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The *Longue Durée* in the *History of Science*

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in memory

This is a printed version of the lecture by Frederick Holmes during the colloquium on Longue Durée.
In his memory, we have decided to publish it in its original unfinished state.

The history of science, like other fields of history, has moved in recent years from large to small scale events: from macro- to micro-history. The older texts on which we were once initiated into the field, which told one long story from antiquity to the twentieth century, have not been replaced by similar texts reflecting the many advances in scholarship devoted to the short-range developments that were formerly fitted into these grand narratives. Our detailed researches have shown that the smaller events were more complex than our predecessors portrayed them, and we have come to distrust the larger patterns of progress within which they were once arranged. Have we lost forever the grandeur of the 'origins of modern science' that the older stories celebrated? Are we fated to tell only smaller stories, to juxtapose contested narratives of localized events without attempting to integrate them into something larger? Or can we still return with our deeper knowledge of small-scale scientific change to reconstruct our understanding of the *longue durée?*

I

Fernand Braudel, with whom we most often associate the concept of the *longue durée,* had principally in mind the quasi-immobile geographical, climactic, and other physical conditions, and the limits on productivity, that both supported and provided obstacles to social development over very long periods of time. The history of science too, however, he believed to have had large stable structures that endured for centuries before being replaced. The structures that he gave as examples, such as the Aristotelian universe, the geometric universe arising from the achievements of Galileo, Descartes, and Newton, and the Einsteinian revolution, he took from the broad narrative of the earlier histories of science.[1] Braudel himself proclaimed in 1969,

[1] Fernand Braudel, 'La longue durée,' in *Écrits sur l'histoire* (paris: Flammarion, 1969), p. 52.

however, that studies of the *longue durée* will require a 'change of style, of attitude, a reversal of thought, and a new conception of the social'.[2] To apply his formulation to the history of science today, we need not restrict ourselves to the intellectual structures formerly identified as supporting and constraining science over long stretches of time.

Braudel did not claim that we should abandon the short term history of events for the *longue durée*, but that we pay equal attention to the multitude of different scales of time, or chronological realities, each following its own rhythm, through which the course of history flows. In the domain of social history he recognized three distinct historical dimensions: 1) a 'quasi-immobile history, that of man in relation to the milieu that surrounds him'; 2) a 'slowly rhythmic history, ...a *social* history of groups and groupings'; and 3) the traditional history of the individual, or history of events. Compared to the former two, the latter, which had most fixed the attention of historians, was only an 'agitation of the surface, the waves that are raised on the seas by their powerful movements. A history of brief, rapid, nervous oscillations'.[3]

In the middle dimension of history lay studies of economic cycles and fluctuations of prices extending over periods ranging from a decade to a half century. The periods of social conjunctures are more difficult to determine, due to the lack of precise measures. Underneath these rhythmic progressions, however, lay more permanent regularities and systems, whose secular movement is measured in centuries. 'For better or worse,' Braudel asserted, 'the word "structure" dominates the problems of the *longue durée*.'

By *structure*, social observers understand an organization, a coherence, or fixed relations between realities and social masses. For us, as historians, a structure is, no doubt, an assemblage, an architecture, but still more a reality that time erodes and deeply transforms. Certain long-lived structures become stable elements for an immense number of generations: they encumber and block history and command its flow. Others collapse more quickly. But all are simultaneously supports and obstacles. As obstacles they mark boundaries that humans and their experience can scarcely cross. Imagine the difficulty of breaking fixed geographical frameworks, fixed biological realities, fixed limits of productivity, of this or that spiritual constraint. Mental frameworks, too, are prisons for the *longue durée*.[4]

[2] *Ibid.*, p.54.
[3] Braudel, 'Préface,' from *La Méditerranée et le Monde Méditerranéen*, in *ibid.*, pp.10-12.
[4] Braudel, 'La longue durée', pp. 50-51.

Like political institutions, mental frameworks, techniques, and civilizations, Braudel added, 'the sciences ...equally have their rhythms of life and growth'.[5]

The challenge for historians of science is, to what extent can a conception of the *longue durée* that Braudel developed in great detail for the case of the Mediterranean world, but at whose equivalent categories in the history of science he only hinted, help us to redefine and reinvigorate the study of long periods in the history of our subject? Are the traditional intellectual structures he briefly mentioned the primary markers of the eras into which we can divide the duration of Western science, or can we identify others? Does science as a whole fit into one framework of long enduring structures, or have each of the main subfields within the overall inquiry into nature that we call science have their own rhythms of life and growth? Now that we have shifted our attention so largely from the history of scientific thought to that of practices, institutions, and cultures in science, should we identify long eras less by the thought structures that have prevailed in the past than by organizational assemblages, techniques, deeper mental frameworks, spiritual constraints, or economic systems that have provided the support for and the limits that science could not transgress for long periods of time?

Traditionally historians of science have focused on change, and have regarded structures that impede change as symptoms of past ages in which science was not free to develop according to its natural potential. To divert our attention from the dynamics of development to the structures that, for extended periods – including the most recent ones – have limited change, might provide refreshing new perspectives from which we may view change itself in novel ways.

II

The three successive systems – the Aristotelian, the Geometric, and the Einsteinian universes – to which Braudel alluded, frame a traditional history of science, according to which all the branches of natural knowledge were parts of a unified movement in which the study of the physical world consistently led the way: the intellectual tradition in which the 'Copernican revolution' became the template on which twentieth century historians shaped a more inclusive

[5] *Ibid.*, p. 49.

'scientific revolution'. From this perspective, 'biology' and chemistry were seen as subjected to the same seismic shift from an Aristotelian to a mechanical world view during the seventeenth century. If we dissolve this somewhat forced unification, however, we may find, for the sciences dealing respectively with life and with the operations that were carried out in the distinctive environment of the prototypical 'laboratory', quite different rhythms of stability and change.

It has for some time been considered anachronistic to talk of a biology existing before the invention of that word at the beginning of the nineteenth century. We are advised not to organize retrospectively subjects that were classified differently in earlier periods. Nicholas Jardine has recently argued, however, that we need not always be so strict in avoiding the application of such terms to times preceding their invention or use. Much of the investigative domain that we include within 'biology' today was explored by Aristotle under such titles as 'The Parts of Animals', 'The Natural History of Animals', and 'On Generation', and extended by his pupil Theophrastus to plants. There may be sufficient continuity between these explorations and the formation of a science of biology in the nineteenth century to enable us to follow a meaningful story over a very *longue durée*.

Among the structures that supported and constrained biological investigation for many centuries was that of the human or animal body itself. Aristotle examined the internal anatomy of many animals, but of none in great detail. Thus he established that the heart and blood vessels comprised a coherent system that connected all parts of the body with a central organ; but his knowledge of the chambers of the heart and its specific openings into the pulmonary and systemic arteries and veins was imprecise. By the time of Galen, this knowledge had not only become quite accurate, but was extended to include other systems, such as the brain, spinal cord and peripheral nerves, as well as the relations and insertions of the major and minor skeletal muscles.

From Aristotle onward, anatomists sought to explain the functions of these organs and systems of organs in terms of their forms. The form-function relationship thus supported an investigative trajectory that lasted for many centuries. The renewed anatomical tradition of the sixteenth century continued the life and growth of an ancient investigative activity that had been interrupted in the century after Galen. The discovery of the circulation and of the Lymphatic vessels during the seventeenth century exemplify the long duration of a successful investigative science based on the functional interpretation of anatomical structures. The seventeenth century also illustrates the

obstacles posed to the further growth of a science limited to this structure. The question of what role the passage of blood through the lungs played, and what relation the passage of blood might have to the passage of air in and out of the lungs, could not be answered within the framework of anatomical observation and experimentation on living animals alone.

One succession of enduring structures that commanded the flow of biological history may be identified with Braudel's category of *techniques*. The first long era was defined by dissection and observation of what could be seen by unaided vision. What was too small to be seen was defined, in Aristotelian terms, as 'uniform parts': that is, as substances such as flesh, tendon, or fat, characterized by a material composition, but without organized invisible structures. The second era was initiated by the invention of the first compound microscopes to be applied to the investigation of plant and animal material. These instruments revealed that there were further structures, such as kidney tubules and other glandular ducts, too small to have been seen before, but interpretable by the same form-function relationships that had previously been applied to the more readily visible organs. The early microscope was considered quickly to have reached limitations that hindered its usefulness as a tool of biological investigation, but it continued through the eighteenth century to reveal form-function relationships, such as the way in which the blood flows through the finer arteries, capillaries, and veins. Conceptually these microscopic observations permanently changed, not only the domain of the visible, but the way in which anatomists and physiologists imagined what lay below the visible. Instead of uniform substance, they conceived of successive orders of structure, each resembling, except in its dimensions, structures such as nerve fibers and blood vessels that they could already see.

The third structural era in biology marked by a *technique* that overcame long-standing previous obstacles began around 1830 with the spreading use of achromatic microscopes. Even though the new microscopes were only improvements of the older instruments, they enabled biological observations to cross a critical threshold, bringing into view the common organization of plant and animal tissues as aggregations of cells. Cells emerged, not only as structures with recognizable nearly universal elements underlying their manifold variations of secondary form, but as fundamental units of function. The essential vital processes of nutrition, respiration, growth, reproduction, and response to external stimuli, previously assigned to organs and organ systems, were now relocated, at least in principal, in these tiny 'elementary organisms', as Ernst Brücke called them in 1861. This relocation at the same time disrupted the relation between form and function that had endured since antiquity, because, with few exceptions, the functions that had previously been attributed to organs at a level at which the visible shapes, connections, and modes of organization of the latter explained their suitability for their respective roles, could not be explained by the very simple internal organization of the cells then observable. Not until late in the nineteenth century, when staining techniques and further improved optics brought the mitotic process into view, was it again possible to associate at least one of the central functions of cells - their reproduction - with visible changes in form.

This third structural era came to an end after World War II, when the advent of the electron microscope allowed investigators to penetrate to deeper levels of cellular organization. During the half century since then, form and function within the cell have become reconnected in a far tighter manner even than they had once been connected at bigger levels of organization. How long the *durée* of this fourth era will turn out to be cannot yet be foretold.

Unlike 'biology', chemistry cannot be traced as an organized investigative activity back to antiquity. Some of the operations that later came to be investigated by chemists were carried on as practical crafts for as far back as records go, but when Aristotle, his predecessors and successors thought about the nature of matter and its changes, they had in mind only the phenomena that take place in the natural world. The first recognizable chemical era emerged in the sixteenth and seventeenth centuries, when a distinctive set of operations carried out by herbalist distillers, pharmacists, metallurgists, and alchemists, in specially equipped spaces known as laboratories (or, perhaps more descriptively, as 'elaboratories') began to be seen as the foundation for an understanding of the composition of the matter itself.

Both the scope for, and the limits on this emergent activity were set by the apparatus, instruments, and the repertoire of substances with which chemists could perform their operations. The structure of *technique* afforded by these traditional laboratories remained 'quasi-immobile' for the first two centuries in the history of chemistry, providing both the opportunities and the boundaries within which one of the major branches of 'modem' science lived and grew.

The era of 'pneumatic' chemistry originated with the invention in 1728, by Stephan Hales, of a simple device for collecting and measuring 'air'. By the end of the century chemistry had become

'three dimensional', fully incorporating the gaseous state, as well as solids and liquids, into its operations and interpretations of chemical change. What we call the 'chemical revolution' can be viewed as a short term event raised up by the powerful movement of a chemistry whose techniques were no longer bounded by the traditional repertoire. Whether the events of nineteenth century chemistry can be assimilated within a *longue durée* beginning in the previous century, or whether the rapid evolution of methods and apparatus in that century require a different interpretation, remains to be seen. It is clear, however, that during the twentieth century a whole new layer of precision instruments adopted largely from physics fundamentally transformed the structure of chemical *technique*.

III

The preceding illustrations of the ways in which structures of *technique* may dominate eras of long duration are intended only to suggest how Braudel's vision of the *longue durée* can lead us back to take fresh looks at our old stories. Were we to concentrate on social groups and groupings, we may wish to revisit the account of the gradually evolving role of scientists in society that Joseph Ben-David carried from antiquity down to the early twentieth century.

A conference devoted to the *longue durée* in science need not be restricted to categories of duration analogous to those posited by Braudel. We should reexamine also the older histories of ideas, such as Lovejoy's Great Chain of being; or of those histories which traced fundamental concepts, such as space, time, and force, over many centuries.

It may be fruitful to focus, not only on concepts which have endured through time, but on long-lasting problems that have been examined through different conceptual frameworks or received different solutions through time. We have become suspicious of earlier histories that traced such threads through very long periods, because of instances in which historians have tended to project backward problems as they are conceived in modem times, imposing frameworks on earlier thinkers who may have addressed themselves to quite different problems. This skepticism should be taken, however, not as a prohibition on such studies, but as a challenge to be cautious in how we recognize long enduring continuities, to be rigorous in our criteria for defining them, and to recognize also transformations which may set limits on the length of the periods in which we find continuities. The objects of our study of the *longue durée* in science need not be traceable either to the beginning of science nor to the present day to be worthy of our attention.

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Continuité et transformation des logiques corporelles

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ABSTRACT - This article is concerned with two distinct corporeal logics. In the first, corporeality is founded on joints, tendons, and mobility; in the second, the envelope and its apertures are considered primordial. The first logic is extant in very few works. Although these texts (e.g. *The Iliad, Beowulf*) clearly share the same, very specific, conception of the body, they belong to different histories. The corporeal logic of the 'jointed body' (*corps articulaire*) cannot, therefore, be appraised in terms of *longue durée*. The texts represent, instead, a moment of transition between the psychodynamics of orality and literacy. A problem correlated to this fact is that readers (ancient and modern) no longer think using the same logic as that pertaining to the jointed body. They tend to translate information regarding the logic of the jointed body into data meaningful in their own logic.

Je souhaite poser la question de la longue durée dans l'histoire de la médecine sous l'angle des logiques corporelles (Bolens 2000). Par logique corporelle j'entends la façon particulière qu'a un groupe humain d'organiser les données du corps en faisant jouer un rôle prioritaire à certains aspects de la réalité corporelle. Les résultats de ma recherche m'ont poussée à distinguer deux logiques principales: la logique du corps articulaire et la logique du corps-enveloppe. Dans la première, les jonctions osseuses, les attaches tendineuses et les modifications de la motricité sont considérées comme vitales, tandis que dans la deuxième, la vie et la mort s'expliquent par le rapport interne/externe et par des événements qui concernent la peau, les orifices corporels et la capacité à contenir ou à expulser. Dans l'une, on peut mourir d'une blessure à la cheville – c'est le cas d'Achille –, comme toute disjonction osseuse est catastrophique; dans l'autre, un coup mortel consiste typiquement à percer le ventre qui se vide de ses entrailles; l'intérieur passe à l'extérieur, et l'âme quitte alors son enveloppe charnelle.

A ces aspects s'ajoutent des éléments récurrents qui permettent de parler de logiques et non simplement de thèmes ou de motifs. La logique articulaire, outre les blessures types, réunit dans tous les textes qui en sont porteurs les questions d'une production du feu et du