy turned up. Ondaatje seems however to have hedged his bets somewhat, saying in the text that Billy, "...ate corn, drank coffee, used a knife and fork alternately – always with his right hand. The three days we were together .. he never used his left hand for anything except of course to shoot". The Vintage International edition of 1996 somewhat undermines Ondaatje's sub-title of 'left handed poems' by having a clearly right-handed Billy on its front cover, with his six-shooter at the right hand. Ondaatje (p.98) also reproduces the cover of "The Five Cent Wide Awake Library' edition of the *True life of Billy the Kid*, undated but clearly around the turn of the century, on which it is clear also that Billy is shooting right-handed, suggesting that his left-handedness is a relatively late addition to the mythology.

Billy the Kid is apparently not the only villain who is left-handed, and he has undoubtedly been overtaken in notoriety by Osama (Usama) bin Laden, who is featured in several different news photos using a Kalashnikov in a left-handed way (e.g. *The Observer* 16th Sept 2001), Reuters' prints PD*1701300 and PD*1697121[58]). Bin Laden is also described on the FBI's

[58] I am grateful to *The Observer* for providing me with copies of these photographs, both of which were frames grabbed from a video. There seems little likelihood that they have been inadvertently reversed.

web-site as left-handed (www.fbi.gov/mostwant/topten/fugitives/laden.htm). Perhaps the most intriguing thing about bin Laden is that despite there being a myriad of web-sites devoted to famous left-handers, several of which request assistance in keeping their lists up to date, as of 24th Feb 2002 only a single site, based in Japan, has been updated to include bin Laden as a famous left-hander.

☞WWW☜ 13:6

The most obvious example in *Titanic* that the embarcation scene is reversed is that the majority of people on the quayside waving good-bye are doing so with their left hand, even though right-handers usually wave goodbye with their right hand. There are also other subtle errors, my favourite continuity problem being the moment when the ships hawser is being cast off, and then a few seconds later it is seen being hauled in on the deck. When cast off it has a right-hand twist (a Z twist), whereas the rope being hauled in on the deck of the boat has a left-hand twist (an S twist). Since ropes mostly have a right-hand twist, I presume the long shot along the departing boat is mirror-reversed, and the close up of the rope being cast off is not reversed.

☞WWW☜ 13:8

Jack Magg's mirror writing is also described on page 179 (Carey, 1997). and on page 188 the writing is described as being "back to front like a Chinaman". Quite why Maggs writes in mirror-script is never really clear, although it is in part a device for ensuring secrecy, particularly when accompanied by the use of invisible ink. That Maggs is undoubtedly right-handed is clear from him keeping his dagger by his right ankle (p.129), and right-handedness is also implied on page 172.

The ability to mirror-write on a blackboard is also helped by the difference in motor organisation between large, slow movements made with the large, proximal muscles of the shoulder girdles, when mirror writing is easy, and the fine, fast movements made with the distal muscles of the hands, when mirror writing is much more difficult.

☞WWW☜ 13:12

Pacioli wrote, "Scrivesi ancora allo rovescia e mancina che non si posson leggere se non con lo spectro ovvero guardando la carta del suo rovescio, contro alla luce...": "he wrote in the reverse direction and left-handed, so that it could only be read when held to a mirror, or by looking at the paper from the reverse, against the light..." (Critchley, 1928 p.13). Vasari also comments on Leonardo's left-handedness and mirror writing, saying how Leonardo, "wrote in letters of an ill-shaped character, which he made with the left hand, backwards; and whoever is not practised in reading them cannot understand them, since they are not to be read save in a mirror (de Vere, 1111 vol I, p.634).

The maps of Val di Chiana are in the Royal collection at Windsor, numbers RL12278 and RL 12682 (Clark, 1968b), and can be seen in fine reproductions in Clayton (1996 pp97-99). Schott(Schott, 1999) points out that we will probably never know whether the normal script was written with the right or the left hand, although it has been claimed elsewhere that graphological analysis suggests that Leonardo used his left hand for the normal writing, as well as the mirror script (Posèq, 1997g p.43).

☞WWW☜ 13:13

There is a real problem in attributing drawings to Leonardo since, as Kenneth Clark put it, "all Leonardo's drawings are done with the left hand and the diagonal shading invariably runs down from left to right. ... Almost every drawing attributed to Leonardo that is shaded from right to left is either unlike him in other respects or is demonstrably a copy" (Clark, 1968b vol 1, p.xvii). The problem is that this is a self-fulfilling prophecy, particularly with regard to the possibility that early in his life Leonardo may have been right handed. There does however seem little doubt that, as Clark points out, from 1473, in a famous dated drawing of the Arno, that Leonardo was mostly using his left hand. However that same drawing, on the verso, does include an inscription written with the right hand (or, to be more precise, written from left to right) (Venturi, 1956 p.89). Venturi concludes that "in his earliest drawings [Leonardo] seems to have employed both the right and the left hand to some extent, but he soon uses the left exclusively" (Venturi, 1956 p.90). Venturi does argue that Leonardo's left-handedness was "congenital", and that "after the earliest drawings, in which he occasionally used the right hand", he was left-handed. That however seems unlikely; congenital left-handers do not usually "occasionally use their right hand", particularly for tasks such as drawing (although they do use the right hand for writing). It is at least possible that Leonardo started out right handed, and had to become left handed because of an accident, and that after the accident he tried, for a while, to use the deformed right hand.

Leonardo does refer explicitly to his right and left hands in describing an episode in which he is striving to look inside a cave: "I came to the mouth of a huge cavern before which for a time I remained stupefied, not having been aware of its existence, my back bent to an arch, my left hand clutching my knee, while with the right I made shade for my lowered and contracted eyebrows" (BM 155.r; MacCurdy, 1958 p.1127). It is difficult to know precisely what to make of this episode, but my feeling is that most right-handers would bend down with their hand on their left knee, and use the right hand to shade the eyes, whereas left-handers would do the converse. If correct, that implies that Leonardo was indeed a natural right-hander.

An interesting feature of Leonardo's mechanical drawings is that when he uses a screw thread it is invariably a left-handed thread (e.g. the design for a screw jack, in the Madrid Codex, I, f.26r). However when, for an exhibition, some of those machines were constructed, they invariably had right-hand screw threads (Anonymous., 1989 pp.223,226).

Late in his life, while he was living in France, Leonardo was visited by Antoni de' Beatis, secretary to Cardinal Louis of Aragon. De Beatis was a careful and accurate observer, and he noted that "on account of a certain paralysis having seized [Leonardo] in the right hand, one cannot expect more fine things from him". Clark suggests that the use of right was a simple error, "*Destra*, presumably meaning his working hand, although Leonardo was left-handed" (Clark, 1959 p.157). That interpretation is vehemently disputed by Clayton (Clayton, 1996 pp.134-6), who says that de Beatis, "meant exactly what he said. Leonardo's notes and drawings, done with the left hand, were strong and confident almost to the end of his life, and it is likely that only painting and other larger-scale manual tasks that required both hands were curtailed by the paralysis in the right hand. Leonardo had continued the physically demanding

task of anatomical dissection well into his Roman period, and it may be assumed that his right hand was just as strong then".

☞WWW☜ 13:20

Whether or not Prince Charles is left-handed is unclear to me. He writes with his right hand and is said only to show sinistrality when kicking a football or digging Barsley, 1966c pp.169-70, not strong evidence for left-handedness. Barsley (1970 p.166) does however say that there are photographs of Prince Charles presenting prizes with his left hand. As always it shows the difficulty of knowing even whether living, very well-photographed, people are left-handed.

The attribution of left-handedness to Queen Victoria is on the authority of Sir Edwin Landseer, the artist and Queen Victoria's painting tutor, who was himself ambidextrous, and said to be able to draw different objects with the right and left hands simultaneously (Langford, 1984 p.101).

☞WWW☜ 13:22

Although George W Bush is 43rd President, he is only the 42nd person to have been President because Grover Cleveland was both 22nd and 24th President.

☞WWW☜ 13:24

Woodrow Wilson had a series of strokes on the both the right and the left sides, as well as blindness in the left eye, all probably due to atherosclerosis caused by his hypertension, with thomboses and haemorrhages being the final consequence. Wilson's ability to write so easily with his left hand, coupled with his apparent dyslexia early in life, have suggested to one of his biographers that Wilson suffered from dyslexia. Although Wilson himself was right-handed, one of his three daughters was left-handed, suggesting that either Wilson or, slightly less probably given Wilson's dyslexia, his wife, were carriers of the gene for left-handedness (Weinstein, 1970; Weinstein, 1981).

Examples of Wilson's left and right-handed script can be found in Weinstein (1981 pp142-4, and plates 7-8).

☞WWW☜ 13:25

Tumours were said to be 2.6 times more common on the side on which the phone was usually held (Hardell et al., 1999; Hardell & Hansson Mild, 2001), with 57% of patients reporting they used the phone mostly on the right ear, 28% on the left ear, and 15% about equally on the right and left sides. The interpretation of the result is controversial (Hardell & Hansson Mild, 2001; Rothman, 2000; Rothman, 2001) because there seems to be no overall increased rate of tumours. The numbers of cases involved are however small, and a replication is badly needed. What does seem clear is that if it is generally the case that mobile phones are held to the right ear (and about 60% of people are right eared), then the presence or absence of an excess of right-sided brain tumours provides a strong test that local heating due to electromagnetic radiation could cause temporal lobe tumours.

☞WWW☜ 13:26

I do not know the original source for the translation of *Ecclesiastes* quoted by Critchley (Critchley & Critchley, 1978 p.94).

☞WWW☜ 13:27

Wölfflin was far from the first to recognise that pictures look different in mirrors, although he was probably the first to ask why it was the case. Leon Battista Alberti in his *De Pictura* of 1435 (Grayson, 1991) says that "the mirror shows every weakness in a painting manifestly deformed" (Posèq, 1997g; and Leonardo also made a similar comment in his notebooks, "When you are painting you should take a flat mirror and often look at your work within it, and it will then be seen in reverse, and will appear to be by the hand of some other master, and you will be better able to judge of its faults than in any other way" (MacCurdy, 1958 pp.887-8); see also Posèq (1997g). Wölfflin (1941b) has been much cited, for instance by Gaffron (1950b), Oppé (1944) and Uhrbrock (1973c).

An interesting question was whether when Rembrandt drew his picture he took into account that it would be reversed during printing. The answer seems to be, almost certainly yes, particularly given that Rembrandt was well aware of the effects of mirrors, having a large one in his studio (Konstom, 1977), and that he would modify pictures drawn using the mirror to ensure he obtained the effects he wanted (van de Wetering, 1999).

Although naive observers do not seem to be able to distinguish a portrait and its mirror image (Blount et al., 1975), and using a technique known as the semantic differential observers make the same judgements about the meaning of a portrait and its mirror image, nevertheless those portraits painted by the artist as showing the left cheek have a different perceived meaning from those painted as showing the right cheek (McManus, 1979f). Artists themselves must therefore distinguish the meaning of the right and the left cheek.

☞WWW☜ 13:28

The question of quite why right-right and left-left chimeric or composite faces look so different is complicated. For a good review see Asthana, Bhushan, & Mandal, 2000.

Painted portraits and photographs are very rarely straight on to the camera, except sometimes in passport photos and 'mug shots'. The 'canonical position' is the 3/4 turn, with both eyes visible and the profile of the nose also clearly outlined (Laeng & Rouw, 2001). Painted portraits and photographs tend preferentially to show the left cheek, which has the effect of swinging the critical information, the nose and mouth, into the area which will be preferentially processed by the right hemisphere (Humphrey & McManus, 1973; McManus, 1979f; McManus & Humphrey, 1973).

☞WWW☜ 13:29

There is a suggestion that the left-right differences in shadowing are partly reversed in left-handers (Sun & Perona, 1998).

☞WWW☜ 13:30

The finding of a left-sided bias in child holding has been repeated in a range of Western countries (Sieratzki & Woll, 1996), as well as in Sri Lanka (Bruser, 1981), and in the Yanamano Indians of the Amazon basin (Bolton, 1978). Many explanations have been put forward, including the involvement of cerebral dominance, either on the part of the mother or the child, typically to do with improved perception of language by the left hemisphere or emotion by the right hemisphere when the child is held on the left side (Sieratzki & Woll, 1996). Although ingenious, most studies have only looked at population proportions, and when detailed individual studies have been carried out the hypotheses find no support (Turnbull & Bryson, 2001). Any explanation invoking cerebral dominance will have troubles coping with the finding that infant chimpanzees prefer to suckle from the nipple on the mother's left side (Nishida, 1993).

Since writing this chapter and suggesting that the key test of Salk's heartbeat theory of cradling is to look at mothers with s*itus inversus*, I have become aware of the chapter by Turnbull and Lucas (2000v), where they describe a single case report of a mother with dextrocardia (Todd & Butterworth, 1998) who cradled on the left side. Of course a single case is not sufficient to refute the model, but as Turnbull and Lucas say, it does confirm that the theory is in principle testable. Turnbull and Lucas, after reviewing a number of theories of the phenomenon conclude, "It appears that the cause of the leftward cradling bias continues to elude us. It is certainly regrettable that such an apparently simple, and empirically robust, phenomenon does not have an acceptable explanation." (Turnbull & Lucas, 2000v p.284).

☞WWW☜ 13:32

The original study (Weiskrnatz, Elliott, & Darlington, 1971) confirmed an old suggestion, going back at least to Darwin, that it is more difficult to tickle oneself than to be tickled by someone else.

The experimenters comparing the tickle sensitivity of the right and left foot (Smith & Cahusac, 2001) carried out their study because in an earlier investigation an incidental finding was that the right foot seemed to be more sensitive to tickle than the left foot (Ruggieri & Milizia, 1983). The new finding is therefore a replication, giving it greater validity.

☞WWW☜ 13:34

Whether the definition actually emphasised the *left* feet, as has been claimed by the National Physical Laboratory (Anonymous, 2000c), I have been unable to confirm. However the authoritative *The weights and measures of England* (Connor, 1987 p.44) does not mention which particular foot, although it does mention a late woodcut in Jakob Kobel's *Geometrei* of 1535, printed in Frankfurt am Main, of a line of men standing heel to toe, wearing shoes, while the combined length is measured. I have not seen the original and so am not clear if they are the left feet. However practicality would seem to require that all the men had the same foot heel to toe.

☞WWW☜ 13:35

There is also a theory attributed to Michael C.S. Kingsley and Malcom A. Ramsay (http://www.gi.alaska.edu/ ScienceForum/ASF8/895.html that the rotation occurs precisely because it does keep the tusk straight. Without the rotation any tiny deviation in growth would make the tusk massively curved (rather like an elephant's or a wart hog's) and that would undoubtedly interfere with swimming. Even if that is correct though there still seems to be some additional factor to explain why it is only the left tusk that grows and why it always spirals to the left.

☞WWW☜ 13:36

For a good description of the curious history of the unicorn and its evolution and transformation during the Middle Ages, see http://pages.infinit.net/cerame/ heraldicamerica/etudes/unicorn.htm.

☞WWW☜ 13:39

The quotation marks around the tile *"Pip"* are seemingly a formal part of the title. Barsley summarises 'Pip' with fine irony: "Ian Hay's hero is certainly a topping example of how a good sort can be left-handed". Barsley claims also that "no doubt Pip played [golf] right-handedly. Left-handed golf-clubs had yet to be introduced" (p.89). However in *"Pip"* it is clearly stated that "At the next hole Pip sliced his drive, the ball flying an immense distance and curling away out of sight to their left. (You must remember that he was a left-handed player)" (Hay, 1939 p.229). 'To slice' in golf means the ball is hit so that it deviates *away* from the striker, so that presumably means Pip was playing left-handed. When left-handed golf clubs were introduced I have no idea but presumably on this basis before 1907.

☞WWW☜ 13:40

The translation is by Thomas Carlyle, originally published in 1824 (Carlyle, 1874). The passage raises the interesting question of whether Goethe himself was left-handed, and needless to say there have been claims to that effect, usually suggesting he wrote with his right-hand but was a natural left-hander (see Sattler, 1999 pp.267-8). Goethe spent several years of his life trying to become an artist, although he eventually decided that he had insufficient talent. The drawings he produced during that period appear to have the diagonal shading that one would expect a right-hander to produce (Sieveking, 1998), and so it seems he probably was a right-hander.

☞WWW☜ 13:41

Interestingly, Holmes emphasises the importance of right and left earlier in the story, as he says to Watson,

> "There is nothing more obvious deceptive than an obvious fact ... To take the first example to hand [sic], I very clearly perceive that in your bedroom the window is upon the right-hand side..."
>
> "How on earth —"

> “My dear fellow, I know you well. ... You shave every morning, and in this season you shave by the sunlight; but since your shaving is less and less complete as we get farther back on the left side, until it becomes positively sloven as we get round the angle of the jaw, it is surely very clear that that side is less illuminated than the other”.

Watson is, of course, right-handed, and has more difficulty shaving on the left hand side.

☞WWW☜ 13:42

I tried searching on the internet for jokes and found very many appalling jokes, but hardly any about the right and left hands. Certainly I don't count the 'rightie' jokes on web-sites such as http://www.getodd.com/fun/left/rhjokes.html, where 'right-hander' has merely been substituted for 'Irishman', 'Pole', Newfoundlander', 'blonde' or whatever in a host of stereotyped jokes in which the right-handedness plays no role at all in the humour.

Barsley is not so foolish as only to claim 'copyleft', since presumably that would have no legal value, and so the international copyright symbol, ©, is also there.

During 2001 there was a vociferous movement within science to make scientific publishing open and non-commercial, with ready access to all, principally by using the internet (see Lawton (2002c). That would mean abolishing much of the copyright held by commercial publishers, and replacing it with what has also been called 'copyleft', which in effect makes all publications open to all from six months or less after publication. It is an interesting transmutation of right to left.

Chapter 14: Hypernotes

☞WWW☜ 14:1

George Herbert's poem was published in *The Temple*, in 1633, the year of Herbert's death (Tobin, 1991). I have left the original spelling for poetic effect. In his mediation on *Man*, Herbert also mentions, a few lines earlier, the difference between man and beasts, and emphasises “reason and speech we only bring”. .

☞WWW☜ 14:2

The Greek word is σύμμετρος. Bochner (1973d) starts his account by quoting Pliny's remark, “Latin does not have a word for 'symmetry'” (Rackham, 1952 pp. 175-7); and indeed no other European language would appear to either, all having taken over the Greek word. Bochner (1973d p.346) says that the word “belonged to a group of terms and locutions that designated harmony, rhythm, balance, equipoise, stability good proportions, and evenness of structure”.

Translations of Plato do vary, and a standard one Fowler, 1962 p65.a has, “Then if we cannot catch the good, with the aid of one idea, let us run it down with three – beauty, proportion [ξυμμετρία], and truth...”. Van Fraassen (1989 p.232) has the rather more evocative image, "Then, if we are not able to hunt the goose with one idea, with three we make take our prey; Beauty, Symmetry, Truth are the three..." Philebus, 65.a. (see Van Fraassen, p.232).

The relation of truth and beauty was put most famously by Keats in his *Ode on a Grecian Urn*, “Beauty is truth, truth beauty, that is all / Ye know on earth, and all ye need to know”. The position is not however accepted by everyone, Plotinus for instance reversing the causal relations and arguing that “beauty is what illuminates good proportions [symmetry] rather than the good proportions themselves” (Armstrong, 1988 VI.7.25-7).

☞WWW☜ 14:3

In looking for copies of the Rorschach figures I was surprised by how many introductory textbooks of psychology do not show the actual figures, which are surprisingly rich and subtle (and in colour), but instead show very crude blobs “of the sort used in the Rorschach test”. It was only when I asked for copyright permission to use one of the original figures that I realised why – the copyright owners will only allow one of the figures to be reproduced and then at great expense. The figure shown is, therefore, my own. It is the second figure I made, and I found it most intriguing, not least because of what, to my eye at least, appear at the top

to be two erect phalluses. These were generated by pure chance, but I couldn't resist leaving them in.

Rorschach himself thought that symmetry was a necessary part of the test stimuli: “Asymmetrical figures are rejected by many subjects; symmetry supplies part of the necessary artistic composition. It has a disadvantage in that it tends to make the answers somewhat stereotyped.” (Rorschach, 1942 p.17). The figures I had hoped to include in the book are cards II (top) and III (bottom). It is said that, “Clinicians generally cite Card II as sexually evocative (with a penis area near the top and a vaginal area beneath)", whereas “Many clinicians place great stock in responses to Card III as an indication of social interaction patterns.” (Aronow, Reznikoff, & Moreland, 1994 p.35). Over a half of subjects see anatomical, animal or human content in the cards (Harrower & Steiner, 1951 p.94). There has been a continuing controversy for the past half century over the reliability and validity of the Rorschach test (Lilenfeld, Wood, & Garb, 2001).

See Meglitsch and Scram (1991 pp. 591-597) for the role of bilateral symmetry in defining organisms.

☞WWW☜ 14:4

A good and very readable introduction to many aspects of symmetry can be found in Stewart and Golubitsky (1992g), where they come up with fine description that “a symmetry isn’t a *thing*; it’s a *transformation* ... a transformation that leaves [an object] *apparently* unchanged”. A similar definition can be found in Van Fraassen (1989 p.262): “The general notion of symmetry is this: *a symmetry is a transformation that leaves all relevant structure the same”*; that word 'relevant' allows a far broader group of phenomena to be included as symmetries.

On the reduction of all symmetries to reflection see van Fraassen (1989 p.263), and Coxeter (1969e).

There are several more technical accounts of the applications of symmetry in science (Boardman, O'Connor, & Young, 1973; Wolbarst, 1977).

☞WWW☜ 14:5

Strictly the two-dimensional patterns are conceptualised mathematically as being infinite, although in practice as long as there are three or four cycles the pattern is very visible.

Wyle (1952 p.103) claims that all seventeen patterns were known to the Egyptians, and Stewart and Golubitsky (1992g p.238) say they can all be found in the Alhambra. See also Gombrich (1979g).

☞WWW☜ 14:6

It may have taken Ørsted eight years to find his result, but when he did so it was at least noticed. The discovery had also been made in 1802 by the Italian, Gian Domenico Romagnosi, but was published in such an obscure place that it was totally ignored at the time.

A useful biography of Ørsted, along with the background to his experiment can be found in Dibner (1961e). The precise date of Ørsted's experiment is not clear, but Altmann (1992i p.13) provides evidence that the critical work was probably done in January to March 1820.

Ampère, who built on and extended Ørsted's work was much influenced by ideas of symmetry (D'Agostino, 2000w), which he took into account in the design of his experiments.

☞WWW☜ 14:8

The magnet is what is called an axial vector, in effect spinning on its own length, which gives it an asymmetry (Altmann, 1992i p.22).

☞WWW☜ 14:9

“One would have thought that the lesson learned from the Ørsted paradox would have stopped people from ever again making the same mistake. This, alas, was not so...” (Altmann, 1992i p.35).

☞WWW☜ 14:10

Gleick (1994 pp.306-7) has emphasised that the idea of symmetry for physicists is essentially the same as that for everyone else:

> "Symmetry for physicists was not far removed from symmetry for children with paper and scissors: that idea that something remains the same when something else changes. Mirror symmetry is the sameness that remains after a reflection of left and right. Rotational symmetry is the sameness that remains when a system turns on an axis. Isotopic spin symmetry, as it happened, was the sameness that existed between the two components of the nucleus, the proton and the neutron, two particles whose relationship had been oddly close, one carrying charge and the other neutral, their masses nearly but not exactly identical. The new way to understand these particles was this: They were two states of a single entity, now called a nucleon. They differed only in their isotopic spin, One was 'up', the other 'down' ".

Eugene Wigner won the Nobel Prize in 1963 for his work on symmetries and invariances. He describes invariance thus:

> “In the classic example of the falling body, one can disregard almost everything except the initial position and velocity of the falling body; its behaviour will be the same and independent of the degree of illumination, the neighbourhood of other objects, their temperature, etc.. ... [T]he result will be the same no matter where and when we realise [the experiment]. ... The above invariance is called in modern mathematical parlance invariance with respect to displacement in time and space” (Wigner, 1967 p.4).

Feynman (1963) goes on to describe how the phase symmetry of the wave function means also that there has to be conservation of electrical charge: "This is altogether a very interesting business!", as he adds.

Symmetry arguments in their essential form go back to the beginning of the study of electrodynamics, D'Agostino (2000w) showing how Ampère used arguments about the geometric symmetry of electric currents and magnets.

☞WWW☜ 14:11

Van Fraassen (1989 p.242)has put the distinction between the distinction clearly between the two types of symmetry argument:

> "... it is very important to distinguish symmetry arguments *proper* – logical exploitations of the symmetries of a problem as studied – from, arguments based on substantive assumptions about symmetry in the world."

The argument is related to that of Hume, who said that one cannot derive an *ought* from an *is*.

Lee and Yang (1956 p.258), in their seminal paper in *Physical Review,* commented that, "The conservation of parity is usually accepted without questions concerning its possible limit of validity being asked. There is actually no *a priori* reason why its violation is undesirable."

☞WWW☜ 14:12

Steven Weinberg has given a balanced view of the strengths and weaknesses of the Snthropic principle, "the requirement that [parameters] have to be in a range that allows the appearance of beings that can ask why they are and what they are" (Weinberg, 2001 p.50).

☞WWW☜ 14:13

Peter Ayton tells me that the term 'cognitive illusion' seems first to have been used by LJ Cohen in 1981 in a paper in *Behavioural and Brain Sciences*.

Hermann Weyl approvingly quoted Sir Thomas Browne, who said that "nature Geometrizeth and observeth order in all things" (Weyl, 1952 p.64).

☞WWW☜ 14:14

Martin Gardner (1990a p.348) described well the need by physicists for symmetry:

> "There is an old joke about someone who said, 'I'd give my right arm to be ambidextrous'. For some reason many physicists seem willing to give their right arm to make the universe ambidextrous."

Despite his book being called *The ambidextrous universe*, it is not clear that Gardner really believes in such symmetry, the book ending a few lines later with a line reminiscent of Horatio in *Hamlet*, "A man is a small thing and the night is very large and full of wonders".

Johnson (1997 pp.314-5) continues, "Rather than let ourselves be overwhelmed by the messiness, the randomness, the unruliness that so often prevails, we construct our creation myths, we dream of a time when order prevailed".

In my use of Feynman's example of the clock I have conflated two examples (Feynman, Leighton, & Sands, 1963 pp.52-4, 52-11), one of the ordinary clock and the other of a clock which actually is an atomic clock and relies on counting the emission of electrons from the decay of cobalt-60. The difference in timing of the right and left-handed conventional clocks would be vanishingly small, although theoretically still possible.

The first hints that supersymmetry might be experimentally demonstrable came with observation that B mesons did not seem to be exact mirror images of antimatter B mesons (Cho, 2001a), and that there were small discrepancies in the magnetic field of the muon (Cho, 2001b). However subsequent checking of the results has cast serious doubt on those discrepancies (Cho, 2001c). Nevertheless, as Nilles (2002d) the "uniqueness and theoretical beauty of [super]symmetry" means that interest in it will continue for many years, even in the absence of experimental support.

The full quotation from Nabokov (1974 pp.144-5) is:

> "We shall imagine then a prism or prison where rainbows are but octaves of ethereal vibrations... Then we give a good shake to the telescopoid kaleidoscope (for what is your cosmos but an instrument containing small bits of coloured glass which, by an arrangement of mirrors, appear in a variety of symmetrical forms when rotated – mark: when rotated) and throw the damned thing away".

☞WWW☜ 14:16

Perhaps most striking about the claim that D-amino acids are found in cancer is that the controversy was conducted entirely at the empirical level, with little or no theoretical discussion of why tumour proteins might or might not contain D-amino acids (Kögl & Erxleben, 1939, Miller, 1950). Such silence suggests almost that the various protagonists regarded it as reasonable that tumours might contain the D-amino acids. Without the reasons for the reasonableness being made explicit, symbolism must remain as a possible explanation.

It must be said that there is something not very logical about the theory that L-sugars will help the obese (Clemmit, 1991). If L-sugar tastes sweet then it must be because it is bound to the same surface receptors as D-sugar. But if that is the case then it may be metabolised by the same mechanism as well, since cells can recognise it. The way mythologies develop is also shown by an article in the Sunday Times (Gram, 1986b) where it is said that "Levin's innovation was to taste the stuff and discover that it is indistinguishable from ordinary sugar". It was certainly not his innovation, since the fact that left-handed sugar tastes sweet was mentioned by the physicist Richard Feynman in his Lectures on Physics (1963 p.52-6).

☞WWW☜ 14:19

Harrington (1987 pp. 223-4) describes Jackson's ideas as being "shaped by certain a priori convictions about how the hierarchy of sensory-motor functions in the nervous system 'should' be organised", ideas that she refers to as "semi-aesthetic, semi-philosophical sentiments".

☞WWW☜ 14:20

Altmann (1992i) emphasises that this is the second part of Curie's principle, and that the first part is also strictly correct ("When certain causes produce certain effects, the symmetry elements of the causes must be found in the effects produced"). However while correct it needs using with extreme care – it does not say that the *only* symmetries found in the effects will be those found in the causes (and Altmann provides an example of just such a situation (p.27)).

Van Fraassen (Van Fraassen, 1989 p.240) is pragmatic in his warning about the Curie principle:

> "What is to be said of this fundamental, profound principle that an asymmetry can only come from an asymmetry? The first reply is that *qua* general principle it is most likely false and certainly untenable. ...On the positive side we must say that the conviction is a good guide for humans looking for theories. Their speculation about hidden asymmetries often pays off. It is only important not to raise a tactic to the status of strategy."

For a good account of symmetry breaking see Stewart and Golubitsky (1992g pp.54-72).

☞WWW☜ 14:21

There is, it seems, little of substance to support the story of Buridan's ass (Altmann, 1992i p.8), or perhaps even nothing at all (Zupko, 1998). The ass has even suggested to have been a dog. Buridan's name may have been associated with the story as a later parody of his ideas on freedom of will apparently leading to the absurd outcome of inaction. The modern philosophical interest in the story is a result of it being discussed by Leibniz in his essay on the freedom of man and the origin of evil, where he talks about "the snares of equipoise". In another variant of the story, Leibniz describes the ass as being between two meadows. In the present context the interest is, as Altmann points out, that Leibniz realised that neither the ass nor the universe is entirely symmetric:

> "fundamentally the question deals in the impossible, unless it be that God brings the thing about expressly. For the universe cannot be halved by a plane through the middle of the ass, which is cut vertically through its length, so that all is equal and alike on both sides ... Neither the parts of the universe nor the viscera of the animal are alike nor are they evenly placed on both sides of [a] vertical plane. There will therefore always be many things in the ass and outside the ass, although they may not be apparent to us, which will determine him to go on one side rather than the other. ..." (Leibniz, 1951 p.310).

Van Fraassen (1989 p.239) also points out in similar vein that the animal, which is now a donkey, may have "myopia in its left eye; or a difference between the right and left hemispheres of its brain".

☞WWW☜ 14:22

The same idea was clearly elucidated by Alan Turing in a paper on morphogenesis. He starts with what seems like a problem for his theory – that a cell with perfect spherical symmetry can never lose that symmetry, so how does it become something like a horse, which is clearly not spherically symmetric – and he then explains how the slightest irregularities can lead to an unstable equilibrium: "the presence of irregularities, including statistical fluctuations in the numbers of molecules undergoing the various reacions, will, if the system has an appropriate kind of instability, result in [the symmetry] disappearing" (Turing, 1952 p.42). Turing also discusses the problems of how a system can develop a population level asymmetry of right and left handed organisms.

Stewart and Golubitsky (1992g p.58) have defined the, "Extended Curie Principle: Physically realizable states of a symmetric system come in bunches, related to each other by symmetry. To put it another way, a symmetric cause produces one from a symmetrically related *set* of effects".

☞WWW☜ 14:23

In general by 'harder to see' is meant that it would take longer to decide if a stimulus was symmetric or not in free viewing conditions. If the stimuli were presented for only a few hundred milliseconds in a tachistoscope or on a computer screen then subjects would get the answer wrong more often.

☞WWW☜ 14:25[59]

Mach (1995g) had his own theory of why vertical symmetry was so important: “because our apparatus of vision, which consists of our eyes and of the accompanying muscular apparatus is itself vertically symmetrical”, the symmetry being seen in the placement of the two eyes to either side of the nose. Although the theory is not entirely clear, Mach seems to have thought the sense of symmetry came from a 'right-handed' image in the right eye being repeated as a 'left-handed image' in the left eye. Whatever the details, Mach himself provided a clear refutation of his own theory: “The presence of a sense for symmetry in people possessing only one eye from birth, is indeed a riddle”. Indeed; and if the symmetry of our two eyes were somehow essential for perceiving symmetry then our sense of symmetry should also disappear as we close one eye, which it clearly does not.

For good recent reviews of the perception of symmetry see Tyler (1995h, 1995i). The corpus callosum seems to play some role in the perception of the vertical, but the effect is limited and cannot account for the overall advantage of the vertical (Herbert & Humphrey, 1996).

[59] **☞WWW☜** was inadvertently omitted from the notes in the book.

Chapter 15: Hypernotes

☞WWW☜ 15:1

Figure 1a is taken from Weyl (1952 Fig 4), who describes it as Sumerian, although it is in fact modern, but based on an Assyrian sculpture of about 870 BC. Weyl's image was a head-piece in Swindler (1929), who says it was drawn by one of her students, Miss Mary Wyckoff, whose initials can be seen in the bottom right hand corner. It seems to be a composite of several Assyrian bas-reliefs from the palace at Nineveh, now in the British Museum, WA 124583 and WA 124576, although neither is precisely the same in the details. Weyl tries to restore a symmetry to the picture by suggesting that one figure is simply the other rotated, although there is then the problem that the wings and the feet will have also altered their relationships, which are properly symmetrical in the drawing. There is little agreement on the nature of the tree (which may be a distant relation of the palm), or the cone held in the right hand (which may be a male flower for fertilising palm trees or a pine cone held for purely symbolic reasons), or indeed the overall meaning of the ceremony which is taking place (Reade, 1998).

My figure 1b was created by cutting out the left half of figure 1a, flipping it horizontally, and then pasting it back onto the original left half. This also happens to remove the original artist's signature.

☞WWW☜ 15:4

The quotation from *The magic mountain* continues in the same vein as Richard Feynman, "Hans Castorp felt he understood now the reason why the builders of antiquity purposely and secretly introduced minute variation from absolute asymmetry in their columnar structures"

I can't help hearing Feynman tell this story to his students at the end of their first term, as they go off for their Christmas vacation — a perfect way to send them back to their homes from across the States, seeing the relationship between physics and the wider life.

In his lectures Feynman builds on Kepler's disappointment that the orbits of the planets were merely ellipses and not the more perfectly symmetrical circle: “So our problem is to explain where symmetry comes from.. Why is nature so nearly symmetrical? No one has any idea why.” (Feynman, Leighton, & Sands, 1963 p.52-12).

The idea of a purposely introduced asymmetry is widespread, for instance it being claimed that in Persian carpets there is always a detail that breaks the symmetry, for only God is perfect.

☞WWW☜ 15:5

There is clearly also a whole set of other pairs which could be added in to a table such as this as well, perhaps best captured by the psychoanalytic distinction of anal retentiveness and anal expressiveness (Kline, 1972).

The distinction Carlyle makes is well seen in the other comments he makes about Voltaire's style:

> "[Voltaire's] objects do not lie round him in pictorial, not always in scientific grouping; but rather in commodious rows, where each may be seen and come at, like goods in a well-kept warehouse. ... Compare, for example, the plan of the *Henriade* to that of our so barbarous *Hamlet.* The plan of the former is a geometrical diagram by Fermat; that of the latter a cartoon by Raphael. The *Henriade*, as we see it completed, is a polished, square-built Tuileries: *Hamlet* is a mysterious star-paved Valhalla and dwelling of the gods..."

The analogy with the Tuileries is interesting in that it is precisely the one which the physicist Frank Close uses as the metaphor at the start of his *Lucifer's legacy* (2000f).

☞WWW☜ 15:6

Jacques Monod, who won the Nobel Prize for Physiology in 1965, put it thus: "For without invariants, without order, without symmetry, science would not only be dull; it would be impossible" (Monod, 1969 p.27). One is tempted to add that if there were only symmetry, only order, then science would be either trivially easy or frustratingly banal. Just as life seems to hover in that space between complete regularity and total chaos, as Stuart Kauffman (1993g) has suggested, so science also seems to inhabit that same location.

☞WWW☜ 15:8[60]

The possibility that chiral simple molecules can impose their asymmetry on large-scale macromolecular systems has been revived also with the finding that when calcite is crystallised in the presence of D- or L-ascorbic acid, then large-scale asymmetries are apparent in the crystals (Orme et al., 2001). It has been suggested that such factors may even be responsible for the presence of asymmetries in the shells of foraminifera (Addadi & Weiner, 2001). This seems to provide a separate mechanism by which, in principle, Chothia's gap can be bridged.

☞WWW☜ 15:9[61]

The handedness of proteins can be somewhat confusing. There is no doubt a protein made of D-amino acids would be the mirror-image of one made of L-amino acids – as can be seen in chapter 6. The point at issue here, though, is that any particular protein is as likely to be left-

---

[60] **☞WWW☜** not included in the notes in the book.

[61] **☞WWW☜** was inadvertently omitted from the notes in the book.

handed in its overall conformation as it is to be right-handed, even though it is made up of L-amino acids. However even if one arbitrary protein is right-handed, and another happens to be left-handed, if they were made of D-amino acids they would be left-handed and right-handed respectively. See the discussion of the paper of Chothia (1991j).

☞WWW☜ 15:10

The quotation, from *The Ring and the Book* (I:828) (Altick, 1971), which is of course meant in an entirely different way, imposes a greater humility in the face of the enormity of the questions asked:

> "... how heart moves brain, and how both move hand,
> What mortal ever in entirety saw?"

It cannot be stressed enough here that although there is an evolutionary link between the asymmetry of the heart and the asymmetry of the brain, that is not to say there is a link within the development of the individual organism (since handedness and situs are not linked). The association is phylogenetic not ontogenetic.

☞WWW☜ 15:11

Elytis (1911-1996) won the Nobel Prize for Literature in 1979.

References

Adair, R. K. 1988, "A flaw in a universal mirror", *Scientific American*, **258 (February)**, 30-36.

Adam, D. 2001g, "Chemistry prize reflects tailor-made reactions", *Nature*, **413**, 661-661.

Adams, N. A., IV 1996i, "Jurisprudence without moral consensus: constitutional arguments in Idd for driving on the right or left side of the road", *Constitutional.Commentary*, **13 (Spring)**, 101-106.

Addadi, L. & Weiner, S. 2001, "Crystals, asymmetry and life", *Nature*, **411**, 753-754.

Adler, R. 2000, "Voices from the past", *New Scientist*, **26th Feb 2000**, 36-40.

Afzelius, B. A. 1999e, "Asymmetry of cilia and of mice and men", *Int.J Dev.Biol.*, **43**, 283-286.

Aggleton, J. P., Kentridge, R. W., & Good, J. M. M. 1994, "Handedness and musical ability: a study of professional orchestral players, composers, and choir members", *Psychology of Music*, **22**, 148-156.

Aggleton, J. P., Kentridge, R. W., & Neave, N. J. 1993, "Evidence for longevity differences between left handed and right handed men: an archival study of cricketers", *Journal of Epidemiology and Community Health*, **47**, 206-209.

Aggleton, J. P. & Wood, C. J. 1990h, "Is there a left-handed advantage in 'ballistic' sports?", *International Journal of Sport Psychology*, **21**, 46-57.

Aiello, L. & Dean, C. 1990, *An introduction to Human Evolutionary Anatomy,* London: Academic Press.

Ainsworth, C. 2000, "Left right and wrong", *New Scientist*, **17th June**, 40-45.

Alberti, K. G. M. M. 2000, "Multicentre research ethics committees: has the cure been worse than the disease?", *British Medical Journal*, **320**, 1157-1158.

Alter, I. 1989, "A cerebral origin for "directionality."", *Neuropsychologia*, **27**, 563-573.

Altick, R. D. 1971, *Robert Browning: The ring and the book,* Harmondsworth: Penguin.

Altmann, S. L. 1992i, *Icons and symmetries,* Oxford: Clarendon Press.

Amoore, J., Johnston, J., Jr., & Rubin, M. 1964, "The stereochemical theory of odor", *Scientific American*, **February**, 42-49.

Anderson, M. 1976c, "The neurological illness of Sir Walter Scott", *Practitioner*, **217**, 968-974.

Anderson, R. H., Webb, S., & Brown, N. A. 1998, "Defective lateralisation in children with congenitally malformed hearts", *Cardiology in the Young*, **8**, 512-531.

Annett, M. 1964, "A model of the inheritance of handedness and cerebral dominance", *Nature*, **204**, 59-60.

Annett, M. 1970b, "A classification of hand preference by association analysis", *British Journal of Psychology*, **61**, 303-321.

Annett, M. 1978, *A single gene explanation of right and left handedness and brainedness,* Coventry: Lanchester Polytechnic.

Annett, M. 1995e, "The right shift theory of a genetic balanced polymorphism for cerebral dominance and cognitive processing", *Cahiers de Psychologie Cognitive/ Current Psychology of Cognition*, **14**, 427-480.

Annett, M. 1996d, "In defence of the right shift theory", *Perceptual and Motor Skills*, **82**, 115-137.

Annett, M. 1998j, "Handedness and cerebral dominance:the right shift theory", *Journal of Neuropsychiatry*, **10**, 459-469.

Annett, M. 2002b, *Handedness and brain asymmetry: The right shift theory,* Hove: Psychology Press.

Annett, M. & Annett, J. 1991g, "Handedness for eating in gorillas", *Cortex*, **27**, 269-275.

Annett, M. & Kilshaw, D. 1983b, "Right and left-hand skill: II. Estimating the parameters of the distribution of L-R differences in males and females", *British Journal of Psychology*, **74**, 269-283.

Anonymous 1834, "Review of Forbes' 'Original cases with Dissection and Observation...'", *Lancet*, **5**, 144-160;169-180.

Anonymous 1870a, "Charles Dickens", *British Medical Journal*, **i**, 636-636.

Anonymous 1870b, *Charles Dickens: The story of his life: By the author of the 'Life of Thackeray',* London: John Camden Hotten.

Anonymous 1882, "Sir Thomas Watson [Obituary]", *British Medical Journal*, **ii**, 1282-1285.

Anonymous 1912, "William Ogle [Obituary]", *British Medical Journal*, **i**, 929-930.

Anonymous 2000c, "Barleycorns and the rod", *Metromnia: News from the National Physical Laboratory*, **Issue 7, Summer**.

Anonymous 2000a, "Dumb? Welcome to the no-brain society", *The Guardian*, **October 28th**.

Anonymous 2000b, "Help for left-handers", *Which?*, **March**, 34-36.

Anonymous. 1872, "Review of Sir Thomas Watson's *Principles and practice of physic, 5th edition*", *Edinburgh Medical Journal*, **17**, 935-936.

Anonymous. 1876, "Physical and Natural History Society, Jan 20", *Nature*, **13**, 400-400.

Anonymous. 1878, *Right and left hand screw propellors: Some practical hints by an old ship master,* Cardiff: H.Morgan.

Anonymous. 1916, *The Jewish Encyclopaedia,* New York: Funk and Wagnalls.

Anonymous. 1958, *The compete letters of Vincent van Gogh,* London: Thames and Hudson.

Anonymous. 1971, *Encyclopaedia Judaica,* Jerusalem: Keter.

Anonymous. 1989, *Leonardo da Vinci: Catalogue of an exhibition held at the Hayward Gallery,* London: Yale University Press.

Anonymous. 1993, "Cricket's highest innings", *Independent on Sunday*, **18th April**, 24-24.

Armstrong, A. H. 1988, *Plotinus: Enneads VI: 6-9,* Cambridge, MA: Harvard University Press.

Armstrong, G. C. 1935, *Aristotle, vol XVIII: Magna Moralia,* Cambridge, MA: Harvard University Press.

Arnold, G. L., Bixler, D., & Girod, D. 1983, "Probable autosomal recessive inheritance of polysplenia, situs inversus and cardiac defects in an Amish family", *American Journal of Medical Genetics*, **16**, 35-42.

Aronow, E., Reznikoff, M., & Moreland, K. 1994, *The Rorschach technique: Perceptual basics, content interpretation, and applications,* Needham Heights, MA: Allyn and Bacon.

Arthur, W. B. 1988f, "Self-reinforcing mechanisms in economics," pp. 9-31 in *The economy as a complex evolving system*, P. W. Anderson, K. J. Arrow, & D. Pines, eds., New York: Addison-Wesley.

Arthur, W. B. 1989f, "Competing technologies, increasing returns, and lock-in by historical events", *Economic Journal*, **99**, 116-131.

Arthur, W. B. 1990i, "Positive feedbacks in the economy", *Scientific American*, **262 (February)**, 80-85.

Ashton, R. 2002, "Not quite so simple", *Times Literary Supplement*, **Jan 18th**, 30-31.

Asimov, I. 1976, *The left hand of the electron,* London: Panther.

Asthana, H. S., Bhushan, B., & Mandal, M. K. 2000, "Side bias in facial expression," pp. 289-312 in *Side bias: A neuropsychological perspective*, M. K. Mandal, M. B. Bulman-Fleming, & G. Tiwari, eds., Dordrecht: Kluwer.

Atkins, J. F. & Gesteland, R. F. 2000, "The twenty-first amino acid", *Nature*, **407**, 463-464.

Avalos, M., Babiano, R., Cintas, P., Jiménez, J. L., Palacios, J. C., & Barron, L. D. 1998, "Absolute asymmetric synthesis under physical fields: Facts and fictions", *Chemical Reviews*, **98**, 2391-2404.

Bailey, J., Chrysostomou, A., Hough, J. H., Gledhill, T. M., McCall, A., Clark, S., Ménard, F., & Tamura, M. 1998, "Circular polarization in star-formation regions: Implications for biomolecular homochirality", *Science*, **281**, 672-674.

Baker-Cohen, K. F. 1961a, "Visceral and vascular transposition in fishes, and a comparison with similar anomalies in man", *American Journal of Anatomy*, **109**, 37-55.

Baldassari, A. 1997, *Picasso and photography: The dark mirror,* Paris: Flammarion.

Balistier, T. 2000, *The Phaistos Disk: An account of its unsolved mystery,* Mahringen: Balistier.

Bannister, D. & Fransella, F. 1971, *Inquiring man: the theory of personal constructs,* 2 edn, Harmondsworth: Penguin.

Bantle, J. P., Hunninghake, D. B., Frantz, I. D., Kuba, K., Mariash, C. N., & Oppenheimer, J. H. 1984, "Comparison of effectiveness of thyrotropin-suppressive doses of D- and L-thyroxine in treatment of hypercholesterolemia", *Am.J.Med*, **77**, 475-481.

Barbeito, R. 1981, "Sighting dominance: an explanation based on the processing of visual direction in tests of sighting dominance", *Vision Research*, **21**, 855-860.

Barrett, P. H., Gautrey, P. J., Herbert, S., Kohn, D., & Smith, S. 1987, *Charles Darwin's Notebooks, 1836-1844,* Cambridge: Cambridge University Press.

Barron, L. D. 1996, "True and false chirality, *CP* violation, and the breakdown of microscopic reversibility in chiral molecular and elemtary particle processes," pp. 162-182 in *Physical origin of homochirality in life*, D. B. Cline, ed., Woodbury, NY.

Barron, L. D. 2000, "Chirality, magnetism and light", *Nature*, **405**, 895-896.

Barsley, M. 1966c, *The left-handed book: An investigation into the sinister history of left-handedness,* London: Souvenir Press.

Barsley, M. 1970, *Left-handed man in a right-handed world,* London: Pitman.

Bastian, C. 1869, "On the various forms of loss of speech in cerebral disease", *British and Foreign Medical-Chirurgical Review*, **45**, 158-180; 293-329.

Bastian, H. C. 1880, *The brain as an organ of mind,* London: Kegan Paul.

Bastian, H. C. 1913a, *The origin of life: being an account of experiments with certain superheated saline solutions in hermetically sealed vessels,* 2 edn, London: Watts.

Beck, B. E. F. 1970, "The right-left division of South Indian society", *Journal of Asian Studies*, **29**, 779-798.

Beekes, R. S. P. 1995c, *Comparative Indo-European Linguistics: An introduction,* Amsterdam: John Benjamins.

Beeley, A. L. 1918, *An experimental study in left-handedness,* Chicago: University of Chicago Press.

Behrmann, M. 1994d, "Neglect dyslexia: Attention and word recognition," pp. 173-214 in *The neuropsychology of high-level vision*, M. J. Farah & G. Ratcliff, eds., Hillsdale, NJ: Lawrence Erlbaum.

Bell, C. 1834a, *The hand: its mechanism and vital endowments as evincing design,* London: John Murray.

Bellman, A., Meuli, R., & Clarke, S. 2001, "Two types of auditory neglect", *Brain*, **124**, 676-687.

Benbow, C. P. 1986e, "Psychological correlates of extreme intellectual precocity", *Neuropsychologia*, **24** , 719-725.

Bender, D. A. 1985, *Amino acid metabolism,* 2 edn, Chichester: John Wiley.

Bennett, J. 1970, "The difference between right and left", *American Philosophical Quarterly*, **7**, 175-191.

Bennett, J. 1962, *Sir Thomas Browne,* Cambridge: Cambridge University Press.

Benton, A. L. 1959, *Right-left discrimination and finger localization: Development and pathology,* New York: Hoeber.

Berg, H. C. 1991, "Bacterial motility: handedness and symmetry," pp. 58-72 in *Biological asymmetry and handedness (Ciba foundation symposium 162)*, G. R. Bock & J. Marsh, eds., Chichester: Wiley.

Berker, E. A., Berker, A. H., & Smith, A. 1986a, "Translation of Broca's 1865 report: Localisation of speech in the third left frontal convolution", *Archives of Neurology*, **43**, 1065-1072.

Berlin, B. & Kay, P. 1969, *Basic color terms: Their universality and evolution,* Berkeley: University of California Press.

Berlyne, D. E. 1971b, *Aesthetics and psychobiology,* New York: Appleton-Century-Crofts.

Bernadac, M.-L. 1991, *Faces of Picasso,* Paris: Editions de la Réunion des Musées Nationaux.

Bernstein, I. H. & Teng, G. 1989, "Factoring items and factoring scales are different: spurious evidence for multidimensionality due to item categorization", *Psychological Bulletin*, **105**, 467-477.

Bernstein, J. 1962b, "A question of parity", *New Yorker*, **May 12th**, 49-104.

Bever, T. G. & Chiarello, R. J. 1974c, "Cerebral dominance in musicians and nonmusicians", *Science*, **185** , 137-139.

Bickerton, D. 1996b, "Catastrophic evolution: the case for a single step from protolanguage to full human language," in *Evolution of language: Social and cognitive bases for the emergence of phonology and syntax*, J. Hurford, M. Studdert-Kennedy, & C. Krugar, eds., Cambridge: Cambridge University Press.

Bickerton, D. 1996a, *Language and human behaviour,* London: UCL Press.

Bigelow, J. 1887, *The complete works of Benjamin Franklin,* New York: G P Putnam's Sons.

Billings, K. 1994, "Q & A", *Independent on Sunday*, **13th November**, 2-2.

Bishop, D. V. M. 1980, "Handedness, clumsiness, and cognitive ability", *Developmental Medicine and Child Neurology*, **22**, 569-579.

Bishop, D. V. M. 1984c, "Using non-preferred hand skill to investigate pathological left-handedness in an unselected population", *Developmental Medicine and Child Neurology*, **26**, 214-226.

Bishop, D. V. M. 1990, *Handedness and developmental disorder,* Oxford: Blackwell.

Bisiach, E. & Luzzatti, C. 1978, "Unilateral neglect of representational space", *Cortex*, **14**, 129-133.

Bjorksten, T., David, P., Pomiankowski, A., & Fowler, K. 2000, "Fluctuating asymmetry of sexual and nonsexual traits in stalk-eyed flies: a poor indicator of developmental stress and genetic quantity", *Journal of Evolutionary Biology*, **13**, 89-97.

Bjorksten, T., Fowler, K., & Pomiankowski, A. 2002, "What does sexual trait FA tell us about stress?", *TREE (Trends in Ecology and Evolution)*, **15**, 163-166.

Blackett, P. M. S. 1959, "The Rutherford Memorial lecture, 1958", *Proceedings of the Royal Society of London, Series A*, **251**, 293-305.

Blackmore, S. 1999c, *The meme machine,* Oxford: Oxford University Press.

Blake-Coleman, B. C. 1982a, "The left heresy and directional preference in early science and technology", *Folklore*, **93**, 151-163.

Blake, D. F. & Jenniskens, P. 2001, "The ice of life", *Scientific American*, **August**, 37-41.

Blashke, G., Kraft, H. P., Fickentscher, K., & Köhler, F. 1979e, "Chromatographische Racemattrennung von Thalidomid und teratogene Wirkung der Enantiomere", *Arzneimittel Forschung*, **29**, 1640-1642.

Blount, P., Holmes, J., Rodger, J., Coltheart, M., & McManus, I. C. 1975, "On the ability to discriminate original from mirror-image reproductions of works of art", *Perception*, **4**, 385-389.

Bo, C. & Mandel, G. 1978, *L'opera completa del Botticelli,* Milan: Rizzoli Editore.

Boardman, A. D., O'Connor, D. E., & Young, P. A. 1973, *Symmetry and its applications in science,* London: McGraw Hill.

Bochner, S. 1973d, "Symmetry and asymmetry," pp. 345-353 in *Dictionary of the history of ideas*, P. P. Wiener, ed., New York: Charles Scribner's Sons.

Boling, R. G. 1975, *Judges: Introduction, translation and commentary,* New York: Doubleday.

Bolton, R. 1978, "Child-holding patterns", *Current Anthropology*, **19**, 134-135.

Bonabeau, E., Dorigo, M., & Theraulaz, G. 2000, "Inspiration for optimisation from social insect behaviour", *Nature*, **406**, 39-42.

Bonner, W. 1998g, "Homochirality and life," pp. 159-188 in *D-amino acids in sequences of secreted peptides of multicellular organisms*, P. Jollès, ed., Basel: Birkhäuser Verlag.

Borel, E. 1960b, *Space and Time,* New York:

Bouchiat, M.-A. & Pottier, L. 1984b, "An atomic preference between left and right", *Scientific American*, **250**, 100-111.

Bourdieu, P. 1977, *Outline of a theory of practice,* Cambridge: Cambridge University Press.

Bourdieu, P. 1990, *The logic of practice,* Cambridge: Cambridge University Press.

Bowen, A., McKenna, K., & Tallis, R. C. 1999, "Reasons for variability in the reported rate of occurrence of unilateral spatial neglect after stroke", *Stroke*, **30**, 1196-1202.

Bowlby, J. 1990c, *Charles Darwin: a new biography,* London: Hutchinson.

Boyer, P. 1996a, "Symbolism," pp. 860-861 in *The Social Science Encyclopedia*, A. Kuper & J. Kuper, eds., London: Routledge.

Bozo, D., Besnard-Bernadac, M.-L., Richet, M., Seckel, H., & Marceillac, L. 1986, *The Musée Picasso, Paris: Paintings, papiers collés, picture reliefs, sculptures, ceramics,* London: Thames and Hudson.

Böck, A. 2001, "Invading the genetic code", *Science*, **292**, 453-454.

Bracha, H. S., Seitz, D. J., Otemaa, J., & Glick, S. D. 1987, "Rotational movement (circling) in normal humans: sex difference and relationship to hand, foot and eye preference", *Brain Research*, **411**, 231-235.

Bradford, S. 1995, "Childhood at Renishaw," pp. 12-23 in *The Sitwells and the arts of the 1920s and 1930s*, London: National Portrait Gallery.

Brain, W. R. 1945, "Speech and handedness", *Lancet*, **ii**, 837-841.

Brandt, J. & Mackavey, W. 1981, "Left-right confusion and the perception of bilateral symmetry", *Int.J Neurosci.*, **12**, 87-94.

Braunlich, A. F. 1936, "'To the right' in Homer and Attic Greek", *American Journal of Philology*, **57**, 245-260.

Brewster, J. H. & Laskowski, M. 1992, "Left-handed comments", *Science*, **258**, 1289-1289.

Brimicombe, M. 2000, "Notes and Queries: Mirror-image twins", *The Guardian*, **April 20th, 2nd section**, 16-16.

Brimnes, N. 1999, *Constructing the colonial encounter: Right and left hand castes in early colonial South India,* Richmond, Surrey: Curzon Press.

Broadbent, D. E. 1954, "The role of auditory localization in attention and memory", *Journal of Experimental Psychology*, **47**, 191-196.

Broca, P. 1861, "Remarques sur le siège de la faculté du langage articulé, suivies d'une observation d'aphémie (perte de la parole)", *Bulletin de la Société d'Anatomique de Paris*, **2nd series, 6**, 330-357.

Broca, P. 1865, "Sur le siège de la faculté du langage articulé", *Bulletin de la Société d'Anthropologie de Paris*, **6**, 377-393.

Brodie, B. C. 1862, *Psychological inquiries,* 4 edn, London: Longman, Green, Longman, Roberts and Green.

Brown, N. A. & Lander, A. 1993, "On the other hand ...", *Nature*, **363**, 303-304.

Brown, N. A. & Wolpert, L. 1990, "The development of handedness in left/right asymmetry", *Development*, **109**, 1-9.

Bruce, V. & Young, A. 1998, *In the eye of the beholder: The science of face perception,* Oxford: Oxford University Press.

Brugger, P., Kollias, S. S., Muri, R. M., Crelier, G., & Hepp-Reymond, M.-C. 2000l, "Beyond re-membering: Phantom sensations of congenitally absent limbs", *Proceedings of the National Academy of Sciences of the USA*, **97**, 6167-6172.

Bruser, E. 1981, "Child transport in Sri Lanka", *Current Anthropology*, **22**, 288-290.

Bryan, D. 1824, "A case where the thoracic and abdominal viscera were found misplaced", *Lancet*, **5**, 44-46.

Bryden, M. P. 1962c, "Order of report in dichotic listening", *Canadian Journal of Psychology*, **16**, 291-299.

Bryden, M. P. 1982c, *Laterality: functional asymmetry in the intact brain,* New York: Academic Press.

Bryden, M. P., McManus, I. C., & Bulman-Fleming, M. B. 1994a, "Evaluating the empirical support for the Geschwind-Behan-Galaburda model of cerebral lateralization", *Brain and Cognition*, **26**, 103-167.

Bryden, M. P., McManus, I. C., & Bulman-Fleming, M. B. 1994b, "GBG, BMB, R&L, X&Y ... Reply to commentaries", *Brain and Cognition*, **26**, 312-326.

Bryden, M. P., McManus, I. C., & Bulman-Fleming, M. B. 1995, "GBG, hormones, genes, and anomalous dominance: A reply to commentaries", *Brain and Cognition*, **27**, 94-97.

Buchanan, M. 2000t, "It's flaming freezing!", *New Scientist*, **15th July**, 28-31.

Buchanan, R. 1901, *The complete poetical works of Robert Buchanan,* London: Chatto and Windus.

Buchenau, A. 1922, *Vorkritische Schriften von Immanuel Kant, Band II,* Berlin: Bruno Cassirer.

Buck, C. D. 1949, *A dictionary of selected synonyms in the principal Indo-European languages,* Chicago: University of Chicago Press.

Bulman-Fleming, M. B. & Bryden, M. P. 1994e, "Simultaneous verbal and affective laterality effects", *Neuropsychologia*, **32**, 787-797.

Burdine, R. D. & Schier, A. F. 2000, "Conserved and divergent mechanisms in left-right axis formation", *Genes and Development*, **14**, 763-776.

Burgess, A. 1964b, *Language made plain,*

Burkhardt, F. & Smith, S. 1986, *The correspondence of Charles Darwin vol 2 1837-1843,* Cambridge: Cambridge University Press.

Burkhardt, F. & Smith, S. 1988, *The correspondence of Charles Darwin vol 4 1847-1850,* Cambridge: Cambridge University Press.

Burn, J. 1991, "Disturbance of morphological laterality in humans," pp. 282-299 in *Biological asymmetry and handedness (Ciba foundation symposium 162)*, G. R. Bock & J. Marsh, eds., Chichester: Wiley.

Burt, C. 1961, *The backward child,* 5 edn, London: University of London Press.

Buss, D. H. 1995, "Tennis cycles", *New Scientist* 58-58.

Butler, A. J. 1898, *Bismarck: The man and the statesman; being the reflections and reminiscences of Otto Prince von Bismarck,* London: Smith, Elder and Co.

Butterworth, B. 1999, *The mathematical brain,* London: Macmillan.

C.H.P. 1856, "'Right' and 'Left' hand", *Notes and Queries*, **1 (2nd Series)**, 178-179.

Cahen, D., Keeley, L. H., & Van Noten, F. L. 1979, "Stone tools, toolkits, and human behavior in prehistory", *Current Anthropology*, **20**, 661-683.

Calvin, W. H. 1982d, "Did throwing stones shape hominid brain evolution?", *Ethology and Sociobiology*, **3** , 115-124.

Cantagallo, A. & Della Sala, S. 1998m, "Preserved insight in an artist with extrapersonal spatial neglect", *Cortex*, **34**, 163-189.

Cantalupo, C. & Hopkins, W. D. 2001, "Asymmetric Broca's area in great apes", *Nature*, **414**, 505-505.

Capdevila, J., Vogan, K. J., Tabin, C. J., & Belmonte, J. C. I. 2000, "Mechanisms of left-right determination in vertebrates", *Cell*, **101**, 9-21.

Caramazza, A. & Hillis, A. E. 1990, "Spatial representation of words in the brain implied by studies of a unilateral neglect patient", *Nature*, **346**, 267-269.

Carey, D. P., Smith, G., Smith, D. T., Shepherd, J. W., Skriver, J., Ord, L., and Rutland, A. 2000, "Two-footedness in world soccer: A preliminary analysis of France '98", *Journal of Sport Sciences*, in press.

Carey, P. 1997, *Jack Maggs,* St Lucia, Queensland: University of Queensland Press.

Carlier, M., Spitz, E., Vacher-Lavenu, M. C., Villeger, P., Martin, B., & Michel, F. 1996, "Manual Performance and Laterality in Twins of Known Chorion Type", *Behavior Genetics*, **26**, 409-417.

Carlyle, T. 1874, *Wilhelm Meister's apprenticeship and travels (translated from Goethe) [1824],* London: Chapman and Hall.

Carpenter, K., Berti, A., Oxbury, S., Molyneux, A. J., Bisiach, E., & Oxbury, J. M. 1995, "Awareness of and memory for arm weakness during intracarotid sodium amytal testing", *Brain*, **118**, 243-251.

Cary, E. 1927, *Dio's Roman History,* London: William Heinemann.

Casey, B. & Hackett, B. P. 2000, "Left-right axis malformations in man and mouse", *Current opinion in genetics and development*, **10**, 257-261.

Cassell, J. 1998, *The woman in the surgeon's body,* Cambridge, MA: Harvard University Press.

Cassy, J. 2000, "Dot.com directors hang on to their suits", *Guardian*, **August 31st**, 22-22.

Castaigne, P., Lhermitte, F., Signoret, J. L., & Abelanet, R. 1980, "Description et étude scannographique du cerveau de Leborgne: La découverte de Broca", *Rev.Neurol.Paris*, **136**, 563-583.

Castro, S. L. & Morais, J. 1987, "Ear differences in illiterates", *Neuropsychologia*, **25**, 409-417.

Cavalli-Sforza, L. L. & Bodmer, W. F. 1971, *The genetics of human populations,* San Francisco: W.H.Freeman.

Chadwick, J. & Mann, W. N. 1950, *The medical works of Hippocrates,* Oxford: Blackwell.

Chamberlain, H. D. 1928b, "The inheritance of left-handedness", *Journal of Heredity*, **19**, 557-559.

Chandler, C. 1996e, *I, Fellini,* London: Bloomsbury.

Chaplin, C. 1964, *My autobiography,* London: Bodley Head.

Chaurasia, B. D. 1976, "La position 'palthi' et ses relations avec les croisements des mains et des bras", *Anthropologie*, **80**, 325-334.

Chen, J.-Y., Huang, D.-Y., & Li, C.-W. 1999, "An early Cambrian craniate-like chordate", *Nature*, **402**, 518-522.

Chen, J. 2001, "Physicists put a value that matters on the standard model", *Nature*, **411**, 229-229.

Cherry, E. C. 1953, "Some experiments on the recognition of speech, with one ear and two ears", *Journal of the Acoustical Society of America*, **25**, 975-979.

Chiang, C., Litingtung, Y., Lee, E., Young, K. E., Corden, J. L., Westphal, H., & Beachy, P. A. 1996, "Cyclopia and defective axial patterning mice lacking *Sonic hedgehog* gene function", *Nature*, **383**, 407-413.

Cho, A. 2001b, "Doppelgänger", *New Scientist* , **5th May**.

Cho, A. 2001c, "Sign of supersymmetry fades away", *Science*, **294**, 2449-2451.

Cho, A. 2001a, "Substandard model?", *New Scientist*, **169 (17th Feb)**, 9-9.

Chothia, C. 1991j, "Asymmetry in protein structures," pp. 36-57 in *Biological asymmetry and handedness (Ciba foundation symposium 162)*, G. R. Bock & J. Marsh, eds., Chichester: Wiley.

Christina, R. W., Feltz, D. L., Hatfield, B. D., & Daniels, F. S. 1981, "Demographic and physical characteristics of shooters," p. 89 in *Psychology of motor behavior and sport*, G. Roberts & D. Landers, eds., Champaign, IL: Human Kinetics.

Christman, S. S. & Buckingham, H. W. 1991, "Jargonaphasia," pp. 111-130 in *The characteristics of aphasia*, C. Code, ed., Hove: Lawrence Erlbaum.

Chwast, S. 1985, *The left-handed designer,* Paris: Booth-Clibborn.

Chyba, C. F., Thomas, P. J., Brookshaw, L., & Sagan, C. 1990, "Cometary delivery of organic molecules to the early Earth", *Science*, **249**, 366-373.

Clark, H. H. 1973b, "Space, time, semantics, and the child," pp. 27-63 in *Cognitive development and the acquisition of language*, T. E. Moore, ed., New York: Academic Press.

Clark, K. 1959, *Leonardo da Vinci: an account of his development as an artist,* Harmondsworth: Penguin.

Clark, K. 1968b, *The drawings of Leonardo da Vinci in the collection of Her Majesty the Queen at Windsor Castle,* 2 edn, London: Phaidon.

Clark, R. 1968a, *J.B.S.: The life and work of JBS Haldane,* London: Hodder and Stoughton.

Clark, R. W. 1983, *Benjamin Franklin: A biography,* London: Weidenfeld and Nicolson.

Clarke, G. 1993, *Left-handed children: The teacher's guide,* London: Left-Handers Club.

Clayton, M. 1996, *Leonardo da Vinci: A curious vision,* London: Merrell Holberton.

Clemmit, M. 1991, "The sticky business of non-caloric sugars", *The Scientist*, **August 19th**, 1.

Cline, D. B. 1996, "On the determination of the physical origin of homochirality," pp. 266-282 in *Physical origin of homochirality in life*, D. B. Cline, ed., Woodbury, NY.

Close, F. 2000f, *Lucifer's legacy: The meaning of asymmetry,* Oxford: Oxford University Press.

Cockayne, E. A. 1938, "The genetics of transposition of the viscera", *Quarterly Journal of Medicine*, **31** , 479-493.

Cockrell, J. R. 1998, ""Gourmand syndrome."", *Neurology*, **Vol 50**, 831.

Code, C. 1995, "Asymmetries in ear movements and eyebrow raising in men and women and right- and left-handers", *Perceptual and Motor Skills*, **80**, 1147-1154.

Code, C. e. 1991e, *The characteristics of aphasia,* Hove: Lawrence Erlbaum.

Cohen, E. & Meininger, V. 1987, "Ultrastructural analysis of primary cilium in the embryonic tissue of mouse", *International Journal of Developmental Neuroscience*, **5**, 43-51.

Collinge, N. E. 1985a, *The laws of Indo-European,* Amsterdam: John Benjamins.

Collins, R. L. 1968, "On the inheritance of handedness. I: Laterality in inbred mice", *Journal of Heredity*, **59**, 9-12.

Collins, R. L. 1969, "On the inheritance of handedness. II: Selection for sinistrality in mice", *Journal of Heredity*, **60**, 117-119.

Collins, R. L. 1977, "Toward an admissible genetic model for the inheritance of the degree and direction of asymmetry," pp. 137-150 in *Lateralization in the Nervous System*, S. Harnad et al., eds., New York: Academic Press.

Collins, R. L. 1985, "On the inheritance of direction and degree of asymmetry," pp. 41-71 in *Cerebral lateralization in non-human species*, S. D. Glick, ed., New York: Academic Press.

Concha, M. L., Burdine, R. D., Russell, C., Schier, A. F., & Wilson, S. W. 2000, "A Nodal signalling pathway regulates the laterality of neuroanatomical asymmetries in the zebrafish forebrain", *Neuron*, **28**, 399-409.

Concha, M. L. & Wilson, S. W. 2001, "Asymmetry in the epithalamus of vertebrates", *Journal of Anatomy*, **199**, 63-84.

Connor, R. D. 1987, *The weights and measures of England,* London: HMSO.

Cook, T. A. 1914, *The curves of life,* Constable (Reprinted in Dover Books, 1979): London.

Cooke, J. 1995, "Vertebrate embryo handedness", *Nature*, **374**, 681-681.

Cooper, G., Kimmich, N., Belisle, W., Sarinana, J., Brabham, K., & Garrel, L. 2001, "Carbonaceous meteorites as a source of sugar-related organic compounds for the early Earth", *Nature*, **414**, 879-882.

Copeman, S. M. 1919, "Experiments on sex determination", *Proceedings of the Zoological Society*, **1919**, 433-435.

Coppens, P., Parente, M. A. d. M. P., & Lecours, A. R. 1998, "Aphasia in illiterate individuals," pp. 175-202 in *Aphasia in atypical populations*, P. Coppens, Y. Lebrun, & A. Basso, eds., Mahwah, NJ: Lawrence Erlbaum.

Corballis, M. C. 1991f, *The lop-sided ape: evolution of the generative mind,* New York: Oxford University Press.

Corballis, M. C. & Beale, I. L. 1976, *The psychology of left and right,* Hillsdale, NJ: Lawrence Erlbaum Associates.

Corballis, M. C. & Beale, I. L. 1983, *The ambivalent mind: The neuropsychology of left and right,* Chicago: Nelson-Hall.

Corballis, M. C. & Morgan, M. J. 1978, "On the biological basis of human laterality: I. Evidence for a maturational left-right gradient", *Behavioral and Brain Sciences*, **2**, 261-269.

Coren, S. 1992, *The left-hander syndrome: the causes and consequences of left-handedness,* London: John Murray.

Coren, S. & Searleman, A. 1990, "Birth stress and left-handedness: the rare trait marker model," pp. 3-32 in *Left-handedness: Behavioral implications and anomalies*, S. Coren, ed., Amsterdam: North-Holland.

Cornish, K. M. & McManus, I. C. 1996, "Hand preference and hand skill in children with autism", *Journal of Autism and Developmental Disorders*, **26**, 597-609.

Cornish, K. M., Pigram, J., & Shaw, K. 1997, "Do anomalies of handedness exist in children with Fragile-X syndrome?", *Laterality*, **2**, 91-101.

Correia, A. C. M. & Laskar, J. 2001a, "The four final rotation states of Venus", *Nature*, **411**, 767-780.

Coulmas, F. 1996h, *The Blackwell encyclopaedia of writing systems,* Oxford: Blackwell.

Cox, R. T., McIlwraith, C. G., & Kurrelmeyer, B. 1928, "Apparent evidence for polarization in a beam of β-rays", *Proceedings of the National Academy of Sciences of the USA*, **14**, 544-549.

Coxeter, H. S. M. 1969e, "Helices and concho-spirals," pp. 29-33 in *Symmetry and function of biological systems at the macromolecular level*, A. Engström & B. Strandberg, eds., Stockholm: Almqvist and Wiksell.

Crampton, P. 1833b, "On acute inflammation of the brain", *Dublin Journal of Medical and Chemical Science*, **2**, 199-211.

Crampton, P. 1833a, "On certain injuries of the head, with remarks on the utility of reporting cases in medical and surgical practice", *Dublin Journal of Medical and Chemical Science*, **2**, 30-45.

Crew, F. A. E. 1952, in *Marshall's Physiology of Reproduction, Volume II*, 3 edn,

Critchley, M. 1928, *Mirror-writing,* London: Kegan Paul, Trench and Trubner.

Critchley, M. 1964e, "La controverse de Dax et Broca", *Revue Neurologique*, **110**, 553-557.

Critchley, M. 1966, "The enigma of Gerstmann's syndrome", *Brain*, **89**, 183-198.

Critchley, M. 1979, *The divine banquet of the brain and other essays,* New York: Raven Press.

Critchley, M. & Critchley, E. A. 1978, *Dyslexia defined,* London: Heinemann.

Critchley, M. & Critchley, E. A. 1998, *John Hughlings Jackson: Father of English neurology,* Oxford: Oxford University Press.

Crow, T. J. 1998k, "Sexual selection, timing and the descent of man: A theory of the genetic origins of language", *Cahiers de Psychologie Cognitive/ Current Psychology of Cognition*, **17**, 1079-1114.

Crystal, D. 1987c, *The Cambridge encyclopaedia of language,* Cambridge: Cambridge University Press.

Csikszentmihalyi, M. 1998p, "Creativity and genius: A systems perspective," pp. 39-64 in *Genius and the mind: Studies of creativity and temperament*, A. Steptoe, ed., Oxford: Oxford University Press.

Cunningham, D. J. 1902, "Right-handedness and left-brainedness", *Journal of the Anthropological Institute of Great Britain and Ireland*, **32**, 273-296.

Curie, P. 1894, "Sur la symétrie dans les phénomenes physiques, symétrie d'un champ électrique et d'un champ magnétique", *Journal de Physique Theorique et Appliquee*, **3rd Series, 3**, 393-415.

Cushing, H. 1925, *The life of Sir William Osler,* Oxford: Clarendon Press.

D'Agostino, S. 2000w, *A history of the ideas of theoretical physics: Essays on the nineteenth and twentieth century physics,* Dordrecht: Kluwer.

Daix, P. 1993, *Picasso: Life and art,* London: Icon Editions.

Damasio, A. R. 1992d, "Aphasia", *New England Journal of Medicine*, **326**, 531-539.

Damásio, A. R. & Damásio, H. 1977a, "Musical faculty and cerebral dominance," pp. 141-155 in *Music and the brain: Studies in the neurology of music*, M. Critchley & R. A. Henson, eds., Springfield,IL: Charles C Thomas.

Daniels, P. T. & Bright, W. 1996g, *The world's writing systems,* New York: Oxford University Press.

Darnton, R. 1999, "The real Marquis", *New York Review of Books*, **14th January**.

Darwin, C. 1874b, *The descent of man and selection in relation to sex,* 2 edn, London:

Darwin, C. 1877, "A biographical sketch of an infant", *Mind*, **2**, 285-294.

Darwin, C. 1905, *The variation of animals and plants under domestication,* Popular edn, London: John Murray.

Darwin, C. & Huxley, T. H. 1974, *Autobiographies,* London: Oxfrord University Press.

Das, T. 1945, *The Purums: An old Kuki tribe of Manipur,* Calcutta: University of Calcutta Press.

Davenport, G. 1964c, *Carmina Archilochi: The fragments of Archilochos,* Berkeley, CA: University of Califronia Press.

David, B., Lefebvre, B., Mooi, R., & Parsley, R. 2000, "Are homalozoans echinoderms? An answer from the extraxial-axial theory", *Paleobiology*, **26**, 529-555.

David, P., Hingle, A., Fowler, K., & Pomiankowski, A. 1999, "Measurement bias and fluctuatung asymmetry estimates", *Animal Behaviour*, **57**, 251-253.

David, P., Hingle, A., Greig, D., Rutherford, A., Pomiankowski, A., & Fowler, K. 1998, "Male sexual ornament size but not asymmetry reflects condition in stalk-eyed flies", *Proceedings of the Royal Society of London, Series B*, **265**, 2211-2216.

Davies, P. 2001c, "Liquid space", *New Scientist* , **3rd November**, 30-34.

Davis, A. P. 1999, "Synthetic molecular motors", *Nature*, **401**, 120-121.

Daviss, B. 2000, "Access all areas", *New Scientist*, **26th August**, 28-31.

Dawkins, R. 1997, *Climbing Mount Improbable,* London: Penguin Books.

Dawson, R. 1909, *The causation of sex,* London:

Dax, M. 1865a, "Lesions de la moitié gauche de l'encéphale coincidant avec l'oubli des signes de la pensee", *Gazette Hebdomadaire de Medecine et de Chirurgie*, **2 (2nd series)**, 259-262.

Dax, M. G. 1865b, "Sur le même sujet", *Gazette Hebdomadaire de Medecine et de Chirurgie*, **2 (2nd series)**, 259-262.

Day, M. 1999, "Where to find lust on the mind map", *New Scientist*, **6th March**, 14-14.

De Agostini, M., Khamis, A. H., Ahui, A. M., & Dellatolas, G. 1997d, "Environmental influences in hand preference: An African point of view", *Brain and Cognition*, **35**, 151-167.

de Kay, J. T. 1994g, *The left-hander's handbook (incorporating The left-handed book, 1966; The natural superiority of the left-hander, 1979; The world's greatest left-handers, 1985, and Left-handed kids, 1989),* New York: Quality Paperback Book Club.

De la Faille, J.-B. 1970, *The works of Vincent van Gogh,* Revised, augmented and annotated edition edn, London: Weidenfield and Nicolson.

de Luna, F. A. 1993, "Left, right, or down the middle?", *Beaver*, **73 (4)**, 17-21.

de Rocher, G. D. T. 1989, *Popular Errors; Laurent Joubert,* Tuscaloosa: University of Alabama Press.

de Silva, A. P. 1995d, "Bright spies for chiral molecules", *Nature*, **374**, 310-310.

de Vere, G. d. C. 1111, *Giorgio Vasari: Lives of the painters, sculptors and architects,* London: Everyman's Library.

de Zarate, J. C. O. & de Zarate, C. O. O. 1991, "Hair whorl and handedness", *Brain and Cognition*, **16**, 228-230.

Debré, P. 1998l, *Louis Pasteur,* Baltimore: Johns Hopkins University Press.

Deery, J. 1996, *Aldous Huxley and the mysticism of science,* Basingstoke: Macmillan.

Deglin, V. L. & Kinsbourne, M. 1996, "Divergent thinking styles of the hemispheres: How syllogisms are solved during transitory hemisphere suppression", *Brain and Cognition*, **31**, 285-307.

Dehaene, S., Bossini, S., & Giraux, P. 1993, "The mental representation of parity and numerical magnitude", *Journal of Experimental Psychology: General*, **122**, 371-396.

Dehaene, S., Dehaene-Lambertz, G., & Cohen, L. 1998d, "Abstract representations of numbers in the animal and human brain", *Trends in Neurosciences*, **21**, 355-361.

Delamarre, X. 1984a, *Le vocabulaire Indo-Européen: lexique étymologique thématique,* Paris: Librairie d'Amérique et d'Orient.

Dellatolas, G., Viguier, D., Deloche, G., & De Agostini, M. 1998c, "Right-left orientation and significance of systematic reversal in children", *Cortex*, **34**, 659-676.

Derom, C., Thiery, E., Vlietinck, R., Loos, R., & Derom, R. 1996, "Handedness in Twins According to Zygosity and Chorion Type: A Preliminary Report", *Behavior Genetics*, **4**, 407-417.

Desmond, A. 1994, *Huxley: The devil's disciple,* London: Michael Joseph.

Dibner, B. 1961e, *Oersted and the discovery of electromagnetism,* Norwalk, Connecticut: Burndy.

Diringer, D. & Regensburger, R. 1968d, *The alphabet: A key to the history of mankind,* 3 edn, London: Hutchinson.

Dolgopolsky, A. 1998b, *The Nostratic macrofamily and linguistic palaeontology,* Cambridge: McDonald Institute for Archaeological Research.

Domhoff, G. W. 1968a, "But Why Did They Sit on the King's Right in the First Place?", *Psychoanalytic Review*, **56**, 587-596.

Doncaster, L. & Marshall, F. H. A. 1910, "The effects of one-sided ovariotomy on the sex of the offspring", *Journal of Genetics* , **1**, 70-72.

Downward, J. 2001, "The ins and outs of signalling", *Nature*, **411**, 759-762.

Driever, W. 2000, "Bringing two hearts together", *Nature*, **406**, 141-142.

Dudley, H. 1995, "Letter", *The left-hander*, **No 21**, 8-8.

Dumézil 1974a, "'Le Borgne' and 'Le Manchot': the state of the problem," pp. 17-28 in *Myth in Indo-European antiquity*, G. J. Larson, C. S. Littleton, & J. Puhvel, eds., Berkeley, CA: University of California Press.

Dumézil, G. 1988, *Mitra-Varuna: An essay on two Indo-European representations of sovereignty,* New York: Zone Books.

Dumont, L. 1980, "On value", *Proceedings of the British Academy*, **66**, 207-241.

Dumont, L. 1979b, "The anthropological community and ideology", *Social Science Information*, **18**, 785-817.

Duncan, D. D. 1958, *The private world of Pablo Picasso,* New York: Ridge Press.

Duncan, D. D. 1996, *Picasso paints a portrait,* New York: Harry N Abrams.

Durkheim, E. 1995, *The elementary forms of religious life (translated by Karen E Fields) [1912],* New York: The Free Press.

Dyson, F. 1999, *Origins of life: Revised edition,* Cambridge: Cambridge University Press.

East, T. 1957, *The story of heart disease,* London: William Dawson.

Eco, U. 1984, *Semiotics and the philosophy of language,* London: Macmillan.

Edinburgh International Science Festival 1993, *How much do Scots know about their own bodies? A survey on public awareness of the body,* Edinburgh: News Release, 1st Feb 1993.

Edwards, B. 1989, *Drawing on the right side of the brain: A course in enhancing creativity and artistic confidence. Revised edition,* New York: Perigee Books.

Eggert, G. H. 1977, *Wernicke's works on aphasia,* The Hague: Mouton.

Eling, P. 1984e, "Broca on the relation between handedness and cerebral speech dominance", *Brain and Language*, **22**, 158-159.

Eling, P. 1994a, *Reader in the history of aphasia: From [Franz] Gall to [Norman] Geschwind,* Amsterdam: John Benjamins.

Eliot, G. 1965, *Middlemarch,* Harmondsworth: Penguin.

Elkind, D. 1961c, "Children's conception of right and left: Piaget replication study IV", *Journal of Genetic Psychology*, **99**, 269-276.

Elliot Smith, G. 1919, *The evolution of the dragon,* Manchester: Manchester University Press.

Ellis, A. W., Young, A. W., & Flude, B. M. 1993, "Neglect and visual language," pp. 233-255 in *Unilateral neglect: Clinical and experimental studies*, I. H. Robertson & J. C. Marshall, eds., Hove: Lawrence Erlbaum Associates.

Ellis, H. 1967, *My Life (first published 1940),* London: Neville Spearman.

Ellis, L. & Engh, T. 2000u, "Handedness and age at death: New evidence on a puzzling relationship", *Journal of Health Psychology*, **5**, 561-565.

Ellis, P. J., Marshall, E., Windridge, C., Jones, S., & Ellis, S. J. 1998a, "Left-handedness and premature death", *Lancet*, **351**, 1634-1634.

Ellis, S. J., Ellis, P. J., & Marshall, E. 1988, "Hand preferences in a normal population", *Cortex*, **24**, 157-163.

Ellis, S. J., Ellis, P. J., Marshall, E., Windridge, C., & Jones, S. 1998b, "Is forced dextrality an explanation for the fall in the prevalence of sinistrality with age? A study in northern England", *Journal of Epidemiology and Community Health*, **52**, 41-44.

Elze, C. 1924, "Rechtslinksempfinden und Rechtslinksblindheit", *Zeitschrift für angewandte Psychologie*, **24**, 129-135.

Elze, C. 1926, "Kann Jedermann Rechts und Links unterscheiden?", *Deutsche Zeitschrift für Nervenheilkunde*, **90**.

Engel, M. H. & Macko, S. A. 1997, "Isotopic evidence for extraterrestrial non-racemic amino acids in the Murchison meteorite", *Nature*, **389**, 265-268.

Engel, M. H., Macko, S. A., & Silfer, J. A. 1990, "Carbon isotope composition of individual amino acids in the Murchison meteorite", *Nature*, **348**, 47-49.

Engel, M. H. & Nagy, B. 1982, "Distribution and enantiomeric compositon of amino acids in the Murchison meteorite", *Nature*, **296**, 837-840.

Englund, R. K. 1996, "The proto-Elamite script," pp. 160-164 in *The world's writing systems*, P. T. Daniels & W. Bright, eds., New York: Oxford University Press.

Epstein, S., Krishnamurthy, R. V., Cronin, J. R., Pizzarello, S., & Yuen, G. U. 1987, "Unusual stable isotope ratios ini amino acid and carboxylic acid extracts from the Murchison meteorite", *Nature*, **326**, 477-479.

Eriksson, T., Bjorkman, S., Roth, B., Fyge, A., & Hoglund, P. 1995, "Stereospecific determination, chiral inversion in vitro and pharmacokinetics in humans of the enantiomers of thalidomide", *Chirality*, **7**, 44-52.

Eriksson, T., Bjorkman, S., Roth, B., Fyge, A., & Hoglund, P. 1998, "Enantiomers of thalidomide: blood distribution and the influence of serum albumin on chiral inversion and hydrolysis", *Chirality*, **10**, 223-228.

Erspamer, V. 1992, "The opioid peptides of the amphibian skin", *International Journal of Developmental Neuroscience*, **10**, 3-30.

Esteban, C. R., Capdevila, J., Economides, A. N., Pascual, J., Ortiz, A., & Belmonte, J. C. I. 1999, "The novel Cer-like protein Caronte mediates the establishment of embryonic left-right asymmetry", *Nature*, **401**, 243-251.

Etaugh, C. & Brausam, M. 1978, "Sensitivity to laterality as a function of handedness", *Perceptual and Motor Skills*, **Vol 46**, 420-422.

Etaugh, C. & Fredman, M. 1980, "Salience of handedness in the spontaneous description of others", *Perceptual and Motor Skills*, **Vol 51**, 273-274.

Eviatar, Z. 1997, "Language experience and right hemisphere tasks: the effects of scanning habits and multilingualism", *Brain Lang*, **58**, 157-173.

Eysenck, H. J. 1954, *The psychology of politics,* London: Routledge and Kegan Paul.

Fabbro, F. 1994b, "Left and right in the Bible from a neuropsychological perspective", *Brain and Cognition*, **24**, 161-183.

Fabbro, F., Brusaferro, A., & Bava, A. 1990e, "Opposite musical-manual interference in young vs expert musicians", *Neuropsychologia*, **28**, 871-877.

Fabro, S., Schumacher, H., Smith, R. L., Stagg, R. B. L., & Williams, R. T. 1965, "The metabolism of thalidomide: Some biological effects of thalidomide and its metabolites", *British Journal of Pharmacology*, **25**, 352-362.

Fabro, S., Smith, R. L., & Williams, R. T. 1967, "Toxicity and teratogenicity of optical isomers of thalidomide", *Nature*, **215**, 296-296.

Façon, E., Wertheim, N., & Mestes, E. 1960, "Syndrome d'inattention spatiale avec douleurs d'origine corticale: Étude anatomo-clinique", *Revue Neurologique*, **102**, 61-74.

Farnoux, A. 1996, *Knossos: Unearthing a legend,* London: Thames and Hudson.

Farrell, W. S. 1979d, "Coding left and right", *Journal of Experimental Psychology: Human Perception and Performance*, **5**, 42-51.

Feldman, D. 1987, *Why do clocks run clockwise? and other imponderables,* New York: Harper and Row.

Feringa, B. L. 2001, "A new twist on chirality", *Science*, **292**, 2021-2022.

Fernandes, M. A. & Smith, M. L. 2000, "Comparing the Fused Dichotic Words Test and the Intracarotid Amobarbital Procedure in children with epilepsy", *Neuropsychologia*, **38**, 1216-1228.

Ferster, D. 1996, "Is Neural Noise Just a Nuisance?", *Science*, **273**, 1812-1812.

Feynman, R. P., Leighton, R. B., & Sands, M. 1963, *The Feynman lectures on physics. Vol I: Mainly mechanics, radiation, and heat,* Reading, MA: Addison-Wesley.

Figureau, A., Duval, E., & Boukenter, A. 1995, "Can biological homochirality result from a phase transition?", *Orig.Life.Evol.Biosphere.*, **25**, 211-217.

Finch, C. E. & Kirkwood, T. B. L. 2000s, *Chance, development and Aging,* Oxford: Oxford University Press.

Fincher, J. 1977b, *Sinister people: The looking-glass world of the left-hander,* New York: G P Putnam's Sons.

Finger, S. & Roe, D. 1999a, "Does Gustave Dax deserve to be forgotten? The temporal lobe theory and other contributions of an overlooked figure in the history of language and cerebral dominance", *Brain and Language*, **69**, 16-30.

Firth, R. 1975, "The right hand and the wrong", *Times Literary Supplement* 190-191.

Flanagan, T. 1998, "Game theory and professional baseball: Mixed strategy models", *Journal of Sport Behavior*, **Vol 21**, 121-138.

Flor-Henry, P. 1991, "Sinistrality and psychopathology," pp. 415-440 in *Left-handedness: Behavioral implications and anomalies* , S. Coren, ed., Amsterdam: North-Holland.

Forbes, J. 1824, *Original cases with Dissection and Observations, illustrating the use of the STETHOSCOPE and PERCUSSION in the diagnosis of diseases of the Chest,* London: Underwood.

Foster, M. L. 1995a, "Symbolism: The foundation of culture," pp. 366-393 in *Companion Encyclopedia of Anthropology*, T. Ingold, ed., London: Routledge.

Fowler, A. 1971a, *Milton: Paradise Lost,* London: Longman.

Fowler, H. N. 1962, *Plato: Philebus,* London: Heinemann.

Fragaszy, D. M. 1998, "How non-human primates use their hands," pp. 77-96 in *The psychobiology of the hand*, K. J. Connolly, ed., London: MacKeith Press.

Fraser, G. 2000, *Antimatter: The ultimate mirror,* Cambridge: Cambridge University Press.

Frederick, R. E. 1991, "Introduction to the argument of 1768," pp. 1-14 in *The philosophy of right and left*, J. Van Cleve & R. E. Frederick, eds., Dordrecht: Kluwer.

Freeman, A. 2001, "'The stealthy school of criticism': Redisovery of a suppressed pathmplet by Dante Gabriel Rosetti", *Times Literary Supplement*, **July 20th**, 14-14.

Freud, S. 1976, *The interpretation of dreams,* Harmondsworth: Penguin Books.

Freud, S. 1985, *The complete letters of Sigmund Freud to Wilhelm Fliess 1887-1904 (translated by Jeffrey Moussaieff Masson),* Cambridge, MA: Harvard University Press.

Fricker, J. 1999, "A big hand for...", *Wellcome News*, **Issue 20, Q3**, 30-31.

Friedman, J. H., Golomb, J., & Mora, M. N. 1952, "The hair whorl sign for handedness", *Diseases of the Nervous System*, **13**, 208-216.

Fritsch, V. 1968c, *Left and right in science and life,* London: Barrie and Rockliff.

Froude, J. A. 1885, *Thomas Carlyle: A history of his life in London 1834-1881,* London: Longman, Green & Co.

Fudin, R., Renninger, L., Lembessis, E., & Hirshon, J. 1993, "Sinistrality and reduced longevity: Reichler's (1979) data on baseball players do not indicate a relationship", *Perceptual and Motor Skills*, **76**, 171-182.

Fujiyama, A., Watanable, H., Toyoda, A., & et al 2002, "Construction and analysis of a human-chimpanzee comparative clone map", *Science*, **295**, 131-134.

Gabbard, C. & Hart, S. 2000j, "Examining the notion of foot dominance," pp. 249-265 in *Side bias: A neuropsychological perspective*, M. K. Mandal, M. B. Bulman-Fleming, & G. Tiwari, eds., Dordrecht: Kluwer.

Gaffan, D., Harrison, S., & Gaffan, E. A. 1986, "Visual identification following infero-temporal ablation in the monkey", *Q.J Exp.Psychol.B*, **38**, 5-30.

Gaffron, M. 1950b, "Right and Left in Pictures", *Art Quarterly*, **13**, 312-331.

Gamkrelidze, T. V. & Ivanov, V. V. 1995, *Indo-European and the Indo-europeans: A reconstruction and historical analysis of a proto-language and a proto-culture,* Berlin: Mouton de Gruyer.

Gangestad, S. W. & Thornhill, R. 1999, "Individual differences in the developmental precision and fluctuating asymmetry: a model and its implication", *Journal of Evolutionary Biology*, **12**, 402-416.

Gardner, M. 1990a, *The new ambidextrous universe: revised edition,* New York: W H Freeman.

Garwin, R. L., Lederman, L. M., & Weinrich, M. 1957, "Observations of the failure of conservation of parity and charge conjugation in meson decays: the magnetic moment of the free muon", *Physical Review*, **105**, 1415-1417.

Gatesy, S. M., Middleton, K. M., Jenkins, F. A., & Shubin, N. H. 1999, "Three-dimensional preservation of foot movements in Triassic theropod dinosaurs", *Nature*, **399**, 141-144.

Gee, H. 1996b, *Before the backbone: Views on the origins of the vertebrates,* London: Chapman and Hall.

Gee, H. 2000, *Deep time: Cladistics, the revolution in evolution,* London: Fourth Estate.

Geison, G. L. 1978, *Michael Foster and the Cambridge school of physiology,* Princeton, NJ: Princeton University Press.

Gell-Mann, M. 1995, *The quark and the jaguar,* London: Abacus.

George, J. C. & et al 2000, "Age and growth estimates of bowhead whales (*Balaena mysticetus*) via aspartic acid racemization", *Canadian Journal of Zoology*, **77**, 571-???

Geschwind, N. & Behan, P. 1982, "Left-handedness: association with immune disease, migraine and developmental learning disorder", *Proceedings of the National Academy of Sciences of the USA*, **79**, 5097-5100.

Geschwind, N. & Galaburda, A. M. 1987, *Cerebral Lateralization: Biological mechanisms, associations, and pathology,* Cambridge, Massachusetts: MIT Press.

Ghika, S. F., van Melle, G., Guex, P., & Bogousslavsky, J. 1999, "Subjective experience and behavior in acute stroke: the Lausanne Emotion in Acute Stroke Study", *Neurology*, **52**, 22-28.

Gilbert, A. N. & Wysocki, C. J. 1992f, "Hand preference and age in the United States", *Neuropsychologia*, **30**, 601-608.

Gislén, T. 1930, "Affinities between the Echonodermata, Enteropneusta and Chordonia", *Zool.Bidr.Uppsala*, **12**, 199-304.

Glanville, P. 1972, *London in maps,* London: The Connoisseur.

Gleick, J. 1994, *Genius: Richard Feynman and modern physics,* London: Abacus.

Glick, S. D. 1983, "Cerebral lateralization in the rat and tentative extrapolations to man," pp. 7-26 in *Hemisyndromes: psychobiology, neurology, psychology*, M. S. Myslobodsky, ed., New York: Academic Press.

Goethe, J. W. 1970, *Italian Journey, translated by W.H. Auden and Elizabeth Mayer,* London: Penguin.

Goffman, E. 1963, *Stigma: Notes on the management of spoiled identity,* Englewood Cliffs, NJ: Prentice-Hall.

Golbin, A., Golbin, Y., Keith, L., & Keith, D. 1993d, "Mirror imaging in twins: biological polarization - an evolving hypothesis", *Acta Genet Med Gemellol*, **42**, 237-243.

Goldstein, A. M., Ticho, B. S., & Fishman, M. C. 1998, "Patterning the heart's left-right axis: from zebrafish to man", *Dev.Genet.*, **22**, 278-287.

Goldstein, S. R. & Young, C. A. 1996, ""Evolutionary" stable strategy of handedness in major league baseball", *Journal of Comparative Psychology*, **110**, 164-169.

Gombrich, E. H. 1979g, *The sense of order,* London: Phaidon Press.

Gomez-de-Terreros-Caro, F. J., Gomez-Stern, A. C., Alvarez-Sala, W. R., Prados, S. C., Garcia, R. F., & Villamor, L. J. 1999, "[Kartagener's syndrome. Diagnosis in a 75 year-old woman]", *Arch Bronconeumol.*, **35**, 242-244.

Goodfield, G. J. 1970, "Brodie, Benjamin Collins," pp. 482-484 in *Dictionary of Scientific Biography: Volume II*, C. C. Gillispie, ed., New York: Charles Scribner's Sons.

Gordon-Taylor, G. & Walls, E. W. 1958, *Sir Charles Bell: His life and times,* Edinburgh: E&S Livingstone.

Gordon, A. G. 1998, "Handedness and laterality of the viscera revisited [letter]", *Neurology*, **51**, 1515.

Gordon, H. W. & Bogen, J. E. 1974, "Hemispheric lateralization of singing after intracarotid sodium amylobarbitone", *Journal of Neurology, Neurosurgery and Psychiatry*, **37**, 727-738.

Gordon, N. & McKinlay, I. 1980, *Helping clumsy children,* Edinburgh: Churchil Livingstone.

Gore, M. M. 1991, "The nasal cycle - a review in relation to yogic literature and scientific research", *Yoga-Mimamsa*, **30**, 60-74.

Gotestam, K. O. 1990, "Lefthandedness among students of architecture and music", *Perceptual and Motor Skills*, **70**, 1323-1327.

Gould, G. M. 1904, "The pathological results of dextrocularity and sinistrocularity", *Ophthalmology*, **1**, 10-15.

Gould, G. M. 1908, *Righthandedness and lefthandedness,* Philadelphia: J B Lippincott.

Gould, S. J. 1989d, *Wonderful life: The Burgess shale and the nature of history,* New York: W W Norton.

Gould, S. J. 1997, *Dinosaur in a haystack: Reflections in natural history,* London: Penguin Books.

Gould, S. J. 1997, *Life's grandeur: The spread of excellence from Plato to Darwin,* London: Vintage.

Gómez, F. J. & Waymouth, R. M. 2002a, "Catalysts rise to the challenge", *Science*, **295**, 635-636.

Gram, D. 1986b, "One lump or two ... but take it left-handed", *Sunday Times*, **5th January**.

Gram, D. 1986a, "One lump or two ... but take it left-handed", *Sunday Times (London)*, **5th January**.

Granet, M. 1973a, "Right and left in China (originally published in French in 1933)," pp. 43-58 in *Right and left: Essays on dual symbolic classification*, R. Needham, ed., Chicago: University of Chicago Press.

Gratzer, W. 2000, "Review of *Medicine quest: In search of nature's healing secrets* by Mark J Plotkin", *Nature*, **406**, 235-236.

Gray, E. 1989, "Equine Asymmetrical Dexterity or, The Preferred Lead Syndrome", *American Farriers Journal*, **Jan/Feb**.

Grayson, C. 1991, *Leon Battista Alberti: On painting,* Harmondsworth: Penguin.

Graziano, M. S. A. 2001, "Awareness of s[ace", *Nature*, **411**, 903-904.

Greenberg, J. M. 1996, "Chirality in interstellar dust and in comets: Life from dead stars," pp. 185-210 in *Physical origin of homochirality in life*, D. B. Cline, ed., Woodbury, NY.

Gregory, R. 1998q, *Mirrors in mind,* London: Penguin Books.

Grimshaw, G. M., Bryden, M. P., & Finegan, J. K. 1995, "Relations between prenatal testosterone and cerebral lateralization in children", *Neuropsychology*, **9**, 68-79.

Gross, M. & Alexander, R. 1978, *Bob Dylan: An illustrated history,* London: Elm Tree Books.

Gubbay, S. S. 1975, *The clumsy child: A study of developmental apraxic and agnosic ataxia,* W.B.Saunders: London.

Gur, R. C., Sackheim, H. A., & Gur, R. E. 1976, "Classroom seating and psychopathology: Some initial data", *Journal of Abnormal Psychology*, **85**, 122-124.

Gur, R. E. & Gur, R. C. 1975, "Defense mechanisms, psychosomatic symptomatology, and conjugate lateral eye movements", *Journal of Consulting and Clinical Psychology*, **43**, 416-420.

Gura, T. 2000, "On guard!", *New Scientist*, **2nd December**, 25-27.

Güse, E.-G. 1991, *Paul Klee: dialogue with nature,* Munich: Prestel.

Györgyei, F. 1976, "Thomas Watson -- Semmelweis egyik elöfutára", *Orvosi Hetilap (Budapest)*, **117**, 104-107.

Hagoort, P., Brown, C. M., & Osterhout, L. 1999h, "The neurocognition of syntactic processing," pp. 273-316 in *The neurocognition of language*, C. M. Brown & P. Hagoort, eds., Oxford: Oxford University Press.

Haldane, J. B. S. 1932, *The causes of evolution,* London: Longmans, Green and Co.

Halligan, P. W. & Marshall, J. C. 1993, "The history and clinical presentation of neglect," pp. 3-25 in *Unilateral neglect: Clinical and experimental studies*, I. H. Robertson & J. C. Marshall, eds., Hove: Lawrence Erlbaum Associates.

Halligan, P. W. & Marshall, J. C. 1997, "The art of visual neglect", *Lancet*, **350**, 139-140.

Hallpike, C. R. 1979, *The foundations of primitive thought,* Oxford: Clarendon Press.

Halpern, D. F. & Coren, S. 1988d, "Do right-handers live longer?", *Nature*, **333**, 213-213.

Halpern, D. F. & Coren, S. 1990, "Laterality and longevity: is left-handedness associated with a younger age at death?," pp. 509-545 in *Left-handedness: Behavioral implications and anomalies*, S. Coren, ed., Amsterdam: North-Holland.

Halpern, D. F. & Coren, S. 1991, "Handedness and life span", *New England Journal of Medicine*, **324**, 998-998.

Halpern, D. F. & Coren, S. 1993, "Left-handedness and life span: a reply to Harris", *Psychological Bulletin*, **114**, 235-241.

Halpern, D. F., Haviland, M. G., & Killian, C. D. 1998o, "Handedness and sex differences in intelligence: Evidence from the Medical College Admission Test", *Brain and Cognition*, **38**, 87-101.

Hamburger, V. 1988, *The heritage of experimental embryology: Hans Spemann and the organizer,* New York: Oxford University Press.

Hamburger, V. 1999, "Hans Spemann on vitalism in biology: Translation of a portion of Spemann's *Autobiography*", *Journal of the History of Biology*, **32**, 231-243.

Hamer, M. 1986c, "Left is right on the road", *New Scientist*, **25th December**, 16-18.

Hamilton, A. 1993, "Cuddy-wifties right wronged sinistrals", *Times*, **14th August**, 3-3.

Hamilton, H. W. & Deese, J. 1971, "Does linguistic marking have a psychological correlate?", *Journal of Verbal Learning and Verbal Behavior*, **10**, 707-714.

Hansen, J. N. 1993, "Antibiotics synthesised by post-translational modification", *Annual Review of Microbiology*, **47**, 535-564.

Hardell, L. & Hansson Mild, K. 2001, "Cellular telephones and risk of brain tumours", *Lancet*, **357**, 960-961.

Hardell, L., Nasman, A., Palilson, A., Hallquist, A., & Hansson Mild, K. 1999, "Use of cellular phones and the risk for brain tumours: a case-control study", *International Journal of Oncology*, **15**, 113-116.

Hardyck, C., Petrinovich, L. F., & Goldman, R. D. 1976e, "Left-handedness and cognitive deficit", *Cortex*, **12**, 266-279.

Hargittai, I. & Hargittai, M. 2000, *In our own image: Personal symmetry in discovery,* New York: Kluwer Academic.

Harnad, S. R. 1987, "Category induction and representation," pp. 535-565 in *Categorical perception: The groundwork of cognition*, S. Harnad, ed., Cambridge: Cambridge University Press.

Harrington, A. 1987, *Medicine, mind, and the double brain; a study in nineteenth-century thought,* Princeton, NJ: Princeton University Press.

Harris, L. J. 1980, "Left-handedness: Early theories, facts, and fancies," pp. 3-78 in *Neuropsychology of left-handedness*, J. Herron, ed., New York: Academic Press.

Harris, L. J. 1990f, "Cultural influences on handedness: historical and contemporary theory and evidence," pp. 195-258 in *Left-handedness: Behavioral implications and anomalies*, S. Coren, ed., Amsterdam: North-Holland.

Harris, L. J. 1991, "Cerebral control for speech in right-handers and left-handers: an analysis of the views of Paul Broca, his contemporaries, and his successors", *Brain and Language*, **40**, 1-50.

Harris, L. J. 1993a, "Do left-handers die sooner than right-handers? Commentary on Coren and Halpern's (1991) "Left-handedness: A marker for decreased survival fitness"", *Psychological Bulletin*, **114**, 203-234.

Harris, L. J. 1993b, "Reply to Halpern and Coren", *Psychological Bulletin*, **114**, 242-247.

Harris, L. J. 2000, "On the evolution of handedness: A speculative analysis of Darwin's views and a review of early studies of handedness in "the nearest allies of man"", *Brain and Language*, **73**, 132-188.

Harris, L. J. & Snyder, P. J. 1992e, "Subjective mood state and perception of emotion in chimeric faces", *Cortex*, **28**, 471-481.

Harris, L. J. & Snyder, P. J. 1997, "Cerebral anesthesia for localization of speech: the contribution of W. James Gardner", *Brain Lang*, **56**, 377-396.

Harris, N. 1985, "David Gower found to be right-handed", *Sunday Times*.

Harris, W. A. & Holt, C. E. 1999, "Slit, the midline repellent", *Nature*, **398**, 462-463.

Harrower, M. R. & Steiner, M. E. 1951, *Large scale Rorschach techniques,* 2 edn, Springfield, IL: Charles C Thomas.

Hay, I. 1939, *"Pip": A romance of youth [Originally published 1907],* Harmondsworth: Penguin.

Hay, R. L. & Leakey, M. D. 1982, "The fossil footprints of Laetoli", *Scientific American*, **246**, 50-57.

Healey, J. F. 1990, *The early alphabet,* London: British Museum Publications.

Healey, J. M., Liederman, J., & Geschwind, N. 1986, "Handedness is not a unidimensional trait", *Cortex*, **22**, 33-53.

Heaney, S. 1999, *Beowulf,* London: Faber and Faber.

Hebron, M. E. 1985, *Statistical studies of the iconography of the dragon in Biblical texts of the 13th and 14th centuries,* London: Chameleon Press.

Heffer, S. 1995, *Moral desperado: A life of Thomas Carlyle,* London: Weidenfeld and Nicolson.

Heger, W., Schmahl, H. J., Klug, S., Felies, A., Nau, H., Merker, H. J., & Neubert, D. 1994, "Embryotoxic effects of thalidomide derivatives in the non-human primate callithrix jacchus. IV. Teratogenicity of micrograms/kg doses of the EM12 enantiomers", *Teratog.Carcinog.Mutagen.*, **14**, 115-122.

Hegstrom, R. A. & Kondepudi, D. K. 1990b, "The handedness of the universe", *Scientific American* 98-105.

Heilbronner, E. & Dunitz, J. D. 1993, *Reflections on symmetry: In chemistry ... and elsewhere,* Basel: Verlag Helvetica Chimica Acta.

Heilman, K. M., Bowers, D., & Watson, R. T. 1984d, "Pseudoneglect in a patient with partial callosal disconnection", *Brain*, **107**, 519-532.

Henderson, A. H. 1996, "Chest pain," pp. 2165-2169 in *Oxford textbook of medicine,* 3 edn, D. J. Weatherall, J. G. G. Ledingham, & D. A. Warrell, eds., Oxford: Oxford University Press.

Henry, R. G. J. 1979, "Monaural studies eliciting an hemispheric asymmetry: A bibliography", *Perceptual and Motor Skills*, **48**, 335-338.

Henry, R. G. J. 1983, "Monaural studies eliciting an hemispheric asymmetry; A bibliography: II", *Perceptual and Motor Skills*, **56**, 915-918.

Hepper, P. G., McCartney, G. R., & Shannon, E. A. 1998i, "Lateralized behaviour in first-trimester human foetuses", *Neuropsychologia*, **36**, 531-534.

Hepper, P. G., Shahidullah, S., & White, R. 1991d, "Handedness in the human fetus", *Neuropsychologia*, **29**, 1107-1111.

Herbert, A. M. & Humphrey, G. K. 1996, "Bilateral symmetry detection: Testing a "callosal" hypothesis", *Perception*, **25**, 463-480.

Hertz, R. 1960, *Death and the right hand,* Aberdeen: Cohen and West.

Hewes, G. 1949, "Lateral dominance, culture, and writing systems", *Human Biology*, **21**, 233-245.

Hewson, M. A. 1975, *Giles of Rome and the mediaeval theory of conception,* London: Athlone Press.

Hécaen, H. & Albert, M. L. 1978, *Human neuropsychology,* New York: John Wiley.

Hécaen, H. & de Ajuriaguerra, J. 1964d, *Left-handedness: manual superiority and cerebral dominance,* New York: Grune and Stratton.

Hécaen, H. & Dubois, J. 1969a, *La naissance de la neuropsychologie du langage (1825-1865),* Paris: Flammarion.

Hécaen, H. & Piercy, M. 1956, "Paroxysmal dysphasia and the problem of cerebral dominance", *Journal of Neurology, Neurosurgery, and Psychiatry*, **19**, 194-201.

Hiroi, T., Zolensky, M. E., & Pieters, C. M. 2001, "The Tagish Lake meteorite: A possible sample from a D-type asteroid", *Science*, **293**, 2234-2236.

Hirst, M. 1981, *Sebastiano del Piombo,* Oxford: Clarendon Press.

Hoglund, P., Eriksson, T., & Bjorkman, S. 1998, "A double-blind study of the sedative effects of the thalidomide enantiomers in humans", *J.Pharmacokinet.Biopharm.*, **26**, 363-383.

Holden, C. 2001, "Ötzi death riddle solved", *Science*, **293**, 795-795.

Holland, J. H. 1998n, *Emergence: From chaos to order,* Oxford: Oxford University Press.

Honour, H. 1995f, "Burma: Splendor and Miseries", *New York Review of Books*, **42**, 56-61.

Hoogmartens, M. J. & Caubergh, M. A. 1987, "Chewing side preference in man correlated with handedness, footedness, eyedness and earedness", *Electromyography and Clinical Neurophysiology*, **27**, 293-300.

Hopkins, W. D. & Fernández-Carriba, S. 2000q, "The effect of situational factors on hand preferences for feeding in 177 captive chimpanzees (*Pan troglodytes*)", *Neuropsychologia*, **38**, 403-409.

Horder, T. J. & Weindling, P. J. 1986, "Hans Spemann and the organiser," pp. 183-242 in *A history of embryology*, T. J. Horder, J. A. Witkowski, & C. C. Wylie, eds., Cambridge: Cambridge University Press.

Horton, R. 2001, "Thalidomide comes back", *New York Review of Books*, **48, May 17th**, 12-15.

Howard, D. & Hatfield, F. M. 1987, *Aphasia therapy,* Hove: Lawrence Erlbaum.

Howard, P. 2001, "Neanderthal revolutionary or Cro-Magnon fascist, on your head be it", *The Times*, **2oth July**, 20-20.

Huber, J. B. 1910, "Why are we right-handed?", *Scientific American*, **102**, 260-269.

Huberman, A. & Aguilar, M. B. 1998, "D-amino acids in crustacean hyperglycemic neurohormones," pp. 73-83 in *D-amino acids in sequences of secreted peptides of multicellular organisms*, P. Jollès, ed., Basel: Birkhäuser Verlag.

Hugdahl, K., Satz, P., Mitrushina, M., & Miller, E. N. 1993, "Left-handedness and old age: Do left-handers die earlier?", *Neuropsychologia*, **31**, 325-333.

Humphrey, N. K. & McManus, I. C. 1973, "Status and the left cheek", *New Scientist*, **59**, 437-439.

Humphreys, G. W. & Riddoch, M. J. 1987f, *To see but not to see: A case study of visual agnosia,* London: Lawrence Erlbaum.

Hunt, G. R., Corballis, M. C., & Gray, R. D. 2001, "Laterality in tool manufacture in crows", *Nature*, **414**, 707-707.

Huxley, A. 1963, *Literature and science,* London: Chatto &Windus.

Huxley, A. 1996, *Point counter point (originally published 1928),* Illinois: Dalkey Archive Press.

Huxley, J. S. & de Beer, G. R. 1934, *The elements of experimental embryology,* Cambridge: Cambridge University Press.

Huxley, J. S. & de Beer, G. R. 1934, "The origin of polarity, symmetry, and asymmetry," pp. 60-82 in *The elements of experimental embryology*, Cambridge: Cambridge University Press.

Huxley, T. H. 1877, *Physiography: An introduction to the study of nature,* London: MacMillan.

Huxley, T. H. 1967, *On a piece of chalk [edited by L. Eiseley],* New York: Charles Scribner's Sons.

Ibbotson, N. R. & Morton, J. 1981, "Rhythm and dominance", *Cognition*, **9**, 125-138.

Ida, Y., Mandal, M. K., & Bryden, M. P. 2000, "Factor structures of hand preference questionnaires: A 'skilled' and 'unskilled' factors artifacts?," pp. 175-190 in *Side bias: A neuropsychological perspective*, M. K. Mandal, M. B. Bulman-Fleming, & G. Tiwari, eds., Dordrecht: Kluwer.

Ingrosso, D. & Perna, A. F. 1998, "D-amino acids in aging erythrocytes," pp. 119-141 in *D-amino acids in sequences of secreted peptides of multicellular organisms*, P. Jollès, ed., Basel: Birkhäuser Verlag.

Ireland, W. W. 1880, "Notes on left-handedness", *Brain*, **3**, 207-214.

Irion, R. 2001, "Slip-sliding away", *New Scientist*, **18th August**, 35-37.

Ivemark, B. L. 1955, "Implications of agenesis of the spleen on the pathogenesis of cono-truncus anomalies in childhood: analysis of the heart malformations in splenic agenesis syndrome, with fourteen new cases.", *Acta Paediatrica*, **44 (Suppl 104)**, 1-110.

Iwasaki, S. 2000n, "Age and generation trends in handedness: An Eastern perspective," pp. 83-100 in *Side bias: A neuropsychological perspective*, M. K. Mandal, M. B. Bulman-Fleming, & G. Tiwari, eds., Dordrecht: Kluwer.

Izraeli, S., Lowe, L. A., Bertness, V. L., Good, D. J., Dorward, D. W., Kirsch, I. R., & Kuehn, M. R. 1999, "The *SIL* gene is required for mouse embryonic axial development and left-right specification", *Nature*, **399**, 691-694.

Jackson, C. J., Furnham, A., and Miller, T. 2001, "Moderating effect of ear preference on personality in the prediction of sales performance", *Laterality*, in press.

Jackson, J. H. 1866, "Hemiplegia of the left side, with defect of speech", *Medical Times and Gazette*, **2** , 210-210.

Jackson, J. H. 1868, "Aphasia with hemiplegia of the left side", *Lancet*, **i**, 316-316.

Jackson, J. H. 1874a, "On the nature of the duality of the brain", *Medical Press and Circular*, **i**, 19,41,63.

Jackson, J. H. 1876, "Case of large cerebral tumour without optic neuritis and with left hemiplegia and imperception", *Royal Ophthalmological Hospital Reports*, **8**, 434-444.

Jackson, J. H. 1878, "On affections of speech from disease of the brain", *Brain*, **i**, 304-330.

James, W. 1890, *The principles of psychology,* London: Macmillan.

James, W. H. & Orlebeke, J. F. 2002, "Determinants of handedness in twins", *Laterality*, **in press**.

James, W. 1890, *Principles of Psychology,* London: Macmillan.

Jandl, E. 1997, *lechts und rinks,* München: Deutscher Taschenbuch Verlag.

Jandl, E. 2000, *Reft and light: Poems by Ernst Jandl with multiple versions by American poets,* Providence RI: Burning Deck.

Jardot, M. 1959, *Pablo Picasso: Drawings,* New York: Harry N Abrams.

Jaynes, J. 1976d, *The origin of consciousness in the breakdown of the bicameral mind,* Harmondsworth: Penguin Books.

Jäncke, L., Peters, M., Himmelbach, M., Nösselt, T., Shah, J., & Steinmetz, H. 2000, "fMRI study of bimanual coordination", *Neuropsychologia*, **38**, 164-174.

Jefferies, R. P. S. 1986, *The ancestry of the vertebrates,* London: British Museum (Natural History).

Jeffrey, L. H. 1990g, *The local scripts of archaic Greece (revised edition),* Oxford: Clarendon Press.

Johnson, E. 1970, *Sir Walter Scott,* London: Hamish Hamilton.

Johnson, G. 1997, *Fire in the mind: Science, faith, and the search for order,* London: Penguin.

Johnson, K. A., Muir, P., Nicoll, R. G., & Roush, J. K. 2000, "Asymmetric adaptive modeling of central tarsal bones in racing greyhounds", *Bone*, **27**, 257-263.

Jones, E. 1907, "The precise diagnostic value of allochiria", *Brain*, **30**, 490-532.

Jones, E. 1909, "An attempt to define the terms used in connection with right-handedness", *Psychological Bulletin*, **6**, 130-132.

Jones, G. V. & Martin, M. 2000h, "A note on Corballis (1997) and the genetics and evolution of handedness: Developing a unified distributional model from the sex-chromosomes gene hypothesis", *Psychological Review*, **107**, 213-218.

Jones, N. 1999, *Rupert Brooke: Life, death and myth,* London: Richard Cohen.

Joyce, J. 1975, *Finnegans Wake [3rd edition; first published 1939],* London: Faber and Faber.

Joynt, R. J. & Benton, A. L. 1964a, "The memoir of Marc Dax on aphasia", *Neurology*, **14**, 851-854.

JØrgensen, L., Crabtree, N. J., Reeve, J., & Jacobsen, B. K. 2000, "Ambulatory level and asymmetrical weight bearing after stroke affects bone loss in the upper and lower part of the femoral neck differently: bone adaptation after decreased mechanical loading", *Bone*, **27**, 701-707.

Karev, G. B. 2000, "Cinema seating in right, mixed and left handers", *Cortex*, **36**, 747-752.

Karnath, H.-O., Ferber, S., & Himmelbach, M. 2001, "Spatial awareness is a function of the temporal not the posterior parietal lobe", *Nature*, **411**, 950-953.

Kartagener, M. 1933, "Zur Pathogenese der Bronchiektasen. I Mitteilung Bronchiektasien bei situs viscerum inversus", *Beiträge zur Klinik und Erforschung der Tuberkulose und der Lungenkrankenheiten*, **83**, 489-501.

Kauffman, S. A. 1993g, *The origins of order: Self-organization and selection in evolution,* New York: Oxford University Press.

Keegan, R. T. & Gruber, H. E. 1985, "Charles Darwin's unpublished 'Diary of an infant': an early phase in his psychological work," pp. 127-145 in *Contributions of a history of developmental psychology: International Wm. T Preyer Symposium*, G. Eckhardt & et al, eds., Berlin: Mouton.

Kelley, E. M. 1992, *The metaphorical basis of language: A study in cross-cultural linguistics, or, The left-handed hummingbird.,* Lewiston, NY: Edwin Mellen Press.

Kelly, G. A. 1955, *A theory of personality: The psychology of personal constructs,* New York: W.W. Norton.

Kelvin, L. W. T. 1904, *Baltimore lectures on molecular dynamics and the wave theory of light,* London: Cambridge University Press.

Kemp, M. 1995b, "Spirals of Life: D'Arcy Thompson and Theodore Cook, with Leonardo and Durer in Retrospect", *Physis*, **32**, 37-54.

Kennedy, D. N., O'Craven, K. M., Ticho, B. S., Goldstein, A. M., Makris, N., & Henson, J. W. 1999, "Structural and functional brain asymmetries in human situs inversus totalis", *Neurology*, **53**, 1260-1265.

Kennedy, M. 1999, "Rome had sinister drivers as well as dextrous builders", *The Guardian*, **27th October**, 6-6.

Kerford, G. B. & Walford, D. E. 1968b, *Kant: Selected pre-critical writings and correspondence with Beck,* Manchester: Manchester University Press.

Kilmurray, E. & Ormond, R. 1998, *John Singer Sargent,* London: Tate Gallery.

Kilner, P. J., Yang, G.-Z., Wilkes, A. J., Mohiaddin, R. H., Firmin, D. N., & Yacoub, M. H. 2000, "Asymmetric redirection of flow through the heart", *Nature*, **404**, 759-761.

Kimura, D. 1961d, "Cerebral dominance and the perception of verbal stimuli", *Canadian Journal of Psychology*, **15**, 166-171.

Kimura, D. 1999f, *Sex and cognition,* Cambridge, MA: MIT Press.

Kincaid, P. 1986b, *The rule of the road: An international guide to history and practice,* New York: Greenwood Press.

King, H. E. 1909, "Studies on sex determination in amphibians II", *Biological Bulletin*, **16**, 27-43.

King, H. E. 1911, "The effects of semi-spaying and of semi-castration on the sex-ratio of the albino rat (*Mus norvegicus albinus*).", *Journal of Experimental Zoology*, **10**, 381-392.

Kinsbourne, M. 1975c, "The mechanism of hemispheric control of the lateral gradient of attention," pp. 81-97 in *Attention and performance, volume 5*, P. M. A. Rabbitt & S. Dornic, eds., New York: Academic Press.

Kinsbourne, M. & Warrington, E. K. 1962a, "A study of finger agnosia", *Brain*, **85**, 47-66.

Klar, A. J. S. 1996c, "A Single Locus, *RGHT*, Species Preference for Hand Utilization in Humans", *Cold Spring Harbor Symposia on Quantitative Biology*, **61**, 59-65.

Klee, P. 1970, *Unendliche Naturgeschichte,* Basel: Schwabe.

Kline, P. 1972, *Fact and fantasy in Freudian theory,* London: Methuen.

Knecht, S., Deppe, M., Dräger, B., Bobe, L., Lohmann, H., Ringelstein, E.-B., & Henningsen, H. 2000, "Language lateralization in healthy right-handers", *Brain*, **123**, 74-81.

Knecht, S., Deppe, M., Ebner, A., Henningsen, H., Huber, T., Jokeit, H., & Ringelstein, E.-B. 1998b, "Noninvasive determination of language lateralization by functonal transcranial Doppler sonography: A comparison with the Wada test", *Stroke*, **29**, 82-86.

Knecht, S., Deppe, M., Ringelstein, E.-B., Wirtz, M., Lohmann, H., Dräger, B., Huber, T., & Henningsen, H. 1998a, "Reproducibility of functional transcranial Doppler sonography in determining hemispheric language lateralisation", *Stroke*, **29**, 1155-1159.

Knecht, S., Dräger, B., Deppe, M., Bobe, L., Lohmann, H., Floël, A., Ringelstein, E.-B., & Henningsen, H. 2000m, "Handedness and hemispheric language dominance in healthy humans", *Brain*, **123**, 2512-2518.

Knecht, S., Dräger, B., Floël, A., Lohmann, H., Breitenstein, M., Deppe, M., Henningsen, H., & Ringelstein, E.-B. 2001, "Behavioural relevance of atypical language lateralization in healthy subjects", *Brain*, **124**, 1657-1665.

Knightley, P., Evans, H., Potter, E., & Wallace, M. 1979, *Suffer the children: The story of thalidomide,* London: Andre Deutsch.

Konstom, N. 1977, "Rembrandt's use of models and mirrors", *Burlington Magazine*, **99**, 94-98.

Kögl, F. & Erxleben, H. 1939, "The glutamic acid of tumour proteins", *Nature*, **144**, 111-111.

Kraig, B. 1978, "Symbolism in burial orientations among early Indo-Europeans", *Journal of Indo-European Studies*, **6**, 149-172.

Kurti, N. & Sutton, C. 1997b, "Parity and chivalry in nuclear physics", *Nature*, **385**, 575-575.

Labaree, L. W., Boatfield, H. C., Fineman, H. H., & Hutson, J. H. 1966, *The papers of Benjamin Franklin: volume 10, January 1, 1762, through December 31, 1763,* New Haven: Yale University Press.

Laeng, B. & Rouw, R. 2001, "Canonical views of faces and the cerebral hemispheres", *Laterality*, **6**, 193-224.

Lalumière, M. L., Blanchard, R., & Zucker, K. J. 2000i, "Sexual orientation and handedness in men and women: a meta-analysis", *Psychological Bulletin*, **126**, 575-592.

Lamzin, V. S., Dauter, Z., & Wilson, K. S. 1995, "How nature deals with stereoisomers", *Current Opinion in Structural Biology*, **5**, 830-836.

Lanchner, C. 1987, *Paul Klee,* New York: Museum of Modern Art.

Landes, D. S. 2000, *Revolution in time: Clocks and the making of the modern world,* London: Viking.

Langford, S. 1984, *The left-handed book,* London: Granada Publishing.

Larsen, W. J. 1998, *Essentials of human embryology,* New York: Churchill Livingstone.

Laska, M. 1998, "Laterality in the use of the prehensile tail in the spider monkey (*Ateles geoffroyi*)", *Cortex*, **34**, 123-130.

Laska, M. & Tutsch, M. 2000, "Laterality of tail resting posture in three species of New World primates", *Neuropsychologia*, **38**, 1040-1046.

Latham, R. E. & Godwin, J. 1994, *Lucretius: On the nature of the universe,* Harmondsworth: Penguin.

Latimer, H. B. & Lowrance, E. W. 1965, "Bilateral asymmetry in weight and in length of human bones", *Anatomical Record*, **152**, 217-224.

Lauterbach, C. E. 1925, "Studies in twin resemblance", *Genetics*, **10**, 525-568.

Lawler, A. 2001, "Writing gets a rewrite", *Science*, **292**, 2418-2420.

Lawless, J. G., Kvenvolden, K. A., Peterson, E., Ponnamperuma, C., & Moore, C. 1971, "Amino acids indigenous to the Murray meteorite", *Science*, **173**, 626-627.

Lawton, G. 2002c, "The great giveaway", *New Scientist*, **2nd Feb**, 34-37.

Layton, C. 1993, "Incidence of left- to right-handedness in British Shotokan karate masters", *Percept.Mot.Skills*, **76**, 969-970.

Layton, W. M. 1976b, "Random determination of a developmental process", *Journal of Heredity*, **67**, 336-338.

Layton, W. M. 1976a, "Random determination of a developmental process", *Journal of Heredity*, **67**, 336-338.

Layton, W. M. 1978, "Heart malformations in mice homozygous for a gene causing situs inversus", *Birth Defects*, **14**, 277-293.

Lazarus, L. H., Bryant, S. D., Cooper, P. S., & Salvadori, S. 1999, "What peptides these deltorphins be", *Prog.Neurobiol.*, **57**, 377-420.

Leach, E. 1976, *Culture and communication: The logic by which symbols are connected,* Cambridge: Cambridge University Press.

Lecours, A. R. 1980, "Correlations anatomo-cliniques de l'aphasie. La zone du langage.", *Revue Neurologique,* **136**, 591-608.

Lecours, A. R., Mehler, J., Parente, M.-A., & Vadeboncoeur, A. 1988a, "Literacy and the brain," pp. 291-300 in *The alphabet and the brain: the lateralization of writing*, D. De Kerckhove & C. J. Lumsden, eds., Berlin: Springer-Verlag.

Lee, J. J., Ekker, S. C., Von Kessler, D. P., Porter, J. A., Sun, B. I., & Beachy, P. A. 1994, "Autoproteolysis in hedgehog protein biogenesis", *Science*, **266**, 1528-1537.

Lee, T. D. & Yang, C. N. 1956, "Question of parity conservation in weak interactions", *Physical Review*, **104**, 254-258.

Leeming, J. J. 1969c, *Road accidents: prevent or punish?,* London: Cassell.

Leibniz, G. W. 1951, *Theodicy: Essays on the goodness of God the freedom of man and the origin of evil [Translated by E.M. Huggard],* London: Routledge and Kegan Paul.

Leibowitz, J. O. 1970, *The history of coronary heart disease,* London: Wellcome Institute of the History of Medicine.

Lenhoff, H. M. 1991, "Ethel Browne, Hans Spemann, and the discovery of the organizer phenomenon", *Biological Bulletin*, **181**, 72-80.

LeQuesne, A. L. 1982, *Carlyle,* Oxford: Oxford University Press.

Levin, M. & Mercola, M. 1998, "Gap junctions are involved in the early generation of left-right asymmetry", *Developmental Biology*, **203**, 90-105.

Levin, M., Pagan, S., Roberts, D. J., Cooke, J., Kuehn, M. R., & Tabin, C. J. 1997, "Left/right patterning signals and the independent regulation of different aspects of *situs* in the chick embryo", *Developmental Biology*, **189**, 57-67.

Levin, M., Roberts, D. J., Holmes, L. B., & Tabin, C. 1996, "Laterality defects in conjoined twins", *Nature*, **384**, 321-321.

Levy, J., Heller, W., Banich, M. T., & Burton, L. A. 1983c, "Asymmetry of perception in free viewing of chimeric faces", *Brain and Cognition*, **Vol 2**, 404-419.

Lias, J. J. 1902, *The Book of Judges,* Cambridge: Cambridge University Press.

Liederman, J. & Healey, J. M. 1986, "Independent dimensions of hand preference: reliability of the factor structure and the handedness inventory", *Archives of Clinical Neuropsychology*, **1**, 371-386.

Lightbown, R. 1989, *Sandro Botticelli: Life and work,* London: Thames and Hudson.

Lilenfeld, S. O., Wood, J. M., & Garb, H. N. 2001, "What's wrong with this picture?", *Scientific American*, **284 (May)**, 73-79.

Lindsay, R. 1980, *The left-handed book,* New York: Franklin Watts.

Lindsay, R. 1996k, *Left is right: The survival guide for living lefty in a right-handed world,* Englewood Cliffs, NJ: Gilmour House.

Lipson, H. & Pollack, J. B. 2000, "Automatic design and manufacture of robotic lifeforms", *Nature*, **406**, 974-978.

Litchfield, H. E. 1915, *Emma Darwin: A century of family letters, 1792-1896,* London: John Murray.

Lloyd, G. E. R. 1966b, *Polarity and analogy,* London: Cambridge University Press.

Lockhart, J. G. 1896, *The life of Sir Walter Scott, Bart.,* London: Adam and Charles Black.

Lowrie, W. & Alvarez, W. 1981, "One hundred million years of geomagnetic polarity history", *Geology*, **9**, 392-397.

Lubec, G., Weninger, M., & Anderson, S. R. 1994, "Racemization and oxidation studies of hair protein in the *Homo tyrolensis*", *FASEB Journal*, **8**, 1166-1169.

Lucas, P. H. 1946, "The importance of the dominant eye", *Optometric Weekly*, **37**, 1132-1132.

Ludwig, W. 1932, *Das Rechts-Links-Problem im Tierreich und beim Menschen,* Berlin: Verlag Julius Springer.

Luhrmann, T. M. 2001, "The touch of the real", *Times Literary Supplement*, **12th January**, 3-4.

Luria, A. R. 1970c, *Traumatic aphasia: Its syndromes, psychology and treatment,* The Hague: Mouton.

MacCurdy, E. 1958, *The notebooks of Leonardo da Vinci,* New York: George Braziller.

MacDermott, A. J. 1996, "The weak force and SETH: The Search for Extra-Terrestrial Homochirality," pp. 241-254 in *Physical origin of homochirality in life*, D. B. Cline, ed., Woodbury, NY.

MacDermott, A. J., Barron, L. D., Brack, A., Buhse, T., Drake, A. F., Emery, R., Gottarelli, G., Greenberg, J. M., Haberle, R., Hegstrom, R. A., Hobbs, K., Kondepudi, D. K., McKay, C., Moorbath, S., Raulin, F., Sandford, M., Schwartzman, D. W., Thiemann, W. H.-P., Tranter, G. E., & Zarnecki, J. C. 1996, "Homochirality as the signature of life: the SETH cigar", *Planetary and Space Science*, **44**, 1441-1446.

Mach, E. 1910, *Popular scientific lectures,* 4 edn, Chicago: Open Court.

Mach, E. 1914, *The analysis of sensations,* 5 edn, Chicago: Open Court.

MacNulty, A. S. 1933, *Sir Walter Scott: The wounded falcon,* London: Johnson.

Maddox, J. 1991i, "The semantics of plane-mirror inversion", *Nature*, **353**, 791-791.

Madge, N., Diamond, J., Miller, D., Ross, E., McManus, I. C., Wadsworth, J., & Yule, W. 1993, *The National Childhood Encephalopathy Study: A ten year follow-up. A report on the behavioural and educational outcomes after serious, acute, neurological illness in early childhood,* London: Developmental Medicine and Child Neurology, Supplement No.68, vol 35, No.7, MacKeith Press.

Mair, P. 2000, "Pariah politics", *The Guardian* 15-15.

Maki, R. H., Grandy, C. A., & Hauge, G. 1979c, "Why is telling right from left more difficult than telling above from below?", *Journal of Experimental Psychology Human Perception and Performance*, **5**, 52-67.

Mallory, J. P. & Adams, D. Q. 1997, *Encyclopaedia of Indo-European culture,* London: Fitzroy Dearborn.

Man, E. H. & Bada, J. L. 1987, "Dietary D-amino acids", *Annual Review of Nutrition*, **7**, 209-225.

Marchant-Haycox, S. E., McManus, I. C., & Wilson, G. D. 1991, "Left-handedness, homosexuality, HIV infection and AIDS", *Cortex*, **27**, 49-56.

Marchetti, C. & Della Sala, S. 1997, "On crossed apraxia. Description of a right-handed apraxic patient with right supplementary motor area damage", *Cortex*, **33**, 341-354.

Markey, T. L. 1982, "Indo-European etyma for 'left,left-handed' and markedness reversal", *Mankind Quarterly*, **23**, 183-194.

Marks, J. S. & Williamson, D. F. 1991, "Left-handedness and life expectancy", *New England Journal of Medicine*, **325**, 1042-1042.

Marsh, G. G. & Philwin, B. 1987, "Unilateral neglect and constructional apraxia in a right-handed artist with a left posterior lesion", *Cortex*, **23**, 149-155.

Marshall, J. C. 2001, "Auditory neglect and right parietal cortex", *Brain*, **124**, ???-???

Marshall, J. C. & Halligan, P. W. 1993, "Visuo-spatial neglect: a new copying test to assess perceptual parsing", *Journal of Neurology*, **240**, 37-40.

Martin, M. & Jones, G. V. 1999, "Hale-Bopp and handedness: Individual differences in memory for orientation", *Psychological Science*, **10**, 267-270.

Mason, S. F. 1989, "The development of concepts of chiral discrimination", *Chirality*, **1**, 183-191.

Mason, S. F. 1991, *Chemical evolution: Origin of the elements, molecules and living systems,* Oxford: Clarendon Press.

Mather, J. Y. & Speitel, H. H. 1975, *The linguistic atlas of Scotland: Scots Section, Volume 1,* London: Croom Helm.

Mattevi, A., Vanoni, M. A., Todone, F., Rizzi, M., Teplyakov, A., Coda, A., Bolognesi, M., & Curti, B. 1996, "Crystal structure of D-amino acid oxidase: a case of active site mirror-image convergent evolution with flavocytochrome b2", *Proc.Natl.Acad.Sci.U.S.A*, **93** , 7496-7501.

Mauss, M. 1990, *The gift: The form and reason for exchange in archaic societies,* London: Routledge.

Maxwell, A. E. 1977, *Multivariate analysis in behavioural research,* London: Chapman and Hall.

Mayes, I. 2001, "I kid you not", *The Guardian*, **3rd March, Saturday Review**, 7-7.

Mayhew, A. L. 1895, "Left-handedness", *Notes and Queries (Eighth Series)*, **7**, 316-316.

Maynard Smith, J. & Szathmáry, E. 1995, *The major transitions in evolution,* Oxford: W.H.Freeman.

Mazziotti, M. V., Willis, L. K., Heuckeroth, R. O., LaRegina, M. C., Swanson, P. E., Overbeek, P. A., & Perlmutter, D. H. 1999, "Anomalous development of the hepatobiliary system in the Inv mouse", *Hepatology*, **30**, 372-378.

McGuire, W. J. & McGuire, C. V. 1980, "Salience of handedness in the spontaneous self-concept", *Perceptual and Motor Skills*, **1980**, 3-7.

McLean, J. M. & Churczak, F. M. 1982, "Bimanual dexterity in major league baseball players: A statistical study", *New Engl.J.Med.*, **307**, 1278-1279.

McManus, I. C. 1979f, *Determinants of laterality in man,* University of Cambridge: Unpublished PhD thesis.

McManus, I. C. 1980, "The aesthetics of simple figures", *British Journal of Psychology*, **71**, 505-524.

McManus, I. C. 1981, "Handedness and birth stress", *Psychological Medicine*, **11**, 485-496.

McManus, I. C. 1983, "Pathological left-handedness: Does it exist?", *Journal of Communication Disorders*, **16**, 315-344.

McManus, I. C. 1984, "The genetics of handedness in relation to language disorder," pp. 125-138 in *Advances in Neurology, vol 42: Progress in Aphasiology*, F. C. Rose, ed., New York: Raven Press.

McManus, I. C. 1985a, *Handedness, language dominance and aphasia: a genetic model. Psychological Medicine, Monograph Supplement No.8,*

McManus, I. C. 1985b, "Right- and left-hand skill: failure of the right shift model", *British Journal of Psychology*, **76**, 1-16.

McManus, I. C. 1991c, "The inheritance of left-handedness," pp. 251-281 in *Biological asymmetry and handedness (Ciba foundation symposium 162)*, G. R. Bock & J. Marsh, eds., Chichester: Wiley.

McManus, I. C. 1995a, "Familial sinistrality: the utility of calculating exact genotype probabilities for individuals", *Cortex*, **31**, 3-24.

McManus, I. C. 1995b, "Increased mortality in women doctors [letter]", *Lancet*, **345**, 796-797.

McManus, I. C. 1996, "Handedness," pp. 367-376 in *The Blackwell Dictionary of Neuropsychology*, J. G. Beaumont, P. M. Kenealy, & M. J. C. Rogers, eds., Oxford: Blackwell.

McManus, I. C. 1997b, "Anaesthetists are younger than other doctors [letter]", *British Medical Journal*, **315**, 314-314.

McManus, I. C. 1997a, "Which doctors die first? Recording the doctors' sex might have led authors to suspect their conclusions [correspondence]", *British Medical Journal*, **314**, 1132-1132.

McManus, I. C. 1999, "Handedness, cerebral lateralization and the evolution of language," pp. 194-217 in *The descent of mind: Psychological perspectives on hominid evolution*, M. C. Corballis & S. E. G. Lea, eds., Oxford: Oxford University Press.

McManus, I. C. 2001b, "Charles Dickens: A neglected diagnosis?", *Lancet*, **358**, 2158-2161.

McManus, I. C. 2001a, "H C Bastian, Aldous Huxley, and Jonathan Osborne", *Lancet*, **357**, 1210-1210.

McManus, I. C. & Bryden, M. P. 1991, "Geschwind's theory of cerebral lateralization: Developing a formal causal model", *Psychological Bulletin*, **110**, 237-253.

McManus, I. C. & Bryden, M. P. 1992c, "The genetics of handedness, cerebral dominance and lateralization," pp. 115-144 in *Handbook of Neuropsychology, Volume 6, Section 10: Child neuropsychology (Part 1)*, I. Rapin & S. J. Segalowitz, eds., Amsterdam: Elsevier.

McManus, I. C. & Cornish, K. M. 1997, "Fractionating handedness in mental retardation: What is the role of the cerebellum?", *Laterality*, **2**, 81-90.

McManus, I. C., Edmondson, D., & Rodger, J. 1985, "Balance in pictures", *British Journal of Psychology*, **76**, 311-324.

McManus, I. C. & Humphrey, N. K. 1973, "Turning the left cheek", *Nature*, **243**, 271-272.

McManus, I. C. & Mascie-Taylor, C. G. N. 1979, "Hand-clasping and arm-folding: a review and a genetic model", *Annals of Human Biology*, **6**, 527-558.

McManus, I. C. & Mascie-Taylor, C. G. N. 1983d, "Biosocial correlates of cognitive abilities", *Journal of Biosocial Science*, **15**, 289-306.

McManus, I. C., Murray, B., Doyle, K., & Baron-Cohen, S. 1992, "Handedness in childhood autism shows a dissociation of skill and preference", *Cortex*, **28**, 373-381.

McManus, I. C., Porac, C., Bryden, M. P., & Boucher, R. 1999g, "Eye dominance, writing hand and throwing hand", *Laterality*, **4**, 173-192.

McManus, I. C. & Richards, P. 1984, "An audit of admission to medical school: 1. Acceptances and rejects", *British Medical Journal*, **289**, 1201-1204.

McManus, I. C., Richards, P., & Maitlis, S. L. 1989, "Prospective study of the disadvantage of people from ethnic minority groups applying to medical schools in the United Kingdom", *British Medical Journal*, **298**, 723-726.

McManus, I. C., Richards, P., Winder, B. C., Sproston, K. A., & Styles, V. 1995, "Medical school applicants from ethnic minorities: identifying if and when they are disadvantaged", *British Medical Journal*, **310**, 496-500.

McManus, I. C., Richards, P., Winder, B. C., Sproston, K. A., and Vincent, C. A. 1993, "British medical students' perceptions of medical school teaching", *Medical Education*, in press.

McManus, I. C., Shergill, S., & Bryden, M. P. 1993a, "Annett's theory that individuals heterozygous for the right shift gene are intellectually advantaged: Theoretical and empirical problems", *British Journal of Psychology*, **84**, 517-537.

McManus, I. C., Sik, G., Cole, D. R., Mellon, A. F., Wong, J., & Kloss, J. 1988, "The development of handedness in children", *British Journal of Developmental Psychology*, **6**, 257-273.

McManus, I. C. & Weatherby, P. 1997, "The golden section and the aesthetics of form and composition: a cognitive model", *Empirical Studies of the Arts*, **15**, 209-232.

Meglitsch, P. A. & Schram, F. R. 1991, *Invertebrate zoology,* New York: Oxford UNiversity Press.

Meister, A. 1965, *Biochemistry of the amino acids,* 2 edn, New York: Academic Press.

Melchior-Bonnet, S. 2001h, *The mirror: A history (translator K.H. Jewett),* New York: Routledge.

Mendelson, E. 1976, *W.H. Auden: Collected poems,* London: Faber and Faber.

Mercola, M. & Levin, M. 2001e, "Left-right asymmetry determination in vertebrates", *Annual Review of Cell and Developmental Biology*, **17**, 779-805.

Merrell, D. J. 1957b, "Dominance of hand and eye", *Human Biology*, **29**, 314-328.

Messerli, P., Pegna, A., Sordet, N., & AUDITORY PERCEPTION 1995, "Hemispheric dominance for melody recognition in musicians and non-musicians", *Neuropsychologia*, **33**, 395-405.

Mestel, R. 1998, "Avarice", *New Scientist*, **28th March**, 38-39.

Michael Coren 1995, *Conan Doyle,* London: Bloomsbury.

Michell, P. C. 1913, *Thomas Henry Huxley: A sketch of his life and work,* 2 edn, London: Methuen.

Millar, S. 1999, "Veering re-visited: noise and posture cues in walking without sight", *Perception*, **28**, 765-780.

Miller, G. H., Magee, J. W., & Jull, A. J. T. 1997, "Low-latitude glacial cooling in the Southern Hemisphere from amino-acid racemization in emu eggshells", *Nature*, **385**, 241-244.

Miller, J. 1998, *On reflection,* London: National Gallery.

Miller, J. A. 1950, "Do tumour proteins contain D-amino acids? A review of the controversy", *Cancer Research*, **10**, 65-72.

Milner, A. D. & Goodale, M. A. 1995, *The visual brain in action,* Oxford: Oxford University Press.

Milton, R. C. d., Milton, S. C. F., & Kent, S. B. H. 1992, "Total chemical synthesis of a D-enzyme: the enantiomers of HIV-1 protease show demonstration of reciprocal chiral substrate specificity", *Science*, **256**, 1445-1448.

Mitchison, N. 1965, pp. 51-55 in *Aldous Huxley 1894-1963*, J. Huxley, ed., London: Chatto & Windus.

Mittwoch, U. & Kirk, D. 1975, "Superior growth of the right gonad in human foetuses", *Nature*, **257**, 791-792.

Mochizuki, T., Yukio, S., Tsuchiya, K., Shirayoshi, Y., Takai, S., Taya, C., Yonekawa, H., Overbeek, P. A., Hamada, H., & Yokoyama, T. 1998, "Cloning of inv, a gene that controls left/right asymmetry and kidney development", *Nature*, **395**, 177-181.

Moffat, S. D. & Hampson, E. 1996, "Salivary testosterone levels in left- and right-handed adults", *Neuropsychologia*, **34**, 225-233.

Moffat, S. D. & Hampson, E. 2000, "Salivary testosterone concentrations in left-handers: an association with cerebral language lateralization?", *Neuropsychology*, **14**, 71-81.

Monod, J. 1969, "On symmetry and function in biological systems," pp. 15-27 in *Symmetry and function of biological systems at the macromolecular level*, A. Engström & B. Strandberg, eds., Stockholm: Almqvist and Wiksell.

Moore, G. F. 1895, *A critical and exegetical commentary on Judges,* Edinburgh: T&T Clark.

Moore, M. R., Saver, J. L., Johnson, K. A., & Romero, J. A. 1991, "Right parietal stroke with Gerstmann's syndrome. Appearance on computed tomography, magnetic resonance imaging, and single-photon emission computed tomography", *Arch Neurol.*, **48**, 432-435.

Morgan, M. J. 1977, "Embryology and inheritance of asymmetry," pp. 173-194 in *Lateralization in the nervous system*, S. Harnad et al., eds., New York: Academic Press.

Morgan, M. J. 1978, "Author's response", *Behavioral and Brain Sciences*, **2**, 325-331.

Morgan, M. J. & Corballis, M. C. 1978, "On the biological basis of human laterality: II. The mechanisms of inheritance", *Behavioral and Brain Sciences*, **2**, 270-278.

Morgan, M. J., O'Donnell, J. M., & Oliver, R. F. 1973, "Development of left-right asymmetry in the habenular nuclei of *Rana temporaria*", *Journal of Comparative Neurology*, **149**, 203-214.

Morris, J. S., Smith, K. A., Cowen, P. J., Friston, K. J., & Dolan, R. J. 1999, "Covariation of activity in habenula and dorsal raphe nuclei following tryptophan depletion", *NeuroImage*, **10**, 163-172.

Morris, K. 1998, "Meditating on yogic science", *Lancet*, **351**, 1038-1038.

Morrison, P. 1957a, "The overthrow of parity", *Scientific American*, **196 (April)**, 45-55.

Mouret, M. A. 1959, *Chronique medicale de la ville de Sommières,* Montpellier: Ets Valette.

MØller, A. P. & Pomiankowski, A. 1993, "Fluctuating asymmetry and sexual selection", *Genetica*, **89**, 267-279.

Mullins, J. 2000r, "Integrated circuits (Inside Science No. 136)", *New Scientist*, **9th December**, 1-4.

Mullins, J. 2001, "Perfect focus", *New Scientist*, **14th April**, 35-37.

Mullins, J. 1999b, "Grottoes new", *New Scientist*, **25th Dec 1999**, 66-67.

Munk, W. 1878, *The roll of the Royal College of Physicians of London,* London: Royal College of Physicians.

Murray, A. T. & Wyatt, W. F. 1999, *Homer: Iliad Books 13-24,* Cambridge, MA: Harvard University Press.

Musgrave, J. H. 1971, "How dextrous was Neanderthal man?", *Nature*, **233**, 538-541.

MØller, A. P. & Swaddle, J. P. 1997a, *Asymmetry, developmental instability and evolution,* Oxford: Oxford University Press.

Nabokov, V. 1974, *Bend sinister [First published 1947],* Harmondsworth: Penguin.

Nabokov, V. 1995, *Lolita,* London: Penguin.

Nagata, Y., Akino, T., Ohno, K., Kataoka, Y., Ueda, T., Sakurai, T., Shiroshita, K.-I., & Yasuda, T. 1987, "Free D-amino acids in human plasma in relation to senescence and renal diseases", *Clinical Science*, **73**, 105-108.

National Portrait Gallery 1994, *The Sitwells and the arts of the 1920s and 1930s,* London: National Portrait Gallery.

Naveh, J. 1988b, "The origin of the Greek alphabet," pp. 84-91 in *The alphabet and the brain: the lateralization of writing*, D. De Kerckhove & C. J. Lumsden, eds., Berlin: Springer-Verlag.

Needham, J. 1931, *Chemical embryology,* Cambridge: Cambridge University Press.

Needham, J. 1934, *A history of embryology,* Cambridge: Cambridge University Press.

Needham, R. 1958, "A structural analysis of Purum society", *American Anthropologist*, **60**, 75-101.

Needham, R. 1960a, "The left hand of the Mugwe: An analytical note on the structure of Meru symbolism", *Africa*, **30**, 20-33.

Needham, R. 1973, *Right and Left: Essays on dual symbolic classification,* Chicago: University of Chicago Press.

Needham, R. 1979, *Symbolic classification,* Santa Monica, California: Goodyear.

Needham, R. 1987b, *Counterpoints,* Berkeley, CA: University of California Press.

Nelson, D. L. & Cox, M. M. 2000, *Lehninger: Principles of biochemistry,* New York: Worth.

Nerlich, G. 1973, "Hands, knees, and absolute space", *Journal of Philosophy*, **70**, 337-351.

Newman, H. H. 1111, "Symmetry reversal and mirror-imaging in twins and double monsters," pp. 164-189 in *The Physiology of Twinning*, Chicago: The University of Chicago Press.

Newman, H. H., Freeman, F. N., & Holzinger, K. J. 1966, *Twins: A study of heredity and environment,* Chicago: The University of Chicago Press.

Nicholls, M. E. R. & Bradshaw, J. L. M. J. B. 1999, "Free-viewing perceptual asymmetries for the judgement of brightness, numerosity and size", *Neuropsychologia*, **37**, 307-314.

Nichols, J. 1999i, *Linguistic diversity in space and time,* Chicago: University of Chicago Press.

Nicholson, S. 1926, "Social organization of the malas -- An outcaste Indian people", *Journal of the Royal Anthropological Institute of Great Britain and Ireland*, **56**, 91-103.

Nicolle, J. 1962, *Louis Pasteur: A master of scientific enquiry.,* London: The Scientific Book Guild.

Nilles, H. P. 2002d, "Supersymmetrical physics. Review of *The qunatum ftheory of fields: Volume III, Supersymmetry* by Steven Weinberg.", *Nature*, **412**, 483-484.

Nishida, T. 1993, "Left nipple sucking preference in wild chimpanzees", *Ethology and Sociobiology*, **14**, 45-52.

Nonaka, S., Tanaka, Y., Okada, Y., Takeda, S., Harada, A., Kanai, Y., Kido, M., & Hirokawa, N. 1998, "Randomisation of left-right asymmetry due to loss of nodal cilia generating leftward flow of extraembryonic fluid in mice lacking KIF3B motor protein", *Cell*, **95**, 829-837.

O'Boyle, M. W. & Benbow, C. P. 1990, "Handedness and its relationship to ability and talent," pp. 343-372 in *Left-handedness: Behavioral implications and anomalies*, S. Coren, ed., Amsterdam: North-Holland.

O'Shea, T. M. 1994f, *Symmetry and self: James Joyce and boustrophedonic writing,* University of Minnesota: PhD thesis.

Obersteiner, H. 1882, "On allochiria: A peculiar sensory disorder", *Brain*, **4**, 153-163.

Ogle, W. 1871, "On dextral pre-eminence", *Medical-Chirurgical Transactions (Transactions of the Royal Medical and Chirurgical Society of London)*, **54**, 279-301.

Okada, Y., Nonaka, S., Tanaka, Y., Saijoh, Y., Hamada, H., & Hirokawa, N. 1999, "Abnormal nodal flow precedes situs inversus in *iv* and *inv* mice", *Molecular Cell*, **4**, 459-468.

Oldfield, R. C. 1969d, "Handedness in musicians", *British Journal of Psychology*, **60**, 91-99.

Ondaatje, M. 1989g, *The collected works of Billy the Kid [first published 1970],* London: Picador.

Oort, J. H. 1957, "The Crab nebula", *Scientific American*, **196**, 52-60.

Oppe, A. P. 1944, "Right and Left in Raphael's Cartoons", *Journal of the Warburg and Courtauld Institutes*, **7**, 82-94.

Oppenheimer, J. M. 1974b, "Asymmetry revisited", *American Zoologist*, **14**, 867-879.

Orgel, L. E. 1973, *The origins of life: Molecules and natural selection,* London: Chapman and Hall.

Orme, C., Noy, A., Wierzbicki, A., McBride, M. T., Grantham, M., Teng, H. H., Dove, P. M., & DeYoreo, J. J. 2001, "Formation of chiral morphologies through selective binding of amino acids to calcite surface steps", *Nature*, **411**, 775-778.

Orwell, G. 1970, *The collected essays, journalism and letters of George Orwell: Volume I: An age like this, 1920-1940.,* Harmondsworth: Penguin.

Orwell, G. 1970, *The collected essays, journalism and letters of George Orwell: Volume IV: In front of your nose, 1945-1950.,* Harmondsworth: Penguin.

Osborne, J. 1834b, "On the loss of the faculty of speech depending on forgetfulness of the art of using the vocal organs", *Dublin Journal of Medical and Chemical Science*, **4**, 157-170.

Osler, W. 1883, "Sir Thomas Watson, Bart, MD, FRS", *Canadian Practitioner (Toronto)*, **8**, 54-55.

Osler, W. 1939, *Aequanimitas,* London: H K Lewis.

Oster, J. 1971, "Varicocele in children and adolescents", *Scandinavian Journal of Urology and Nephrology*, **5**, 27-32.

Palmer, A. R. 1996f, "From symmetry to asymmetry: Phylogenetic patterns of asymmetry variation in animals and their evolutionary significance", *Proceedings of the National Academy of Sciences of the USA*, **93**, 14279-14286.

Palmer, A. R. 2000d, "Quasireplication and the contract of error: Lessons from sex ratios, heritabilities and fluctuating asymmetry", *Annual Review of Ecology and Systematics*, **31**, 441-480.

Palmer, A. R. & Hammond, L. M. 2000e, "The emperor's codpiece: A post-modern perspective on biological asymmetries", *International Society for Behavioural Ecology Newletter*, **12 (2)**, 13-20.

Palmer, A. R. & Strobeck, C. 1986, "Fluctuating asymmetry: measurement, analysis, patterns", *Annual Review of Ecology and Systematics*, **17**, 391-421.

Palmer, A. R. & Strobeck, C. 2001d, "Fluctuating asymmetry analyses revisited", *Manuscript submitted*.

Palmer, S. E. 1978, "Fundamental aspects of cognitive representation," pp. 259-303 in *Cognition and categorization*, E. Rosch & B. B. Lloyd, eds., Hillsdale, NJ: Lawrence Erlbaum.

Parkin, A. J. 1996, *Explorations in cognitive neuropsychology,* Hove: Psychology Press.

Parkin, R. 1996, *The dark side of humanity: The work of Robert Hertz and its legacy,* Amsterdam: Harwood.

Parraudeau, M., Scott, J., Walsh, C., Oakley, C., Bloom, S., & Brooks, D. 1994, "Late presentation of Kartagener's syndrome", *British Medical Journal*, **308**, 519-521.

Paskauskas, R. A. 1993, *The complete correspondence of Sigmund Freud and Ernest Jones 1908-1939,* Cambridge, MA: Harvard University Press.

Paul, D. 1990, *Living left-handed,* London: Bloomsbury.

Paul, D. 1993f, *Left-handed helpline: An essential guide for teachers, teacher trainers and parents of left-handed children,* Manchester: Dextral Books.

Paxman, J. 1999, *The English: A portrait of a people,* London: Penguin Books.

Payne, L. M. 1960, "Title of the Royal College of Physicians of London", *British Medical Journal*, **1**, 123-124.

Pearsall, R. 1971, *The worm in the bud,* Harmondsworth: Penguin.

Pearson, H. 1943, *Conan Doyle,* London: Methuen.

Peck, A. L. 1937, *Aristotle: Parts of animals,* London: Heinemann.

Peck, A. L. 1953, *Aristotle: Generation of Animals,* Cambridge,MA: Loeb.

Peckham, M. 1959, *The Origin of Species by Charles Darwin: A variorum text,* Philadelphia: University of Pennsylvania Press.

Penrose, R. 1971, *Portrait of Picasso,* 2 edn, London: Lund Humphries.

Perelle, I. B. & Ehrman, L. 1982, "What is a lefthander?", *Experientia*, **38**, 1257-1258.

Peters, M. 1987e, "A nontrivial motor performance difference between right-handers and left-handers: attention as intervening variable in the expression of handedness", *Canadian Journal of Psychology*, **41**, 91-99.

Peters, M. 1990d, "Subclassification of non-pathological left-handers poses problems for theories of handedness", *Neuropsychologia*, **28**, 279-289.

Peters, M. 1992h, "Are there more lefthanders among the mathematically gifted? Benbow's evidence is weak", *Canadian Journal of Psychology*, **????**, ????-????

Peters, M. & Servos, P. 1989b, "Performance of subgroups of left-handers and right-handers", *Canadian Journal of Psychology*, **43**, 341-358.

Peterson, J. M. & Lansky, L. M. 1974, "Left-handedness among architects: Some facts and speculations", *Perceptual and Motor Skills*, **38**, 547-550.

Petroski, H. 1989a, *The pencil,* London: Faber and Faber.

Petroski, H. 1994c, *The evolution of useful things,* New York: Vintage Books.

Petsko, G. A. 1992, "On the other hand ...", *Science*, **256**, 1403-1404.

Piaget, J. 1928, *Judgement and reasoning in the child,* London: Kegan Paul, Trench and Trubner.

Pilgrim, I. 1986, "A solution to the too-good-to-be-true paradox and Gregor Mendel", *Journal of Heredity*, **77**, 218-220.

Pipe, M.-E. 1990, "Mental retardation and left-handedness: evidence and theories," pp. 293-318 in *Left-handedness: behavioral implications and anomalies*, S. Coren, ed., Amsterdam: North-Holland.

Piro, J. M. 1993c, "Laterality effects for music perception among differentially talented adolescents", *Perceptual and Motor Skills*, **76**, 499-514.

Pizzarello, S. & Cronin, J. R. 2000, "Non_racemic amino acids in the Murchison and Murray meteorites", *Geochim.Cosmochim.Acta*, **64**, 329-338.

Pizzarello, S., Huang, Y., Becker, L., Poreda, R. J., Nieman, R. A., Cooper, G., & Williams, M. 2001, "The organic content of the Tagish Lake meteorite", *Science*, **293**, 2236-2239.

Plessner, M. 1970a, "New and old topics relative to left and right," pp. 107-107 in *Folklore Research Center Studies: Volume 1* , D. Noy & I. Ben-Ami, eds., Jerusalem: Magnes Press.

Policansky, D. 1982, "The asymmetry of flounders", *Scientific American*, **246 (May)**, 96-102.

Porac, C. 1993b, "Are age trends in adult hand preference best explained by developmental shifts or generational differences?", *Canadian Journal of Experimental Psychology*, **47**, 697-713.

Porac, C. & Coren, S. 1976, "The dominant eye", *Psychological Bulletin*, **83**, 880-897.

Porac, C. & Coren, S. 1981, *Lateral preferences and human behaviour,* New York: Springer Verlag.

Porta, G. B. d. 1593, *De refractione, optices parte: liber novem,* Naples: Horatii Salvania.

Porter, C. 2000c, "That famous double helix takes a sinister turn", *Nature*, **406**, 234-234.

Posèq, A. W. G. 1997g, "Left and right in Leonardo", *Konsthistorisk tidskrift.*, **66**, 37-50.

Posnansky, M. 1959, "Some functional considerations on the handaxe", *Man*, **59**, 42-44.

Powell, M. A. 1981, "Three problems in the history of cuneiform writing: origins, direction of script, literacy", *Visible Language*, **15**, 419-440.

Previc, F. H. & Saucedo, J. C. 1992, "The relationship between turning behavior and motoric dominance in humans", *Perceptual and Motor Skills*, **75**, 935-944.

Price, C. M. & Gilden, D. L. 2000, "Representations of motion and direction", *Journal of Experimental Psychology Human Perception and Performance*, **26**, 18-30.

Prigatano, G. P. 1996, "Anosognosia," in *The Blackwell Dictionary of Neuropsychology*, J. G. Beaumont, P. M. Kenealy, & M. J. C. Rogers, eds., Oxford: Blackwell.

Provins, K. A. 1997c, "Handedness and speech: A critical reappraisal of the role of genetic and environmental factors in the cerebral lateralization of function", *Psychological Review*, **104**, 554-571.

Pujol, J., Deus, J., Losilla, J. M., & Capdevila, A. 1999, "Cerebral lateralization of language in normal left-handed people studied by functional MRI", *Neurology*, **52**, 1038-1043.

Pye-Smith, P. H. 1871, "On left-handedness", *Guy's Hospital Reports*, **16**, 141-146.

Quercy 1943, "Les fondateurs de la doctrine française de l'aphasie: III. Broca.", *Ann.Mèd.-Psychol.*, **101**, 161-188.

Quinn, H. R. & Witherell, M. S. 1998e, "The asymmetry between matter and antimatter", *Scientific American*, **279 (October)**, 50-55.

Rackham, H. A. 1952, *Pliny: Natural History, volume IX,* Cambridge, MA: Loeb.

Rackham, H. A. 1983, *Pliny: Natural History, volume III,* Cambridge, MA: Loeb.

Ramaley, F. 1913b, "Inheritance of left-handedness", *American Naturalist*, **47**, 730-739.

Rao, Y. & Wu, J. 2001, "Neuronal migration and the evolution of the human brain", *Nature Neuroscience*, **4**, 860-862.

Rapscak, S. Z., Gonzalez-Rothi, L. J., & Heilman, K. M. 1987, "Apraxia in a patient with atypical cerebral dominance", *Brain and Cognition*, **6**, 450-463.

Ravoire, J. 1933, *Le Docteur Marc Dax (de Sommières) et l'Aphasie,* Monpellier: Imprimerie Mari-Lavit.

Raymer, A. M., Merians, A. S., Adair, J. C., Schwartz, R. L., Williamson, D. J. G., Rothi, L. J. G., Poizner, H., & Heilman, K. M. 1999, "Crossed apraxia: Implications for handedness", *Cortex*, **35**, 183-199.

Raymond, M., Pontier, D., Dufour, A., & Pape Møller, A. 1996j, "Frequency-dependent maintenance of left-handedness in humans", *Proceedings of the Royal Society of London, Series B*, **263**, 1627-1633.

Reade, J. 1998, *Assyrian sculpture,* London: British Museum.

Regard, M. & Landis, T. 1997, ""Gourmand syndrome": Eating passion associated with right anterior lesions", *Neurology*, **Vol 48**, 1185-1190.

Regard, M. & Landis, T. 1998, ""Gourmand syndrome": Reply", *Neurology*, **Vol 50**, 831.

Regis, E. 1998, *Who got Einstein's office? Eccentricity and genius at the Institute for Advanced Study,* London: Simon and Schuster.

Reiss, M. 1994, "Leg-crossing: Incidence and inheritance", *Neuropsychologia*, **32**, 747-750.

Renfrew, C. 1987d, *Archaeology and language: the puzzle of Indo-European origins,* London: Jonathan Cape.

Reynolds, L. M. & Locke, S. 1971, "Relation between handedness and side of onset of Parkinsonism", *Lancet*, **ii**, 714-714.

Ribó, J. M., Crusats, J., Sagués, F., Claret, J., & Rubires, R. 2001, "Chiral sign induction by vortices during the formation of mesophases in stirred solutions", *Science*, **292**, 2063-2066.

Richardson, J. 1991, *A life of Picasso. Vol I: 1881-1906,* London: Jonathan Cape.

Richmond, B. G. & Strait, D. S. 2000, "Evidence that humans evolved from a knuckle-walking ancestor", *Nature*, **404**, 382-385.

Rife, D. C. 1940, "Handedness, with special reference to twins", *Genetics*, **25**, 178-186.

Rigby, P. 1966a, "Dual symbolic classification among the Gogo of central Tanzania", *Africa*, **36**, 1-16.

Rikken, G. L. J. A. & Raupach, E. 2000g, "Enantioselective magnetochiral photochemistry", *Nature*, **405**, 932-935.

Robertson, I. H. 1993, "The relationship between lateralised and non-lateralised attentional deficits in unilateral neglect," pp. 257-275 in *Unilateral neglect: Clinical and experimental studies*, I. H. Robertson & J. C. Marshall, eds., Hove: Lawrence Erlbaum Associates.

Roche, H., Delagnes, A., Brugal, J. P., Feibel, C., Kibunjia, M., Mourre, V., & Texier, P. J. 1999, "Early hominid stone tool production and technical skill 2.34 Myr ago in West Turkana, Kenya", *Nature*, **399**, 57-62.

Rogers, L. J. 2000p, "Evolution of side biases: Motor versus sensory lateralization," pp. 3-40 in *Side bias: A neuropsychological perspective*, M. K. Mandal, M. B. Bulman-Fleming, & G. Tiwari, eds., Dordrecht: Kluwer.

Roper, T. A. 1999, "Time for a sinister practice", *British Medical Journal*, **319**, 1509-1509.

Rorschach, H. 1942, *Psychodiagnostics,* Berne: Huber.

Rosch, E. 1978, "Principles of categorization," pp. 27-48 in *Cognition and categorization*, E. Rosch & B. B. Lloyd, eds., Hillsdale, NJ: Lawrence Erlbaum.

Rosen, J. 1975b, *Symmetry discovered: Concepts and applications in nature and science,* Cambridge: Cambridge University Press.

Ross, P. E. 1991a, "Hard words", *Scientific American*, **April**, 70-79.

Rothman, K. J. 2000, "Epidemiological evidence on health risks of cellular telephones", *Lancet*, **356**, 1837-1840.

Rothman, K. J. 2001, "Cellular telephones and risk of brain tumours", *Lancet*, **357**, 961-961.

Rowe, K. 1999, *Dead hands: Fictions of agency, renaissance to modern,* Stanford, CA: Stanford University Press.

Rubin, W. 1980, *Pablo Picasso: A retrospective,* New York: Museum of Modern Art.

Ruggieri, V. & Milizia, M. 1983, "Tickle perception as micro-experience of pleasure: Its phenomenology on different areas of the body and relation to cerebral dominance", *Perceptual and Motor Skills*, **56**, 903-914.

Ruiz-Trillo, I., Riutort, M., Littlewood, D. T. J., Herniou, E. A., & Baguña, J. 1999, "Acoel flatworms: Earliest extant Bilaterian metazoans, not members of platyhelminthes", *Science*, **283**, 1919-1923.

Runciman, D. 1997e, "Lexicon, 54: Southpaw", *Guardian*, **3rd October, Sport section**, 16-16.

Russell, B. A. W. 1896, "The logic of geometry", *Mind*, **5**, 23.

Rutledge, L. W. & Donley, R. 1992, *The left-hander's guide to life: A witty and informative tour of the world according to southpaws,* New York: Penguin.

Ryan, A. K., Blumberg, B., Rodriguez-Esteban, C., Yonei-Tamura, S., Tamura, K., Tsukui, T., de la Pena, J., Sabbagh, W., Greenwald, J., Choe, S., Norris, D. P., Robertson, E. J., Evans, R. M., Rosenfeld, M. G., & Izpisua Belmonte, J. C. 1998, "Pitx2 determines left-right asymmetry of internal organs in vertebrates", *Nature*, **394**, 545-551.

Rybczynski, W. 2000b, *One good turn: A natural history of the screwdriver and the screw,* New York: Simon and Schuster.

Sacks, O. 1985, *The man who mistook his wife for a hat,* London: Duckworth.

Sadler, N. 1996a, *A sinister way of life: Research into left-handedness in schools in Waltham Forest.,* Vestry House Mueseum, Waltham Forest: Unpublished manuscript.

Sadler, N. 1997f, "A sinister way of life: a search for left-handed material culture," pp. 140-153 in *Experiencing material culture in the western world*, S. M. Pearce, ed., London: Leicester University Press.

Sadler, N. 1996b, "Left on the shelf", *Museums.Journal*, **96**, 30-31.

Sakhuja, T., Gupta, G. C., Singh, M., & Vaid, J. 2001, "Reading habits affect asymmetries in facial affect judgements: A replication", *Brain and Cognition*, **32**, 162-165.

Salam, A. 1958, "Elementary particles and space-time symmetries", *Endeavour*, **17**, 97-105.

Salam, A. 1991, "The role of chirality in the origin of life", *Journal of Molecular Evolution*, **33**, 105-113.

Salam, A. 1992, "Chirality, phase transitions and their induction in amino acids", *Physics Letters B*, **288**, 153-160.

Salmons, J. C., Joseph, B. D., & [Editors] 1998a, *Nostratic: Sifting the evidence,* Amsterdam: John Benjamins.

Samatey, F. A., Imada, K., Nagashima, S., Vonderviszt, F., Kumasaka, T., Yamamoto, M., & Namba, K. 2001, "Structure of the bacterial flagellar protofilament and implications for a switch for supercoiling", *Nature*, **410**, 331-337.

Sandson, T. A., Wen, P. Y., & LeMay, M. 1992, "Reversed cerebral asymmetry in women with breast cancer", *Lancet*, **339**, 523-524.

Sasson, J. M. 1990, *Jonah: A new translation with introduction, commentary and interpretation,* New York: Doubleday.

Sattler, J. B. 1999, *Der umgeschulte Linkshänder, oder, Der Knoten im Gehirn,* Donauwörth: Auer.

Sattler, J. B. 2000, *Links und Rechts in der Wahrnehmung des Menschen: Zur Geschichte der Linkshändigkeit,* Donauwörth: Auer Verlag.

Satz, P. 1972, "Pathological left-handedness: An explanatory model", *Cortex*, **8**, 121-135.

Satz, P., Baymur, L., & Van der Vlugt, H. 1979, "Pathological left-handedness: cross-cultural tests of a model", *Neuropsychologia*, **17**, 77-81.

Scaloni, A., Simmaco, M., & Bossa, F. 1998, "Characterization and analysis of D-amino acids," pp. 3-26 in *D-amino acids in sequences of secreted peptides of multicellular organisms*, P. Jollès, ed., Basel: Birkhäuser Verlag.

Scarr, M. M. 1988e, *The Dial in Old Court, Queens' College Cambridge: Its background, history and use,* Cambridge: Queens' College.

Schaeffer, A. A. 1928, "Spiral movement in man", *Journal of Morphology*, **45**, 293-398.

Schaeffer, A. A. 1931, "On molecular organisation in Ameban protoplasm", *Science*, **74**, 47-51.

Schiller, F. 1979a, *Paul Broca: Explorer of the brain,* Oxford: Oxford University Press.

Schmahl, H. J., Dencker, L., Plum, C., Chahoud, I., & Nau, H. 1996, "Stereoselective distribution of the teratogenic thalidomide analogue EM12 in the early embryo of marmoset monkey, Wistar rat and NMRI mouse", *Arch Toxicol.*, **70**, 749-756.

Schnider, A., Regard, M., Benson, D. F., & Landis, T. 1993, "Effects of a right-hemisphere stroke on an artist's performance", *Neuropsychiatry, Neuropsychology, and Behavioral Neurology*, **6**, 249-255.

Schott, G. D. 1999, "Mirror writing: Allen's self observations, Lewis Carroll's 'looking glass' letters, and Leonardo da Vinci's maps", *Lancet*, **354**, 2158-2161.

Schultz, A. H. 1969, *The life of primates,* London: Weidenfeld and Nicolson.

Schultz, W. W., van Andel, P., Sabelis, I., & Mooyaart, E. 1999, "Magnetic resonance imaging of male and female genitals during coitus and female sexual arousal", *British Medical Journal*, **319**, 1596-1600.

Schwartz, T., Rould, M. A., Lowenhaupt, K., Herbert, A., & Rich, A. 1999, "Crystal structure of the Zα domain of the human editing enzyme ADAR1 bound to left-handed Z-DNA", *Science*, **284**, 1841-1845.

Scott, T. & Eagleson, M. 1983, *Concise Encyclopaedia: Biochemistry,* Berlin: Walter de Gruyter.

Seddon, B. & McManus, I. C. The incidence of left-handedness: a meta-analysis. 1991.

Semaw, S., Renne, P., Harris, J. W. K., Feibel, C. S., Bernor, R. L., Fesseha, N., & Mowbray, K. 1997, "2.5-million-year-old stone tools from Gona, Ethiopia", *Nature*, **385**, 333-336.

Server, P. G., Garcia, H. J., Prieto, G. A., Rigabert, M. M., & Perez, A. M. 1998, "[Right varicocele as first manifestation of situs inversus]", *Actas.Urol.Esp.*, **22**, 528-530.

Shaw, Mr. 1878, "On righthandedness", *Journal of the Anthropological Institute of Great Britain and Ireland*, **7**, 94-96.

Sheeran, T. J. 1985, "Effect of pure and crossed dextrality on marksmanship skill", *Perceptual and Motor Skills*, **61**, 1171-1174.

Shelston, A. 1971, *Thomas Carlyle: Selected writings,* London: Penguin Books.

Shick, J. 1977, "Relationship between hand-eye dominance and lateral errors in basketball free-throw shooting", *Perceptual and Motor Skills*, **44**, 549-550.

Sholl, M. J. & Egeth, H. E. 1981, "Right-left confusion in the adult: A verbal labelling effect", *Memory and Cognition*, **9**, 339-350.

Sicotte, N. L., Woods, R. P., & Mazziotta, J. C. 1999k, "Handedness in Twins: A Meta-analysis", *Laterality*, **4**, 265-286.

Sieratzki, J. S. & Woll, B. 1996, "Why do mothers cradle babies on their left?", *Lancet*, **347**, 1746-1748.

Sieveking, H. 1998, *Fuseli to Menzel: Drawings and watercolors in the the age of Goethe from a German private collection,* Munich: Prestel.

Siewert, A. 1904, "Uber einem fall von Bronchiektasien bei einem Patienten mit situs inversus viscerum", *Klinische Wochenschriften*, **41**, 139-141.

Signoret, J. L., Castaigne, P., Lhermitte, F., Abelanet, R., & Lavorel, P. 1984, "Rediscovery of Leborgne's brain: anatomical description with CT scan", *Brain Lang*, **22**, 303-319.

Silva, D. A. & Satz, P. 1979, "Pathological left-handedness: Evaluation of a model", *Brain and Language*, **7**, 8-16.

Silveri, M. C., Leggio, M. G., & Molinari, M. 1994, "The cerebellum contributes to linguistic production: a case of agrammatic speech following a right cerebellar lesion", *Neurology*, **44**, 2047-2050.

Simoni, A. 1965, *Orologi Italiani dal cinquecento all' ottocento,* Milan: Antonio Vallardi Editore.

Singh, M., Manjary, M., & Dellatolas, G. 2001, "Lateral preferences among Indian school children", *Cortex*, **37**, 231-241.

Sipper, M. & Reggia, J. A. 2001, "Go forth and replicate", *Scientific American*, **August**, 27-35.

Sitwell, O. 1945, *Left hand, Right hand!,* London: Macmillan.

Sitwell, O. 1946, *The scarlet tree,* London: Macmillan.

Skoyles, J. R. 1984f, "Alphabet and the Western mind", *Nature*, **309**, 409-410.

Skoyles, J. R. 1985d, "Did ancient people read with their right hemispheres?: a study in neuropalaeographology", *New Ideas in Psychology*, **3**, 243-252.

Skoyles, J. R. 1988c, "Right hemisphere literacy in the ancient world," pp. 363-380 in *The alphabet and the brain: the lateralization of writing*, D. De Kerckhove & C. J. Lumsden, eds., Berlin: Springer-Verlag.

Slobodin, R. 1997, *W.H.R.Rivers: Pioneer anthropologist, psychiatrist of The ghost road,* Stroud: Sutton.

Smith, J. L. & Cahusac, P. M. B. 2001, "Right-sided asymmetry in sensitivity to tickle", *Laterality*, **6**, 233-238.

Smith, L. L. & Hines, M. Language lateralization and handedness in women prenatally exposed to diethylstilbestrol(DES). 1998.

Smithers, D. W. 1979, *Dickens' doctors,* Oxford: Pergamon Press.

Snyder, P. J. & Harris, L. J. 1997, "The intracarotid amobarbital procedure: an historical perspective", *Brain and Cognition*, **33**, 18-32.

Snyder, T. J. 1991, "Self-rated right-left confusability and objectively measured right-left discrimination", *Developmental Neuropsychology*, **Vol 7**, 219-230.

Sobel, N., Khan, R. M., Saltman, A., Sullivan, E. V., & Gabrieli, J. D. E. 1999, "The world smells different to each nostril", *Nature*, **402**, 35-35.

Soggin, J. A. 1987, *Judges: A commentary,* 2 edn, London: SCM Press.

Sommer, I. E. C., Ramsey, N. F., Bouma, A., & Kahn, R. S. 1999, "Cerebral mirror-imaging in a monozygotic twin", *Lancet*, **354**, 1445-1446.

Soper, H. V. & Satz, P. 1984, "Pathological left-handedness and ambiguous handedness: a new explanatory model", *Neuropsychologia*, **22**, 511-515.

Spalding, J. M. K. & Zangwill, O. L. 1959, "Disturbance of number-form in a case of brain injury", *Journal of Neurology, Neurosurgery, and Psychiatry*, **13**, 24-29.

Spemann, H. 1938, *Embryonic development and induction,* New Haven: Yale University Press.

Spence, K. 2000a, "Ancient Egyptian chronology and the astronomical orientation of pyramids", *Nature*, **408**, 320-324.

Sperber, D. 1975a, *Rethinking symbolism,* Cambridge: Cambridge University Press.

Sperber, D. 1980, "Is symbolic thought prerational?," pp. 25-44 in *Symbol as sense: New approaches to the analysis of meaning*, M. L. Foster & S. H. Brandes, eds., New York: Academic Press.

Sperber, D. 1996, *Explaining culture: A naturalistic approach,* Oxford: Blackwell.

Spiers, P. A., Schomer, D. L., Blume, H. W., Kleefield, J., O'Reilly, G., Weintraub, S., Osborne-Shaefer, P., & Mesulam, M.-M. 1990, "Visual neglect during intracarotid amobarbital testing", *Neurology*, **40**, 1600-1606.

Spindler, K. 1996, "Iceman's last weeks," pp. 249-263 in *Human mummies: A global survey of their status and the techniques of conservation*, K. Spindler et al., eds., Wien: Springer-Verlag.

Splitt, M., Wright, C., Sen, D., & Goodship, J. 1999, "Left-isomerism sequence and maternal type-1 diabetes", *Lancet*, **354**, 305-306.

Stashower, D. 2000, *Teller of tales: The life of Arthur Conan Doyle,* London: Allen Lane, The Penguin Press.

Steele, J. 2000o, "Handedness in past human populations: Skeletal markers", *Laterality*, **5**, 193-220.

Steenhuis, R. E. & Bryden, M. P. 1989, "Different dimensions of hand preference that relate to skilled and unskilled activities", *Cortex*, **25**, 289-304.

Stein, D. L. 1989, "Spin glasses", *Scientific American*, **261 (July)**, 36-42.

Steinberg, G. M., Frehlich, S. G., & Tennant, L. K. 1995, "Dextrality and eye position in putting performance", *Percept.Mot.Skills*, **80**, 635-640.

Stellman, S. D., Muscat, J., & Wynder, E. L. Left-handedness and risk factors in a group of hospitalised patients. 1993.

Stewart, I. & Golubitsky, M. 1992g, *Fearful symmetry: Is God a geometer?,* Oxford: Blackwell.

Stodert-Walker, A. 1901, *Robert Buchanan: Thepoet of modern revolt: An introduction to his poetry,* London: Grant Richards.

Stoléru, S., Grégoire, M. C., Gèrard, D., Decety, J., Lafarge, E., Cinotti, L., Lavenne, F., Le Bars, D., Vernet, M. E., Rada, H., Collet, C., Mazoyer, B., Forest, M. G., Magnin, F., Spira, A., & Comar, D. 1999, "Neuroanatomical correlates of visually evoked sexual arousal in human males", *Arch Sex Behav.*, **28**, 1-21.

Stone, S. P., Halligan, P. W., & Greenwood, R. J. 1993, "The incidence of neglect phenomena and related disorders in patients with an acute right or left hemisphere stroke", *Age and Ageing*, **22**, 46-52.

Stone, S. P., Wilson, B., Wroot, A., Halligan, P. W., Lange, L. S., Marshall, J. C., & Greenwood, R. J. 1991, "The assessment of visuo-spatial neglect after acute stroke", *Journal of Neurology, Neurosurgery, and Psychiatry*, **54**, 345-350.

Storfer, M. D. 1995, "Problems in left-right discrimination in a high-IQ population", *Perceptual and Motor Skills*, **81**, 491-497.

Stroud, R. S. 1989c, "The art of writing in ancient Greece," pp. 103-120 in *The origins of writing*, W. M. Senner, ed., Lincoln, Nebraska: University of Nebraska Press.

Sun, J. & Perona, P. 1998, "Where is the sun?", *Nature Neuroscience*, **1**, 183-184.

Supp, D. M., Brueckner, M., Kuehn, M. R., Witte, D. P., Lowe, L. A., McGrath, J., Corrales, J., & Potter, S. S. 1999, "Targeted deletion of the ATP binding domain of left-right dynein confirms its role in specifying development of left-right asymmetries", *Development*, **126**, 5495-5504.

Supp, D. M., Potter, S. S., & Brueckner, M. 2000, "Molecular motors: the driving force behind mammalian left-right development", *Trends in Cell Biology*, **10**, 41-45.

Sutherland, J. 1995, *The life of Walter Scott: A critical biography,* Oxford: Blackwell.

Sutherland, R. J. 1982, "The dorsal diencephalic conduction system: a review of the anatomy and functions of the habenular complex", *Neurosci.Biobehav.Rev.*, **6**, 1-13.

Swanton, R. H. 1996, "Angina and unstable angina," pp. 2321-2331 in *Oxford textbook of medicine*, 3 edn, D. J. Weatherall, J. G. G. Ledingham, & D. A. Warrell, eds., Oxford: Oxford University Press.

Swindler, M. H. 1929, *Ancient painting: From the earliest times to the period of Christian art,* New Haven: Yale University Press.

Sylvester, D. 1999, "Serra in Bilbao", *Modern Painters*, **12 (3)**, 26-33.

Taine, H. A. 1877, "Taine on the acquisition of language by children", *Mind*, **2**, 252-259.

Tanaka, S., Kanzaki, R., Yoshibayashi, M., Kamiya, T., & Sugishita, M. 1999, "Dichotic listening in patients with situs inversus: brain asymmetry and situs asymmetry", *Neuropsychologia*, **37**, 869-874.

Tapley, S. M. & Bryden, M. P. 1985, "A group test for the assessment of performance between the hands", *Neuropsychologia*, **23**, 215-221.

Tazelaar, M. A. 1929, "The effect of a temperature gradient on the early development of the chick", *Quarterly Journal of Microscopical Science*, **72**, 419-446.

Tazelaar, M. A., Huxley, J. S., & De Beer, G. R. 1930, "Some further effects of an antagonistic temperature gradient upon the frog's egg", *Anatomical Record*, **47**, 1-11.

Tcherkézoff, S. 1983a, *Le Roi nyamwezi, la droite et al gauche,* Cambridge: Cambridge University Press.

Tcherkézoff, S. 1987a, *Dual classification reconsidered: Nyamwezi sacred kingship and other examples,* Cambridge: Cambridge University Press.

Testen, D. D. 1996, "Old Persian cuneiform," pp. 134-137 in *The world's writing systems*, P. T. Daniels & W. Bright, eds., New York: Oxford University Press.

The Economist 1990, *The Economist: Book of vital world statistics,* London: Hutchinson Business Books.

Thorndike, L. 1941a, "Invention of the mechanical clock about 1271 AD", *Speculum*, **16**, 242-243.

Ticho, B. S., Goldstein, A. M., & Van Praagh, R. 2000, "Extracardiac anomalies in the heterotaxy syndromes with focus on anomalies of midline-associated structures", *American Journal of Cardiology*, **85**, 729-734.

Tihen, J. A., Charles, D. R., & Sippel, T. D. 1948, "Inherited visceral inversion in mice", *J.Hered.*, **39**, 29-31.

Tobin, J. 1991, *George Herbert: The complete English poems,* Harmondsworth: Penguin.

Todd, B. & Butterworth, G. 1998, "Her heart is in the right place: An investigation of the 'heartbeat hypothesis' as an explanation of the left side cradling preference in a mother with dextrocardia", *Early Development and Parenting*, **7**, 229-233.

Torgersen, J. 1950a, "Situs inversus, asymmetry and twinning", *American Journal of Human Genetics*, **2**, 361-370.

Townsend, G. C., Brown, T., Richards, L. C., Rogers, J. R., Pinkerton, S. K., Travan, G. R., & Burgess, V. B. 1986d, "Metric analyses of the teeth and faces of South Australian twins", *Acta Genet Med Gemellol*, **35**, 179-192.

Trechmann, E. J. 1935, *The essays of Montaigne,* London: Oxford University Press.

Tucker, D. M. 1985e, *Lateral dialectics,* Unpublished manuscript:

Tucker, G. T. 2000, "Chiral switches", *Lancet*, **355**, 1085-1087.

Tuohy, A. P. & Stradling, S. G. 1987g, "Maximum salience vs golden section proportions in judgmental asymmetry", *British Journal of Psychology*, **78**, 457-464.

Turing, A. M. 1952, "The chemical basis of morphogenesis", *Philosophical Transactions of the Royal Society of London,Series B*, **237**, 37-72.

Turnbull, O. H. & Bryson, H. E. 2001, "The leftward cradling bias and hemispheric asymmetry for speech prosody", *Laterality*, **6**, 21-28.

Turnbull, O. H. & Lucas, M. D. 2000v, "'Tell me, where is [this] fancy bred?': The cardiac and cerebral accounts of the lateral cradling bias," pp. 267-287 in *Side bias: A neuropsychological perspective*, M. K. Mandal, M. B. Bulman-Fleming, & G. Tiwari, eds., Dordrecht: Kluwer.

Twitty, V. C. 1928a, "Experimental studies on the ciliary action of amphibian embryos", *Journal of Experimental Biology*, **50**, 319-344.

Twitty, V. C. 1966, *Of scientists and salmanders,* San Francisco: W H Freeman.

Tyler, C. W. 1995i, "Empirical aspects of symmetry perception", *Spatial Vision*, **9**, 1-7.

Tyler, C. W. 1995h, "Theoretical issues in symmetry perception", *Spatial Vision*, **8**, 383-391.

Uhrbbrock, R. S. 1973c, "Laterality in Art", *The Journal of Aesthetics and Art Criticism*, **32**, 27-33.

Upton, C. & Widdowson, J. D. A. 1996, *An atlas of English dialects,* Oxford: Oxford University Press.

Utley, R. M. 2000, *Billy the Kid: A short and violent life,* London: Tauris Parke Paperbacks.

Uylings, H. B. M., Malofeeva, L. I., Bogolepova, I. N., Amunts, K., & Zilles, K. 1999, "Broca's language area from a neuroanatomical and developmental perspective," pp. 319-336 in *The neurocognition of language*, C. M. Brown & P. Hagoort, eds., Oxford: Oxford University Press.

Van Agtmael, T., Forrest, S. M., & Williamson, R. 2001, "Genes for left-handedness: How to search for the needle in the haystack?", *Laterality*, **6**, 149-164.

Van Cleve, J. 1987, "Right, left, and the fourth dimension", *The Philosophical Review*, **96**, 33-68.

Van Cleve, J. & Frederick, R. E. 1991, *The philosophy of right and left: Incongruent counterparts and the nature of space,* Dordrecht: Kluwer.

van de Wetering, E. 1999, "The multiple functions of Rembrandt's self-portraits," pp. 8-37 in *Rembrandt by himself*, C. White & Q. Buvelot, eds., London: National Gallery.

Van Doren, C. 1939, *Benjamin Franklin,* London: Putnam.

Van Fraassen, B. C. 1989, *Laws and symmetry,* Oxford: Clarendon Press.

Van Horn, J. D. 1992b, *Brain structural abnormality and laterality in schizophrenia,* University College London: Unpublished PhD thesis.

Van Horn, J. D. & McManus, I. C. 1992, "Ventricular enlargement in schizophrenia: a meta-analysis of studies of the ventricle-brain ratio", *British Journal of Psychiatry*, **160**, 687-697.

Van Sommers, P. 1984, *Drawing and cognition: descriptive and experimental studies of graphic production processes,* Cambridge: Cambridge University Press.

Venturi, A. 1956, "The drawings of Leonardo," pp. 89-91 Anonymous., ed., New York: Reynal.

Vigouroux, R. A., Bonnefoi, B., & Khalil, R. 1990, "Réalisations picturales chez un artiste peintre présentent une héminégligence gauche", *Revue Neurologique*, **146**, 665-670.

Vinken, P. 1999d, *The shape of the heart,* Amsterdam: Elsevier.

Volkmann, R. A. & Heck, S. D. 1998, "Biosynthesis of D-amino acid-containing peptides: Exploring the role of peptide isomerases," pp. 87-105 in *D-amino acids in sequences of secreted peptides of multicellular organisms*, P. Jollès, ed., Basel: Birkhäuser Verlag.

Von Kraft, A. 1999, "Symmetry and asymmetry in the development of inner organs in parabiotic twins of amphibians (Urodela)", *Laterality*, **4**, 209-255.

Wade, G. W. 1925, *The books of the prophets Micah, Obadiah, Joel and Jonah,* London: Methuen.

Wade, N. J. 1998h, "Early studies of eye dominances", *Laterality*, **3**, 97-108.

Wagemans, J. 1995g, "Detection of visual symmetries", *Spatial Vision*, **9**, 9-32.

Wagner, M. K. & Yost, H. J. 2000, "The roles of nodal cilia", *Current Biology*, **10**, R149-R151.

Wagner, R. 1888, *Gesammelte Schriften und Dichtungen von Richard Wagner, volume 6,* 2 edn, Leipzig: G.M. Fritzsch.

Walford, D. & Meerbote, R. 1992, *The Cambridge edition of the works of Immanuel Kant: Theoretical philosophy, 1755-1770,* Cambridge: Cambridge University Press.

Walker, C. B. F. 1990, "Cuneiform," pp. 15-74 in *Reading the past*, J. T. Hooker, ed., London: British Museum.

Wang, A. H.-J., Quigley, G. J., Kolpak, F. J., Crawford, J. L., Van Boom, J. H., Van der Marel, G., & Rich, A. 1979, "Molecular structure of a left-handed double helical DNA fragment at atomic resolution", *Nature*, **282**, 680-686.

Wang, L., Brock, A., Herberich, B., & Schultz, P. G. 2001, "Expanding the genetic code of *Escherichia coli*", *Science*, **292**, 498-500.

Warner, R. t. 1972, *Thucydides: History of the Peloponnesian War,* Revised edn, Harmondsworth: Penguin.

Warrington, E. K. & Davidoff, J. 2000, "Failure at object recognition improves mirror image matching", *Neuropsychologia*, **38**, 1229-1234.

Watson, R. T., Heilman, K. M., & Bowers, D. 1985c, "Magnetic resonance imaging (MRI, NMR) scan in a case of callosal apraxia and pseudoneglect", *Brain*, **108**, 535-536.

Watson, T. 1843, *Lectures on the principles and practice of Physic,* 1 edn, London: Jon W Parker.

Watson, T. 1871, *Lectures on the principles and practice of Physic,* 5 edn, London: Jon W Parker.

Wehrmaker, A. 1969b, "Right-left asymmetry and situs inversus in *Triturus alpestris*", *Wilhelm Roux' Archiv für Entwicklungsmechanik*, **163**, 1-32.

Weinberg, S. 2001, "Can science explain everything? Anything?", *New York Review of Books*, **48 (May 31st)**, 47-50.

Weinstein, E. A. 1970, "Woodrow Wilson's neurological illness", *Journal of American History*, **57**, 324-351.

Weinstein, E. A. 1981, *Woodrow Wilson: A medical and psychological biography,* Princeton,NJ: Princeton University Press.

Weiskrnatz, L., Elliott, J., & Darlington, C. 1971, "Preliminary observations on tickling oneself", *Nature*, **230**, 598-599.

Weismann, A. 1892, *Das Keimplasma. Eine Theorie der Vererbung.,* Jena: Gustav Fischer.

Weiss, B. P., Kirschvink, J. L., Baudenbacher, F. J., Vali, H., Peters, N. T., Macdonald, F. A., & Wikswo, J. P. 2000, "A low temperature transfer of ALH84001 from Mars to Earth", *Science*, **290**, 791-795.

Wes, P. D. & Bargmann, C. I. 2001, "*C. elegans* odour discrimination requires asymmetric diversity in olfactory neurons", *Nature*, **410**, 698-701.

Wexler, B. E. & Halwes, T. 1983, "Increasing the power of dichotic methods: the fused rhymed words test", *Neuropsychologia*, **21**, 59-66.

Weyl, H. 1952, *Symmetry,* Princeton, NJ: Princeton University Press.

Wheeler, E. 1988, "The Battle of Hastings: Math, myth and melee", *Military Affairs*, **52**, 128-134.

Whiston, W. 1906, *The works of Flavius Josephus,* London: Routledge.

Whitehead, A. N. 1927, *Symbolism: Its meaning and effect,* New York: MacMillan.

Whiten, A. & Boesch, C. 2001, "The culture of chimpanzees", *Scientific American*, **January**, 48-55.

Whitlock, M. 1996, "The heritability of fluctuating asymmetry and the genetic control of developmental stability", *Proc.R.Soc.Lond.B Biol.Sci.*, **263**, 849-854.

Whitman, M. & Mercola, M. 2001f, "TGF-β superfamily signalling and left-right asymmetry", *Science's STKE*, **http://www.stke.org/cgi/content/full/OCV_sigtrans;2001/64/re1**.

Wieschoff, H. A. 1938, "Concepts of right and left in African cultures", *Journal of the American Oriental Society*, **58**, 202-217.

Wiesenfeld, K. & Moss, F. 1995, "Stochastic resonance and the benefits of noise: from ice ages to crayfish and SQUIDS", *Nature*, **373**, 33-36.

Wigner, E. P. 1967, *Symmetries and reflections,* Bloomington: Indiana University Press.

Wile, I. S. 1934, *Handedness: Right and left,* Boston: Lothrop, Lee and Shepard.

Wilkin, S. 1852, *The works of Sir Thomas Browne (revised version of 1836 edition),* London: Henry Bohn.

Williams, H. 1994, "Freelance", *Times Literary Supplement* 14-14.

Williams, H. 2001b, "Freelance", *Times Literary Supplement*, **December 28th**, 14-14.

Williams, R. J., Standen, K., & Ricciardelli, L. A. 1993, "Sex differences in self-reported right-left confusion by adults: A role for social desirability?", *Social Behaviour and Personality*, **21**, 327-332.

Williams, R. 1961b, *The long revolution,* London: Chatto and Windus.

Wilson, D. 1891, *The right hand: left-handedness,* London: Macmillan.

Wilson, F. R. 1998, *The hand: How its use shapes the brain, language, and human culture,* New York: Vintage.

Wilson, M. 1971, *Religion and the transformation of society: a study in social change in Africa,* Cambridge: Cambridge University Press.

Winokur, M. 1984g, *Einstein: A portrait,* Corte Madera, CA: Pomegranate Artbooks.

Winter, W. & Frankus, E. 1992, "Thalidomide enantiomers", *Lancet*, **339**, 365-365.

Winterson, J. 1997, *Gut symmetries,* London: Granta Books.

Witelson, S. F., Kigar, D. L., & Harvey, T. 1999l, "The exceptional brain of Albert Einstein", *Lancet*, **353**, 2149-2153.

Wittling, W. 1995, "Brain asymmetry in the control of autonomic-physiologic activity," pp. 305-357 in *Brain asymmetry*, R. J. Davidson & K. Hugdahl, eds., Cambridge, MA: MIT Press.

Wittling, W., Block, A., Schweiger, E., & Genzel, S. 1998, "Hemisphere asymmetry in sympathetic control of the human myocardium", *Brain and Cognition*, **38**, 17-35.

Wnendt, S., Finkam, M., Winter, W., Ossig, J., Raabe, G., & Zwingenberger, K. 1996, "Enantioselective inhibition of TNF-alpha release by thalidomide and thalidomide-analogues", *Chirality*, **8**, 390-396.

Wnendt, S. Z. & Zwingenberger, K. 1997, "Thalidomide's chirality", *Nature*, **385**, 303-304.

Wolbarst, A. B. 1977, *Symmetry and quantum systems,* New York: Van Nostrand Reinhold.

Wolf, P. A., D'Agostino, R. B., & Cobb, J. 1991, "Left-handedness and life expectancy", *New England Journal of Medicine*, **325**, 1042-1042.

Wolpert, L., Beddington, R., Brockes, J., Jessell, T., Lawrence, P., & Meyerowitz, E. 1998, *Principles of Development,* London: Current Biology.

Wood Jones, F. 1941, *The principles of anatomy as seen in the hand,* London: Bailliere, Tindall and Cox.

Wood Jones, F. 1949, *Structure and function as seen in the foot,* 2 edn, London: Bailliere, Tindall and Cox.

Wood, C. J. & Aggleton, J. P. 1989e, "Handedness in 'fast ball' sports: Do left-handers have an innate advantage?", *British Journal of Psychology*, **80**, 227-240.

Wood, C. J. & Aggleton, J. P. 1991h, "Occupation and handedness: An examination of architects and mail survey biases", *Canadian Journal of Psychology*, **45**, 395-404.

Woods, R. P. 1986, "Brain asymmetries in situs inversus: a case report and review of the literature", *Archives of Neurology*, **43**, 1083-1084.

Worboys, M. 1981, "The British Association and Empire: Science and social imperialism, 1880-1940," pp. 170-187 in *The Parliament of science: The British Association for the Advancement of Science, 1831-1981* , R. MacLeod & P. Collins, eds., Northwood, England: Science Reviews.

Wölfflin, H. 1941b, "Über das Rechts und Links im Bilde," p. 82 in *Gedanken zur Kunstgeschichte*, Basel:

Wright, C. V. E. 2001, "Mechanisms of left-right asymmetry: What's right and what's left?", *Developmental Cell*, **1**, 179-186.

Wu, C. S., Ambler, E., Hayward, R. W., Hoppes, D. D., & Hudson, R. P. 1957, "Experimental test of parity conservation in beta decay", *Physical Review*, **105**, 1413-1415.

Wurtz, R. H., Goldberg, M. E., & Robinson, D. L. 1982b, "Brain mechanisms of visual attention", *Scientific American*, **246 (June)**, 100-107.

Yasuda-Kamatani, Y. 1998, "Molluscan neuropeptides," pp. 37-56 in *D-amino acids in sequences of secreted peptides of multicellular organisms*, P. Jollès, ed., Basel: Birkhäuser Verlag.

Yokoyama, T., Copeland, N. G., Jenkins, N. A., Montgomery, C. A., Elder, F. F. B., & Overbeek, P. A. 1993, "Reversal of left-right asymmetry - a novel situs inversus mutation", *Science*, **260**, 679-682.

Yost, H. J. 1992a, "Regulation of vertebrate left-right asymmetries by extracellular matrix", *Nature*, **357**, 158-161.

Yost, H. J. 2001, "??????????", *International Review of Cytology*, **203**, 357-381.

Young-WF, J., Gorman, C. A., Jiang, N. S., Machacek, D., & Hay, I. D. 1984, "L-thyroxine contamination of pharmaceutical D-thyroxine: probable cause of therapeutic effect", *Clinical Pharmacology and Therapeutics*, **36**, 781-787.

Zatorre, R. J. 1989, "Perceptual asymmetry on the dichotic fused words tests and cerebral speech lateralization determined by the carotid sodium amytal test", *Neuropsychologia*, **27**, 1207-1219.

Zatorre, R. J., Perry, D. W., Beckett, C. A., Westbury, C. F., & Evans, A. C. 1998, "Functional anatomy of musical processing in listeners with absolute pitch and relative pitch", *Proc.Natl.Acad.Sci.U.S.A*, **95**, 3172-3177.

Zhou, W. & King, W. M. 1998, "Premotor commands encode monocular eye movements", *Nature*, **393**, 692-695.

Ziegler, P. 1999j, *Osbert Sitwell: A biography,* London: Pimlico.

Zubay, G. 1998f, *Biochemistry,* 4 edn, Dubuque, IA: Wm. C Brown.

Zupko, J. 1998, "Buridan, John (c.1300 - after 1358)," pp. 131-136 in *Routledge encyclopaedia of philosophy*, E. Craig, ed., London: Routledge.

Zur Nedden, D., Wicke, K., Knapp, R., Seidler, H., Wilfing, H., Weber, G., Spindler, K., Murphy, W. A., Hauser, G., & Platzer, W. 1994, "New findings on the Tyrolean 'Ice Man': Archaeological and CT-body analysis suggest personal disaster before death", *Journal of Archaeological Science* , **21**, 809-818.