



Technical Details

Microscope Camera "DFK MKU 130 – 10x22"

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Introduction

At the end of 2014, The Imaging Source (Bremen, Germany) brought a new microscope camera on the market with the intention of offering a detachable eyepiece camera with excellent image quality which could be used with practically every standard microscope on the market.

If such a "universal camera" is even technically possible is often the question asked since the optical systems (and the resulting calculations) of various microscopes are usually very heterogeneous. Normally, therefore, any camera must be configured to fit the optical design of a particular microscope. Given these fundamental challenges, we were of course very interested to test this innovative camera. The manufacturer provided us with a loaner camera for testing purposes.

Basic Technical Data

The camera is equipped with a 13 MP CMOS color sensor (1/2.5" Sony Exmor, pixel size 1.4 x 1.4 μm). The maximum resolution is 4128 x 3096 pixels, but lower resolutions can also be selected (3264 x 2448, 2592 x 1944, 1920 x 1080, 1600 x 1200, 1280 x 960, 1280 x 720 pixels). Images can be saved as Bitamp, TIF or JPG files. Video clips (AVI only) can be saved at a maximum of 30 frames per second (FPS) at full HD format (1920 x 1080 pixels) and using higher resolutions at 1 FPS. Exposure times of 1 s to 1/5000 s range were achieved; the ISO sensitivity ("gain") spans from ISO 50 to ISO 3200. In addition to automatic white balance, further adjustments to the color characteristics of six different light sources (e.g. lighting set ups) can be preset. The camera is controlled using software (available for Windows and Linux) which can be downloaded from the manufacturer's website (<http://www.theimagingsource.com/>).

The manufacturer's software, IC Capture, enables the image capture of photos and videos. When the various toolbars are temporarily collapsed, this software can also be used for live observations and demonstrations of the microscope's output image. Additionally for this purpose, there is also IC Fullscreen Presenter software which enables the use of the entire monitor for real-time viewing of the camera image. This software is complimented by measurement software; this additional software component is not included in the scope of our testing.



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Special Features

The camera is comprised of three main components which are delivered pre-assembled by the manufacturer. The cube-shaped camera body (Fig. 1a) is approximately 4.4 cm long and measures about 3 x 3 cm (weight: 57 g). On the camera back there is a USB port for the cable which comes included with the camera. On the middle front, there is an aperture of about 1 mm in which the small front lens (with AR coating) of the integrated optics assembly is mounted. Furthermore, the camera front comes equipped with a 2.5 cm diameter center-mounted internal screw thread. This screw thread takes the camera tube (weight: 28 g) which when measured from the thread edge is about 3.5 cm long. The inside clearance of this tube is approximately 3.3 cm. Fig. 1b shows the tube mounted to the camera body. The third component is a high-eyepoint ocular for glasses wearers, (magnification 10 x, Field Number 22, Eye-tube O.D. 30 mm included) which fits exactly into the aforementioned camera tube without any axial deviation and which can then be affixed with an Allen head screw (Fig.2). This ocular has "SWH 10x, MT" embossed on it; it comes from the Japanese manufacturer Meiji Techno Ltd. and can be purchased separately from many suppliers. Originally this ocular was designed as a finder eyepiece for one of Meiji's own microscopes. The eyepiece is designed for magnified, fully-corrected intermediate images and therefore does not function as a compensating eyepiece.

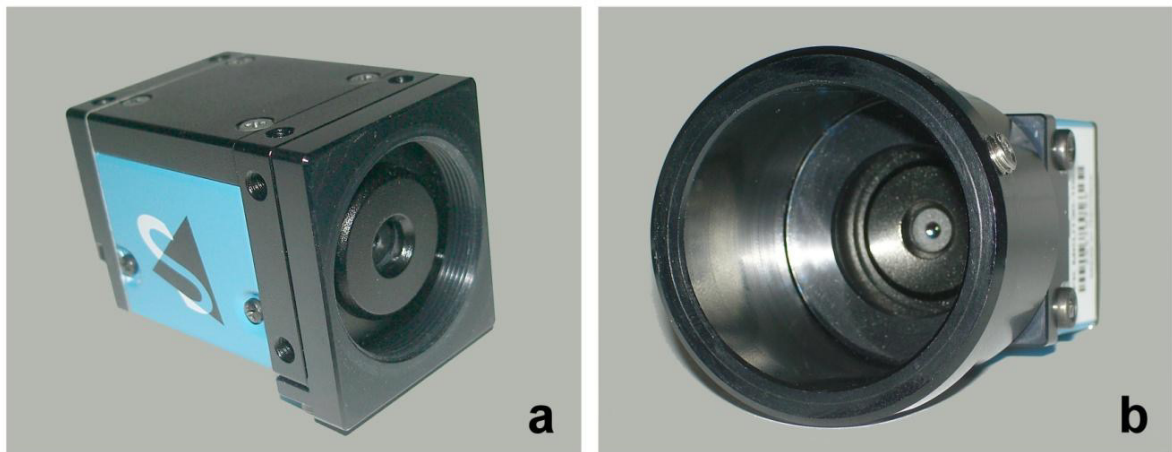


Fig. 1. Camera body. Front view showing screw thread for camera tube and aperture (a). Body with camera tube. View of the aperture and outermost lens (b).



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Fig. 2. Camera with attached camera tube and included eyepiece. Arrow: Allen head screw to tighten and loosen the eyepiece.

Technical Realization of a Universal Application

The conspicuously small aperture on the front of the camera calls to mind a very tightly constricted human pupil and the aperture of a so-called pinhole camera. Behind this aperture, inside the camera, one finds a zoom lens system with autofocus. According to the manufacturer, in the zoom position 1x, the focal length of the lens system is 5.3 mm which corresponds to the small format image of 35mm (AOV: 64°). In combination with the relatively small sensor, this optical configuration (the very small entrance pupil and the short focal length) ensures a maximized depth of field. By loosening the Allen head screw, the included ocular can be adequately adjusted in the camera tube to ensure a vignette-free illumination of the imaged field of view and that the eyepoint of the ocular corresponds as precisely as possible with the exit pupil of the integrated optics; as a rule, pulling the eyepiece around 1 cm from its lowest position is sufficient.

When a microscope has a tube which fits with a 30 mm ocular, an eyepiece can simply be replaced with the manufacturer's included eyepiece and camera assembly. If the eyepiece diameter of the microscope is smaller, then the included eyepiece cannot be used. Nevertheless, in such cases a viable camera adaptation can usually be achieved. To this end, the included eyepiece must first be removed from the camera. The lens-less camera tube should now instead be connected to the microscope's original eyepiece or slipped over the microscope's eyepiece head. If necessary, a paper cuff can be placed around the microscope's eyepiece head so that the camera tube can be securely fitted without axial deviation or canting (see example in **Fig. 3**).



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Fig. 3. Use on a tube for eyepieces with a small standard diameter (23.2 mm). The eyepiece head encircled with a paper cuff (left). Camera tube placed on the eyepiece head while using the original microscope eyepiece (shown in the background right).

In cases where the eyepiece's outer diameter is larger than the inner diameter of the camera tube (33 mm), the camera tube will also need to be removed. In this case, the camera body as such can be placed (at a suitable distance respective to the exit pupil) directly on or over the microscope's eyepiece. If necessary, the end-user must make a mechanically suitable adapter themselves since the manufacturer only currently offers the aforementioned camera tube and eyepiece for glasses wearers.

In the case where a microscope with a trinocular port (c-mount thread) is available, the included C-mount-adaptor can be used. In so doing, the camera/tube/eyepiece combination can be docked directly onto the microscope's C-mount port.



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Camera Software

The IC Capture software allows the operator extensive control over the final image. The numerous "Toolbars" for the regulation of quality-defining image parameters can be selected or minimized through the Toolbar Manager. Located in the upper area of the screen is the control panel in which all of the available tool bars can be found (Fig. 4). Among other parameters the following can be adjusted: ISO sensitivity ("gain"), brightness, contrast, gamma, focus, color saturation, white balance and parts of individual color channels (especially red and blue). Additionally, zoom factor (here: 1.0), image resolution (in example as shown: 1920 x 1080) as well as frame rate (here: 30 FPS) can be controlled. In addition to manual adjustment of the parameters, the operator can also select automatic settings by checking "auto" for each parameter. An exception to this is the optionally activated autofocus (see "One Push" at the bottom edge of the menu window). With one mouse click on the "One Push" button, the software selects a center autofocus point for the entire image. Additionally, the software features a selective autofocus function. A left click on the cross hairs (looks like a plus sign) to the right of the "One Push" button activates the cross hairs which can now be moved from the menu to the live image and placed on whichever area the operator would like to focus on. Another left click on the selected area allows the software to selectively focus on that area. Video recording can also be initiated, paused or stopped directly from the menu seen in Fig.4. (please see the red video button on the left edge of the menu). Images can be saved in the usual way by opening the "File" menu (top left) and by then clicking on "Save Image." The save location can be chosen freely.

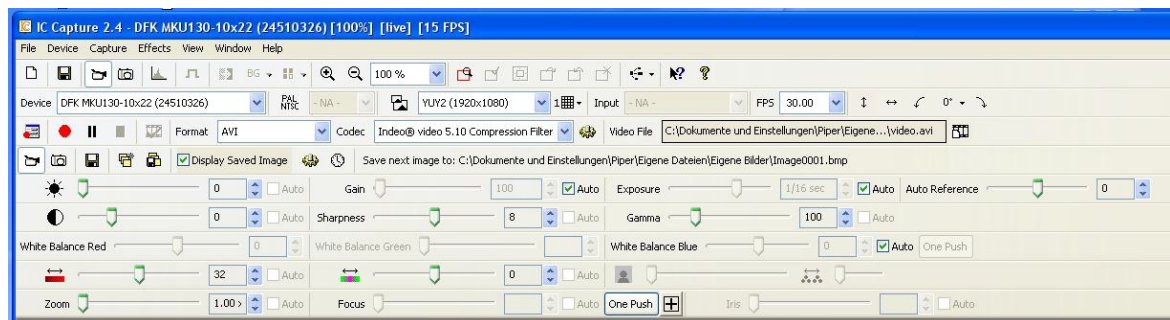


Fig. 4. Control panel with all available "toolbars."

Some of the previously mentioned parameters and functions can be adjusted via "Properties" which is found in the "Device" submenu. Furthermore, there are additional features which can be found in this submenu (see examples in Fig. 5). Specifically, in the HDR submenu one has the option of selecting (or deselecting) an automatic HDR function. From the submenu "Image," one can enable "Noise Reduction" as well as "Image Stabilization."



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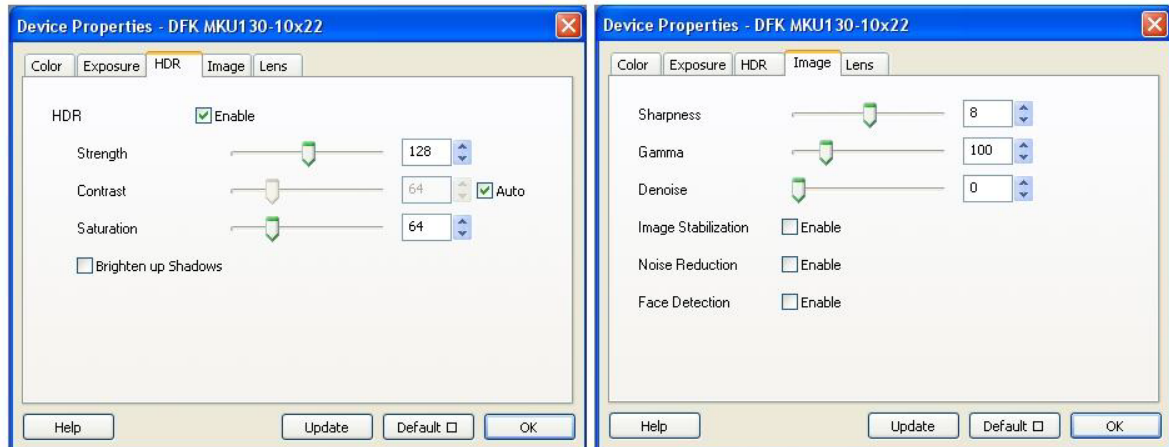


Fig. 5. Windows for activating and deactivating HDR (left), and noise reduction and image stabilization (right).

The IC Presenter Software functions, as the name implies, exclusively for the purpose of live on-screen microscopy; image- or video-capture function is not available here. Upon starting the program, the desired video format must be selected. At a frame rate of 1 FPS the default setting, "YuY2 (4128 x 3096)," does not allow for a smooth live image. Therefore, the program should be set to YUY2 (1920 x 1080 HD 1080) for routine use. The default frame rate (30 FPS) can be left as-is or can be reduced to 15 or 20 FPS for low luminous efficiency values. With a right click in the displayed live image, resolution and frame rate can be adjusted at any time ("Select Device"). Additionally with a right click in the displayed live image, "One Push" autofocus (submenu "Lens") and adjustments to other important image parameters (submenus for "Color," "Exposure," and "Image") can be made. These functions correspond to those of the IC Capture software.



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Practical Tests

Screen Image

According to all tests which were carried out, adequate adjustment of the camera and its accompanying eyepiece (barrel diameter: 30mm) on the eyepiece head of a binocular observation tube will ensure a usable, that is, vignette-free and evenly illuminated image which can be presented via the monitor from probably every microscope. The most sensible choice of resolution for live demonstrations (namely the maximum video resolution of 920 x 1080 pixels) delivers, at 30 FPS, a smooth, fluid image using either IC Capture or IC Fullscreen Presenter. Adjustments to the stage, made at a normal speed, can be accomplished without annoying blurring effects. At a zoom factor of 1.0, a round edge demarcation can be seen. By moderately zooming the image, however, a presentable full image without vignetting can be produced (**Fig. 6**).

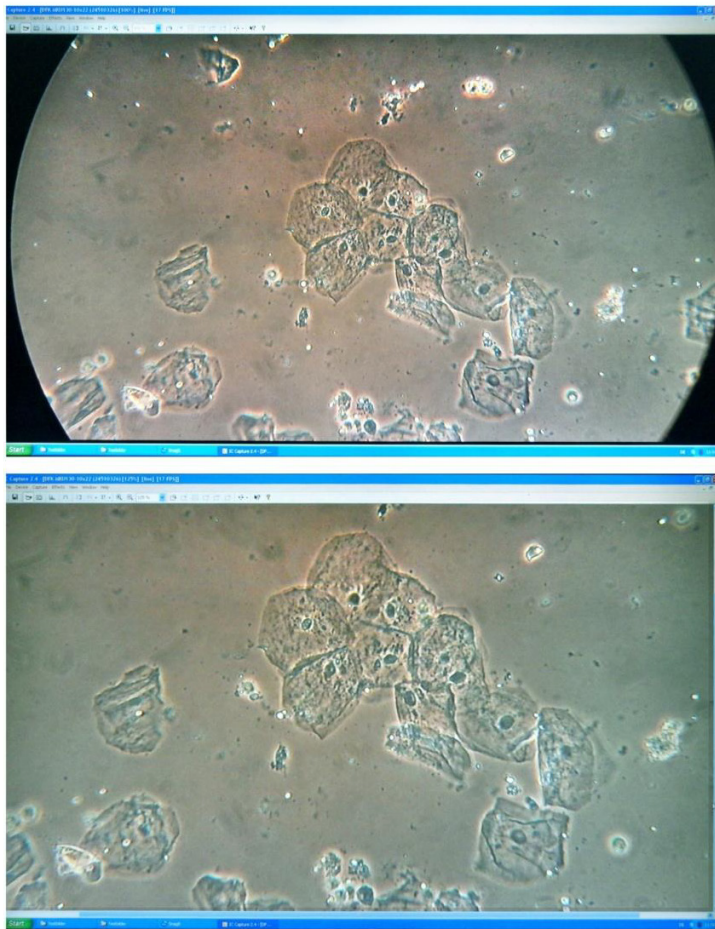


Fig. 6. Monitor image via the Capture software with collapsed "toolbars" no zoom (top). Moderate zoom (bottom). Free-hand photo of the laptop display. Oral mucosal epithelial cells. Phase contrast. Teaching-level microscope Leitz HM Lux 3 (cf. Fig. 10)..



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Camera Eyepiece

Specifically, we tested the camera with its integrated eyepiece on large-field microscopes from the manufacturers Leitz, Leica and Carl Zeiss Jena. It should be mentioned, however, that with all of these microscopes, the images generated with the included eyepiece showed a moderate loss of edge sharpness. This is noticeable when infinity-corrected plan objectives with a fully corrected intermediate image are used (e.g. Leica DMLB-microscope). The difference in planarity between the original eyepiece from Leica and that of the camera can be seen by simple direct observation: Using the same tube, one eyepiece is simply exchanged for the other to view the specimen (ideally a thinly-sliced planar specimen). Both eyepieces deliver a sharp image without additional adjustment which indicates that their parfocal lengths are the same. With the Leica eyepiece, the viewed image is absolutely sharp at the edges. Whereas the camera eyepiece (Field Number 22) only delivers a planar, sharp image without any recognizable loss of edge focus in the center of the field of view; this roughly corresponds to Field Number 18 (**Fig. 7**). Even when the image is enlarged just enough so that the vignette around the field of view disappears, there is still some edge softness visible in the upper right and left corners of the image (**Fig. 8**); apart from this, however, the sharp image center is impressive because of its high precision rendering of fine structures.

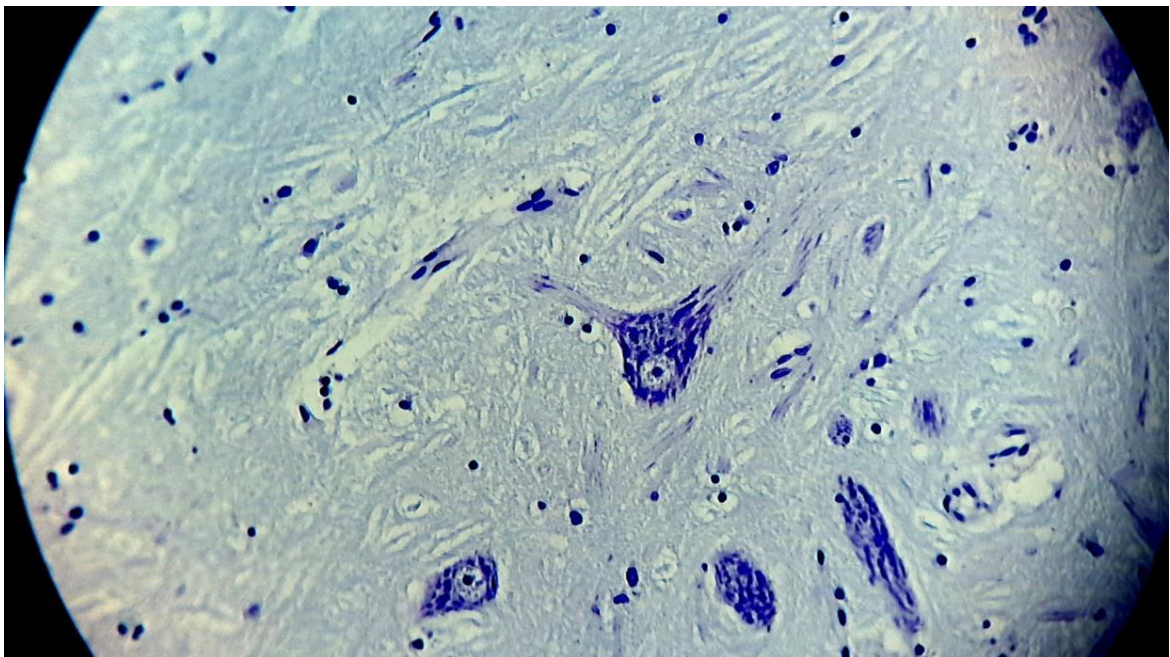


Fig. 7. Image from camera with included eyepiece (manufacturer: Meiji) used with Leica microscope DMLB, thinly-sliced planar specimen of nerve tissue (medulla oblongata, nucleus ambiguus), Nissl .. stain, 40x, bright-field plan objective, micrograph without zoom, distinct edge blur from the camera eyepiece.



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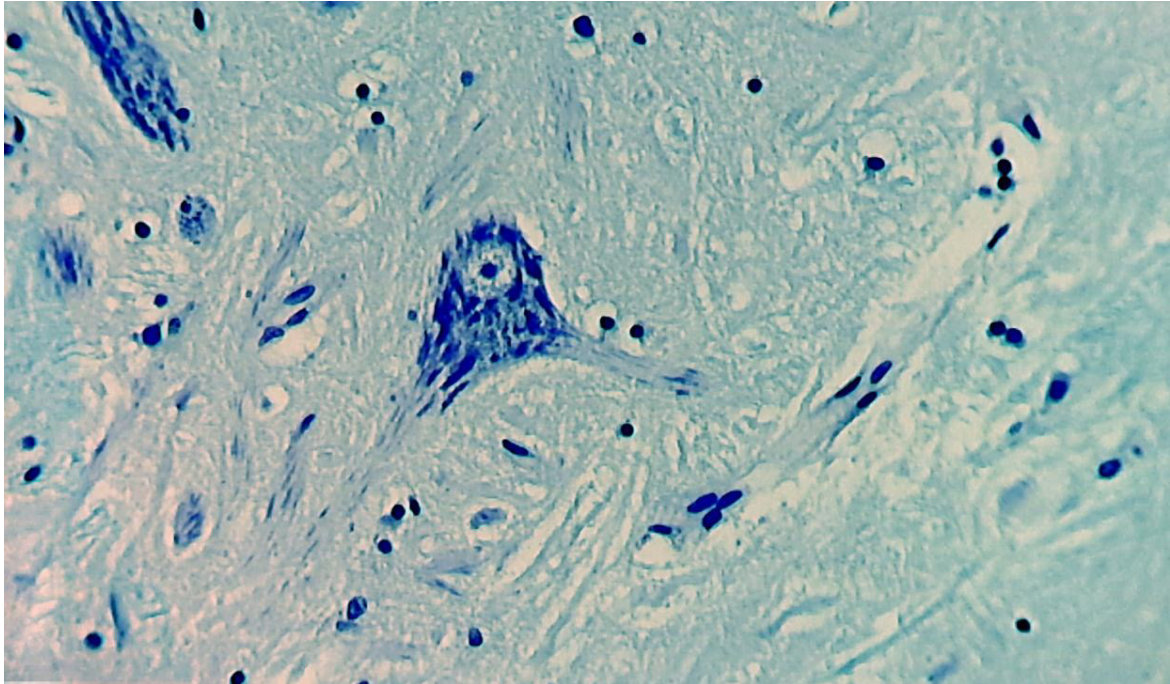


Fig. 8. Specimen and equipment as in Fig. 7, moderately zoomed micrograph without vignetting, edge blur can still be seen on the left and right edges of the image.

In addition to standard optical microscopes, the camera / eyepiece combination can be easily adapted to stereo microscopes (tested on Leica stereo microscope M 80). At the comparatively low magnification of such a microscope, the less-than-ideal edge focus of the camera ocular is barely noticeable at the visible peripheral edge (Fig. 9).

The assembly of the camera / eyepiece combination on a C-mount port can be problematic, however, at least when the respective trinocular is designed with another ocular in mind. Such is the case with the Leica DMLB; whose phototube is equipped with a special projection eyepiece which cannot be exchanged with standard eyepieces. Consequently, so mounted in the microscope's C-mount port, the camera / eyepiece combination did not deliver a usable image.



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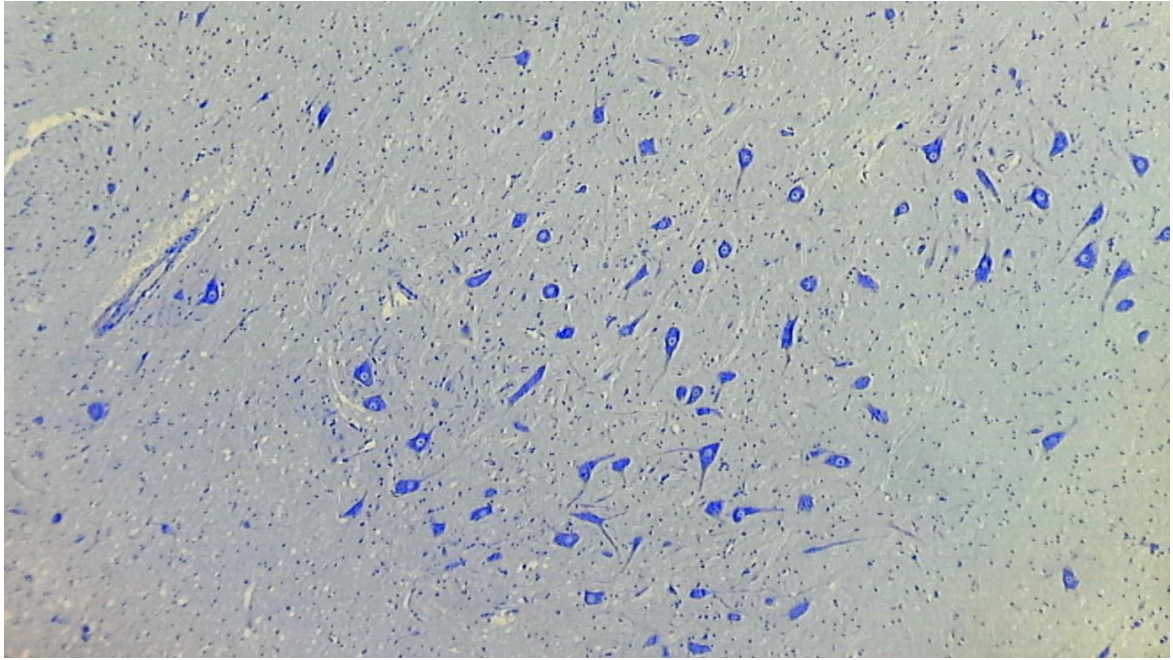


Fig. 9. Image from camera with included eyepiece (manufacturer: Meiji) used with Leica stereo microscope M 80. Specimen from Figs. 7 and 8, bright-field.



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Combination with Other Eyepieces

By removing the included camera eyepiece, the camera and camera tube can be mounted on many other microscopes having similarly sized (i.e. diameter) eyepieces. In this simple and uncomplicated way, the camera was adapted to a Leitz HM-Lux 3 student microscope fitted with its original 10x Leitz Periplan large field high-eyepoint eyepiece (Field Number 18). The camera tube fit exactly over the rubber eyeguard of one the Leitz eyepieces. From **Fig. 10**, one can see that even with such a simple student microscope, the aforementioned method produced respectable phase contrast images.

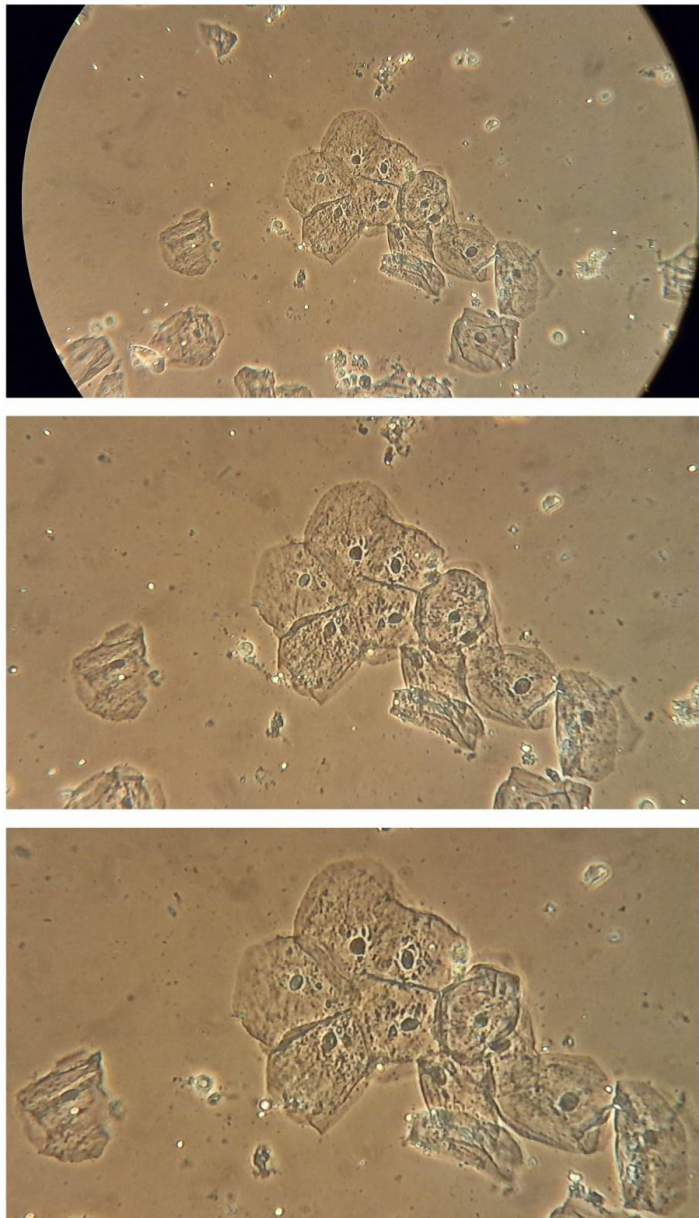


Fig. 10. Image from camera used with Leica teaching-level microscope Leitz HM Lux 3, objective: Phaco L 32/0 40, eyepiece: Periplan GF 10x/18 (for eyeglasses wearers). Wet-mount slide of epithelial cells, phase contrast, image created with simple annular phase rings (without Köhler illumination) micrograph without zoom (top), zoom factor 3x (middle), zoom factor 4x (bottom).



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Even older optical microscopes (e.g. with a cast iron base, mirrors and basic objectives with lower field numbers such as the Studio-Mikroskop and Enuro-Optik) and microscopes with non-standardized eyepieces and objectives with an even smaller diameter (e.g. the Bresser Biolux AL that was sold a few years ago through grocery stores) could be successfully used; with all of these microscopes a live-stream of the viewed image, video-clips and color images were possible. Those with significantly smaller diameters, must occasionally be fitted with a paper cuff (as mentioned earlier in the article) so that the camera tube can be securely fitted to the tube head without axial deviation or canting. Properly trimmed strips of paper or paper towels affixed with tape were adequate to the task.

As a matter of principle, the camera can be placed directly (i.e. without the lens-less camera tube) over the microscope's own ocular lens if the diameter of the original eyepiece is larger than the internal diameter of the camera tube so that the eyepiece does not slide into the camera tube. In the best case scenario, the camera body can be mounted directly on the ocular lens mounting flange. For test purposes, this strategy worked perfectly for the Leica DMLB. One person stabilized the camera on the Leica eyepiece while a second person operated the computer and captured the images. In so doing, the differences between the camera's ocular versus that from Leica could be easily visualized. The edge softness produced by the camera's eyepiece was not a problem when the original Leica eyepiece was used and was additionally characterized by an increase in image sharpness and improved contrast (**Fig. 11**).

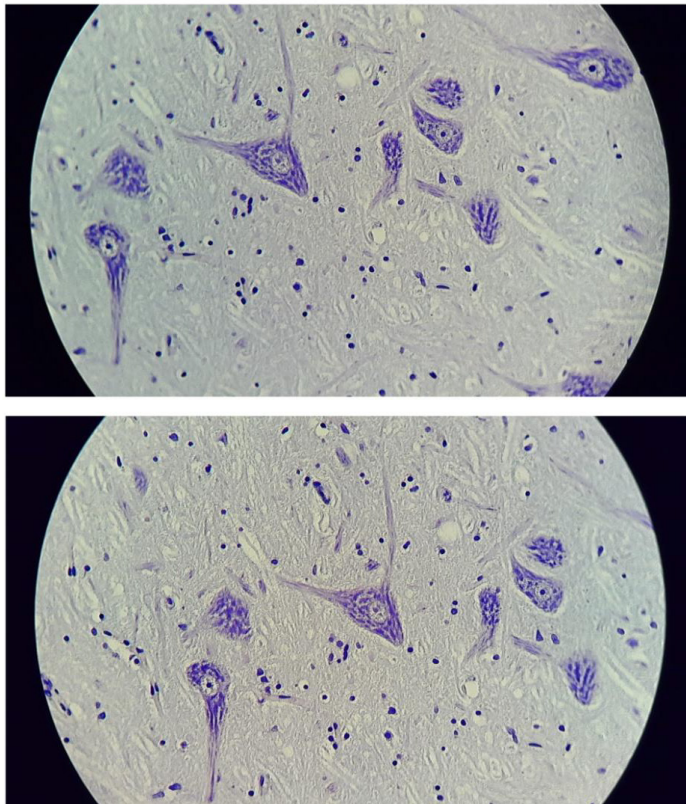


Fig. 11. Comparison of eyepieces, nerve cells (same slide used in Fig. 7-9), microscope: Leica DMLB, camera with Meiji eyepiece 10x (above), camera body placed manually on the original Leica eyepiece 10x (below), perceptible visual superiority of the Leica eyepiece (edge focus, contour focus, contrast).



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Autofocus

The camera's autofocus functioned with surprising reliability and precision. Even in difficult situations, in all practical tests it worked with absolute accuracy. A visual assessment indicates that the level of focus delivered by the autofocus couldn't be additionally corrected or improved upon. Even when the image itself wasn't sharply in focus in the microscope, the camera's wide range of autofocus adjustment enabled it to produce a sharp image on the monitor without adjusting the working distance of the objective. An illustrative measurement of the adjustment range was made using objective L 32/0.40 (long working distance combined with eyepiece 10x). With the autofocus sharply focused on the observed slide in mid-position, the microscope's focus could be adjusted by $8\mu\text{m}$ in either direction before the autofocus could no longer correct the image (which was no longer in focus in the microscope) seen on the monitor. This means that at least when using the 10x eyepiece, the autofocus could compensate over the total $16\mu\text{m}$ adjustment range. This corresponds approximately to three times the observable depth of field one would expect from the objective / eyepiece combination used in this test.

In this way, if for testing purposes a non-Plan-corrected objective (simple achromat) with significant edge softness is being used, consistent focus on the specimen can be maintained in the microscope and the selective autofocus used either to focus centrally or peripherally, as desired, in the field of view (Fig. 12). Even when one had made only an approximate manual adjustment to the focal plane while leaving the focus unchanged, by using the selective autofocus one could easily carry out any refocusing necessary to observe interesting details on the monitor image –from the image center to the periphery.

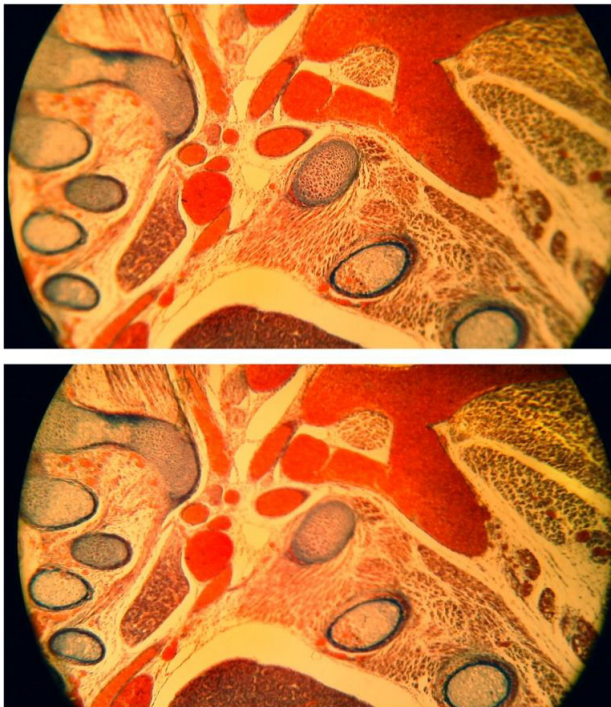


Fig. 12. Demonstration of the selective autofocus, histological routine slice (rat embryo), bright-field, unfiltered incandescent light, student microscope Leitz HM-Lux, Phaco 10/0.25 (basic achromatic objective, Will Wetzlar), eyepiece: Periplan GF 10x/18 (for eyeglasses wearers), extreme edge blurring, automatic focusing for the image center (above) and the image periphery (below).



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Illumination Types and Filters

In addition to bright-field images, images produced via polarized light, darkfield and phase contrast techniques can be flawlessly visualized, photographed and filmed. Even very narrowly filtered monochromatic light (red, green and blue) did not pose any problems for the camera—neither with regard to the exposure nor the precision of the autofocus. Monochromatically filtered objects produced flawless black-and-white images. Figs. 13 – 16 show some application examples which were taken using various types of lighting, filters and microscopes.

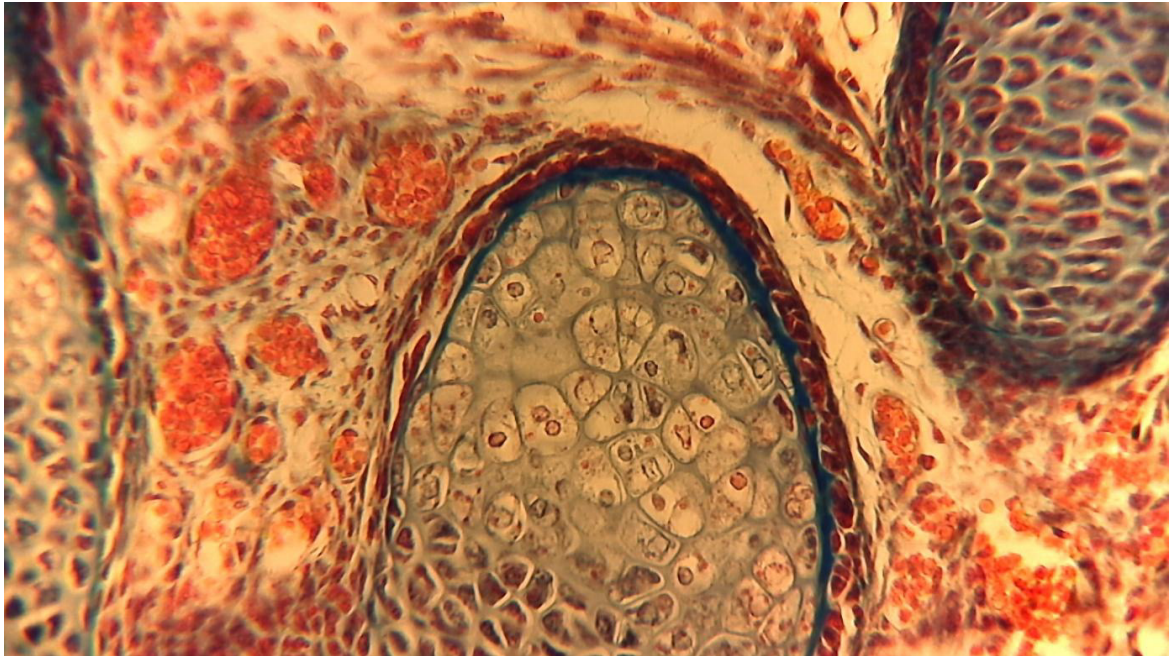


Fig. 13. Image from camera with Meiji eyepiece on a 30 mm large-field tube von Carl Zeiss Jena in combination with a plan-corrected Leitz objective NPL 40/0.65, rat embryo, cartilaginous vertebral column, bright-field, usable result despite missing compensating eyepiece.



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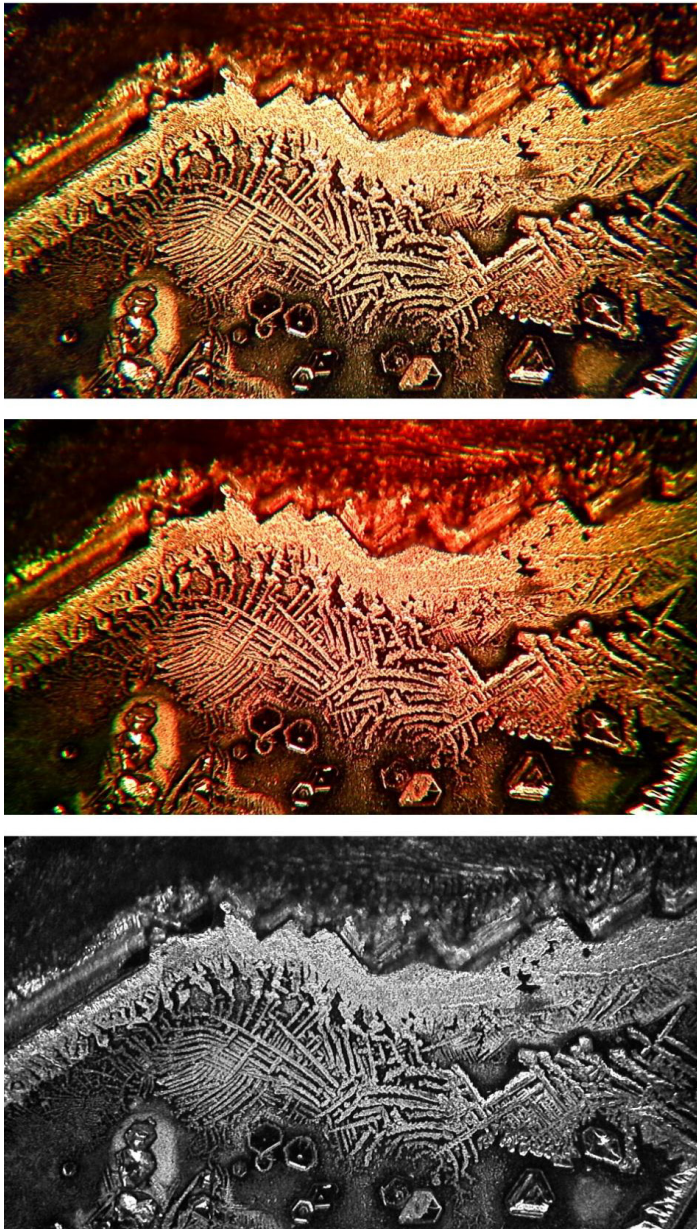


Fig. 14. Camera with Meiji eyepiece a 30 mm large-field tube von Carl Zeiss Jena, Leitz plan-corrected scanning objective PI Fl 4/0.15, alum crystal without cover slip, dark-field, unfiltered halogen light (top), "minus-violet" type filter (Baader Semi-Apo-Filter, middle), monochromatic green filter 540 nm (Baader Solar-Continuum-Filter, below). Focus with One-Push autofocus.



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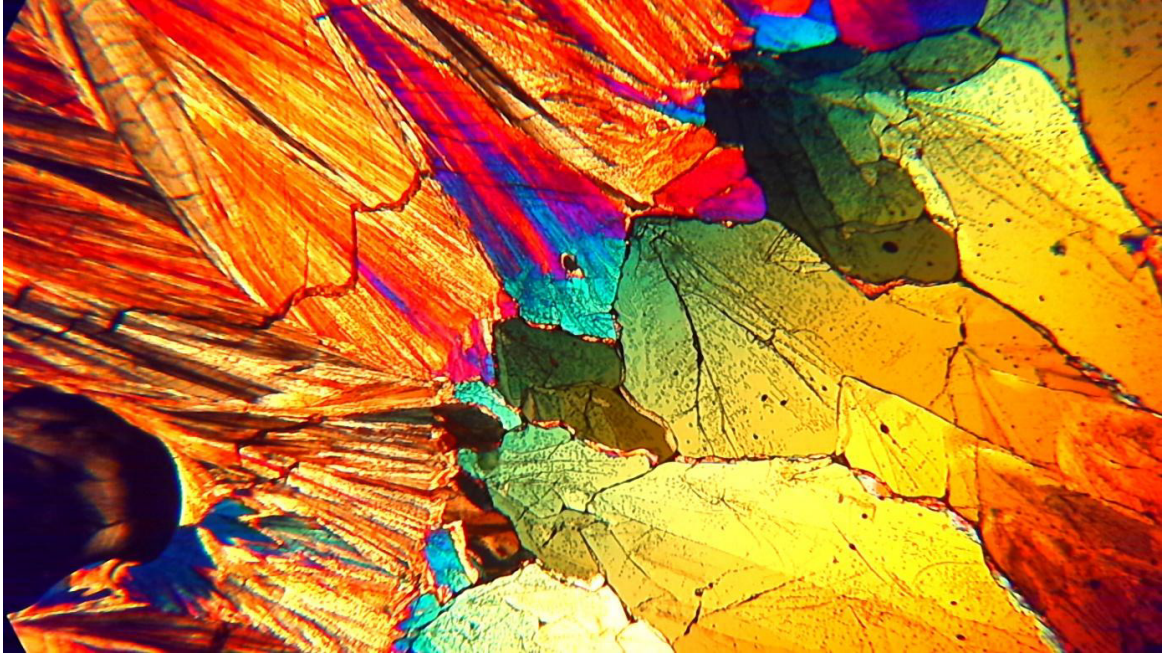


Fig. 15. Camera with Meiji eyepiece a 30 mm large-field tube von Carl Zeiss Jena, Leitz plan-corrected scanning objective PI 2.5/0.8, xylit crystal without cover slip, polarization, lambda compensator, One Push autofocus.

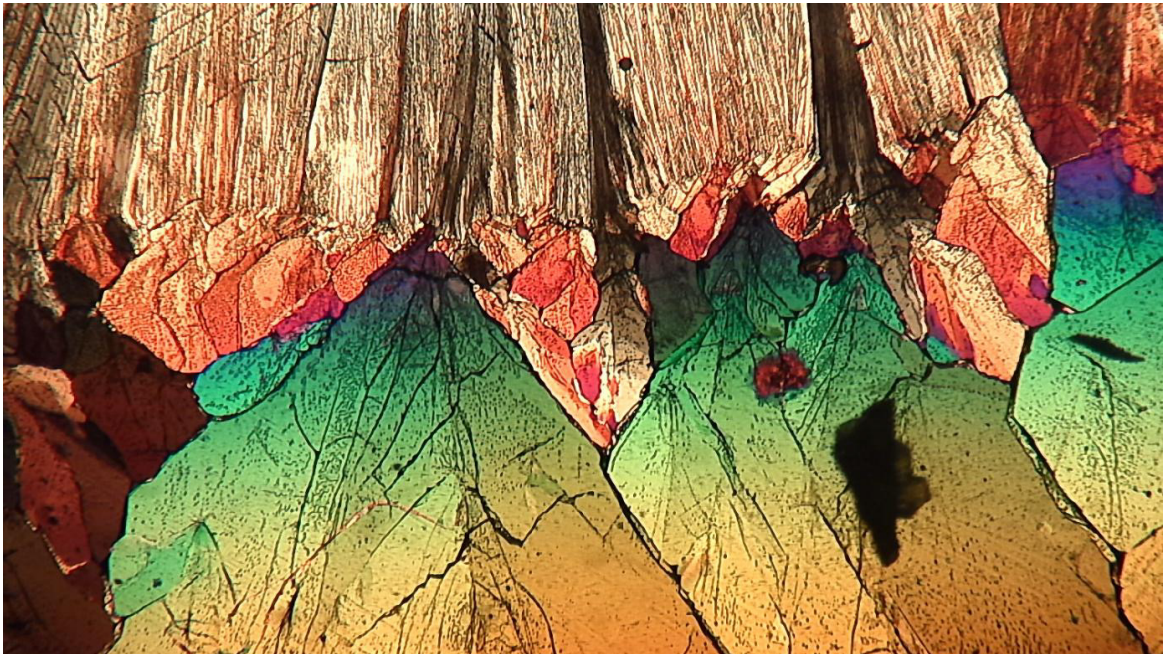


Fig. 16. Camera with Meiji eyepiece a 30 mm large-field tube von Carl Zeiss Jena, Leitz plan-corrected scanning objective PI FI 4/0.15, xylit crystal without cover slip, polarization, without compensator, One Push autofocus



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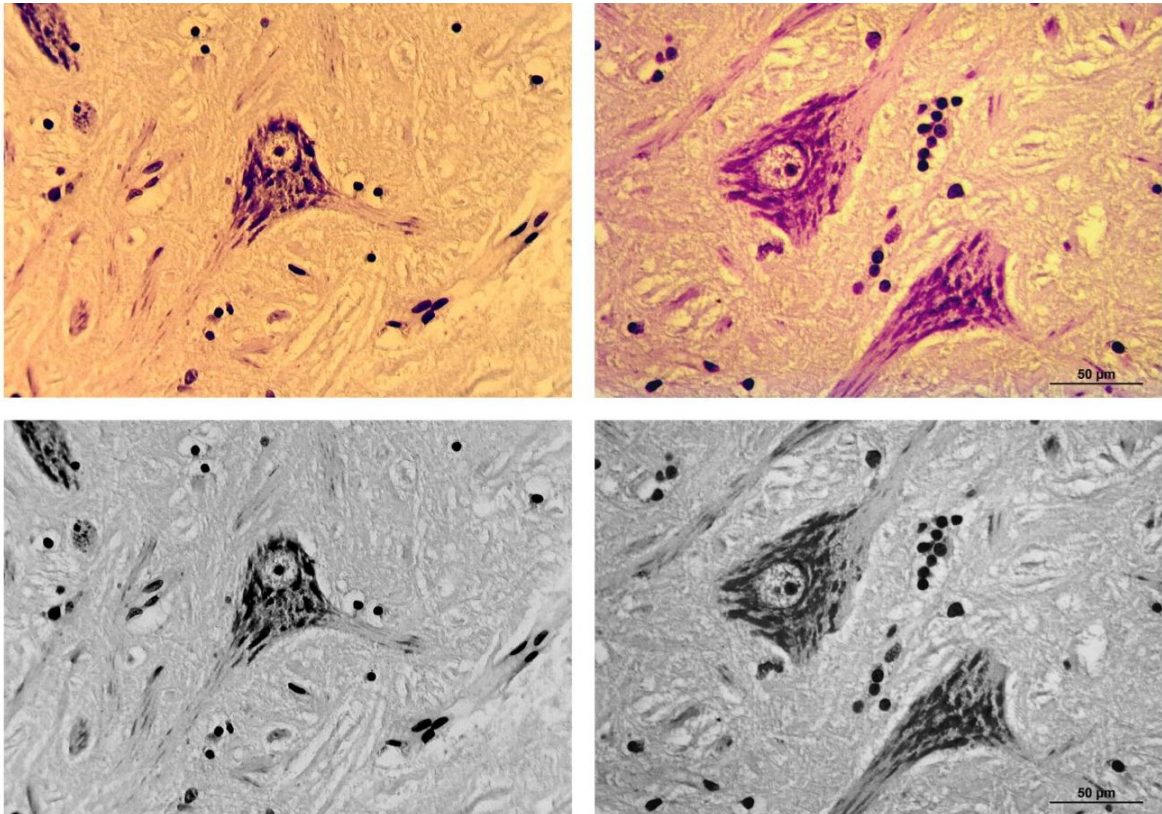


Fig. 17. Nerve cell specimen from Figs 7-9 and 11, Microscope: Leica DMLB, Objective: Plan 40x, bright-field, tested camera used with Meiji eyepiece (left), Leica camera MC 170 HD (right), color images (above), black-and-white conversions (below).



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Comparison with a Leica Add-on Camera

Even though a direct comparison of two different cameras can be problematic because of the diverse parameters and factors which may influence the results, nevertheless a comparison between the test subject of this article and the Leica MC 170 HD for orientation purposes should not be excluded. Using the Leica microscope DMLB, we started by photographing the neurons (in bright-field) of the specimens from Figs. 8, 9 and 11 with the aforementioned Leica system camera (using the microscope's original 40x Plan-corrected objective). The camera was affixed as designed by the manufacturer on the C-mount head of the trinocular photo tube. The image displayed on the monitor had to be manually adjusted because the Leica camera is not equipped with One-Push autofocus. Subsequently for purposes of comparison, the same Plan-corrected objective was used with the camera / eyepiece combination from The Imaging Source to image the neurons of the same specimen (selective One Push autofocus was used here).

The Leica camera delivered a resolution of 2592 x 1807 pixels; the highest-possible resolution (4128 x 3096 pixels) was selected for the camera from The Imaging Source. The neurons were imaged significantly smaller by the later camera and its 10x eyepiece than in the case of the Leica camera and its special projective lens. Consequently, a section of the larger overall image (4128 x 3096 pixels) could be cut out which exactly corresponds to the original image size of the of the Leica camera (2592 x 1807 pixels); now both single images displayed the neurons in almost the same magnification. The panel of images in Fig. 17 juxtaposes the resultant images; in addition to the original color images, optimized black and white conversion images were also created. This comparison shows that for routine applications, such as the documentation of bright-field images, the camera from The Imaging Source need not fear comparison with a leading manufacturer's modular camera solution as it pertains to image quality.

Software

The software downloads which can be found on the manufacturer's website (Driver, Capture, Presenter) were easily downloaded and installed; all of the parameters and functions worked perfectly and gave no cause for complaint. The function "vignetting" which can be activated from the "Effects" menu is especially useful as it effectively reduces the brightness drop off at the image periphery.

When black-and-white images are needed, color saturation need only be set to "zero" (Fig. 4 slider bar "Saturation" in the toolbar window below left between "Zoom" and "White Balance Red").

It should be mentioned, however, that the HDR function used in the software only substantially lightens dark areas of the image moderately well, but nevertheless does not significantly improve overexposed areas of the image. Regarding this, specialized HDR software offers a much wider variety of contrast correction possibilities.



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Video Function

In order to test the video function, the camera was tested on a "gamer" laptop (Dell XPS M 1730) which in 2008 was considered to have a "high-end" performance standard and consequently was still a high-performance computer but which was no longer considered to be state-of-the-art. This choice of computer should reflect real-world conditions since by far most operators will not continually purchase the newest generation computer; the camera should, therefore, function on a somewhat older system if it should be of interest to a larger group of potential users. In order to ensure compliance with the required USB 3 standard, the laptop was fitted with a USB 3 ExpressCard Adapter.

The IC Capture software allows one to choose from 16 different video codices which do not all work on the aforementioned computer.

When one wishes to capture moving objects on video, it is advantageous to be able to follow the microscopic live image in real time on the monitor since such objects must, when necessary, be followed and their movement adapted to by adjusting the slide.

At full HD resolution (1920 x 1080) and maximum frame rate (30 FPS), only the use of a video codec enabled fluid observation of the live image on the above-mentioned laptop during the real-time recording: Y800, a codec for black-and-white videos. At full resolution and frame rate, its data volume amounts to around 34 MP per second. So whoever would like to capture detail-rich black-and-white videos at 30 FPS with full HD resolution while maintaining unrestricted real-time tracking of the live image is well served by this video codec.



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An additional video codec for black-and-white (Microsoft RLE) delivered a smooth, trackable live image during live recording after the resolution was reduced to 1600 x 1200 pixels and the frame rate to 15 frames per second. The reduced data load at this setting, however, corresponded to only a 19 MB reduction per film second.

For color videos, on the other hand, there is no codec which would, at maximum frame rate (30 FPS) and full HD resolution (1920 x 1080), enable parallel recording and smooth live-observation via the monitor. At 30 FPS, only the "unspecified" mode delivered a smooth image in real-time when the resolution was reduced to 1280 x 720 pixels (data volume: 45 MB per second). At a lowered frame rate (15 FPS), the following codices enabled real-time observation via monitor during video recording (information given for resolution and data volumes): "unspecified" (1280 x 960, 39 MB/s), RGB 24 (1280 x 720, 43 MB/s) and Microsoft Video 1 (1280 x 960, 1.7 MB/s high data compression!). "Unspecified" and "RGB 24" largely comparable and usable results. Because of its high data compression and resulting pixilation (or more specifically, the spotty image artifacts appearing in homogenous areas), "Microsoft Video 1" shouldn't be used if a lot of importance is placed on high image quality.

A short video clip (full HD, codec "unspecified") of the epithelial cell phase contrast specimen from Fig. 10 taken using a student microscope Leitz HM-Lux 3, Periplan-GF-Eyepiece 10x and Phaco L 32/0.4 objective can be found on the internet. This clip illustrates the realization of a video sequence using simple microscope equipment. The phase contrast produced on the student microscope used was created without Köhler illumination but instead with simple annular phase rings which were inserted in a bright-field dry condenser. Using the lens-free tube, the camera body (without the included eyepiece) was, as described earlier, placed directly over one of the Leitz-Periplan eyepieces.



Microscope Camera "DFK MKU130 – 10x22"

Use of the Camera without Microscope

Since the camera body has its own lens with autofocus and zoom function, it can in principle be used as an imaging device on its own. The lens-free tube was removed here for reasons of expedience since its outer edge cast a round shadow in the field of view. It was found that this "mini-camera" has a very wide range of settings: from infinity to approximately 4 cm. At the minimum focusing distance an object length of 5.5 cm was recorded (this corresponds to an aspect ratio of 1920 x 1080). Even here, the zoom can be used freely. The sample images shown in Figs 18 – 20 attest to the camera's large depth of field and high image resolution in stand-alone operation. More advanced macro functionality can be realized by equipping the camera with a close-up filter and flash system which can work to augment the camera's own zoom optics. For orientation purposes, an achromatic close-up filter and flash system (20 diopters) from "Magniflash" was used (Fig. 21) in such a way that at minimum focusing distance (without activation of the zoom) an object length of 2.5 cm was measured with high resolution, sharp focus and with little influence from field curvature in the way of image distortion. If motion blur is to be avoided, however, a set up like this is no longer manageable without an adjustable tripod. The "Magniflash" system was examined in depth in an earlier issue of this magazine (Mikroskopie 2014;1: 39-51).



Fig. 18. Image from camera without ocular and tube. Hand-held snapshot taken out of a window demonstrating camera's depth of field. Metal latticework is approximately 1 meter away whereas the house is approximately 50 meter away.



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Fig. 19. Image from camera without ocular and tube. 1 Euro coin. Hand-held snapshot, camera propped up on a book (5 cm thick), diffuse ambient lighting.

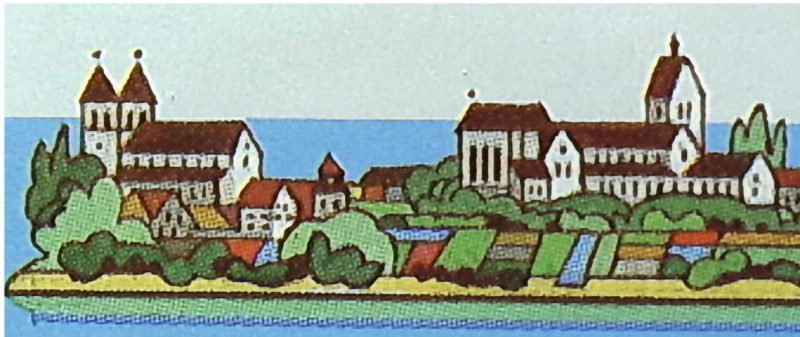


Fig. 20. Details from stamps. Hand-held snapshot, camera propped up on a book (5 cm thick), diffuse ambient lighting. Halftone grid lines are visible.





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Conclusion

With the camera presented here, the manufacturer has made an important contribution to the concept of the "universal camera." In comparison to other add-on cameras where upon disassembly an operator could look at the sensor directly, the camera tested here presented a complete and self-contained device – comprised of a lens system, autofocus and small-dimensioned aperture. These components ensure a deep depth of field and efficient correction of any deviations from the ideal focal plane. Which is why, according to our testing, this camera is capable of delivering usable images from diverse microscope designs and manufacturers. The manufacturer-provided eyepiece is made for tubes with an O.D. 30 mm and a fully corrected intermediate image. When the intermediate image is not fully corrected, it is a matter of "luck" as to how much the residual optical error will cause a visible reduction in quality.

The camera's universal application is further supported by the fact that the camera is not limited to its own eyepiece but can also be used in conjunction with the original eyepieces of various microscope manufacturers. In this way of course, the problem of the uncorrected intermediate image is avoided altogether by combing the camera with the original compensating eyepiece.

The camera sensor has proven itself very efficient; it can indeed "keep up with" the sensors from much costlier and more complex designs of leading microscope manufacturers. When the complete field of view needs to be imaged, it is a disadvantage that the edge focus of the included eyepiece is less than ideal. For images with perfect edge focus, only the middle two-thirds of the field of view should be used. Other Plan-corrected large field eyepieces from leading manufacturers can – also in combination with the camera – deliver visibly better edge focus.

A real "highlight" is the averaged and selective autofocus. This works so quickly and accurately that it delivers reproducible precision in image focus which (depending on the eye) could be seen to rival, or even be superior to, subjective visual focus.

All in all, the camera offers excellent features as well as an excellent price-to-performance ratio. With regards to the video function, it could be discussed if a video recording via standard camera or video camera might be advantageous since, as a rule, these easily produce real-time images on the monitor even while recording in color at full HD and additionally require less disk space than the AVI format.

As a positive side effect it should be noted that the camera as such, outside of its application in microscopy, can also be used for photos and videos which feature excellent depth of field and whose quality (especially in close ups) is more than adequate for simple documentation purposes. According to our tests, the camera could even prove itself useful for some medical applications such as the quick documentation of wounds and other changes in the skin or as a dental camera.



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Constructive Suggestions for Further Development

It would be desirable, if the camera came with even higher performance eyepieces with less field curvature than the Meiji eyepiece with which is currently equipped. Additionally, it would be suggested that several camera tubes of various or variable (i.e. adjustable) diameters be made available. This could be accomplished with relatively little effort since these are merely cylindrical tubes with a standardized screw thread. This would enable the customer to acquire a tube whose diameter properly fits their eyepiece head / eyepiece or which is made to adapt with fewer necessary adjustments. Because the software offers extensive options to manually adjust a multitude of parameters, a suggestion would be to integrate a "reset" function which with one mouse click would return the software to standard default settings.



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All weights and dimensions are approximate. Unless otherwise specified the lenses shown in the context of cameras are not shipped with these cameras.