

Lens-cups and Lieberkühns: the story of the single-lens microscope

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During the time I was studying the moth-plant and its flowers (Gardner 2017) two beautiful colour-plates of the related *Asclepias curassavica*, the milkweed, came to my attention. They were done in 1805 by Kew's Franz Bauer, the older of the two famous artist-brothers. Robert Brown of the British Museum was interested in the floral details of this plant at about the same time; indeed, the plates are reproduced in a biography of this great botanist (Mabberley 1985, pl. 23 & 24). One of them can be seen on the Natural History Museum's web-site, NHM images.com, as "image 6184".

The numerous small figures that make up each plate carry pencilled magnifications, from x5 for the flower bud to x100 for the pollinia and the pollen grains. We do not have to suppose they were done using just a hand-lens — Bauer and Brown were both said to be remarkable for their skill with the microscope. Wondering what the microscopes of the time were like, and how difficult they might have been to draw from, I consulted the histories of Bradbury (1967) and Ford (1985).



Ellis Aquatic Microscope, London, c. 1760. This simple microscope was designed by John Ellis for his pioneering research in marine biology; Banks and Solander took four of them on the Endeavour. Photograph by Jaime Plaza, Royal Botanic Gardens, Sydney.

Fig. 1. "Ellis Aquatic Microscope, London, c. 1760. The single-lens microscope is mounted on top of its carrying box. The base of another box shows various compartments for the parts, including a set of eight lenses. Lens, forceps and specimen-mounts etc. lie in the foreground. The two lens are oriented with their eye-cups (dark inside) upwards, that is, as they would be in use. The lens in position on the 'scope, and two of the lens in the box base, are fitted with a Lieberkühn reflector." (Duyker & Tingbrand 1995, plate facing p. 236).

Compound microscopes, with their two-lens system — an 'objective' lens close to the specimen, separated by a tube from the 'eyepiece' lens — had been in use since the early seventeenth century. They gave a relatively large field of view, but because of the lack of theoretical knowledge about lenses, and the imperfect glass of the time, gave poorly resolved images. It was the older invention, the "single lens" microscope, as perfected by one of biology's most original pioneers, Anthony van Leeuwenhoek (1632–1723), that gave the highest powers and the best resolution. The stronger ones magnified up to nearly three hundred times and were quite able to reveal a marvellous variety of tiny things: the protozoan "animalcules" that have lured so many into biology, cellular detail, bacteria, and even the agitation of fine particles, living and non-living, that we now call 'Brownian Motion'.

The problem with the single-lens system was that a high magnification was usually obtained with a spherical "glass droplet" lens just a millimetre or so in diameter. The specimen had to lie very close to the lens and would be poorly illuminated and nearly impossible to dissect. The eye too had to be very close to the lens and at a precise distance from it. This was eased to some degree by the fixing of an eye-cup; nevertheless, using the single lens was often an exercise in frustration and eyestrain.

Van Leeuwenhoek himself had the rare skill of being able to grind small double-convex lenses, thus giving the single-lens an improved resolution and a larger field of view. He did not pass on his methods, though, and in the following century improvements to the microscope, both single-lens and compound, were confined largely to its mechanics, e.g., in the provision of a fine-focus mechanism and a mechanical stage. Duyker and Tingbrand (1995) show a typical single-lens microscope of the 1750s, like the four that Banks and Solander took on Cook's First Voyage (Fig. 1). It was called an "aquatic" microscope because its stage could carry a watchglass with liquid in it, allowing the (very fashionable at the time) examination of small animals, such as the freshwater *Hydra*.

Brown used a single-lens microscope to determine how the pollen-bearing apparatus of the asclepiad flower formed. A microscope used by him for many years, almost until his death in 1858, still exists; Ford (1985:149) provides a drawing of it, reproduced here as Fig. 2. He notes that two of the lenses were fitted with a cupular parabolic mirror, known as a

'Lieberkühn reflector'. Acting like a modern ring-flash, this brings in light from all sides on to the object, to give a bright and realistic image. (One is shown in position on the microscope in Fig. 1).

Towards the middle of the nineteenth century the performance of lenses was greatly improved through mathematical analysis and better manufacturing techniques. The single lens was replaced by two or three lenses cemented together ('doublets' and 'triplets') to give excellent results in hand-lenses and low-magnification dissecting microscopes. Similarly, improvements to the optics of the compound microscope meant that this soon replaced the single-lens system for high-power work.

Nevertheless, the single-lens microscope is a remarkably effective tool. Those who might want to make their own will find numerous Web sites on the topic. Some focus on history, e.g., that of the Corning Glass Company, while others have a "you really should build this at home" emphasis.

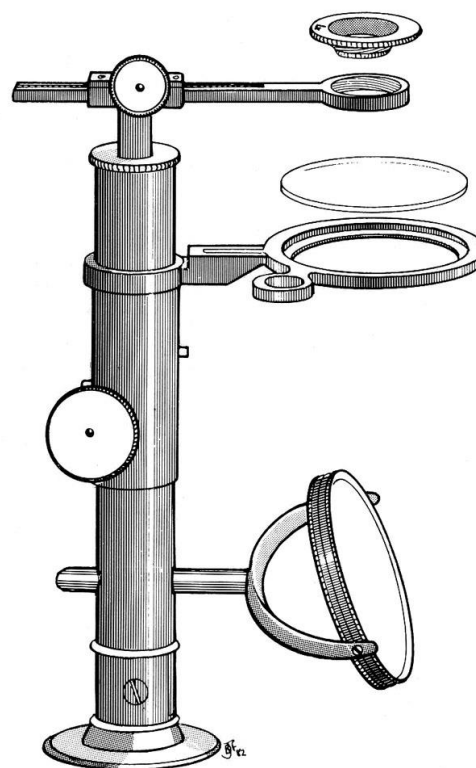


Fig. 2. "Robert Brown's microscope at the Linnaean Society. Visible are the two milled wheels controlling the focus and the lens arm. Note also the screw-in lens cup and the circular glass stage. The instrument could be inclined through a fulcrum at the base. It dates from before 1820 and produces clear images of good magnification". Ford (1985: 149, fig. 24).

References

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