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Digital Imaging: From Grains to Pixels

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Digital imaging is replacing conventional photographic techniques in light and electron microscopy. The continuing decrease in cost of this technology is even more amazing. The current cost of taking and storing a single SEM image is about .034 cents A publication quality 5 x 7inch print now costs about 20 cents.

This talk will examine photographic techniques and compare them directly to current digital imaging techniques and attempt to answer the question: Is a digital micrograph as good as a photograph?

This question is in constant debate in the world of photography and no clear answer has emerged. The main reason for this is that the "resolution" of film is not a simple value to obtain. It is perhaps better to talk about resolution in terms of the modulation transfer function of film which includes resolution and contrast considerations. The problem with this is that many photographers rate some images as "better" when the MTF rates it as poorer.

Photography with film is often called analog because the images are perceived to be continuous. This is not the case as the process involves light or electrons exciting silver halides' conversion to a microscopic grain of silver. The development process amplifies this grain (1000 fold) to produce the image. Our perception of tonal gradations groups these grains. A "pixel" is thus an artificial construct that allows us to quantize these groups of grains into the number of levels of gray that we require. As humans perception needs over 128 levels of gray to perceive a continuous tone we need a group that produces this many divisions. This construct is far from perfect so that detail may be present that is sharper than our pixel construct. This complex interaction makes a simple model inadequate.

In scanning electron microscopy, digital has replaced Polaroid film for all new microscopes. The classic 1,000 line resolution can be achieved comfortably by a digital 1280 x 960 pixel scan. The resolution of 35 mm film is closer to 3000 x 2000 (or slightly higher). It is not difficult to achieve this resolution with a Digital SLR. Interfacing to microscopes is facilitated because the digital camera body can couple to the light microscope with the same interface that the film SLR utilized.

In TEM, the question is more difficult. The resolution of TEM film is about 10,000 by 10,000 pixels. No current digital TEM camera meets this specification. Using film and a digital scanner can theoretically meet this resolution standard but there remains the question. How do the images compare? The answer may take some time to decide since it is still raging among professional photographers.

In order to replace photography, one also must produce a hardcopy. The latest Epson R800 has an extremely small drop size.(1.5 picoliter). The quality achieved when placed side by side with an 8 x 10 is truly amazing versus digital dots) The production of a photographic print produces silver grains in an emulsion on the surface of the paper. The digital print takes the pixels of the image and

converts them to dots. The dots of the Epson R800 are very small (1.5 picoliter) The dots are smaller than the eye can see but still do not approach the small size of photographic grains. (Fig 1a) (Dots that are visible to the eye are shown in the Epson 800 panel) If we perceive a continuous tone from the dots, we are now arguing about the grain size of the dots.

The question of storage is actually a non-issue. Storage is unlimited and free.(Unless you consider .034 cents a considerable operating cost) Storage is so expansive that compression should only be considered in limited instances that involve the internet (email and Web pages) This is only a temporary condition as the bandwidth of the "standard" internet will soon make compression have no place in scientific use.

The transition to digital is marching forward at a pace that no person could have envisioned. The promise of this new technology is that we will be more productive and will be able to produce images that are as good as the highest quality digital image. Until that time, I still have my darkrooms.

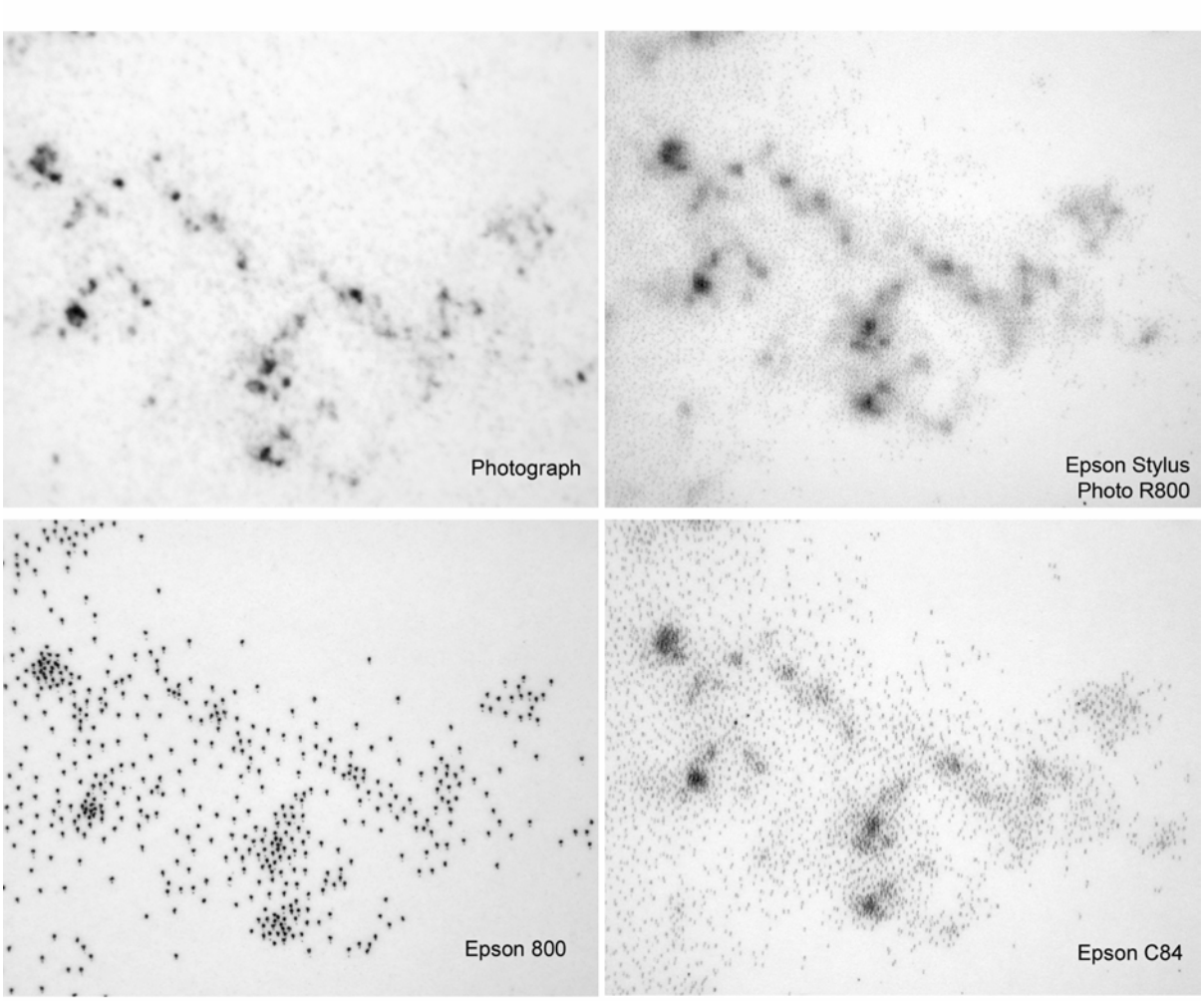

FIG. 1. Comparison of the grains in a photograph to the dot patterns of various Epson printers.

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