



OPTICAL PROPERTIES OF THE LENSES OF AN EARLY 19th CENTURY CUFF-TYPE MICROSCOPE

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A description of the lacquered, brass, monocular microscope to determine the authenticity of the instrument and its accessories has been made by Jones (2006). The optical properties and imaging capabilities of the microscope lenses are described here and indicate what microscopists could see through their microscopes

Fig. 1a. Cuff-type microscope. The height of mahogany pyramidal-shaped box is 450 mm.



Fig. 1b. Numbered objectives 3, 4 and 5.

MATERIALS AND METHODS

The lenses

There are six objectives, numbered 1-6, each a single bi-convex component. Lens 1 gives the highest magnification and lens 6 the lowest. All six objective mounts have a serrated edge and three of them are shown in Fig. 1b. Objective number 5, unlike the others, has a rim inside this edge. The ends of this lens are pointed at both ends whereas the lenses in the other objectives have straight edges. There is an eyepiece lens, protected by a brass slider, and also a field lens.

Focal length of lenses

The method used to measure this parameter was that described by Reid (1998).

Abbe test slide

This was purchased from Carl Zeiss Ltd. and was based on the original slide made by E. Abbe in the 19th century. Spitta (1907) gives a description of the slide.

Photomicrography

An Olympus OM10 single-lens reflex camera, with lens removed, was attached to the eyepiece of the microscope with a cardboard tube and black paper to eliminate extraneous light. The light source to

illuminate specimens on the stage was a 60-watt tungsten electric light bulb in an angle-poise lamp and the film used was 35mm Fujichrome 64T professional film.

RESULTS

Lens 3 (Figures 2 and 3) gives a fairly clearly defined photographic image of a cat flea and transverse section of *Iris germanica* stele. Lens 6 (Figure 5) gives a reasonable image of this transverse section. Lens 4 gives a somewhat poor image. Lenses 1, 2 and 5 give an image which is rather hazy and poorly defined. The cat flea shown in Figure 2 and imaged through lens 3 compares favourably in photographic quality with that achieved through a modern Olympus 'Provis AX 70' research microscope in an article by Jones (1996) and photographed by Mr. Roger Stacey, formerly of Olympus Optical Co. Ltd. However, the proboscis of the blue-bottle fly in a Victorian slide and imaged with the Cuff microscope (Figures 7, 8) does not compare in clarity with that photographed with the Provis microscope (Figure 9). There is debris on some of the transparencies (Figures 2, 3 and 6) and this is from the camera. No specimens were imaged through lens 1.

Lenses 3, 4 and 6 show typical signs of spherical aberration, common in early biconvex lenses, and

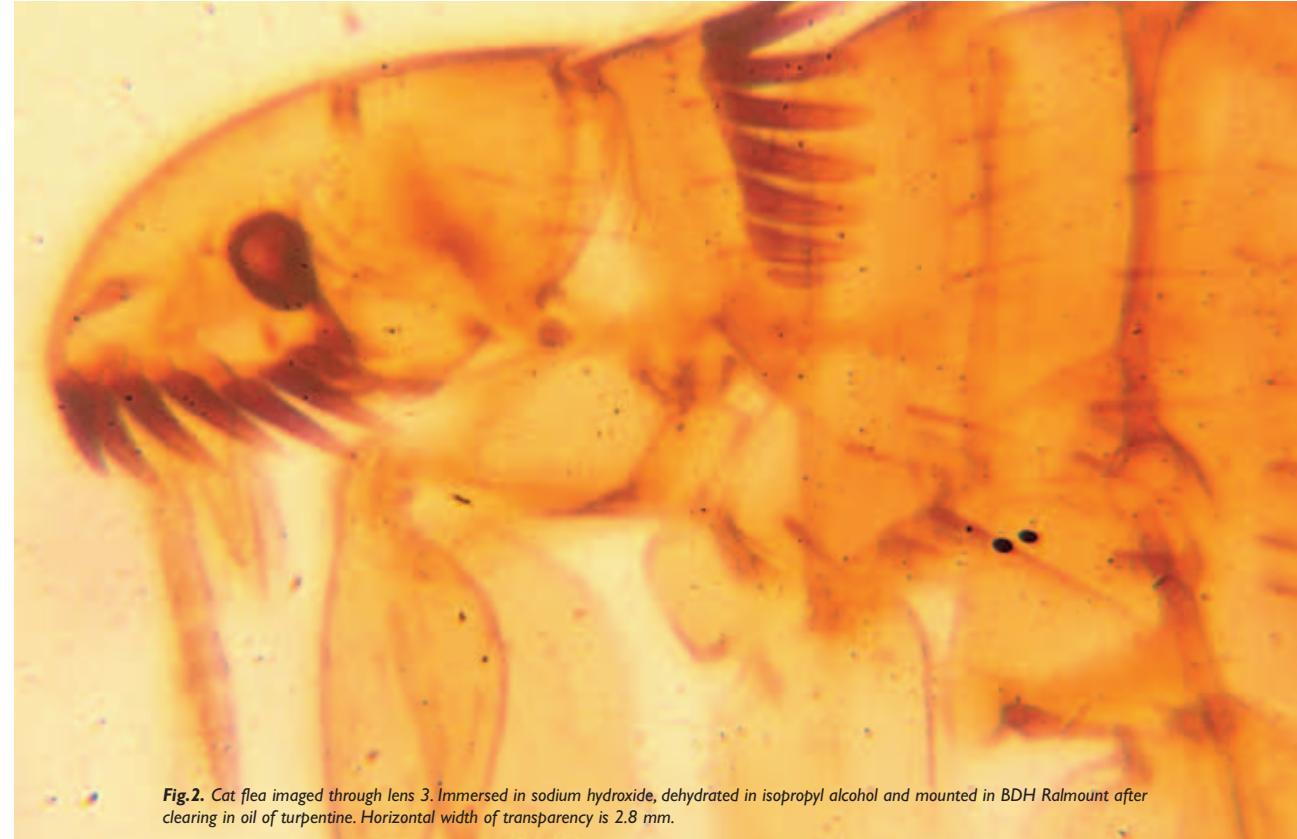


Fig. 2. Cat flea imaged through lens 3. Immersed in sodium hydroxide, dehydrated in isopropyl alcohol and mounted in BDH Ralmount after clearing in oil of turpentine. Horizontal width of transparency is 2.8 mm.



Fig. 3. Transverse stained section of root stele of *Iris germanica* imaged through lens 3. Width of root stele at widest point is 1.6 mm.

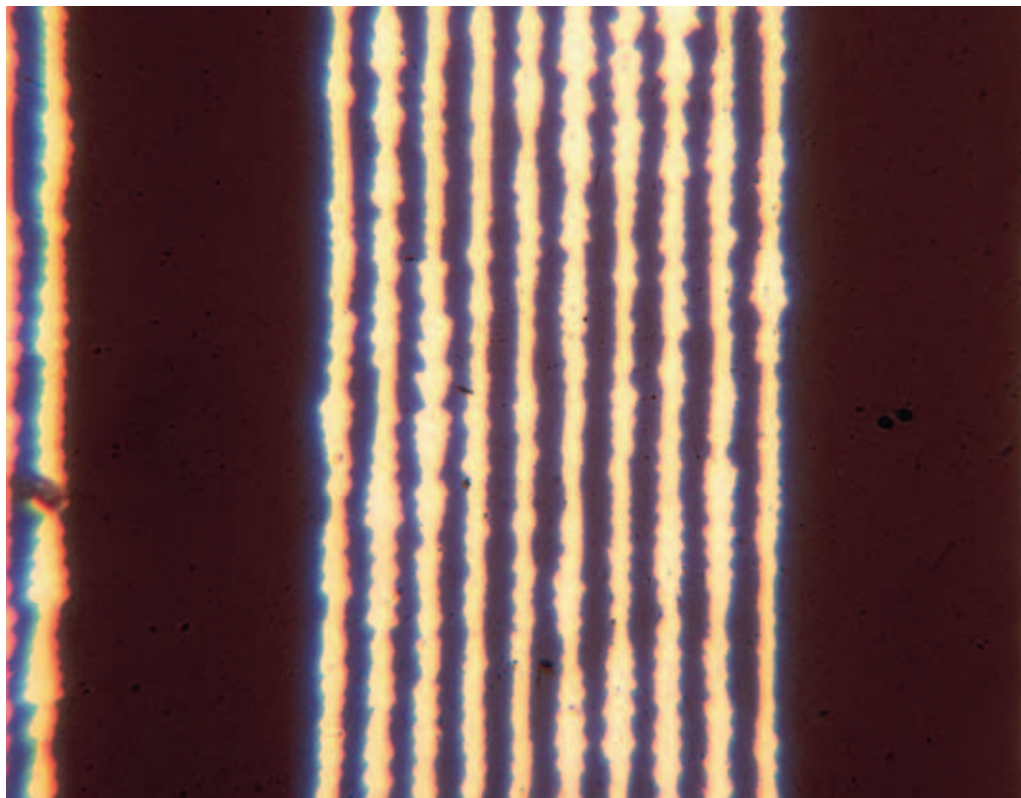


Fig.4. Abbe test slide imaged through lens 3. Band of 10 lines is 0.6 mm wide.

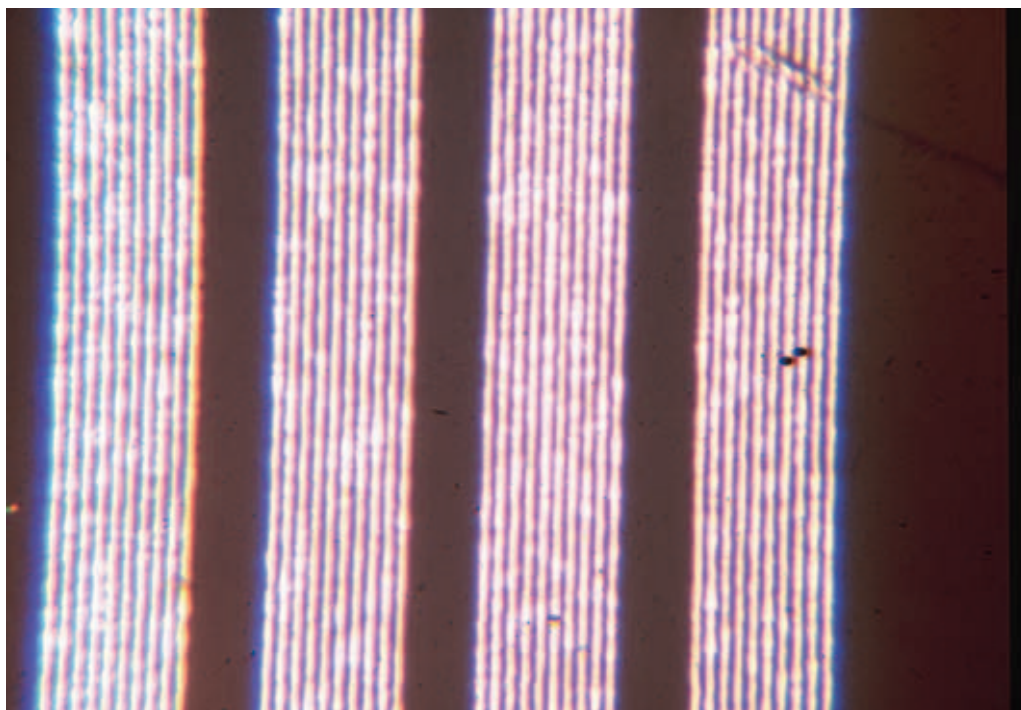


Fig.6. Abbe test slide imaged through lens 6. The fieldwidth covering the 4 sets of 10 lines is 3.3 mm.

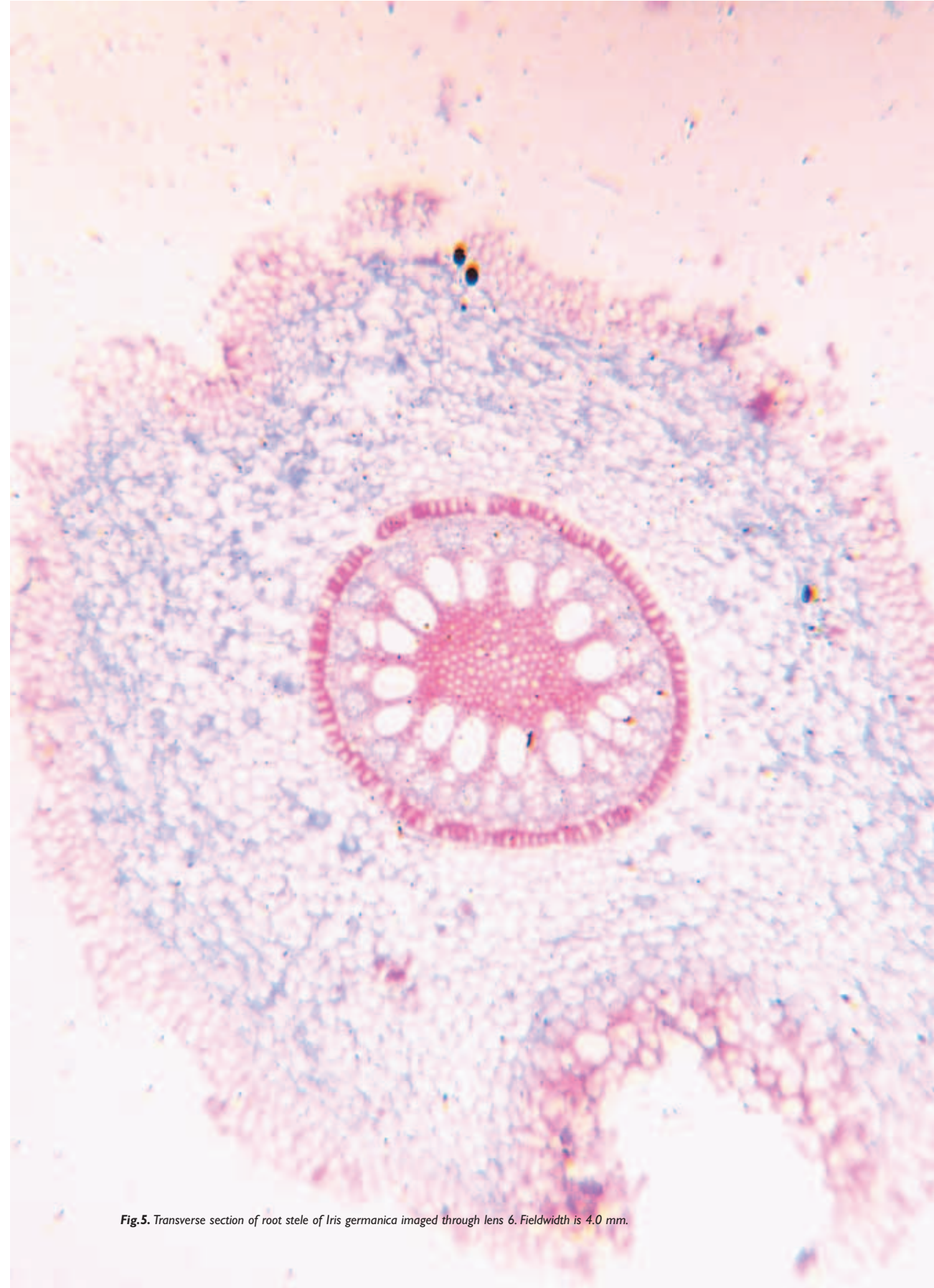


Fig.5. Transverse section of root stele of *Iris germanica* imaged through lens 6. Fieldwidth is 4.0 mm.



Fig.7 and 8. Proboscis (tongue) of a blue-bottle fly imaged through the Cuff-type microscope. Width of proboscis is 1.6 mm.

this manifests itself in distorted lines appearing in the Abbe test slide although the feature is not particularly marked (Figures 4 and 6).

Lenses 3 and 6 have focal lengths (in mm) of 12.03 and 27.28, respectively, and the corresponding numerical apertures are 0.08 and 0.058. These readings compare favourably with focal lengths of 12.3 and 30.24 and corresponding numerical apertures of 0.06 and 0.03 of lenses 3 and 6 of a late 18th Century Cuff-type microscope signed 'Thomas Ribright London fecit ' (Jones & Reid, 2006).

Dr Brian Bracegirdle, Editor of the Quekett Journal of Microscopy, has kindly provided the authors with corresponding focal lengths and numerical

apertures of lenses 3 and 6 of a 1750/60 Cuff microscope of 8.18mm (NA 0.09) and 29.82mm (NA 0.04).

CONCLUSION

Both the flea and the root section of *Iris germanica* are fairly clearly imaged with lens 3 of the Cuff -type microscope made about 200 years ago but are inferior in clarity to those imaged through the modern Olympus microscope. The proboscis is not clearly defined when photographed through the Cuff microscope. The images through this Cuff -type microscope are superior to those seen through the Jones's Most Improved Microscope made somewhat earlier in the late 18th Century (Jones, 1996). Of course, the fine focussing, a feature of the Cuff-type microscope, does help

considerably during the photomicrography to produce sharper images and there does not appear to be the considerable fall-off in focus towards the perimeter of the image so characteristic of early single, biconvex lenses.

Acknowledgement

We thank Mr. Alan Lasslett of Olympus Optical Company for Figure 9.

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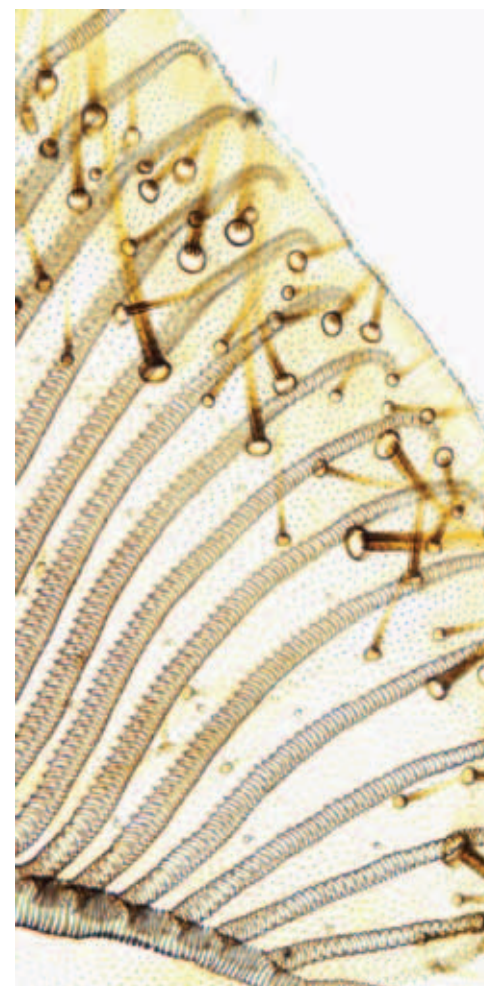


Fig.9. Proboscis of blue-bottle fly imaged through a modern Olympus Provis microscope. Fieldwidth is 0.3 mm wide by 0.6 mm.

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