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Book of the Quarter

SALT AND WATER IN CULTURE AND MEDICINE

Poul Astrup, Peter Bie and Hans Chr. Engell, Munksgaard International Publishers, Copenhagen, pp 287, £49.00

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What a joy it is to come across a book written by scientists which is not only a pleasure to read but is interesting and covers a topic from not only a medical and physiological point of view but also from that of early history and culture. Salt forms such an important part of our physiology that it is easy to ignore its role in these other aspects. The development of inorganic and organic chemistry was heavily dependent on salt in the broader sense of that word, a crystalline combination of metallic cations and anions. Water too is the very substance of our being. We cannot live without water, we cannot live without salt and we must have them in the right proportions. Why should this be? A modern biochemist might reply glibly that it must be so otherwise particular enzymes would not function, but the answer is surely deeper than that. Why are these particular concentrations and why are these particular salts important in human physiology? These are questions that need to be considered in relation to the development of the galaxy and to planets such as earth. In some respects this is the most interesting part of the book but also the weakest.

The available evidence for the origins of our planet is sound but not testable and the origins of life even less so; still, sensible deductions have been made by analyses of sedimentary rocks that reflect the life forms prevalent at the time that they were laid down. These suggest that our dependence on salt and water arose from the particular geological conditions that prevailed on this planet when the seas were formed. The subsequent evolution of life was shaped, not only by the random mutations of genes which enabled them to meet changing conditions, but also by geological upheavals and major changes in the mineral content of earth and water.

The historical/cultural perspective was fascinating for me as a doctor and yet the book is very approachable by those with only a limited knowledge of biology and medicine. Salt is an ancient word and is more or less the same in all European languages, and there is evidence that the use of salt in Europe began with the spread of agriculture. There are some cultures where the word for salt refers to shaking or spreading, words which are associated with the emergence of agriculture. Presumably the human requirement for salt had been satisfied previously by a carnivorous diet and it was the move to a more vegetable based diet that brought about a requirement for additional sodium.

How early agricultural man discovered that he needed salt is hard to fathom but he perhaps observed the habits of herbivores, who today frequent particular swamps with a higher salt content or lick rocks that contain sodium chloride. Salt could be used for preserving and, because the science of those times saw it as indestructible, it became sacred and the use and availability of salt was associated with religion and with majesty. The early Greeks and Pliny were able to

distinguish between land salt, which was said to have superior taste, and sea salt. How fashions change!

The importance of salt in the development of chemistry is one of those absorbing tales that may be familiar to inorganic chemists but unknown to most of us. Different white crystalline salts were recognised by the early Egyptians; in 5000 BC they could distinguish between sodium chloride and sodium carbonate. Indeed they mixed them for embalming and for the making of glazed stone. Later a similar mixture was used for early glass. As early as 2000 BC ammonium chloride was known and also potassium nitrate. This is evident in two widely separated cultures because both Egypt and China were capable of using these substances for explosions and for gun powder during the next 6 centuries. The Arabs in the 13th century called gun powder 'Chinese Salt'.

The alchemists were interested in salt because of their observation that rock salt could react with camel urine and dung to produce ammonia and then ammonium chloride. Ammonium chloride was much used by alchemists of the 12th and 13th centuries who were convinced that they could purify metals such as gold by the reaction of salts with common acids.

It was not until the 16th century that a Swiss physician, Paracelsus, felt able to attack the ancient teachings of Aristotle on earth, air, water and fire and replace them with a chemistry which emphasised the elements sulphur and mercury together with their salts. In the next century Glauber in Germany demonstrated the formation of hydrochloric acid by heating common salt with sulphuric acid and his most celebrated product was sodium sulphate. He called it *Salmirabile* because of its laxative properties which did wonders for sales. Epsom salts soon followed. Little appears to have changed in the 20th century.

It was during an investigation of potash and other salts that Joseph Black in Edinburgh discovered carbon dioxide. The idea that there might be a gas trapped in a crystallised solid was an enormous step forward and led to rapid developments in theoretical chemistry. The history of salt in chemistry and its place in industrial development and in our cultural heritage takes up a full third of this book.

The authors provide fascinating insights by linking discoveries in one place to similar discoveries in others. They illustrate how 17th to 19th century networking took place; not of course over the telephone but by one person going, often enormous distances, to live and study with another and so being away from home for several years. Scientists of those days believed in long hard sabbatical leave and took it seriously.

The biological sections are an interesting anthology of the development of this branch of science. The Swedish chemist, Berzelius, in a series of lectures between 1806 and 1808 described the presence of both sodium chloride and potassium chloride in blood and urine, and gave a credible account of the chemical composition of the human body. This laid the foundation for further work on how the concentrations of sodium and potassium were maintained in the body and regulated by the kidneys and the related control of the absorption and excretion of water. 'Cholera raging through the Baltics in the 1830s gave a further stimulus. Carl Schmidt demonstrated that sodium and chloride were found mainly in serum whereas potassium and phosphorus were predominant in red blood cells. This was an observation, contrary to the prevailing view that the same fluid was present on either side of the membrane of red cells. Professor

Hamburg at Groningen demonstrated that 0·9 per cent sodium chloride was the concentration at which red cells maintain their volume and concluded that the concentration of sodium chloride was equivalent to the osmotic concentration of plasma. He also demonstrated the exchange of chloride and bicarbonate ions across red blood cells during the respiratory cycle.

Developments in the second half of the 19th century were rapid and there was an explosion of interest in the physiology of salt and water, measurements of the ionic concentrations of secretions into the intestinal canal and crude measurements of several hormones. Ernest Starling was a prominent physiologist in Britain whose lectures published in 1909 illustrated his grasp of theoretical concepts and hypotheses. Starling's description of the movement of salt and water through the circulation and the interstitial space, and its relationship to lymph, has so far stood the test of time. The validity of his views has been maintained during almost a century of further experimentation. John Peters, professor of internal medicine at Yale, published his book, *Body Water*, in 1935. Although it contributes no ideas different from Starling's it presented much more experimental data and he elaborated on mechanisms by which the kidney excretes and controls salt and water.

Further chapters deal in detail with contributions made by Thomas Addison, Charles Brown-Sequard and many others to the control of salt and water within the body by the kidneys and the adrenal glands. Tigerstadt demonstrated the existence of renin, followed rapidly by the discovery of angiotensins simultaneously in Cleveland, Ohio and Buenos Aires. There was a similar rapid evolution in the discovery of arginine-vasopressin in the regulation of water excretion. Parallel to all this physiological effort was similar effort by pharmaceutical companies in developing diuretics which were soon used effectively in the treatment of patients with oedema.

Clinical assessment of salt and water status in patients is not a modern phenomenon. The Greeks and Paracelsus were interested not just in their theories of salt as part of the composition of the body, but in the use of salt in the treatment of disease. Many observations have been made over the centuries of the deleterious effects of either depletion or excess of salt and water. These problems were recognised long before their causes were understood or before satisfactory treatment could be administered.

The history of fluid infusion from the introduction in Britain of saline infusions during the cholera epidemic of 1832 through to the arguments this century about the wisdom of using colloid or crystalloid infusions in the resuscitation of trauma victims, gives a fascinating insight into the methods of clinical empiricism. There is a sharp contrast between the scientist in the earlier part of the book and the clinician in this latter half. Scientists were prepared to take risks, but they were calculated ones. They built on what was known, experimented, often in quite unexpected ways, and developed testable hypotheses for future generations to support or knock down. Not so the clinicians. These men, and they are almost all men, come out as being empiricists and lacking any scientific training or credibilty. Perhaps it had to be so in that it is clear that these doctors were caring for extremely sick people. They were prepared to take risks, often very big ones. When risks paid off, the lessons learned could be applied to future victims of disease and mankind moved a significant step forward. When these risks did not succeed, then nobody could be too disappointed because the end

result was no different from what it might have been. The arguments between doctors were also quite extraordinary. Arguments about the appropriate treatment of volume depleted states by intravenous infusions of saline were conducted on the basis of opinion, and of comparing one patient with another. It is only in the 20th century that doctors have systematised their clinical work and joined the empirical scientists in the collection of observations and development of theories and hypotheses which could be tested later. Nevertheless one is struck by the rapidity of advances in clinical medicine and by the enthusiasm with which doctors would take up the theories of fellow doctors or scientists for a treatment, often of a particular patient. The book (thankfully) comes to no conclusions about the merits of crystalloid or colloid infusions. It indicates quite properly the evidence supporting each but in different situations. It does contain one nugget of useful information—that the determination of plasma colloidosmotic pressure as a routine test would help to end nearly a century of dispute on the correct use of saline. There is a history of early blood transfusion and of the short lived trials of milk infusion in the USA between 1870 and 1880. The book concludes with a chapter on the development of analytical techniques.

Finally this book is an excellent exposition of the development of the culture, history, science and clinical medicine of salt and water. It is not in any sense a medical text book that provides a student or practitioner with guidelines for treatment: that is not its purpose. As a historical work it fulfils a genuine need, as it provides those of us with a practical interest in the subject a review of where our present day theories have come from. It makes no attempt to end with a grand flourish, to provide a unified explanation for all the numerous loose ends demonstrated throughout the pages. Rather it leaves us, as a good history book should with questions and an eagerness to know the next part of the story. The authors do a great service in bringing together so much fascinating historical and archival material.