

Consumer vs Scientific Digital Cameras

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INTRODUCTION

This article discusses a few key concepts of digital cameras, optics and associated software to illustrate scientific and economic differences between consumer and scientific digital cameras for scientists. Consumer digital cameras have gone from low resolution curiosities to very capable, high resolution, low-cost cameras. Depending on the intended use, consumer digital cameras could have a place in the scientific market.

Consumer digital cameras typically have a resolution of 2 to 5 megapixels per image, are portable, take pictures remote to a computer, and can be bought cheaply at any electronics store. Scientific grade cameras are more expensive, at least initially. But let's consider the scientific issues in camera selection and the true cost of the cameras in relation to image capture time.

RESOLUTION

The basic element of an image is the pixel. The number of pixels determines camera resolution and, generally, more pixels mean better image quality. Maximising the resolution in the final image is important. Each component in your imaging system has the power to degrade the resolution from a theoretical maximum, so the optimum solution is one that matches the resolving power of each component.

Imaging system resolution constraints in cameras are the microscope objective characteristics, optical coupler quality, and CCD chip size. In microscopy, microscope optics may be the limit to your system's resolution. Depending on the grade and magnification of your objectives, the resolving power of the system can vary. To calculate the resolving power of each microscope objective, consider the objective magnification-numerical aperture (NA) limit, the type of objective, the quality of manufacturing as well as the optical coupler magnification and characteristics.

An example of resolving power can be demonstrated using a 20x/0.5NA objective and either a 1.0x or 0.63x optical coupler. With the 1.0x coupler, the required camera resolution to obtain the highest resolving power of that objective is a 1275 x 969 pixel CCD resolution. Figure 1 shows two digital images of bone marrow: Fig 1a has a resolution of 1024 x 768 pixels, whereas Fig 1b has 2048 x 1536 pixel resolution. At normal digital zoom levels, small objects (red and white blood cells) appear to be resolved properly. When the same images are zoomed to 400% (Fig 2) the cells are resolved only at the appropriate resolution matched to the resolving power of the objective and coupler (Fig 2b).

OPTICAL COUPLING

The optical coupler, situated between the microscope and the camera, functions to properly size the microscope image to fit the camera's image sensor. Many baseline couplers are not designed for higher resolution digital cam-

eras or quality microscope objectives and tend to be priced higher due to the small number of adapters sold for consumer cameras.

SYSTEM COST

A consumer digital camera system for microscopes cost less than £2,000. This includes the camera, charger, spare battery and larger memory card, a card reader for the memory card, a quality optical coupler to attach it to your microscope, and software to manipulate your images. The typical scientific digital camera system costs up to £9,300, including the camera, coupler and software. Based on price alone, the consumer camera may seem like the economical choice, but this does not account for the actual time in capturing images.

EASE OF USE AND PRODUCTIVITY

Focusing and framing specimens with the consumer digital cameras is time consuming. Small LCD screens limit the visual field and focusing, changing settings entail camera removal and computer image transfer requires either a memory card or a transfer cable with camera restart. Recapturing images requires repeating the process. Capture speed is in multiple images per hour.

Scientific cameras allow real time monitoring, rapid focusing, framing, and image adjustment and near instantaneous image acquisition. Most camera software packages contain powerful features such as auto white balance, auto exposure, image enhancement and more advanced functions. Capture speed here is multiple images per minute.

Also, strongly consider software with a macro utility for automating image capture and processing functions. Productivity from macros can be an additional 20% or more.

THE ECONOMIC ISSUE

Price differences between consumer and scientific digital cameras can be demonstrated by actual capture time. Consider the following example of taking 48 images to document, four days a week. With a consumer camera at 1 image per 10 minutes, 48 images will take 8 hours work. The scientific camera at 1 image per 2 minutes can do the same in 1.6 hours. So the savings in time will be 6.4 hours, the sav-

Table 1:

Camera resolution table for determining microscope objective resolving powers.

Objective	Mag	NA	Lines per mm TV-Cpk 1.0x	Necessary Camera Resolution	Lines per mm TV-Cok 0.63x	Necessary Camera Resolution
Plan-Neofluar	1.25	0.04	96	1632 x 1229	152	2548 x 1946
Fluar	2.5	0.12	144	2448 x 1843	229	3893 x 2931
Plan-Neofluar	5	0.15	90	1530 x 1152	143	2431 x 1830
Achroplan	10	0.25	75	1275 x 960	119	2023 x 1523
Fluar	10	0.5	75	2550 x 1920	238	4046 x 3046
Plan-Neofluar	20	0.5	75	1275 x 960	119	2023 x 1523
Plan-Apochromat	20	0.75	113	1921 x 1446	179	3040 x 2291
Plan-Neofluar Multi-Imm	25	0.80	96	1632 x 1229	152	2548 x 1946
Plan-Neofluar	40	0.75	56	952 x 717	89	1513 x 1139
Plan-Neofluar	40	1.3	98	1666 x 1254	155	2635 x 1984
Plan-Apochromat	63	1.4	67	1139 x 858	106	1802 x 1357
Epiplan-Neofluar	100	0.90	27	459 x 346	43	731 x 550
Plan-Apochromat	100	1.4	42	714 x 538	67	1139 x 858

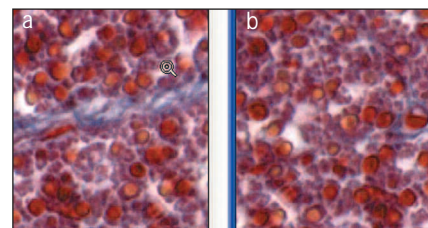


Figure 1:
Bone marrow: 20x 0.5NA, 1.0x coupler. (a) 1024 x 768 pixels. (b) 2048 x 1536 pixels. Cells appear normally resolved at normal zoom level.

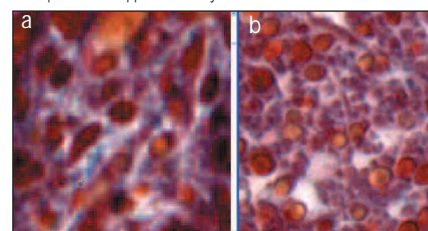


Figure 2:
Bone marrow. (a) 1024 x 768 pixels (400% zoom). (b) 2048 x 1536 pixels (400% zoom). At higher zoom, only the image on the right is properly resolved.

ings in money (at £25 per hour) would be £160 per day, or £640 per week. So the time to break even would be around 12 weeks.

SUPPORT

Last, strongly consider that only scientific digital cameras are supported by your local microscope dealer or other imaging professional. Adequate technical support for this important decision is critical.

CONCLUSIONS

In summary, although consumer cameras may have high resolution and low cost, the scientist must purchase a digital camera that addresses the actual resolution requirements, while not compromising the economics and productivity of scientific research. The term caveat emptor takes on an expanded meaning when considering the purchase of a digital camera for research.

AUTHOR DETAILS

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