provoking – more so than any other work upon life's origins that I have read in recent years.

This book is replete with information of interest to anyone studying the origins of life, whether biochemist, crystallographer, biologist or earth scientist. It is also a key text in the continuing debate on life's origins. Whether one is sceptical or accepting, this is a book which cannot be ignored.

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Phage Mu. Edited by N. SYMONDS, A. TOUSSAINT, P. VAN DE PUTTE and M. M. HOWE. New York: Cold Spring Harbor Laboratory 1987. 368 pages. Cloth, $75.00. ISBN 0 87969 301 1.

When this book was advertised I said to myself 'At last – and high time too!' and I think this will be the reaction of many geneticists and microbiologists who have been intrigued by the mysteries of this extraordinary bacteriophage and have had difficulties with the paucity of literature on it. The new book looks rather slim when compared with the second large volume on bacteriophage Lambda, *Lambda II*, already five years old, a contrast which reflects the very different levels of popularity of Lambda and Mu among phage geneticists (though it has to be borne in mind that Lambda was discovered 12 years before Mu). The Mu genome is also a little shorter than that of Lambda: 37 kbp compared with 48 kbp; and one might add another rather irritating difference, that lysates of Mu are very unstable, which means that the phage has to be kept in the lysogenic state.

Phage Mu (for mutagen) was first described by Austin Taylor in 1963; and was immediately remarkable for its ability to insert anywhere in the bacterial chromosome (and stay there), and so produce a wealth of stable mutations in the *E. coli* genome. But interest in Mu was slow in spreading: 3 papers over the next seven years, 4 in 1971, 8 in 1972 and 12–15 per year in 1973–5. The (presumably complete) list of references at the end of the book contains about 450 papers specifically on Mu and 300 on related topics, a surprisingly modest total. The reason for this slow growth seems to have been that the few people who started working on Mu in the late 1960's kept strangers away by exchanging information in 'Mu workshops', secret or unpublicized meetings with no published proceedings, and there was no pressure to publish the experimental results since all those in the Charmed Circle were in close touch. It was not until 1981 that, at a meeting on temperate phages, the speakers at the session on Mu were actually congratulated by the Lambda experts on making their talks comprehensible!

Mu had one disadvantage: unlike lambda it is not inducible by UV or other agents; but this problem was soon solved by making thermo-inducible mutants which can lysogenize at 30 °C, but become lytic at 42 °C. But it has many unexpected characteristics. Whether grown lytically by infection or induced by heat, Mu reproduces by a system of replication which requires multiple transpositions of its DNA into many sites in the bacterial chromosome, followed by 'headfull' packaging of the DNA into preformed phage heads. There is room in these heads for a little extra DNA, so the virion DNA has 50–150 base pairs (bp) of host DNA at the *c*-terminal end and 1500–3000 bp of host DNA at the other end, which is believed to be the end packed last into the head. These host DNA fragments are picked up at random from the host chromosome and differ between individual phage progeny even when these come from a single burst. Transposition is essential for phage replication, and, together with the extra bits of chromosomal DNA taken up, makes up a quite novel form of DNA reproduction, giving Mu many of the properties of a transposon.

A further novelty is the method of changing host range, which depends on inversion of 3 kbp of phage DNA, the G segment, through the action of a specific DNA invertase coded by the *gin* gene. The G segment controls the nature of the phage tail fibres; and one orientation, G(+), produces fibres which bind to *E. coli* K12 and B, while the other orientation, G(−), binds to *E. coli* C, *Citrobacter freundii* and *Shigella sonnei*. It should be borne in mind that one can get strains labelled *Citrobacter freundii* from many different sources which look rather different (I have done so), and I would be surprised if they all showed sensitivity to G(−) phage.

The book starts with some variable-quality photographs of members of the Mu tribe, for those who want to recognize them when they meet one. This is a requirement for Cold Spring Harbor books, but I wish they could afford a better photographer – or a better camera. A dedication to Ahmad Bukhari, who was a major inspiration to Mu workers, is followed by 16 well-organized chapters entitled: A history of Mu; Phage Mu – an overview; Regulation of transcription; The SE region; Late genes, particle morphogenesis and DNA packaging; The invertible G segment; Regulation and expression of the *mom* gene; Integration of the infecting Mu DNA; Transposition of Mu DNA *in vivo*; Transposition-replication of Mu *in vitro*; Replication of Mu DNA *in vivo*; Transposable elements – an overview; Transposable Mu-like phages; Mu as a genetic tool; Some lessons of Mu; and The evolution of Mu. After this we have appendixes on Genetic and physical maps; Mu DNA sequences, from the left and the right end; Useful Mu and Mini-Mu derivatives. Finally the bibliography and subject-index.

To add a few remarks on some of these chapters, let us start with 'The SE Region'. This consists of 5 kb between genes B and C in the early transcription region. Originally labelled non-essential because no

conditional-lethal phage mutations were found in it, genes that affected several aspects of Mu behaviour were later identified, e.g. *kil*, *arm*, *cim*, *gam/sot* and *lig*, not all of which are necessarily separate genes. So this region is labelled SE (for semi-essential), rather than NE (for non-essential). The product of the *kil* gene apparently kills the host cell during lytic Mu growth by affecting cell wall synthesis. However, another gene, *lys*, to the right of SE is necessary (or responsible) for lysis of the infected cell, by a mechanism not yet understood. Two conclusions drawn from this chapter are: first, SE proteins are involved in many facets of the Mu cycle, including integration, replication and lysis; and second, SE proteins include a number of novel enzymes, involved directly or indirectly with DNA replication, whose biochemical properties will be of great interest at both the practical and the conceptual level.

Mystery also still attaches to the *mom* gene of Mu, which codes for a DNA modification system. This modification is dispensable for phage growth and is not a methylation, but a novel type, regulated by a complex interaction without precedence in prokaryotes. The Mom function allows the phage to overcome host-controlled restriction/modification systems with G(+) phage in *E. coli*, but appears to be not expressed, or ineffective, during growth of G(−) phage in other bacteria. Clearly much remains to be elucidated in this system.

The chapter on Mu as a genetic tool describes a large number of Mu derivatives which have actual or prospective uses in DNA manipulation. These are generally designed to make use of the transpositional abilities of Mu carrying deletions which leave the two ends and the A early gene but not usually B, and not the Kil function operative. A selectable gene to make transfer more easily recognized, such as Ap, Cm, Kn or Tc is incorporated into many of them; and some contain a *lac* fusion segment, the *lux* gene or a truncated *nptI*. All have the thermo-inducible cts62 Mu repressor mutation. In addition there are several broad host–range plasmids, mostly RP4, with a mutant Mu, a mini-Mu or even a mini-D108 insertion (D108 is a phage with very close homology to Mu – 90% by heteroduplex analysis). Many possible applications of these plasmids are suggested, and a number have already been tried out: the reader who wants to use them will have to study this chapter carefully, look up the references, and then see which tricks can be persuaded to work efficiently. pULB113, which is RP4 carrying a mini-Mu of 7·5 kb, is the most promising for picking up DNA from one bacterial species and transferring it to another: the chromosomal DNA is sandwiched between two mini-Mu DNAs lying in the same orientation within RP4. This plasmid is said to be able to pick up about 250 kbp of DNA, or two genes separated by about 3·5 minutes on the *E. coli* map. All this Mu technology will, of course, have to compete with the continuing advances in techniques based on Lambda, multicopy plasmids, etc., and we must wait to see which techniques win out.

With this book, Mu and Mu-workers have come of age – a ripe old age of 25 years! *Phage Mu*, I am glad to report, is an excellent book, very readable and full of information and surprises; and it undoubtedly meets an important need. The price is rather high for a comparatively slim volume, and I think a cheaper 'paperback' edition would enable it to be much more widely read.

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Visual Display Terminals and Workers' Health. WHO Offset Publication No. 99. Geneva. World Health Organization 1987. 206 pages. Paper. Sw.Fr. 32, US $19.20. ISBN 92 4 170099 8.

Molecular geneticists are becoming increasingly glued to their Visual Display Terminals (VDTs) as they search for meaning and homologies in the wealth of new DNA sequences pouring into the Gene Banks. So they may begin to wonder whether long hours of this occupation are good for their health. This is a question of world-wide interest, since millions of workers over the globe are daily involved with VDTs, and much literature has appeared on their experiences, including a number of claims of health problems. WHO therefore set up an expert committee in 1985 to assess these reports, and the book under review is the result. The WHO Regional Office for Europe has also organized a scientific review, in view of the particular concern expressed in Europe, which is being prepared by I. A. Marriott and M. A. Studily.

The WHO book gives a critical review of about 300 publications and makes recommendations on the basis of their findings. A summary of their main conclusions will, I hope, encourage scientific libraries to obtain copies of the book and Departmental Safety Officers to think more ergonomically. In fact the book is relevant to University Administrative and Arts Departments also.

(1) *Eye and visual problems.* Eye discomfort was found to be a common problem, but there was no definite evidence of permanent eye damage. Such discomfort is considered largely avoidable if proper attention is given to the design of equipment, work environment and work practices.

(2) *Musculoskeletal disorders.* These are commonplace in VDU work, and injury from repeated stress to the musculoskeletal system is possible; but further research on this syndrome is needed. Application of ergonomic principles to the workplace and conditions should reduce such health problems.

(3) *Stress-related disorders.* It is very difficult to distinguish between the role of the VDT system and other factors, such as job design and organization, in causing these disorders, as one might expect; but