HHICC

Digital Images

Pictures/Photos

OUTLINE

Vision: How we see.

Digital Images

- What are they
- Pixels
- Color
- How are they stored
- Computer Numbers
- Image example

Where are the images?

Image Storage Techniques

- Vector, Raster, Combination
- Compression

Image Formats

Image Manipulations

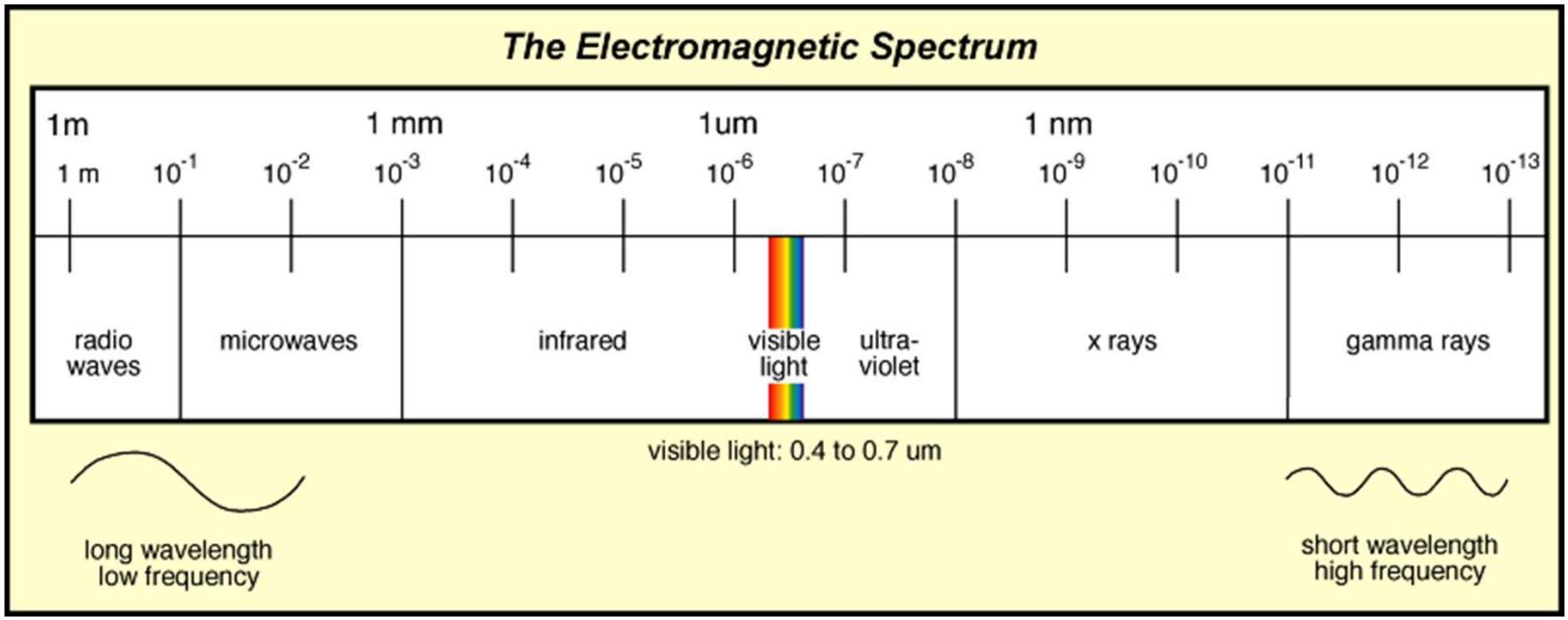
- Resize (Scale)
- Skew (Warp/Deform)
- Smudge
- Aspect Ratio
- Fill
- Color Picking
- Crop
- Clone
- Transparency

Today's Software

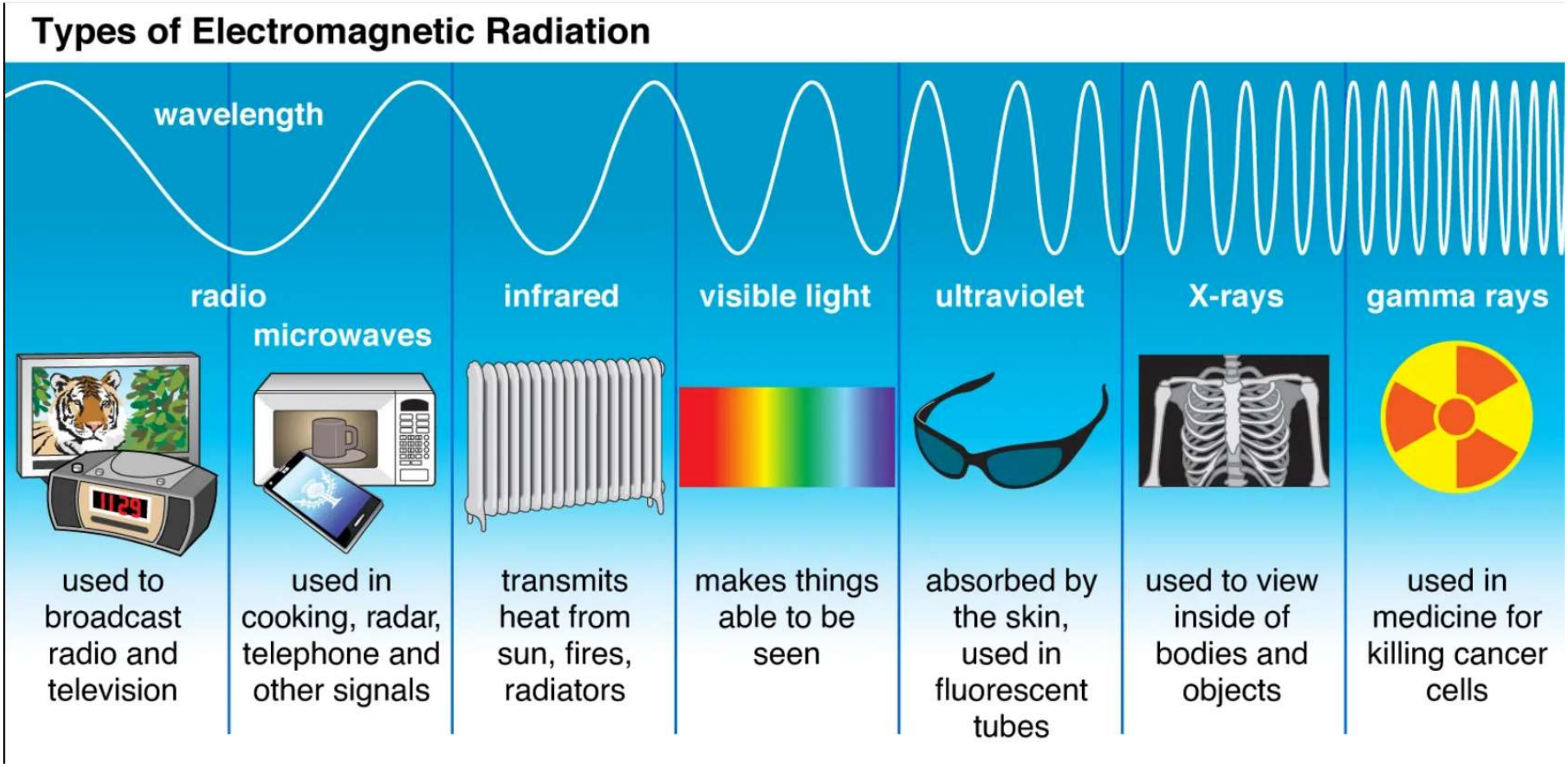
- PowerPoint - Presentation Software
- UltraEdit - Text Editor
- IrfanView - Simple Image Utility Program
- Gimp - Image Editing Program (Free Photoshop)
- Chrome – Web Browser
- Calc – Built-in Calculator

QUESTION: IS RADIATION HARMFUL?

Yes and No


The Electromagnetic Spectrum
1m
1 mm
1um
1 nm
1 m
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
10^{-7}
10^{-8}
10^{-9}
10^{-10}
10^{-11}
10^{-12}
10^{-13}
radio waves
microwaves
infrared
visible light
ultra-violet
x rays
gamma rays
visible light: 0.4 to 0.7 um
long wavelength
low frequency
short wavelength
high frequency

Yes and No


Types of Electromagnetic Radiation
wavelength
radio
microwaves
infrared
visible light
ultraviolet
X-rays
gamma rays
used to broadcast radio and television
used in cooking, radar, telephone and other signals
transmits heat from sun, fires, radiators
makes things able to be seen
absorbed by the skin, used in fluorescent tubes
used to view inside of bodies and objects
used in medicine for killing cancer cells

How do we see?

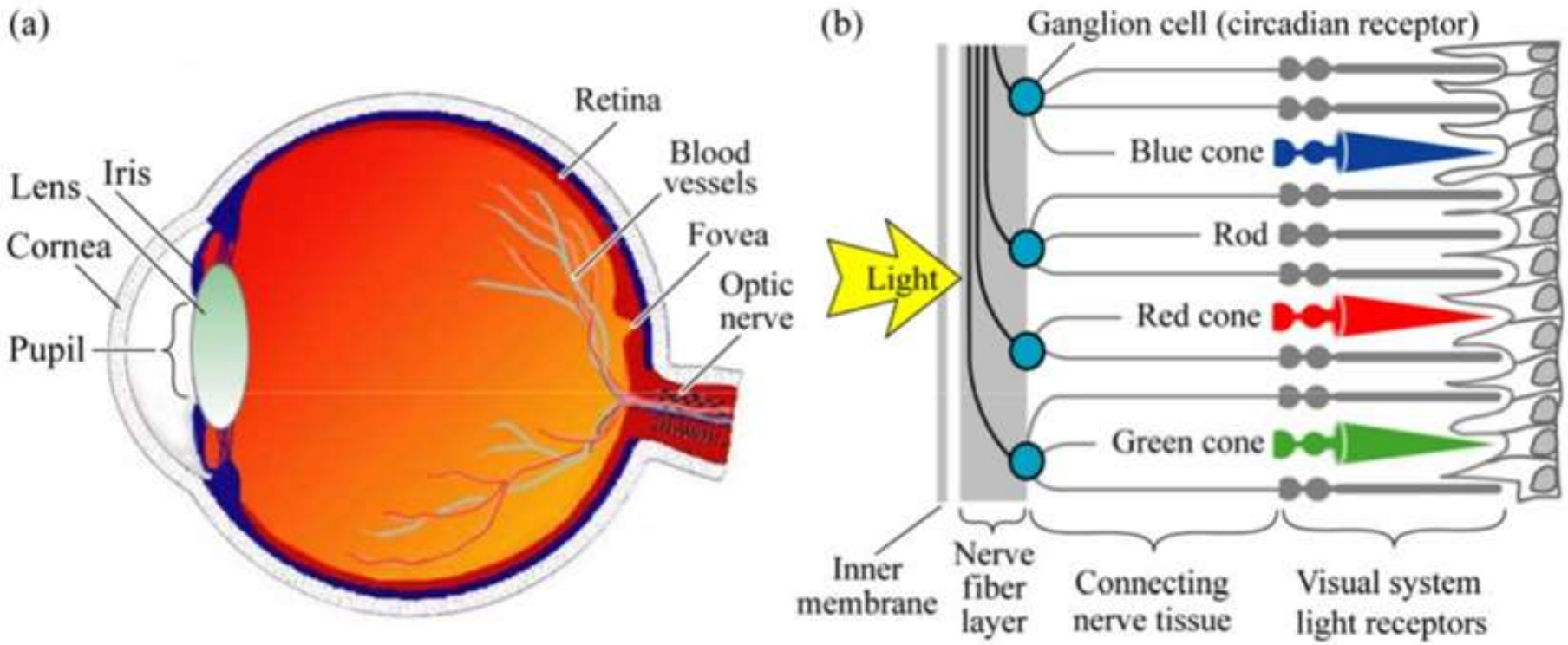


Fig. 16.1. (a) Cross section through a human eye. (b) Schematic view of the retina including rod and cone light receptors

Rods & Cones

- Rods
  - Brightness and Low Light Sensitive
  - 100 million
- Cones
  - Color
  - 6 million

The Eyes Have It

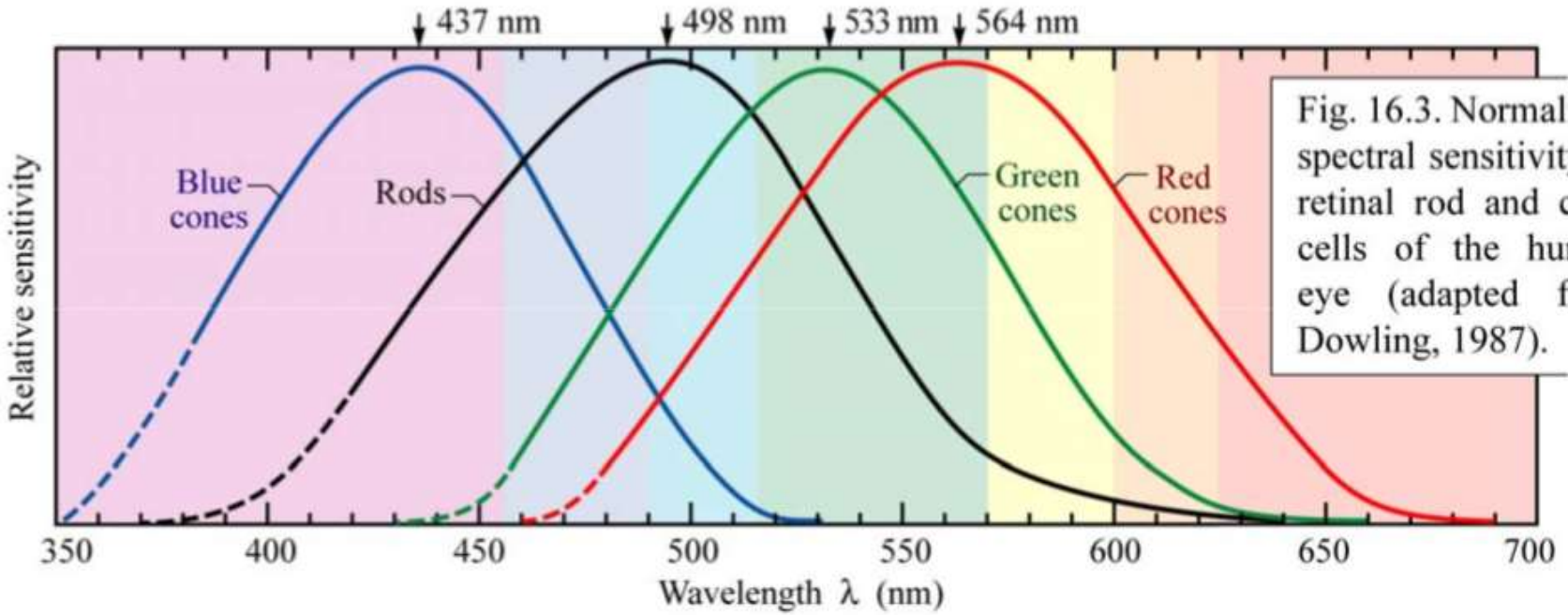


Fig. 16.3. Normalized spectral sensitivity of retinal rod and cone cells of the human eye (adapted from Dowling, 1987).

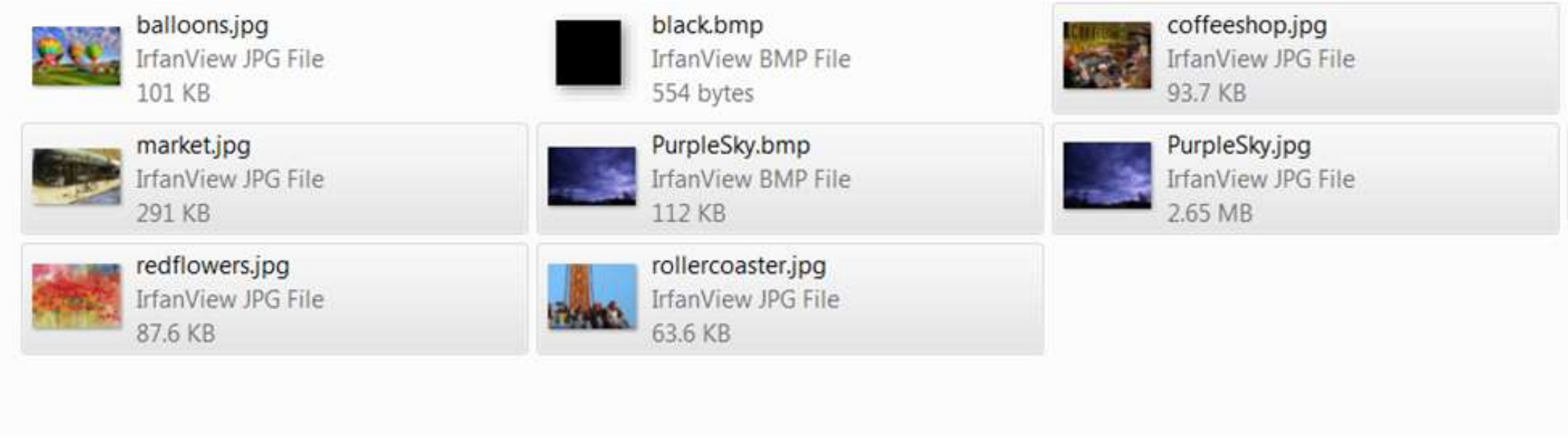
Where are digital images?

Cameras/Phones

The Internet

Computer hard drive
Solid state drive

Typical Directory or Folder



= Data Unit =

B Byte — **KB** Kilo-byte — **MB** Mega-byte — **GB** Giga-byte — **TB** Tera-byte

1024 times **1024 times** **1024 times** **1024 times**

Unit	Definition	Storage space size
Bit	0 or 1	Yes/No
1 Byte	8 bit	Alphabets and one number
1 kilobyte (KB)	1,024 Byte	A few paragraphs
1 megabyte (MB)	1,024 KB	One minute-long MP3 song
1 gigabyte (GB)	1,024 MB	30 minute-long HD movie
1 terabyte (TB)	1,024 GB	About 200 FHD movies

Samsung Semiconstory
samsungsemiconstory.com

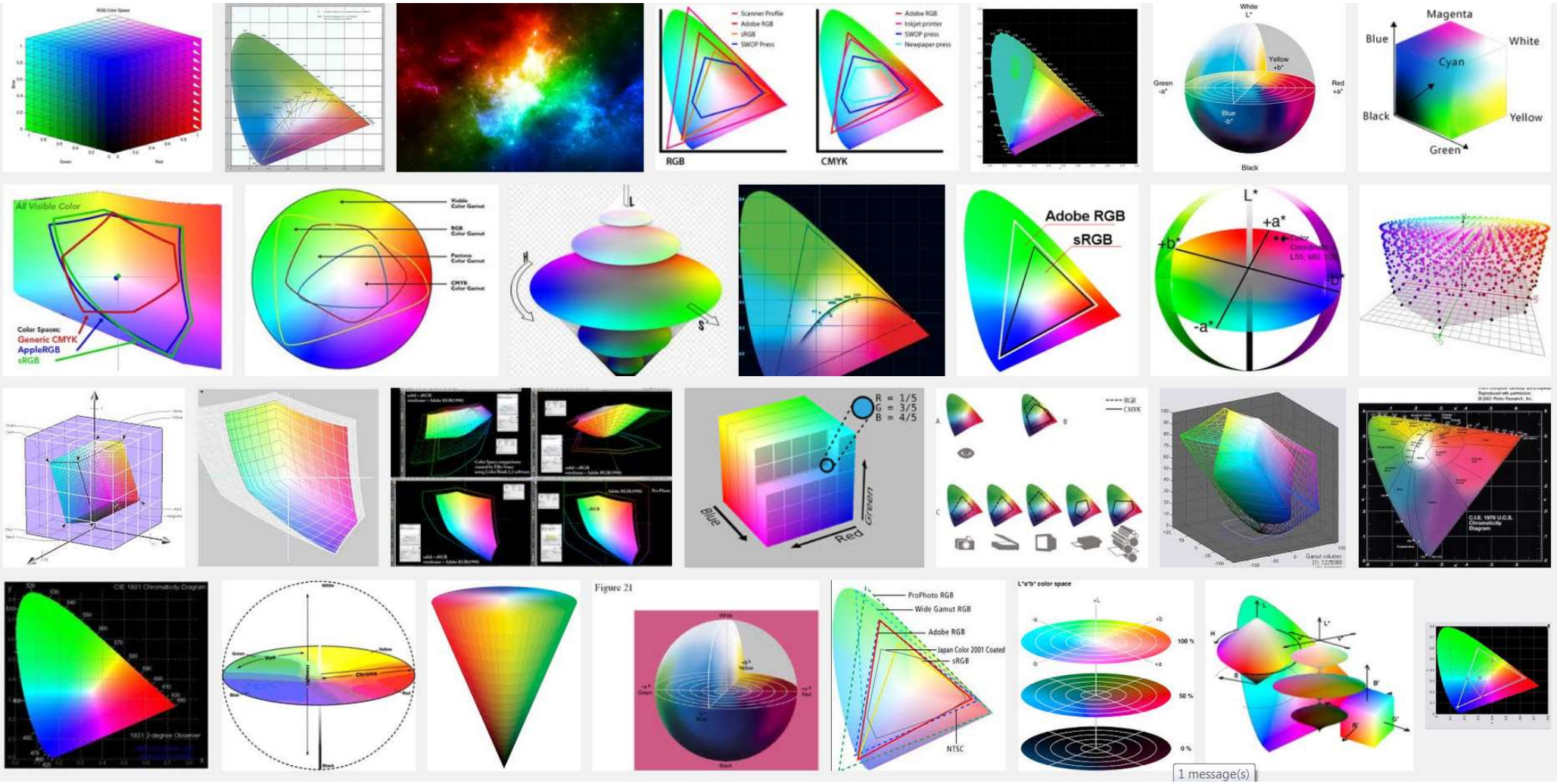
Wait, what exactly is an image?

- On the disk there is a file containing
  - Information about the image
    - Size
    - Type of file
    - Camera details
    - Etc.
  - The actual data that defines what the image looks like. i.e. 3 numbers for each pixel

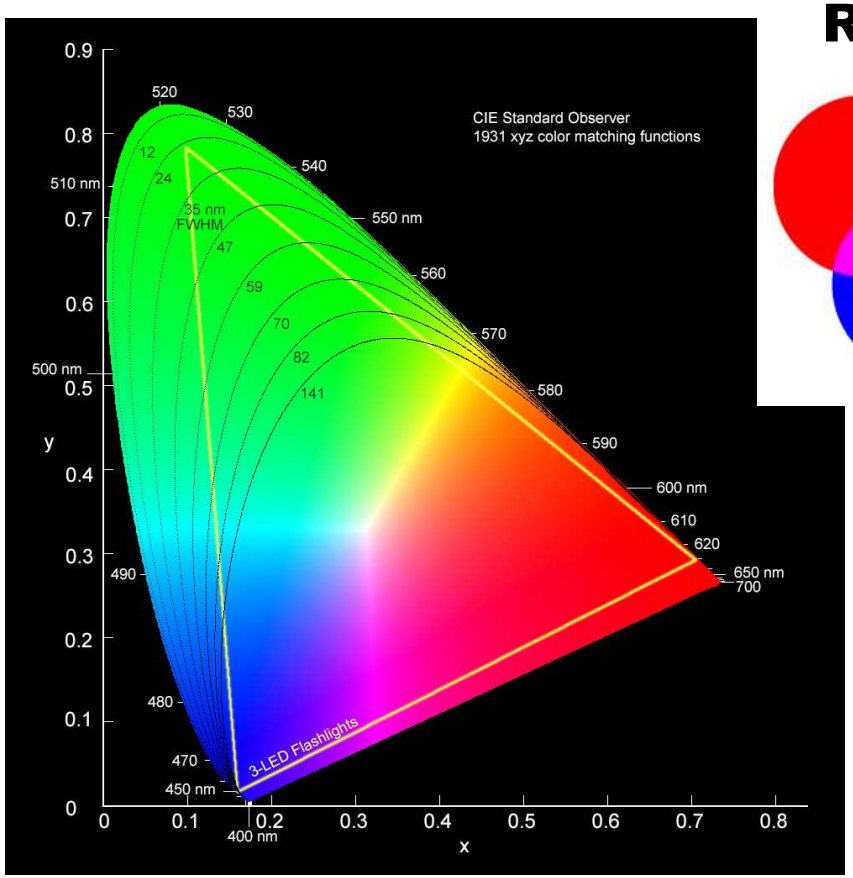
Pixel

- Short for Picture Element
- A pixel is all one color (at a time)
- Images are made of pixels
- The color of a pixel can be expressed as
  - Amount of red
  - Amount of green
  - Amount of blue
- This is a system known as RGB

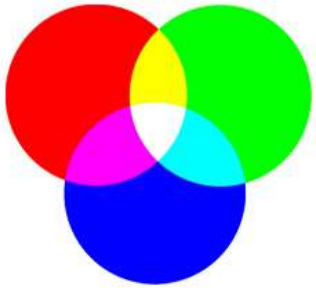
There are lots of systems…

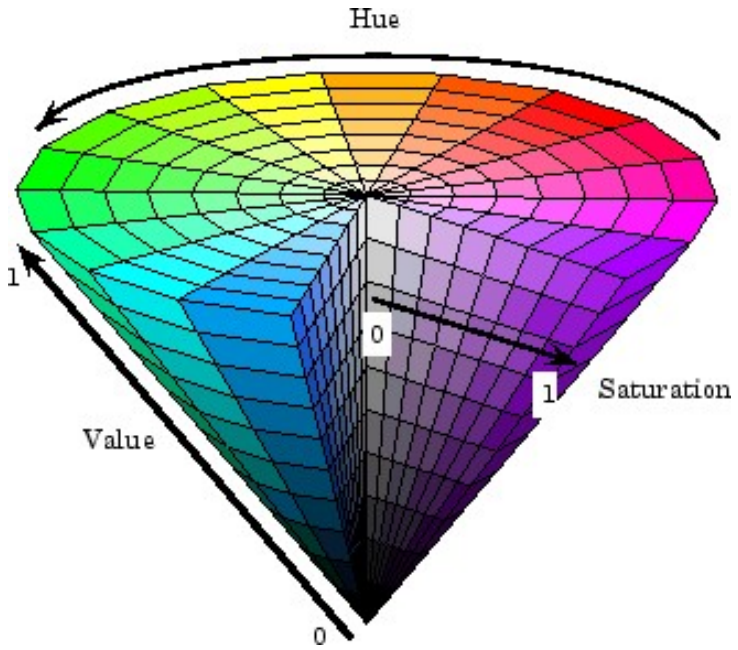


Two Common Systems

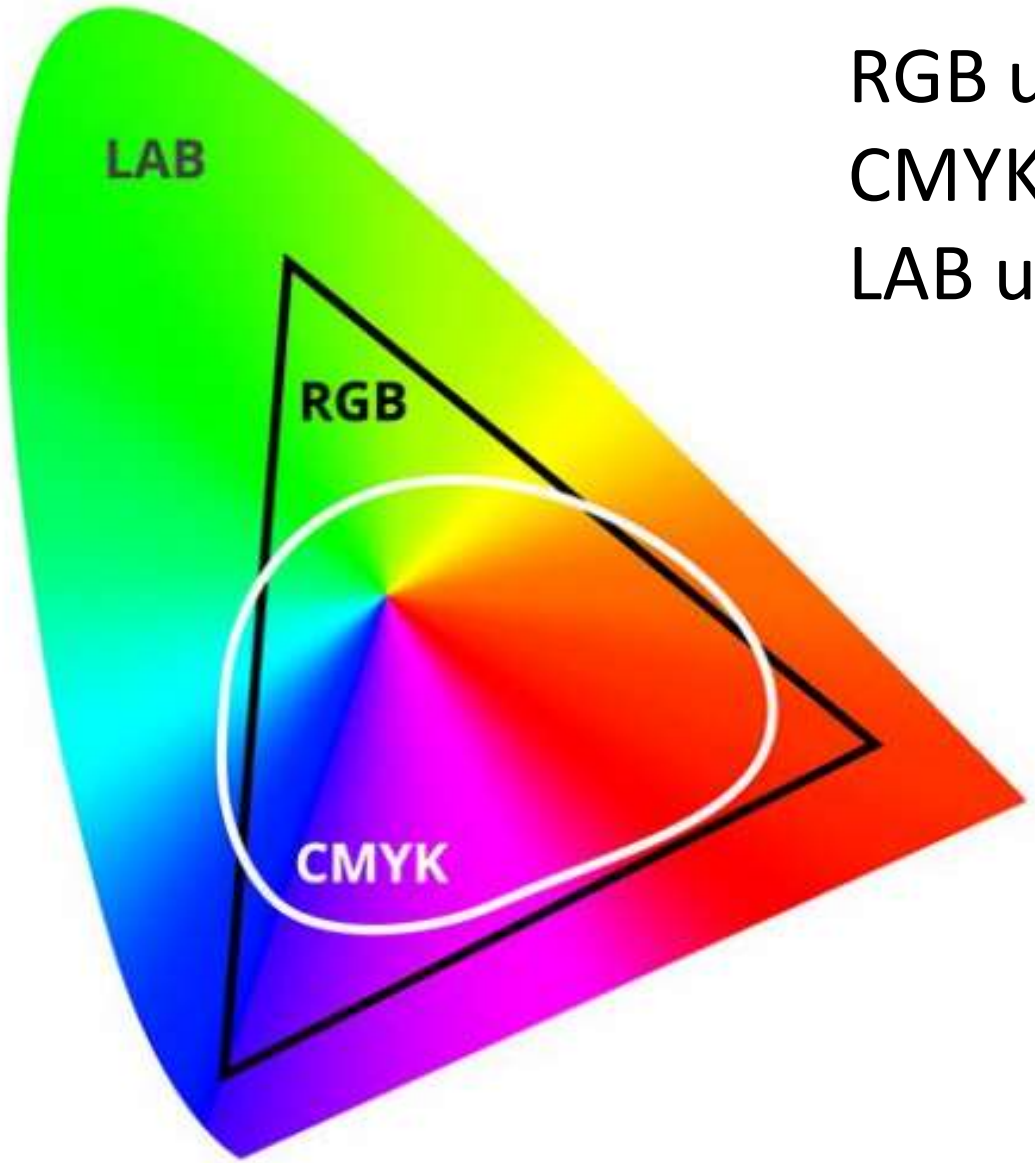


Red, Green, and Blue RGB





Hue, Saturation, and Luminance (Value) HSL



RGB used for light
CMYK used for printing
LAB universal system

LAB

- **L*: Lightness**
- **a*: Red/Green Value**
- **b*: Blue/Yellow Value**

Figure 17. CIELAB color chart

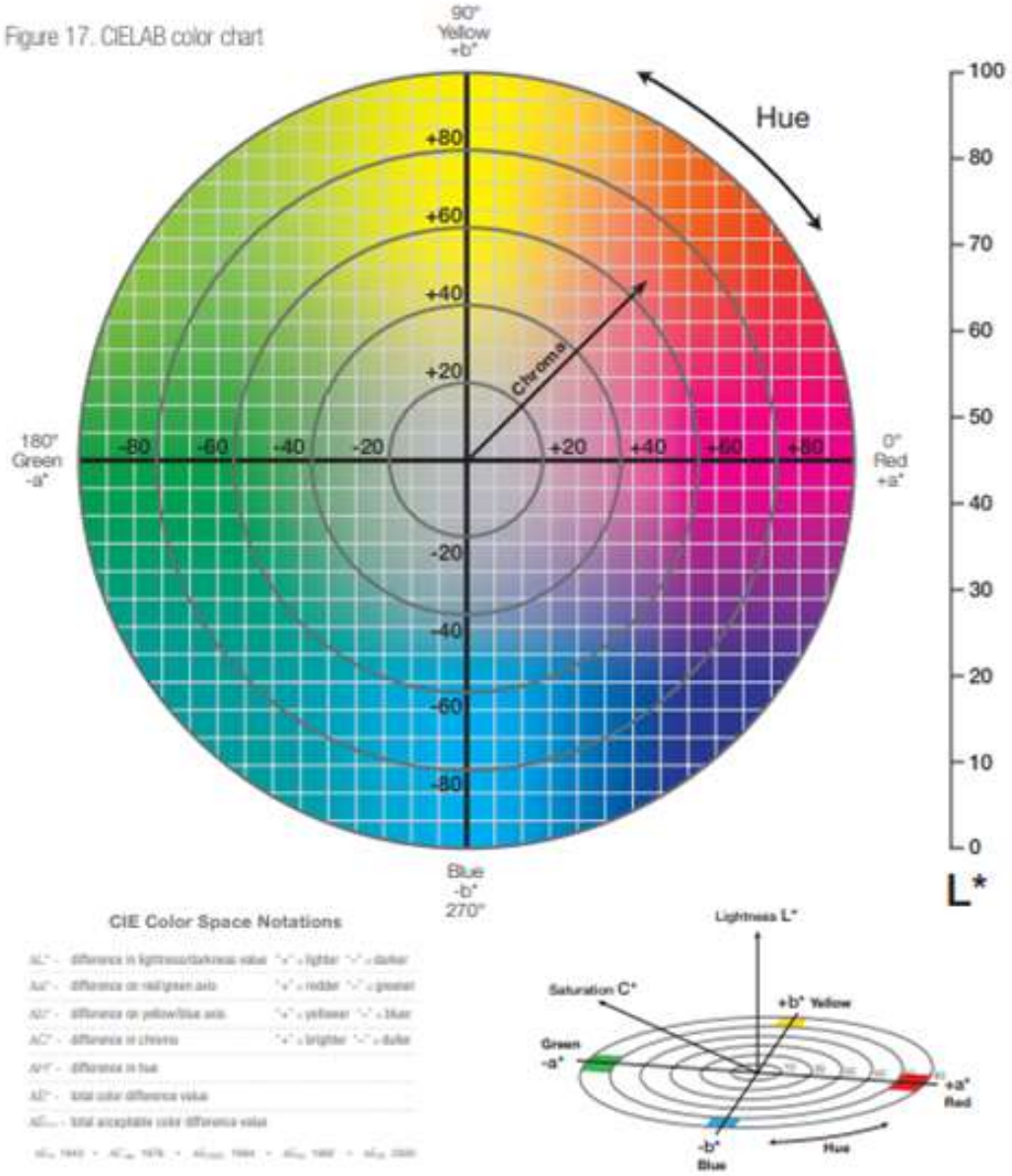


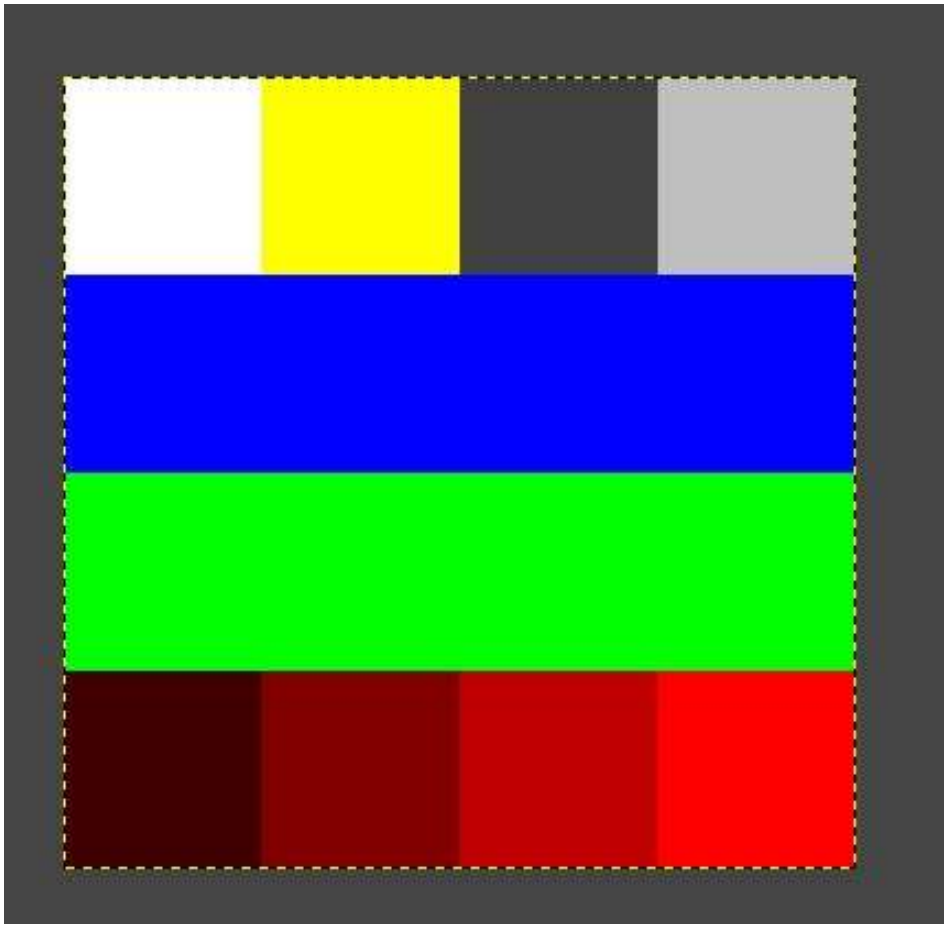
Figure 18. The L* value is represented on the center axis. The a* and b* axes

RGB & HSV

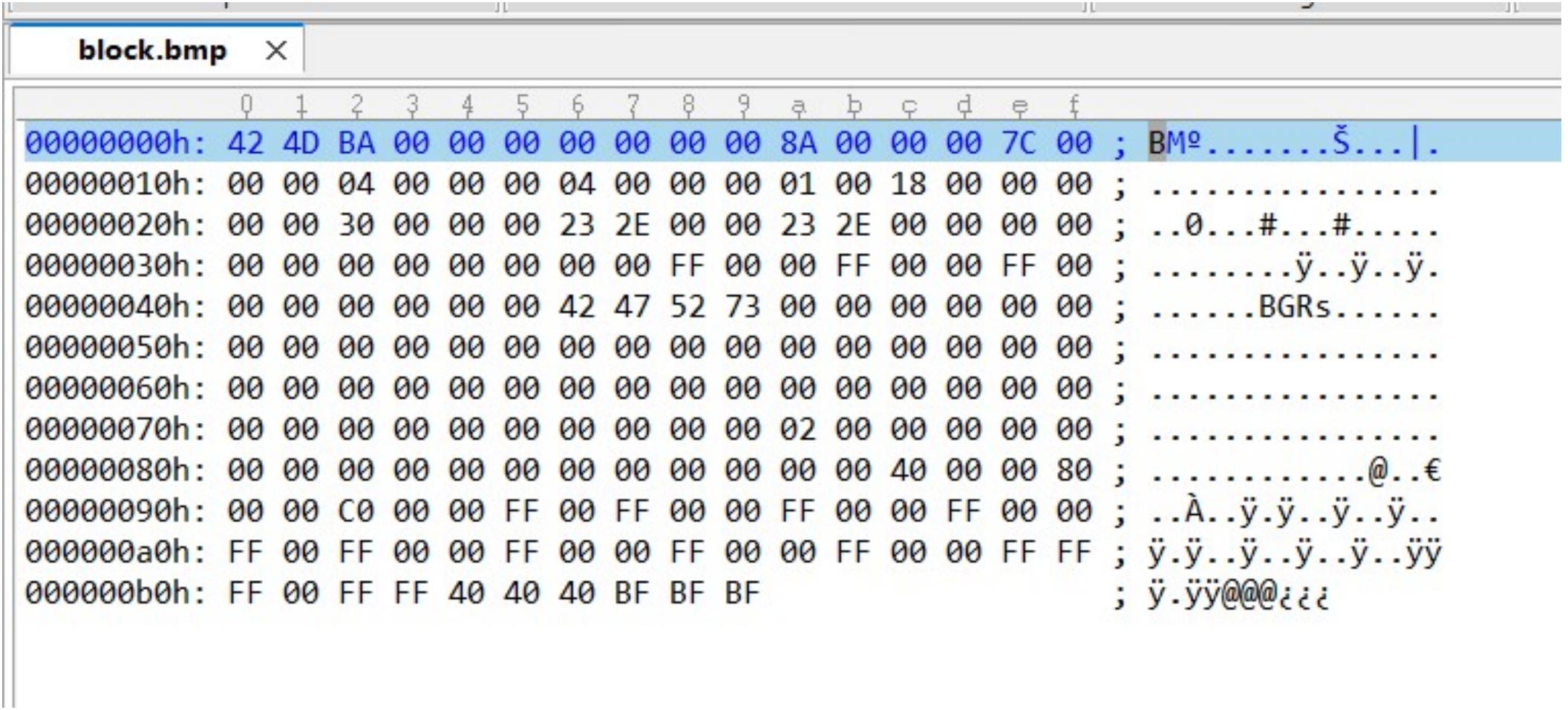
https://math.hws.edu/graphicsbook/demos/c2/rgb-hsv.html

Back to Pixels

Let's look at a picture! As numbers???



Don’t Panic!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00000090h: 00 00 C0 00 00 FF 00 FF 00 00 FF 00 00 FF 00 00 ; ..À..ÿ.ÿ..ÿ..ÿ..
000000a0h: FF 00 FF 00 00 FF 00 00 FF 00 00 FF 00 00 FF FF ; ÿ.ÿ..ÿ..ÿ..ÿ..ÿÿ
000000b0h: FF 00 FF FF 40 40 40 BF BF BF ; ÿ.ÿÿ@@@¿¿¿

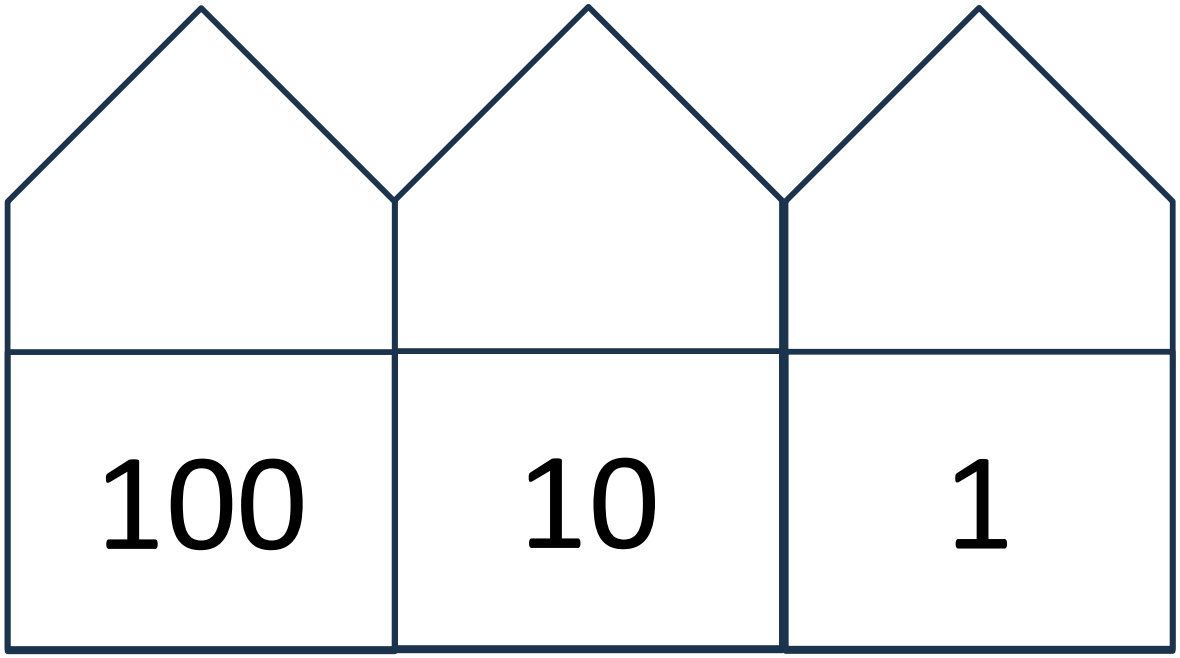
Decimal Numbers

What does

146

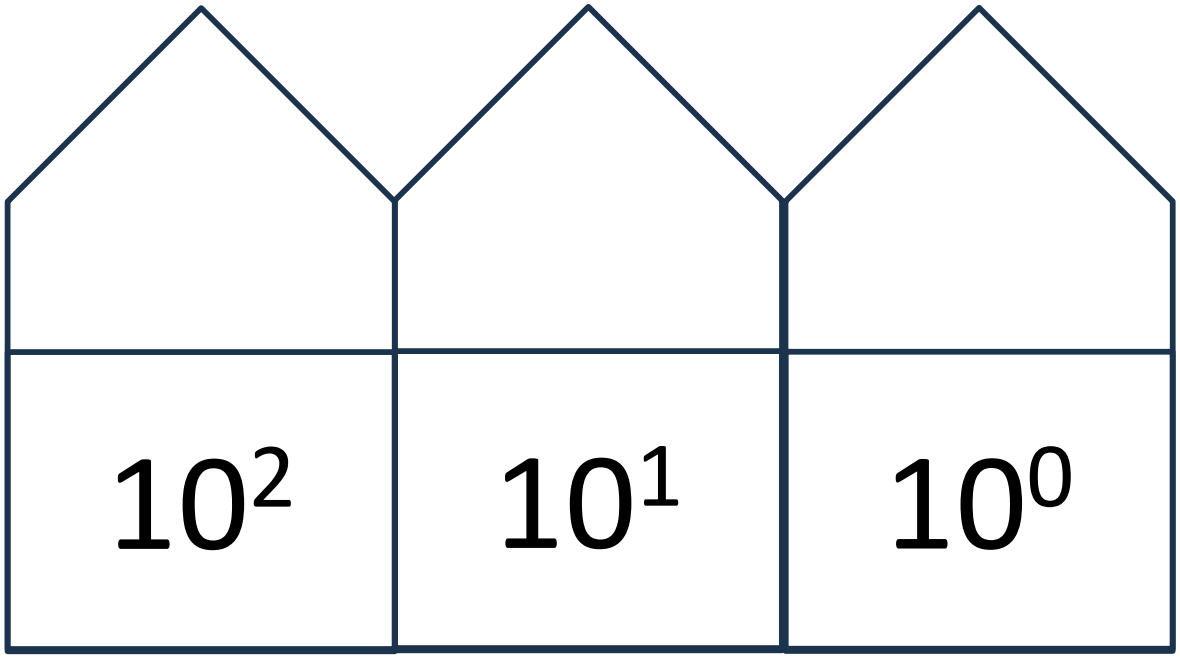
mean?

Houses



1 4 6

Base 10



1 4 6

Thought Question

How many different numerals are there in Base 10 (Ordinary numbers)?

Thought Question

How many different numerals are there is Base 10 (Ordinary numbers)?

0 1 2 3 4 5 6 7 8 9

Thought Question

Can you have number systems that have a different base?

Thought Question

Can you have number systems that have a different base?

Yes!

Like you could have Base 2

Thought Question

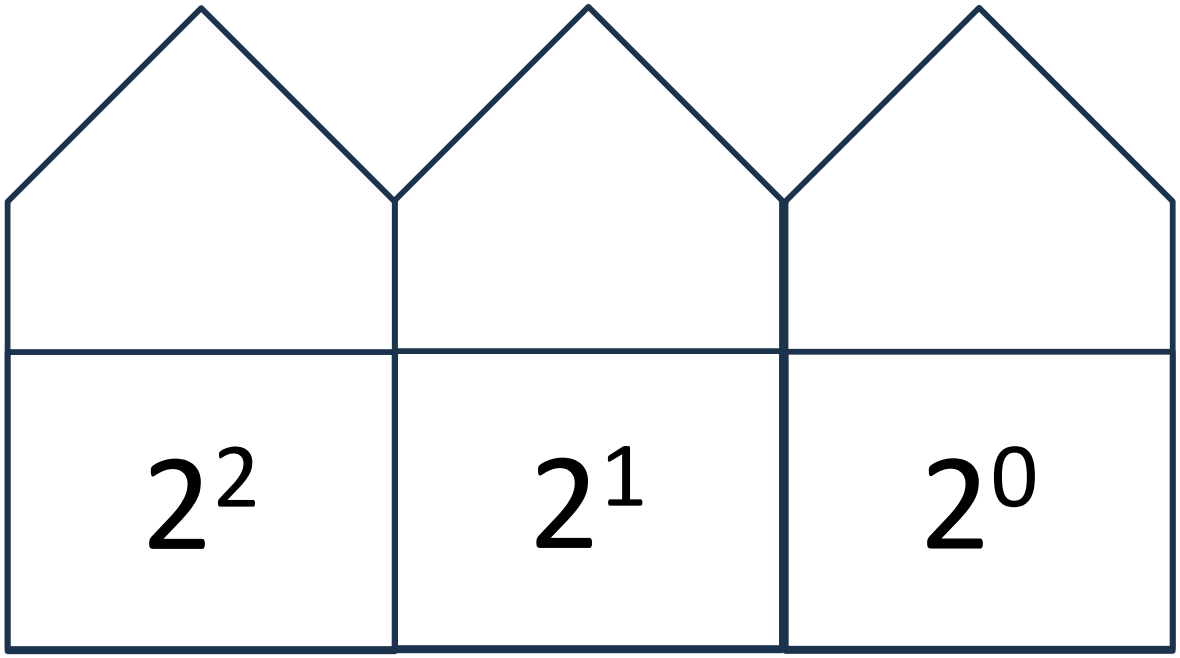
If Base 10 uses 10 different numerals can you guess how many different numerals Base 2 would have?

Thought Question

If Base 10 uses 10 different numerals can you guess how many different numerals Base 2 would have?

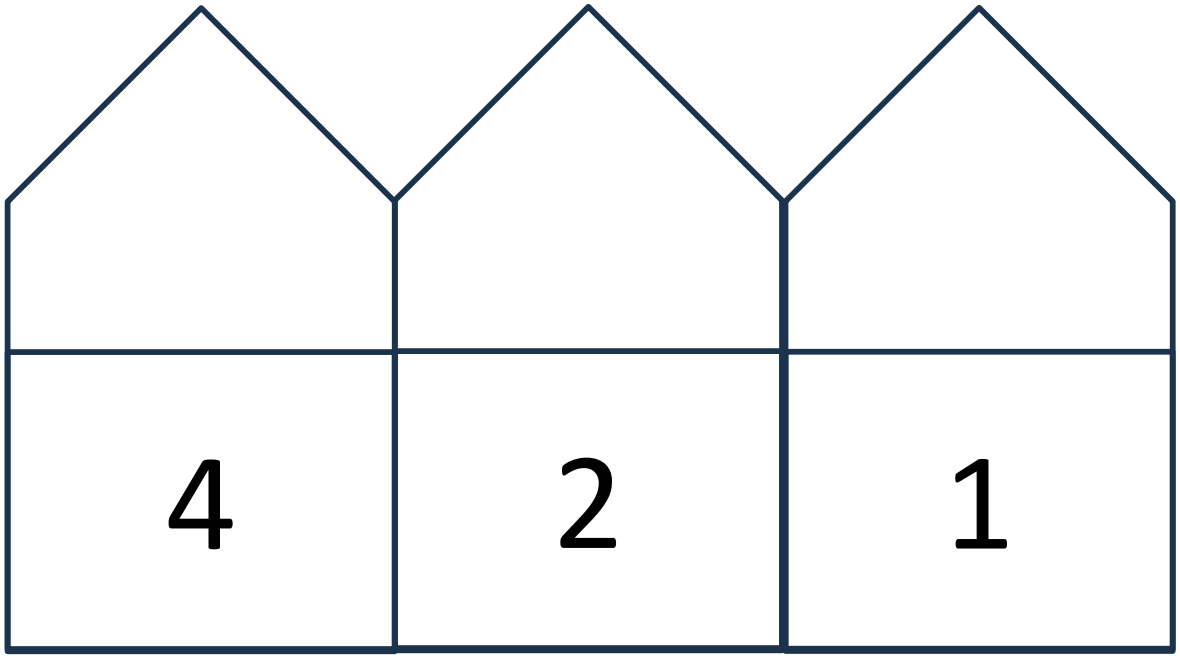
2

Base 2



1 0 1

Back to Houses

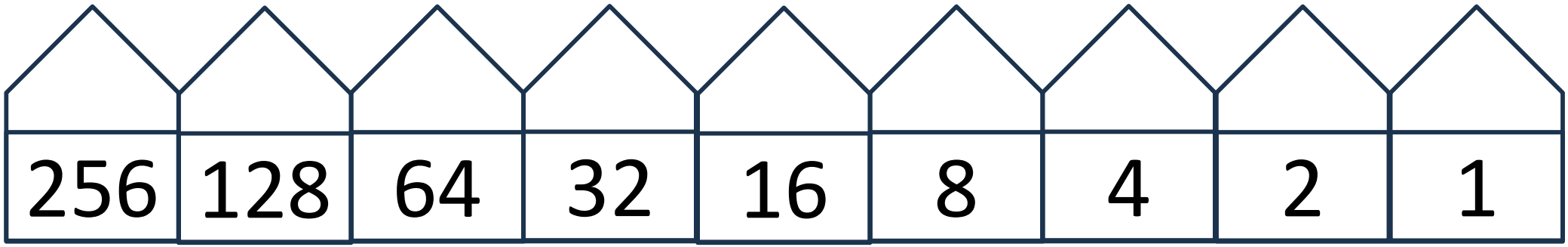


1 0 1

$$101_2 = 5_{10}$$

What about 146?

Base 2



0 1 0 0 1 0 0 1 0

128 + 16 + 2 = 146

$10010010_2 = 146_{10}$

People Who Work with Binary

01010010110010100010101010101001

People Who Work with Binary

01010010110010100010101010101001

0101 0010 1100 1010 0010 1010 1010 1001

All possible combinations of 4 bits

0000	0
0001	1
0010	2
0011	3
0100	4
0101	5
0110	6
0111	7
1000	8
1001	9
1010	10
1011	11
1100	12
1101	13
1110	14
1111	15

Binary, Decimal, Hexadecimal

Bin	Dec	Hex	Bin	Dec	Hex
0000	0	0	1000	8	8
0001	1	1	1001	9	9
0010	2	2	1010	10	?
0011	3	3	1011	11	?
0100	4	4	1100	12	?
0101	5	5	1101	13	?
0110	6	6	1110	14	?
0111	7	7	1111	15	?

Binary, Decimal, Hexadecimal

Bin	Dec	Hex	Bin	Dec	Hex
0000	0	0	1000	8	8
0001	1	1	1001	9	9
0010	2	2	1010	10	A
0011	3	3	1011	11	B
0100	4	4	1100	12	C
0101	5	5	1101	13	D
0110	6	6	1110	14	E
0111	7	7	1111	15	F

People Who Work with Binary

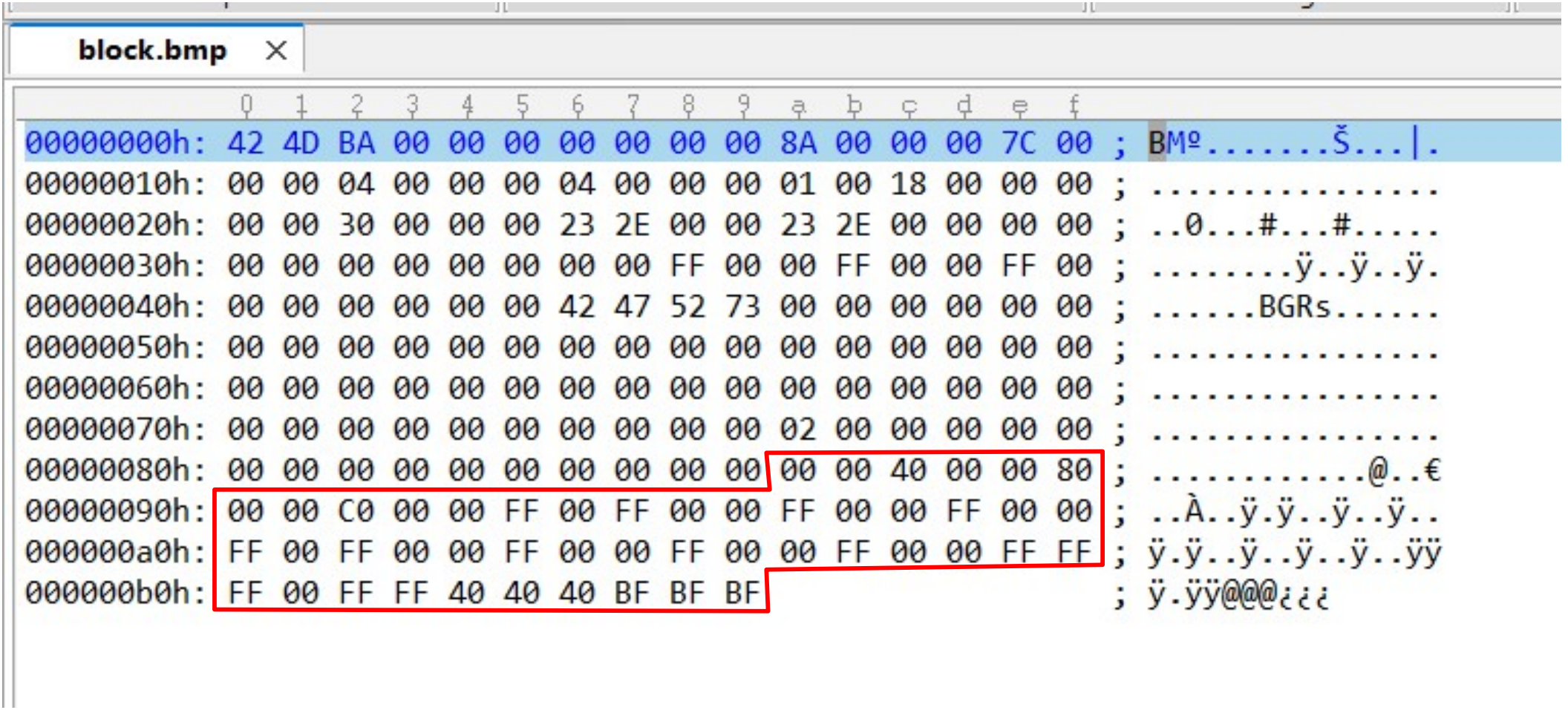
```
01010010110010100010101010101001
0101 0010 1100 1010 0010 1010 1010 1001
 5    2    C    A    2    A    A    9

52CA 2AA9
52 CA 2A A9
```

Hexadecimal

0	10	20	30	40	50	60	70	80	90	A0	B0	C0	D0	E0	F0
1	11	21	31	41	51	61	71	81	91	A1	B1	C1	D1	E1	F1
2	12	22	32	42	52	62	72	82	92	A2	B2	C2	D2	E2	F2
3	13	23	33	43	53	63	73	83	93	A3	B3	C3	D3	E3	F3
4	14	24	34	44	54	64	74	84	94	A4	B4	C4	D4	E4	F4
5	15	25	35	45	55	65	75	85	95	A5	B5	C5	D5	E5	F5
6	16	26	36	46	56	66	76	86	96	A6	B6	C6	D6	E6	F6
7	17	27	37	47	57	67	77	87	97	A7	B7	C7	D7	E7	F7
8	18	28	38	48	58	68	78	88	98	A8	B8	C8	D8	E8	F8
9	19	29	39	49	59	69	79	89	99	A9	B9	C9	D9	E9	F9
A	1A	2A	3A	4A	5A	6A	7A	8A	9A	AA	BA	CA	DA	EA	FA
B	1B	2B	3B	4B	5B	6B	7B	8B	9B	AB	BB	CB	DB	EB	FB
C	1C	2C	3C	4C	5C	6C	7C	8C	9C	AC	BC	CC	DC	EC	FC
D	1D	2D	3D	4D	5D	6D	7D	8D	9D	AD	BD	CD	DD	ED	FD
E	1E	2E	3E	4E	5E	6E	7E	8E	9E	AE	BE	CE	DE	EE	FE
F	1F	2F	3F	4F	5F	6F	7F	8F	9F	AF	BF	CF	DF	EF	FF

Don’t Panic!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Don’t Panic!

block.bmp

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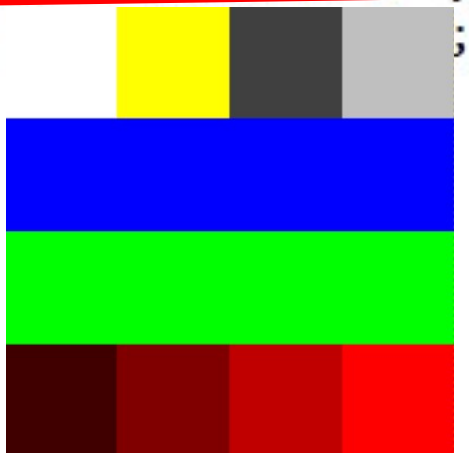

Don’t Panic!

block.bmp

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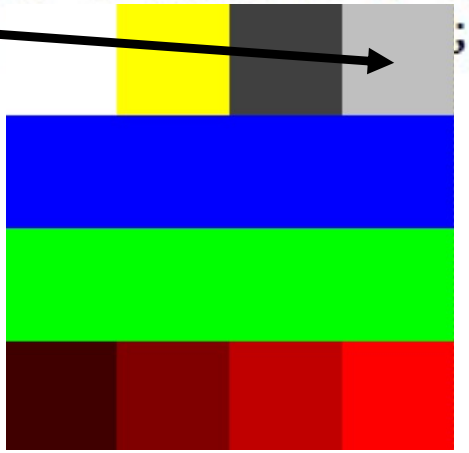

Don’t Panic!

block.bmp

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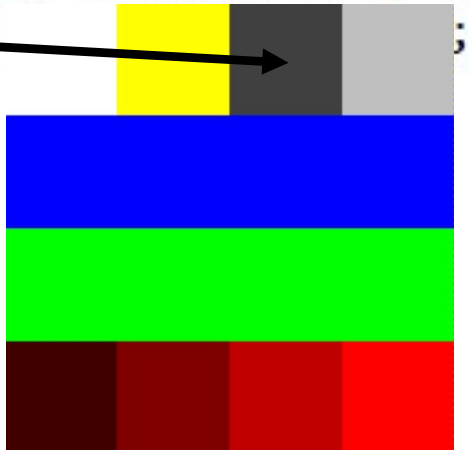

Don’t Panic!

block.bmp

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00000050h: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 ; ................
00000060h: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 ; ................
00000070h: 00 00 00 00 00 00 00 00 00 00 02 00 00 00 00 00 ; ................
00000080h: 00 00 00 00 00 00 00 00 00 00 00 00 40 00 00 80 ; ............@..€
00000090h: 00 00 C0 00 00 FF 00 FF 00 00 FF 00 00 FF 00 00 ; ..À..ÿ.ÿ..ÿ..ÿ..
000000a0h: FF 00 FF 00 00 FF 00 00 FF 00 00 FF 00 00 FF FF ; ÿ.ÿ..ÿ..ÿ..ÿ..ÿÿ
000000b0h: FF 00 FF FF 40 40 40 BF BF BF                   ; ÿ.ÿÿ@@@¿¿¿
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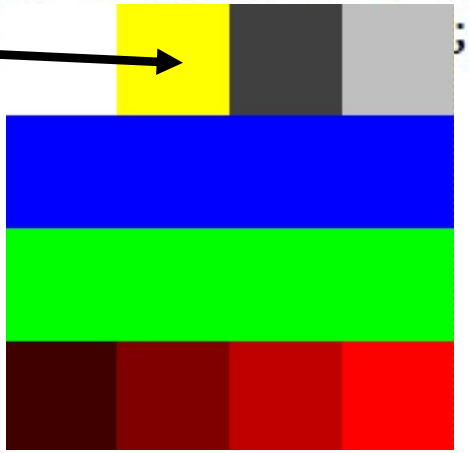

Don’t Panic!

block.bmp

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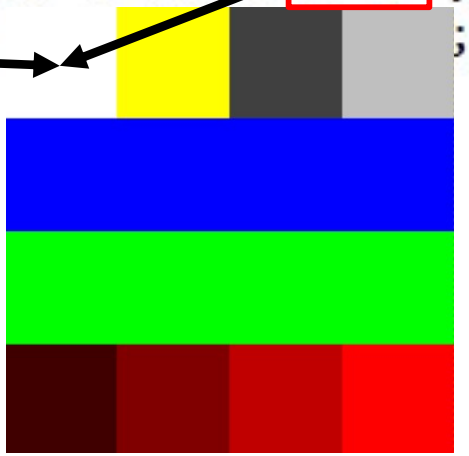
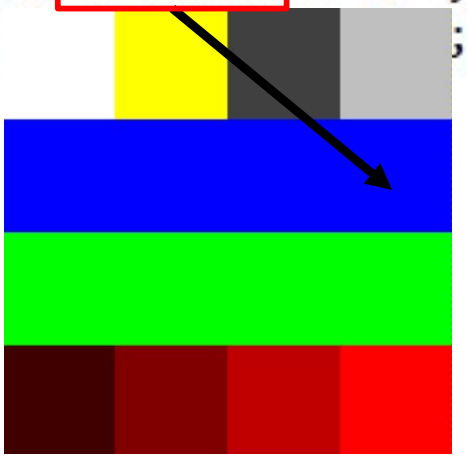
00000000h: 42 4D BA 00 00 00 00 00 00 00 8A 00 00 00 7C 00 ; BMº.......Š...|.
00000010h: 00 00 04 00 00 00 04 00 00 00 01 00 18 00 00 00 ; ................
00000020h: 00 00 30 00 00 00 23 2E 00 00 23 2E 00 00 00 00 ; ..0...#...#.....
00000030h: 00 00 00 00 00 00 00 00 FF 00 00 FF 00 00 FF 00 ; ........ÿ..ÿ..ÿ.
00000040h: 00 00 00 00 00 00 42 47 52 73 00 00 00 00 00 00 ; ......BGRs......
00000050h: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 ; ................
00000060h: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 ; ................
00000070h: 00 00 00 00 00 00 00 00 00 00 02 00 00 00 00 00 ; ................
00000080h: 00 00 00 00 00 00 00 00 00 00 00 00 40 00 00 80 ; ............@..€
00000090h: 00 00 C0 00 00 FF 00 FF 00 00 FF 00 00 FF 00 00 ; ..À..ÿ.ÿ..ÿ..ÿ..
000000a0h: FF 00 FF 00 00 FF 00 00 FF 00 00 FF 00 00 FF FF ; ÿ.ÿ..ÿ..ÿ..ÿ..ÿÿ
000000b0h: FF 00 FF FF 40 40 40 BF BF BF                   ; ÿ.ÿÿ@@@¿¿¿
```



Don’t Panic!

block.bmp

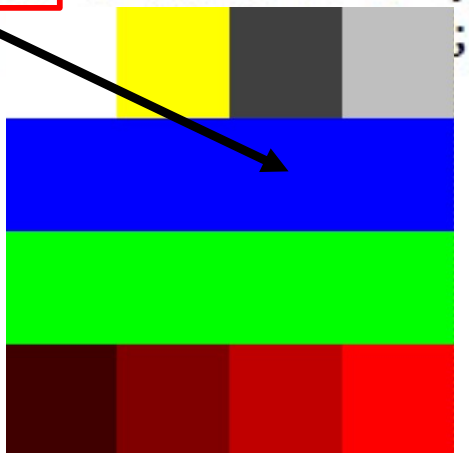
```
          0  1  2  3  4  5  6  7  8  9  a  b  c  d  e  f
00000000h: 42 4D BA 00 00 00 00 00 00 00 8A 00 00 00 7C 00 ; BMº.......Š...|.
00000010h: 00 00 04 00 00 00 04 00 00 00 01 00 18 00 00 00 ; ................
00000020h: 00 00 30 00 00 00 23 2E 00 00 23 2E 00 00 00 00 ; ..0...#...#.....
00000030h: 00 00 00 00 00 00 00 00 FF 00 00 FF 00 00 FF 00 ; ........ÿ..ÿ..ÿ.
00000040h: 00 00 00 00 00 00 42 47 52 73 00 00 00 00 00 00 ; ......BGRs......
00000050h: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 ; ................
00000060h: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 ; ................
00000070h: 00 00 00 00 00 00 00 00 00 00 02 00 00 00 00 00 ; ................
00000080h: 00 00 00 00 00 00 00 00 00 00 00 00 40 00 00 80 ; ............@..€
00000090h: 00 00 C0 00 00 FF 00 FF 00 00 FF 00 00 FF 00 00 ; ..À..ÿ.ÿ..ÿ..ÿ..
000000a0h: FF 00 FF 00 00 FF 00 00 FF 00 00 FF 00 00 FF FF ; ÿ.ÿ..ÿ..ÿ..ÿ..ÿÿ
000000b0h: FF 00 FF FF 40 40 40 BF BF BF                   ; ÿ.ÿÿ@@@¿¿¿
```



Don’t Panic!

block.bmp

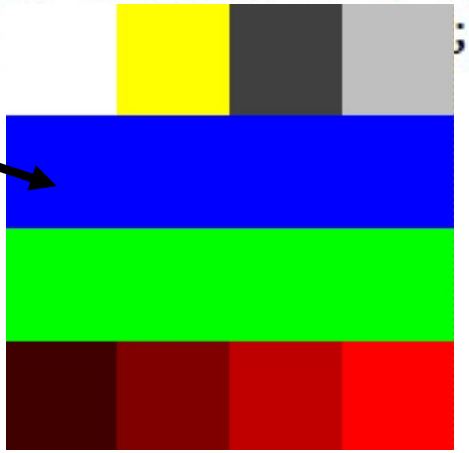
```
          0  1  2  3  4  5  6  7  8  9  a  b  c  d  e  f
00000000h: 42 4D BA 00 00 00 00 00 00 00 8A 00 00 00 7C 00 ; BMº.......Š...|.
00000010h: 00 00 04 00 00 00 04 00 00 00 01 00 18 00 00 00 ; ................
00000020h: 00 00 30 00 00 00 23 2E 00 00 23 2E 00 00 00 00 ; ..0...#...#.....
00000030h: 00 00 00 00 00 00 00 00 FF 00 00 FF 00 00 FF 00 ; ........ÿ..ÿ..ÿ.
00000040h: 00 00 00 00 00 00 42 47 52 73 00 00 00 00 00 00 ; ......BGRs......
00000050h: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 ; ................
00000060h: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 ; ................
00000070h: 00 00 00 00 00 00 00 00 00 00 02 00 00 00 00 00 ; ................
00000080h: 00 00 00 00 00 00 00 00 00 00 00 00 40 00 00 80 ; ............@..€
00000090h: 00 00 C0 00 00 FF 00 FF 00 00 FF 00 00 FF 00 00 ; ..À..ÿ.ÿ..ÿ..ÿ..
000000a0h: FF 00 FF 00 00 FF 00 00 FF 00 00 FF 00 00 FF FF ; ÿ.ÿ..ÿ..ÿ..ÿ..ÿÿ
000000b0h: FF 00 FF FF 40 40 40 BF BF BF                   ; ÿ.ÿÿ@@@¿¿¿
```



Don’t Panic!

block.bmp

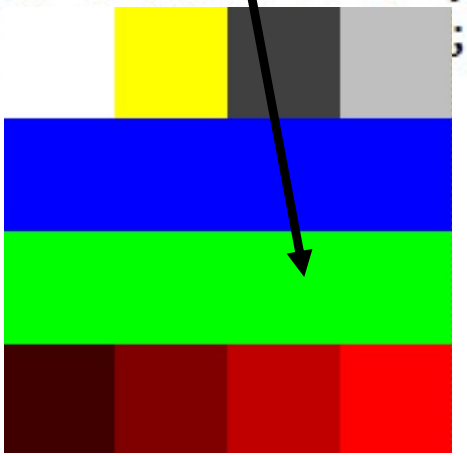
```
          0  1  2  3  4  5  6  7  8  9  a  b  c  d  e  f
00000000h: 42 4D BA 00 00 00 00 00 00 00 8A 00 00 00 7C 00 ; BMº.......Š...|.
00000010h: 00 00 04 00 00 00 04 00 00 00 01 00 18 00 00 00 ; ................
00000020h: 00 00 30 00 00 00 23 2E 00 00 23 2E 00 00 00 00 ; ..0...#...#.....
00000030h: 00 00 00 00 00 00 00 00 FF 00 00 FF 00 00 FF 00 ; ........ÿ..ÿ..ÿ.
00000040h: 00 00 00 00 00 00 42 47 52 73 00 00 00 00 00 00 ; ......BGRs......
00000050h: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 ; ................
00000060h: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 ; ................
00000070h: 00 00 00 00 00 00 00 00 00 00 02 00 00 00 00 00 ; ................
00000080h: 00 00 00 00 00 00 00 00 00 00 00 00 40 00 00 80 ; ............@..€
00000090h: 00 00 C0 00 00 FF 00 FF 00 00 FF 00 00 FF 00 00 ; ..À..ÿ.ÿ..ÿ..ÿ..
000000a0h: FF 00 FF 00 00 FF 00 00 FF 00 00 FF 00 00 FF FF ; ÿ.ÿ..ÿ..ÿ..ÿ..ÿÿ
000000b0h: FF 00 FF FF 40 40 40 BF BF BF                   ; ÿ.ÿÿ@@@¿¿¿
```



Don’t Panic!

block.bmp

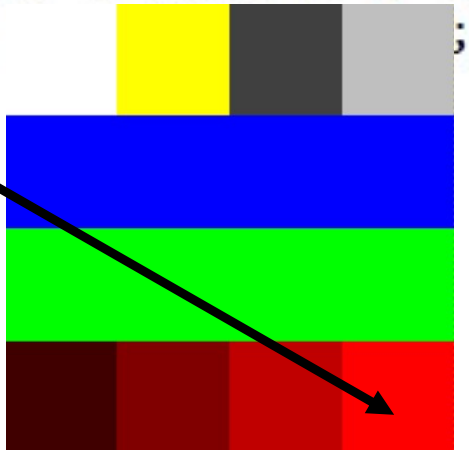
```
          0  1  2  3  4  5  6  7  8  9  a  b  c  d  e  f
00000000h: 42 4D BA 00 00 00 00 00 00 00 8A 00 00 00 7C 00 ; BMº.......Š...|.
00000010h: 00 00 04 00 00 00 04 00 00 00 01 00 18 00 00 00 ; ................
00000020h: 00 00 30 00 00 00 23 2E 00 00 23 2E 00 00 00 00 ; ..0...#...#.....
00000030h: 00 00 00 00 00 00 00 00 FF 00 00 FF 00 00 FF 00 ; ........ÿ..ÿ..ÿ.
00000040h: 00 00 00 00 00 00 42 47 52 73 00 00 00 00 00 00 ; ......BGRs......
00000050h: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 ; ................
00000060h: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 ; ................
00000070h: 00 00 00 00 00 00 00 00 00 00 02 00 00 00 00 00 ; ................
00000080h: 00 00 00 00 00 00 00 00 00 00 00 00 40 00 00 80 ; ............@..€
00000090h: 00 00 C0 00 00 FF 00 FF 00 00 FF 00 00 FF 00 00 ; ..À..ÿ.ÿ..ÿ..ÿ..
000000a0h: FF 00 FF 00 00 FF 00 00 FF 00 00 FF 00 00 FF FF ; ÿ.ÿ..ÿ..ÿ..ÿ..ÿÿ
000000b0h: FF 00 FF FF 40 40 40 BF BF BF                   ; ÿ.ÿÿ@@@¿¿¿
```



Don’t Panic!

block.bmp

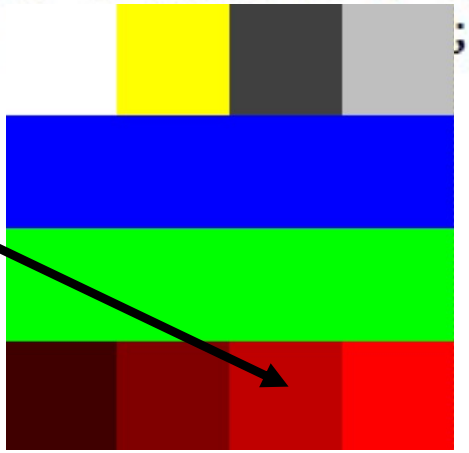
```
          0  1  2  3  4  5  6  7  8  9  a  b  c  d  e  f
00000000h: 42 4D BA 00 00 00 00 00 00 00 8A 00 00 00 7C 00 ; BMº.......Š...|.
00000010h: 00 00 04 00 00 00 04 00 00 00 01 00 18 00 00 00 ; ................
00000020h: 00 00 30 00 00 00 23 2E 00 00 23 2E 00 00 00 00 ; ..0...#...#.....
00000030h: 00 00 00 00 00 00 00 00 FF 00 00 FF 00 00 FF 00 ; ........ÿ..ÿ..ÿ.
00000040h: 00 00 00 00 00 00 42 47 52 73 00 00 00 00 00 00 ; ......BGRs......
00000050h: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 ; ................
00000060h: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 ; ................
00000070h: 00 00 00 00 00 00 00 00 00 00 02 00 00 00 00 00 ; ................
00000080h: 00 00 00 00 00 00 00 00 00 00 00 00 40 00 00 80 ; ............@..€
00000090h: 00 00 C0 00 00 FF 00 FF 00 00 FF 00 00 FF 00 00 ; ..À..ÿ.ÿ..ÿ..ÿ..
000000a0h: FF 00 FF 00 00 FF 00 00 FF 00 00 FF 00 00 FF FF ; ÿ.ÿ..ÿ..ÿ..ÿ..ÿÿ
000000b0h: FF 00 FF FF 40 40 40 BF BF BF                   ; ÿ.ÿÿ@@@¿¿¿
```



Don’t Panic!

block.bmp

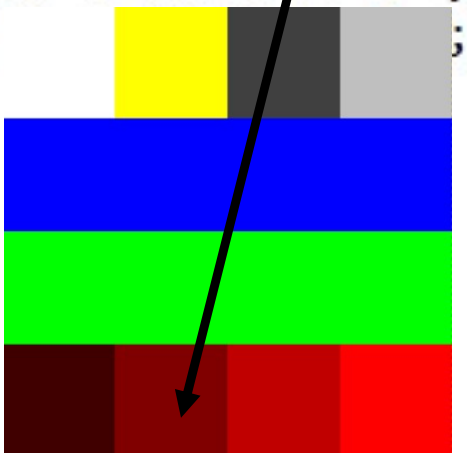
```
          0  1  2  3  4  5  6  7  8  9  a  b  c  d  e  f
00000000h: 42 4D BA 00 00 00 00 00 00 00 8A 00 00 00 7C 00 ; BMº.......Š...|.
00000010h: 00 00 04 00 00 00 04 00 00 00 01 00 18 00 00 00 ; ................
00000020h: 00 00 30 00 00 00 23 2E 00 00 23 2E 00 00 00 00 ; ..0...#...#.....
00000030h: 00 00 00 00 00 00 00 00 FF 00 00 FF 00 00 FF 00 ; ........ÿ..ÿ..ÿ.
00000040h: 00 00 00 00 00 00 42 47 52 73 00 00 00 00 00 00 ; ......BGRs......
00000050h: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 ; ................
00000060h: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 ; ................
00000070h: 00 00 00 00 00 00 00 00 00 00 02 00 00 00 00 00 ; ................
00000080h: 00 00 00 00 00 00 00 00 00 00 00 00 40 00 00 80 ; ............@..€
00000090h: 00 00 C0 00 00 FF 00 FF 00 00 FF 00 00 FF 00 00 ; ..À..ÿ.ÿ..ÿ..ÿ..
000000a0h: FF 00 FF 00 00 FF 00 00 FF 00 00 FF 00 00 FF FF ; ÿ.ÿ..ÿ..ÿ..ÿ..ÿÿ
000000b0h: FF 00 FF FF 40 40 40 BF BF BF                   ; ÿ.ÿÿ@@@¿¿¿
```



Don’t Panic!

block.bmp

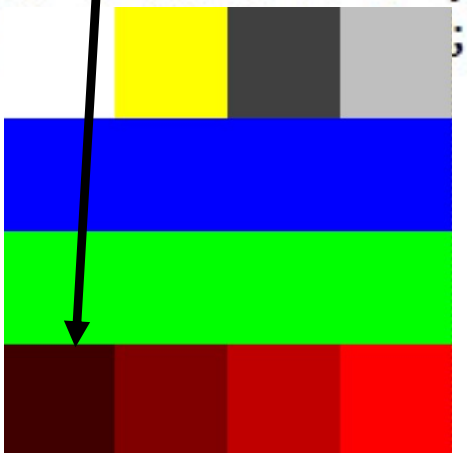
```
          0  1  2  3  4  5  6  7  8  9  a  b  c  d  e  f
00000000h: 42 4D BA 00 00 00 00 00 00 00 8A 00 00 00 7C 00 ; BMº.......Š...|.
00000010h: 00 00 04 00 00 00 04 00 00 00 01 00 18 00 00 00 ; ................
00000020h: 00 00 30 00 00 00 23 2E 00 00 23 2E 00 00 00 00 ; ..0...#...#.....
00000030h: 00 00 00 00 00 00 00 00 FF 00 00 FF 00 00 FF 00 ; ........ÿ..ÿ..ÿ.
00000040h: 00 00 00 00 00 00 42 47 52 73 00 00 00 00 00 00 ; ......BGRs......
00000050h: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 ; ................
00000060h: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 ; ................
00000070h: 00 00 00 00 00 00 00 00 00 00 02 00 00 00 00 00 ; ................
00000080h: 00 00 00 00 00 00 00 00 00 00 00 00 40 00 00 80 ; ............@..€
00000090h: 00 00 C0 00 00 FF 00 FF 00 00 FF 00 00 FF 00 00 ; ..À..ÿ.ÿ..ÿ..ÿ..
000000a0h: FF 00 FF 00 00 FF 00 00 FF 00 00 FF 00 00 FF FF ; ÿ.ÿ..ÿ..ÿ..ÿ..ÿÿ
000000b0h: FF 00 FF FF 40 40 40 BF BF BF                   ; ÿ.ÿÿ@@@¿¿¿
```

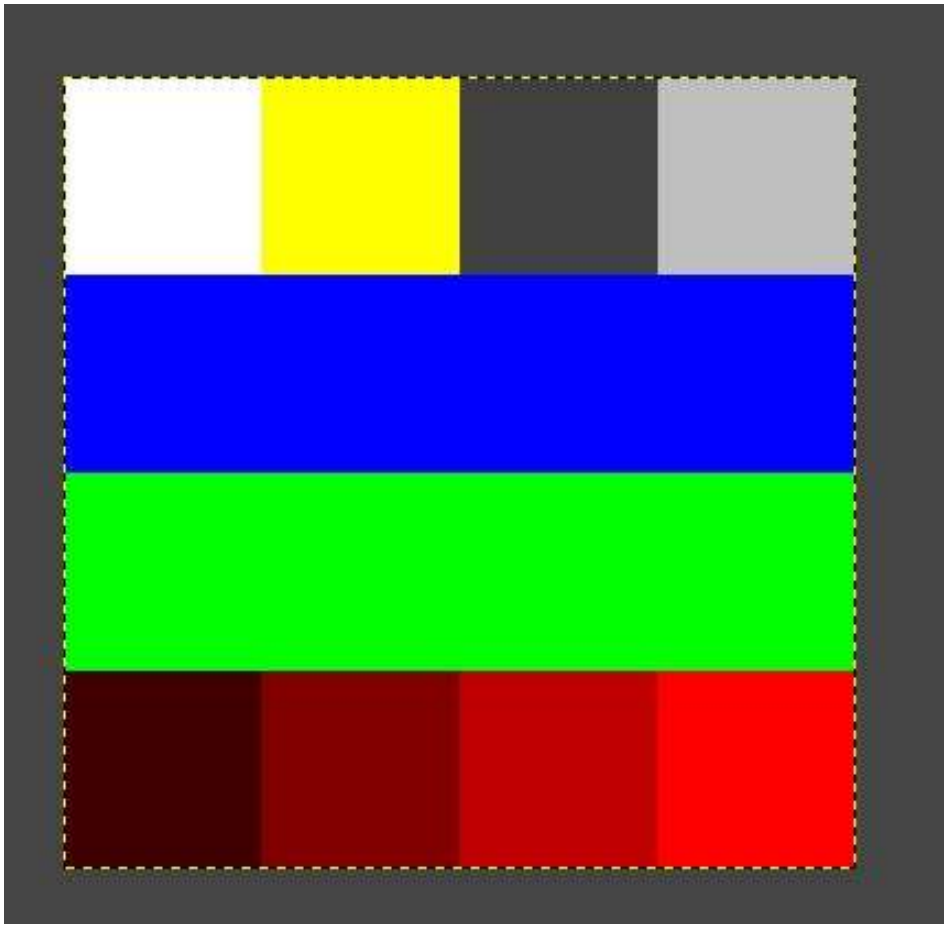


Don’t Panic!

block.bmp

```
          0  1  2  3  4  5  6  7  8  9  a  b  c  d  e  f
00000000h: 42 4D BA 00 00 00 00 00 00 00 8A 00 00 00 7C 00 ; BMº.......Š...|.
00000010h: 00 00 04 00 00 00 04 00 00 00 01 00 18 00 00 00 ; ................
00000020h: 00 00 30 00 00 00 23 2E 00 00 23 2E 00 00 00 00 ; ..0...#...#.....
00000030h: 00 00 00 00 00 00 00 00 FF 00 00 FF 00 00 FF 00 ; ........ÿ..ÿ..ÿ.
00000040h: 00 00 00 00 00 00 42 47 52 73 00 00 00 00 00 00 ; ......BGRs......
00000050h: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 ; ................
00000060h: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 ; ................
00000070h: 00 00 00 00 00 00 00 00 00 00 02 00 00 00 00 00 ; ................
00000080h: 00 00 00 00 00 00 00 00 00 00 00 00 00 40 00 00 80 ; .............@..€
00000090h: 00 00 C0 00 00 FF 00 FF 00 00 FF 00 00 FF 00 00 ; ..À..ÿ.ÿ..ÿ..ÿ..
000000a0h: FF 00 FF 00 00 FF 00 00 FF 00 00 FF 00 00 FF FF ; ÿ.ÿ..ÿ..ÿ..ÿ..ÿÿ
000000b0h: FF 00 FF FF 40 40 40 BF BF BF                   ; ÿ.ÿÿ@@@¿¿¿
```

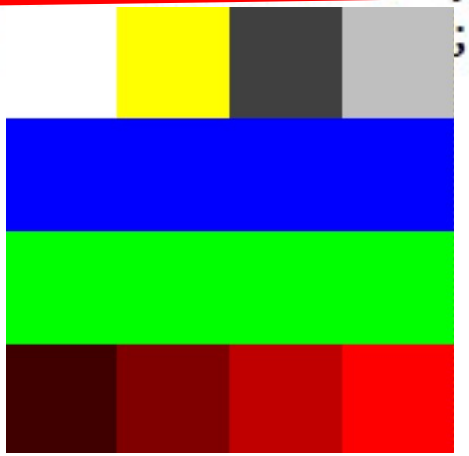




Don’t Panic!

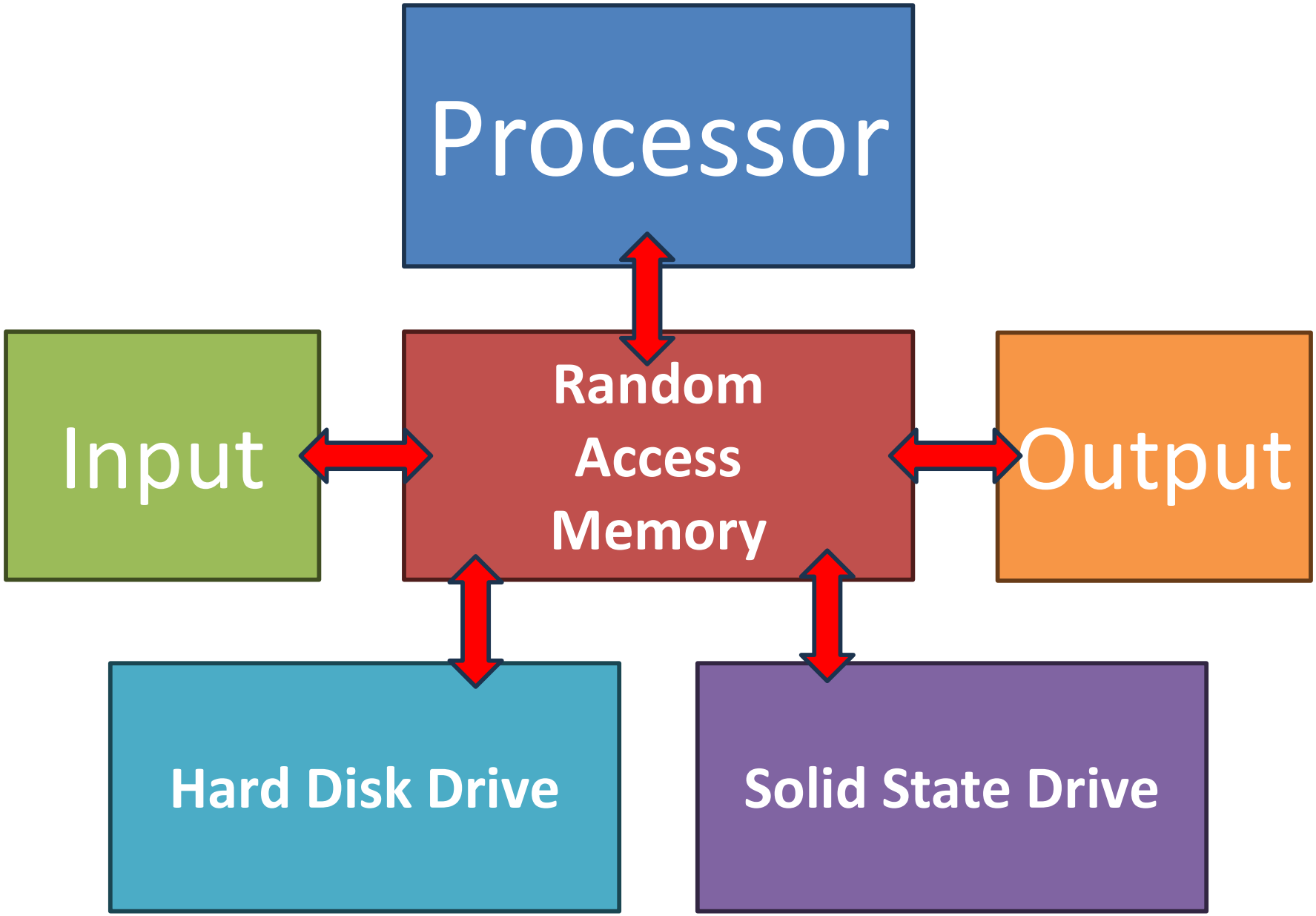
block.bmp

```
          0  1  2  3  4  5  6  7  8  9  a  b  c  d  e  f
00000000h: 42 4D BA 00 00 00 00 00 00 00 8A 00 00 00 7C 00 ; BMº.......Š...|.
00000010h: 00 00 04 00 00 00 04 00 00 00 01 00 18 00 00 00 ; ................
00000020h: 00 00 30 00 00 00 23 2E 00 00 23 2E 00 00 00 00 ; ..0...#...#.....
00000030h: 00 00 00 00 00 00 00 00 FF 00 00 FF 00 00 FF 00 ; ........ÿ..ÿ..ÿ.
00000040h: 00 00 00 00 00 00 42 47 52 73 00 00 00 00 00 00 ; ......BGRs......
00000050h: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 ; ................
00000060h: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 ; ................
00000070h: 00 00 00 00 00 00 00 00 00 00 02 00 00 00 00 00 ; ................
00000080h: 00 00 00 00 00 00 00 00 00 00 00 00 40 00 00 80 ; ............@..€
00000090h: 00 00 C0 00 00 FF 00 FF 00 00 FF 00 00 FF 00 00 ; ..À..ÿ.ÿ..ÿ..ÿ..
000000a0h: FF 00 FF 00 00 FF 00 00 FF 00 00 FF 00 00 FF FF ; ÿ.ÿ..ÿ..ÿ..ÿ..ÿÿ
000000b0h: FF 00 FF FF 40 40 40 BF BF BF                   ; ÿ.ÿÿ@@@¿¿¿
```

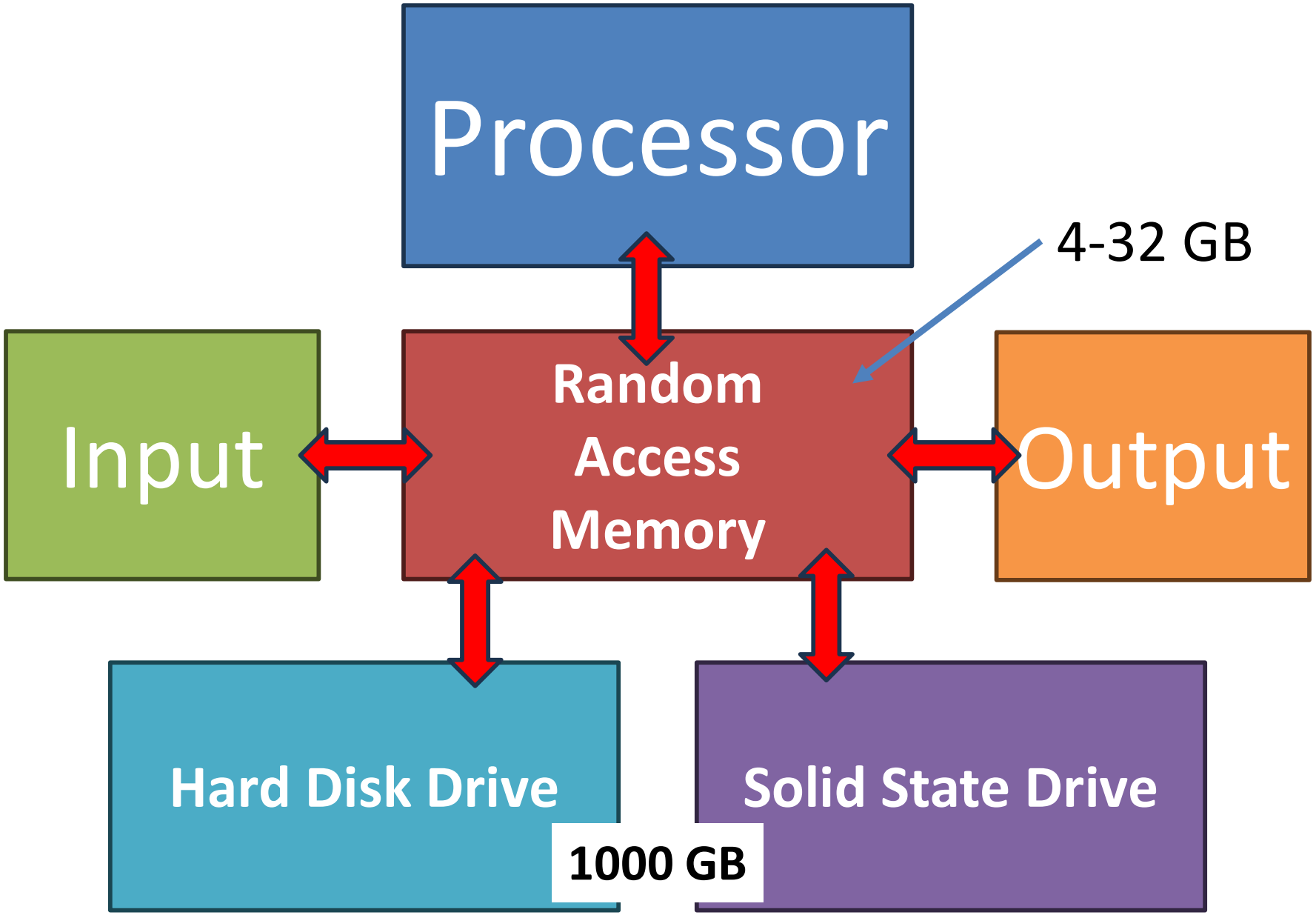


But where are the images?

Parts of a Computer



Parts of a Computer



= Data Unit =

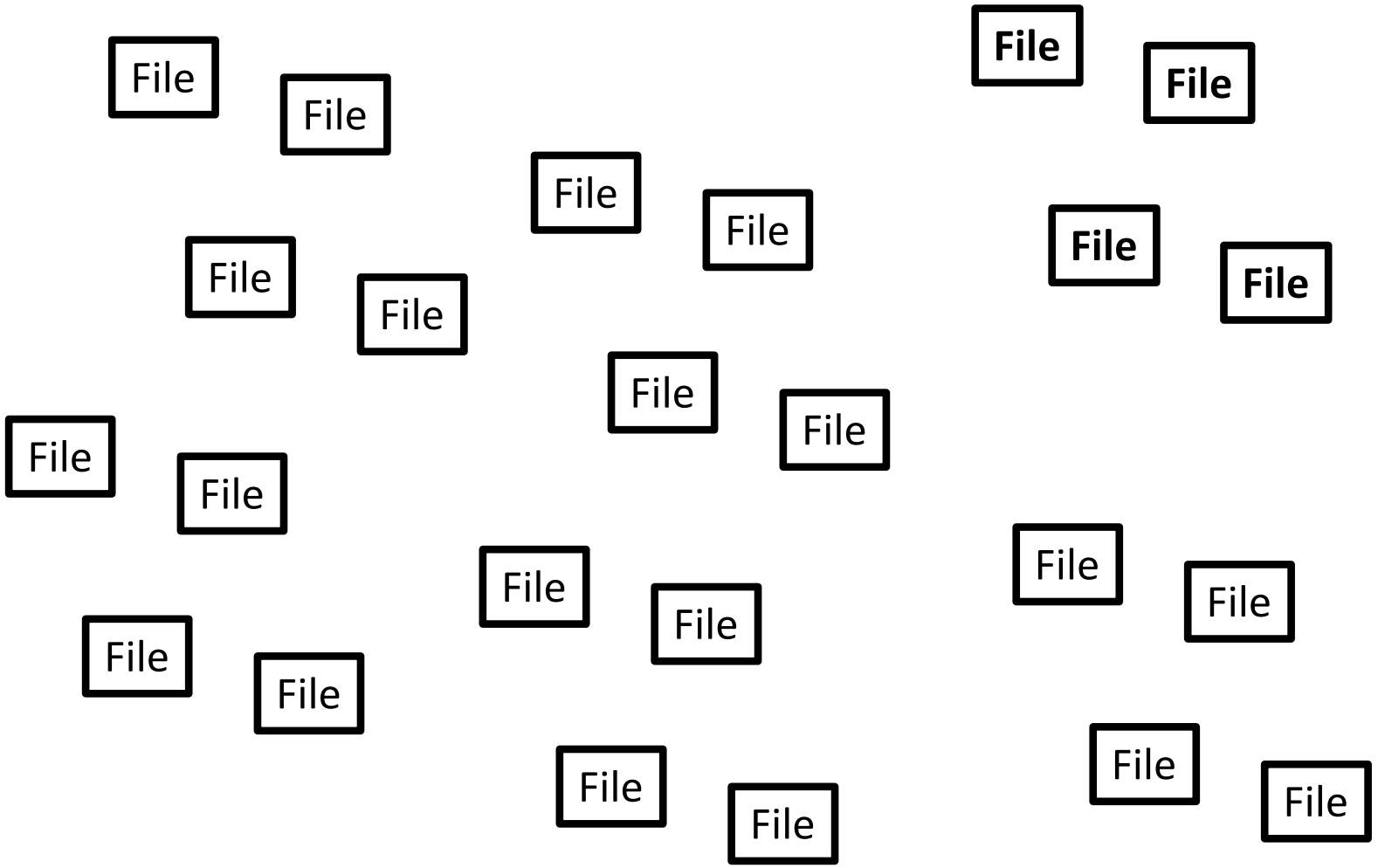
B Byte — **KB** Kilo-byte — **MB** Mega-byte — **GB** Giga-byte — **TB** Tera-byte

1024 times **1024 times** **1024 times** **1024 times**

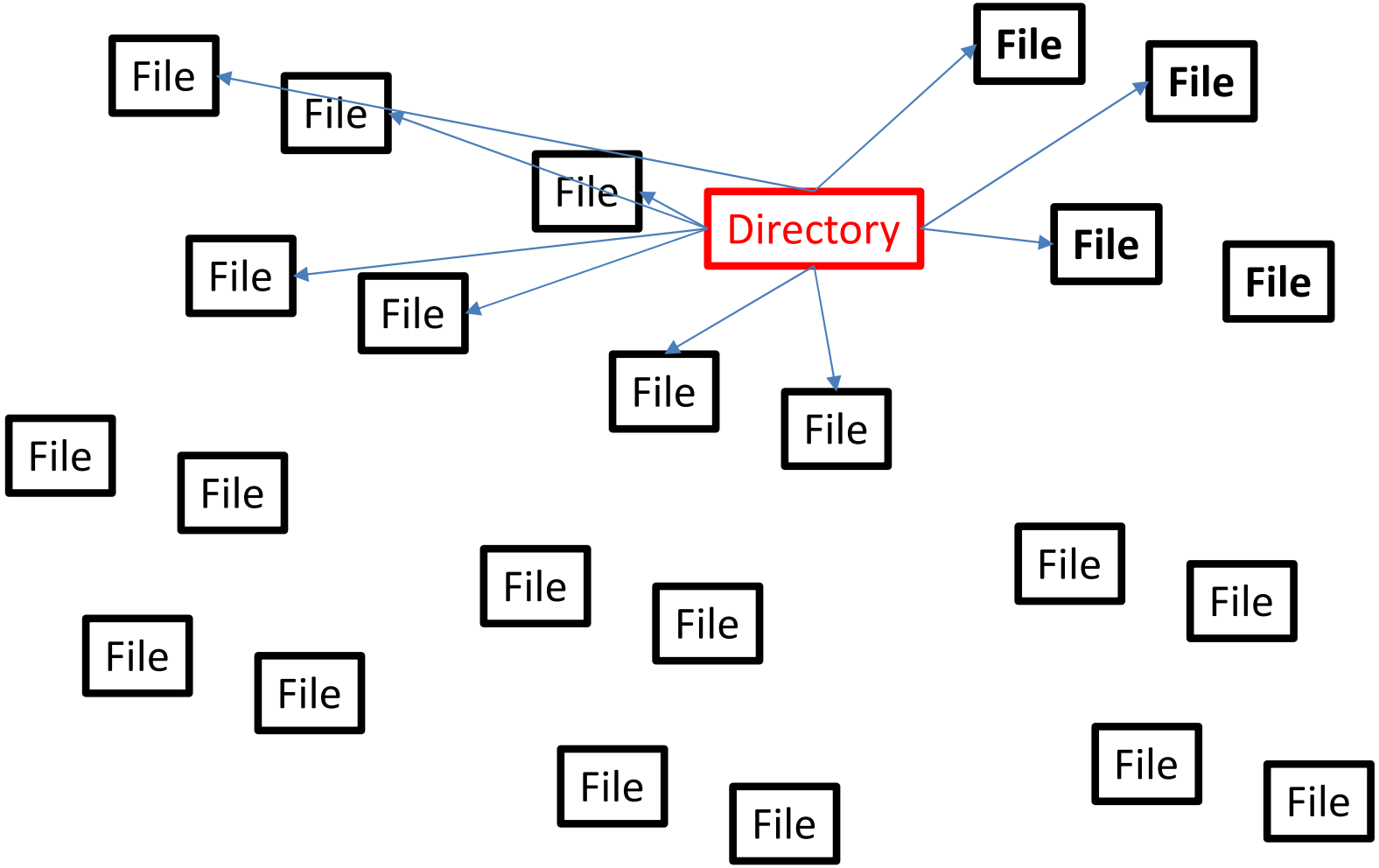
Unit	Definition	Storage space size
Bit	0 or 1	Yes/No
1 Byte	8 bit	Alphabets and one number
1 kilobyte (KB)	1,024 Byte	A few paragraphs
1 megabyte (MB)	1,024 KB	One minute-long MP3 song
1 gigabyte (GB)	1,024 MB	30 minute-long HD movie
1 terabyte (TB)	1,024 GB	About 200 FHD movies

Samsung Semiconstory
samsungsemiconstory.com

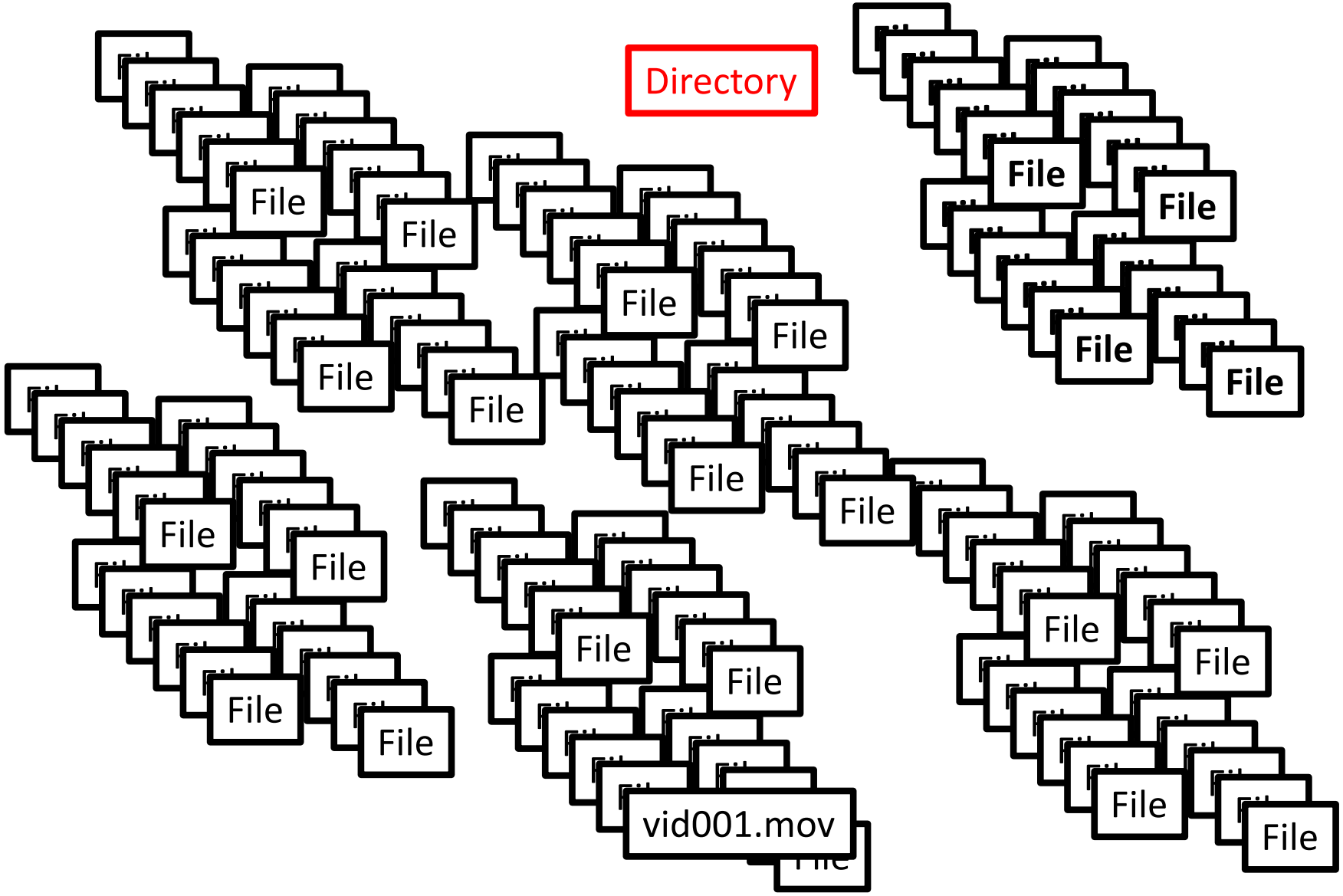
A disk holds files



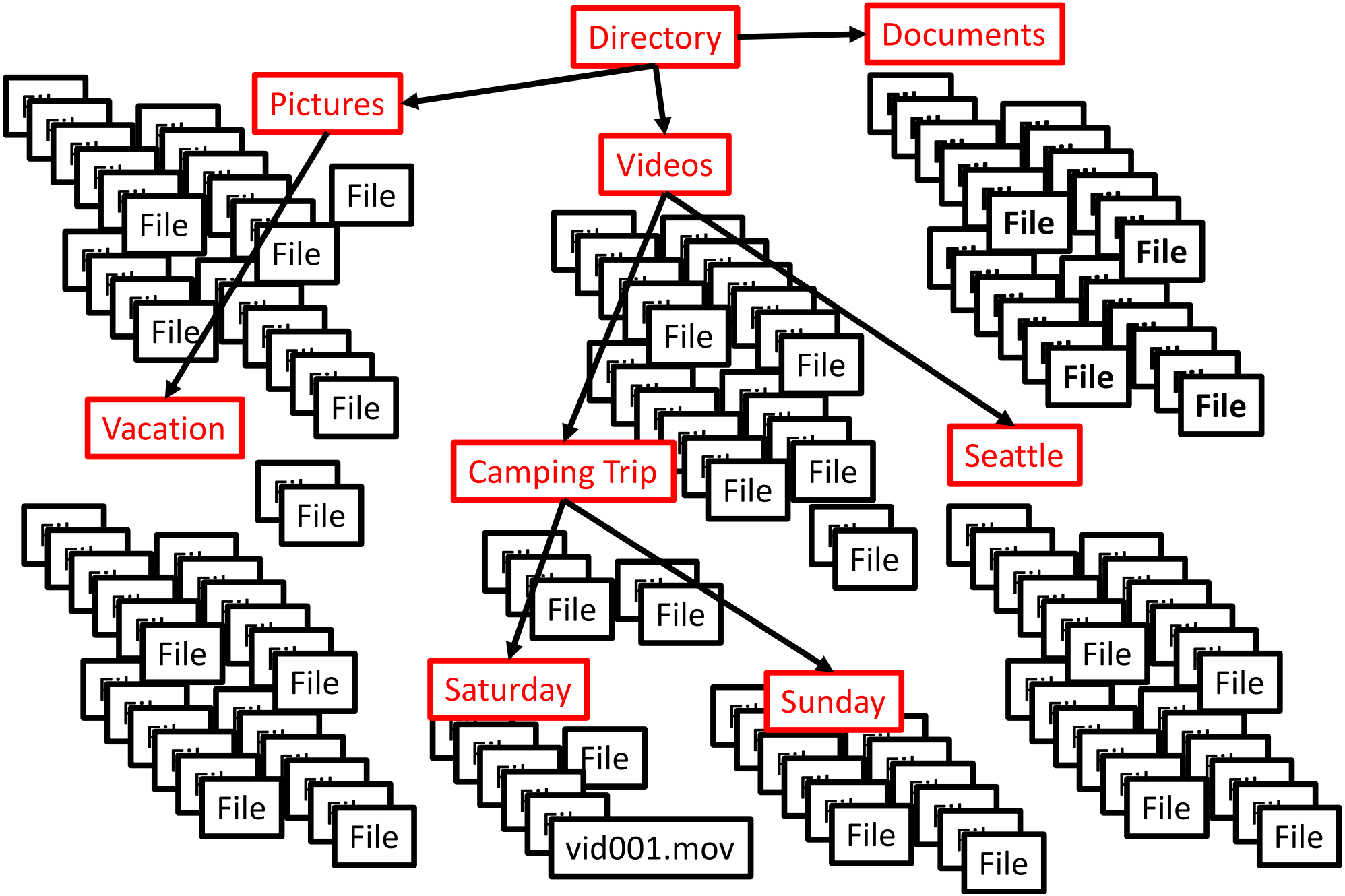
There is a special file which has the names of all the other files



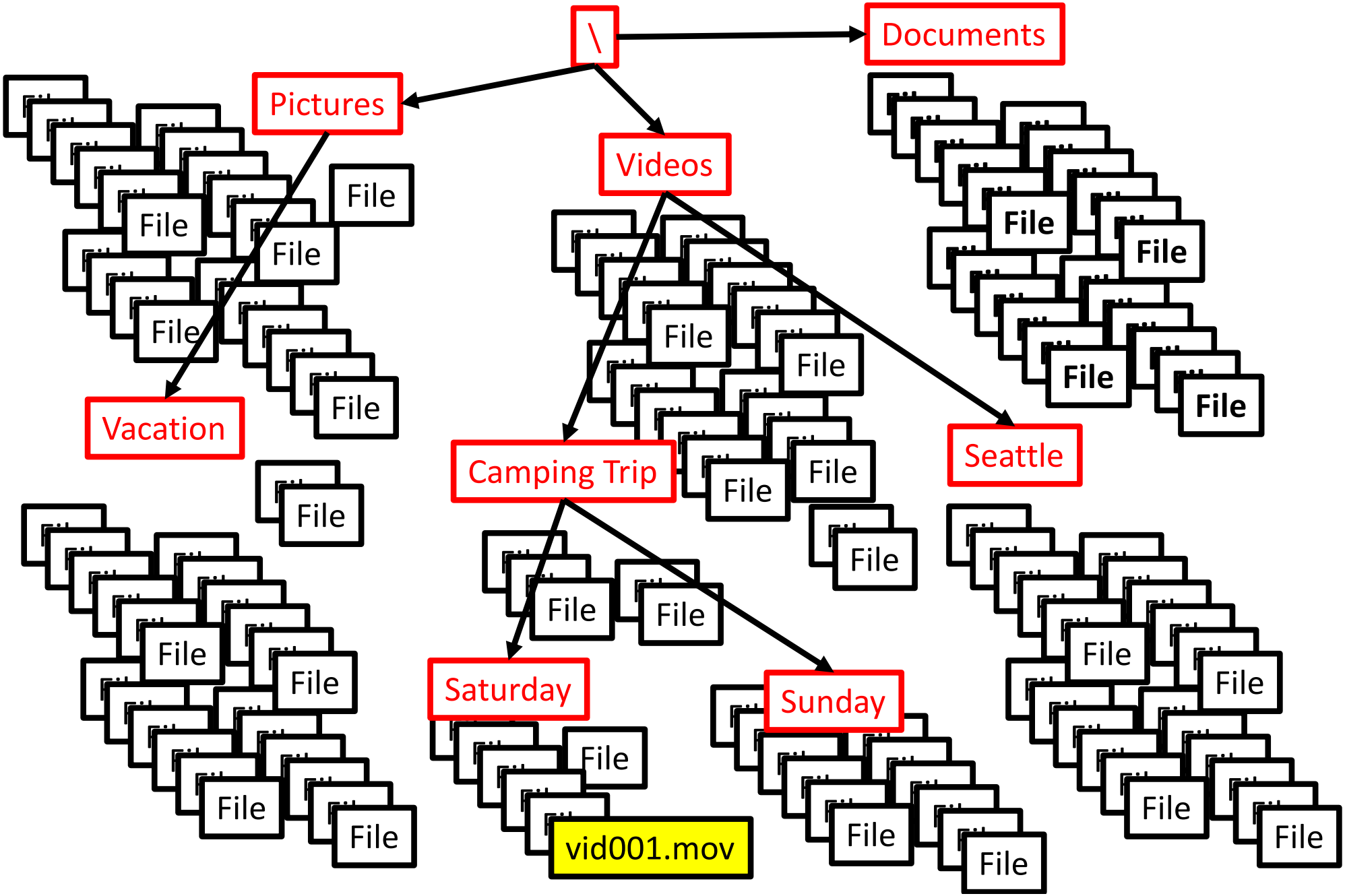
As disks got bigger the number of files got bigger. The directory became too big...



Solution: Make multiple directories



Solution: Make multiple directories



File Names

C:\videos\camping trip\Saturday\vid001.mov

Big Picture

	Uncompressed	Lossless Compressed	Lossy Compressed
Vector		SVG	
Combination		PDF	
Raster	BMP	GIF, PNG	JPG

Big Picture

WAYS TO DRAW IMAGES

	Uncompressed	Lossless Compressed	Lossy Compressed
Vector		SVG	
Combination		PDF	
Raster	BMP	GIF, PNG	JPG

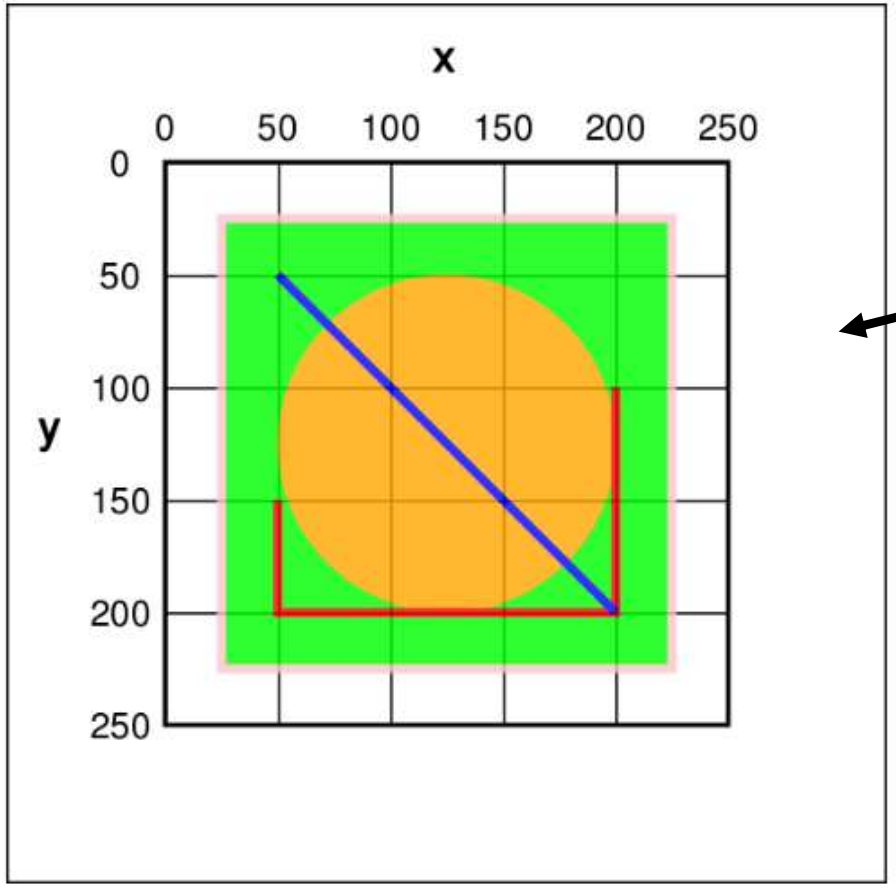
Big Picture

COMPRESSION	Uncompressed	Lossless Compressed	Lossy Compressed
Vector		SVG	
Combination		PDF	
Raster	BMP	GIF, PNG	JPG

Ways to Draw Images

- Vector Graphics
  - https://www.youtube.com/watch?v=Ctr54kopo8I
  - Very fast
  - Doesn't work well with filled polygons
  - November 1980
- Raster Graphics
  - https://www.youtube.com/watch?v=Bp57Lo2grfM
  - Slower (Fixed with hardware)
  - Great for polygons and shading
  - System used by Television

Vector



150 Kb

1 Kb

This code will produce the colored shapes shown in the image, excluding the grid and labels:

```
<?xml version="1.0" encoding="UTF-8" standalone="no"?>
<!DOCTYPE svg PUBLIC "-//W3C//DTD SVG 1.1//EN" "http://www.w3.org/Graphics/SVG/1.1/DTD/svg11.dtd">
<svg width="391" height="391" viewBox="-70.5 -70.5 391 391" xmlns="http://www.w3.org/2000/svg"
xmlns:xlink="http://www.w3.org/1999/xlink">
<rect fill="#fff" stroke="#000" x="-70" y="-70" width="390" height="390"/>
<g opacity="0.8">
    <rect x="25" y="25" width="200" height="200" fill="lime" stroke-width="4" stroke="pink" />
    <circle cx="125" cy="125" r="75" fill="orange" />
    <polyline points="50,150 50,200 200,200 200,100" stroke="red" stroke-width="4" fill="none" />
    <line x1="50" y1="50" x2="200" y2="200" stroke="blue" stroke-width="4" />
</g>
</svg>
```


Raster

Vector vs. Raster

Vector

- Vectors are perfect for creating designs using simple and solid colors. These images have dedicated color gradients, scales, shadows, and shading, which means they can be scaled further without pixelating. i.e. Adobe Illustrator etc.

Raster

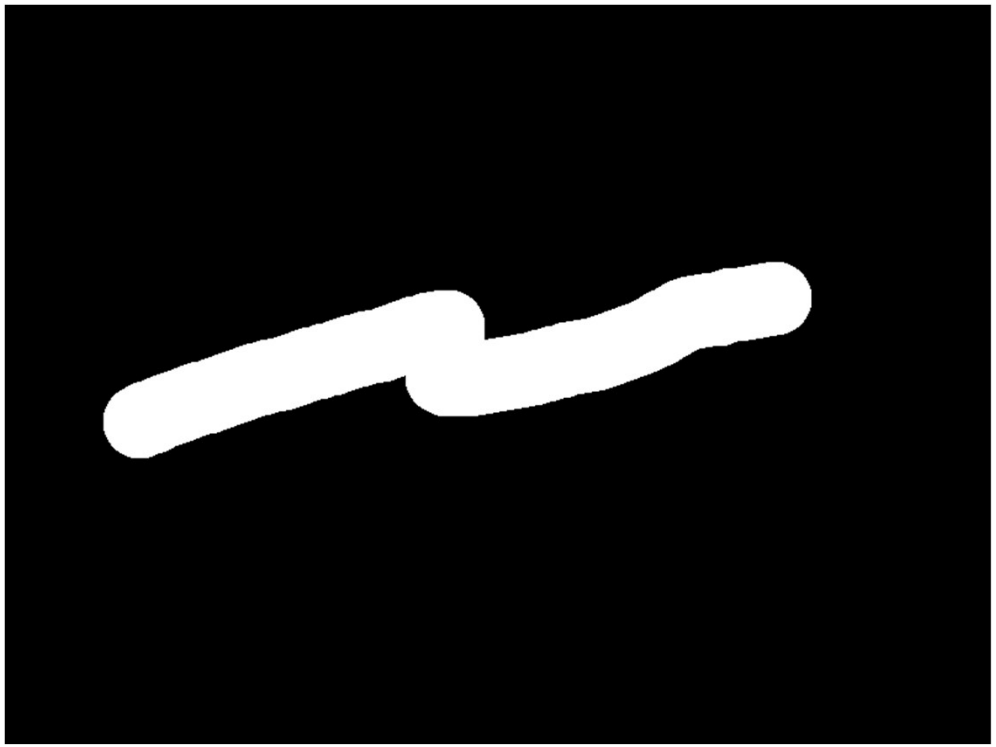
- Raster images are more capable of rendering complex, soft-colored, vibrant multi-colored visuals. i.e. Photographs

Time and Space

- Computer scientists are always trying to make things run faster and take up less space
- But there are tradeoffs
- Moving picture data from your disk to you screen is fast
- Moving picture data from www.whatever.com is slow
- We use both systems vector, raster and a blend

Compression

- Computer scientists have come up with lots of clever ways to make big image files smaller
- Compuserve GIFs
- JPEGs



Compression Flavors

- Lossless – We reduce the size of the file using algorithms that preserve all the detail. When we uncompress the file we get exactly the same image. GIF
- Lossy – We reduce the size of the file by discarding information that our eyes normally wouldn’t see. JPEG

Image Formats

Standard	Type Data	Created	Comments
TGA	Raster	1984	Early format not used much now
PICT	Raster	1984	Early format not used much now
IFF	Raster	1985	Early format not used much now
PCX	Raster	1985	Early format not used much now
BMP	Raster	1985	Windows
EPS	Both	1985	Adobe
TIFF	Raster	1986	High quality photographic images
GIF	Raster	1987	Compressed, animated, Lossless
PSD	Both	1990	Adobe
JPEG	Raster	1992	Compressed photos
PDF	Both	1993	Adobe
PNG	Raster	1994	Patent Buster
SVG	Vector	1999	Graphic design, high quality, Scalable
AI	Both	2000	Adobe
RAW	Raster	2001	Photos, large, no compression
HEIC	Raster	2017	MPEG. First adopted by Apple

Image Compression

Standard	Type Data	Created	Comments
TGA	Raster	1984	Early format not used much now
PICT	Raster	1984	Early format not used much now
IFF	Raster	1985	Early format not used much now
PCX	Raster	1985	Early format not used much now
BMP	Raster	1985	Windows
EPS	Both	1985	Adobe
TIFF	Raster	1986	High quality photographic images
GIF	Raster	1987	Compressed, animated, Lossless
PSD	Both	1990	Adobe
JPEG	Raster	1992	Compressed photos
PDF	Both	1993	Adobe
PNG	Raster	1994	Patent Buster
SVG	Vector	1999	Graphic design, high quality, Scalable
AI	Both	2000	Adobe
RAW	Raster	2001	Photos, large, no compression
HEIC	Raster	2017	MPEG. First adopted by Apple

Image Manipulations

- Resize (Scale)
- Aspect Ratio
- Crop
- Skew (Warp/Deform)
- Fill
- Clone
- Smudge
- Color Picking
- Transparency

Resize

Resize

Aspect Ratio

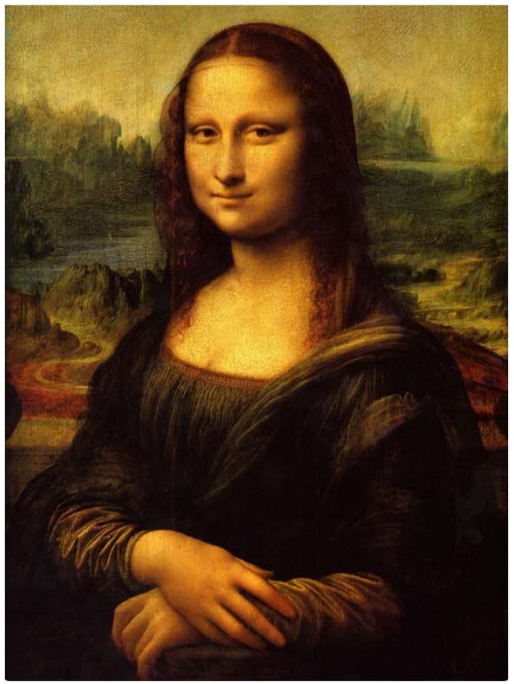
width

height

Aspect Ratio = width/height

Landscape vs. Portrait

Landscape



Portrait

Common Aspect Ratios

- Paper
  - 8-1/2 x 11 (Letter)
  - 8-1/2 x 14 (Legal)
  - A1, A2, A3, A4
- Photos
  - 4 x 6
  - 5 x 7
  - 8 x 10
- PC Screens
  - 640 x 480
  - 800 x 600
  - 1024 x 768
  - 1920 x 1080
- TV
  - NTSC 4:3
  - ATSC 16:9++

```
Cell Phones
6:13 Commonly used in modern smartphones
9:16 Commonly used in mid-late 2010s smartphones
3:5  Commonly used in early 2010s smartphones
2:3  Commonly used in late 2000s smartphones
```

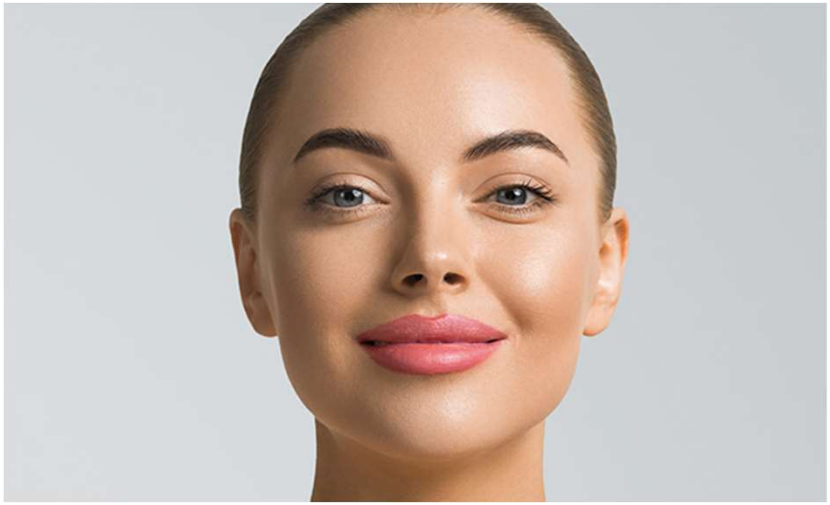
Crop

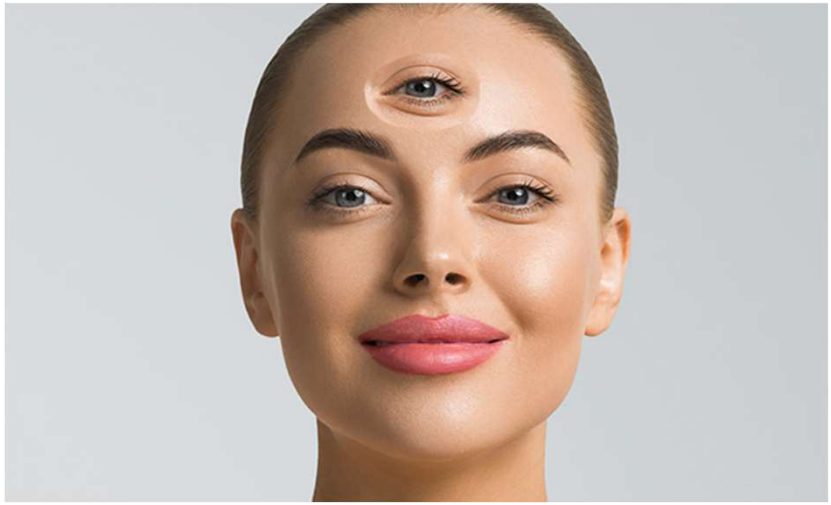
Skew/Warp/Deform

BARN

Fill

Clone





Smudge

Color Picker

Transparency

Can You See Me?

Transparency is Simple!

α - alpha

= 0 completely transparent

= 1 completely opaque

Background Color: R_B G_B B_B

Foreground Color: R_F G_F B_F

Color for Transparency effect:

$R_B(1 - \alpha) + R_F(\alpha)$

$G_B(1 - \alpha) + G_F(\alpha)$

$B_B(1 - \alpha) + B_F(\alpha)$

Questions?