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The understanding of scurvy during the heroic age of Antarctic exploration

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ABSTRACT. At the start of the heroic age of Antarctic exploration there was great confusion concerning the cause of scurvy. It was known that it was related, in some way, to food but it was uncertain as to how, and there were two main theories. The first was that it was caused by a deficiency of fruit and vegetables and the other that it was caused by a toxic material in tinned foods. In addition, older theories that it was caused by dirt and damp still carried weight and Almroth Wright had proposed that scurvy was caused by too much acid in the blood. An additional confusion was that vitamin C deficiency was often combined with other vitamin deficiencies and so other diseases might be labelled as scurvy. The discovery of vitamins occurred over the same period but, as with all new scientific concepts, the knowledge that scurvy was caused by a vitamin deficiency took time to be universally accepted. It was generally accepted by about 1920, although some people did not accept it until vitamin C had been isolated in 1932.

Introduction

Scurvy had been a major problem on the early Arctic explorations and was recognised as a potential problem for the early Antarctic explorers and, indeed, there were outbreaks of scurvy on R.F. Scott's *Discovery* (1901–1904) and *Terra Nova* (1910–1913) expeditions; J-B Charcot's *Pourquoi Pas?* expedition (1908–1910) and in E.H. Shackleton's Ross Sea Party (1914–1917). Most of what has been written about the understanding of scurvy on the expeditions discusses the controversies around whether scurvy was caused by a lack of fresh food or by a toxic substance in the tinned food. However the understanding was more complicated than that and made more difficult by the fact that the discovery of the cause of scurvy occurred over the time of these expeditions. The aim of this paper is to describe how scurvy was understood during these expeditions.

It is not intended to describe the history of scurvy in detail as this has been done by others (Carpenter 1986; Bown 2003) but it is, of course, necessary to explain some of the history in order to describe how the expedition members understood the disease.

Scurvy, as described, was not necessarily the same as what we now call scurvy

First it must be recognised that scurvy as it was understood before and during the heroic age is not necessarily the same as the disease we now call scurvy. Scurvy is caused by a deficiency of vitamin C and since the discovery of vitamins, the clinical features of the disease have been worked out in volunteers fed diets deficient only in vitamin C (Crandon and others 1940; Medical Research Council Vitamin C Subcommittee of the Accessory Foods Committee 1953; Hodges and others 1969). These have shown that the clinical features of scurvy are, largely, bleeding (and its complications) and gum disease. Descriptions of scurvy at the time describe these symptoms but also describe others. A standard medical textbook of 1907 describes oedema, palpitations, irregularity of the heart and, occasionally, night- and day-blindness in addition to those now recognised as being due to vitamin C deficiency (Osler 1907: 751–752). These are not features of vitamin C deficiency but are symptoms of deficiencies of thiamine (vitamin B1) and vitamin A in addition to vitamin C. It seems that what was described as scurvy was, often, a deficiency of several vitamins and pure beri-beri might be referred to as scurvy (Guly in press).

Failure of lime juice to prevent scurvy

It had long been known that scurvy could be cured or prevented by eating fresh fruit and vegetables and Lind's famous experiment demonstrated that scurvy could be cured with fresh lime juice. However there was also a belief that dirt and damp also contributed to the disease. Captain Cook (who recognised the importance of fresh food) said, in relation to scurvy: 'To this [keeping sailors and their clothes and bedding, dry] and cleanliness, as well in the ship as among the people, too great attention cannot be paid; the least neglect occasions a putrid, offensive smell below, which nothing but fires will remove' (Carpenter 1986: 82). Following the introduction of lime juice into the Royal Navy in 1796, the incidence of scurvy fell considerably. In the Merchant Navy, lime juice was introduced by the Merchant Shipping Amendment Act of 1867, following which the incidence of scurvy also fell in that service too (Cook 2004).

However during the late 19th century, the incidence of scurvy started to rise again. We now know that this is because the navy changed from Mediterranean lemons to West Indian limes. Chick and others (1918) found that fresh West Indian limes contained about a quarter of the vitamin C content of Mediterranean lemons (though more modern research has found that they contain about two thirds as much vitamin C) (Carpenter 1986: 237) and Chick (1918) also found that the preserved lime juice of the time contained almost no vitamin C. This is because the vitamin C was destroyed by the heat that

was used to try to concentrate the lime juice and by the copper vats and tubing used in the production of concentrated lime juice (Carpenter 1986: 237–240). Seamen developed scurvy despite taking regular lime juice and this coincided with Arctic explorers reporting that Eskimos, whose diet consisted almost wholly of meat, did not get scurvy. Thus, although the cure for scurvy was known, the cause was unknown and the theory that it was caused by a deficiency of fruit and vegetables and could be prevented by regular lime juice was dealt a blow.

The understanding of scurvy at the time is probably best summed up by E. Ekelöf, the surgeon to the Swedish Antarctic Expedition (1901–1903) when he wrote: 'That food is the determining factor as regards outbreaks of scurvy . . . has long been acknowledged, but we are still in ignorance concerning the particular fault in the food which is the ultimate cause of the disease (Ekelöf 1904).

A medical textbook of the time states that there were three theories:

a) That it is the result of an absence of those ingredients in the food that are supplied by fresh vegetables. . .
b) That it is due to toxic materials in the foods. . . [or]
c) . . . it depends upon a specific (as yet unknown) micro-organism (Osler 1907: 751–752).

If scurvy was due to a deficiency of some sort, then some foods were intrinsically antiscorbutic. Thus Charcot wrote of the *Pourquoi Pas?* expedition: 'We kept on board an ample stock of antiscorbutics, such as sauerkraut, tomatoes and lime juice. This combined with vegetables and fruit, either dried or in jam etc, were evidently more than sufficient to save us from the scurvy of old. . .' (Charcot 1978). E. Gourdon, who sailed with Charcot extensively, said 'one cannot deny that wine is an excellent anti-scorbutic and it can be recommended' (Gourdon 1913: 32). *The Lancet* had also, somewhat earlier, stated that 'alcohol is undoubtedly an antiscorbutic (though perhaps not a powerful one)' (Anon 1876).

The Jackson–Harmsworth Expedition (1894–1897) and the ptomaine theory

The experience of this expedition to Zemlya Frantsa-Iosifa (Franz Joseph Land) had a major influence on the way that scurvy was understood on the Antarctic expeditions, not least because R. Koettlitz, the surgeon on the expedition, and A.B. Armitage later became members of Scott's *Discovery* expedition and W.S. Bruce, the zoologist, went on to lead his own *Scotia* expedition (1902–1904).

On this expedition the land based explorers had no lime juice but ate fresh polar bear meat every day and none of them developed scurvy. However the ship's crew refused to eat the rather unpalatable meat but had the regulation lime juice every day. All developed scurvy and two died. Koettlitz realised that scurvy could be prevented and cured with fresh meat and concluded that the cause of the scurvy was that 'something was radically wrong with the preserved meats, whether tinned or salted. . .' (Koettlitz 1902).

Bruce had also sailed as surgeon on *Balaena*, one of the ships of the Dundee whaling expedition (1892–1893), He says that by the time they got back to England 'one and all [of the crew] were more or less tainted with scurvy, including one seaman who was very seriously ill' despite taking regular lime juice whereas the crew of the Norwegian ship, *Jason*, had no scurvy despite not taking lime juice (Bruce 1911: 105–106).

The Jackson–Harmsworth expedition met F. Nansen on the return from his attempt to reach the North Pole on the *Fram* expedition (1893–1896) and he introduced them to a theory from Professor S. Torup of Christiana University, that scurvy was caused by a bacterial toxin. Nansen was well respected as an explorer and (later) as a scientist and statesman and so his views received much attention (Anon. 1897). At that time, acute food poisoning was considered to be due to ptomaines, a toxin produced by bacteria in the food. Koettlitz states that Torup concluded that: 'although the acute form of ptomaine poisoning was well known, a chronic form was unknown; that there must also be a chronic form, and that scurvy must be this chronic form.' Thus scurvy was caused by chronic ptomaine poisoning. The food appeared to be of good quality but was 'tainted' in some way. Scurvy could be prevented as long as it was ensured that meat was fresh when it was tinned; that it was tinned properly and the tins were kept in a good condition. He goes on to say: 'That these precautions will be sufficient to relieve us of the danger of . . . scurvy I have little or no doubt, and if . . . there will be a sufficiency of fresh game in the shape of penguins and seals, we can take it as certain that no scurvy will be heard of in connection with the expedition, however long it may remain in the High South' (Koettlitz 1902). In saying this, he was echoing what Nansen had told him:

> As to the provisions of Polar Expeditions I think it is very essential that all the tinned and dried foods are fully examined before they are taken, and that no box is used which is in any way suspicious . . . The most important is, however, that precautions are taken that all food is perfectly sterilized, so that there is no possibility of ptomaines or similar poisons being formed in the tins . . . Give the men good healthy food and I garantee (sic) you will have no diseases' (Nansen 1900).

Koettlitz's belief was 'That there is no antiscorbutic property in any food or drug is to my mind a certainty. An animal food is either scorbutic – in other word, scurvy-producing – or it is not' (Koettlitz 1902).

This theory was developed by F.G. Jackson, the leader of the Jackson–Harmsworth expedition in a paper in *The Lancet* (Jackson and Harley 1900). Interestingly Koettlitz, the expedition doctor, was not an author of the paper.

Ekelöf only partially accepted this theory: 'I wish to remark . . . that this theory cannot be true in its entirety, there being unquestionable examples of expeditions

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having been attacked by scurvy, where, as far as can be judged, the provisions have been of first rate quality, and the blame cannot be ascribed to *bad* preservation of the food' (Ekelöf 1904). He felt that scurvy was caused by autolysis due to the *prolonged* storage of food (Anon 1905) and recommended that food be tinned as late as possible.

The *Discovery* Expedition (1901–1904)

Despite the fact that the taint was not obvious, it was the doctors' job to inspect the food. Edward Wilson states: 'Not a tin of suspicious food was ever passed, and every day not only was every tin of meat examined by sight and smell but also every tin of milk the moment it was opened' (Wilson 1905).

Koettlitz's faith that scurvy would not occur on the expedition was misplaced and it is interesting to explore what happened when scurvy did occur. Both Koettlitz and Armitage knew the value of fresh food and this was provided in the form of seal meat. As has been well described, Koettlitz grew some mustard and cress and other vegetables. Some of the descriptions of this might indicate it to be a botanist's experiment to see whether Antarctic soil would support plant life. However the timing was perfect for the treatment of scurvy and that is probably why the plants were grown as growing mustard and cress on board ship had been recognised since the early 19th century as a treatment for scurvy (Anon. 1869; Cook 2004). Lime juice was also served out. (Armitage 1984: 46)

Scott seems to have accepted the fresh food treatment for scurvy but also seems to have harboured the much earlier ideas of dirt as a cause of scurvy. He reports that: 'We have had a thorough clearance of the hold, disinfecting the bilges, whitewashing the sides, and generally made them sweet and clean' and 'as a next step I tackled the clothes and hammocks . . . we have had them all thoroughly aired. We have cleaned all the deck-lights so as to get more daylight below, and we have scrubbed the decks and cleaned out all the holes and corners until everything is as clean as a new pin' (Scott 1929: 400).

When the news of scurvy reached England, the *British Medical Journal* thundered: 'It is very disappointing to learn that in the Antarctic expedition . . . should have been crippled by scurvy. . . "Some one has blundered", and we must await further particulars of the circumstances to discover where the blame is to be laid.' (Anon. 1903). At a British Medical Association meeting Inspector-General Turnbull, R.N., said that the true antiscorbutic is purity of food. 'When we learn that "at least some of the food was so bad that not only did the men suffer, but the dogs died," we hope, with the *Times*, that a searching inquiry will be made to discover who is the culprit' (Anon. 1903).

Nimrod (1907–1909) and *Pourquoi Pas?* (1908–1910) Expeditions

In the late 19th century an atypical form of beri-beri appeared in sailors, particularly on Scandinavian ships. This was called 'ship beri-beri' (Holst 1907) and was, almost certainly, what is now known as wet beri-beri. Holst and Frölich (1907) tried to reproduce this disease in guinea pigs using diets similar to those of the sailors, but they developed scurvy instead. Scurvy did not develop if they were also fed cabbage but boiled cabbage lost most of its protective power. This was the first real evidence that scurvy was a deficiency disease.

Their research was published in 1907 and came too late for the next two Antarctic expeditions, Shackleton's *Nimrod* expedition which left in 1907 and Charcot's *Pourquoi Pas?* expedition which left the following year. Shackleton had the same beliefs on scurvy as Koettlitz, writing that it was 'often produced by eating preserved food that is not in a perfectly wholesome condition. It is now recognised that scurvy may be avoided if the closest attention is given to the preparation and selection of foodstuffs along scientific lines . . .' (Shackleton 1999) . E. Marshall, one of Shackleton's surgeons was no more enlightened and said that: 'Before going South, I had hoped to add something to our knowledge of Scurvy and interviewed several men who were reputed to have knowledge of the subject, but it seemed largely "guess work"' (Marshall 1950).

Some of the polar expeditions were affected by beri-beri and the understanding of scurvy was complicated by the fact that on several expeditions this was considered to be scurvy but did not respond to treatment in the same way. This has been described elsewhere. (Guly in press). The *Pourquoi Pas?* expedition was affected by both beri-beri and scurvy. Charcot believed this to be a single disease which he called 'modern scurvy' or 'disease of preserved foods' saying that 'it is provoked by the preserved-foods and not by the absence of fresh meat (Charcot 1978: 235). He explained this by suggesting that the disease had changed: 'In the past when crews lived almost entirely on salt meat they were attacked by the well-known variety of scurvy, with large black spots, ulceration of the gums, etc. But everything changes, even diseases, and with the modern preserved food the classical scurvy has been replaced by the curious kind from which we suffered, characterised especially by oedema of the lower limbs and myocarditis without anything wrong with the gums' (Charcot 1978: 216).

His (and others') thoughts were undoubtedly influenced by the long-held supposition that disease was caused by a harmful substance for example a poison or a bacterium with little concept of disease being caused by lack of a substance.

Terra Nova Expedition (1910–1913) and the acid intoxication theory

This expedition coincided with much research into 'anti-scorbutic factor', that is the factor that prevented scurvy (now known as vitamin C) that was known to exist although it had not been chemically isolated. No knowledge of this had reached E.L. Atkinson, Scott's senior

surgeon, nor R. Amundsen who was racing Scott to the Pole.

Before the Jackson–Harmsworth expedition, Almroth Wright (the military professor of pathology based at the army medical school and hospital at Netley, Hampshire) wrote to Koettlitz, warning him that 'you may have to deal with scurvy' and gave him some advice on how to prevent it. He believed that scurvy was due to excessive acid in the diet and that lime juice was not only useless but was harmful and said 'I would therefore urge you to take a supply of acetate and citrate of soda in lieu of, or in addition to the lime juice. A very few grains daily ought to prevent any diminution of the natural alkalinity of the system' (Wright 1894). In this letter he described his theory that scurvy was caused by excessive acid, a full six years before this was described in *The Lancet* (Wright 1900) although he described it in the military literature in 1897 (Wright 1900). There is no evidence that Koettlitz accepted this theory.

Scott says that Atkinson 'holds the first cause to be tainted food, but secondary or contributory causes may be even more potent in developing the disease. Damp, cold, over-exertion, bad air, bad light, in fact any condition exceptional to normal healthy existence'. Scott also states that Atkinson was a believer in Wright's theory of 'acid-intoxication' of the blood. (Scott 2005: 269–270). This is what is now known as 'metabolic acidosis'.

Normal blood is slightly alkaline (pH 7.4) and Wright had developed a test to investigate the degree of alkalinity by adding a fixed volume of sulphuric acid to a blood sample and observing what concentration of acid was required to render the blood neutral. Normal blood might be neutralised by a 1 in 30 (N/30) concentration of sulphuric acid but blood that was more acidic than normal would be neutralised by a N/60 or N/80 concentration. The normal value was between N/30 and N/45 (Wright 1897). Wright had investigated some soldiers with scurvy and had found their blood to be excessively acid and concluded that the acidity was the cause of scurvy. (Wright 1900). Thus one reads in Wilson's diary: 'Atkinson has been testing the alkalinity of everyone's blood. All indicate good health, my own is as good as anyone here, N/30, but 2 are decidedly less good than the others. Most are N/40, but these two are N/50 which is not good' (Wilson 1972: 128).

Levick obviously believed the same as he had written details of the testing in his diary:

DN	S	= N/10				
DN	H20	S	=N/20			
DN	H20	H20	S	=N/30		
DN	H20	H20	H20	H20	S	= N/40

About normal (Levick 1910).

In fact the acidosis was an effect of the scurvy rather than the cause, as the dental problems with scurvy led to starvation and the build up of keto-acids (Holt 1972). The sodium lactate that Wright now recommended to correct the acidosis would not only have been ineffective but might deflect attention from other treatments. Scott says that sodium lactate 'is the only chemical remedy suggested' (Scott 2005) and Levick, in his notebook had recorded that the treatment of scurvy was sodium lactate once a day for a week, after meals (Levick 1910). However Atkinson did recommend fresh vegetables though he felt that fresh meat was of no value. Wilson disagreed, (Cherry-Garrard 2001: 219) presumably because he had seen that treatment work on the *Discovery*.

Amundsen, as a protégé of Nansen, not unexpectedly, also believed that 'any carelessness, any perfunctory packing [of the tinned foods] on the part of the factory, will as a rule lead to scurvy' (Amundsen 1913: 54). He had no doubts about the value of fresh meat and ate both seal and dog meat.

Citric acid

Citric acid had been isolated in 1784 and it had been claimed that this was the active antiscorbutant in lime juice (Carpenter 1986: 91) although by 1848, it had been found to be ineffective (Carpenter 1986: 108). Despite this, Gourdon following his experiences on the French expeditions recommended that everybody should take a citric acid tablet every day (Gourdon 1913: 42).

Large quantities of citric acid tablets were taken on both of Scott's expeditions and also on Shackleton's *Nimrod* and *Endurance* expeditions. I presume they were taken for scurvy though the manufacturers also recommended them for rheumatism, hepatic inactivity, catarrhal jaundice and to decrease blood coagulability (Anon. 1917: 46).

The only description of its use by the British is by Levick in the *Terra Nova* northern party which was stranded, without adequate food supplies, when the vessel was unable to rescue them because of ice. In his diary, he wrote: 'I have got a large supply of citric acid tabloids, and have started serving them out, 4 tabloids (20 grains) every 3 days for each man. They are refreshing and very pleasant and ought to be good for us in the absence of vegetable acids' (Levick 1910–1913: 8 June 1912). He seems to imply a medical value to them but it is probable that they were used just to add variety to a rather tedious diet of seal meat as R. Priestley states: 'When Levick produced ginger tabloids and tabloids of citric acid from our medicine-chest, we used to ring the changes also on preserved ginger (ginger and sugar) and lemonade (citric acid, sugar and a little hot water). Indeed as soon as the citric acid tabloids were produced, our drink of reboiled tea on Mondays was almost completely done away with and hot sweet lemonade was substituted. The citric acid was the only thing to take away the taste of the blubber from the water and it was the only clean-tasting drink we had' (Priestley 1974: 284).

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Vitamins

The word 'vitamine' was coined in 1911 and in 1912 it was postulated that there were four diseases, including scurvy, caused by 'vitamine' deficiency. By the time of Shackleton's *Endurance* expedition (1914–1917), there was more knowledge available but the vitamin theory was not universally accepted. A.H. Macklin (one of Shackleton's surgeons) later wrote:

> It was clear that there was a grave risk of scurvy developing on the trans-continental sledge journey and a great deal of thought was given to the problem before the ship left England... The workers at the Lister Institute very kindly passed on to Shackleton the latest results resulting from Gowland Hopkin's work ... I was personally deeply interested in the whole question of scurvy and its prevention, and read all I could find on the subject in the past and current literature. I also discussed the new 'vitamine' theory with a number of the more prominent medical men of the time. Most of them were very sceptical and I came to the conclusion that scurvy really was the result of a 'gastro-intestinal' toxin which developed in the absence of green foods. I decided that it was important to ensure scrupulous cleanliness in preparation of food, to maintain general health at the highest level, to avoid constipation, to keep quarters clean and bright, and to eat, while we had it, as great a variety of foods as possible, particularly bottled fruits and preserved vegetables. I also had the impression that the toxin might be contained in tinned meats and that therefore they should be avoided... Shackleton, who had a very versatile mind, and who also had very carefully searched the literature and made enquiries about all aspects of scurvy, enthusiastically accepted the vitamin theory ... (Macklin 1951).

To Priestley, he wrote: 'When I joined the "Endurance" expedition much of the pleasure of the trip ... was clouded by the fear of scurvy, for having assimilated all the available literature on the subject I was left with a mass of conflicting evidence – I did not know the cause of scurvy, and I had not the least idea of how to tackle it if it broke out away from supplies. The vitamin theory was in its infancy and the evidence for it too slender to be convincing' (Macklin 1926).

J. Cope, a biologist with no medical training, who had to act as the surgeon on the Ross Sea party in the absence of a doctor, had a clearer idea of the cause of scurvy. As a recent graduate from Cambridge, he had probably learned about modern theories and was not encumbered by medical traditions. He wrote:

> Scurvy is not due to any germ or bacteria and cannot be cured or prevented by tinned or dried foods. There is in the blood of man (and as far as is known at present in some other mammals) a substance known generally as a "vitamine". This substance is found in the blood but its origin is quite unknown. The same remarks apply to fresh foods and vegetables, and from these substances the individual vitamins can be extracted. But it has not been possible to prepare these substances synthetically. These extracts are just as advantageous in curing the disease as fresh animal foods, vegetables or fruits and I tried to obtain some from Messrs Burroughs Wellcome in Sydney (N.S.W.) before we left civilisation but was unable to procure any samples. Scurvy is due to the absence of this vitamine owing to the lack of fresh animal or vegetable food stuffs, the vitamins in these being transformed into the specific vitamine of the body and circulating in the blood although as I have said the origin of this substance from the food stuffs to the blood is quite unknown. Lastly the state of health of the patient not only affects the course of the disease but is a great factor in resisting its incidence (Cope 1917).

This was written in 1917 at the end of the expedition but it is clear that he understood vitamins in 1914.

All new theories take time to be accepted and while by 1920, it was generally recognised that both beriberi and scurvy were caused by vitamin deficiency, this was not universally accepted. In 1931 Charcot again described 'maladie des conserves' or 'scorbut moderne' and wrote that 'it will serve no benefit to take in large quantities of fresh meat, vegetables, fruits etc – let us say the word – and vitamins if one continues to consumes preserved foods, even in small quantities .... (Charcot 1931). Wright did not accept that scurvy was a vitamin deficiency disease until 1934 (Holt 1972), despite the fact that vitamin C had been isolated in 1932.

Quest expedition (1921–1922)

By the time of the *Quest* expedition, much more was known about vitamin C. It was known what foods contained the vitamin and how it was destroyed by heat and it was understood why lime juice had failed to prevent scurvy. However Macklin, was still not convinced that vitamin deficiency was the only cause as he wrote, after the expedition that:

> For practical purposes it [scurvy] may be regarded as due to two main causes
>
> The lack in the food of an essential factor or vitamin, which leads to a condition of the body with diminished resistance to deleterious influences.
>
> The addition to the system during this devitalized state of a poison
>
> Prevention aims, therefore, at the provision of food containing the active vitamin in sufficient quantity and in taking steps to eliminate as far as possible poisons from the system.

In addition he commented:

> The elimination of poisons from the system is aimed at firstly, ... to avoid sources of poisons in the body itself, eg, the mouth, teeth, throat, and nasal passages with their accessory sinuses, and, secondly, by ensuring that no bad or 'high' food shall be eaten.

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> Constipation . . . must be avoided and it is necessary that all hands be impressed with the importance of a regular daily movement of the bowels and a complete evacuation at each act. . . . Constipation is followed by absorption of poison from the bowel, and so must be especially avoided if the risk of scurvy is imminent. Its correction in bad weather must be carefully carried out, for the cruelty of drastic purgation under these conditions can be imagined (Macklin 1923).

Despite the knowledge of vitamins, there was still a real practical problem of preventing scurvy on polar expeditions as while fresh food would prevent scurvy, it was impossible to carry enough fresh food on a long sledge journey inland. Although the effects of vitamin C were known, the way it worked was still unknown. McCarrison wrote: 'whatever the true nature of vitamins, they resemble in their action that of hormones' and went on to say that 'endocrine extracts . . . can delay in their onset and alleviate the symptoms of polyneuritis in pigeons resulting from deprivation of vitamin B. The beneficial effects of these extracts appears to be due as much to their action as metabolic stimulants as to any vitamins they may contain . . .. (McCarrison 1921: 131).

It was probably this that led Macklin and L.D.A. Hussey to propose that 'Extracts of thyroid or of some of the other endocrine glands, may therefore be of use in staving off the more pronounced effects of scurvy, and in this way might be of real value on a sledging journey. . ... (Macklin and Hussey 1921). In fact no major sledging expeditions were done on the *Quest* expedition so this theory was never tested.

Death of Scott and colleagues

Since the expeditions there has been much discussion on whether Scott and his companions died of scurvy but both Marshall and Macklin considered that they did.

Marshall believed that 'The "weakness" complained of by Scott in his last journey was, in my opinion, not so much due to a low intake . . . but to weakness from scurvy, which I have always considered to be one of the first symptoms when it is associated with hard work' and 'Later the growing weakness and readiness to frost bite by all was indicative of lowered resistance due to scurvy' (Marshall 1950).

Macklin said that '. . . in my mind there is not a shadow of doubt that the cause of the [Scott] party weakening was vitamin deficiency.' Although Wilson made no comment about scurvy in his diary, 'in Wilson's day scurvy was not recognised until certain well-marked signs began to make their appearance.' In the First World War Russian campaign:

> I learnt that scurvy as we have been taught to recognise it was only the last stage of a prolonged and progressive disease.
>
> . . . I developed the disease myself; felt tired, lethargic, chilly, and could only carry out physical work at the cost of great mental effort. I became short of breath and was diagnosed by a British doctor as having heart disease, and advised to return to base. A Russian physician who saw me said I had scurvy, I was given appropriate food, and within a week was fit to go back to my work. So you have the picture of a doctor, with his mind obsessed with scurvy, having it himself and not in the least suspecting it (Macklin 1926).

Macklin also described lethargy in a medical journal. He said that in the Russian campaign, scurvy 'occurred amongst our own troops, but in the early stages-that is, what might be called the prescorbutic stage. They were not always recognized owing to the vagueness of symptoms and absence of well marked signs. The symptoms consisted chiefly of tiredness and lethargy. . . (Macklin 1925).

These quotations indicate a change in the understanding of scurvy from a disease caused by vitamin C deficiency and characterised by specific physical signs (bleeding and gum disease) to a disease defined by vitamin C deficiency alone without the necessity of physical signs. While there are undoubtedly other reasons to believe than Scott and his colleagues were vitamin C deficient (analyses of their diet; Lt. E.R.G.R. Evans' scurvy), it may not be safe to attribute fatigue sufficient to lead to death, to vitamin C deficiency. Fatigue is a very non-specific symptom which can be caused by very many physical and psychological illnesses. A case report on an individual on an experimental vitamin C deficient diet described 'easy fatigue and slight weakness' (Crandon and others 1940) and a study of 12 men showed a small increase in the time taken to perform an agility test (Vitamin C subcommittee of the Accessory Food Factors Committee 1953). Neither of these suggests that fatigue was a major problem and another study of six men who also walked ten miles a day, said that fatiguablity and general malaise started at about the same time as the objective manifestations of scurvy. (Hodges and others 1969).

In summary

When scurvy is referred to in the literature of the heroic age of Antarctic exploration, what was meant and understood was not always the same and varied depending on the beliefs of the individual and when it was written.

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References

Amundsen, R. 1913. *The South Pole* (translator Chater, A.G.). New York: John Murray.

Anon. (Anonymous).1869. Death of Mr James Haviland. *British Medical Journal* 2:640.

Anon. (Anonymous). 1876. Scurvy and Arctic exploration. *The Lancet* 2:689–690.

Anon. (Anonymous). 1897. Dr Nansen on the prevention of scurvy. *British Medical Journal* 1:465–466.

Anon. (Anonymous). 1903. Scurvy on the *Discovery*. *British Medical Journal* 1: 807.
Anon. (Anonymous). 1905. Diseases due to preserved food. *British Medical Journal* 1:670–671.
Anon.(Anonymous). 1917. *Wellcome's excerpta therapeutica*. London: Burroughs Wellcome and Co.
Armitage, A.B. 1984. *Two years in the Antarctic*. Bungay: Bluntisham Books and the Paradigm Press.
Bown, S.R. 2003. *Scurvy*. Chichester: Summersdale Publishers Ltd.
Bruce, W.S. 1911. *Polar exploration*. London: Williams and Norgate.
Carpenter, K.J. 1986. *The history of scurvy and vitamin C*. Cambridge: Cambridge University Press.
Charcot, J-B. 1978. *The voyage of the 'Pourquoi Pas?'* (translator Walsh, P.) London: C Hurst and Co.
Charcot, J-B. 1931. La maladie des conserves. *La Presse Médicale* 55: 1057–1058.
Cherry-Garrard, A. 2001. *The worst journey in the world*. London: Picador.
Chick, H., M. Hume, R.F. Skelton, and A. Henderson Smith. 1918.The relative content of antiscorbutic principle in limes and lemons. *The Lancet* 2:735–738.
Cook, G.C. 2004. Scurvy in the British mercantile marine in the 19th century and the contribution of the Seaman's Hospital Society. *Postgraduate Medical Journal* 80:224–229.
Cope, J. 1917. Medical report of the Ross Sea Base ITAE. Cambridge: Scott Polar Research Institute MS 1537/4/3.
Crandon, J.H., C.C. Lund, and D.B. Dill. 1940. Experimental human scurvy. *The New England Journal of Medicine* 233: 353–359.
Ekelöf, E. 1904. Medical aspects of the Swedish Antarctic Expedition October 1901-January 1904. *Journal of Hygiene* 4:511–540.
Gourdon, E. 1913. *Thèse pour le Doctorat en Médecine; un hivernage dans l'Antarctique*. Paris: G Steinheil.
Guly, H.R. 'Polar anaemia': cardiac failure during the heroic age of Antarctic exploration. *Polar Record* in press.
Hodges, R.E., E.M. Baker, J. Hood, H.E. Sauberlich, and S.C. March. 1969. Experimental scurvy in man. *American Journal of Clinical Nutrition* 22: 535–548.
Holst, A. 1907. Experimental studies relating to 'ship-beri-beri' and scurvy. *Journal of Hygiene* 7:619–633.
Holst, A., and T. Frölich. 1907. Experimental studies relating to ship-beri-beri and scurvy. *Journal of Hygiene* 7: 634–671.
Holt, L.B. 1972. Medical aspects of polar exploration: sixtieth anniversary of Scott's last expedition. *Proceedings of the Royal Society of Medicine* 65:47–48.
Jackson, F.G., and V. Harley. 1900. An experimental inquiry into scurvy. *The Lancet* 1:1184–1188.
Koettlitz, R. 1902. The British Antarctic expedition: precautions against scurvy in the victualling of the 'Discovery'. *British Medical Journal* 1:342–343.
Levick, G.M. 1910–1912. Notebooks. Cambridge: Scott Polar Research Institute MS 1555/1–3.
McCarrison, R. 1921. *Studies in deficiency diseases*. London: Henry Frowde and Hodder and Stoughton.
Macklin, A.H. 1923. Appendix V – medical. In: Wild, F. *Shackleton's last voyage: the story of the' Quest'* . London: Cassells and Co. Ltd: 352–365.
Macklin, A.H. 1925. Lime juice and lemon juice for the prevention of scurvy *British Medical Journal* 1: 660.
Macklin, A.H. 1926. Letter to Raymond Priestley, 12 October 1926. Cambridge Scott Polar Research Institute MS 924.
Macklin, A.H. 1951. Letter to John Kendall, 19 February 1951. Cambridge: Scott Polar Research Institute MS 656/3/1–2.
Marshall, E.S. Letter to John Kendall, 24 August 1950. Cambridge: Scott Polar Research Institute MS 656/1–4.
Medical Research Council Vitamin C Subcommittee of the Accessory Foods Committee. 1953. *Vitamin C requirement of human adults*. London: HMSO.
Nansen, F. 1900. Letter to Reginald Koettlitz, 27 February 1900. London: Royal Geographical Society MS LMS K12.
Osler, W. 1907. *The principles and practice of medicine*. 6th edition. London: Appleton.
Priestley, R.E. 1974. *Antarctic adventure: Scott's northern party*. London: C. Hurst and Co.
Scott, F.R. 1929. *The Voyage of the 'Discovery'*. London: John Murray. 400.
Scott, R.F. 2005. *Robert Falcon Scott journals: Captain Scott's last expedition*. (editor Jones, M.). Oxford: Oxford University Press.
Shackleton, E.H. 1999. The heart of the Antarctic. London: Robinson Publishing.
Wilson, E.A. 1905. The medical aspect of the *Discovery's* voyage to the Antarctic. *British Medical Journal* 2: 77–80.
Wilson, E.A. 1972. *Diary of the Terra Nova expedition to the Antarctic 1910–1912*. (editor King, H.G.R.) London: Blandford Press.
Wright, A.E. 1894. Letter to Reginald Koettlitz, 4 July 1894. London; Royal Geographical Society MS SSC/8/2.
Wright, A.E. 1897. On a simple method of measuring the alkalinity of the blood. *The Lancet* 2:719–721.
Wright, A.E. 1900. On the pathology and therapeutics of scurvy. *The Lancet* 2:565–567.