public dissection since the Alexandrine era was a post-mortem examination conducted to determine cause of death for legal purposes. This paper seeks to find precedents for that procedure in the decretals of Innocent III. A spirit of inquiry is discernible in those legal documents which helped to supply the impetus necessary to inaugurate the acceptance of scientific post-mortem examinations from which academic dissections, and ultimately the modern study of human anatomy evolved.

JAMES LIND AND THE PREVENTION OF SCURVY

by

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A FALSE PREMISE is irrelevant, if the cure arrived at works. Lind used the scientific method to find a cure for scurvy and nothing can detract from that.[1]

Before Lind there was a great variety of alleged cures—some genuine, some possible but not probable and a number (probably the majority) either ineffective or dangerous. Hughes[2] implies that Lind was lucky in that one (and only one) of his six tested remedies contained vitamin C. But it is evident from Lind's other writings and actions that he was, like Pasteur, an observer who also analysed. Unlike some scientists in later controversies he put his observations into practice without superfluous theory. Thus his conclusions about typhus led him to segregate, cleanse and reclothe new crew.[3] His observations on malaria led him to suggest that soldiers be billeted in hulks moored offshore;[3] a measure which, if taken, could have saved thousands of lives in later wars.

Why should we presume that Lind selected his remedies empirically from those favoured by ships' surgeons? Why should he have cluttered his book with the reasons for choosing these six? If he had tested six of Wesley's remedies,[4] he would have had one success at the very least, and almost certainly more, because of the eleven remedies, only five do not contain antiscorbutics.

It would seem logical to conclude that Lind devised his experiments to compare two possible cures for scurvy with four supposed cures for which he had previously seen no effectiveness. Such experiments would give him a controlled clinical trial in which if two or possibly four men recovered, they would be contrasted with at least eight who had not recovered and were still scorbutic. As all twelve were on the same basic diet, any improvement would be due to the curative properties of the individual remedy alone. The weakness of all previous remedies was that they were anecdotal and, not being controlled, the cures might have been coincidental.[5,6]

Lind was thus able to show clearly their curative properties—but not to distinguish between those of oranges and lemons—and the beneficial properties of cider. A

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more serious objection could be that there was no control group: a possible explanation of his results could be that the oranges and lemons had no effect, and that the other remedies made the scurvy worse. At least this would have been a step forward—an infant Dunlop Committee. But Lind of course could not have left two of his scorbutic sailors without any treatment as he was bound by the Hippocratic Oath.

I. LIND AS THE PRACTICAL MAN

Lind was a naval surgeon. He shows throughout his work that he was a practical man concerned with the problems that surrounded him. Not scurvy, but scurvy at sea interested him, and moreover, scurvy in the lower decks not among the officers who seemed almost immune. The six remedies of Wesley which contained antiscorbutics were nettle and goose-grass juice, water and garden cresses, mustard and scurvy grass, as well as lemon juice, pulped orange and orange in milk. These remedies would be commendable on land where they are obtainable—but as shown by Hirsch,[7] there have been few true outbreaks of scurvy on land and most of these have been in closed communities such as prisons where those affected had little access to any of Wesley's remedies. In the absence of records of clinical scurvy, it is unlikely that Wesley tried his cures on cases as severe as Lind's. Lind was obviously aware of the efficacy of fresh salads, including Wesley's garden cresses:

> I have known several captains, who by carrying out boxes filled with earth, which stood in their quarter galleries, were supplied with wholesome salads, after being some months out of harbour. A cask of rich garden-mould put occasionally in boxes on the poop, and sown with the seed of garden-cresses, would furnish these at any time. Such seeds will likewise grow in wet cotton.[8]

Such remedies were suitable for the officers, who already had enough food to preserve them from scurvy, but obviously could not be used to prevent scurvy among the hundreds of men living between decks. Any protection for the crew must of necessity be taken on board in large quantities, must keep in conditions of darkness and not rot. Pots of garden-mould were all right on the poop but would have been out of place on the maindeck.

Hughes says that the only cure for which any experimental evidence is adduced by Lind is oranges and lemons.[9] He says that the Vitamin C content of cider is negligible,[10] and quotes as evidence that a sample of commercially produced cider has a vitamin content of 0.33 mg/100 ml.[11] But Lind had included in his trial two sailors who "were ordered each a quart of cyder a day".[12] Modern commercial cider is a pale shadow of the old-fashioned brew but even modern cider would have given them an intake of 3.8 mg Vitamin C a day. This is approaching the intake of 5–10 mg/day which it is suggested may protect against scurvy.[13] Lind quotes from a letter by Mr. Ives who treated scorbutic seamen with a quart or three pints of cider daily and reduced the mortality from 20–50 to two or three, and these only when the cider had been expended.[14] Three pints of cider a day would have given, on Hughes' figure for modern commercial cider, 5.8 mg Vitamin C daily, just within the range to be effective. Unfortunately Lind does not state whether he received the letter from Mr. Ives before or after his experiments. However it might be reasonable to suppose that

it was before, and that the quart a day prescribed by Lind was chosen on the basis of Mr. Ives' experience.

Lind's recommendation for cider, prefaced "by my own experience",[15] was based on his experiments:

> Next to the oranges, I thought the cyder had the best effects . . . those that had taken it, were in a fairer way of recovery than the others at the end of the fortnight, which was the length of time of all these different courses were continued, except the oranges. The putrefaction of their gums, but especially their lassitude and weakness, were somewhat abated, and their appetite increased by it.[16]

II. ORANGE JUICE

Hughes shows that in producing inspissated juice (rob) from oranges, about fifty per cent of the Vitamin C is lost.[17] He concludes that this loss and the subsequent loss in storage negate Lind's claim for inspissation as a method of preserving their virtues for years.[18] However, Hughes' analysis does less than justice to the solutions contrived by Lind and his successors to the practical problems. Lind himself used fresh oranges and lemons in his experiments and quotes other ships' surgeons using fresh fruit to cure or possibly prevent scurvy. The use of fresh fruit was practicable so long as the ships were in regions where oranges and lemons grew, could be obtained and stored. It was an impractical solution for long voyages, blockades or in regions such as the Baltic. Citrus fruits would be required in large quantities and would be liable to go mouldy particularly if stored in damp, dark places. Storage would have been particularly difficult in warships as the fruit would have been bruised and damaged even if packed in barrels. Lind's proposals were more practical than is apparent from Hughes' analysis of the Vitamin C content of rob.

Fresh orange juice would take less space in barrels than the fruit itself. Twenty-five small-medium oranges occupied a volume of more than 5000 cc when placed in a box.[20] Juice from twenty-five oranges would occupy about 800 ml[11] but would ferment in a few days and be useless. The inspissate, however, would keep. Moreover, although half the Vitamin C would be lost, the volume of inspissate would be only one-tenth that of the juice. By reducing the oranges to inspissate, a far greater amount of Vitamin C could be carried in the same volume. In spite of the loss through storage[17] of seventy-five per cent, the remaining Vitamin C after twenty-eight days would still have been greater than that provided by the equivalent volume of oranges.

Table 1 shows that the Vitamin C content of the inspissate would have been about seven times that of the fresh oranges or allowing for possible differences in the size of the oranges used by Hughes, five times. Moreover, twenty-eight days at sea would not have improved the fresh oranges. Thus Lind's rob was a practical solution to the problem of scurvy at sea.

The loss of Vitamin C in rob might not have been as great as Hughes suggested. Rob would have been made at places where citrus fruits were grown. If freshly prepared for a ship, it would have been stored below the water-line. Average sea temperatures are 12–15 and 22–25°C in the Mediterranean and 25–27 and 28°C in the West Indies.[21] Hughes stored his inspissate at an unspecified room temperature.[11] Of course, if rob had been stored in warehouses or left in the sun for long periods,

the Vitamin C content might have fallen more rapidly. The loss of Vitamin C content in Hughes' inspissate was not constant and the rate increased with time: the percentage loss of what remained each week was eight per cent and eighteen per cent for the first and second weeks respectively and thirty-three per cent as an average for the third and fourth weeks. Vitamin C is sensitive to light, atmospheric oxygen and heavy metals.[22] Hughes does not say if his inspissate was exposed to light or tightly sealed. Rob manufactured for the navy would have been stored in tightly sealed barrels which would have excluded light and oxygen. However, there may well have been heavy metal contamination. It is therefore very difficult to judge how potent rob may have been and different batches may well have varied from very high Vitamin C content to none.

TABLE 1

Vitamin C content of a volume of inspissate equal to that occupied by the oranges.

	Volume (ml)	Vitamin C content (g)
Space to contain 25 small-medium oranges[20]	5000	4.0
Fresh juice[17]	800	4.0
Inspissate (rob)	80	2.0
Vitamin C content of rob	5000	125
—After 28 days storage (75% loss)		30

III. SCURVY AT SEA

Lind saw that scurvy at sea was a more complex disease than the similar condition seen more rarely on land. Scurvy became apparent shortly after putting to sea and was far more severe. Lind "emphasised that the cause of scurvy at sea was inseparably connected with the life of the sailor, in which cold, damp, infection, alcohol and discontent were all part of the picture."[23]

Lind's experiments had one basic weakness for proof of the aetiology of scurvy; but this fault was irrelevant to Lind's purpose —the *cure* of scurvy. The weak link in the proof lay in the effects of the remedies as interpreted by more recent writers. Lind describes the scorbutic sailors at the beginning of the experiments as having "putrid gums, the spots and lassitude with weakness of their knees".[12] It is clear from his description of the sailors who were given cider, "their appetite increased by it",[16] that scorbutic sailors suffered loss of appetite; the food itself was monotonous and unappetizing. Hughes rejects cider as an antiscorbutic because it does not contain enough Vitamin C. But Lind's sailors were taking other food: "water-gruel sweetened with sugar . . . puddings, boiled biscuit with sugar etc., . . . barley and raisins, rice and currants, sago and wine or the like."[12]

If the cider did not provide enough Vitamin C, the other food might have complemented it. If the cider acted as an appetizer for these men, they, and not those receiving *elixir vitriol,* vinegar, seawater or electuary, would have taken more of the other food and hence some further Vitamin C. In fact a basic diet, though dreary, monotonous and unappetizing, could contain enough Vitamin C to avert scurvy but if the sailors due to cold, damp, exposure and exhaustion lost all appetite, scurvy would result. In these circumstances, anything which stimulated the appetite would appear to be antiscorbutic. Cider, wine, orange and lemon juice and possibly other concoctions—especially alcoholic ones—may have acted partly or wholly as stimulants to eating.

It is also doubtful whether the effects attributed to scurvy were due entirely to lack of Vitamin C: it is probable that some of the ill effects at sea were due to multiple vitamin deficiencies and that some antiscorbutic remedies relieved symptoms due to these other deficiencies. Some of the remedies will have contained vitamins e.g. B complex, and others will have stimulated appetites.

CONCLUSIONS

Lind did not think scurvy a nutritional disorder caused by a specific deficiency.[10] But he may well have been near another truth: the clinical condition with which he was familiar may have been a multiple vitamin deficiency syndrome of which lack of Vitamin C was one factor. It would be difficult today to reproduce the living conditions and stresses of the British sailor of the eighteenth century and so determine the correctness of Lind's observations. Hughes is right that the pickling of onions destroys their Vitamin C content[10] but Lind's theory that the antiscorbutics corrected the quality of hard and dry food[10] might be correct—pickled onions may have stimulated the appetite.

A much greater weakness in Lind's experiment lay in his choice of subjects for the various remedies. Although he claims that "their cases were as similar as I could have them",[12] he later says that "two of the worst patients, with the tendons in the ham rigid (a symptom none of the rest had), were put under a course of sea-water". It would have been much sounder if his remedies had been allocated at random or, at the very least, that his possible cures should have been tried on one of his two worst patients.

Lind did not conduct a perfect experiment but he was far ahead of his time. He was that rare individual, a person like Pasteur, with acute observation and discrimination: he was also practical and able to translate his observations into convincing means and ends.

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2. R. E. Hughes, 'James Lind and the cure of scurvy: an experimental approach', *Med. Hist.,* 1975, **19**: 342–351.
3. S. F. Dudley, in op. cit., note 1 above, pp. 381–386.
4. Hughes, op. cit., note 2 above, p. 343.

5. Lind, op. cit., note 1 above, p. 146–147, footnote.
6. Hughes, op. cit., note 2 above, p. 343.
7. A. Hirsch, *Handbook of geographical and historical pathology*, vol. II: Chronic infective, toxic, parasitic, septic and constitutional diseases. Translated from the 2nd German edition, London, The New Sydenham Society, 1885, p. 507 ff.
8. Lind, op. cit., note 1 above, p. 161.
9. Hughes, op. cit., note 2 above, p. 345.
10. Ibid., p. 349.
11. Ibid., p. 347. The method of measurement of Vitamin C used by Hughes also includes dehydroascorbic acid which has been reduced to Vitamin C. When apples are sliced or crushed as in a cider press, the Vitamin C is oxidised to dehydroascorbic acid which still has antiscorbutic activity.
12. Lind, op. cit., note 1 above, p. 145.
13. S. Davidson, R. Passmore and J. F. Brock, *Human nutrition and dietetics*, 5th ed., Edinburgh, Churchill Livingstone, 1972, p. 136.
14. Lind, op. cit., note 1 above, p. 146–147, footnote.
15. Ibid., p. 161–162.
16. Ibid., p. 146–147.
17. Hughes, op. cit., note 2 above, Table 1, p. 347.
18. Ibid., p. 348.
19. Lind, op. cit., note 1 above, p. 148–149.
20. Hughes, note 17 above, does not give the volume sufficient to contain his twenty-five oranges. The oranges I bought may have been a little larger than the ones used by Hughes. The volume sufficient to contain them would also be different if they were packed in a barrel.
21. Surface sea temperatures for February and August respectively. A. Defant, *Physical oceanography*, Oxford, Pergamon, 2 vols., 1961, vol. 1, p. 140, plates 3a, 3b.
22. K. Diem and C. Lentner (editors), *Scientific tables*, Documenta Geigy. 7th ed., 1970, p. 489.
23. Guthrie and Meiklejohn, in op. cit., note 1 above, p. 396.

Dr. R. E. Hughes made the following reply to Dr. Wyatt's comments:

To theorise about the ascorbic acid content of eighteenth-century cider would be a somewhat sterile exercise; however, I find difficulty in accepting that cider, because of a supposed "appetite effect", could materially increase the intake of ascorbic acid—particularly as the diet described by Dr. Wyatt in this respect (water gruel, sugar, puddings, boiled biscuit, barley, raisins, rice . . .) would contain no ascorbic acid. The claim that an orange juice inspissate could be a valuable source of ascorbic acid after twenty-eight days is equally irrelevant. Twenty-eight days is scarcely a meaningful period in terms of scurvy. Scurvy emerged after 90–200 days at sea—a finding confirmed in recent years by observations on human volunteers; at this stage the ascorbic acid content of the inspissate would be virtually zero and beyond the reach of even Wyatt's skilful advocacy! More to the point perhaps is that the inspissate was tried and rejected on a number of occasions following the publication of Lind's book. It is difficult to reconcile these findings with Lind's unqualified claim that this was "a method of preserving their virtues entire for years . . ."—and similar arguments are adducible against his other supposed remedies—pickled onions, fermented drinks and bottled gooseberries.

I should not wish to detract from Lind's scientific reputation in other directions—his undeniable powers of observation and interpretation, and his use of the experimental method, albeit, to my way of thinking, in an imperfectly structured form. What should interest medical historians is that Lind, at the same time, made claims which, in the light of current scientific knowledge, could not possibly be true.