

Warm up Question:

- How big will a picture PRINT that was saved at 50DPI and is 200 pixels by 200 pixels?
- If we have an image that was scanned in at 300dpi and was 2 inches by 3 inches, how many pixels will it be?
- How many lines of text could you fit on a page given the following information?
 - The font size in a MS Word Document is set to be 36 points.
 - We are using standard 8 1/2 by 11 inch paper, portrait, with a 1 inch margin at the top and a 1/2 inch margin at the bottom.
 - The leading is 0 (no space between the lines).

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More questions

- Convert the following binary numbers to decimal
 - 1001
 - 0101
 - 1010
 - 0011
 - 1111



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Computer Science 1033 – Week 4

GRAPHICS → YES, SIZE DOES MATTER!



Afternoon, n:

That part of the day we spend worrying about how we wasted the morning → Unix Fortune

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Overview of Today's Topics

- Announcements
- Sampling an image
- Black and White, Gray and True Colour
- Indexed Colour
- Review and worksheet
- Bitmaps vs. Vectors
- Image file size
- Why we need compression

Readings

- Textbook readings:
 - Understanding Computers
 - Files and Folders
 - Graphics
 - Basics of Graphics *
 - Digitized Images *
 - File Size (first portion of Image Formats and Compression Techniques)
- * These two readings were suggested in previous weeks too. You don't have to read them if you did before!

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Announcements

- This is the last time I can remind you to do the syllabus quiz (due Jan 31)
- There will be consulting by t.a.s from Feb 2 – Feb 4 in MC16a (see owl for times)
- Let's review the poster assignment
- The poster assignment is posted in Owl. Due Friday, Feb 7th at 3pm.
- Sample of winning posters from [last term](#) and [last year](#); and [year before that](#) and [year before that](#)

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Hints on the marking of assignment

- Follow the instructions carefully, for example:
 - you get 2 marks if you named your files as stated in the instructions!
 - If you get a mark for every requirement we ask for.
- DON'T Collapse your layers
- Name your layers with good names
- Check for spelling
- Text:
 - Contrast
 - Edges
- Images
 - Crisp
 - Appropriate
- Colours
- Professional looking – remember CRAP

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Poster Assignment Tips

- Follow the instructions carefully. Just by following the instructions, you can get a good mark for this assignment!
- Check that you have all the required criteria such as a shape from the shape tool.
- Check that you named all your files EXACTLY as we indicated.
- Make sure you picked good layer names
- Remember to follow the CRAP rules!
- [Other tips](#)
- Colour Choices → <https://kuler.adobe.com/> and <http://design-seeds.com/>

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Hints on Assignment

- Use the shape tool to create:
 - A shape, you can use the custom shape tool
 - Give the shape a good name, don't collapse the layers



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Big Ideas for Today

- **Big Idea 1:** Mo bits per pixel ... Mo Colors!
- **Big Idea 2:** Bitmapped vs Vector: Thumbnail Vectors Icons on the size of a bus? IT IS DOABLE!
- **Big Idea 3:** Mo bits, Mo problems! (The more bits you have to transmit, the slower your image will load unless you compress)
- **Big Idea 4:** Go Smaller or Go Compressing!

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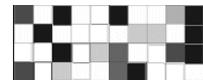
Quantizing The Image

- Now that we know how many pieces our image will be broken into, how many colours will we have available to represent each pixel?
- Assume for each pixel we have 1 bit to represent the colour.
- 1 bit can hold either 0 or 1
 - 0 could be white
 - 1 could be black
- Thus 1 bit allows for 2 colours, usually black and white ($2^1 \rightarrow 2$)



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- How many colours can 2 bit hold? $2^2 \rightarrow 4$
 - 00 → White
 - 01 → Light Gray
 - 10 → Dark Gray
 - 11 → Black



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Does 1 bit colour look realistic?

- YES → Can you tell what this image represents?



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2 Bit Colour

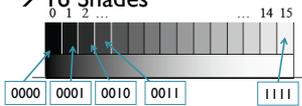
- 4 shades of gray



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More bits, more shades of gray

- 4 bit colour → 2^4 → 16 Shades



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How many shades of gray will 8 bits give us?



http://www.modernimaging.com/bit_depth.htm

How about some Colour?



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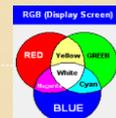
Subtractive Model - CMYK

- Used for printing
- Ink applied to paper
- Primary Colours → Cyan, Magenta and Yellow
- Ink when applied removes (subtracts) the white



Additive Model - RGB

- Use on monitors
- “Adding” light to a black background (the monitor)
- Primary Colours → Red, Green and Blue



How do we represent the colours

• True Colour

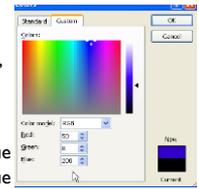
- Can represent 2^{24} colours \rightarrow about 16 million different colours
- $2^{24} = 2^8 \times 2^8 \times 2^8 = 256$ shades of red, X 256 shades of green X 256 shades of blue
- Need 3 bytes (remember: 1 byte=8 bits) for True Colour (1 byte for red, 1 byte for green, 1 byte for blue)

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2 Ways to encode True Colours

• 1. <RGB> <amount of Red, amount of Green, amount of Blue> DECIMAL NUMBER

- Where 0 is no amount and 255 is the most allowed
- <255, 0, 0> \rightarrow the most of red, no green, no blue
- <0, 255, 0> \rightarrow the most green, no red, no blue
- <100, 100, 100> \rightarrow equal middle amounts of red, green and blue
- <50, 0, 200> \rightarrow a little red, a lot of blue
- <200, 0, 50> \rightarrow a lot of red, a little blue



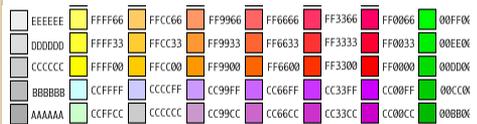
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• 2. Hexadecimal Code

- #RRGGBB \rightarrow RR are the digit place holders for the amount of red, GG amount of Green, BB amount of Blue
- Amounts are counted in hexadecimal with these digits: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, F
- 00 still means 0
- Hex FF= Decimal 255 (try the calculator to see)
- Hex to Dec \rightarrow 00=0, 01=1, 02=2, 03=3, 04=4, 05=5, 06=6, 07=7, 08=8, 09=9, 0A=10, 0B=11, 0C=12, 0D=13, 0E=14, 0F=15, 10=16, 11=17, FD=253, FE=254, FF=255.
- #FF0000 \rightarrow Red
- #00FF00 \rightarrow Green
- #000000 \rightarrow Black
- Question: what is the hex for WHITE?

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Some hexadecimal colours:



Question: Are these colours the same:

- <0,0,0> and #000000?
- <0,0,0> and #000000?
- <9,8,7> and #090807
- <10,15,09> and #0A0F09
- <255,0,255> and #FF00FF
- <255,0,255> and #FF00FF
- <66,0,99> and #660099?
- <66,0,99> and #660099 ? NO

<http://easycalculation.com/color-coder.php>
<http://easycalculation.com/rgb-coder.php>

Can you represent the same number of colours using Hex as using RGB

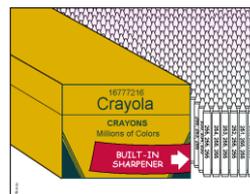
- YES <https://www.rapidtables.com/convert/number/hex-dec-bin-converter.html>

	Red	Green	Blue	How many colours?
Smallest Value (RGB)	0	0	0	
Biggest Value (RGB)	255	255	255	
Total number of shades you can represent	256	256	256	$256 \times 256 \times 256 \rightarrow 16$ million colours
Smallest Value (Hex)	00	00	00	
Biggest Value (Hex)	FF	FF	FF	
Total number of shades you can represent	$16 \times 16 \rightarrow 2^4 \times 2^4 \rightarrow 2^8$	$16 \times 16 \rightarrow 2^4 \times 2^4 \rightarrow 2^8$	$16 \times 16 \rightarrow 2^4 \times 2^4 \rightarrow 2^8$	$2^8 \times 2^8 \times 2^8 \rightarrow 2^{24} \rightarrow 16$ million colours
Smallest Value (Binary)	00000000	00000000	00000000	
Biggest Value (Binary)	11111111	11111111	11111111	
Total number of shades you can represent	$2 \times 2 \times 2 \times 2 \times 2 \times 2 \times 2 \rightarrow 2^8$	$2 \times 2 \times 2 \times 2 \times 2 \times 2 \times 2 \rightarrow 2^8$	$2 \times 2 \times 2 \times 2 \times 2 \times 2 \times 2 \rightarrow 2^8$	$2^8 \times 2^8 \times 2^8 \rightarrow 2^{24} \rightarrow 16$ million colours

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How many colours do we need to encode?

- QUESTION: Roughly, what is the maximum number of colours the human eye can detect?



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Colour Continued...Indexed Colour (not true colour)



Why do the bottom boxes appear to have no colours in them?

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Indexed Colour

- Indexed Colour can look pretty good even though we will only ever have at most, 8-bit colour (or 256 shades of colour)



<http://www.csd.uwo.ca/~lreid/cs033/BitDepth/>

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Review:

- Match the encoded colour to the correct colour name:

Encoded Colour	Colour Name
a) #FFFFFF	1. White
b) #00FF00	2. Black
c) #FAFAFA	3. Dark Gray
d) (0,0,255)	4. Light Gray
e) (0,0,0)	5. Medium Gray
f) (14,14,14)	6. Bright Green
g) (125,125,125)	7. Bright Blue

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Review Sheet

- Work on the review sheet for about 5 minutes (alone or with a friend) and we will take it up as a group.

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BREAK

- Link sent to me by one of our students, cool photoshop video:
 - <http://www.youtube.com/watch?v=53m0syaPg9A&t=0m39s>
- Video created by a high school kid from Stratford Ontario (took him 2 years):
 - <http://www.youtube.com/watch?v=qluxiwHUGz4>

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Bitmapped Images vs. Vector Graphics

- Bitmapped Graphic Image**
 - Image consists of pixels in a grid
 - Icons are an example of a bitmapped image (do you recognize this icon? → 🌐)
 - Icons are usually 32 pixels by 32 pixels
 - When bitmapped images are enlarged (resampled), the computer adds new pixels and guesses on the colour to colour the new pixels (called **interpolation**) based on surrounding pixels
 - This icon is now 245 pixels by 245 pixels
 - Bitmapped images edges become jagged



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Bitmapped Images

- Also called *raster graphics* image
- Bitmapped images are resolution dependent
 - Bitmapped image on a 640 by 480 screen (lower resolution) appear larger than on a 1280 by 1024 screen (higher resolution)
- Bitmapped images that are enlarged:
 - Have larger file size than original
 - Become distorted
- All images from scanners and digital cameras are bitmapped images

Dimensions: 100 x 100
Image Size: 20k



Dimensions: 200 x 200
Image Size: 48k



Dimensions: 400 x 400
Image Size: 98k



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Common Bitmap Formats

- **Common bitmap file formats are:**
 - BMP (has little compression, makes big files!)
 - GIF
 - JPEG, JPG
 - PNG
 - PICT (Macintosh)
 - PCX
 - TIFF
 - AFPHOTO (Affinity Photo)
 - PSD (Adobe Photoshop)
- **Popular bitmap editing tools/software packages:**
 - Microsoft Paint
 - Adobe Photoshop
 - Affinity Photo
 - Corel Photo-Paint
 - Corel Paint Shop Pro
 - The Gimp

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Vector Graphics

- Vector image is made up of individual, scalable objects.
- Objects are defined by mathematical equations
- Objects consist of lines, curves and shapes
- No distortion as image is enlarged

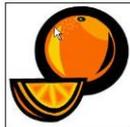
Dimensions:
100 x 100



Dimensions:
200 x 200



Dimensions:
400 x 400



Vector Graphics

- As image is enlarged, still has crisp clean lines.
- Most browsers don't display vector graphics without a plug in.
- Only can be used with drawings, not photographs
- Usually vector graphic image has a smaller file size than the same image stored as a bitmap.
- Below: enlarging and shrinking an image: left using a vector graphical image, right using a bitmapped image



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Vector Images

- Example: HTML 5 allows it now: https://www.w3schools.com/graphics/svg_inhtml.asp
 - Try changing the values
- Great for logos because
 - Can be scaled down for business card
 - Can be scaled up for a trade show poster
- <https://youtu.be/PJFc3KIEdLM?t=61> (watch till about minute 4)
- Note: the text in PDF files are Vector based (but not the images in a pdf file)

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Common Vector File Formats

- **Common Vector file formats include:**
 - AI (Adobe Illustrator)
 - CDR (CorelDRAW)
 - CMX (Corel Exchange)
 - CGM Computer Graphics Metafile
 - DXF AutoCAD
 - WMF Windows Metafile
 - EPS (Encapsulated PostScript)
 - PDF
- **Popular vector drawing programs/software packages are:**
 - Adobe Illustrator
 - Affinity Designer
 - CorelDRAW
 - Xara Xtreme
 - Serif DrawPlus

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Activity 1

- Open MS Paint
(Start>Programs>Accessories>Paint)
- Pick the text tool, set the font to 50pt, type in your name
- Pick the text tool again, set the font to 12pt, type in your name
- Select the small font and resize it to the size of the big font
- Do they look the same?

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Activity 2

- Draw an oval in MS Paint, then select it and resize it, watch what happens
- Draw an oval in Affinity Photo,
 - Select Layer>Layer Style and give it an outline (Stroke)
 - Select the oval layer and select Edit>Transform Path>Scale and resize it, watch what happens.
- Usually when you see the command **“Document>Flatten”** in Affinity Photo, it is changing your Vector layers into a one flat Bitmapped layer!

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Bitmapped Graphics vs. Vector Graphics

- **Question: Which of these statements do you think is TRUE: A or B?**

A: You can convert a vector graphic image into a bitmapped image easily but you cannot easily convert a bitmapped image into a vector graphic image.

B: You can convert a bitmapped image into a vector graphic easily but you cannot easily convert a vector graphic image into a bitmapped image.

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How to lose customers before you ever even had them!

- Have you ever gone to a website and then left within seconds because the graphics were taking too long to download?
- Do you ever return?
- <http://www.flamingpear.com/examples-sbp/images/blue-green-sea-large.jpg>
- <http://www.csd.uwo.ca/~lreid/cs1033/resolution/UncompressedGraphics.html>

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How Big Is An Image?

- Let's figure out how many bytes one large picture in true colour (2²⁴ colours) would take up.
- Roughly:
 - Total Numbers of pixels (Sampling) * Colour Bit Depth (Quantize)
 - Length (px) * width (px) * Colour bit depth(bytes)
- **Question:** Assume we have a picture that is:
 - 1600 pixels by 1200 pixels (takes up the whole screen and more depending on your resolution)
 - Each pixel will need 3 bytes (8 bits for red, 8 bits for green, 8 bits for blue) to represent the colour of each pixel <R,G,B>
- **How many bytes, kilobyte and megabytes is the image?** →

- Save a picture this size in Affinity Photo as .raw to find size
- <http://www.csd.uwo.ca/~lreid/cs1033/resolution>
- Look at the size of the file with the extension .raw

UNITS OF MEASURE:

- How about kilobytes, megabytes, etc?
 - 1 KB = 1024 B
 - 1 MB = 1024 KB
 - 1 GB = 1024 MB
 - 1 TB = 1024 GB

* Some people use 1000 for these conversions.

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For Printing in a Flyer or Magazine:

- File size doesn't matter
- Most important issue is the quality of the image!
- Image will be printed with at least 300dpi



For Displaying in a Web Page:

- File size is very important
- Bigger files take longer to download
- Quality is important too but want to try to get best quality with smallest file size.



We need to decide what are we going to use the image for?

How long will it take that uncompressed sunset image to download if we are using it in a webpage?

- If the client is using high speed connect at 1500 kilobits per second?
- If the client is on a modem that is 56 kilobits per second
- On a really old modem that is 28.8 kilobits per second?



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We need to make our webpages download as fast as possible

- We want them to be the “appropriate size” for our page, in terms of proportion
- Want the image to look good (“high quality”)
- Want image to download quickly
- **THUS WE NEED TO MAKE OUR IMAGE FILES SMALLER BUT OUR IMAGE TO STILL LOOK GOOD!**

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Below,
-Image size isn't appropriate
-Doesn't look good
-BUT it does download faster than the top page because the image is smaller

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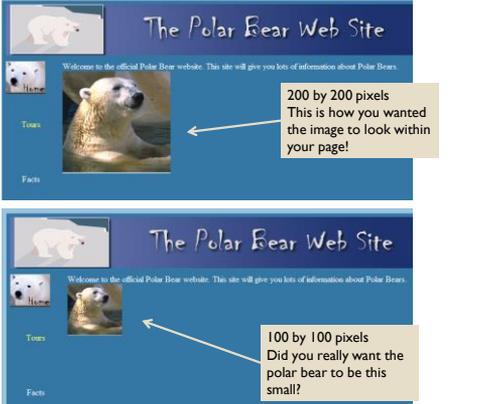
How do we download faster?

Make our image file size smaller!

Question: What can we do to make our images smaller?

- **OPTION 1: Make the image be physically smaller → LESS PIXELS** (BUT that will change the size it is displayed at on the screen).
 - For example, a 100 pixel by 100 image pixel (30KB) is smaller than a 200 pixel by 200 pixel image (118KB)

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The Polar Bear Web Site

Welcome to the official Polar Bear website. This site will give you lots of information about Polar Bears.

200 by 200 pixels
This is how you wanted the image to look within your page!

The Polar Bear Web Site

Welcome to the official Polar Bear website. This site will give you lots of information about Polar Bears.

100 by 100 pixels
Did you really want the polar bear to be this small?

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How do we download faster and keep the image the size we want it?

- **OPTION 2: COMPRESS THE IMAGE FILE:** use tricks to make file smaller without losing the quality of the image or the size (in pixels of the image)
 - Still 200 pixels by 200 pixels but the file size is smaller than the original.
- An uncompressed image that is:
 - 200 by 200 pixels
 - True Colour (16 million colours → <R,G,B>)
 - Will be 200 * 200 * 3 bytes = **120,000 bytes**
 - Will be 120,000 / 1024 = **117.2 Kilobytes**

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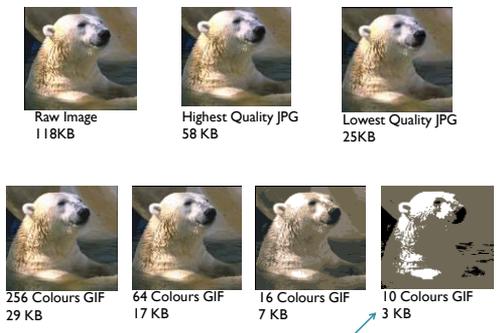
Compress To The Rescue!



- The same image that is:
 - 200 by 200 pixels
 - Original size was 118 kbytes (200*200*3/1024)
 - Looks almost like true colour when:
- SAVED AS A COMPRESSED JPG WILL BE:
 - Highest Quality → **58 KB**
 - Lowest Quality → **25 KB**
- SAVED AS A COMPRESSED GIF WILL BE:
 - 256 Colours → **29KB**
 - 64 Colours → **17KB**
 - 16 Colours → **7KB**
 - 10 Colours → **3KB**

Name	Size	Type
polarbearinwater200by200_10Colours.gif	3 KB	GIF Image
polarbearinwater200by200_16Colours.gif	7 KB	GIF Image
polarbearinwater200by200_64Colours.gif	17 KB	GIF Image
polarbearinwater200by200_ever Colours.gif	17 KB	GIF Image
polarbearinwater200by200_256Colours.gif	29 KB	GIF Image
polarbearinwater200by200_lowestQuality.jpg	25 KB	JPEG
polarbearinwater200by200HighestQuality.jpg	58 KB	JPEG
polarbearinwater.raw	118 KB	RAW

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Raw Image 118KB

Highest Quality JPG 58 KB

Lowest Quality JPG 25KB

256 Colours GIF 29 KB

64 Colours GIF 17 KB

16 Colours GIF 7 KB

10 Colours GIF 3 KB

Note: this one is **40 times** than the uncompressed file smaller BUT the quality of the image is very poor!

Compression

- Key Concept: **Compress as much as you can WITHOUT sacrificing quality (losing information)!**
- Is there a way we can stuff the bits and bytes down into less bits and bytes?

A Real World Example of Compression ☺:

<http://www.youtube.com/watch?v=I5eypklyjiY>

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Two Types of Compression

- Lossless:**
 - Compress the original bits and bytes into less bits and bytes without losing any of the original information about the picture
 - When we reopen the file, all the original information about the picture is still there!
 - NO INFORMATION IS LOST
- Lossy:**
 - When compression occurs, some of the original information is lost
 - Selected portions of the image are discarded but the selected portions are the ones that will be the ones that least missed or noticed
 - CANNOT GET THIS INFO BACK ONCE IT IS DISCARDED

Nerf Ball vs. Orange ☺

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Several different algorithms for (ways to perform) compression

- Each different type of image file format represents the use of a different compression algorithm
- Common compressed image file formats that are acceptable on the World Wide Web:
 - gif
 - jpg, jpeg
 - png
- Uncompressed file formats:
 - bmp (for Windows)
 - raw (common on digital cameras)

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Review

- Question:** How big will an image be in terms of bytes if it is uncompressed, true colour and 200 by 400 pixels?
- Question:** how many colours can you represent with 5 bits?

2⁵

Could be 0 or 1

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