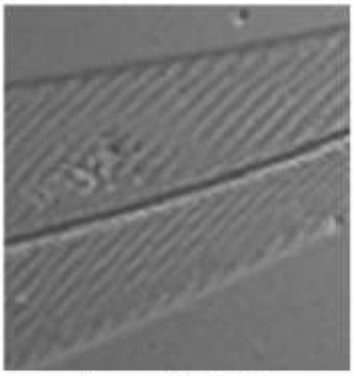
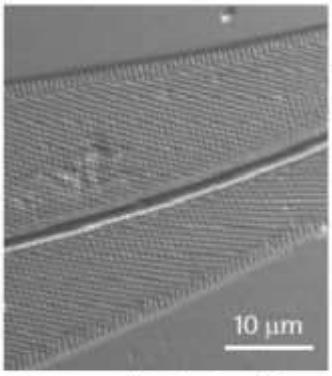
Box 31-1 Aliasing

Photons transmitted through, reflected off or emitted from a specimen comprise a continuous analogue signal. When these photons are transformed into a digital electronic signal, they can only be represented as discrete intensities and/or colours within pixels. This means that the analogue signal must be sampled, and the digital signal is only a representation. How good that representation is will depend whether or not you have taken Nyquist's sampling theorem into account. This is explained in the text.



An under-sampled aliased image



Correct sampling showing all the detail resolved by the objective

In order to record the image adequately, we must know the resolving power of the microscope, and sample the image so that (a) no high-frequency fine detail is lost nor (b) is spurious information encoded into the digital image by the sampling process. Both these events will occur through under-sampling, which leads to aliasing. The most well-known example of aliasing is the jagged edges – especially along diagonal lines - seen in under-sampled and pixellated images. Ultimately, contrast will be lost as well as resolved detail.

Original size, pixel size = 35 µm

4x zoom, pixel size = 141 µm

Correct display size of the 2x zoom image, pixel size = 70 µm at half-size to avoid aliasing & pixellation

8x zoom, pixel size = 282 µm

32x zoom, pixel size = 1.10 mm

Correct display size of the 4x zoom image, pixel size = 141 µm, at quarter-size

An aliased signal provides a poor representation of the analog signal. When aliasing happens, the original analogue signal cannot be correctly reconstructed by the digital dataset.

Continuous signals of differing frequency become indistinguishable from one another (aliases of one another) when sampled.

Aliasing can be seen as Moiré fringing displayed as a false period in images with regular features. It also occurs where the display device has a periodic structure, such as CCD or TV monitor with geometric pixels or raster lines.

Since Nyquist's sampling criterion also holds good for temporal sampling as well as sampling in the x,y,z spatial dimensions, this is the reason why aliasing can be seen in old films which are under-sampled when they are digitised or displayed on TV. A well-known example is the appearance of spoked carriage wheels turning differently, or in reverse, behind a galloping horse. The number of frames per second by which the film is sampled does not match the speed of the wheel, or else the rotating wheel is illuminated by flickering light of a different frequency to the true rotation.