

PRELIMINARY NOTE

THE contribution to the history of science contained in the following four chapters first appeared as the opening part of a treatise on Chemical Embryology, published in 1931. They were delivered in the form of lectures about the same time at the University of London under the title "Speculation, Observation and Experiment as illustrated by the History of Embryology." The munificence of that University assured their appearance in separate, and amplified, form.¹

I suppose that the study of the history of science needs no apology. If at first sight the discussion of what was thought in the past rather than what is known now appears to be of merely antiquarian value, a deeper consideration will admit, with Louis Choulant, that the history of science is the guarantee of its freedom. The mistakes of our predecessors remind us that we may be mistaken; their wisdom prevents us from assuming that wisdom was born with us; and by studying the processes of their thought, we may hope to have a better understanding, and hence a better organisation, of our own. Theoretical errors, such as the final cause, preformationism or phlogiston; practical errors, such as the divorce between speculation and technique in the Hellenistic age, are always able to show us a more excellent way.

The present contribution does not claim, what probably no historical work can truly deserve, the ascription of a complete lack of bias in its presentation. Designed as it was to introduce a discussion of the borderline between embryology and biochemistry, it sought rather to lay bare the roots of chemical embryology in history, than to collect data indiscriminately on all the interesting aspects of the subject. Its title, "The Origins of Chemical Embryology," made no secret of this. And no obvious disadvantage attaches to such a plan, except the difficulty of deciding when to leave off. For although it is possible in reasonable space to try to do justice to all aspects of embryology before 1800, after that date the number of investigators and the variety of problems attacked becomes too great to handle conveniently on the same scale as before.²

¹ By embryology we mean in this book the embryology of animals exclusively. The history of the embryology of plants has been fully written only in Russian, by Baranov, but there is a shorter work by Souèges in French.

² Cf. the valuable work of Studnička; Florian; Dogelb; Oppenheimer; Fischer & Schopfer; and others.

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Bifurcation begins; the spheres of morphology and physiology more obviously separate, and in the latter division chemical researches play an ever-increasing part. It is now hoped that a group of workers will soon be able to continue the story in a companion volume through the nineteenth century under a number of separate headings.

No exhaustive treatise on the history of embryology as yet exists.¹ The nearest approach to it is the very valuable memoir of B. Bloch with its epitome, but this only covers the era of the Renaissance with thoroughness. Hertwig's account, which he printed at the beginning of his great *Handbuch der Entwicklungslehre*, does not deal very fully with any aspect of the subject before 1800, nor do the much shorter ones of Henneguy and Minot. The latter paper is interesting in that it ends with an emphasis on the need for physico-chemical work in the future. The introduction to Keibel's book is much slighter, but contains some useful information. There are various monographs and papers on special points, such as Pouchet's rather untrustworthy treatment of the embryology of Aristotle, and Lones' discussion of it, which is worse. Camus' notes are still the best commentary on the *Historia Animalium*. Again, useful information on some cultural points is to be had from the treatise of Ploss & Bartels. The introductions to certain books also contain valuable information, and in this class comes Dareste's remarkable book on teratology. The bibliographies contained in von Haller's eighth volume and in the books of Schurig and Heffter are naturally of the greatest assistance. The valuable books of F. J. Cole and Thadeusz Bilikiewicz on seventeenth-century embryology appeared too late for use in the first preparation of this book, but have contributed to its revision.²

In 1939 there appeared a work, *The Rise of Embryology*, by the learned Californian anatomist A. W. Meyer, author of numerous periodical publications on our subject, some of which are referred to in the bibliography. His book stands to mine in much the same relation as the second volume of David Eugene Smith's notable *History of Mathematics* to the first; the one adopting a basically chronological treatment, the other a topical form in which separate subjects are chosen in succession for consideration. However, Meyer devotes the bulk of his work to

¹ Here we cannot attempt to provide a bibliography of the most important modern works dealing with the subject itself. Yet in case scientific men or historians of other fields might appreciate some helpful introduction to embryology, mention may be made of the popular books of Rostand, Waddington and Guttmacher. An engineer or an historian of astronomy might then proceed to the recent surveys of Waddington, Barth, or Willier *et al.*

² Certain minor works on the history of embryology have proved inaccessible—Beseke; Eccleshymer; H. Fasbender; Favaro; Ferckel; Gilis; Hopf; Ottow. Other articles deserving mention are those of Gerber; Keller; du Bois.

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the eighteenth and nineteenth centuries, passing over the earlier periods in his first thirty pages. His treatment of the nineteenth century is interesting indeed, though nothing could supersede the remarkable work of E. S. Russell, *Form and Function*. Particular interest attaches to L. A. Blacher's monograph on *Embryology in Russia in the 18th and 19th Centuries* (1955), since so much of the classical work centring around 1800 was done or published in that country.

These observations made, the principal reviews of the subject are chiefly to be found in histories of science in general, such as Sarton's; histories of biological theory, such as Rádl's; histories of obstetrics, such as von Siebold's, Spencer's and E. Fasbender's; histories of gynaecology, such as McKay's; and histories of anatomy, such as Singer's and von Töply's. Histories of medicine as a whole are numerous and good: I have found those of Garrison and Neuburger-Pagel most useful. Those which deal with special periods are also of assistance, such as Schrutz and Browne on Arabian, I. Bloch on Byzantine, and Harnack on Patristic medicine. Histories of chemistry provide no help, for ancient chemistry was so oriented towards "practical" results, such as the *lapis philosophorum* and *elixir vitae*, that the egg was only considered as a raw material for various preparations. The investigation of its change of properties during the development of the embryo did not occur to the alchemists. Detailed studies of particular subjects, such as those contained in Singer's two excellent volumes, *The History and Method of Science*, may also be of some assistance. Again, there are books which give a wonderful orientation and an articulate survey of vast tracts: of these Clifford Allbutt's *Greek Medicine in Rome*, with its mass of references, is among the most valuable. And Miall's *Early Naturalists* must not be omitted, for, apart from the peculiar charm of style which marks it, it contains some singularly helpful bibliographical data.¹ But the study of the original sources, so far as that is possible, is a duty which cannot be avoided, and in what follows I have been careful to copy down no statement from a previous review when it was possible to read the actual words of the writer himself. This practice of going to the originals is made peculiarly necessary in a case such as the present one, when the history of a subject is regarded from a rather new angle.

The arrangement of my chapters I adopted in the first edition, and now preserve, only on the ground that it is suitable enough in the present state of historical knowledge. Little was then said about embryology in China because at that time I could find out little about it, but it will be thoroughly treated in the eighth volume of my work on the

¹ A fine beginning has been made on the bibliographies of seventeenth-century men of science by Keynes and Fulton.

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history of science in general in that great culture, *Science and Civilisation in China*. Nor am I content with the short section on embryology in India, but here there are special difficulties owing to the absence of an established chronology for ancient and mediaeval Indian texts, and an adequate account of it must be left for others to give. No permanent framework for historical facts is proposed in what follows; I only attempt to bring them together, and to reveal some of the relationships between them. If the traditional pattern turns out to be badly distorted—and there are many signs that it may—the facts can be rearranged.

But in whatever way this may turn out to be desirable, one necessity must constantly be kept before the mind's eye, namely the knowledge of the relations between scientific thought and technical practice at any given period. For embryology this knowledge is difficult to acquire, since up to the time of the Renaissance obstetrics remained a part of primitive folk-medicine rather than of serious medical science. We see, however, in the publication of the Hellenistic gynaecological treatises in the sixteenth century (Bauhin, Spach; see p. 109) the satisfaction of a new demand, even though it took the typical Renaissance form of what might be called palaeolatry. It was part of that movement to rationalise obstetrics which included Harvey's *De Generatione* and Malpighi's *De Formatione Pulli* and culminated in the celebrated man-midwives of the eighteenth century.¹ Again, the relation of the early systematists—Belon, Rondelet, Aldrovandus, Ray—to the beginnings of mercantile expansion is fairly clear, for the mediaeval bestiary could not cope with the influx of new animals and plants from hitherto unknown regions, any one of which might prove to be an exploitable commodity.

The Hellenistic divorce between scientific thought and empirical technique is an important case in point. Greek life was divided strictly into *θεωρία* and *πράξις*. The latter was not thought fitting for a man of good birth. "Antiquity," says Diels, "was entirely aristocratic in attitude. Even prominent artists, such as Pheidias, were classed as artisans, and were incapable of bursting through the barrier separating the workers and peasants from the upper class. A second cause of the slight technical progress in antiquity was its slave-holding system, which led to a lack of any impulse to develop the machine as a substitute for manual labour."² Xenophon in the *Oeconomicus* held the industries in poor repute.³ "Men engaged in the mechanical arts," he says, "must ever be

¹ E.g. the Chamberlens, Palfyn (see Stein), Mauriceau, William Smellie, John Burton of York ("Dr Slop"), and Joseph Needham of Devizes; see the articles of Rosenthal and Mengert. The dissertation of Caspar Bose (1729) is a typical attack on the midwives of the time.

² See Ciccotti.

³ IV, 3; VI, 13–16.

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both bad friends and feeble defenders of their country.” He troubled himself little with those skilful in carpentry, metallurgy, painting and sculpture, but was always anxious to meet a “gentleman” (*καλός τε καὶ ἀγαθός*). The results of this were inevitable. Classical surgery and obstetrics benefited practically nothing from the speculations of the biologists from Alcmaeon to Herophilus (see pp. 29 ff.). Surgeons and midwives remained members of the painter-cobbler-builder group, the group of base-born “mechanicks”, entirely distinct from the astronomer-mathematician-metaphysician-biologist group, the group familiar with courts and tyrants.

Only the greatest broke away from this tradition: Aristotle, when he conversed with fishermen, Archimedes perhaps, when he constructed his mechanical devices. For the rest, it was too strong. Down to the end of the Roman period the artillery in use remained precisely what it had been six hundred years before, although the Empire was crumbling under barbarian pressure, and would have given anything, one would imagine, for an improved artillery capable of withstanding the Gothic armies. It is strange, as has been acutely said, that the Romans never invented anything so much in the Roman taste as a railway. So far as Hellenistic empirical industrial chemistry was concerned, the Democritean and Epicurean atoms might never have existed. And in medicine, the only effect of the brilliant Greek atomic speculations was to give rise to the Methodic school of Roman physicians, described by Allbutt, whose influence was never strong, and who contributed relatively little to the main stream of therapeutics originating with Hippocrates.

In sum, we must not dissociate scientific advances from the technical needs and processes of the time, and the economic structure in which all are embedded. We shall never understand the failure of Greek science if we consider it in abstraction from the environment which sterilised its speculation. The history of science is not a mere succession of inexplicable geniuses, direct Promethean ambassadors to man from heaven. Whether a given fact would have got itself discovered by some other person than the historical discoverer had he not lived, it is certainly profitless and probably meaningless to enquire. But scientific men do not live in a vacuum; on the contrary, the directions of their interest are ever conditioned by the structure of the world they live in. Further historical research will enable us to take into account the social and economic status of the investigator himself (cf. Chambers for the Hellenistic artist, and Yearsley for the sixteenth-century physician).

It would thus be of the greatest interest to know accurately the sources of the emoluments of embryologists at different times.¹ From Orn-

¹ On this, cf. Cumston and Dittrick.

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stein's admirable book on the scientific societies of the Renaissance, the suspicion arises that their royal patronage was dictated not only by a purely disinterested passion for abstract truth, but by a desire to profit as much as possible by the new techniques which the decay of the anti-usury doctrines, the willingness of the rising mercantile class to make industrial "ventures," and the far-ranging thought of the scientific men were combining to produce. In England's Royal Society, indeed, the preoccupation of the early Fellows with the "improvement of trade and husbandry" is patent to anyone acquainted with its early history (cf. Thomas Sprat's account of it).¹ Thus Dr Jasper Needham, elected in 1663, read only one paper before the Society—not, as might have been expected from his profession, on the transfusion of blood or the anatomy of the brain; but on the value and use of "China Varnish". However, it is probable that for the most part the embryologists whose work we shall have to discuss were practising physicians, free or relatively free from the ancient tradition, and conscious that to understand the mystery of generation would be to advance the science and art of medicine.

In this connection it is of interest that the Church in the seventeenth and eighteenth centuries provided a certain source of demand for embryological research. Of this Swammerdam and Malebranche (see p. 169) provide interesting examples, and the conviction, then widely held, that research into the nature of generation would throw light on orthodox theological doctrines, such as that of original sin, led to an economic situation of value for biological development. Finally, it would be rash to minimise the factor of pure curiosity in seventeenth-century science. The recreational quality of Leeuwenhoek's investigations is, as Baas-Becking says, too obvious to be overlooked.²

The history of single forms of scientific knowledge is in a way happier because containing more of continuity than that of civilisation as a whole. The assiduity with which men of different periods in the rise and decline of a culture pursue the different forms of human experience may, as Spengler has shown, vary much, but those forms remain fundamentally the same, even if their manifestations are profoundly changed.

¹ And the very interesting letter of Robert Boyle to a friend, Marcombes, quoted by Fulton. "The other humane studies I apply myself to" (1646) "are natural philosophy, the mechanics, and husbandry, according to the principles of our new philosophical college, that values no knowledge, but as it hath a tendency to use. And therefore I shall make it one of my suits to you, that you would take the pains to enquire a little more thoroughly into the ways of husbandry etc. practised in your parts; and when you intend for *England*, to bring along with you what good receipts or choice books of any of these subjects you can procure; which will make you extremely welcome to our *invisible college*, which I had now designed to give you a description of." Fulton remarks that this statement of its aim was inadequate, but we may take leave to think it was not so inadequate as many would suppose.

² The full scope of Leeuwenhoek's discoveries is now appearing, thanks to the labours of van Rijnberk and his collaborators.

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That science, at any rate, does maintain some sort of continuity whatever gaps there may be between the phases of its progress, is a belief agreeable with all the available facts, and one which no criticism will easily shake.

It only remains to record my indebtedness to those who have assisted me in the preparation of this work. Primarily I am grateful to Dr Charles Singer, who annotated my typescript with valuable comments and lent me many papers and pictures, and to Professor R. C. Punnett, who placed unreservedly at my disposal his knowledge of the history of generation and his library of old and rare biological books. To Dr Arthur Peck I am indebted for the correction of my Greek, and it was Professor A. B. Cook who introduced me to the embryology of the ancients. For guidance on Talmudic and Jewish matters I thank Dr Walter Pagel, the late Dr Louis Rapkine and Dr H. Loewe. Without the assiduous backing of Mr Powell, the Librarian of the Royal Society of Medicine, and his assistants, and of Mr H. Zeitlinger, I should have dealt much more inadequately than I have with papers and books which cannot be consulted in Cambridge. And in addition to those mentioned above, the following friends kindly read through and criticised the proofs: Professor Reuben Levy, the late Professor F. M. Cornford, the late Sir William Dampier, Mr Gregory Bateson, Professor Roy Pascal and the Rev. W. L. Elmslie.

To the Master of Gonville and Caius College I am indebted for permission to reproduce the portrait of William Harvey (attributed to Rembrandt) which hangs in our Senior Combination Room. Although the authenticity of this is not accepted by Keynes in his recent study of the portraits of Harvey, it has been in the possession of the College since 1798, when it came to us from the Earl of Leicester. After comparison with other portraits of Harvey, many feel unable to concur in its rejection.

J. N.

CHAPTER I

EMBRYOLOGY IN ANTIQUITY

1. Ideas of Primitive Peoples

SINCE biological science as a whole was little cultivated in ancient Egypt and the ancient civilisations of Babylonia, Assyria¹ and India, the study of embryology was equally little pursued. Doubtless the undeveloped embryo, whether in egg or uterus, carried with it, for these persons of remote antiquity, some flavour of the obscene in the literal sense of the word. But embryology stands in a peculiar relation to the history of humanity, in that even at the most remote times children were being born, and, though the practitioners of ancient folk-medicine might confine their ideas for the most part to simple obstetrics,² they yet could hardly avoid some slight speculation on the growth and formations of the embryo. Figure 1 illustrates this level of culture. It is a painted and carved door from a house in Dutch New Guinea, taken from de Clercq's book; the original was of yellowish brown wood. The male embryo is clearly shown, but the artist evidently had a hazy conception of the umbilical cord. The line passing from the uterus to the head may or may not be merely ornamental. The movement of the foetus *in utero* played and still plays a large part in the folklore of primitive peoples, as may be read in the exhaustive treatise of Ploss & Bartels. For information concerning god-embryos in primitive religion see Briffault.³ The works of Hutton and of Ashley Montagu may be consulted for a mass of information regarding primitive philosophies of life and its development.

2. Egyptian Antiquity

Egyptian medicine did not venture on embryological speculation, or so it would seem from the writings which have come down to us—the Ebers medical papyrus does not once mention the embryo (Brugsch).⁴ But there are points of interest as regards Egypt in this connection. One particular aspect of Egyptian thought is certainly of embryological

¹ See Zervos.² See R. F. Spencer.³ Vol. 1, p. 96.⁴ A general account of ancient Egyptian gynaecology and obstetrics is given by Reinhard.

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interest, namely the theory of the placenta, recently investigated by Murray.

In Frazer's *Folk-Lore in the Old Testament* there is a chapter entitled "The Bundle of Life" in which he discusses the idea of the external soul, and the various receptacles used to contain it. He draws attention to the compliment which Abigail paid to David at their first meeting: "And though man be risen up to pursue thee, and to seek thy soul, yet the soul of my lord shall be bound in the bundle of life with the Lord thy God; and the souls of thine enemies, them shall he sling out, as from the hollow of a sling." This implies, as he says, that the souls of living people could be tied up for safety in a bundle, and that on the contrary, when the souls were those of enemies, the bundle might be undone and the souls scattered to the winds.

Murray explains that this was a distinctively Egyptian doctrine, since Syria was an Egyptian province and had been so for centuries. She discovered among the titles of the Egyptian royal officials the significant "Opener of the King's Placenta." Other evidence demonstrates that the fate of the placenta, at any rate in the dynastic families, was regarded as of great importance, since it was thought to be the especial seat of the external soul. Although the above-mentioned title (which had ten holders, all related to the royal house, in the fourth, fifth and sixth dynasties) ceased to exist towards the end of the Old Kingdom, a standard representing the royal placenta was carried before the Pharaoh down to the time of the Ptolemies. Murray conjectures that the term "Opener" originated from some actual or forgotten ritual king-murder, the bundle of life containing the placenta being ceremonially opened at the conclusion of the reign.

The standard (Murray & Seligman) is here illustrated (Fig. 2 A, B), as are also bundles of life (Fig. 2 C-F).

Reverence for the placenta and umbilical cord is also noted in various

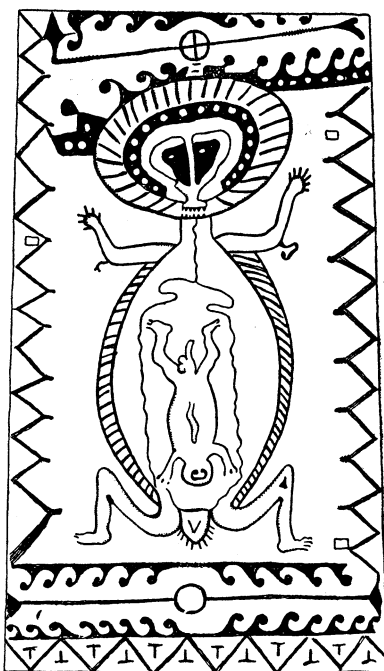


Fig. 1: Painted and carved door from Dutch New Guinea (de Clercq).

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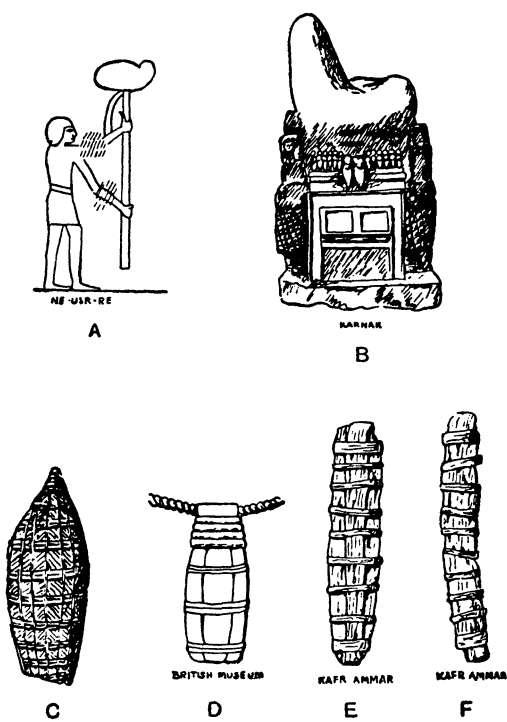


Fig. 2: The Bundle of Life (Murray).

African tribes (Roscoe). The whole subject is of interest as being a definite theory, even if pre-scientific, about the nature of an easily observed biological phenomenon, namely the placenta.¹

Ancient Egypt supplies the starting-point for another and profounder train of thought which recurs constantly throughout the history of embryology, and to which I shall have to refer again more than once. This was concerned with the problem of deciding at what point the immortal constituent universally regarded as existing in living beings took up its residence in the embryo. Some fragments of ancient Indian philosophy assure us that the Vedic writers occupied themselves with

¹ To be compared with this preservation of the placenta is the care taken in the disposal of the umbilical cord by primitive peoples, including the early Greeks. Cook shows, with much detail (vol. 2, pp. 169 ff.), that the stone called "Omphalos," which was a cult-object at many temples, especially that of Delphi, though exoterically supposed to represent the navel of the earth (and in this way connected with a pillar supporting the heavens), was probably also intended to mark the burial-place of the umbilical cord of the priest-king, or perhaps of Zeus. Modern Greek folklore, too, includes special cares in the bestowal of the umbilical cord. "Omphalos" has been the subject of special monographs by Roscher.