## **Open Topics**

## MIM.6.P087 The Sad and Sorry State of Phage Electron Microscopy

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About 6,300 bacterial viruses have been examined in the electron microscope until 2012. Each year, 100 novel phages are desribed. A total 261 publications from the years 1966 to 2012 were sorted according to the quality of micrographs. They were classified as good (71), mediocre (22), and poor (168). This is in agreement with a downward trend already noticed 10 years ago. The publications originated from 36 countries and appeared in 76 journals. Two journals featured 56 articles with phage descriptions. Micrographs were obtained by means of an astonishing selection of 80 different electron microscopes or models, all produced by 4 manufacturers (Philips/FEI, 24; Hitachi and JEOI, 23 each; Zeiss, 10).

The classification of micrographs is evidently subjective. The benchmark is the atlas of viral electron microscopy by Dalton and Haguenau (1973). Poor papers typically feature low-magnification, unsharp, contrastless, grey to dark micrographs with pint-size viruses without details such as tail striations and tail fibers. Some do not show micrographs at all and many are silent on virus purification, calibration, dimensions, and even the types of EMs and stains used. Micrographs are often vastly inferior to the very first pictures of negatively stained phages published in 1959 (Brenner et al.). The most common problem is lack of contrast (all is grey in grey). Due to absence of magnification control (calibration), dimensions are often unlikely. Such kind of investigation is useless for virology.

This situation cannot be attributed to a particular country, journal, electron microscope, or camera. Indeed, any countries or electron microscopes may produce good or poor pictures. However, manual EMs (with films and darkrooms) offers the possibility of improving contrast with graded filters and paper, whereas digital EMs (in particular a certain JEM model) seem to have intractable contrast problems. The deterioration of phage electron microscopy (this extends to all viruses) is attributed to generally lowered standards, due to the disappearance of excellent electron microscopists (Bradley, Kellenberger, Tikhonenko), absence of instructions and EM courses, lenient or incompetent reviewers, uncritical journals, bulk-sequencing of virus genomes, and over-emphasis on genomics to the detriment of electron microscopy.

<sup>1.</sup> A. Dalton, F. Haguenau, eds. Ultrastructure of Animal Viruses and Bacteriophages. An Atlas. (Academic Press, New York-London) (1973), 413 p.

<sup>2.</sup> S. Brenner, G. Streisinger, R.W. Horne, S.P. Champe, L. Barnett, S. Benzer and M.W. Rees. Strucural components of bacteriophage. J. Mol. Biol. 1 (1959), p. 281.

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Figure 1. Two examples of *Pseudomonas* myoviruses that almost were published:

