Coats of many colours

Anne McLaren

The Coat Colors of Mice. By W.K. Silvers. Pp.379. (Springer: Berlin, Heidelberg and New York, 1979.) DM59.60, $32.80.

SOME targets of scientific study are inherently attractive. One such is soap bubbles. Another is coat colours and patterns. In the days when I knew R.A. Fisher, the father of modern statistics, his true pride and love was for mouse genetics, and to be asked the effect of umbrous on an agouti pink-eyed brown background would really make his eyes twinkle.

W.K. Silvers' book is also a labour of love. There is no mention of Sturtevant's intriguing suggestion that Mendel discovered his 'laws' of segregation and assortment by illicitly crossing different-coloured mice in his monastery cell, later using his curiously exact pea ratios as a mere didactic demonstration; but in other respects the early history of the subject is well covered. The references include more than 20 papers published in the first two decades of this century on the genetics of coat colour in mice, starting with the classic 1902 paper of Cuénot. One of these pioneers is still living, Naomi Mitchison, who, with her brother J.B.S. Haldane, published in 1915 the linkage between albino and pink-eyed dilution, the first to be established in any mammal. A start was also made in those early years on the chemistry of mouse pigmentation (Onslow, 1915) and on the developmental analysis of lethal yellow (Ibsen and Steigleder, 1917), while C.C. Little's lifelong interest in mouse spotting genes gave rise to a series of papers beginning in 1913.

Moving to more modern times, Silvers pays tribute to Grüneberg's monumental *Genetics of the Mouse* (Nijhoff: The Hague, 2nd edition; 1952), to Searle's *Comparative Genetics of Coat Colour in Mammals* (Logos Press: London; 1968), to Mintz's illuminating studies on experimental chimeras ('allophenic' mice) and to the great amount of assistance that he received from Rita Phillips, whose very recent death is a sad loss to mouse genetics as well as to her many friends and colleagues.

Apart from its aesthetic appeal, the study of coat colours embraces not only genetics (148 alleles at 63 loci), but also biochemistry, cytology, histology, anatomy, embryology and endocrinology. Silvers does justice to all these aspects. The first half of the book, in which he deals with the various colour-controlling loci and their complex interactions, is perhaps more satisfactory than the second half, which covers spotting genes, chimeras and X-chromosome mosaics. The etiology of spotting and coat colour pattern is still widely debated, and even the experimental evidence is sometimes conflicting. Silvers does his best to summarize the literature, but the picture that emerges is patchy in more senses than one. For example, in the field with which I am most familiar, he perpetuates confusion by failing to make clear that Mintz's 'standard' or archetypal pattern is a valuable abstraction rather than an observed pattern ("observed relatively rarely" is misleading when the true probability, for one side of the mouse alone, is 2^{-16}, less than 1 in 100,000); he does not mention Lyon's interesting suggestion that the frequent brindled sectors of chimeras arise because each territory may be colonized, not by one but by two 'primordial melanoblasts', of the same or contrasting genotype; and he affords the same status to the clonal theory of pattern formation for hair follicle chimeras as for melanocyte chimeras, though the evidence is far less cogent for the former than for the latter.

But these are minor grumbles. The book as a whole will be a standard reference work in every mouse genetics laboratory for many years to come. Not only does it make admirably clear the complex interplay of genetic (and in some cases environmental) factors in determining coat colour, but it also uncovers areas where further research is badly needed. These include spotting genes, of course; the intriguing behaviour of silver, resembling the effects on pigmentation of irradiation, and perhaps also ageing; the 'reds' of the mouse fancy, and no doubt other fancy types also, not yet analysed genetically; and, above all, the need for a codification of colour, a decent set of colour standards, which although doubtless imperfect could hardly but improve on such phrases as "a dull brown colour", "a medium shade of sepia", "a faint cream or ivory color", "a brownish shade, a little lighter than an ordinary pink-eyed brown with a slight dull yellowish cast". The three colour plates in the present volume are not of very high quality, though better than nothing; really good colour reproduction would have presumably escalated the price unacceptably.

As it is, the book at about £15 is reasonably priced, there are good author and subject indexes, and the bibliography is comprehensive. □

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The classic electricians

W.D. Hackmann

Electricity in the 17th and 18th Centuries. By J. L. Heilbron. Pp. 606. (University of California Press: Berkeley, Los Angeles and London, 1979.) £24.

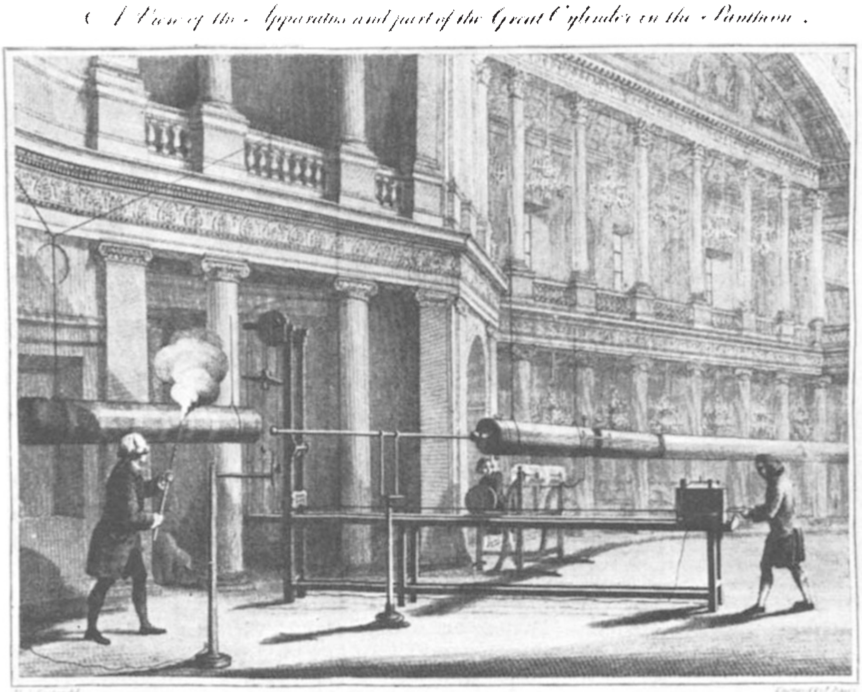
AN ambitious work that deserves to become a classic in this subject. Not only has Professor Heilbron incorporated all the historical papers on early electricity that have appeared since I. B. Cohen's *Franklin and Newton An Inquiry into Speculative Newtonian Experimental Science and Franklin's Work in Electricity as an Example Thereof* (The American Philosophical Society: Philadelphia, 1956), but he has also included much new material, such as the importance of the seventeenth century Jesuit polymaths in the study of physics in general, and in electricity in particular. For those of us reasonably well versed in this subject, the main developments as given in this book are known, but it is useful to have such a broad and up-to-date survey. The general reader interested in the history of physics, or of electricity, should find this a fascinating story, although he might miss some of the finer philosophical or technical nuances. Any historical treatment of a scientific subject must contain inevitable distortions as all is focused on specific aspects of the total picture, but by attempting such a broad canvas, Heilbron has managed to keep these distortions to a minimum.

A work of this nature, covering such a large time span, is inevitably faced with historiographical problems. Terms and concepts change their meaning, brought about by new discoveries and by changes in philosophical outlook, and this makes interpretation difficult. The author has to make it clear to the reader that a problem dealt with in the seventeenth century was handled differently from the same problem looked at by physicists one hundred years later. When surveying a subject over a very long period, it is possible to give it a false appearance of continuity, while the subject progressed (or changed) in a much more convoluted manner. In the context of this book, both the concepts of physics and of electricity changed dramatically during these two hundred years. The word 'electricity' was to undergo subtle changes in meaning during the century after its use by Sir Thomas Browne in his *Pseudodoxia Epidemica: or, Enquiries into very many received tenents and commonly presumed truths* (1646), causing endless confusion to historians of science in the past. At first it simply referred to the attractive property of amber and other substances. The word only began to denote a separate entity or substance causing the electrical behaviour of attraction and repulsion during the early 1740s. Heilbron has coped admirably with this kind of problem, not least by the way he has structured this book, which he has divided into five parts.

Part 1 sets the scene by giving a general survey of early modern physics, its underlying principles and the ways in which it was diffused, including the founding of scientific societies, the development of better instruments and the importance of lecture-demonstrations. He divides some 210 electricians (as those studying this subject called themselves) into five groups according to their chief means of support: members of religious orders (especially Jesuits), paid academicians, professors, public lecturers, and others (primarily instrument-makers, doctors, lawyers, clergy and the independently wealthy). Between one-quarter and one-half were professors of universities or secondary schools. It is difficult to determine how approximate these figures are. They contain overt generalizations (of which the author is aware), and there are inevitably minor inconsistencies and errors. For instance, in the table dealing with the number of academies founded between 1660 and 1800, he lists no provincial societies under Britain (apart from one by name), while under 'others' in the case of France, he lists 27, and under Holland 14 (these include agricultural societies). This produces a distorted and not very meaningful picture. In general, however, his conclusions are justified.

Part 2 surveys the progress of electricity during the seventeenth century, starting with Gilbert's experiments on the amber effect in *De magnete* (1600), terminating soon after Otto von Guericke's experiments with his 'globus mineralis' in the 1660s. Part 3 covers the first half of the eighteenth century, starting with the researches of Hauksbee the elder, at the Royal Society during the early 1700s. Part 4 deals with the impact of the Leyden jar (a primitive condenser), discovered in 1745, and the reception of the theories of Benjamin Franklin. Part 5 covers the last thirty years or so of the eighteenth century, during which the main electrostatic principles were finally formulated and attempts were made at quantification. This period is terminated with an Epilogue describing the invention of the voltaic pile or battery in 1799. During the entire two hundred years, 'electricity' meant electrostatics, then known as 'frictional electricity', as it dealt with charges generated by rubbing glass or other electrics.

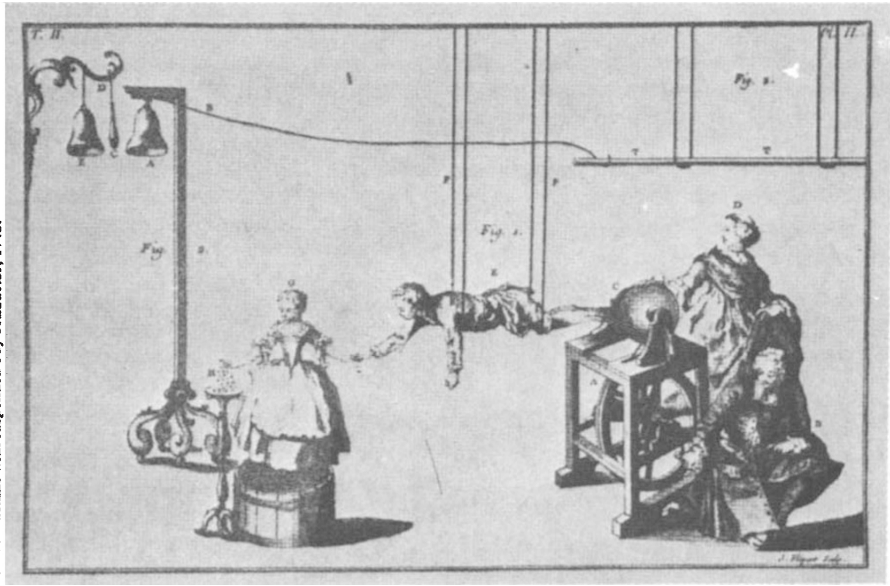
The sub-title, "A Study of Early Modern Physics", is significant, for the author has tried to relate the history of electricity to the broader conceptual changes that occurred during the rise of early modern physics. Effectively, he has divided the history of this subject into three stages. The first stage, which lasted until 1700, was still dominated by Aristotelian physics, a textbook science which included organic and psychological as well as inorganic phenomena. The second stage, lasting until the 1750s was dominated by the followers first of Descartes, and then of Newton. The Newtonians, who by their virulent empiricism had taken Newton's "hypotheses non fingo" much further than had been intended by their master, gained the upper hand during the 1720s. Physics took on a more restrictive and modern meaning; the subject now being restricted to astronomy and experimental physics (alternatively known by the vague English term of natural philosophy), which included mechanics, hydrostatics, pneumatics, optics, electricity and magnetism, but excluded subjects such as psychology, medicine and the biological sciences. The importance of applied mathematics in the formulation of physical laws began to be stressed, amongst others, by 's Gravesande, but this approach only gained momentum during the third and final stage. Heilbron points out that the advances made in quantifying electrical phenomena from the 1760s onwards owed nothing to the progress of mathematics. Indeed, not until the turn of the nineteenth century did electricians require mathematical techniques not fully available a hundred years earlier.



Wilson's public model lightning conductor experiments at the Pantheon, London, 1777.

In order to make progress in electricity, required were (1) carefully worked out experimental procedures which could be replicated by different physicists, (2) accurate and reliable instruments, and (3) the isolation from the mass of experimental details of those factors that were important in producing the observed phenomena. Heilbron's narrative demonstrates how the conflicting data took many years to untangle. These three requirements are, of course, interrelated. Nature was often 'manipulated' in those areas in which new phenomena were expected. Attempts to store charge and to electrify water resulted in the discovery of the Leyden jar by von Kleist in Germany, and Cunaeus and Van Musschenbroek in Holland, although the results were unexpected and went far beyond the experimenters' expectations. Incidentally, Heilbron honours Cunaeus with this invention, but this claim cannot be substantiated. Simultaneous and independent discoveries of this nature usually signify that the conceptual framework and experimental techniques have become available for these breakthroughs to be made.

Heilbron is fully aware of the importance of the Leyden jar. It led to the study of more powerful electrical phenomena, and it assisted with the formulation of new concepts such as that of electric circuit, intensity or level of electrification (an anticipation of potential), capacity or area of coated surface electrified, and quantity of charge, for it could readily be compared with the behaviour of liquids flowing from vessels of different sizes. The invention of the electrophorus (1775) and the parallel plate condenser (1778), based on the Franklinian explanation of the Leyden jar, not only strengthened the formulation of these concepts, but also focused on minute electrical charges (Volta's 'contact electricity'), which eventually led to the invention of the voltaic pile. Early attempts to explain this remarkable device in terms of standard electrostatic theory based on the Leyden jar failed, and it did not take long for scientists to realize that other concepts such as current intensity and electrical resistance were necessary. Thus, instruments influenced the formulation of new concepts, and the latter in turn affected instrument design. Although his conclusions are broadly in agreement with this view, Heilbron's general discussion on the development of electrostatic instruments is weak, and contains minor factual



Globe machine with suspended boy conductor, 1748.

errors.

Quite properly, Heilbron devotes an entire chapter to electrometry. He discusses the key electrometers, especially those of Robison (1770s) and Coulomb (1784). One does not, however, become aware of the existence of the great number and diversity of electrometers invented during the final decades of the eighteenth century, caused by the search for replicability of measurements. Attempts to standardize measuring techniques and introduce electrometric standards prior to Coulomb's work failed, mainly because there was no proper understanding of what the different electrometers were actually measuring. According to Heilbron, what was lacking was the appreciation between the difference of electrostatic force at a macroscopic level (moving force or kinetic energy), and an (idealized) microscopic *force* as an unobservable push or pull between elements of electrostatic charge. The triumph of Newton's theory of gravitation was to compute force by summing *forces*, but this distinction was not generally understood by physicists before the second half of the eighteenth century. Modern historians of science, too, have not always made this distinction when interpreting the early attempts by Bernoulli (1760) and others to relate the behaviour of electrostatic force to the inverse-square law of gravitation. Robison, Cavendish and Coulomb were the first to achieve this. They were the vanguard of a new breed of physicist, unlike their predecessors more interested in exact mathematical descriptions than in the qualitative models which had played such an important role in the early history of electricity. They formed the bridge between the qualitative work of the preceding two hundred years and the mathematical synthesis by Poisson and others in the nineteenth century. □

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Plasmid horizons

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Plasmids. By Paul Broda. Pp.197. (Freeman: Oxford and San Francisco, 1979.) £6.90, $18.50.

RESEARCH on plasmids is exciting and varied. It includes intensive study of very basic biological functions such as DNA replication. F-mediated conjugation provides an example of differentiation of structure and function in a single-celled organism, subjected to detailed genetic analysis. Insertion sequences and transposons are newly discovered and evidently important means of genetic variation allowing evolutionary changes in response to changing environment. Plasmid-determined antibiotic resistance and determinants affecting bacterial virulence are of great medical relevance, and study of the latter, in particular, may lead to new insights into bacterial pathogenicity. Plasmid synthetic and degradative enzyme systems, evolving all the time, are likely to be of increasing commercial and environmental importance. And, as well as all these reasons for the study of plasmids as they exist in nature, their use as vectors in genetic engineering opens up new horizons in biological research both academic and pragmatic. No wonder that the number of papers published on plasmids seems to be increasing exponentially. An up-to-date, comprehensive and comprehensible guide to the subject was badly needed by undergraduates or research workers starting out in this field. Here it is — Paul Broda has provided just the thing, and it is not only newcomers to the subject who will welcome his *Plasmids*. Plasmid research has its own specializations, broadly on the lines of the subject-matter of the different chapters of this book, and people knowledgeable about any one of them cannot hope to keep up with all the others.

This is a short book, only 148 pages of text excluding references and index, and I was surprised at the amount and variety of detail packed into such a small space. The layout is organized imaginatively to assist a reader to grasp principles with which he may not be previously familiar. The many summarizing tables inserted in the text are particularly successful both as teaching aids and for quick reference. After a brief introduction to define the subject and sketch in its short history, we are presented in a thoroughly practical way with the methods used for isolating plasmids from their host cells. These methods are of two main kinds, either on a fairly large scale to obtain plasmid DNA for further study, or rapid and small-scale, adaptable to many experimental purposes. Great advances in methods of both these kinds have been made in the last few years. It is appropriate that this section should come early on in the book since much of the information on plasmids in later chapters has resulted from the use of these methods.

The chapter on the structure and evolution of plasmids illustrates how those creatures have developed by connecting as well as by diverging evolutionary paths. The use of endonucleases is described, in the characterization of plasmid DNA and also for the construction, *in vitro*, of new plasmid molecules. This implies a very broad meaning for 'evolution', but why not?

The complex subject of DNA replication is considered in Chapter 4. Plasmids are more accessible to experimental manipulation than are whole cells and therefore plasmid replication has been studied, not only for its own sake, but also to elucidate host mechanisms for, and controls over, DNA replication. This chapter covers both plasmid-determined and host functions and throws considerable light on a confusing area of research. Here, as elsewhere in the book, the limitations of current knowledge are pointed out. It is a comfort, sometimes, to be told that something is still unknown.

Transfer of DNA by conjugation in bacteria is, as far as is known, always plasmid-determined. The chapter on the subject summarizes the results of detailed investigations into the conjugative functions of F and its relations, and indicates how little is known about conjugation determined by many other, unrelated, plasmids. It is possible that the production of pili is a prerequisite for conjugation despite the instance, cited on p. 97, where they were apparently not essential. This case referred to plasmids of