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Scurvy and Vitamin C

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Abstract

This paper outlines the history of scurvy and vitamin C. The first section of the paper outlines the science of vitamin C. The second discusses outlines the medical progression of vitamin C deficiency and scurvy. The third section gives a brief timeline of scurvy throughout human history. The fourth section discusses the conditions during the age of sail that combined to make scurvy the greatest killer of sailors. The final section follows the scientific drive to find a cure and eventual elimination of scurvy during the age of sail. **I. Medical Examination of Vitamin C**

This section of the paper examines vitamin C and scurvy in terms of what is know within the medical community today. The first section identifies the chemical structure of vitamin C, the second examines the mechanisms by which vitamin C is absorbed and processed within the body, the third looks at the known and possible health benefits of vitamin C consumption, the fourth describes the potential toxicity of vitamin C overdosing, and the fifth and final section analyzes vitamin C consumption within the modern diet.

Scurvy is a nutritional deficiency disease resulting from a lack of vitamin C.[1] Apart from natural occurrences of vitamin C, it was first produced in guinea pigs in 1907.[2] Vitamin C was first isolated between 1928 and 1930 by Hungarian Albert Szent-Gyorgy and American Glean King.[3] At first, the compound was called hexeronic acid, but the name was later changes to ascorbic acid because of its anticorbutic power (fighting scurvy).[4]

1. What is Vitamin C?

The molecular structure of ascorbic acid (Vitamin C) was first determined in 1933 when a laboratory synthesis was perfected.[5] The chemical structure of Vitamin C is shown in the following figure:[6]

2. How Vitamin C is Digested and Metabolized

Vitamin C is absorbed in the body through the stomach and intestinal walls as a normal part of digestion.[7] Vitamin C available from foods and dietary supplements is identical and the bioavailability of the compound is similar with each method of ingestion.[8] Since vitamin C is water soluble, any ascorbic acid in excess of what the body needs is passed out of the body in urine and feces.[9]

Once vitamin C is digested, it is dispersed throughout the body and accumulates in varying concentrations in various cells and organs.[10] The highest levels of vitamin C accumulation in the body are in the eye lens, adrenal gland, pituitary gland, leukocytes, and brain, while saliva and plasma have very little vitamin C content.[11]

As noted above, excess vitamin C is passed out of the body through excretion.[12] This is because the body is able to self-regulate vitamin C levels through a number of mechanisms.[13] First, the intestinal absorption of vitamin C is inversely proportional to the dose ingested.[14] Therefore, the body will absorb most of the vitamin C at lower levels and will begin to absorb less as vitamin C ingestion increases.[15] Vitamin C which is not absorbed by the intestines will then be passed through defecation.[16]

A second biological mechanism also helps to regulate the concentration of vitamin C in the body. As the level of ascorbic acid in plasma increases, the ability of the renal tubules to reabsorb the compound decrease and the unreabsorbed vitamin C is passed through the urine.[17] However, when ascorbic acid levels are low, the tubules reabsorb larger amounts of the compound, conserving vitamin C in times of deficiency.[18] Therefore, by using the mechanisms of the intestines and the renal tubules, the body is able to self-regulate vitamin C levels by conserving the compound during low consumption and excrete the compound in periods of high consumption.[19]

The human body generally consumes 3% of its vitamin C stores each day.[20] Therefore, it has been determined that the body consumes less vitamin C when concentrations of the vitamin are low, helping to delay the onset of the symptoms of scurvy.[21] However, it has been estimated that the body consumes a minimum 8-10 mg of vitamin C per day.[22] Without this minimum intake, a person will eventually develop scurvy.[23]

3. The Functions of Vitamin C

a. Known Functions of Vitamin C

Vitamin C serves a number of functions for human beings. First, it is the primary reducing agent required in the formation of collagen.[24] Second, vitamin C is the most important and readily available antioxidant in the diet.[25] Third, vitamin C also assists the neurological system by neurotransmitter synthesizer.[26] Fourth, vitamin C assists in the absorption and metabolism of metals such as iron and copper.[27]

Collagen is a necessary structure within the body as it is the tissue that connective tissue that “holds a person together.”[28] Ascorbic acid is a necessary compound for the formation of all collagen.[29] In the formation of collagen, the body requires ascorbic acid, iron, oxygen, and alpha-ketoglutorate.[30] During collagen formation, the enzyme involved (bound to iron), is oxidized.[31] The ascorbic acid then reduces the enzyme back to its normal state, allowing it to react again and form more collagen.[32] Without vitamin C, the enzyme would react once and then remain in its reduced state, halting the production of collagen.[33]

In addition, vitamin C is required for the gene expression for collagen.[34] Even though the mechanism for this reaction is not known, it is known that vitamin C is required for the expression of all connective tissue, including bone matrix, fibronectin, elastin, etc.[35] Without vitamin C, these tissues do not form and this results in the primary and most visible symptoms of scurvy.[36]

Vitamin C is also the most available and useful of the dietary antioxidants.[37] Vitamin C protects the eyes against light generated free radicals.[38] Within cells, ascorbic acid protects DNA from mutation and carcinogenesis (beginning of cancer).[39] In addition, ascorbic acid assists reproduction by protecting sperm cells and seminal fluid from free radical attack.[40] In addition, ascorbic acid can donate electrons to other antioxidants, thereby regenerating them for future use.[41]

Vitamin C is also an important part of neurotransmission, which explains the relatively high amount of the compound in the brain and adrenal gland.[42] In fact, vitamin C is a necessary element in the formation and metabolizing of dopamine, serotonin, and neuropeptides.[43]

Ascorbic acid is also required for iron regulation within the body.[44] Vitamin C acts to reduce iron, allowing it to be absorbed and stored within the body.[45] Low levels of ascorbic acid in the body may lead to low iron levels (anemia), increasing fatigue and lethargy.[46]

Ascorbic acid, along with iron is required for the maintenance of muscle tissue.[47] Without vitamin C, certain muscle compounds begin to decrease.[48] Studies in guinea pigs suggest that this decrease of necessary muscle compounds may account for the fatigue associated with scurvy.[49]

b. Potential benefits of Vitamin C

Vitamin C may also serve a number of other functions within the body which are unrelated to scurvy. First, vitamin C has been shown to improve the effectiveness of the immune system.[50] In lab studies, increased vitamin C levels have been shown to improve resistance to a number of viruses, including HIV.[51] However, vitamin C level testing on humans has led to mixed results, with some studies showing no increased protection against viruses.[52]

Second, lab studies have shown that vitamin C may help prevent cancer.[53] The methods for this benefit are unclear, but proposed mechanisms include enhanced immune response, detoxification of carcinogens, and blockage of carcinogenic pathways through increased antioxidant activity.[54] Epidemiology has shown a strong correlation between increased vitamin C levels and reduced occurrence of oral, esophageal, stomach, and pancreatic cancers.[55] However, current studies do not support using vitamin C as a cancer treatment once the disease has already appeared.[56] Prolonged survival and elimination of cancer through high dosing of vitamin C have been claimed, but are not corroborated by any scientific evidence.[57] Overall, however, vitamin C does seem to have positive anti-carcinogenic effects in the prevention of some types of cancer.

Some studies have also shown that vitamin C may aid in the prevention and treatment of heart disease and stroke.[58] As noted above, ascorbic acid is necessary in the formation of the connective tissue collagen.[59] Some heart problems can be traced to the integrity of heart tissue.[60] Without vitamin C, these tissues would be compromised and heart problems might occur.[61] In addition, it has been shown that vitamin C helps reduce vessel clotting.[62] Increased vitamin C has also been shown to improve HDL cholesterol and decrease blood pressure.[63] However, long term human studies do not show a strong correlation between increased vitamin C and reduced rates of heart disease.[64] These studies do show a reduced incidence of stroke among people who ingest large amounts of vitamin C.[65]

Overall, vitamin C is integral to many functions of the body. It is necessary for the production of collage, is an antioxidant, plays a role in neurotransmission and aids in the absorption of important metals.[66] It may also help fight heart disease, stroke, cancer, and enhance the immune system.[67]

4. Possible Toxicity of Vitamin C Mega-dosing

Some research suggests that vitamin C intake between 1000 mg and 1500 mg per day may impact the body negatively.[68] Large doses may cause gastric pain, diarrhea, and flatulence.[69] Although clinical studies have not shown a correlation, high levels of ascorbic acid may support the formation of kidney stones though the formation of oxalate.[70] In addition, it has been proposed that high levels of vitamin C may cause iron and copper to be absorbed to the point of toxicity.[71] However, these effects have not been proven in laboratory tests.[72] Finally, large amounts of vitamin C in the body may make some common diagnostic tests less accurate.[73] Overall, however, the risks of vitamin C toxicity with high levels of dosing seem to be relatively small when compared to the plethora of health benefits ascorbic acid provides.

5. Vitamin C in the Modern Diet

Today, the average person consumes between 95 and 107 mg of vitamin C daily.[74] The actual intake of vitamin C is probably greater because vitamin C is often added to processed foods to act as an antioxidant.[75] Over 90% of this intake comes from fruits and vegetables, primarily citrus, tomatoes, green vegetables, and potatoes.[76] In addition, multivitamin supplements are used by many to supplement their vitamin C intake.[77] In fact, the U.S. Department of Agriculture

estimates that as much as 35% of the U.S. population takes a daily vitamin C supplement.[78] The Food and Drug Administration has established a recommend daily allowance of 60 milligrams per day of Vitamin C.[79] Vitamin C values[80] for common foods are listed in the following table[81] :

Figure 1. Common Foods and their Vitamin C Content

Food	Vitamin C Content (mg/100g)
Lemon juice	50-80
Lemon Rob[82] (fresh)	240
Lemon Rob (1 month Old)	60
Orange juice	50-80
Oranges	50
Strawberries	40-90
Onions (raw)	5-32
Onions (cooked)	2-3
Dried peas	Trace
Potatoes (raw)	10-30
Potatoes (cooked)	5-15
Broccoli	90-150
Tomatoes	10-40
Rice, bread, grains	0
Meat	0
Malt	0
Sugar	0
Alcohol	0
Milk	0

It should be noted that the vitamin C content for fresh vegetables and fruits may vary greatly.[83] In addition, the vitamin C content for foods drops dramatically once cooked.[84] This loss of nutritional value is due to the destruction of vitamin C at high temperatures and the dispersion of nutrients into cooking water.[85]

II. Vitamin C Deficiency and Scurvy

Almost every species of animal is capable of converting glucose into ascorbic acid.[86] Humans and guinea pigs, however, lack a critical enzyme for this conversion and are unable to produce ascorbic acid independently.[87] Therefore, humans must consume the entirety of their vitamin C needs in the diet.[88] Once vitamin C levels become low enough, symptoms of scurvy begin to occur.[89]

1. The Progression of Scurvy

The onset of scurvy is a slow progression, usually appearing after 60-90 days of a vitamin C deficient diet.[90] The onset of scurvy has been noted to proceed in four stages.[91] In the first stage, people begin to feel abnormally lazy and are prone to sudden fatigue.[92] The muscles ache, especially in the legs and lower abdomen.[93] Upon first waking, a scurvy victim's joints will ache.[94]

During the second stage, patients' gums begin to swell, bleed with slight pressure, itch, and become hot.[95] In addition, teeth become loose at the roots.[96] Patients also begin to feel actual pain throughout the joints and muscles.[97]

When a patient reaches the third stage of scurvy, the gums become putrid and begin to smell like rotting flesh.[98] The gums also begin to bleed profusely.[99] The flesh becomes gangrenous and the skin will spontaneously hemorrhage.[100] The skin, especially in the legs and feet, develop ulcers that turn gangrenous.[101] Finally, the third stage entails excruciating pain throughout muscles, joints, and bones.[102]

In the fourth and final stage of scurvy, the body develops high fevers.[103] The skin develops black spots, the body begins to tremble, sudden faintings occur, and finally death occurs. The acute cause of death is usually caused by hemorrhaging in the brain and heart and is usually brought on by exertion. [104] However, even in stage four, treatment by high levels of vitamin C will reverse the effects of scurvy and the patient will return to good health.[105]

2. Prevalence of Scurvy and Vitamin C Deficiency Today

Today, vitamin C deficiencies and scurvy are rare because of easy access to fresh fruits and vegetables, vitamin fortification of processed foods and drinks, and vitamin supplements.[106] However, cases of scurvy still sometimes appear.[107] Most cases in the United States occur in poor urban populations, alcoholics and the elderly.[108] Individuals who smoke or have illnesses such as cancer or renal failure are also prone to scurvy.[109] Today, elderly poor men develop vitamin C deficiencies more than any other group.[110] In fact, as many as 20% of poor, elderly men may have low amounts of vitamin C in their system, although actual scurvy rates are much lower.[111] Even in elderly, poor men, the rates of vitamin C deficiency are highest among those who are confined to their homes, chronically sick, or institutionalized.[112] Overall, scurvy is extremely rare in developed countries due to improved diets and vitamin supplementation.[113] However, cases still occur and medical personnel must be prepared to diagnose and treat this once deadly disease.

III. A Timeline of Scurvy

This section presents a brief timeline of the history of scurvy and the historical events that frame the search for a cure. It details various writing about the disease from ancient Egypt to modern medical journals. It attempts to frame my later discussion about the scientific pursuit for a cure during the Age of Sail within the framework of medical history. Therefore, the sections discussing the scientific study and pursuit of a cure for scurvy during the age of sail are deliberately brief as they will be discussed in much greater detail later in the paper.

1. Ancient Times

Scurvy, or described ailments equivalent to modern day scurvy, has been prevalent throughout much of human history. Scurvy likely began to occur in humans when agriculture was discovered.[114] Upon the adoption of an agrarian lifestyle, people were able to store various grains for use during winter months.[115] In turn, people were able to move into more temperate regions previously uninhabitable due the lack of a food supply during the long winters.[116] However, stored grains are extremely low in vitamin C, so it is likely that ancient people developed scurvy during the long winters because these grains would dominate their diet.[117]

The first written account of a disease likely to be scurvy comes from the Ebers papyrus which has been dated to 1500 BC Egypt.[118] The Ebers papyrus not only diagnosed scurvy, but prescribed that victims of scurvy be treated with onions, a common source of vitamin C.[119] Ancient Greece also recorded instances of scurvy.[120] Hippocrates, Father of Medicine, wrote that individuals with scurvy “have foetid breath, lax gums, and h[e]mmorrhage from the nose.”[121] Unlike the Egyptians, Hippocrates unnamed cure was likely ineffective as it required “a tedious cure that often ‘accompanied a patient to his death’”.[122] Apart form Hippocrates, however, there is little documentation of incidences of scurvy or its medical treatments in the ancient world.[123] English surgeon, James Lind, who wrote one of the first comprehensive treaties on scurvy, noted that ancient Greek, Roman[124] , and Arab authors and scientists were almost completely silent on the issue of scurvy.[125]

2. The Middle Ages

Additionally, there is little written about scurvy between Hippocrates and the 16th Century. However, the name scurvy sheds light on the fact that scurvy was likely present in northern European countries during the centuries leading to the Age of Sail. James Lind wrote of possible derivations for the word scurvy in his Treatise on Scurvy.[126] Lind theorized that the word scurvy derived from one of four northern European languages.[127] Te first being the Danish word *schorbect* meaning ulcers in the mouth.[128] The second being the Dutch word *scorbeck* with the same meaning as *schorbect* .[129] In addition, the Saxon *schorbok* which means tearing of the stomach/belly is a possible derivation.[130] Finally, the Slav word *scorb* was Lind favored because of the prevalence of scurvy during the long winters in Russian and the Baltic.[131] Based on Lind's writings and the prevalence of possible related terms in a number of northern European languages, it is likely that the disease was a present in much of northern Europe from the time of settling until the Age of Sail.[132]

The Crusades, however, provide an example of one written account of scurvy during the 13th century.[133] During Lent, when soldiers abstained from meat (except eel) and restricted their diets, a scurvy epidemic likely unfolded as "the barber surgeons were forced to cut away the dead flesh from the gums to enable the people to masticate their food."[134] However, it is noted that the Crusaders believed that the disease was cause by eating eel which supposedly ate the dead.[135]

3. The Age of Sail

a. Early Voyages: Vasco da Gama and Jacques Cartier

Scurvy, however, was never particularly prevalent or problematic in Europe until advances in naval technologies allowed ships to extend their stay at sea.[136] Advances in technology, combined with fervor for exploration in Europe set the stage for scurvy to become the plague of the sea. In 1497, Vasco da Gama, a Portuguese explorer, set sail with 160 men to discover a sea route to the East Indies around the Cape of Good Hope.[137] Of the 160 men that set out with da Gama, it is believed that 100 died from scurvy during the voyage.[138] da Gama's voyage resulted in the first record of "sea scurvy."[139] Luis de Camoens, a soldier and poet on da Gama's voyage, wrote the poem The Lusiad about the deaths from scurvy[140] :

A dread disease its rankling horror shed,

And death's dire ravage through mine army spread.

Never mind eyes such dreary sight beheld,

Ghastly the mouth and gums enormous swell'd;

And instant, putrid like a dead man's wound,

Poisoned with foetid streams the air round.

No sage physician's ever-watchful zeal;

No skillful surgeon's gentle hand to heal,

Were found: each dreamy mournful hour we gave

Some brave companion to a foreign grave.

Da Gama, in an odd attempt to cure his men, ordered that they wash their mouths with their own urine.[141] Needless to say, urine as a cure proved both unpalatable and ineffective.

In 1519, Portuguese explorer Ferdinand Magellan was hired by King Charles I (Emperor Charles V of the Holy Roman Empire) of Spain[142] to circumvent the globe by heading west from the southern tip of South America to the Spice Islands and then around the southern cape of Africa and back to Europe.[143] Of the three ships and 250 sailors who departed Spain, only one ship and

eighteen men survived the voyage (Magellan died from battle wounds in the Philippines).[144] Scurvy outbreaks hit the Magellan expedition twice, once in the Pacific and once in the Indian oceans, both occurring far from land.[145] Estimates show that scurvy killed about half of the crew, but the scurvy toll would have been much greater had some of the sailors not died from other reasons (e.g fighting with native peoples, storms, etc.).[146] Antonio Pigafetta, an Italian mariner aboard Magellan's expedition wrote of scurvy that "Of all the misfortunes, this was the worst: the gums of some of the men swelled over their upper and lower teeth, so that they could not eat and so died."[147]

One of the best recorded outbreaks of scurvy during the 15th Century was Jacques Cartier's second expedition to the new world (eastern Canada).[148] Cartier, despite his experience from the first voyage, made a tragic assumption.[149] He had calculated that eastern Canada was at a lower latitude than his departure city of St. Malo, France and could therefore leave late in the season and expect a winter similar to that of France.[150] As the cold and long Canadian winter set in, Cartier's ships became locked in the ice of a frozen inlet.[151] The ships' rations began to run low and those remaining began to rot.[152] Soon, the men began to suffer from a mysterious illness.[153] Their gums began to swell, their stench of their breath unbearable, and they lost all energy to even move.[154] The suffering worsened over several weeks until the men began to die, their shrunken faces and discolored bodies stored in the ships holds as a constant reminder of the remaining crew's fate.[155] Cartier noted

The unknown sickness began to spread itselfe amongst us after the strangest sott that ever was eyther heard of or seens, insomuch as some did lose all their strength, and could not stand on their feete, then did their legges swell, their sinews shrink as black as any cole. Others had all their skins spotted with spots of blood of a purple colour: then did it ascend up to their ankles, knees, thighs, shoulders, armes, and necke: their mouth became stinking, their gummes so rotten, that all the flesh did fall off, even to the roots of the teeth, which also almost fell out. With such infection did the sickness spread itself in our three ships, that about the middle of February, of a hundred and ten persons that we were, there were not ten whole.[156]

Cartier, desperate for a solution after twenty-five of his men died form the disease, ordered an autopsy of one of the dead.[157] Once opened, the dead man's chest revealed a withered, white heart surrounded by "more than a jugful of red date-coloured water."[158] The autopsy also revealed "dark, tainted blood" and the lungs were "very black and gangrened."[159] Although the autopsy Cartier ordered provided little insight into the cause or the cure for scurvy, it did show the first recorded attempt to understand and solve this new medical mystery.

By the end of the winter, only three men, including Cartier, were unaffected by the disease.[160] Out of desperation, Cartier ventured out from the men in search of a solution.[161] Cartier, either by happy coincidence or divine providence, saw a man named Dom Agaya, who had been equally sick from the disease only two weeks prior.[162] Cartier convinced Agaya to divulge the cure for the ailment.[163] Agaya gave Cartier branches from an *annedda* [164] tree and told him that the juice from the branches was the remedy.[165] Cartier returned to his men, where the branches were boiled in water and the water then drank.[166] Within six days, all of Cartier's remaining men had recovered from scurvy.[167] Once spring arrived and the inlet thawed, Cartier and his remaining men were able to return home to France.

During the 16th Century, exploration and colonization became increasingly important to the nations of Western Europe.[168] Spain's conquistadors Hernan Cortez and Francisco Pizarro conquered the Aztecs, Mayans, and Incas in Mexico, Central America, and Peru.[169] The gold and silver plundered and mined surpassed the imagination of Europe's monarchies and focused exploration not only on finding short routes to the East Indies, but on exploring, settling, and exploiting the New World.[170] As a result, European nations sent more voyages into the seas for ever increasing amounts of time.[171] As a result, the isolated cases of scurvy seen in the late 15th and early 16th Centuries became a constant plague on sailors of all nations.[172] In fact, between the years of 1500 and 1800, scurvy was the leading cause of naval death, killing more sailors than all other diseases, disasters, and battles combined.[173] During the Seven Years' War for example, Britain records indicate that 184,899 sailors were in service.[174] Of those, 133,708 died from disease (largely from

scurvy) and only 1,512 died in combat.[175] These numbers illustrate the enormous toll scurvy took on the navies of Europe, killing orders of magnitude more men than battle.

Early accounts of the disease noted its slow, horrific progression toward death. For example, William Clowes, an English surgeon wrote in 1596 that

their gums were rotten even to the very roots of their teeth, and their cheeks hard and swollen, the teeth were loose neere ready to fall out...their breath a filthy savour. The legs were ffeble and so weak, that they were not scarce able to carry their bodies. Moreover they were full of aches and paines, with many blewish and reddish staines or spots, some broad and some small like flea-biting[176]

An unknown 16th century sailor, who suffered but survived scurvy, logged an account of the disease saying

It rotted all my gums, which gave out a black and putrid blood. My thighs and lower legs were black and gangrenous, and I was forced o use a knife each day to cut into the flesh in order to release this black and foul blood. I also used my knife on my gums, which were livid and growing over my teeth...When I had cut away the dead flesh and caused much black blood to flow, I rinsed my mouth and my teeth with my urine, rubbing them very hard...And the unfortunate thing was that I could not eat, desiring more to swallow than chew...Many of our people died form it every day, and we saw the bodies thrown into the sea constantly, three or four times at a time. For the most part they dies without aid given to them, expiring behind some case or chest, their eyes and the soles of their feet gnawed away by rats[177]

These accounts represent only a small fraction of the recorded recollections of scurvy, but they illustrate the immense pain and deadliness of the disease.

c. Sir George Anson's Circumnavigation of the Globe

In 1740, when England was at war with Spain, the Royal Navy decided to mount an expedition, led by Sir George Anson, to attack Spanish Galleons and ports in South America.[178] Ansons' voyage, the first circumnavigation of the world by Britain, is regarded as one of the greatest voyages in British Naval history.[179] The voyage, which led to enormous losses from scurvy, pressured the British Admiralty and scientific community into researching a cure for scurvy.[180]

The voyage was plagued by problems from the outset. The ships were undermanned, so Anson asked for an additional 300 marines.[181] However, the Admiralty sent 500 pensioners straight from a naval hospital.[182] However, only 250 came aboard as the healthiest deserted in port.[183] The chaplain of Anson's ship remarked that "all those who had limbs and strength to walk out of Portsmouth deserted, leaving behind them only such as were literally invalids, most of them being sixty years of age, and some upwards of seventy."[184] The men who cam aboard were all ill, with some carried aboard on stretchers.[185] Of these pensioners, not one would survive the voyage.[186]

Anson was incensed by the manning he received and was able to discharge some of the most sick.[187] To replace the deserters and discharged, the Admiralty supplied Anson with 200 recruits, some impressed men, none having any sea experience.[188] Finally, Anson's fleet was supplied with a number of ships' boys, who were approximately seven or eight years old.[189] Historians believe that the poor manning of Anson's fleet contributed to the voyage's high death rates from scurvy.[190]

Anson's fleet departed St. Helen's, England on September 18, 1740 almost an entire year after preparations for the voyage had begun.[191] As a result, many of the crew were already sick.[192] During the first two weeks of the voyage crossing the Atlantic, two of Anson's captains and head surgeon were dead.[193] When the fleet landed on an island of Brazil, eighty sick men were sent ashore.[194]

The fleet then attempted to sail around Cape Horn, with the first cases of scurvy appearing.[195] Anson's chaplain, Reverend Walter, wrote an account noting

As we did not get to land until the middle of June, the mortality went on increasing; so that, after the loss of above 200 men, we could not at last muster more than sic foremast men in a watch, capable of duty. However, though it frequently puts on the form of many other diseases, and is therefore not described by any exclusive and infallible criterions; yet there are some symptoms which are more general than the rest, and occurring the oftenest deserve more particular enumeration. These common appearances are, large discolored spots over the whole surface of the body; swelled legs; putrid gums; and above all, an extra-ordinary lassitude over the whole body, especially after any exercise, however inconsiderable: and this lassitude at least degenerates into a proneness to swoon, on the least exertion of strength, or even on the least motion. This disease is likewise usually attended with a strange dejection of spirits; and with shiverings, tremblings, and a disposition to be seized with the most dreadful terrors on the slightest accident."[196]

During the month spent rounding the cape, over forty men died from scurvy on Anson's ship alone.[197] Anson then intended to take his fleet northwest to the island of Socorro (the rendezvous point for the fleet).[198] For nearly fifty days, Anson's struggled to take his ship through violent storms in the direction of the island.[199] Records indicate that an average of six men died daily from scurvy during this period.[200] Upon sighting land, Anson realized that he was off the coast of Tierra del Fuego in South America, some 200 miles east of his intended destination, meaning that his ship had fought through a month and a half of storms to remain virtually in the same place.[201] Anson was finally able to take his ship west to Socorro, but after two weeks of waiting for the rest of the fleet, he decided to set sail for the second rendezvous point (Juan Fenandez).[202]

Anson headed northwest until he reached the latitude of Juan Fernandez, but could not calculate his longitude.[203] Needing to make an educated guess, Anson sailed west for four days.[204] Failing to spot the island, he decided that he should have sailed east instead.[205] After two days, the ship reached the coast of Chile and Anson realized his first guess was correct and he had nearly reached Juan Fernandez. This delay cost Anson two weeks of sailing time, in which eighty of his men died from scurvy.[206]

The fleet eventually did meet at Juan Fernandez; however, only four ships managed to round Cape Horn.[207] The rest were either sunk or were forced to turn back.[208] During the time rounding the Cape and sailing to Juan Fernandez, it has been estimated that 750 men were killed mostly by scurvy and various other deficiencies.[209] Even when the ships reached the island, approximately another eighty men died of scurvy while being brought ashore or shortly after.[210] The fleet remained anchored at Juan Fernandez for three months for repairs and rest.[211] By this time, a year had passed and sixty-seven percent of the fleet's men were dead, almost entirely from scurvy.[212] While at Juan Fernandez, the remaining men recovered from scurvy and were again relatively healthy.[213]

The fleet then sailed to the coast of South America, where it took a number of Spanish vessels and raided the port of Payta.[214] After re-supplying, the ships headed into the Pacific in search of Spanish galleons that transported gold between Asia and South America. Soon after departure, the ships were plagued by calm winds and sail failures.[215] Within the first months, scurvy reappeared and the first deaths were reported.[216]

Soon, the crews were so depleted that Anson consolidated his men into one vessel, scuttling the other.[217] Anson's fleet had now shrunk from eight ships to one and at least ten men were dying from scurvy daily.[218] The ship finally arrived in the Mariana Islands where over a hundred men extremely sick from scurvy were sent ashore to a make-shift hospital. In the first few days, thirty of the sick died from scurvy, while the rest slowly recovered.[219] The ship then set sail for Macao (Portuguese province in China) where the crew stayed for the winter.[220] The next spring, Anson and his crew successfully found the Spanish galleon they had been chasing and captured and plundered it.[221]

Anson then directed his ship westward and bound for England.[222] The ship reached port in June of 1744, making the voyage almost four years long.[223] Anson began his voyage with nearly 2,000 men and 1,400 were now dead.[224] Of those that died, only four died in battle and handful more from injury.[225] The rest died from scurvy and other vitamin deficiencies.[226]

Once Anson arrived back in Britain, he was hailed as a hero.[227] Probably the most important outcome of Anson's voyage was that the horrible toll of scurvy was thrust into the forefront of public and government concern.[228] The government, however, cared little about the loss of life, but saw scurvy as a problem of national security because the disease forced expensive ships to be abandoned and depleted the power of the navy in times of war.[229] Thus, Sir George Anson's voyage pushed Britain into an age of research regarding scurvy. The plight of Anson's fleet became the primary motivator for James Lind to write his *Treatise on Scurvy* .[230]

4. The American Civil War

The American Civil War illustrated, in yet another example, that scurvy was land as well as a sea problem. Prior to the Civil War, scurvy was the most common disease in the U.S. Army.[231] For a country whose borders and army were ever increasing, cost, perishability, and logistics of supplying a proper diet to troops in the wilderness proved almost impossible.[232] The U.S. Army began distributing a foodstuff known as "desiccated compressed mixed vegetables" as an antidote for scurvy.[233] The food, however, proved impractical for troops involved in combat or rigorous training or in small groups because it needed to be boiled for five hours before it could be eaten.[234] Even when available, troops would often refuse to eat the mixture, calling it "desecrated vegetables" because the composite was mainly roots, stalks, and leaves.[235] Even when eaten, the mixture supplied almost no vitamin C because the boiling process destroyed almost the entire nutrient contained in the raw composite.[236]

During the Civil War, scurvy rates continually increased, from less than .5% prior to the war to nearly 3% just after the end of combat.[237] However, these figures show a vast amount of underreporting because only soldiers who died from scurvy or were sent to hospitals would have been counted in the total.[238] For example, if one soldier in a group was sent to an army hospital for scurvy, only he would count towards the scurvy total.[239] However, it would be likely that the entire group was suffering from malnutrition and likely was suffering from at least a milder case of scurvy.[240]

Scurvy also had secondary health effects during the Civil War. Since scurvy effects the healing of wounds, the disease led to increased mortality rates for those wounded in combat.[241] In spite of bettering medical techniques and medical supplies, the portion of battlefield wounded who died continually increased throughout the war.[242] This increase in death rates for the wounded almost exactly mirrored the increases in scurvy rates recorded.[243] For example, in William T. Sherman's Southern campaign, scurvy and percent of wounded who died show similar trends.[244] As the army pressed on to Atlanta and vegetables became scarce, scurvy rates rose from .1% to .5% while the death rate of wounded rose from 10% to nearly 25%.[245] Once Atlanta fell and the rail lines were opened to deliver fresh produce, scurvy rates quickly dropped to between .2 and .3% and death rates for the wounded fell to less than 5%.[246]

One surgeon, when considering the increased death rates of wounded, later remarked that

[t]he great increase in secondary hemorrhage appeared to be referable to the prolonged use of salt meat, and to the consequent scorbutic condition of the blood,...the increase in pyaemia and hospital gangrene, may in like manner, have been connected in a measure at least, with the physical and chemical changes of the blood and organs, dependant upon imperfect nutrition and sameness of diet.[247]

Famous Confederate nurse Phoebe Pember, matron at Chimborazo Hospital in Richmond, noted that "Poor food and great exposure had thinned the blood and broken down the system so entirely that secondary amputations performed in the hospital almost invariably resulted in death, after the second year of the war."[248] In fact, she noted that after that time, only two cases under her watch

did not result in death—two Irishmen, but she noted "it was really so difficult to kill an Irishmen that there was little cause for boasting on the part of the officiating surgeon."[249]

Prisons for captured soldiers were extremely prone to scurvy deaths due to the lack of proper nutrition and harsh conditions.[250] For example, the Confederate prison of Andersonville had scurvy death rates as high as 25%.[251] It can be reasonably assumed that given the difficulty in supplying proper nutrition to an army's own men, spending resources to feed prisoners of war was not a top priority.

After a scurvy outbreak among Union troops during the Peninsula campaign of 1862, the public became aware of the disease and the general problem of proper nutrition in the armies.[252] Civilian groups began organizing event and food drives to support troops at the front.[253] The primary focus of these efforts was to collect potatoes and onions, both moderate suppliers of vitamin C.[254] At this point, citrus was known to be the best source of vitamin C, but oranges, lemons, and limes spoiled to quickly to be of much use if sent to distant troops.[255] These civilian groups would ride about their towns collecting potatoes and onions door to door, or would hold special benefit event in which a potato or onion was the fee for entry.[256] The groups would conduct informational campaigns by placing signs encouraging loved ones to send additional food to the troops.[257] For example, one sign posted in Chicago read "Don't send your sweetheart a love-letter. Send him an onion."[258]

Chronic diarrhea and dysentery were also blamed on scurvy.[259] These diseases were among the biggest killers of troops throughout the war.[260] In hindsight, however, it is known that vitamin C deficiency was not the cause of these diseases.[261] Vitamin B and folic acid deficiencies were more likely causes of diarrhea and dysentery.[262] However, the timing of the onset of these vitamin deficiencies and scurvy was likely similar due to the poor nutritional quality of the food supplied to soldiers, so it is understandable that the known disease of scurvy would be tied to the onset of diarrhea and dysentery.[263]

Overall, it is apparent that the government and common citizens were aware of both scurvy and foods that could prevent it. However, logistical problems, conditions during warfare, and cost made scurvy an enormous problem for both the Union and Confederacy during the American Civil War. The war, however, seems to be the last conflict greatly effected by scurvy as food preservation and logistics improved greatly in the coming decades.

5. Modern Cases of Scurvy

As noted above, modern cases of scurvy are rare in developed countries.[264] However, scurvy is still sometimes diagnosed.[265] Scurvy is most prevalent in a number of populations, including the urban poor, the elderly, alcoholics, and the institutionalized.[266] In addition, smokers and individuals who are already sick such as cancer patients are also vulnerable to scurvy.[267] Today, elderly poor men develop vitamin C deficiencies at the highest rate of any population.[268] In fact, as many as 20% of people in this group may have low levels of vitamin C.[269] However, actual scurvy rates are much lower.[270] The greatest risk group for scurvy and vitamin C deficiencies, even in elderly, poor men, are those who are home-bound, chronically sick, or institutionalized.[271] Overall, scurvy is extremely rare in developed countries such as the United States because of plentiful diets and vitamin supplements.[272] However, scurvy still sometimes occurs and medical personnel must be prepared to treat this fatal deficiency.

IV. Scurvy and Seafaring: A Deadly Combination

This section of the paper describes the unique combinations of condition that led to tremendous death toll during the age of sail. First, the inscription and recruitment processes used meant that sailors were often weak and malnourished prior to even setting sail.[273] Second, the rigorous duty and treatment of sailors aboard ship made sailors especially vulnerable to vitamin C deficiency.[274] The third and most important factor contributing to the wrath of scurvy was the poor diet provided aboard ships.[275] Fourth, the living conditions on navy vessels caused sailors to use more vitamin C than normal, leading to increased deaths from scurvy.[276] Finally, poor medical care and diagnostic techniques meant that scurvy went untreated.[277]

1. Inscription

Maintaining sufficient crews for the large number of naval vessels proved to be difficult for countries.[278] As a result, a system called impressment was adopted.[279] Impressment was basically a form of kidnapping, in which captains would send out gangs of men into a port town looking for men.[280] The impress gang would club a man and drag him back to the ship as a new "recruit."[281] The man's family would have no idea what had happened and many of the men never returned home.[282] Although some of the impressed men would have sea experience, many had none at all.[283] Once on boar a ship, an impressed man was subject to the "law of the sea" and any attempt to escape was considered desertion and punishable by execution.[284] On average, a third of a ship's crew was made up by impressed men.[285]

Historian Sir Harold Scott, when writing about impressments, remarked that "it was a curious anomaly: the security of citizens depended on the Fleet. The manning of the Fleet was, therefore, a prime necessity, and the citizens—the pressed men among them, as least—were 'made slaves' in order to keep them free."[286] Impressed men were often in extremely poor health.[287] They were often homeless, the sick, convicts, and the elderly.[288] As such, they were already in poor physical health and malnourished.[289] Even the men who volunteered for naval service were often in poor health.[290] They often volunteered after long winters without much food in order to secure a place to sleep and regular meals.[291] Overall, the men who volunteered or were impressed into naval duty were in very poor health and were most likely already suffering from malnutrition.

2. Duty

Vitamin C deficiency and scurvy was hastened in the age of sail because of the rigorous working conditions for sailors.[292] Discipline aboard ship was harsh.[293] For many crimes, the death penalty might be used.[294] For others, flogging, keelhauling,[295] and starvation were used.[296] In addition, sailors experienced physical exertion, exposure to the elements, the fear of battle, and sleep deprivation.[297] Research has shown that the body needs more vitamin C in when it is under stress, when not sleeping enough or on odd schedules, and when the body is trying to heal from wounds or infections.[298]

3. Diet

The diet of sailors during the age of sail was obviously the main factor in the plight of scurvy. As Vitamin C can not be produced internally by humans, it must be ingested through the diet. Therefore, a close examination of the diet of sailors is needed to show why scurvy took such a stranglehold on the navies of Europe.

a. Supplying the Ships

The food supplies brought aboard ships during the Age of Sail varied little between generations and nations.[299] The primary criterion for supplies was that the food must have been capable of being stored for long periods without spoiling.[300] In addition, the controlling authorities had little concern for the nutritional content of the supplies.[301] The main concern, of course, was to maintain a suitable labor force at the least possible cost.[302]

Prior to a ships sailing from port, food supplies would be loaded onto the ship in large oak barrels and burlap sacks.[303] Every nations typical ships' food supplies would include, salted beef, salted pork, salted fish, kegs of beer, rum, flour, sacks of dried peas, oats, giant wheels of cheese, blocks of butter, and hardtack cakes.[304] The Spanish, however, added oil and pickled vegetables to the list of standard supplies.[305] The Dutch often supplied their ships with sauerkraut and dunderfunk (biscuit fried with lard and molasses).[306] In 1757, the British began stocking their ships with a "portable soup."[307] The "portable soup" consisted of "all the offals of oxen killed in London for use of the Navy" with salt and vegetables added in.[308] The soup, however, was dried so that it had the appearance of slabs of glue.[309] Although the "portable soup" was unappetizing, it was perfect for the navy because it had a shelf life of years.[310] In addition to the supplies stored at the beginning of each voyage, ships often traded for additional supplies in foreign ports and lands.[311] In particular, rice, wince and other hard alcohols were particularly valuable when trading.[312]

Maintaining the vast logistical networks required to support large, worldwide navies proved a formidable task for the countries of Europe.[313] Countries concentrated on providing as much food as possible as cheaply as possible.[314] Fraud, other logistical problems, and the shear volume of food needed contributed to the cost focus of navies.[315] Over the years 1750-1757, it is estimated that England alone supplied it navy with over 54,000 pounds of bread and biscuit, 110,000 "tuns" of beer, 351,000 "tuns" of brandy, 4,500,000 pounds of beef, 6,700,000 pounds of pork, 203,000 bushels of peas, 6,200,000 pounds of flour, 809,000 pounds of suet, 705,000 pounds of raisins, 138,000 pounds of oatmeal, 390,000 gallons of vinegar, 166,000 pounds of fish, and 71,000 gallons of oil.[316]

b. A Sailor's Rations

A sailor's rations were made up of the supplies brought on board the ship in port. A typical weekly ration for a sailor included[317] :

1 lb. of biscuit (hardtack) daily

2 lbs. of salted beef twice weekly

1 lb. of salted pork twice weekly

2 oz. of salted fish three times weekly

2 oz. butter three times weekly

4 oz. cheese three times weekly

8 oz. dried peas four times weekly

1 gal. of beer daily

In addition, sailor rations were sometimes augmented by raisins, dried pears, dried apples, and barley meal.[318] In all, a sailor's rations were in excess of 4000 calories per day.[319] However, the combination of a lack of fresh fruits and vegetables, onion, potatoes, etc. left the diet almost completely void of vitamin C.[320] However, experts have noted that sailors often ate better than what they would have if they had been ashore.[321] This was cause by a combination of the regular supply of meet, access to foreign fruits and vegetables, and the relative poverty of most of the sailors in the navy.[322]

c. Problems with Food Spoilage

Even though ships were supplied with food supplies intended to last lengthy periods of time, food rotting and spoilage became an enormous problem on long voyages. Ships from the Age of Sail were constructed almost entirely of wood for speed and buoyancy.[323] While technically sound, this construction led to a very damp and even waterlogged environment for sailors and their food.[324] Biscuit rooms were often caulked and lined with tin in an attempt to waterproof them since hardtack was particularly prone to molding.[325] However, even the biscuit room would eventually become waterlogged during voyages.[326] Molding was also a problem for the other vegetable products, including flour, peas, and oats.[327]

Meat was particularly susceptible to spoilage.[328] Upon departure from port, the meat quickly began to stink and became riddled with maggots.[329] Another problem with meat was the amount of salt absorbed in the preserving and preparation processes.[330] At the butcher's meat was coated with salt to help make it last longer. The preparation process added to the saltiness of the meat.[331] A day before the meat was to be eaten, it was taken out of storage and slung over the stern of the ship to "wash" the meat.[332] Obviously, the meat became saturated with salt water during its "washing."[333] Finally, because fresh water was so scarce, the meat was boiled in salt water before it was served.[334] Once served, the meat was eaten quickly because any delay would allow the outside of the meat to crystallize with a thick layer of salt.[335] The meat was so salty that it would

burn he mouths and the throats of the sailors and only increase their thirst for limited beer and water.[336]

The giant wheels of cheese brought on board ships also lacked longevity.[337] After a period of time, the cheese would begin to harden eventually becoming inedible.[338] Historians have noted that in the spirit of ingenuity and conservation, sailors would use the hardened cheese to make tools and even to replace buttons on their shirts and jackets.[339]

As can be discerned from above, the overall food quality on ships during the age of sail was quite poor, especially compared to food today. Quotes from sailors of the time evidence their dissatisfaction with the food on board. James Lind noted that supplies consisted of ""putrid beef, rancid pork, m[o]ldy biscuits and flour."[340] Pascoe Thomas, the surgeon on Sir George Anson's famed voyage wrote that almost all of the rations were inedible and that the bread was "so much worm-eaten, it was scarce anything but dust" and the salted pork "was likewise very rusty and rotten."[341] James Patten, surgeon for Captain Cook, wrote that "our bread was...both musty and mouldy, and at the same time swarming with two different sorts of little brown grubs, the circulio granorius (or weevil) and the dermestes paiceus....their larvas, or maggosts, were found in such quanitites in the pease-soup, as if they had strewed over our plates on purpose, so that we could not avoid swallowing some of them in every spoonful we took."[342] These quotes provide just a few, but illustrative, examples that demonstrate the poor quality of food provided to sailors.

Overall, the food aboard ships was of poor nutritional value. It was prone to spoilage, often inedible, and wholly void of vitamin C. In hindsight, it is obvious that poor diet would cause scurvy and other diet deficiencies to be tremendous problems during the age of sail.

4. Quarters

As noted above, conditions aboard ships were dark and damp.[343] Conditions aboard navy ships were often as bad as those in the worst slums on land.[344] The crews would sleep in the forecastle, a dark, wet, crowded space within the sip.[345] The ships' holds were infested with rats, rotting food, and often the dead.[346] Below deck, there was no ventilation, so the smell became incredibly noxious.[347] Research has shown that the onset of scurvy aboard ships was hastened because more vitamin C is needed in damp, cold conditions.[348]

In addition, the ships were overcrowded, making conditions worse and allowing diseased to spread even more quickly.[349] Ships required an enormous amount of manpower because of the number of men needed on deck and because nearly a dozen men were needed to man each cannon.[350] The high death rates on ships required that "reinforcements" needed to be placed on board before a ship set sail.[351] In all, the conditions and overcrowding of naval vessels made sailors especially susceptible to diseases, including scurvy.[352] In fact, as death rates rose, navies began increasing the number of men on board, which only increased death rates further.[353]

5. Medical Care

During the age of sail, European navies provided their larger ships with a surprisingly large compliment of medical specialists.[354] A typical large ship would be supplied with a surgeon and a few surgical mates.[355] Each of these men would have graduated from medical school.[356] For a large fleet, the flagship surgeon would command all of the surgeons within the fleet, coordinating efforts and tracking casualties.[357] In addition to the surgeon and surgical mates, each ship would have a few crew members assigned to caring for the sick and wounded.[358] During the early 18th century, female nurses were also assigned to ships of the line.[359] However, women were later replaced by male nurses because of problems with cohabitation in such tight quarters.[360]

European navies also intermittently used hospital ships.[361] In 1608, the British hospital ship *Goodwill* was commissioned[362] and during the next 130 years, around thirty hospital ships were employed by Britain.[363] These ships differed from normal ships of the line in that they were better ventilated, had areas for segregating and quarantining the diseased, and had beds instead of hammocks.[364] Hospital ships, however, did not carry many more medical staff than normal

warships.[365] In general, hospital ships showed death rates equivalent to civilian hospitals on land, about 20%.[366]

A key problem with medical care aboard ship was that the bulk of a surgeon's time was spent caring fro battle wounds instead of focusing on the prevention and treatment of disease.[367] For example, Surgeon Gilbert Blane tracked medical deaths in the British Caribbean fleet.[368] According to Blane, fifty-nine men died from battle, 666 men died on board from disease, and another 862 men died from disease once they were sent to land hospitals.[369] However, surgeon's manuals and training were almost entirely devoted to treating battle wounds.[370] This lack of early attention, resources, and understanding of the causes and treatments of disease among medical personnel and the Admiralty led to enormous death rates from scurvy, berri berri, typhus, and other diseases.

Overall, a number of factors led to the huge death toll from scurvy during the age of sail. The system of impressments and recruitment led to a navy full of sailors in already poor health.[371] The duty requirements aboard ship made sailors more prone to scurvy as they were under enormous amounts of stress and physical exhaustion.[372] The food supplies aboard ship were prone to spoilage and almost void of vitamin C and other key nutrients and were the primary cause of scurvy during the age of sail.[373] Finally, medical care aboard ship was woefully inadequate in disease prevention and treatment.[374] These factors combined to make scurvy the leading cause of death during the age of sail, eventually forcing the Admiralty and medical community to focus resources on discovering its cause and cure.**V. The Scientific History of Scurvy**

After the voyage of Sir George Anson, a golden age of scurvy research began in Britain.[375] This section of the paper examines the pursuit of a medical cure for scurvy. While the proposed solutions for scurvy may seem ludicrous from a modern viewpoint, the writings of scientists during the age of sail must be viewed within the framework of contemporaneous scientific methods and abilities.

3. The Four Humors

During the late 17th and early 18th centuries, European medical thought was dominated by the writings of Hippocrates.[376] Hippocrates relied on the theory of the four humors, in which all sickness was caused by an imbalance among these humors.[377] Hippocrates wrote

The body of man has in itself blood, phlegm, yellow bile, and black bile; these make up the nature of his body, and through these he ffels pain or enjoys health. Mow he enjoys the most perfect health when these elements are duly proportioned to one another in respect of compounding power and bulk, and when they are perfectly mingled. Pain is felt when one of these elements is in defect or excess, or is isolated in the body without being compounded in the body with all the others.[378]

Hippocrates and later European medical theorists believed the humors were associated with certain organs and emotions: blood (heart) with cheerfulness, phlegm (brain) with calm and composure, yellow bile (liver) with anger and temper, and black bile (spleen) with depression and gloom.[379] For example, cowardice was associated with an imbalance in yellow bile, hence the term "yellow" for someone who lacked bravery.[380] Someone who was depressed or lethargic was thought to have an imbalance in their black bile.[381] Therefore, someone demonstrating the early signs of scurvy, lethargy and fatigue, would be thought to have an imbalance of black bile.[382]

As early as the 16th century, a Dutchman named John Echth had stated that scurvy was a disease in the spleen.[383] Echth based his conclusion on his research of ancient text.[384] Of prime concern to Echth was finding ancient afflictions whose symptoms matched scurvy.[385] Echth found a "match" in the writings of Strabo, a Greek historian and geographer from the 1st century B.C. who wrote of a "stomakake" and "sceletrybe" that resulted in "a kind of paralysis round the mouth and the latter round the legs, both being a result of the native water and herbs."[386] In addition, Echth cited Pliny the Elder who documented a similar disease in a Roman army in Germany.[387] Pliny documented that the disease resulted in a "loss of teeth and a total relaxation of the joints and knees."[388]

Once Echth found the "disease" he was looking for, he attempted to match the disease that Strabo and Pliny wrote of with its cause.[389] Echth looked to the writings of Celus (30 A.D.) in which Celus stated that "these in whom that the spleens are enlarged, in these the gums are diseased, the mouth foul, or blood bursts from some part. When none of these things happen, of necessity bad ulcers will be produced on the legs, and from these black scars."[390] Thus, Echth concluded that scurvy was cause by enlarged and blocked spleens.[391]

Echth then theorized that since the spleen was blocked, black bile could not be purified or discarded so it formed ulcers and dark spots in cases of scurvy.[392] He also theorized that the blood was then corrupted by the excess black bile, so it became sluggish leading to laziness and weakness, both early symptoms of scurvy.[393]

Therefore, it was concluded that scurvy was caused by an imbalance of black bile and an enlarged spleen.[394] Each humor, it was theorized, was associated with various combination of hot, cold, wet, and dry (black bile was cold and dry).[395] To treat a black bile disease, it was theorized that it must be treated with its opposite, a hot and wet medicine.[396] Echth, however, made no recommendations for specific medines or cures for scurvy.[397] Echth's theory of scurvy as a black bile disease took hold of the European establishment until the middle of the 18th century.[398]

4. James Lind and his Treatise on Scurvy

a. The Early Career of James Lind

The first scientific writings on scurvy during the age of sail that identified the healing power of citrus were by the surgeon James Lind.[399] Lind, born in 1716, had begun his medical career at fifteen when he apprenticed for an Edinburgh physician.[400] Lind apprenticed for eight years where he was taught the four humors concept of medicine, letting blood, cleaned and dressed wounds, set broken bones, concocted drugs, and learned Latin and Greek.[401]

In 1739, Spain and England went to war.[402] Lind volunteered for the Royal Navy and was designated a surgeon's mate after he passed an examination and found to be morally fit to fill the position.[403] As a surgeon's mate, Lind would have been required to perform a number of tasks aboard ship.[404] First, he would perform the menial tasks associated with medical treatment.[405] Second, he would assemble the sick each morning for inspection in order to validate their unfitness for duty.[406] Finally, a surgeon's may made evening rounds in the sick bay and officers' quarters.[407]

b. Lind's Experiment on Scurvy

In 1746, after seven years as a surgeon's mate, James Lind passed the surgeon's exam and was promoted to surgeon on the *HMS Salisbry* .[408] It is aboard the *Salisbury* that Lind performed his now famous scurvy experiment.[409] In May 1747, scurvy struck Lind's ship in the English Channel.[410] With the permission of his captain, Lind began an experiment on twelve men with advanced scurvy.[411]

Lind described his experiment in his *Treatise on Scurvy* with the following

I took twelve patients in the scurvy, on board the Salisbury at sea. Their cases were as similar as I could have them. They all in general had putrid gums, the spots and lassitude, with weakness of their knees. They lay together in one place, being a proper apartment for the sick in the forehold; and had one diet common to them all. Two of these were ordered a quart of cider a day. Tow others took twenty-five gutts of vitriol three times a day, on an empty stomach. Tow others took two spoonfuls of vinegar three times a day, upon an empty stomach; having their gruels and their other food well acidulated with it, and also the gargle for their mouth. 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. Of this, they drank half a pint every day, and sometimes more or less as it operated, by way of gentle psychic. Two others had each two oranges and one lemon given them every day. These they ate with greediness, at different times upon an empty stomach. They continued but six days under this course, having the quantity that could be spared. The two remaining patients, took binges of a

nutmeg three times a day, of an electuary recommended by a hospital surgeon. The consequence was, that the most sudden and visible good effects were perceived from the use of oranges and lemons; one of those who had taken them, being at end of six days fit for duty. The spots were not indeed at the time quite off his body, nor his gums sound; but without any other medicine, than a gargarism of elixir vitriol, he became quite healthy before we came into Plymouth, which was on the 16th of June. The other was the best recovered of any in his condition; and being now deemed pretty well, was appointed nurse to the rest o the sick.[412]

From a modern day clinical perspective, Lind's experiment was a "six-armed comparative trial" of oranges and lemons, elixir of vitriol, vinegar, cider, sea water, and nutmeg with no control group.[413]

Lind's experiment was extraordinary in that is took a direct break from the traditional historical and theoretical approach to medicine and embraced the idea of clinical trials.[414] Lind showed an insight clearly ahead of his time by understanding that to develop a cure, treatments must be compared simultaneously in similar patients.[415] Lind's study was eloquent for its time in that it was a concurrent study of commonly used scurvy treatments, with similar patients, in similar conditions.[416] By using a concurrent study, Lind was able to disprove any arguments such as bad air, crowding, etc. were the cause of his positive observations of citrus compared to other "cures."[417]

Lind also identified scurvy as a diet deficiency disease, although he regarded other factors as equally important.[418] Lind stated that scurvy was caused by damp and uncomfortable conditions aboard ship, crowding, depression, and lack of fresh vegetables and fruits.[419] Although we currently know that scurvy can only be caused by a lack of vitamin C in the diet, Lind showed remarkable astuteness in realizing that the conditions for seamen hasten the disease.[420]

In 1753, Lind published his *Treatise on Scurvy* and is considered a classic in medical science.[421] However, it took the Royal Navy over forty years to adopt Lind's recommendations.[422] There are a number of reasons that Lind's recommendations took so long to be adopted.[423] First, it is likely that the small scale of the trial itself did not impress medical scholars or the Admiralty.[424] Second, Lind was only a naval surgeon and not a preeminent scholar at the time his work was published.[425] Finally, Lind did not push to have his findings adopted.[426] In fact, he stated that "it is in the power of others to execute."[427] Lind was later appointed to head the Haslar Naval Hospital, but conducted no further clinical trials and did not use his added influence to promote the use of citrus as an anitscorbutic agent.[428]

5. Wort of Malt, the "Cure" of Choice

There were a number of other popular "cures" for scurvy during the age of sail. The most prevalent and widely accepted of these cures was fermented barley malt, known as wort of malt.[429] Irish physician David MacBride proposed a theory that all living organisms were bound together by "fixed air."[430] As bodies decomposed and putrefied, the fixed air within them theoretically escaped (scurvy being a disease of putrefaction).[431] MacBride then theorized that a food that was fermented could replace the "fixed air" within a body and stop the purification.[432] Malted barley, was an ideal antiscorbutic because it was cheap and would not spoil.[433] It was used extensively within the Royal Navy because it was cheap, portable, and had a number of powerful proponents within the Admiralty.

A number of other cures for scurvy were commonly used during the Age of Sail.[434] These treatments included bloodletting, salt water, vitriol of oil, and extra work to cure idleness.[435] Obviously, these treatments proved ineffective in actually treating scurvy.

6. Citrus Finally Adopted

The British Navy finally adopted citrus juice as its primary antiscorbutic agent in 1795.[436] The change occurred under the direction of Sir Gilbert Blane, who was appointed Physician to the Fleet.[437] Blane was familiar with the findings of Lind and he had the power and initiative to affect a

change to citrus juice.[438] Blane organized a scurvy experiment aboard the *HMS Suffolk* on a twenty-three week trip to India.[439] During the trip, the ship would make no landings, so scurvy would normally certainly occur.[440] During the trip, sailors were given a mixture of rum, water, sugar, and lemon juice.[441] However, during the trip, a few sailors developed slight cases of scurvy.[442] The sailors were given additional rations of lemon juice and the scurvy was quickly cured.[443] With the results from the *HMS Suffolk* and the power of his position, Blane was able to insure that fresh citrus juice became a necessary stable in the British Navy, finally conquering this prolific killer.[444]

It is interesting to note that the British search and eventual discovery of a scurvy cure has led to the modern day term "Limeys."[445] American sailors began referring to British sailors as "lime-juicers" as a derogatory term in the 1850's.[446] Later, Americans began using the term to refer to all British and it was shortened to "Limeys." Today, the British have taken the term on for themselves and use it as a term of affection.[447] The fact that the people of an entire nation are known by a term derived from the cure for scurvy can only emphasize the great importance that the discovery of the cure for scurvy.

Conclusion

Scurvy killed more sailors than all battles, storms and other diseases combined from the 16th to 18th centuries. This paper has given a medical examination of the necessity of vitamin C, an explanation of the physical progression of scurvy, described the effects of scurvy throughout history, and outlined the pursuit of a cure and eventual elimination of scurvy. Today, scurvy is a rare disease that is entirely preventable. Thanks to the efforts of a number of pioneering researchers, we now better understand the importance of diet and necessity of vital nutrients.

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[1] Modern Nutrition in Health and Disease, Scurvy (Maurice Shils, James Olson, Moshe Shike, Catherine Ross eds., 1999) *http://80-pco.ovid.com.libproxy2.usouthal.edu/lrppco/index.html*

[2] *Id* .

[3] *Id* .

[4] *Id* . Ascorbic acid is also known by the chemical names 2,3-didehydro-L-threo-haxano-1, 4-lactone, cevatamic acid, and L-xyloacorbic acid.

[5] *Id* .

[6] *Id* .

[7] *Id* .

[8] *Id* .

[9] *Id* . However, it should be noted that urine is the primary and almost exclusive route for the shedding of excess vitamin C. Defecation provides only a minor role in the regulation of vitamin C levels within the body.

[10] *Id* .

[11] *Id* .

[12] *Id* . However, it has been noted that respiration can shed excess vitamin C through the breath during exhalation.

[13] *Id* .

[14] *Id* .

[15] *Id* . This mechanism closely mirrors the concept of the law of diminishing returns. The more vitamin C a person ingests, the less each additional unit of vitamin C will benefit the person.

[16] *Id* . In fact, excessive levels of vitamin C may cause loose stool or diarrhea.

[17] *Id* .

[18] *Id* .

[19] *Id* .

[20] *Id* .

[21] *Id* .

[22] *Id* .

[23] *Id* .

[24] *Id* . In addition, vitamin C is also critical for the basic gene expression of collagen. Without it, collagen would not even be begun to be produced.

[25] *Id* .

[26] *Id* .

[27] *Id* .

[28] *Id* .

[29] *Id* .

[30] *Id* .

[31] *Id* .

[32] *Id* .

[33] *Id* .

[34] *Id* .

[35] *Id* .

[36] *Id* .

[37] *Id* . An antioxidant is a compound that can give off electrons to Free radicals (elemental compounds with a positive charge (e.g. Fe^{3+}).

[38] *Id* . This may help reduce the risk and occurrence of cataracts. However, studies linking vitamin C levels to cataract risk have had varied results.

[39] *Id* .

[40] *Id* .

[41] *Id* .

[42] *Id* .

[43] *Id* .

[44] *Id* .

[45] *Id* .

[46] *See Id* . Vitamin C act similarly with respect to copper absorption and storage. Therefore, low levels of vitamin C may lead to low copper levels.

[47] *Id* .

[48] *Id* .

[49] *Id* .

[50] *Id* .

[51] *Id* .

[52] *Id* .

[53] *Id* .

[54] *Id* .

[55] *Id* . Less strong correlations have been shown for lung, rectum, cervix, and breast cancers. No correlation has been shown for colon, bladder, prostate, and ovarian cancers.

[56] *Id* .

[57] *Id* .

[58] *Id* .

[59] *Id* .

[60] *Id* .

[61] *Id* .

[62] *Id* .

[63] *Id* ,

[64] *Id* .

[65] *Id* .

[66] *Id* .

[67] *Id* . Vitamin C levels have also been linked depression, anemia, ulcers, gastrointestinal hemorrhaging, miscarriages, and premature birth.

[68] *Id* .

[69] Current Medical Diagnosis and Treatment (Lawrence Tierney, Stephen McPhee, Maxine Papadakis eds., 2003) *http://80-pco.ovid.com.libproxy2.usouthal.edu/lrppco/index.html* (last visited April 19, 2004).

[70] *Id* . Oxalate is a leading cause of kidney stones. Since Ascorbic acid is metabolized and then passed through the kidneys into urine, it is theoretically possible that this would increase the risk of kidney stones.

[71] Modern Nutrition in Health and Disease.

[72] *Id* .

[73] *Id* . Vitamin C may cause false negatives in fecal occult blood tests, and false positives and negatives in urine glucose tests.

[74] Modern Nutrition in Health and Disease, Scurvy. *Supra* note 1. Ascorbic acid, $C_6 H_8 O_6$ (176.3 g/mol) is a solid white powdery substance which is stable, water soluble, alcohol soluble (moderate), and insoluble in inorganic liquids. Modern Nutrition in Health and Disease, Scurvy. *Supra* note 1.

[75] *Id* .

[76] *Id* .

[77] *Id* .

[78] *Id* .

[79] 39 C.F.R. § 317.309 (c)(8)(B)(iv) (2004). The recommended daily allowance of vitamin C for pregnant women is 70 mg/day and 90-95 mg/day while breast feeding. Pimentel at 331.

[80] Modern Nutrition in Health and Disease, Scurvy. *Supra* note 1. A number of analytical tests may be used to determine the vitamin C content of particular foods, tissue, and pharmaceuticals. Depending on the need for greater accuracy, the sample being tested, cost, and time, researchers will select a given method. These methods include: spectrophotometric, fluorometric, electrochemical, and chromatographic procedures. Spectrophotometric procedures prove to be the most convenient technique, but lack accuracy. Chromotography provides a more difficult and timely method, but gives the best sensitivity and accuracy. *Supra* note 1.

[81] Stephen Brown, Scurvy How a Surgeon, a Mariner, and a Gentleman Solved the Greatest Medical Mystery of the Age of Sail 219 (2003).

[82] Lemon rob is a lemon extract used to treat scurvy promoted by James Lind. Details concerning the composition, use, and effects of lemon rob will be discussed later in the paper.

[83] Modern Nutrition in Health and Disease, Scurvy. *Supra* note 1.

[84] *Id* .

[85] *Id* .

[86] *Id* .

[87] *Id* .

[88] *Id* .

[89] *Id* .

[90] Brown, *supra* note 81, at 42.

[91] Laura Pimentel, *Scurvy: Historical Review and Current Diagnostic Approach* , *Amer. J. Emergency Medicine* , 21(4) 328, 330 (2003).

[92] *Id* .

[93] *Id* .

[94] *Id* .

[95] *Id* .

[96] *Id* .

[97] *Id* .

[98] *Id* .

[99] *Id* .

[100] *Id* .

[101] *Id* .

[102] *Id* .

[103] *Id* .

[104] Brown, *supra* note 81, at 42.

[105] Pimentel, *supra* note 91, at 330.

[106] Modern Nutrition in Health and Disease, Scurvy. *Supra* note 1.

[107] *Id* .

[108] Current Medical Diagnosis and Treatment, Vitamin C (Ascorbic Acid), *supra* note 69.

[109] *Id* .

[110] Modern Nutrition in health and Disease, Scurvy, *supra* note 1.

[111] *Id* .

[112] *Id* .

[113] *Id* .

[114] Thomas Jukes, *Historical Perspectives: The Prevention and Conquest of Scurvy, Beri-Beri, and Pellagra* , *Preventative Medicine* 18, 877 (1989)

[115] *Id* .

[116] *Id* .

[117] *Id* .

[118] Pimentel, *supra* note 1; *See also* Rajakamar Kumaravel, *Scurvy* , eMedicine, *at http://www.emedicine.com/ped/topic2073.htm* (last visited April 4, 2004) (Kumaravel dates the first recorded case of scurvy to 1550 BC Egypt).

[119] Charles Finch, *the African Background of Medical Science* , *available at www.raceandhistory.com/selfnews/viewnews.cgi?newid995545990,4925,.shtml* (last visited April 13, 2004)

[120] David Harvie, Limeys, The True Story of One Man's War against Ignorance, the Establishment and the Deadly Scurvy, 11 (2002)

[121] *Id* . (quoting the writings of English surgeon James Lind who analyzed and quoted from the writing of Hippocrates).

[122] *Id* . (quoting the writings of English surgeon James Lind who analyzed and quoted from the writing of Hippocrates).

[123] *Id* .

[124] *But See* Brown, *supra* note 81, at 33 (noting that a disease similar to scurvy had been recorded among Roman legions during the winter months of campaigns in northern Europe).

[125] Harvie, *supra* note 120, at 11.

[126] *Id* .

[127] *Id* .

[128] *Id* .

[129] *Id* .

[130] *Id* .

[131] *Id* .

[132] Brown, *supra* note 81, at 33 (noting that a "distemper" similar to scurvy was known to the Greeks and Romans, especially in soldiers who campaigned in northern Europe).

[133] *Id* . at 12.

[134] A.S. Hess, Scurvy: Past and Present (1982).

[135] Harvie, supra note 120, at 12.

[136] Graham Sutton, *Putrid Gums and 'Dead Men's Cloathes': James Lind aboard the Salisbury* , *J. Royal Soc. Of Medicine.* 96(12) 605 (2003).

[137] Harvie, *supra* note 120, at 12.

[138] *Id* .

[139] *Id* .

[140] *Id* . (quoting from Luis de Camoens' epic poem The Lusiad or Discovery of India translated from Portuguese to English by William Julius Mickle).

[141] *Id* .

[142] Ferdinand Magellan, *available at www.historychannel.com/perl/print_book.pl?ID=99297* (last visited April 14, 2004).

[143] Brown, *supra* note 81, at 33.

[144] *Id* .

[145] *Id* .

[146] *Id* .

[147] *Id* .

[148] Harvie, *supra* note 120, at 12-3.

[149] Brown, *supra* note 81, at 27.

[150] *Id* .

[151] *Id* .

[152] *Id* . at 28.

[153] *Id* .

[154] *Id* .

[155] *Id* .

[156] Harvie, *supra* note 120, at 13 (quoting from Cartier's records of the voyage).

[157] Brown, *supra* note 81, at 28.

[158] *Id* . (quoting from Cartier's records of the voyage).

[159] *Id* . (quoting from Cartier's records if the voyage).

[160] *Id* . at 29.

[161] *Id* .

[162] *Id* .

[163] *Id* .

[164] *Annedda* was the native word for the tree. It is unclear what species the tree actually was because it was not properly identified by Cartier. Harvie, *supra* note 120, at 13-4.

[165] Brown, *supra* note 81, at 29.

[166] *Id* .

[167] *Id* . at 31.

[168] *Id* . at 32.

[169] *Id* .

[170] *Id* .

[171] *Id* .

[172] *Id* . (noting that scurvy was known by similar names throughout Europe: scurvy, *scorbuto* , *scarby* , *scorbu* , *skurvie* , *scorbuck*).

[173] Pimentel, *supra* note 91, at 329 (Pimentel cites the years 1500 through 1800 BC. However, the years the author intended are clearly 1500 and 1800 AD).

[174] Brown, *supra* note 81, at 26.

[175] *Id* .

[176] *Id* . at 34 (quoting the log of William Clowes).

[177] *Id* (quoting an anonymous account by a 16th century sailor).

[178] Harvie, *supra* note 120, at 60.

[179] *Id* .

[180] *Id* at 59.

[181] *Id* . at65.

[182] *Id* .

[183] *Id* .

[184] *Id* . (quoting the records of Sir George Anson)

[185] *Id* .

[186] *Id* .

[187] *Id* . at 65-6.

[188] *Id* . at 66.

[189] *Id* .

[190] *Id* .

[191] *Id* .

[192] *Id* .

[193] *Id* . Although it is not noted what killed the two captains, the surgeon died from typhus. In addition, many of the men had already died from various diseases.

[194] *Id* .

[195] *Id* . at 67.

[196] *Id* . (quoting Reverend Walters account of the scurvy outbreak during the round of Cape Horn).

[197] *Id* . at 68.

[198] *Id* . at 70.

[199] *Id* .

[200] *Id* .

[201] *Id* .

[202] *Id* . In an interesting aside, Juan Fernandez is the fictional setting of Daniel Defoe's Robinson Crusoe .

[203] *Id* . at 70-71.

[204] *Id* . at 71.

[205] *Id* .

[206] *Id* .

[207] *Id* .

[208] *Id* .

[209] *Id* . Gloucester, the last ship to reach Juan Fernandez lost approximately two-thirds of its crew to scurvy.

[210] *Id* .

[211] *Id* .

[212] *Id* . at 72. It should be noted that even though the voyage had been over a year long and over two-thirds of he men had died, no combat had taken place.

[213] *Id* . at 71.

[214] *Id* . at 72-3.

[215] *Id* at 73.

[216] *Id* .

[217] *Id* at 74-5.

[218] *Id* . at 75.

[219] *Id* .

[220] *Id* . at 76.

[221] *Id* . Anson's voyage captured over $1.3 Million dollars in cash and great amounts of bouillon.

[222] *Id* .

[223] *Id* .

[224] *Id* .

[225] *Id* .

[226] *Id* .

[227] Brown, *supra* note 81, at 68.

[228] *Id* .

[229] *Id* . at 69.

[230] Harvie, *supra* note 120, at 79. James Lind's experiments on scurvy and the use of citrus will be detailed in much greater detail later in this paper.

[231] Alfred Bollet, *Malnutrition in Civil War Armies, The Pharos of Alpha Omega Alpha Honor Medical Society* , 19 (Autumn 2003).

[232] *Id* .

[233] *Id* .

[234] *Id* .

[235] *Id* .

[236] *Id* .

[237] *Id* . at 21. (These figures are based only on Union records. Similar Confederate records were kept throughout the war. However, those records were lost in the "Evacuation Fire" of Richmond on April 3,1865).

[238] *Id* . at 20.

[239] *Id* .

[240] *Id* .

[241] *Id* . at 22.

[242] *Id* .

[243] *Id* at 22-3.

[244] *Id* . at 23.

[245] *Id* .

[246] *Id* .

[247] *Id* .

[248] *Id* . at 22.

[249] *Id* .

[250] *Id* . at 21.

[251] *Id* .

[252] *Id* . at 27.

[253] *Id* .

[254] *Id* .

[255] *Id* .

[256] *Id* .

[257] *Id* .

[258] *Id* .

[259] *Id* . at 24.

[260] *Id* .

[261] *Id* . at 27.

[262] *Id* .

[263] *Id* .

[264] Modern Nutrition in Health and Disease, *supra* note 1.

[265] *Id* .

[266] Current Medical Diagnosis and Treatment, Vitamin, *supra* note 69.

[267] *Id* .

[268] Modern Nutrition in health and Disease, Scurvy, *supra* note 1.

[269] *Id* .

[270] *Id* .

[271] *Id* .

[272] *Id* .

[273] Brown, *supra* note 81, at 11-3.

[274] *Id* . at 43.

[275] *Id* . at 18.

[276] *Id* . at 43.

[277] *Id* .

[278] *Id* . at 10.

[279] *Id* .

[280] *Id* .

[281] *Id* .

[282] *Id* . at 11.

[283] *Id* .

[284] *Id* .

[285] *Id* .

[286] *Id* .

[287] *Id* . at 11-13.

[288] *Id* . at 13.

[289] *Id* .

[290] *Id* .

[291] *Id* .

[292] *Id* . at 43.

[293] Harvie, *supra* note 69, at 30.

[294] *Id* .

[295] *Id* . at 31. Keel hauling is a punishment in which a sailor would be dragged underneath the boat from front to back by ropes. The punishment kept the sailor underwater for a lengthy time.

[296] *Id* .

[297] *Id* .

[298] Brown, *supra* note 81, at 43.

[299] *Id* . at 17-18.

[300] *Id* at 17. A second criteria used was that the supplies needed to be cheap as nations were involved in an arms race for naval supremacy with limited resources. In addition, it will be pointed out later in the paper that even food that met these criteria often spoiled or became infested with varmints making it inedible and worthless.

[301] Harvie, *supra* note 69, at 34.

[302] *Id* .

[303] Brown, *supra* note 81, at 17.

[304] *Id* .

[305] *Id* .

[306] *Id* .

[307] *Id* . at 18.

[308] *Id* .

[309] *Id* .

[310] *Id* .

[311] *Id* . at 17-8.

[312] *Id* . at 18.

[313] Harvie, *supra* note 69, at 35.

[314] *Id* .

[315] *Id* at 35-6.

[316] *Id* . It should be noted that a “tun” was a unit of measure equal to 216 gallons and a bushel was equal to 8 gallons.

[317] Brown, *supra* note 81, at 18.

[318] *Id* .

[319] *Id* .

[320] *Id* .

[321] Harvie, *supra* note 69, at 36.

[322] *Id* .

[323] Brown, *supra* note 81, at 19.

[324] *Id* .

[325] *Id* .

[326] *Id* .

[327] *Id* .

[328] *Id* . at 20.

[329] *Id* .

[330] *Id* .

[331] *Id* .

[332] *Id* .

[333] *Id* .

[334] *Id* .

[335] *Id* . at 21.

[336] *Id* .

[337] *Id* .

[338] *Id* .

[339] *Id* .

[340] *Id* . at 19.

[341] *Id* .

[342] *Id* .

[343] *Id* .

[344] *Id* . at 15.

[345] *Id* .

[346] *Id* . Protestant countries would dump corpses overboard, but Catholic countries such as France and Spain would store the dead below deck until they could be buried on land in their native country.

[347] *Id* .

[348] *Id* . at 43.

[349] *Id* . at 15-6. The largest ships, although only a few hundred feet in length, would be manned by more than a thousand.

[350] *Id* . at 16.

[351] *Id* .

[352] *Id* .

[353] *Id* .

[354] Zachary Friedenberg, Medicine Under Sail, 24 (2002).

[355] *Id* . Small vessels in a fleet, however, would typically not be supplied with a surgeon. Instead, the sick and wounded would be transferred to larger vessels for medical attention.

[356] *Id* .

[357] *Id* .

[358] *Id* .

[359] *Id* .

[360] *Id* . at 25.

[361] *Id* . at 31.

[362] *Id* . at 28.

[363] *Id* . at 31.

[364] *Id* . at 30.

[365] *Id* . A typical hospital ship would still only have one surgeon, a few surgical mates, nurses, and a few cooks.

[366] *Id* . at 31.

[367] *Id* . at 34.

[368] *Id* .

[369] *Id* .

[370] *Id* .

[371] Brown, *supra* note 81, at 13.

[372] *Id* . at 43.

[373] *Id* . at 18.

[374] Friedenberg, *supra* note 354, at 34.

[375] Brown, *supra* note 81, at 68.

[376] *Id* . at 77-8. While today scientist place more weight on recent studies and "advancements," scientists during the period of the age of sail believed that the older a medical text was, the truer it must be. This may seem illogical, but science and religion were not always at odds. During this time, it was believed that humans were on a constant pathway of degeneration from the time when Adam and Eve were cast out of the Garden of Eden. Therefore, a medical treatise written nearer to the time of Creation must be more accurate as a former scientist was degenerated as a modern one. Therefore, European scientists would expend extensive resources finding and examining ancient texts and put little emphasis on trying to develop new theories and treatments.

[377] *Id* .

[378] *Id* . (quoting from the writings of Hippocrates)

[379] *Id* .

[380] *Id* .

[381] *Id* .

[382] *Id* .

[383] *Id* . at 78-9.

[384] *Id* . at 79.

[385] *Id* .

[386] *Id* . (quoting Echth's account of the writings of Strabo).

[387] *Id* .

[388] *Id* .

[389] *Id* .

[390] *Id* .

[391] *Id* .

[392] *Id* . at 79-80

[393] *Id* . at 80.

[394] *Id* .

[395] *Id* .

[396] *Id* . Sadly, citrus juices had long been thought to be cold medicines, so they would "obviously" be of no use in treating scurvy.

[397] R. Elwyn Hughes, *The Rise and Fall of the "Antiscorbutics": Some Notes on the Tradiational Cures for "Land Scurvy," Medical History* , 3: 52, 54 (1990).

[398] Brown, *supra* note 81, at 80.

[399] *Id* . at 88.

[400] *Id* . at 89.

[401] *Id* .

[402] *Id* . at 90.

[403] *Id* . Although Lind had no formal medical degree, it was common for the Royal Navy to accept men who had apprenticed under a surgeon.

[404] *Id* .

[405] *Id* . These tasks would include washing the dressings, carrying water and food to patients, cook the sick's special foods, change the dressing of wounds, clean the sick bay, and change the "bed pans." These duties required a surgeon's mate to be on call almost twenty-four hours a day.

[406] *Id* .

[407] *Id* .

[408] *Id* . at 91.

[409] *Id* . at 95-6.

[410] *Id* .

[411] *Id* .

[412] Duncan Thomas, *Sailors, scurvy, and science, J. Royal Soc. of Medicine* , 90:50, 52-3 (1997) (quoting from James Lind's *Treatise on Scurvy*).

[413] Sutton, *supra* note 136, at 608.

[414] *See* Thomas, *supra* note 412 at 53.

[415] *Id* .

[416] *Id* .

[417] *Id* .

[418] *Id* .

[419] *Id* .

[420] *Id* .

[421] D. P. Thomas, *Prevention of Scurvy in the Royal Navy* , *J. Royal Navy Society of Medicine* , 84.2, 107 (1998).

[422] *Id* .

[423] *Id* .

[424] *Id* .

[425] *Id* .

[426] *Id* .

[427] *Id* . (quoting from the writings of James Lind).

[428] *Id* . at 108.

[429] Brown, *supra* note 81, at 124.

[430] *Id* .

[431] *Id* .

[432] *Id* .

[433] *Id* .

[434] *Id* . at 224.

[435] *Id* .

[436] Thomas, *supra* note 421, at 107.

[437] *Id* . at 108.

[438] *Id* .

[439] *Id* .

[440] *Id* .

[441] *Id* .

[442] *Id* .

[443] *Id* .

[444] *Id* .

[445] Harvie, *supra* note 68, at 223.

[446] *Id* . Some say that the term is of Australian origin.

[447] *Id* . at 24.