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Graphics

Foundations

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Digital Image Production Basics

- Getting the best results out of the images you produce involves making informed choices about various image properties.
- *These must be taken into account throughout the image production process*, from acquisition/creation, through manipulation and editing, saving, and deployment.

Basic Image Format Types

- Bitmapped
  - A digital image is displayed as a two-dimensional array of *pixels*. A bitmapped file format stores the list of pixel values to record the image.
  - These formats are the primary focus of this class.
- Vector
  - A vector file format stores the image by describing each line, curve, and other form mathematically, and recording this information in the file.
- Metafile
  - A metafile format is one capable of storing both bitmapped and vector representations of an image.

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Resolution

- As indicated on the previous slide, a bitmapped image is made up of a two-dimensional array of *pixels*.
- *Resolution* refers to the density of pixels, and is measured in pixels per inch (ppi).
- The higher the resolution, the smaller and more numerous the pixels, and hence the sharper the image.

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Resolution

72 ppi 36 ppi 18 ppi

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Choosing the Right Resolution

- It's not as simple as "the higher the better", because you reach a point of diminishing returns, after which the limitations of the display device negate any advantage of higher resolutions.
- Furthermore, there's a tradeoff between image quality and disk space required by the image file. The higher the resolution, the bigger the file.
- The optimal resolution, then, provides the highest image quality attainable by the display device, without wasting space.
- To reiterate the bottom line: *The optimal resolution is determined by the output device*.

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Choosing the Right Resolution

- For onscreen viewing, including Web pages and PowerPoint presentations:
  - 72 ppi
    - This is the nominal resolution of computer displays. Each pixel in your image file corresponds to a pixel of the user's display.

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Choosing the Right Resolution

- For professionally-processed photo prints:
  - 150–250 ppi minimum
    - Print size / Bitmap file

Print size	Bitmap file
Wallet	640 x 480 pixels
4" x 5"	768 x 512 pixels
5" x 7"	1152 x 768 pixels
8" x 10"	1536 x 1024 pixels

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Choosing the Right Resolution

- For inkjet printers:
  - Consult the printer's documentation for the printer manufacturer's recommendation.
  - Otherwise, 150–250 ppi is typically best.
- For laser printers:
  - Consult the printer's documentation for the printer manufacturer's recommendation.
  - If your software provides—or enables you to set—a *screen frequency* (a.k.a. *line screen*, measured in lines per inch [lpi]), follow the guideline for commercial image setters on the next slide.
  - Otherwise, 150–250 ppi is typically best.
  - Note that ppi ≠ dpi. We'll see why this is in a bit….

Choosing the Right Resolution

- For commercial printers:
  - Consult the service bureau for its recommendation.
  - Otherwise, as a rule of thumb, multiply the imagesetter's lpi rating by 1.5–2.
    - For example, for 85 lpi (standard in newspaper printing):
      85 × 1.5 = 127.5
      85 × 2 = 170
      A suitable resolution setting, then, might be 150 ppi.

Choosing the Right Resolution

- For archival:
  - Refer to **Table 2** of "Recommended Standards / Best Practices for Digital Projects, KU Digital Library Initiatives"
    - http://kudiglib.ku.edu/docs/DLI%20Standards.doc

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Choosing the Right Resolution

- Notice that most of these guidelines are only rules of thumb. You should experiment to find the setting that gives the best results for your output device.

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Color Depth

- *Color depth* refers to the total number of possible colors from which each pixel's value may be chosen.
- Like resolution, a higher color depth provides a higher-quality image, but also a greater file size.
- Color depth is also know as *pixel depth*, *bit depth*, and *bit resolution*.
- It may be measured in the number of available colors or, more commonly, the number of bits used to store each pixel's value.

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Color Depth

- Common color depths are:
  - 1 bit = 2 colors (black and white)
  - 8 bit = 256 colors (or grays)
  - 16 bit = 65,536 colors
  - 24 bit = 16,777,216 colors
- 24 bit color is considered photo-quality, as the number of colors afforded exceeds the approximately 1.7 million colors typically distinguishable by the human eye.

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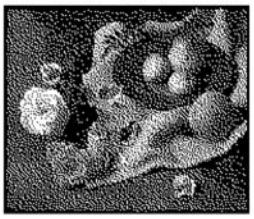
Color Depth



1-bit black and white

8-bit grayscale

8-bit color

24-bit color

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Choosing the Right Color Depth

- Whether you choose a black and white, grayscale, or full-color color depth depends on your output device and the application.
- Beyond that, it's largely subjective; how you want to balance image quality and file size, ideally coupled with experimentation to determine what settings best attain that balance, determines your color depth setting.
- Generally, 24-bit is the maximum color depth required for full-color images, and 8-bit for grayscale images.

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Color Models

- For any given color depth, there are multiple ways to encode color; these are the various *color models*. Each color is represented by specific proportions of component colors or parameters.
- RGB
  - Red, green, blue
- CMYK
  - Cyan, magenta, yellow, black

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Color Models

- Others:
  - HSB
    - Hue, saturation, brightness
  - HLS
    - Hue, lightness, saturation
  - HSV
    - Hue, saturation, value
  - L*a*b
    - Based on the original color model proposed by the Commission Internationale d'Eclairage (CIE) in 1931 as an international standard for color measurement. Consists of a luminance, or lightness, component and two chromatic components.

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Choosing a Color Mode

- These color models may correspond to color mode settings in your image editing software. In much of your work, you can select whichever color mode you find enables you to most easily select the colors you want.
- The *gamut* of a color model is the range of colors it encompasses, and these vary from one color model to another. In other words, there are colors that are represented in one color model that cannot be represented in another. (None of the color models can represent all of the colors that the human eye can typically perceive.)
- In order that the gamut of your image match that of your output device, you should, in the end, choose the color mode accordingly.

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Choosing a Color Mode

- For onscreen viewing, including Web pages and PowerPoint presentations, use RGB mode, since this is the color model used by displays. (Color is displayed by illuminating red, green, and blue phosphors or liquid crystals.)
- For printing, use CMYK mode, since this is the color model commonly used by printers. (Color is printed by depositing cyan, magenta, yellow and black ink or toner on the page.)

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Unfinished Business

- On slide 9, it was mentioned that ppi ≠ dpi when choosing a resolution for printing. Now you can see why: while each pixel in the image file can be any of as many as 16,777,216 colors, each dot in the printout can be one of only *five* color values: cyan, magenta, yellow, black, or (presumably) white. Dots on the page must effectively be subpixels of the original image, corresponding in number to the proportion of the component colors cyan, magenta, yellow, and black in the original's pixels. Clearly then, there cannot be a one-to-one correspondence between image pixels and printout dots.
- One exception: for pure black and white *line art* (no gray), the resolution of the image and the printer can be the same.

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Dithering

- When the color depth does not accommodate all of the colors of the original, the nearest color available is generally substituted for the unavailable color.
- Over a range of pixels, pixels on "either side" of the missing color can be interspersed so as to "average" to the intermediate value. This is called *dithering*, and is done automatically (though it can be enabled or disabled in some software).
- Like the "jaggedness" of too-low resolution, visible dithering makes an image appear grainy and can be a sign of inadequate image settings.
- Some degree of dithering can be acceptable, however, and is often unnoticeable, especially at high resolutions. This can be useful for limiting file size.

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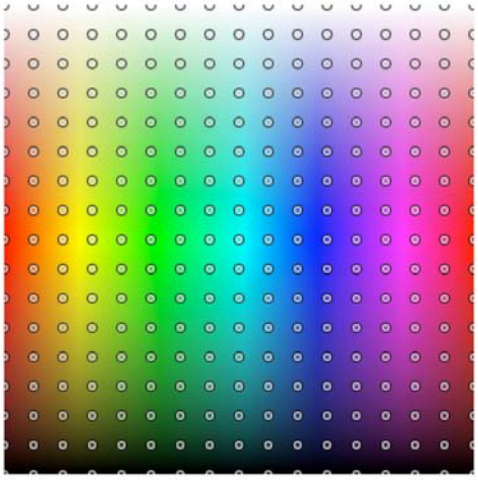
Dithering

Indexed Color and Adaptive Palettes

- *Indexed color* presents a twist on color depth. An 8-bit color table, for example, generally consists of 256 colors evenly distributed across the full gamut of colors in the relevant color model, so as to represent as much of the spectrum as possible….

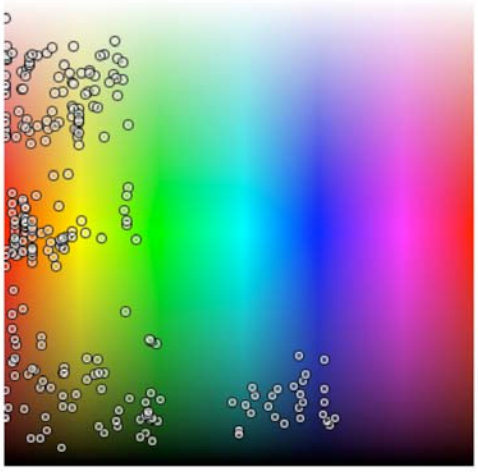
Indexed Color and Adaptive Palettes



Indexed Color and Adaptive Palettes

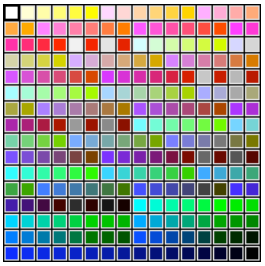
- With indexed color, the available colors are instead chosen arbitrarily from the color model's full gamut.
- A typical 8-bit image of a lush hillside below a clear, blue sky in the springtime, for example, doesn't use many values set aside for shades of red and orange, while the variety of blues and greens is underrepresented. An indexed color palette could be used to choose 256 of the colors actually used in the image. This example might have a hundred shades each of blue and green, without a single orange.
- Such a color palette is known as an *adaptive palette*.

Indexed Color and Adaptive Palettes

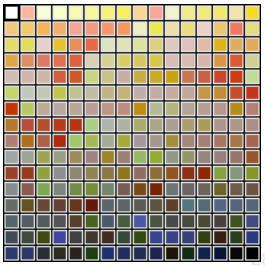


Indexed Color and Adaptive Palettes

8-bit, uniform color palette



8-bit, adaptive color palette



Indexed Color

- Indexed color palettes can be used for color depths of at most 256 colors. They are therefore useful when you want to limit the color depth. Higher color depths, such as 24 bit still produce greater color fidelity (even with uniform palettes).

Browser-Safe Color Palette

- If you're designing for the Web, you've likely encountered references to the *browser-safe color palette*.
- This is a specific indexed palette of 216 colors which are used without variance by common browsers on both Macs and PCs.
- The browser-safe palette is chiefly for work that will be viewed on 256-color (8-bit) computer systems.
- Such systems were common in the early days of Web design, and the browser-safe palette became pervasive.
- Today, very few people view the Web on these systems, so the need to use the browser-safe palette is greatly diminished.

Basic Image Editing

- With a typical graphics program, you can easily manipulate the image by:
  - Cropping it
    - Eliminate all but a selected portion of the image
  - Making color and tonal adjustments
    - Adjust the color to correct for a color cast
    - Brighten or darken the image
  - Altering the focus
    - Make edges sharper or softer
  - And much more…

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Layers

- Many bitmapped image editors support *layers* for such editing. Layers allow for changes to be made to the image without discarding the original values of the underlying pixels.
- Features on higher layers can fully occlude the lower layer pixels, or, through full or partial *transparency*, modify what's below while still allowing it to show through.

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Channels

- As discussed earlier, a program's RGB and CMYK color modes use those component colors to produce all the colors appearing in an image.
- Many bitmapped image editors offer color *channels* as a way to see (and manipulate) the array of values for each component color over the entire image.

Channels

- Additional channels, called *alpha channels*, can store transparency and mask information. *Masks* are used to isolate an area that you want to protect from change while you modify the rest of the image.
- Because alpha channel information, like the color channels depicted on the previous slide, use more than one bit per pixel, varying levels of transparency or masking are possible.

Resizing

- Another modification you can make to your image is resizing.
- You can resize, or *scale*, your image in your image editing application, but you must remember that this affects the image's resolution, since resolution is the number of pixels per inch. There are a number of ways this can take place.
- One possibility is that the number of pixels stays the same, in which case the resolution changes. If the image is made larger or smaller while retaining exactly the same set of pixels, then the pixels themselves must get larger or smaller, respectively, too. The density of pixels, then, decreases or increases, respectively.

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Resizing

- The other possibility is that the image is *resampled*, that is, a new set of pixels is created to represent the image so that the number of pixels keeps the resolution the same. If the image is made larger, the number of pixels must be increased. (Where do the new pixel values come from?) If the image is made smaller, the number of pixels must be decreased. (Pixel information is being thrown away.)
- In the case of enlargement, values from new pixels are interpolated from those of existing, now neighboring, pixels. This can be done using algorithms of greater or lesser sophistication.

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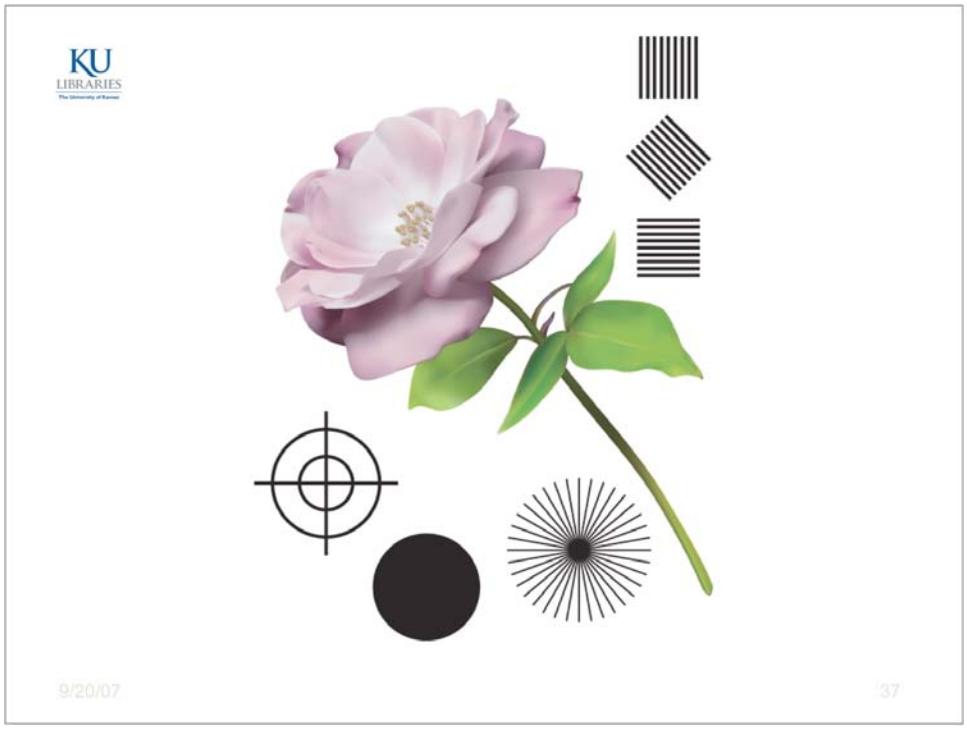
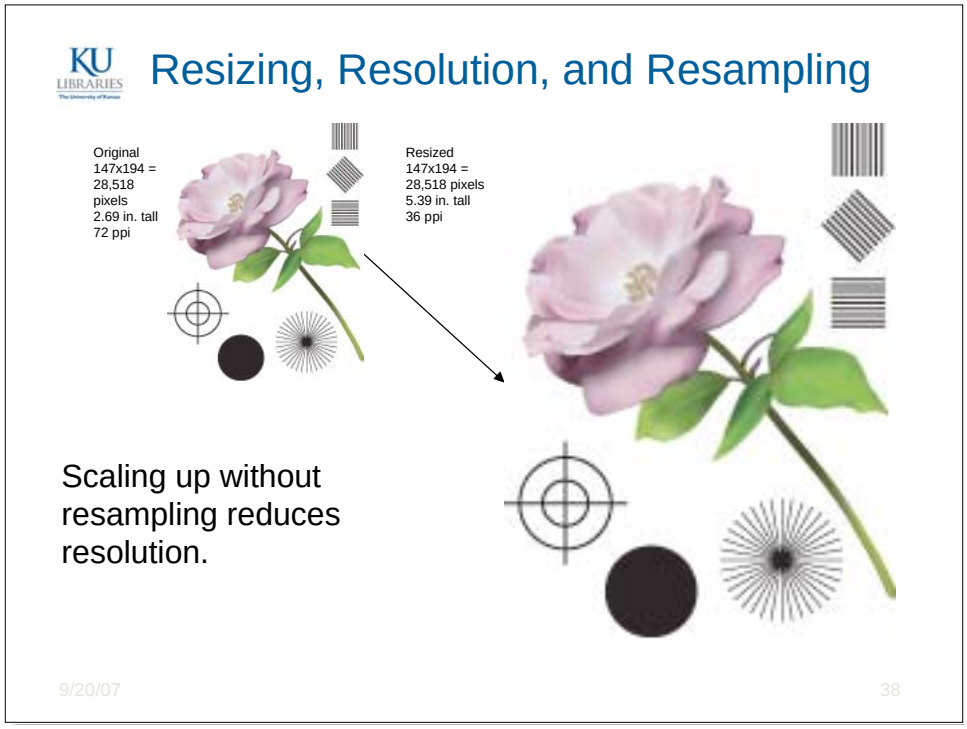
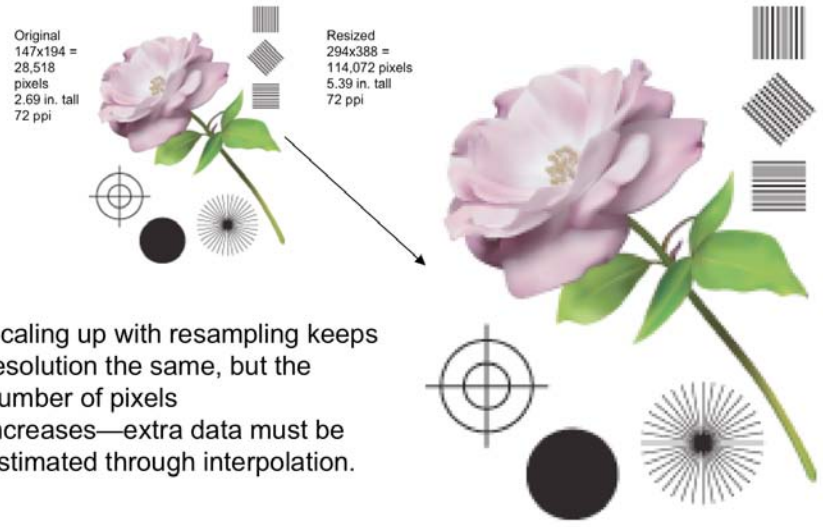




Resizing, Resolution, and Resampling



Scaling up with resampling keeps resolution the same, but the number of pixels increases—extra data must be estimated through interpolation.

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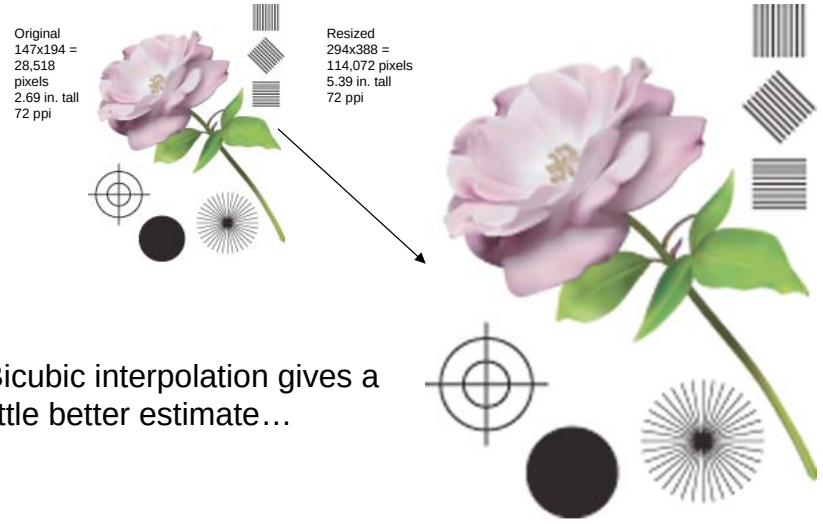
Resizing, Resolution, and Resampling



Bicubic interpolation gives a little better estimate…

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Resizing, Resolution, and Resampling

… but no resampling is as good as the properly-scaled original.

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Resizing, Resolution, and Resampling

Original
294x388 =
114,072 pixels
5.39 in. tall
72 ppi

Resized
147x194 =
28,518
pixels
2.69 in. tall
72 ppi

Scaling down is also affected by resolution and resampling issues, though problems are usually less severe since the original contains more data than the resulting image will require.

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Resizing

- When resizing, take these resampling factors into account.
- When scanning, you can avoid these issues by scanning to the desired scale. The scanning software makes all necessary adjustments to produce the image at the desired size *and* resolution.

Putting It All Together

Choosing a File Format

- The best file format in which to save your file depends on the intended destination and, in some cases, on the image itself.

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For Print

- For print, TIFF is a good choice for bitmapped images, because it is designed to produce precise, high-quality images. If you're using Photoshop, its native file format is also good. (EPS is the top choice for vector images.)

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For the Web

- For the Web, GIF and JPEG are good choices, because these are formats designed to produce small files using compression.
  - GIF is an indexed color format, good for images with blocks of flat color and high-contrast edges, such as line art, poster art, graphics, etc.
  - JPEG is good for images with soft shadows and other smooth gradations of color, such as photographs.
  - Note that which is better depends on the image type. Neither is superior in all cases.
  - When in doubt, experiment to see which is better for your image.
  - GIF does have some features JPEG does not, such as transparency and animation.

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PNG

- PNG is an newer format that will also produce good, small images for the Web, but browser support for it is not yet 100%.
- Specifically, Internet Explorer for Windows does not support PNG images with transparency correctly.
- PNG was designed to be a successor to GIF. It is likewise good for images with blocks of flat color and high-contrast edges.
- It improves on GIF by supporting higher color depths, better compression, and more sophisticated transparency.
- It does not support animation.

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More about Compression

- GIF and PNG use *lossless* compression schemes, meaning they represents the image more compactly while retaining all the original information.
- JPEG uses a *lossy* compression scheme, meaning *it actually alters the image* to decrease the file size.
  - The intent is that information discarded is extraneous, and any loss of image detail or fidelity is negligible.
  - When saving, you select the degree of compression.
  - Experimentation will help you find the greatest degree of compression that does not unacceptably degrade the image quality. Many programs provide a preview feature for this purpose.
  - Note that because JPEG compression is lossy, saving, with compression, and image that has already been compressed degrades the image further.

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GIF and JPEG Compared

GIF
23 K

JPEG
Low quality
46 K

JPEG
High quality
30 K

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GIF and JPEG Compared

GIF
22 K

JPEG
Low quality
17 K

JPEG
High quality
24 K

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Optimizing for the Web

- It's very important that images on the Web be small (in terms of file size), because larger file take longer to download.
- To keep your files small:
  - Keep resolution, color depth, and color palette size as low as possible
  - Save as GIF or JPEG (or PNG)
  - Compress as much as possible
- Several programs are available with built-in Web optimization features to assist you.

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Multipurpose Images

- If you plan to use an image in multiple places, e.g., both in print and on the Web, create and save it with high-quality settings, and produce a low-resolution copy from that.

More about File Formats

- GIF
  - Graphics Interchange Format
  - Bitmapped
  - Minimized file size
  - Lossless compression
  - Up to 256 indexed colors
  - Supports transparency
    - GIF uses a simple form of transparency, where one of the indexed color values can be set to be transparent, allowing the background behind the image to show through. Partial transparency is not supported.
  - Supports animation
  - Common filename extension: .gif

More about File Formats

- JPEG
  - Joint Photographic Experts Group
  - Bitmapped
  - Minimized file size
  - Lossy compression
  - Common filename extension: .jpg
  - Technically, JPEG refers to the compression scheme, and the group that developed it. The file format is properly called JFIF, or JPEG File Interchange Format.

More about File Formats

- PNG
  - Portable Network Graphics
  - Bitmapped
  - Minimized file size
  - Lossless compression
  - Supports transparency
  - Supports one alpha channel
  - Common filename extension: .png
  - See http://www.w3.org/TR/REC-png and http://www.libpng.org/pub/png/ for more information.

More about File Formats

- TIFF
  - Tagged Image File Format
  - Bitmapped
  - High quality
  - Uses a lossless compression scheme called LZW
  - Supports alpha channels
  - Common filename extension: .tif

More about File Formats

- Photoshop
  - Proprietary application format
  - Bitmapped
  - High quality
  - Supports layers
  - Supports transparency
  - Supports alpha channels
  - Common filename extension: .psd
- Other programs may also have their own, proprietary file formats, of varying quality and suitability.

More about File Formats

- EPS
  - Encapsulated PostScript
  - Metafile format
    - Primarily vector, but with ability to store bitmap for onscreen display so rendering time is not an issue
  - High quality
  - Common filename extension: .eps

Other File Formats

- BMP
  - Windows native file format
  - Bitmapped
  - Low quality
  - Common filename extension: .bmp
- WMF
  - Windows native file format
  - Metafile
  - Low quality
  - Common filename extension: .wmf
- PICT
  - Classic Macintosh native file format
  - Metafile, usually used as bitmapped
  - Low quality
  - Common filename extensions: .pict, .pct

Other File Formats

- JPEG 2000
  - Successor to JPEG
  - Lossy and lossless compression schemes
  - "Wavelet" compression
  - Not widely supported
  - See http://www.jpeg.org/JPEG2000.htm for information
- MNG
  - Multiple-image Network Graphics
  - A PNG-like Image Format Supporting Multiple Images, Animation and Transparent JPEGs
  - Not widely supported
  - See http://www.libpng.org/pub/mng/ for information

Other File Formats

- SVG
  - Scalable Vector Graphics
  - Vector
  - Designed for the Web
  - Stores file information in XML
  - Supports animation
  - Not widely supported
  - Common filename extension: .svg
  - See http://www.w3.org/TR/SVG/ for more information.