The *JCB* will let your data shine in RGB

Mike Rossner[1] and Rob O'Donnell[2]
[1]Managing Editor, The Journal of Cell Biology
[2]Electronic Publishing Director, The Rockefeller University Press

The Journal of Cell Biology

The Editors of the *JCB* are pleased to announce that we will now be requesting that authors submit their color image files in RGB format, and we will post these files in this original format on our web site.

"I need someone well versed in the art of torture—do you know PowerPoint?"

©The New Yorker Collection from cartoonbank.com.

CMYK vs. RGB
Color images are printed on paper by separating their colors into four component parts: cyan, magenta, yellow, and black (**CMYK**). Each of the colors in an image is created by assigning a percentage from 0–100 to each of the aforementioned colors (for example, a red color could be created from 0% cyan, 100% yellow, 100% magenta, and 0% black). The color image is then printed on a multipass or multiplate press, with a single piece of paper receiving ink from each of four plates.

CMYK is referred to as subtractive color (i.e., the color black is achieved by the presence of all inks), as opposed to **RGB** (red, green, blue), which is additive color (i.e., the color white is achieved by the presence of all three colors as lightwaves). RGB is the color process used by computer displays and can generate many more colors, and more vivid colors than those that can be generated by CMYK.

Maximizing image quality
The *JCB* has always worked to reproduce the highest quality images in print. In particular, we have taken pride in the quality of color image reproduction. Before we accepted electronic figure files from authors, all figures were scanned to produce files to incorporate into our layout software. Color scans were done in CMYK format, to match the printing mode. In the mixed work flow of the transition to a completely electronic work flow (when we were ac-

cepting both hard copies and electronic files), we requested that authors submit files in CMYK format to match the format in which hardcopy figures were scanned for printing. These figures were then converted to RGB for posting online. Thus, authors' original data was being converted from RGB format to CMYK and back to RGB for posting online, with a loss of quality in each conversion.

Since June 1st of this year, the *JCB* has encouraged all authors to submit their manuscripts electronically. This is now a requirement. With a completely electronic work flow, we have now decided to make the online version of the journal the "journal of record" and to optimize the reproduction of color images online by posting them without any conversion of the colors from the original. This does not mean that we want the print version to look substandard, but we will not be using the print version as our standard. As such, authors will now receive their figures proofs only electronically, and they must understand that the print version may not have the same color quality.

Our printer is working on an RGB to CMYK converter that will produce

better print quality than the built in converter in Adobe Photoshop, because it will be specific to the profile of their color printing presses. This converter will be used to convert authors' RGB files to CMYK for printing.

Other file formatting issues
In addition to color mode, we have other requirements for the file formats and image resolutions of figure files. In the light of the confusion that we have encountered from authors about these requirements, we'll take this opportunity to explain them.

The requirements serve three purposes. They ensure that:
- sufficient information is present for reproduction of high quality images;
- that information is not lost or compromised at any step along the way; and
- file formats are compatible with our production software.

Choosing the correct image resolution
People refer to the size of an image in various ways, such as length by width, total number of pixels, or number of megabytes that it takes to store on a

computer disk. For the purposes of this editorial, **image size** is defined as the total number of pixels in the image. A **pixel** is a square (or dot) of uniform color in an image. The size of a pixel can vary, and the **resolution** of an image is the number of pixels per unit area. Although resolution is defined by area, it is often described using a linear measurement, dots per inch (**dpi**). Thus, 300 dpi indicates a resolution of 300 pixels per inch × 300 pixels per inch = 90,000 pixels per square inch. The *JCB* is printed in the United States, and certain steps in the production process do not handle files measured in dots per centimeter (Adobe Solutions Network, 2003). We thus maintain the American-centric request that resolution be measured in dpi.

The resolution requirements for the *JCB* are listed below (for more detailed information, see Instructions to Authors: http://www.jcb.org/misc/ifora.shtml). **Note that this should be the resolution of the image at the dimensions at which you want to have it printed.**

300 dpi for micrographs. This has been determined by our printer as the minimum resolution required to prevent "pixelation" of images (i.e., to not see individual pixels) when the image is printed on paper.

The best digital cameras these days can acquire an image of 6 megapixels in size. This can generate an image of ∼2,400 × 2,400 pixels, or 8 inches × 8 inches at 300 dpi. Note that, with the right settings in Photoshop, physical size and resolution can be traded off against each other without a gain or loss in the amount of information. That is, you can resize an image without altering the number of pixels. Thus, a 1 inch × 1 inch image (too small for printing) at 900 dpi will convert into a 9 inch by 9 inch image at 100 dpi (insufficient resolution for printing) or a 3 inch × 3 inch image at 300 dpi (just right for printing).

You should be aware of the resolution at which the image was acquired by the digital camera on your microscope. When that file is imported into an image manipulation application such as Adobe Photoshop, you may get an option to set the size and resolution of the image. If the total number of pixels in the file you create is greater than the total number of pixels in your original, the computer has just created image data for you that was not present in the original. Digital images may also be acquired using a scanner or a phospho- or fluorescence-imager, and it is also important to know the resolution at which these types of images were acquired.

Choosing the correct application: The problem with PowerPoint

Adobe **Photoshop** is an image-processing application. The only way to properly ensure the integrity of the resolution of your original image is to open it in Photoshop at the size and resolution at which it was acquired.

Microsoft **PowerPoint**, however, is presentation software. That is, it is meant to create figures that will be projected on a screen, not printed. You may be able to obtain a nice printout of your PowerPoint files, but that is because the printer driver is creating resolution to place on the paper.

The main problem with PowerPoint files is that they cannot be imported into the desktop publishing application that we use for typesetting and layout (Adobe FrameMaker). The only formats that can be imported are TIFF or EPS (see below). Authors often ask if they can convert their PowerPoint files into usable TIFF or EPS files. The simple answer is no. PowerPoint files can be output as TIFF or JPEG, but this is at 72 dpi. If you open these files in Photoshop and artificially bump them up to 300 dpi, they will be very poor quality, and, once again, you have used your computer to create data. If our production editors receive these sorts of files, they will usually get back to you to request that you make new ones.

This is not meant as a commercial plug for Adobe Photoshop. If there are other applications that can handle your data in the same way, by all means, use them.

Choosing the right file type

The Photoshop images that we have been discussing represent one of two major file types. In these **rasterized** images, the color properties of each pixel are defined (Rossner et al., 1998).

Illustration applications such as Adobe Illustrator can create "object-based" graphics, in which fine lines, curves, and objects are determined through mathematical definition (or **vectors**). These files can be converted to a pixel format (rasterized) by a printer driver or by saving as a different file type. In this process, the graphic can be rendered at any resolution using the vector information.

The two standard file formats for saving digital images have different capabilities when it comes to bitmapped and object-based graphics. EPS (Encapsulated PostScript) files can be used to encode both file types, whereas tagged image file format (TIFF, or TIF format) can be used only for storing rasterized images.

We recommend preparing line art in an illustration application and saving it in EPS format. Photographic images should be handled (including labeling) in Photoshop and saved in TIF format.

For figures containing a combination of line art and photographic images, we recommend preparing the images in Photoshop (at ≥ 300 dpi, as noted above), saving them as TIF files and placing them in an Illustrator file containing the line art. Save as EPS.

Choosing the right image mode

RGB vs. CMYK (see above). The *JCB* now requests figure files in RGB mode.

Grayscale. Images with any shades of gray must be saved as grayscale. A grayscale image in Photoshop is usually encoded at 8 bits/channel, where each pixel is assigned a tonal value from 0 (white) to 255 (black). That is, there are eight possible binary bits of data ($2^8 = 256$) to define each pixel.

Minimizing file size

One of the basic techniques for keeping image files to a reasonable size is to crop closely around the image. You do not have to submit files with borders that bring them up to the size of the printed page. If the file has been generated with layers, they should be flattened in the final file to reduce its size. If a figure has only grayscale images, it should be saved in grayscale format, not RGB format. Finally, images can be acquired at up to 16 bits per channel. To reduce file size,

they should be converted in Photoshop to 8 bits per channel.

Some examples of typical file sizes:
RGB: A 6 × 6 inch image at 300 dpi should be an ∼10 Mb TIFF file.
Grayscale: A 6 × 6 inch image at 300 dpi should be an ∼3 Mb TIFF file.

If your files are considerably larger or smaller than these examples, there is probably something wrong with the way they have been prepared.

File compression
File compression is generally not possible with files submitted for publication. There are "lossless" compression schemes, such as LZW (Lempel-Ziv-Welch), that compress data without deleting any information. However, these schemes are not compatible with our online submission system's automatic PDF generator, and cannot be used with the files you upload. Note that JPEG and ZIP compression involves sampling algorithms, so you would be losing data if you use them. It is tempting to acquire your image files in JPEG format to save disk space, but doing so compromises your data. Always use TIF format.

Conclusion
With this new RGB work flow, our goal is to reproduce your original data as accurately as possible, continuing the *JCB* tradition of leadership in image reproduction.

References
Adobe Solutions Network: Developer Resources. How to: TIFF files (to be resized) need their resolution specified as pixels per inch. http://support.adobe.com/devsup/devsup.nsf/docs/53251.htm (downloaded October 15, 2003).

Rossner, M.T., M.J. Held, G.P. Bozuwa, A. Kornacki. 1998. Managing editors and digital images: shutter diplomacy. *CBE Views* 21:187–192.