Setting White, Black and Gamma on Continuous Tone Grayscale and Color Images using Photoshop

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The contrast range of many digital images needs to be reset before outputting images to various ends. This is especially important when printing to paper because ink absorbs into papers through a capillary action, most in the cheapest papers (such as newspaper) and least in high gloss paper from slick magazines. The capillary phenomenon is known as dot gain in the printing world, since images are redefined as small dots when printing to publications. The result of dot gain is seen most in a loss of details or muddiness in the shadow or the black region of images.

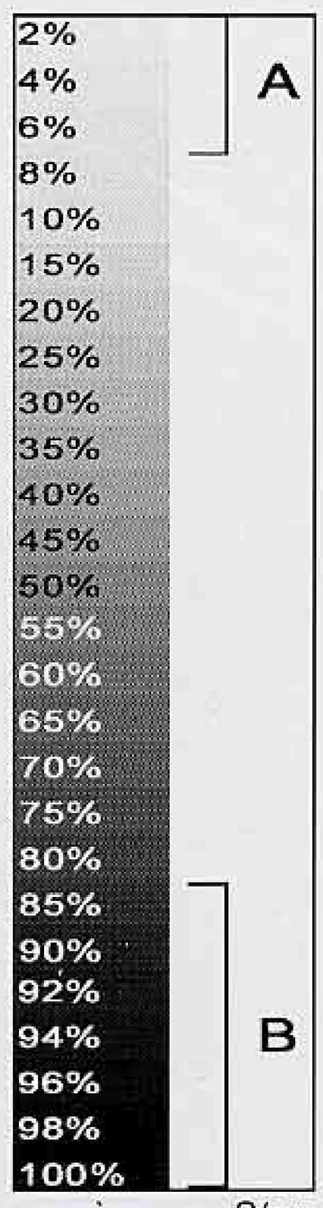
Cheaper paper also has the tendency to resist the absorbance of ink when minute amounts are laid down in the white end of images where the palest whites exist. In the middle gray ranges known as the midtones, all papers have better capacity to show differences in the levels of gray and in gradients, depending on the frequency, shape and size of dots making up the image (the greater the frequency—often described as dots per inch—the greater the capacity to show gradations in midtones).

Coupled with the narrow dynamic range of inked paper from the whitest whites to the blackest blacks is our own eyesight, limited in its ability, also, to see differences among blacks. The computer is able to accurately measure differences in blacks we find difficult to see unless we use visualization methods such as pseudocolor to amplify those differences.

In this discussion, remember that "blackest blacks" also refers to the dark end of colors, especially the color blue. It does not, however, refer so much to the lighter end of colors, unless the colors are so oversaturated that these areas turn absolute white (take care not to do so). The whitest whites that are unprintable on ink-resistant papers generally do not include bright colors; just the whitest whites.

In the end, it makes little sense to keep the deepest blacks and, depending on output, the whitest whites, since these will not output to many devices and we cannot distinguish between the deepest blacks by eye anyway. In order to do that, some adjustments need to be made in Photoshop to reset blacks and whites, and to amplify the midtone range.

Various words are used to describe the black end, the white end and midtones of images. In software, these are often labels next to sliders that make adjustments. When a slider adjusts the black end (usually setting the darkest black point above 0 so that no pixels in the image "saturate," or remain at 0), it is called among other things, Black Level and Contrast. When the slider adjusts the white end (usually setting the whitest pixel value below 255 for an 8-bit camera, 4095 for a 12-bit camera and 65,536 for a 16-bit camera to avoid saturation at the white end), this is labelled, among other things, Gain, White Level, and Brightness. Only one word is commonly used for adjustments to the midtones, and that is Gamma (sometimes "Enhance" is used). Adjustments to the Gamma should not affect the black end or the white end of images, but it will affect linearity of dark to light and should not be adjusted when subsequently measuring pixel intensities.



Step wedge divided into K values. Printing problems, especially with cheaper papers, occur within regions A and B.

To make adjustments in Photoshop with the final output of that image in mind, adjustments to the white and black levels need to be made, as well as to the gamma. Typically digital cameras and laser/PMT systems create blacks that are too dark for output devices, and these need to be lightened. The whitest whites need to be "grayed" just a bit. The gamma, especially with many EM images, needs to be made more contrasty. Remember, these steps are only carried out when preparing a continuous tone image for subsequent output (not a graph, line drawing or most artwork). Here's a way to do that using tools in Photoshop:

First, set up the tool and the dialogue box that you will be using. Open your image of interest, or select the layer upon which your image resides. If it is a figure or plate consisting of several images, and the plate has been flattened, first outline your image of interest with the marquee tool and fine tune the outline by choosing Transform Selection under Select on the menu—otherwise, the following steps will not only affect the image but everything else as well.

Next, click on the eyedropper tool (double click if version 4x or 5x). In the menu bar set the Sample Size to 5X5 Average (set the Sample Size using the Eyedropper dialogue box in 4x, 5x).

Now open the Info dialogue box. Under Window, select Info or Show Info. In the Info dialogue box, click on the top, right arrowhead to reveal a dropdown list: select Palette Options. Set the First Color Readout to Grayscale (click on arrow to reveal dropdown list and select), and the Second Color Readout to Actual Color. It is a good idea to retain settings because these reveal values that are important for contrast and color adjustments (one cannot rely on the color and contrast displayed on the computer screen: it's best to be able to read values to maintain predictable outcomes when going to print). Click OK.

The Info dialogue box now shows a K value in the top left

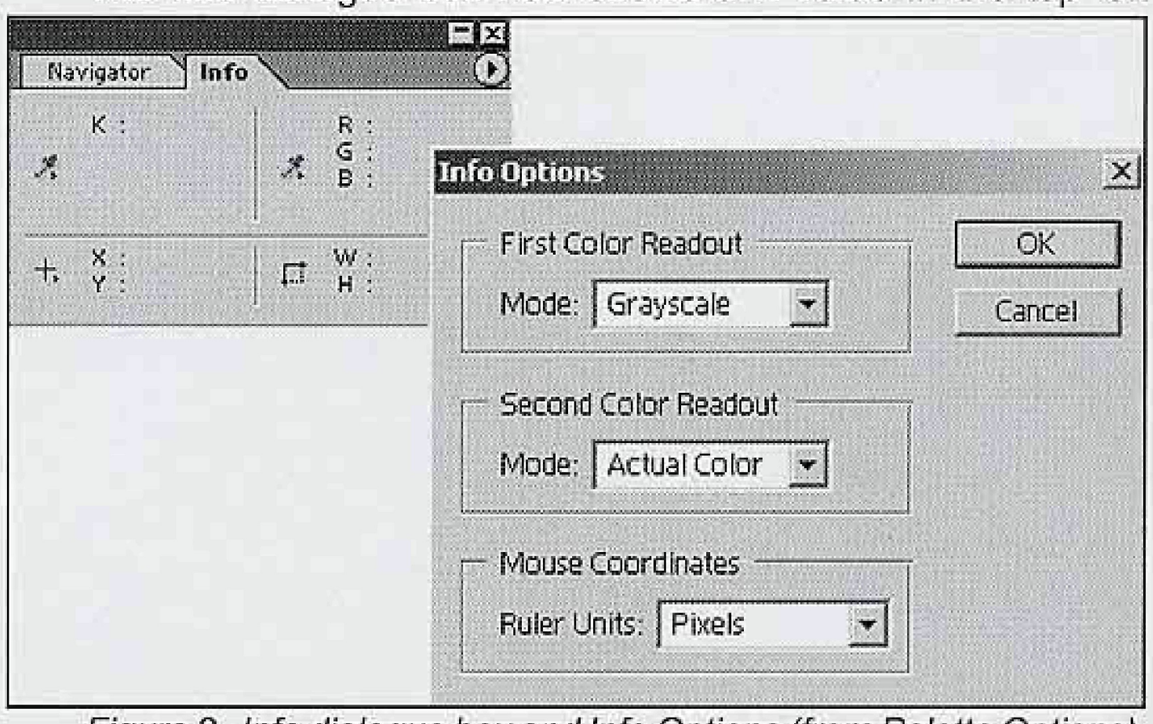


Figure 2. Info dialogue box and Info Options (from Palette Options). Set First Color Readout to Grayscale and Second Color Readout to Actual Color.

quadrant, and RGB (or CMYK) values in the top, right quadrant. The K value is a percentage that is based upon how much black ink will be placed upon the page when the image is printed. Thus, a 100% value would "tell" the printer to saturate with black ink and a 0% value would withhold black ink altogether. RGB values, on the other hand, represent black to white values which range from

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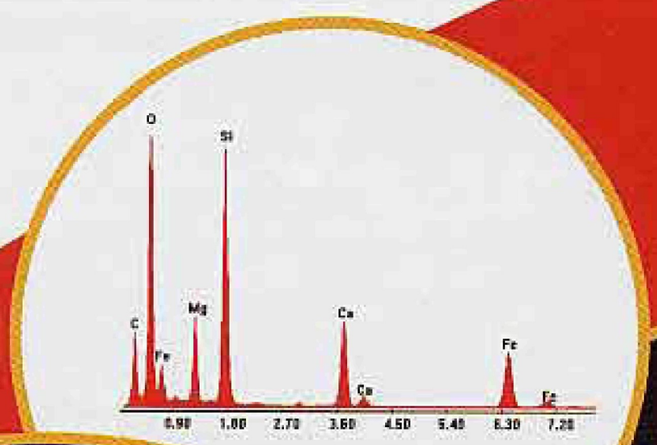

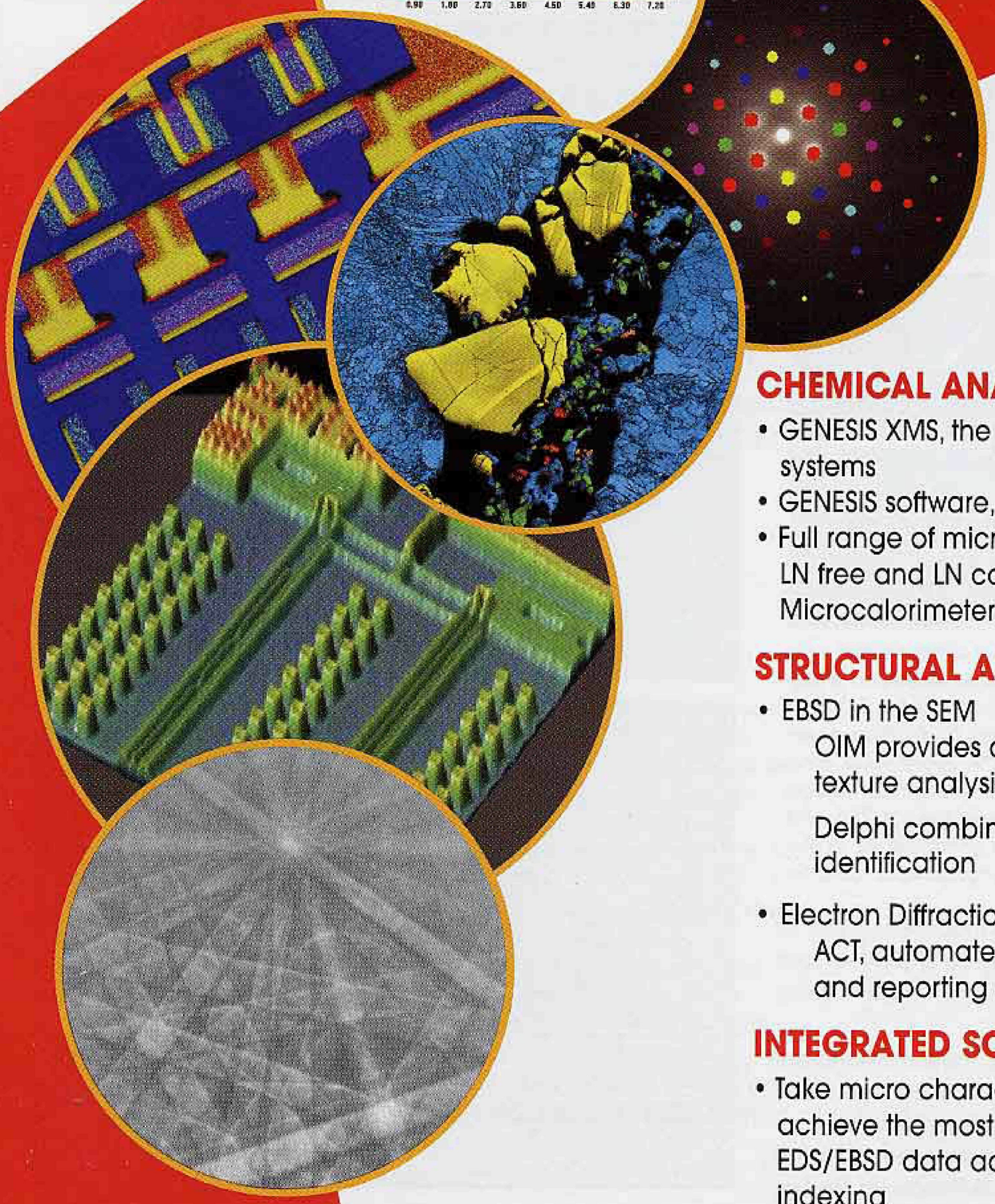

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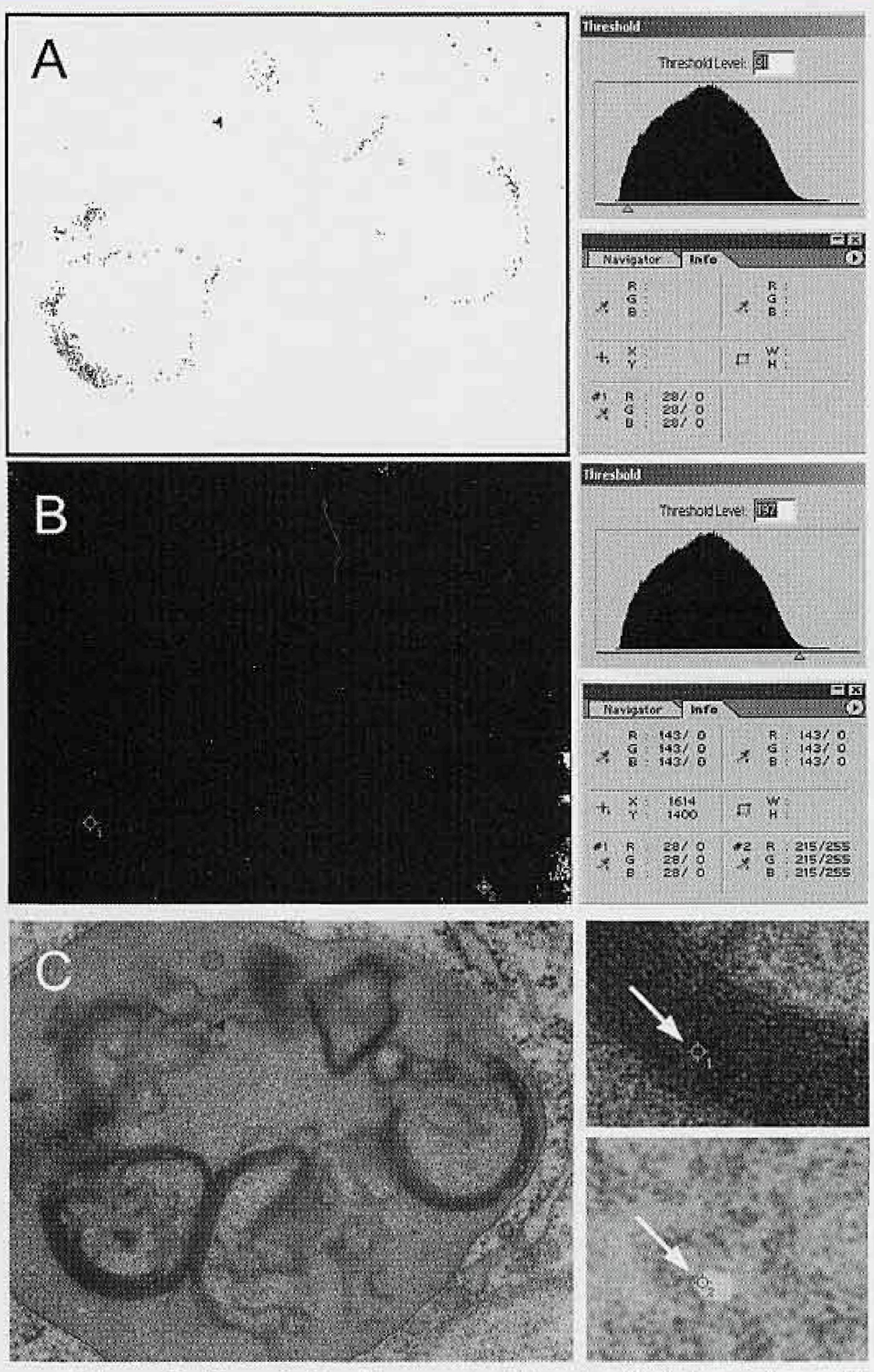

Figure 3. Thresholded image and Threshold dialogue box with Info Box readout. Top image (A) shows the image displayed when slider in the Threshold dialogue box is set closer to 0. Darkest or blackest value is marked with a location mark by holding down the shift key and clicking on that location with the eyedropper tool. The location is #1 on the Info dialogue box. The middle image (B) is thresholded by moving the threshold slider toward 255 and the brightest or whitest location is marked and given the #2 in the Info box. The bottom image (C) shows the original with location markers.

0 to 255 (for 8-bit images) in each color "channel" (red, green or blue, the combination of these three channels used to yield various hues). All three channels (red, green, and blue) are the same value when working with grayscale images.

These values are displayed as the cursor moves around the image displaying the gray value of the pixels that lie under the cursor. When using the eyedropper tool set at a 5X5 average, the value is an average of 5X5 pixels under the cursor icon, read from the end of the eyedropper (unless the cursor display was set to Precise in Preferences under Display & Cursors: then the eyedropper tool shows a crosshair cursor and the value is read from the centermost point). Move the cursor over your image until you are able to find the blackest black and the whitest whites by reading values in the Info Box. For darkfield images from the microscope, the black and white levels are fairly easy to locate because background covers so much area. Because of background noise, however, some variation of values will exist. Read several values to get a feel for the mean.

If the K value for blacks lie between 85% and 100%, then for most printing presses and laserjet printers, the ink volume is too great. The whites aren't quite as predictable, but as a general rule, if whites read 0% to 4% gray, then the values do not allow enough ink to be released. In any case, no values should read 0%.

Inkjet printers are different. Note that inkjet printers may be able to "handle" K values at the white and black ends. That's because the automatic software which comes with inkjet printers often re-calculates your image values to the capabilities of the printer/paper combination. If you can, set the inkjet printer software for the inkjet to use ICM or ICC values (values from your computer screen: for all practical purposes, something closer to the values read in the Info box). The inkjet with glossy paper will then print closer to what might be seen when the image is published.

How to find the blackest blacks and the whitest whites with brightfield and EM images

When looking at an electron micrograph or a brightfield image, these values may be more difficult to find. If you are unsure, then you can use the following technique not only to find these areas but to also create a location mark. This probably goes without saying, but be sure to avoid artifacts when finding these areas.

Under Image, select Adjust(ments) then Threshold. This dialogue box contains values which range from 1 to 255, from the darkest value (1) to the whitest (255). As the slider is moved toward 1, what remains as black indicates the darkest values. As the slider is moved toward 255, what is white indicates whitest values.

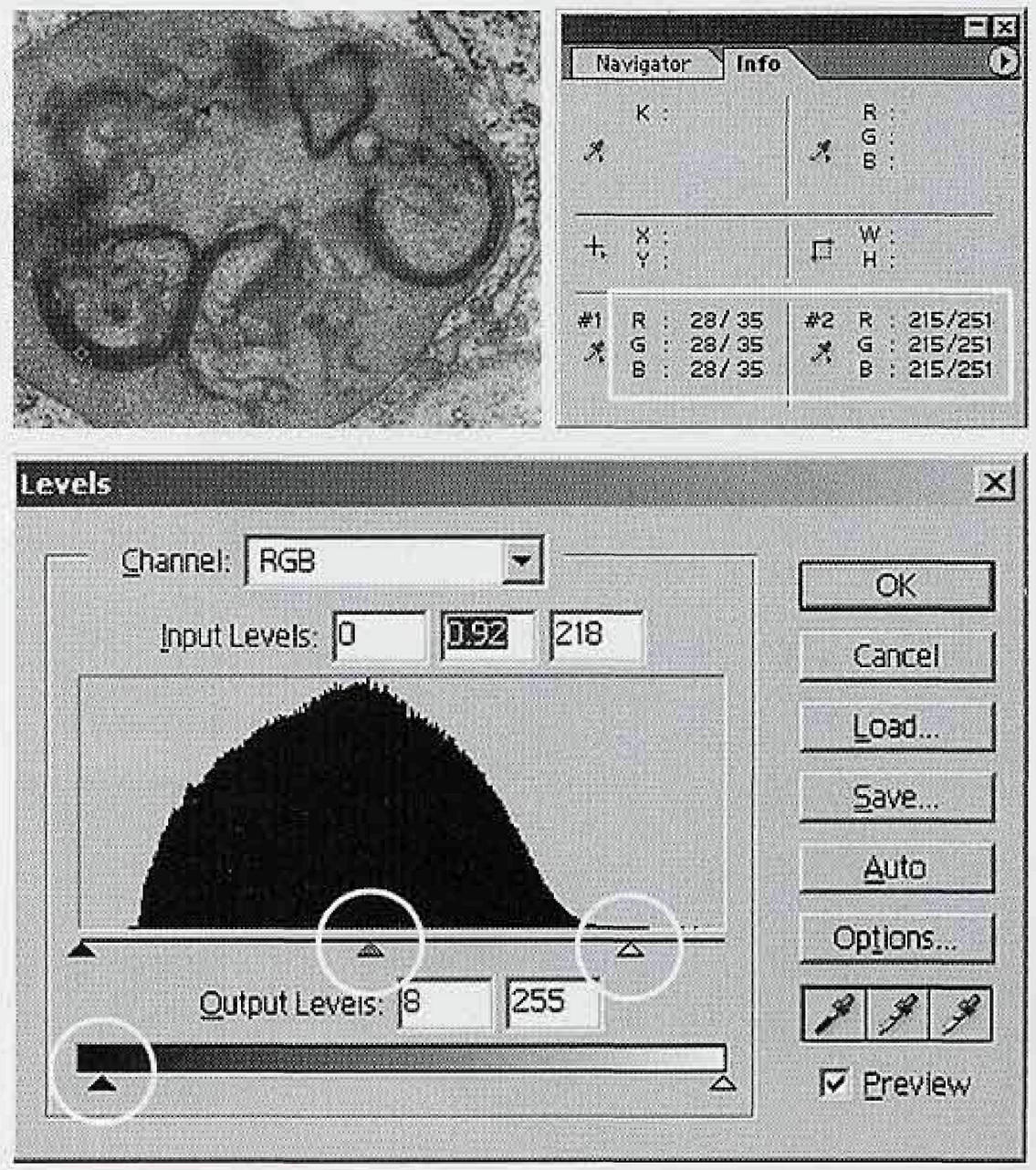

Figure 4. Levels dialgue box settings and Info Box. Set Output sliders (if too dark or too bright) and/or sliders under the histogram (if not dark or bright enough). In this instance, the Output slider for black was increased so that the #1 position reads 35 for the output value (~87% K value when cursor is placed over this location marker). The whitest value was not bright enough, and so the white slider was moved toward the end of the histogram to increase that value. The #2 location marker reads 251 (~3% K value). The middle gamma slider is increased slightly to enhance contrast.

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First find the blackest area by moving the slider to the left toward 1. When that area is found, make a location mark (which also provides a readout in the Info box). Do that by holding down the Shift key, move the eyedropper tool over that area, and click. You may have to zoom in for greater accuracy. You will see a crosshair marking with the number 1 beside it on the image. At the same time, a new quadrant will appear in the Info box at the bottom left with the number 1.

Now find the whitest whites by moving the slider to the right toward 255. Again, mark that area by holding down the shift key and clicking with the eyedropper tool on that area. This shows up as #2 on a new quadrant at the bottom right in the Info box.

Instead of doing the "normal" thing and clicking the OK button, click Cancel. If, by mistake, the OK button is clicked and you now have a thresholded image, you can Undo (under Edit on the Menu) and still keep the location markers. Note that these markers do not print, that there is a limit to four markers, and that the markers disappear when other tools on the toolbar are selected (but reappear when the eyedropper tool is selected).

Set the lowest black level and the highest white level

Under Image, select Adjust(ments) and Levels. Use the Output Levels slider to set the lowest value in all three channels (if grayscale) or any channel (if color) to ~38 to 42 (about an 80% to 85% K value, what you can read by moving the cursor over the location mark). Ignore the Output Level reading in the Levels Dialogue box and only rely upon readings in the Info box. These readings show two numbers with a slash between. The number to the left is the original value and the number to the right is the value were one to OK the Output sliders. Using the slider on the white end of Output Levels, move the slider to the left until the all three channels display 245 (about 4% K value reading).

You may find that your whitest white falls short of 4% on the K scale or 245 on the color channel scale. In that event, when the whites are too gray, use the white slider under the histogram (on the right side) and move it toward the histogram until the values read ~4%. Do the same with the black slider (move the slider toward the end of the histogram) when the blacks fall short of 85% black.

Note: the black level may come off as a miserable gray on your display. The way in which blacks appear depends entirely upon your monitor settings and the amount of ambient light in the room. If these are not optimized, then images may not display correctly.

Set Gamma

Before closing the Levels dialogue box, be sure to also adjust the gamma by eye to a contrasty setting (to the right) by using the middle slider just below the histogram. This can be done to each investigator's satisfaction with the idea that the image is being optimized to best show features of interest. Click OK when satisfied.

For most target printers, your black, white and gamma levels are now optimized. These optimized settings also create a better environment for converting files from RGB to CMYK for publication (when required). Greens and reds in darkfield images print brighter, and dark blues and reds in brightfield images actually appear to contain these colors (versus flat black). Details are less apt to become lost in whites and blacks when printing to a laserjet. In the end, the rule is not so much to trust your screen display as it is to trust the numbers. ■

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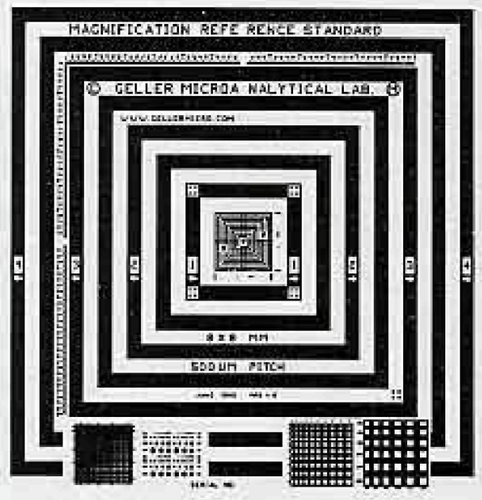

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