

Biographical memoir on Joseph Needham (1900-1995)

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The number of people who are CH, FRS and FBA¹ can be counted with one finger of one hand. Joseph Needham's death on 24th March 1995, leaves no living person in this category. Not surprisingly, therefore, for someone of his distinction, his life has been reviewed in at least one book, in many articles, and in several obituaries. Prominent among these very professional accounts of Joseph Needham's life are the following: Abir-Am (1987, 1988) Haraway (1976), and most interestingly Holorenshaw (1973), an account by Joseph Needham of himself. Rather than attempt to précis or summarise these very professional accounts of his life, we have chosen to address our contribution to particular aspects of the life of such an unusual polymath.

Background, early life, and education

Born on 9th December 1900 to Dr. Joseph and Alicia Adelaide Montgomery Needham, Joseph Needham's early nurturing was by

parents whose own fragile relationship frequently ended in battle. Consequently the young boy, who was to remain an only child, discovered within himself an aptitude for mediation which, many years later, he described as bridge building and which he was able to exercise throughout his long life. At a tender age, Joseph Needham declined his mother's musical and artistic interests and turned almost exclusively to his father's passion for science and philosophy. Joseph Needham senior was born in East London as one of seven children, and had applied himself academically to become, at the height of his career, a Harley Street physician and one of the first to specialise in anaesthesia. While his mother's exuberance was a frequent embarrassment to him, Joseph Needham greatly enjoyed the stimulation of his father's company. At the age of 10, he was taken on Sundays across London by tram to listen to E.W. Barnes, FRS, Master of the Temple in London and later the radical Bishop of Birmingham. Barnes' lectures on philosophers and mediaeval scholastics inspired the young Joseph to further pursue those interests within the sanctuary of his father's library where, among many other fine works, he discovered Schlegel's *History of Philosophy*. It was to Barnes' philosophical theology that Joseph Needham later attributed his own unswerving Christian faith, a faith that was always mediated by rational argument rather than by cynicism, and one that maintained an openness to the religions of other cultures. In an autobiographical essay at the age of seventy, Joseph Needham noted that it would be hard to over-rate the influence upon him of Bishop Barnes.

¹*CH-Companion of Honour*. An exceptional honour bestowed, in Britain, on individuals for outstanding achievement in any walk of life. The total number of living CHs cannot exceed 60.

FRS-Fellow of the Royal Society, i.e. the British Academy of Sciences. Established in 1660, it elects up to 42 individuals from Britain and the Commonwealth per year for distinction over the whole range of science, mathematics, engineering, medicine and technology.

FBA-Fellow of the British Academy. The equivalent of the Royal Society for all aspects of the Humanities and Social Sciences.

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After mounting social unrest throughout the country, and a wave of serious industrial strikes during the preceding four years, 1914 saw the outbreak of the First World War and the despatch of Joseph Needham to Oundle in Northamptonshire, one of the oldest public schools in England. It is not surprising that a very serious only child would find his sudden propulsion into a non-private environment less than enjoyable, but there were compensations in the regime of Frederick William Sanderson, the headmaster described by Needham as “a man of genius” and by H.G. Wells, who sent his own sons to Oundle, as “beyond question the greatest man I have ever known with any degree of intimacy.” In 1892, Sanderson was appointed by its Governors to raise the profile of science and technology at Oundle. In the year in which Needham arrived, an impressive new science block was built, where, regardless of their other studies, Sanderson insisted that every boy should spend time in its metal shops. While pathologically avoiding the school playing fields, the adolescent Needham was a less reluctant visitor to these workshops wherein he acquired a basic knowledge of engineering, for which he remained ever grateful. But it was not purely science and technology that inspired Sanderson’s headmastership. He also encouraged his pupils to think widely, to embrace the concept that, in any field, cooperation leads to greater human achievement than does competition, and to understand that knowledge of the past informs ideas for a better future. Thus, he approached his scripture and

Bible classes from an archaeological perspective, relating historical civilisations to those of the present. Joseph Needham later observed that, without Sanderson’s encouragement of expansive thought at an impressionable age, he might never have attempted his largest work. Retrospectively, it can be said that Sanderson’s parting words, on Needham’s departure for King’s College London, were something of an understatement: “Well, you’ll never do anything to disgrace the school, my boy”.

During school vacations, the young Needham had assisted his father in the operating theatre at three London military hospitals, witnessing at first hand other, more awful, spoils of war. He took an objective interest in this temporary occupation, but it was enough to convince Needham that he would not wish to pursue a career in surgery. However, due to an appalling lack of qualified personnel, his experience was sufficient for the Royal Navy to appoint him as surgeon sub-lieutenant in their Volunteer Reserve. Within months of Needham’s appointment, the war was over, and it was time for Joseph Needham, the man, to go to Cambridge to read Medicine.

Settling into Cambridge

Perhaps because he was not an Oxbridge man himself, Joseph Needham senior made no arrangements with a Cambridge College for his son. Consequently, the young Needham’s choice of Gonville and Caius was almost random, influenced only by a fellow pupil at Oundle who suggested that its medical reputation made it particularly appropriate. Refounded by a distinguished physician, John Caius, in 1558, and Alma Mater a century later to William Harvey, Gonville and Caius College opened its doors in 1918 to Joseph Needham. He was allotted room C1 in St. Michael’s Court where he quickly became absorbed into the religious and philosophical fraternities that existed within the College. Needham valued the encouragement of Sir Hugh Anderson, an eminent neurophysiologist and Master at that time, but was more profoundly influenced by his first Tutor, Sir William Bate Hardy who, with clear foresight, persuaded Needham that preparation for a medical career required the study of atoms and molecules. Thus he dropped Zoology in favour of Chemistry, which he then read in conjunction with Anatomy and Physiology, to obtain his BA in 1921. After a short post-war period of research in Germany, Joseph Needham returned to Cambridge where he was given a Benn Levy Studentship and was admitted as a graduate student to the Cambridge Biochemical Laboratory.

For a considerable part of the ensuing three years, while also engaged in research, Needham was an Anglican lay brother of the Oratory of the Good Shepherd and lived at the Oratory House in Cambridge. In addition to his own deep belief in Anglo-Catholicism, Needham sought to satisfy an intuitive urge to unite science and religion by encouraging other scientists to become lay brothers at the Oratory. This did not happen. Instead, in 1924, having gained his doctorate, Needham abandoned celibacy and married a colleague, Dorothy Moyle. Facilitated weeks later by election to a Fellowship at Gonville and Caius, Joseph Needham gave up all thoughts of medicine and began a career of pure research.

Needham described the Cambridge Biochemical Laboratory as “home in the most real senses from 1920 to 1942” and one where he and Dorothy Moyle flourished “under the aegis of that beloved *fundator et primus abbas* of modern biochemistry in England, Sir Frederick Gowland Hopkins.” Within the Biochemical Laboratory, Needham progressed from student to Demonstrator in Biochemistry in 1928, and thence to succeed J.B.S. Haldane in 1933 as the Sir

William Dunn Reader in Biochemistry. By this time he had published his mammoth *Chemical Embryology* that gained him an international reputation, but eight years of research were to follow before his election to the Royal Society in 1941. His nomination, signed by 15 of the most eminent biochemists of his time, stated that "his exhaustive treatise on chemical embryology, published in 1931, awakened widespread interest in chemical problems presented by developing organisms and encouraged their systematic study by modern methods."

Scientific research

Joseph Needham's scientific work extended over about 20 years from the start of his graduate work in 1921 until the mid-war period in 1942 when he accepted a post as representative of the Royal Society to extend Anglo-Chinese relations in the cultural-scientific field. During the whole of his scientific career, which was based in the Biochemistry Department in Cambridge, he was author of over 100 publications and was in part responsible for the production of another 30 scientific papers which resulted from work carried out in his laboratory, or at his suggestion, but on which he did not have his name as an author. Cambridge University Library has 3 volumes of Needham papers numbered by the National Cataloguing Unit for the Archives of Contemporary Scientists by T.E. Powell and P. Harper. Contrary to common perception, about half of his papers were experimental in the sense that they described the results of biochemical measurements; most of these were published in *Proceedings of the Royal Society (Biology)* and were communicated by Sir Frederick Gowland Hopkins FRS, the head of his department, and one whom Joseph Needham spoke of as '*in loco parentis*'.

The style of Joseph Needham's experimental papers had a uniformity of a commendably logical kind, as is well exemplified by the first three of his publications, on all of which he was sole author. The first established the validity of methods of measuring the amount of inositol (a molecule found in large amounts in muscle and urine). The second described the synthesis of inositol, and the third described changes in the amount of inositol during development (of the chick).

The question that primarily interested Joseph Needham was how changes in chemical composition take place in development, and how morphology can be interpreted in chemical terms. He attributes this interest to his peripheral reading, from which he learnt of the work of Klein, who showed in 1912 that the chicken egg has no detectable content of inositol, but that, by hatching, this has increased to several hundred milligrams. This dramatic increase in the content of a defined chemical compound was seen as a problem of increasing complexity, due to rearrangement within a 'closed system'. The ten years of Joseph Needham's scientific contributions to 1934 centred on determining sources of energy for development, the intracellular pH, oxidation-reduction potential and manometric measurements of respiratory quotient. In all these studies he paid special attention to the validity of methods of measurement, often having to develop new technology before initiating his assays. A good example of this is his work on intracellular pH, which necessitated "the mastering of a technique so difficult that we had few competitors" (Needham, 1941). He decided to employ Chambers' microinjection procedure to intro-



duce dyes directly into eggs or cells rather than to incubate whole cells in dye as had been done before by others. Characteristically, Joseph Needham analysed in detail the shortcomings of the procedures used until then by others, and noted that microinjection and vital staining (the old method) gave diametrically opposite results. Chambers' method of injecting amoebae worked as well for Joseph Needham as it had for Chambers, but Needham found that asterias eggs "resemble a mass of porridge enclosed in a weak rubber envelope". He therefore devised the method of holding eggs in place with the surface tension of a thin hanging drop of medium on the underside of a cover slip. In all, 3,300 eggs were injected in this way to determine intracellular pH. Joseph Needham had the satisfaction of feeling that he had devised new methods to provide reliable information of a kind that did not exist before. However, he took a conservative but realistic view of the significance of his conclusions when he said that this work "did not lead to as great an insight into cell physiology as was at first hoped."

Much of this experimental work was done in collaboration with his wife, Dorothy Moyle Needham, at various marine stations including Millport in the Firth of Clyde (Scotland), Woods Hole (Massachusetts), Monterey (California), and in particular at Roscoff (France). One has the impression that the work was notable for very careful attention to methodology and for the thoroughness with which it was executed, often using several different reagents, assay methods, and species of eggs on which to make measurements. The conclusions reached would now seem somewhat mundane. For example, the pH, the oxidation-reduction potential, and the respiratory quotient were measured exhaustively and values provided, but little change was observed before and after fertilisation and during early development. It could be questioned whether this information has helped us to understand the basis of the chemical changes that accompany development. Joseph Needham would probably have responded by saying that, had substantial changes been observed, this would certainly have been interesting and potentially important, and until reliable measurements had been undertaken, it was not known whether changes were taking place or not. Interestingly, Joseph Needham describes



with particular satisfaction his conclusion that energy sources in development were supplied sequentially by metabolism of carbohydrate, protein and then fat. Needham (1941) states that “I cannot but regard this as one of the most far reaching generalisations which has arisen from my own experimental work.”

In 1934, Joseph Needham commented on the immense importance of Spemann’s 1924 organizer experiments, and switched the work of his laboratory to attempts to identify the organizer substance. In 1930, Joseph Needham had gone to Brussels to learn the technique of embryological micro-operation in Albert Brachet’s laboratory, and was joined in his own lab in 1933 by C H Waddington. Subsequently Joseph Needham, his wife, and C.H. Waddington worked in the Institute of Otto Mangold in Berlin (Needham *et al.*, 1934). Nearly all of Joseph Needham’s work in this field was done in collaboration with C.H. Waddington and he also had collaborative visits from Jean Brachet (Waddington *et al.*, 1936); Waddington and Brachet were two of the most significant embryologists of their time. The motivating idea behind their work was that Holtfreter had found that inducing material retained its activity when dried, heated at 60°C, boiled for 5 min or frozen. What more could a biochemist ask for, when attempting to purify substances without loss of function? The next few years yielded several papers by Needham, Waddington, and of course much work from other laboratories, all of which failed to identify any one substance that was a reasonable candidate for a natural inducer. In retrospect, we now know that the problem was the assay. The conversion of newt ectoderm (the test material used by all in the field at that time) to neural tissue takes place extremely readily, and does not require natural inducers. Other amphibian species do not neuralise nearly so easily and might have been used with more success. As we now look back, we notice that very few natural inducers have been identified by fractionation of normal inducing tissue. These substances seem to work at such low concentrations that the most successful route to their identification has been to start with material from any (however unlikely) source which happens to have exceptionally high activity. Another fault in the assay procedure used in those days was to implant precipitates rather than to test soluble preparations. Inducer substances now known to us (e.g. TGF β and other growth factors) would not have been precipitated by the methods used. This problem affected not only Joseph Needham’s laboratory but numerous other laboratories

for the next three decades. Thus, attempts to purify the organizer were not successful, though it is clear that Joseph Needham’s laboratory was highly regarded internationally as a centre for this type of work.

Apart from the experimental work mentioned above, Joseph Needham had a continuing interest in comparative biochemistry. He was impressed with his finding that the jaw muscle of echinoderms contained creatine phosphate (vertebrates) as well as arginine phosphate (invertebrates), thus supporting Bateson’s views on the origin of the vertebrates.

Joseph Needham is probably better known for his books than for his experimental work. He published reviews and commentaries extensively in ‘Science Progress’, a journal that has now ceased to exist. His *magnissimum opus* was undoubtedly the three volume treatise ‘*Chemical Embryology*’, published in 1931. This was the first such book since W H Preyer’s (1885) ‘*Spezielle Physiologie des Embryos*’. Needham’s three volume work extended to over 2,000 pages, containing more than 10⁶ words, and included over 7,000 references. It consisted very largely of an exhaustive accumulation of facts concerning subjects related to his research interests, including respiration, osmotic pressure, pH, energy, metabolism of carbohydrate, protein, fat, etc, with a strong emphasis, as had his own research, on the chick. The criticism commonly voiced nowadays—that this was an undigested gathering of descriptive information—must have reached the ears of Joseph Needham, since he wrote that his book was sometimes regarded, by those who have not worked in the field, as a mere compilation of literature. Joseph Needham felt that he was led, in writing this book, to many correlations unnoticed before. He comments that “practically nothing was left out” and suggests that such a book could be more valuable for subsequent workers than almost any experiments. ‘Who now remembers the detailed experiments of Wilhelm Roux’, he asks. He took the view that he was led to previously unnoticed correlations, exemplified by the concept of the ‘cleidoic’ egg (of birds, reptiles, insects etc) the walls of which are permeable only to matter in the gaseous state. This led him to the only explanation of the origin of uricotelic metabolism (uric acid excretion) ever given, namely that it is necessitated by terrestrial life.

Joseph Needham’s second major work ‘*Biochemistry and Morphogenesis*’ was published in 1942, and was relatively advanced in its time, with descriptions of 81 mutants of *Drosophila*, the mouse, etc, and coverage of many embryological phenomena such as competence, that are not well understood even today. This work seems to have had less impact than might have been expected (compared, for example, to Waddington’s 1956 ‘*Principles of Development*’ and J. Brachet’s 1957 ‘*Biochemical Cytology*’). This was probably because Joseph Needham’s style of writing was exhaustive rather than stimulatory. Nevertheless, it would be wrong to underrate the scholarly contribution of this work. Possibly of greater lasting value than these works is Needham’s 1959 ‘*History of Embryology*’ (in fact a revision of the first 180 pages of his 1931 *Chemical Embryology*). This has many fascinating references to early embryological thinking—for example to that of Aristotle and even to embryologically suggestive paintings in New Guinea.

In summarising his own experimental and review contributions, Joseph Needham states that he has been able to “approach more closely than before to a fundamental aim which I can now begin to visualise as perhaps essentially mine, namely the rapprochement of the realms of biochemical and morphological science.” A further quotation by Joseph Needham comes from Abir-Am (1991) and was drawn to our attention by Scott Gilbert, as exemplifying Joseph Needham’s style of writing and approach to science: “if, arriving in front of the highly fortified living cell, we simply accept the fact of its high organisation as a primary datum, we do no more than sit down before it, and dig ourselves in, but if, advancing boldly to the walls, we blow loud blasts upon the trumpets of mathematical physics, I will not prophesy that what happened at Jericho will happen again, but the odds are heavily in favour of it.”

College and university life

For 77 of his 95 years of life, Joseph Needham was a member of Cambridge University, and of Gonville and Caius College where he progressed through the ranks from being an undergraduate, graduate, research fellow, Fellow, President, Master, to Honorary Fellow. In all, he was a Fellow of the College for 61 years. In spite of this, his own autobiography, and the notes left for the Royal Society, contain minimal reference to his College and University activities and none to his Mastership of the College. Mention is made by Goldsmith (1995) to a fierce controversy in the Caius College Council on whether Joseph Needham should be allocated a second room, apart from his own, to accommodate his rapidly increasing collection of books, permission being eventually granted. The College publication *The Caius* (October 1994-September 1995) contains tributes from Gonville and Caius College, Cambridge after Joseph Needham’s death. As Master of the College, he had the reputation of an ability to defuse the kind of intense disagreements for which Oxbridge dons are famous, not by skilful diplomacy or by the technology of Chairmanship, but because he was interested in people and generally knew more about them than anyone suspected. He attended College Evensong most Sundays in full term. Many recall that Joseph Needham was economic with his small talk, and indeed said of himself “A certain ruthlessness in pursuing objectives is not always easy to live with.” A prevailing impression is that of his prodigious memory and compulsion to explore every last detail about a subject, including his reputation for having offered a course of five lectures on “The History of the Brush.”

Chinese history and culture

While working in Sir Gowland Hopkins’ Biochemistry Institute in Cambridge, before the 1939-45 World War, Joseph Needham acquired a deep interest in Chinese language and culture through contact with Chinese scientists working in Cambridge. He saw an opportunity to build a bridge between China and Europe, as he had tried to do between religion and science, and between chemistry and morphology. In 1942, he was asked to go to Chungking as Scientific Counsellor at the British Embassy, and to be responsible for the activities of the Sino-British Science co-operation office. He was asked, in 1946, to build up the natural sciences division of the United Nations Education, Scientific and Cultural Organisation in Paris. In 1948, he returned to Cambridge and began work on his multi-volume treatise on Science and Civilisation in China, to be

published in parts until his death. It is neither appropriate as a Royal Society Memoir, nor within our qualifications, to review Joseph Needham’s contributions to Chinese history and civilisation. There are however, a number of recent publications which address this aspect of his life. These include Mukherjee and Gosh (1997), Blue (1997, 1998), and Habib and Raina (1999). Finally, we particularly recommend an especially fine article by Lu (1982).

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References

- ABIR-AM, P. (1987). The Biotheoretical Gathering, trans-disciplinary authority and the incipient legitimation of molecular biology in the 1930s: new perspective on the historical sociology of science. *History of Science* 25: 1-67.
- ABIR-AM, P. (1988). The assessment of interdisciplinary research in the 1930s: the Rockefeller Foundation and physico-chemical morphology. *Minerva* 26: 153-176.
- ABIR-AM, P. (1991). The philosophical background of Joseph Needham’s work in chemical embryology. In *A Conceptual History of Modern Embryology*. Volume 7 of *Developmental Biology: a Comprehensive Synthesis*, Chapter 8. (Ed. L. Browder), Plenum, New York.
- BLUE, G. (1997). Joseph Needham—a publication history. *Chinese Science* 14: 90-132.
- BLUE, G. (1998). Joseph Needham, heterodox Marxism and the social background to Chinese science. *Science and Society* 62: 195-217.
- BRACHET, J. (1957). *Biochemical cytology*. Academic Press Inc, New York.
- GOLDSMITH, M. (1995). *Joseph Needham 20th Century Renaissance Man*. Published by UNESCO.
- HABIB, S.I. and RAINA, D. (1999). *Situating the history of Science: dialogues with Joseph Needham*. Oxford University Press.
- HARAWAY, D. (1976). Joseph Needham. In *Crystals, Fabrics, and Fields*. Chapter 4, Yale University Press.
- HOLORENSHAW, H. (1973). The making of an Honorary Taoist, In *Changing Perspectives in the history of Science. Essays in honour of Joseph Needham*. (Ed. Teich, M. and Young, R). Heinemann Educational Books. London. pp1-20. [Joseph Needham used the pseudonym Henry Holorenschaw when writing a book called *The Levellers and the English Revolution, a Marxist interpretation of the Civil War*.]
- KLEIN, H.A. (1910). *Biochem. Zeitschrift*. 29: 465-472.
- LU, G.-D. (1982). The first half-life of Joseph Needham. In *Explorations in the history of Science and Technology in China*. Shanghai Chinese Classics Publicity House. pp 1-38.
- MUKHERJEE, S.M. and GOSH, A. (1997). *The life and works of Joseph Needham*. The Asiatic Society, Calcutta, India.
- NEEDHAM, J. (1931). *Chemical embryology*. Cambridge University Press. Cambridge. Vols 1-3, pp. 1-2021.
- NEEDHAM, J. (1941). *Personal records of the Royal Society*. [Joseph Needham’s views of his own work].
- NEEDHAM, J. (1942). *Biochemistry and morphogenesis*. Cambridge University Press. Cambridge.
- NEEDHAM, J. (1959). *A history of embryology*. Cambridge University Press.
- NEEDHAM, J., WADDINGTON, C.H. and NEEDHAM, D. (1934). Physico-chemical experiments on the amphibian organizer. *Proc. R. Soc. Lond. (Biol.)* 114: 393-422.
- PREYER, W.H. (1885). *Spezielle physiologie des embryos*. Grieben. Leipzig.
- WADDINGTON, J. (1959). *A history of embryology*. Cambridge University Press. Cambridge.
- WADDINGTON, C.H., NEEDHAM, J. and BRACHET, J. (1936). Studies on the nature of the amphibian organization centre. III The activation of the evocator. *Proc. R. Soc. Lond. (Biol.)* 120: 173-198. [The article above by Haraway discusses this work pp118-121.]