

sharply qualify the thesis that natural history served as a unifying flag for nation-building. ‘The nomenclature of nature could be held both to secrete and unmask conflicting identities’, as Burnett puts it. ‘Calling nature’s nation into being with the incantations of natural history could be, when the curtain fell, a very uncertain affair’ (p. 210). He offers the *Maurice vs Judd* case as an early example of subsequent challenges to the claims of expertise of patrician philosophers and naturalists by a new class of artisans and mechanics that had a major impact on the institutions and claims of science in the early republic. In Burnett’s view, such contests should not be seen simply as unfortunate hiccups in the otherwise progressive development of American science but as fascinating sites of negotiation, of great interest in their own right, regarding how the natural world should be known and by whom.

In conclusion, Burnett makes the obvious (to historians) point that, in asking historical questions for the purpose of supporting normative, philosophical arguments, ‘there is no substitute for actually *doing* the history’. As an example, he takes aim at John Dupré’s work on ‘the relationship between ordinary language classification of living creatures and their formal scientific arrangement’ (p. 212; original emphasis), specifically the conjectural history offered by Dupré that greater scientific knowledge of whales, pure and simple, was all that mattered in the modern definition of whales as ‘not fish’.

A close look at how whales actually became non-fish in New York in the early nineteenth century has told a very different story: in fact what happened then and there was that scientific expertise took a terribly public bloody nose, and whales ceased to count as fish because of the behind-the-scenes legislative lobbying by a clique of oil merchants and chandlers ... By the time it was over ‘science’ had been sent to the wings by all concerned. (p. 214)

At times some of the rather extensive commentaries in footnotes would have benefited from editorial culling to avoid such asides making the book read like a dissertation. And, as in any ‘science at the bar’ story, one sometimes wonders whether all the author claims really was at stake. Maybe the records simply illustrate an intelligent lawyer merely doing his job well? But Burnett makes a convincing argument that, whether Sampson personally saw anything grand at stake, he was drawing on the concerns, categories and even jokes of those around him. And by uncovering the contemporary debates and anxieties concerning the natural order, and who had the authority to define that order, Burnett offers readers a fascinating episode in the history of early American science, along the way raising questions about both the authority of professional naturalists and the historiography of modern (and especially American) science.

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JAMIE ELWICK, *Styles of Reasoning in the British Life Sciences: Shared Assumptions, 1820–1858*. London: Pickering & Chatto, 2007. Pp. x+233. ISBN 978-1-85196-920-3. £60.00, \$99.00 (hardback).
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Jamie Elwick’s aim in this important book is to characterize transformation in the life sciences in Britain in the period before the publication of Darwin’s *Origin of Species*. It was a period that saw museums give way to zoos and aquaria, patronage displaced by meritocracy, and a whole research area overturned without having its central projects completed or even acknowledged. With that research area went a particular perspective on what it is to be a biological individual.

Elwick shows us all these changes interwoven as a shift in ‘styles of reasoning’. These styles he takes – in the manner of Ian Hacking and others – to be methodological approaches which determine the appropriate questions to be asked and the right ways to go about answering them. The earlier, overturned style that concerns Elwick is what he calls the ‘analytic:synthetic’ style. A synchronic approach, favouring the use of dead specimens for dissection, it involved the

decomposing of a system into its simplest elements, with the whole then viewed as the sum of these elements. The later, overturning style he calls (after Whewell) the 'palaetiological' style. Here the focus was less on parts and more on origins, on the view that the best way to understand a system is to describe how it emerges dynamically from its starting point. This holistic perspective demanded the observation of living organisms through time.

At the beginning of Elwick's story, the biggest problem for British life scientists concerned the compound nature of organisms. If creatures are understood as aggregations of smaller living parts, then how is unity achieved? What gives rise to the apparent coherence of the soul? And why do some organisms have the ability to live and move after decapitation while others do not? The analytic style prompted researchers to vivisect and dissect organisms in order to investigate these questions. They noticed variation in the degree of unity across organisms, which led Richard Owen to formulate his fourfold classification of life, in which organisms were arranged according to their kind of nervous structure, and ordered according to nervous complexity, with humans at the peak and very simple organisms at the base. The increased ability of lower organisms to regenerate and survive fragmentation was thus explained as a result of their diminished unity.

When the German embryologist Karl Ernst von Baer's work was translated into English, embryonic development became a new focus of interest in Britain. The analysts noted that there was a mirroring of the chain of being in development, with embryos becoming increasingly complex and unified, their nervous centres coalescing into hierarchical structures. This idea of recapitulation came to characterize the analysts' view of development, metamorphosis and taxonomic movement. All three were seen as centripetal processes, in which many separate but similar elements coalesced and then differentiated, giving rise to unity and a division of labour.

However, Elwick also shows that around this time von Baer's work was influencing others in different ways. His studies motivated the emerging palaetilogists to focus on development as a very dynamic process, having a branching structure through time, with early developmental events viewed as much more important than later ones. Palaetilogists concentrated on finding the origin events and using them to define the whole developmental process. They too saw an analogy between development and taxonomy, but they viewed both centrifugally, having an essentially tree-like structure in which the process originates at a singular central point and emanates outwards in increasing complexity.

On Elwick's telling, the two styles eventually came to a head over the issue of reproduction. The analysts were trying to work out why simpler organisms are better at reproducing than higher ones – they have the ability to regenerate lost limbs and produce new individuals from fragments of themselves. One result was Owen's theory of spermatoc force, in which sperm endows cells with a 'fecundating principle' which gets used up during reproduction. Simpler organisms use up less of this when replicating themselves, whereas higher organisms use so much that they require a new input of spermatoc force each time they reproduce. Meanwhile, the palaetilogists, spearheaded by Thomas Huxley, were looking for the origin of the developmental process. Deciding that the origin was sexual fertilization, they were led to define an individual as whatever issues from sexual fertilization. Not only did they then reclassify all other forms of reproduction or replication as growth, but they redefined the entire view of organisms; for if cellular replication was growth, rather than genuine reproduction, then organisms were not compounds of smaller individuals at all, but simply individuals.

By the end of Elwick's story, most of the research questions from the beginning had become unaskable. The problem of unity dissolved because there ceased to be lots of individuals in need of unification. Owen's theory of spermatoc force became defunct because reproduction occurred if and only if sperm fertilized ovum. This resolution by redefinition ultimately pushed out the analytic:synthetic paradigm. The new palaetiological style took over, but not because it was

better at framing old questions or finding their answers. It simply ignored them. Not by inadvertence: Elwick claims that Huxley deliberately misinterpreted Owen, forging a new terminology in order to gain control over who could access the ranks of biologists. Social and economic factors apparently dominated and determined theory itself.

Although Elwick no more than hints that the palaeobiologists ‘won’ in any lasting sense, it is interesting to note that there is a modern analogue to the debate over reproduction in which surprisingly little has changed. Those concerned to isolate the appropriate unit upon which to endow fitness measures sometimes say that an individual is simply the product of a zygote. But there is still no widespread agreement as to whether certain marine invertebrates should be understood as colonies or as individuals, or how to understand the long-term evolutionary consequences of asexual vegetative propagation. Those disagreeing about these issues now will be fascinated to discover in Elwick’s book how central they once were and how politically complex was their disappearance before their time.

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STEVEN FRENCH and DÉCIO KRAUSE, **Identity in Physics: A Historical, Philosophical, and Formal Analysis**. New York: Oxford University Press, 2006. Pp. xv + 422. ISBN 0-19-927824-5. £55.00 (hardback).

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It has often been claimed that quantum physics treats individuality very differently than does classical physics – in fact, that quantum particles are not individuals. This issue lies at the hub of Steven French and Décio Krause’s complex, multifaceted and marvellous book. *Identity in Physics* critically scrutinizes metaphysical issues implicated in classical and quantum physics, making deft use of the history of theoretical developments, and ultimately suggesting a way of rethinking the formal foundations of quantum physics.

French and Krause are concerned ultimately with the relationships between three notions: individuality, distinguishability and identity over time. One tradition, enshrined in Leibniz’s Principle of the Identity of Indiscernibles, holds it impossible for two distinct individuals to share all of the same properties. Another tradition treats individuality as transcending those properties in terms of which items can be distinguished. In the latter, the authors delineate ‘Space–Time Individuality’ (STI), which views individuation in terms of space–time trajectories, and ‘Transcendental Individuality’ (TI), which encompasses individuality understood in terms of haecceity, ‘primitive thisness’ and substance. Their survey of these traditions maps out the metaphysical background to their subsequent discussion, which begins with history.

Their historical discussion focuses on approaches to deriving the statistics employed in classical and quantum physics. Famously, the distributions used in determining the probability of finding a quantum system in a given energy state (Bose–Einstein statistics, or Fermi–Dirac statistics if the Pauli exclusion principle applies) are different from those used in the classical case (Maxwell–Boltzmann statistics). A common interpretation holds that this is because in quantum contexts, unlike in classical settings, all that matters are the numbers of system elements in any given state, not which particle is in any particular state, so that quantum particles are treated as if they were not individuals at all.

Thus the history highlights the role of notions of individuality, whether explicit or implicit, in the development of both classical statistical mechanics and quantum theory. In the classical developments, French and Krause focus on Boltzmann’s two distinct approaches to establishing Maxwell’s distribution law, abandoning a problematic approach requiring the consideration of trajectories of molecules for a ‘Combinatorial Approach’ concerned only with the distribution of molecules across different energy states. Boltzmann’s first approach invoked STI to individuate