

## The medical bequest of disaster at sea: Commodore Anson's circumnavigation 1740-44

**ABSTRACT** - Anson's circumnavigation was characterised by his indomitable leadership which enabled men to triumph over medical and environmental disasters responsible for appalling suffering and loss of life. The medical bequest of the Anson voyage was not only the detailed descriptions of nutritional deficiency diseases in their various guises, but in the spirit of inquiry it generated, the recognition of a need for research and continuing postgraduate education and the requirement for evidence-based medicine. The controversy it aroused resounded until the twentieth century.

The origins of Commodore Anson's circumnavigation from 1740 to 1744 lay in what came to be called the War of Jenkin's Ear, which opened with spectacular éclat when Vernon, in November 1739, captured Porto Bello with the loss of only seven men. Vernon's success encouraged the government to mount a more ambitious campaign to disrupt Spanish trade in Central and South America and capture the initiative for British mercantile interests<sup>1</sup>. Vernon, with Lord Cathcart commanding the land forces, was to launch the main attack on Spanish possessions in the Caribbean with the neutralisation of the key port of Cartagena. Ignoring the medical implications, a naval squadron under Commodore Anson was to make diversionary raids on Spanish possessions in South America, attack Panama and attempt to link up with Vernon's forces from Portobello across the Isthmus of Darien - a hot, humid terrain of stagnant water that provided an ideal breeding ground for *Aedes aegypti*, the mosquito responsible for epidemics of yellow fever so devastating that they had annihilated Hosier's expedition in 1727. Anson was to capture the fabulously rich Spanish treasure galleon, *Nuestra Señora de Covadonga*, plying its annual passage between Acapulco and Manila and, if he survived all that, could choose to return to England either by China and the Cape of Good Hope or by Cape Horn<sup>2</sup>.

### The ships and the men

Admiralty ineptitude and government vacillation, however, deprived the squadron of the element of surprise essential to its success and allowed the Spaniards ample time to take



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counter measures. These included the despatch of a powerful force of six warships under Admiral Joseph Pizarro carrying 'the cream of the Spanish Navy' and instructed to intercept and destroy the squadron and reinforce coastal garrisons in the South Seas<sup>3</sup>. Beside these vessels, Anson's squadron of eight ships was disgracefully fitted out and provisioned. It consisted of the 60-gun flagship *Centurion*, *Gloucester* (50 guns), *Severn* (50), *Pearl (W)*, *Wager* (28), a converted storeship, *Tryal*, a small eight-gun sloop, and *Anna* and *Industry*, both merchant supply vessels.

Anson, then 43 years of age, coped deftly with innumerable frustrations and delays and provided the integrity, resolution and initiative to triumph over disease and disaster with a success so resounding that it awakened in British hearts the dream of Pacific exploration. Through Captain James Cook and his successors, that dream became a reality. It opened up the Pacific to trade and added New Zealand and Australia to the British crown.

The voyage, however, began inauspiciously. In contrast to the highly trained men of Pizarro's squadron, Anson was provided with a motley crew of landlubbers arrested by the press gang or released from prison. Finding himself still 300 sailors short of his needs, Anson's appeal for his authorised numbers brought only 170 men, of whom 32 were taken from hospital and 98 were marines. His soldiers turned out to be the most decrepit of the Chelsea pensioners, many suffering from the sequelae of old wounds or from chronic, incapacitating illnesses, and several were over 70 years of age. Those who had strength to run deserted, and only 259 pathetic specimens actually arrived. To meet the deficiency, Anson was given 210 marines who proved to be raw untrained recruits, unable even to use a gun. When Anson remonstrated, he was told that people who were much better judges than he 'thought invalids the best seasoned and properest sort of troops' for such an expedition<sup>4</sup>.

The most complete records of the total number of men who eventually sailed on all eight vessels are to be found in the ships' muster books in the Public Record Office. These record the entry, discharge, transfer or death of every individual who appeared in a particular ship throughout its commission, so there are literally thousands of entries. There are inevitably omissions and incongruities in the muster books as clerks sickened, died or were transferred and their places taken by unskilled men confused by rapidly changing and often desperate situations. Log books of the captains and independent journalists differ widely, but statements of numbers by captains at fixed points in the voyage provide useful markers by which statistics may be reconciled. Using this method, it can be shown that about 1,854 men actually sailed.

## Medical background

By the time the ships sailed, it was not only the wrong time of year to attempt a passage round the Horn, but medical chests were inadequate and lacked antiscorbutics. In characteristic British fashion, the Admiralty had quite failed to learn a single medical lesson from the journals of its great Elizabethan sea captains, such as Sir Francis Drake and Sir Richard Hawkins, who had recognised the value of lemons and oranges in the prevention and treatment of scurvy. Indeed, Hawkins went so far as to exclaim: "This is a wonderfull secret of the power and wisdom of God, that hath hidden so great and unknowne vertue in this fruit, to be a certaine remedy for this infirmity"<sup>5</sup>. Similarly, in 1601, Sir James Lancaster had conducted a fortuitous clinical trial when he provided the crew of his flagship with three spoonfuls of lemon juice each morning and found that it remained free of scurvy throughout the voyage, while other ships suffered severely<sup>5</sup>.

But perhaps the Admiralty was not entirely to blame, for it had its own independent medical advisers, and who better than the College of Physicians? On the advice of the College, the ships were supplied, for the treatment of scurvy, with elixir of vitriol, the chief ingredients of which were sulphuric acid, alcohol, sugar, and spices<sup>6</sup>. This was because, as one of the College's most distinguished physicians, Dr Richard Mead, explained, it was an excellent substitute for acid fruits, 'such fruits being only of value in their sub-stringent quality'<sup>7</sup>. For fevers, the Admiralty turned to its other consultant, the notorious quack, 'Dr' Joshua Ward, whose patent drop and pill contained antimony, dragon's blood (balsam) and wine, and was a violent purgative and diuretic<sup>8</sup>. The Admiralty quite ignored its own physicians who had learnt the value of cinchona bark or quinine.

## The voyage: Atlantic morbidity

Anson's squadron eventually got underway in September 1740, men and provisions having been on board for several months. The ships were over-run with rats, and the ill-assorted rabble with lice. A plague of flies from rotting provisions invaded some ships<sup>9</sup> so it is little wonder that typhus and dysentery made an appearance. Captain Norris of the *Gloucester* was invalided home from Madeira and Thomas Waller, senior surgeon of the *Centurion*, and his friend, the purser, developed the cerebral symptoms of typhus and died<sup>10</sup>. To add to the problems, the storeship *Industry* departed in mid-Atlantic after distributing her cargo among the various ships. This reduced living space and brought them so low in the water that the lowest gunports could not be opened to provide essential ventilation<sup>4</sup>. Sixty of the most ill sailors were landed at St Catherine's, Brazil, and nursed in tents under the supervision of Thomas Etterick, Waller's successor. *Centurion* and *Severn* were the hardest hit and lost at least 95 sailors, marines and invalids, chiefly the latter.

**Portrait of Admiral Anson by Francis Coates, 1744.** (Reproduced with kind permission from the collection at Shugborough Hall, Staffordshire.)

At St Catherine's, the ships were washed with vinegar to rid them of their 'noisome stench' and mosquitoes attacked convalescents<sup>3</sup>. Malaria subsequently took its toll until eliminated by the colder climate of Patagonia. In February 1741, the squadron anchored in the port of St Julian. The passage had been undertaken in storms and thick fog. *Tryal* lost her mainmast and the captain of *Pearl* had died of cerebral malaria. The ship herself was almost taken by Pizarro until, in an act of daring seamanship, *Pearl's* first lieutenant saved the day by driving the ship through a narrow, rock-strewn passage which the Spaniards were afraid to enter<sup>9</sup>.

## Cape Horn and scurvy

Fevers and death now began to claim their victims. Saunders, in command of the *Tryal*, was suddenly struck down with fever and it fell to Lieutenant Philip Saumarez to take the little sloop round the Horn against westerly gales and mountainous seas sweeping in from the Pacific. Men rapidly fell hostage to scurvy, the sick dying in their sodden hammocks between decks constantly awash and covered, in the *Tryal* at least, by as much as 'a peck of lice'<sup>9</sup>.

**Tempest.** Painting by L J Pearce of the conditions encountered by Anson's squadron round Cape Horn. (Reproduced with kind permission of the artist.)

Richard Walter, *Centurion's* chaplain, described the features of scurvy in vivid detail: putrid bleeding gums, loose teeth, petechial haemorrhages, large dark blotches, jaundice, stiff and swollen limbs, the reopening of old wounds, dissolution of callus in healed fractures, indolent ulcers with luxuriant granulation tissue, shivering, depression, unaccountable terrors, syncope and sudden death on the least exertion<sup>3</sup>. He also described 'pleurisy', actually the pain of subperiosteal or costochondral haemorrhages, while Pascoe Thomas in *Centurion* saw 'four or five dead Bodies at a Time, some sown up in their Hammocks, and other not, washing about the Decks for want of Help to bury them at Sea'<sup>11</sup>. Saumarez described 'asthma', and the 'idiocy, lunacy and convulsions' of niacin deficiency among other symptoms he had witnessed in the *Tryal*, and attributed scurvy to the absence of a *je ne sais quoi* found only in fresh vegetables and fruit<sup>12</sup>.

It is evident that there were multiple vitamin deficiencies, for in *Gloucester*, 'John Phillips', perhaps the pseudonym of surgeon Joseph Allen, described the neurological features of vitamin B<sub>1</sub> (thiamine) deficiency, or beri-beri, probably associated with low levels of folic acid and vitamin B<sub>12</sub>. Ship beri-beri was the 'wet' or cardiac type because of associated scurvy<sup>13</sup>. Mitchell, *Gloucester's* captain, was severely affected<sup>14</sup> and Wallbank, the surgeon, lost both his junior surgeons<sup>15</sup>. Rats infested the ship, eating away the faces, eyes and limbs of the newly-dead and running all over the rotting bodies of the barely living, many so paralysed and anaesthetic that they were unaware their toes had been gnawed away<sup>16</sup>. Frostbite increased suffering<sup>4</sup>.

When the ships reached the island of Juan Fernandes off the coast of Chile, *Centurion* and *Tryal* could scarcely muster enough men to anchor. *Gloucester* drifted to sea and took a month to return, costing the lives of a further 55 men. According to Mitchell's log book, *Gloucester* had lost

219 men rounding the Horn and 14 more died while convalescing at Juan Fernandes<sup>14</sup>, although independent observers and the muster books suggest that the total number of deaths was closer to 266.

The little supply ship *Anna*, on the other hand, had found a sheltered harbour near the Horn providing abundant fresh greens and did not lose a single man. *Centurion*, *Gloucester*, *Tryal* and *Anna* were, in fact, the only ships to round Cape Horn and it had cost them at least 440 lives.

#### *The Pearl and the Severn*

What had happened to the others? By April 1741, during the violent gales, *Pearl's* stricken survivors had lain down in despair and could not be persuaded to go aloft<sup>17</sup>, so Murray, her captain, urged Legge, his senior in the *Severn*, to abandon their attempt to round the Horn and turn back to Rio. Legge needed little persuasion as flux (dysentery) had complicated scurvy, and fevers and vomiting were adding a disturbing new dimension to its ravages<sup>18</sup>. Defeated, the two ships altered course for Rio. It would appear that vitamin deficiencies, particularly niacin, had affected the judgement of the two captains, for once health had been restored in Rio, the implications of deserting Anson quickly dawned and *Pearl's* captain could scarcely be restrained from a further attempt to round the Horn with an unseaworthy vessel and a depleted and convalescent crew<sup>18</sup>.

#### *HMS Wager*

Meanwhile, the scurvy-ridden *Wager* was in a parlous state. Most of the 132 marines substituting for seamen were dead and David Cheap, her captain, was confined to his cabin with scurvy and a dislocated shoulder. Vitamin A deficiency, prevented her master, at the wheel, from seeing the lights of

**Captain Cheap shooting midshipman Cozins after the wreck of the Wager.** Print from a sketch by a survivor.

**The wreck of the Wager.** Frontispiece of *The narrative of the Honorable John Byron, 1768*<sup>21</sup>.

*Centurion* ahead, though they were plainly visible to others<sup>19</sup>. The ships parted company during the night, Cheap insisting upon commanding the vessel from his sick bed and obstinately refusing to heed his officers' warnings of a lee shore<sup>20</sup>. Inevitably, *Wager* fell apart in a raging gale on the rocky, inhospitable shore of 'Wager Island' on the coast of Chile, for only six men could be mustered to attempt to avert the disaster. Here, Cheap's continuing ill-health, superimposed upon his natural intransigence and an irascible nature, caused him to shoot through the head a truculent, but unarmed midshipman and incite to mutiny the starving survivors who were subsisting on rats, shellfish and an occasional dog<sup>21</sup>.

Eighty men escaped in the longboat and launch under the command of the gunner, John Bulkeley. During a harrowing voyage through the Magellan Strait to Brazil's Rio Grande, a journey of 2,000 miles, 30 died of starvation and 20 were abandoned. Of these, 16 died or were murdered by Indians, and 4 survived. Eventually 30 reached England.

Twenty men, however, accompanied the captain in an abortive attempt to sail north, including Elliot, the surgeon, who died from scurvy, and the Honorable John Byron, grandfather of the poet. By this time, Cheap had lost all self-respect. His legs were described as 'big as mill posts, though

his body appeared to be nothing but skin and bone'<sup>21</sup>. Covered with filth and vermin, he resembled a human anthill. His memory gone, he failed even to remember his own name, and with his stumbling gait, displayed all the features of advanced vitamin B and C deficiency syndromes. Yet ironically, in the throes of starvation, Byron described the effects of too much vitamin A. After being reduced to eating their sealskin shoes, the captain's party found a colony of seals and threw a seal's liver to companions who consumed it avidly. They became violently ill with gastrointestinal symptoms, succeeded by peeling of the skin from head to foot, symptoms typical of vitamin A poisoning<sup>21</sup>. Four of the captain's party ultimately survived and only 38 of *Wager's* 243 men eventually reached England.

*Juan Fernandez to Mexico*

The toll imposed by Cape Horn on human life in all seven ships was not less than 751, almost all the result of vitamin deficiencies and their complications. The four ships that had rounded Cape Horn began to arrive at Juan Fernandez - a fertile, peaceful island off the Chilean coast - on 11 June 1741. Tents were erected rapidly for the reception of the bleeding, suffering and enfeebled men dying apace in the squalor, stench and filthiness of the decks, for sprue manifested in 'flux' was now widespread. Men were ravenous for vitamin-rich green grass, preferring it to meat<sup>3</sup>, and they slowly recovered on cresses, wild sorrel and turnip tops<sup>16</sup>. It was three months before Anson could again comply with his orders; he seized Spanish shipping off the coast of Chile, and burned the town of Payta in Peru.

From his Spanish prisoners, he learnt of the destruction of Pizarro's squadron while attempting to round the Horn. Two were sunk, one succeeded in reaching Chile, and only the flagship returned to Spain 'with fewer than 100'

**The watering place at Tinian with *Centurion*.** Drawing by Lieutenant Piercy Brett (Reproduced from Ref 3.)

survivors out of 3,000 hand-picked men<sup>16</sup>. He also learnt of the debacle at Cartagena caused by the mutual antagonism of the commanders and by yellow fever<sup>22</sup>. Anson, thus reprieved from a similar fate, lay in wait for the Spanish treasure galleon off the port of Acapulco. However, the ship stayed in harbour and forced Anson to cross the Pacific to wait for the galleon off Manila during the next sailing season. He was so short of manpower that he had been obliged to destroy *Tryal* and *Anna* and distribute their survivors between *Centurion* and *Gloucester*.

### Disaster in the Pacific

The men were now fighting fit and the ships stocked with fresh provisions for the Pacific crossing. Again it was the wrong time of year: the ships were becalmed, and despite abundant fresh fish, nutritional disorders struck with enhanced virulence. Pascoe Thomas noted blackening of the skin characteristic of pellagra<sup>11</sup>. Sulphuric acid, the remedy recommended by the College of Physicians, failed, so in desperation Anson turned to the drop and pill of the Admiralty's favoured quack, Joseph Ward. Those at death's door merely made a quiet exit, but less serious cases were obliged to mobilise their dwindling resources to combat the violent sweating, vomiting and purging it produced<sup>11</sup>.

At this point, Anson's senior surgeon, Etterick, declared himself defeated. He was 'a very good practical Surgeon' declared Thomas, the schoolmaster, 'but in the Theory Part vain and pragmatical, making Science to consist in a Flow of Words, with little or no meaning'. Apparently, Etterick had performed a number of autopsies on men dying from scurvy and, finding altered blood in their vessels, had developed the hypothesis that cold air had so vitiated the blood that it was incapable of sustaining life, and that glutinous foods, such as bread, grain and salt fish, 'were alone proper on such Voyages'. Now that scurvy was sweep-

ing the two ships during intolerably hot weather, 'it put our scheming Doctor', said Thomas, 'to a sad Nonplus'<sup>11</sup>.

A violent storm then struck the beleaguered ships and both sprang leaks; *Gloucester's* remaining 106 men and boys squandered their failing reserves at the pumps in a vain effort to save the ship<sup>14</sup>. This forced Anson to burn *Gloucester* and take the dying survivors into *Centurion*, which finally made her lone landfall at the island of Tinian in the Marianas with a diminishing crew pumping to keep her afloat. At Tinian the sick were carried ashore on the backs of those still able to walk and rapidly began to

**Plate from a dinner service presented to Anson by Canton merchants.** (Reproduced with kind permission from the collection at Shugborough Hall, Staffordshire.)

recover on the abundant fruit, including oranges, lemons and breadfruit, together with fresh beef and poultry, that the island afforded.

Recovery from thiamine and niacin deficiencies, however, took longer. In a letter from Macao after his passage from Tinian, Anson wrote: 'some have not recovered their senses, for numbers turned Mad and Idiots with the Scurvey'<sup>23</sup>. He was describing the dementia associated with pellagra resulting from vitamin B or niacin deficiency. Anson's own mental state is permanently recorded on a dinner service at Shugborough Hall, the Anson family seat. It was presented to him by Canton merchants, but Anson evidently influenced the design,

central to which is the breadfruit **Encounter between the *Centurion* and the *Nuestra Senora de Covadonga* by John Cleveley.** tree on the island of Tinian which (Reproduced with kind permission from the collection at Shugborough Hall, Staffordshire.)

Anson believed had saved their lives (though Walter reveals that oranges and lemons played the dominant role). Coiled around the tree is a garland in the form of an Aesculapian snake with scenes of home, dogs, sheep, the Eddystone lighthouse and Plymouth Sound, betraying the nostalgia which commonly accompanied vitamin deficiency disorders on long ocean voyages.

#### *Encounter with the Spanish galleon*

When Anson finally achieved his encounter with the Spanish treasure galleon off Manila, the 131 survivors of *Centurion* and 73 from *Gloucester*, *Tryol* and *Anna* had been reinforced by 23 Dutch, Indians and Lascars from Macao. All were now enjoying vibrant health, while the *Nuestra Senora de Covadonga* had just completed a long Pacific crossing. By dint of brilliant tactics, Anson quickly reduced all resistance and when Saumarez boarded her, he found the decks 'promiscuously covered with carcasses, entrails and dismembered limbs'<sup>24</sup>. Anson immediately sent over his surgeons, Allen and Neasmith, who, according to Thomas, performed some 'very surprizing cures'<sup>11</sup>. Indeed, the statistics back this up: *Covadonga* had some 50 killed in action and 70 wounded<sup>10,11,25</sup>, but only about 15 died of wounds. *Centurion* had only 2 killed and 17 wounded with 2 dying of wounds<sup>9,26</sup>.

#### Homecoming

Anson's squadron reached England in July 1744, by way of Canton and the Cape of Good Hope. It was laden with treasure variously estimated to be between 500,000 and one million pounds sterling (an enormous sum for those

days) and was brought by Anson's men to the Tower of London in a triumphant procession<sup>1</sup>. The voyage had cost the lives of at least 1,385 men, mainly from vitamin deficiencies, fevers, dysentery, starvation and exposure. Out of the eight ships and 1,854 men who had started the voyage, only one ship, *Centurion*, and 188 men completed the circumnavigation.

#### The medical bequest

The medical interest of the Anson voyage lies not only in the triumph of the human spirit over disease and disaster, but in the accurate clinical descriptions of syndromes associated with deficiencies of vitamins A, C and B, especially thiamine and nicotinic acid, probably associated with low levels of folic acid and cyanocobalamin, together with the clinical signs of hypervitaminosis A. The voyage also introduced an issue of particular relevance today: the conflict between medicine based on hypothesis and medicine based on evidence.

One of the first physicians to interview Anson upon his return was the aforementioned influential Richard Mead. While acknowledging Anson's testimony to the value of citrus fruits, he was more influenced by the chaplain who appears to have been impressed by the hypothesis of Etterick the surgeon, which had failed the evidence test, that the air of the ships was responsible for such devastating epidemics. He therefore urged the Admiralty to fit air extraction tubes<sup>7</sup>. They were copied by the French in leather and destroyed by French rats. John Huxham, an influential Devonshire physician, who had accompanied naval expeditions and recognised the antiscorbutic value of the citrus fruits, confused the issue further by attributing-

Devonshire colic, actually caused by lead poisoning, to 'the very acid juice of lemons' and ceased to recommend lemon juice for scurvy<sup>27</sup>.

Naval surgeons had been devastated by their apparent impotence in the face of the sea diseases that the Anson voyage had disclosed, and in January 1747 formed an association, for the purposes of scientific discussion and further medical training. It was probably the first postgraduate medical society in Britain and had eminent teachers such as William Hunter<sup>28</sup>. One of its members, James Lind, had made a careful study of the medical aspects of Anson's circumnavigation and identified some apparent paradoxes that led him to a masterly review of the world literature and convinced him that the prevention and cure of scurvy lay in green vegetables and fruit, particularly lemons and oranges<sup>29</sup>. In a scientifically designed controlled clinical trial on board HMS *Salisbury* in 1747, he demonstrated conclusively the power of oranges and lemons to cure matched pairs of scurvy cases on a scorbutic diet over popular remedies of the day including the elixir of vitriol recommended by the College<sup>29</sup>. However, he made the mistake of dedicating his *Thesis* to Lord Anson, by that time a reforming First Lord of the Admiralty who, quick to recognise its importance, appointed Lind over the heads of his seniors in London as physician in charge of the new naval hospital at Haslar, Portsmouth, which doubtless accounts for his subsequent lack of recognition. The Sick and Hurt Board passed Lind's proposals to the College where doctors Schomberg and James damned them with faint praise<sup>30</sup>. Dr James, in fact, had vested interests, for Lind had also urged the use of cinchona bark (quinine) in fevers and James was already making a handsome income by supplying the Navy with his own ineffective patent fever powders<sup>31</sup>.

Anson died in 1762 and Lind lost his patronage. Sir John Pringle, an eminent physician and President of the Royal Society, had performed some experiments that appeared to show that fermentation inhibited putrefaction<sup>32</sup>. Because scurvy was regarded as a putrefactive disease, David McBride, a Dublin physician who had served in the Navy, described a series of experiments à la Pringle ostensibly to show that malt, which fermented in the digestive tract, would cure scurvy<sup>33</sup> and, with Pringle's patronage but without evidence, succeeded in having malt adopted as the principal antiscorbutic at sea<sup>34</sup>. This condemned thousands of sailors to death until Sir Gilbert Blane, a disciple of Lind, used his influence to make lemon juice generally available to the Fleet<sup>35</sup>. Within a year, scurvy had virtually disappeared. In like manner, the initiative in postgraduate medical education which followed in the wake of the Anson voyage was probably influential in founding the Medical Society of London in 1773, since several founding members had a naval background and were disciples of Lind.

It was Lind who first put hypothesis to the test but it has always been difficult to abandon cherished ideas in the light of experimental evidence. Sir Almroth Wright, a distinguished pathologist, who died only in 1947, was wedded to the idea that scurvy was the result of acid intoxication of

the blood and recommended that lime juice, and by implication, all acid fruits, should be avoided in scurvy because it contained citric acid<sup>36</sup>!

Lord Lister, who immediately saw the significance of Pasteur's work on microorganisms and transformed surgery by the introduction of antiseptics, nevertheless became so obsessed with the role of infection in disease that he attributed scurvy to ptomaine poisoning<sup>37</sup>. As a result, Scott carried few antiscorbutics to the South Pole in 1911. Instead he relied on sterilised meat and perished.

Indeed, such was the preoccupation with infection at the turn of the century that Sir William Arbuthnot Lane, a brilliant surgeon, was so carried away by the idea of focal sepsis that he induced countless patients to part unnecessarily with their colons<sup>38</sup>. It was an unproven hypothesis which no doubt he found profitable.

In similar fashion, many of today's practitioners of complementary medicine, having achieved long-sought recognition, often appear curiously reluctant to expose their traditional, but unproven hypotheses to experimental proof.

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