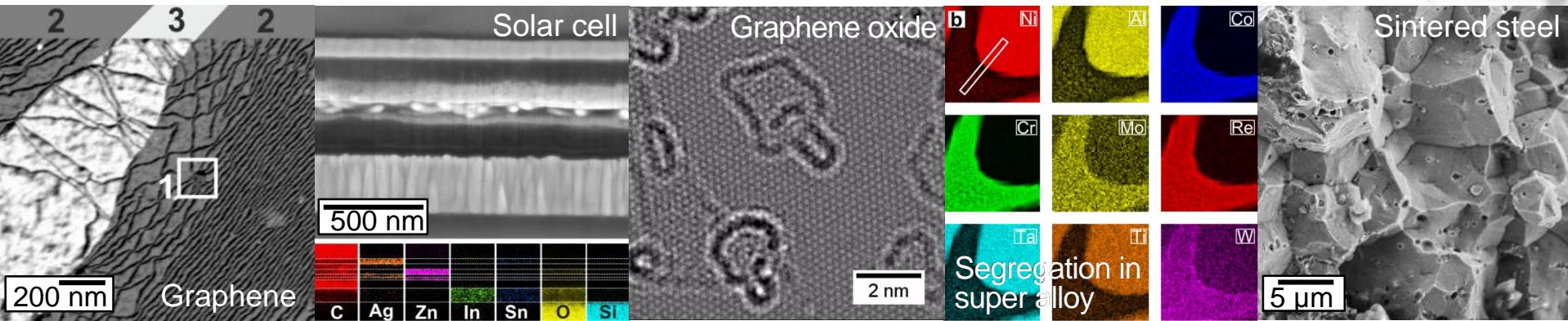


# *The Histogram –* Brightness, Contrast, Saturation, Manipulation

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Micro- and Nanoanalytics Facility MNaF



# Our TEM lab in former years ...



... Maintenance of our TEM ...



# ... Farewell at Stanford ...



... Me at the microscope ...



... Me at the microscope ...

## Image size

1200 px

x

900 px

=

**1.08 Mpx**



... Me at the microscope ...

## Image size

1200 px

x

900 px

=

**1.08 Mpx**



## File size

1.08 Mpx

x

3 Colors

x

8 bit / 1 Byte

=

**3,24 MB**

(uncompressed TIF)

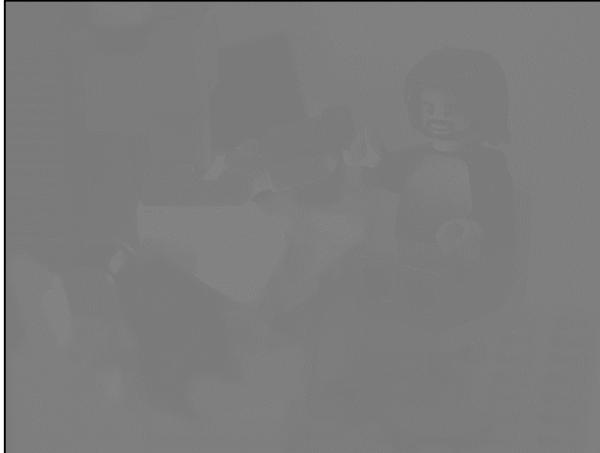


**0,22 kB**

(compressed JPG)

# Image examples — What are the differences?

Saturated



Low contrast

optimal contrast

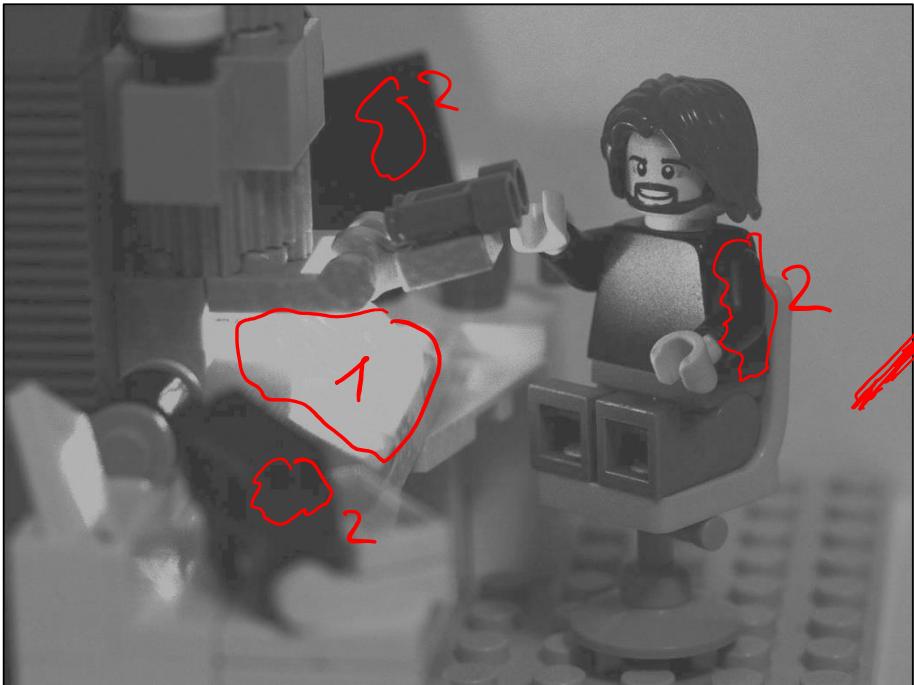


Under-Saturated  
Low contrast

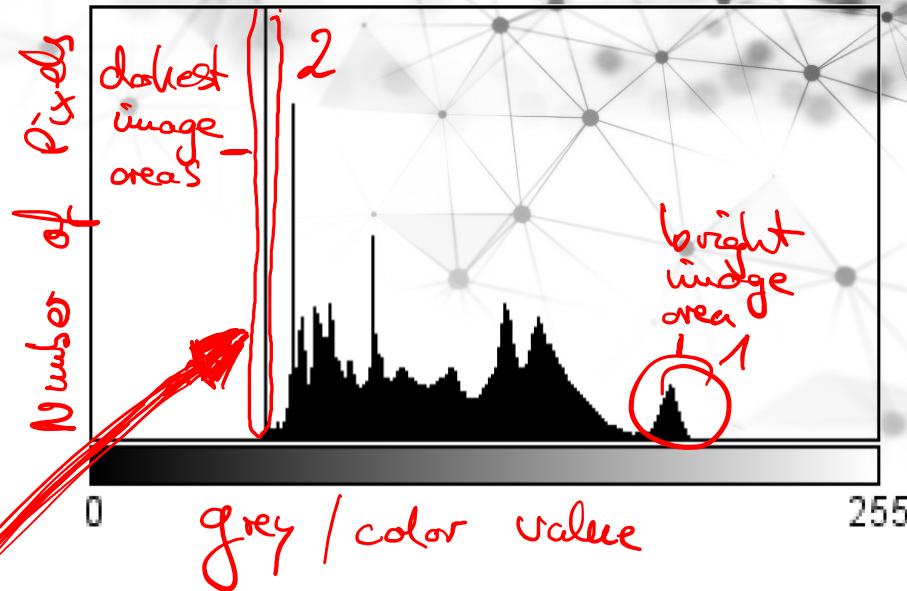


# What is the histogram?

1.08 Mpx



HISTOGRAM

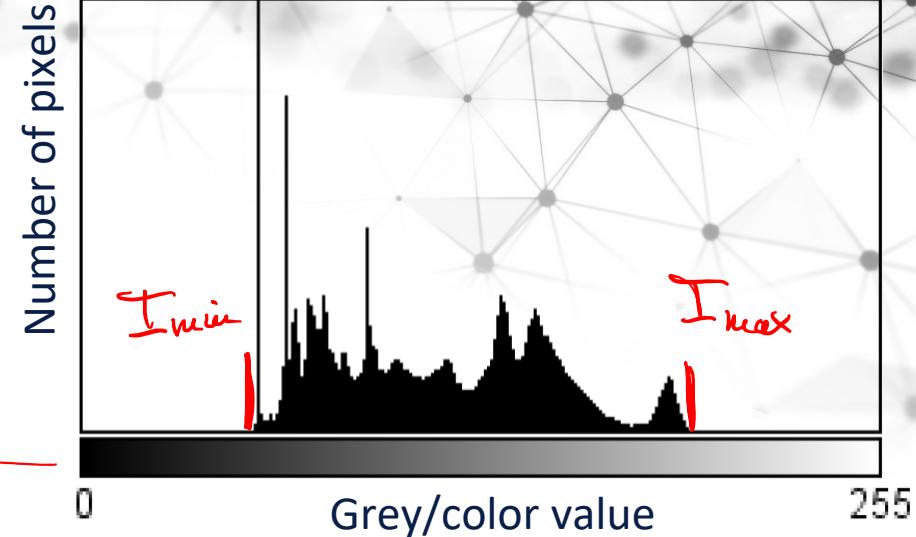


# What is the contrast?

$$C = \frac{I_{\max} - I_{\min}}{I_{\min}}$$

WEBER

$$0 < C < \infty$$



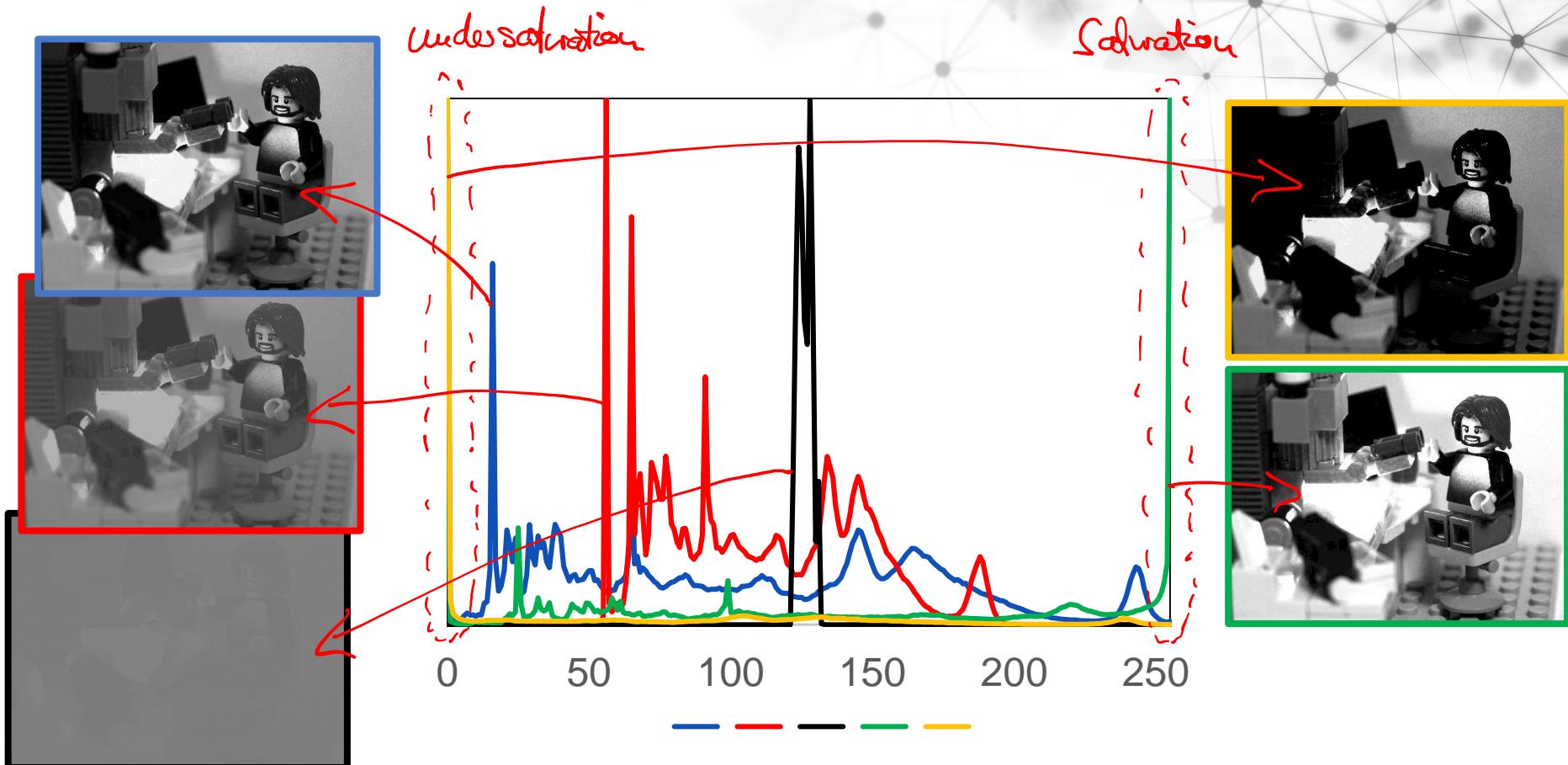
$$C = \frac{I_{\max} - I_{\min}}{I_{\max} + I_{\min}}$$

MICHELSON

$$\Rightarrow 0 < C < 1$$

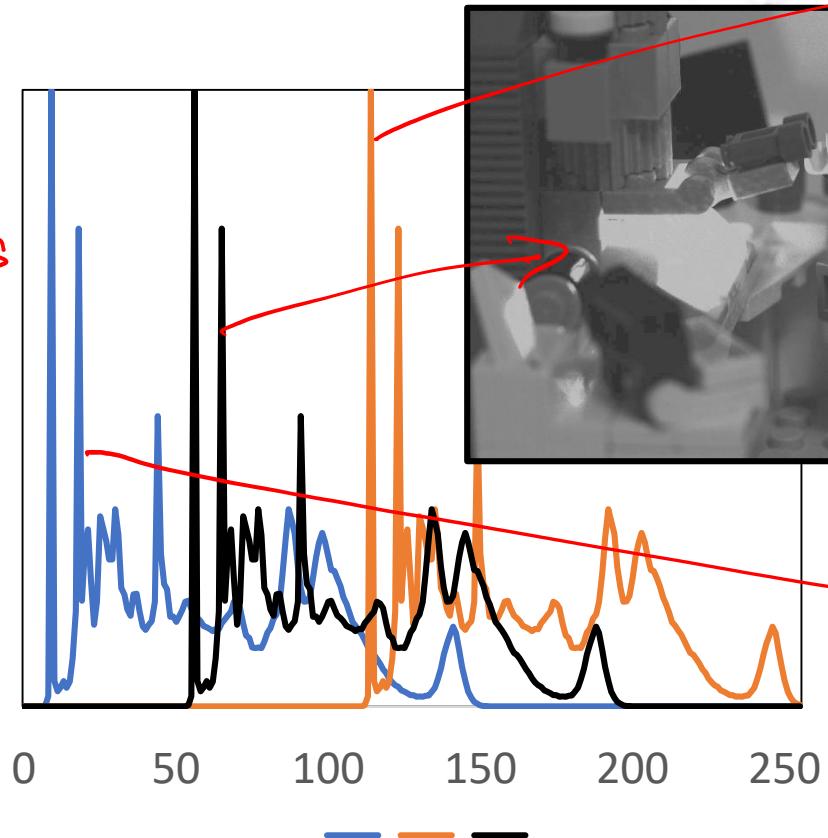
broad histogram  
High contrast

# Histogram optimization → high contrast



# Histogram manipulation (offset/shift)

Linear  
histogram  
transformations

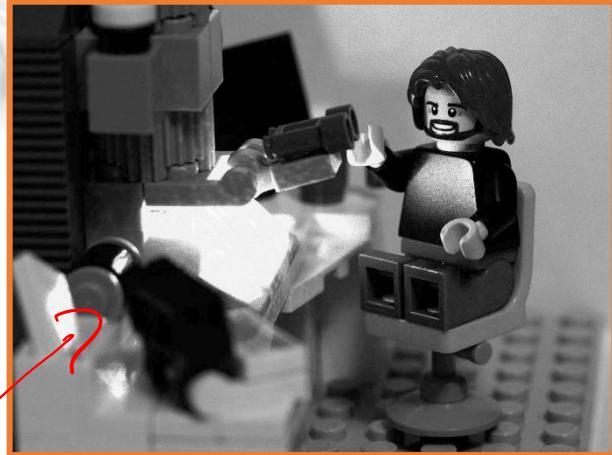
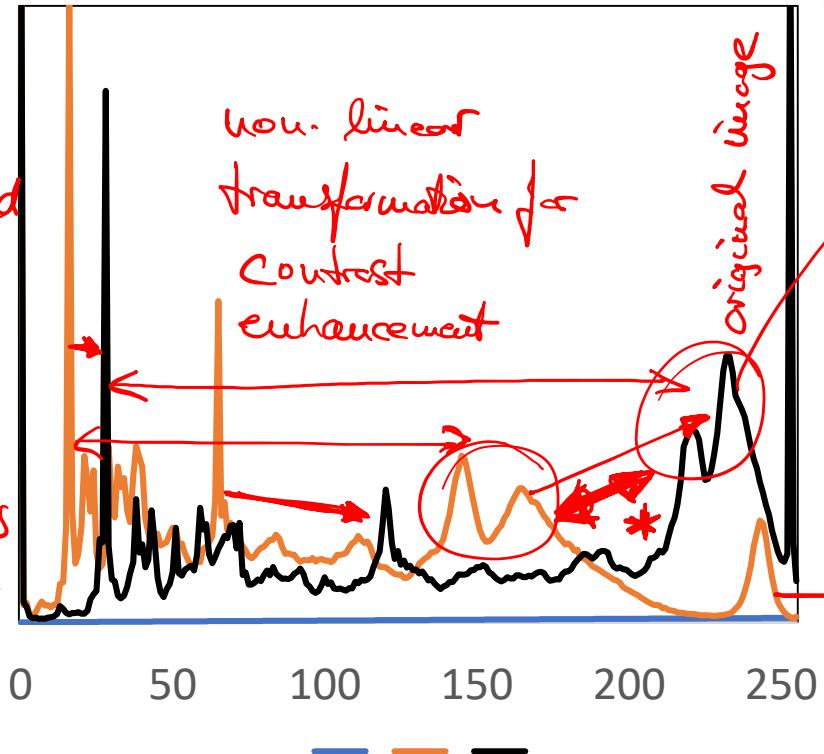


# Histogram manipulation (gamma)

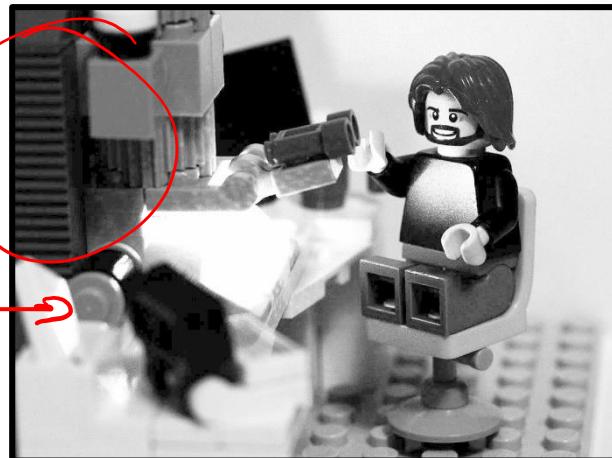
Non-linear  
transformations  
have to be  
named / described



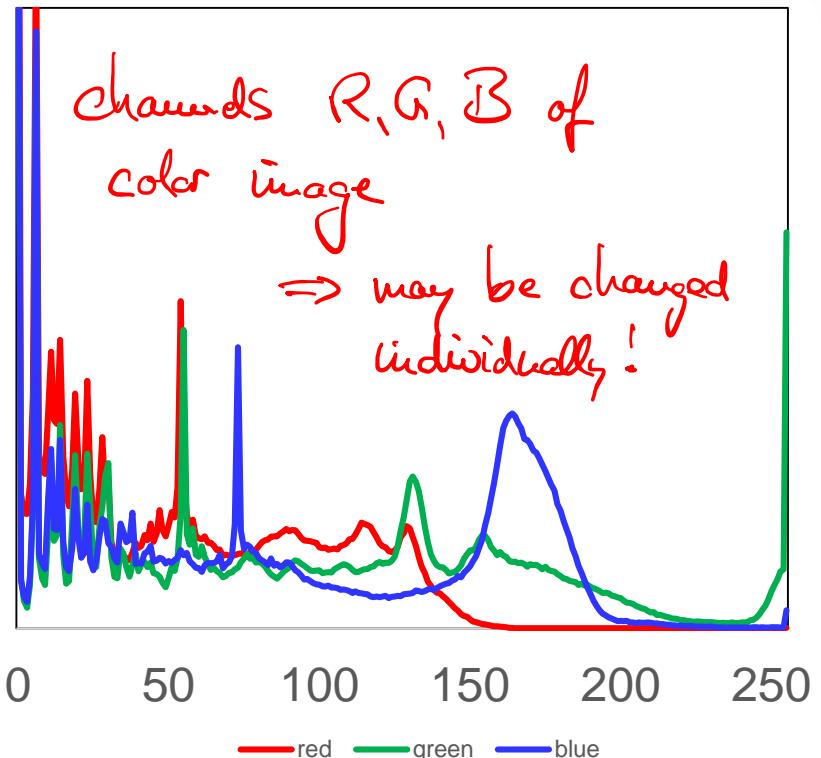
\* Those might  
change fractions  
of images of the  
same grayscale



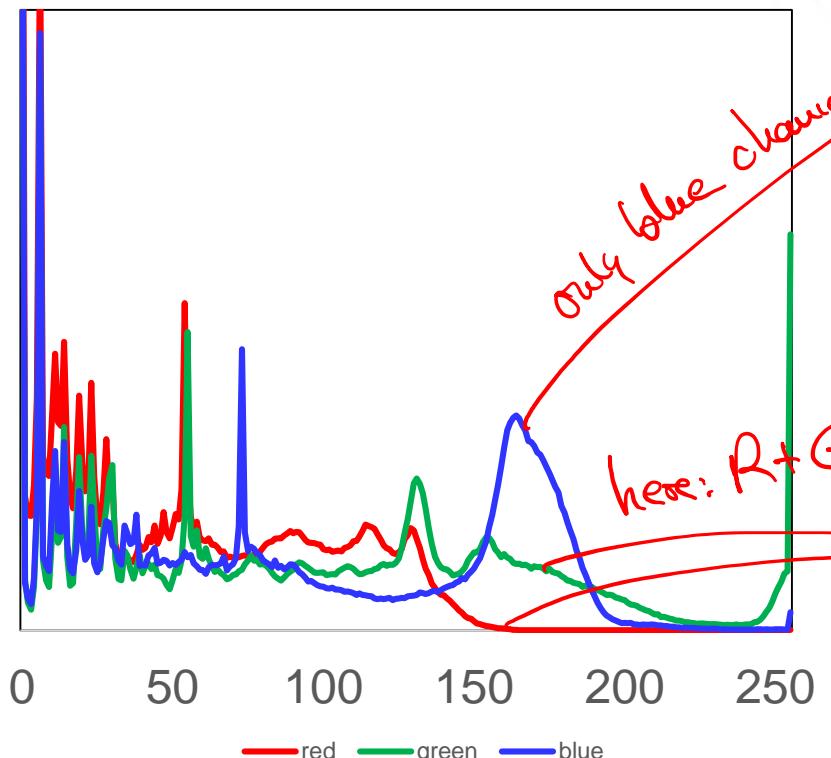
more details in dark areas!



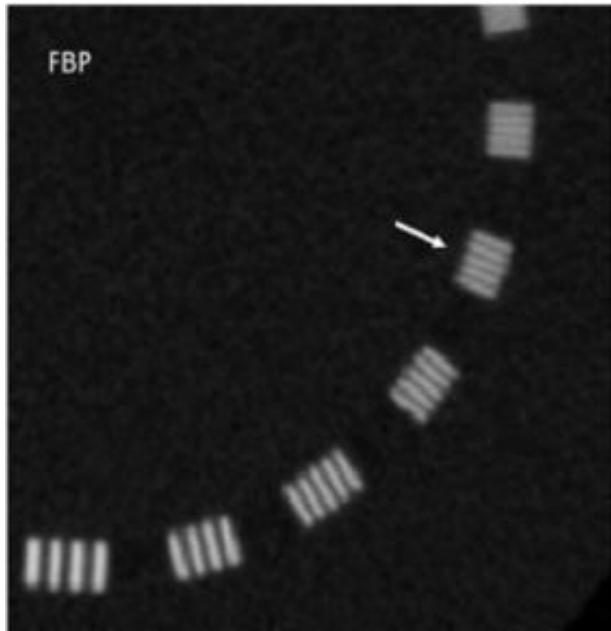
# Histogram manipulation (multichannel data)



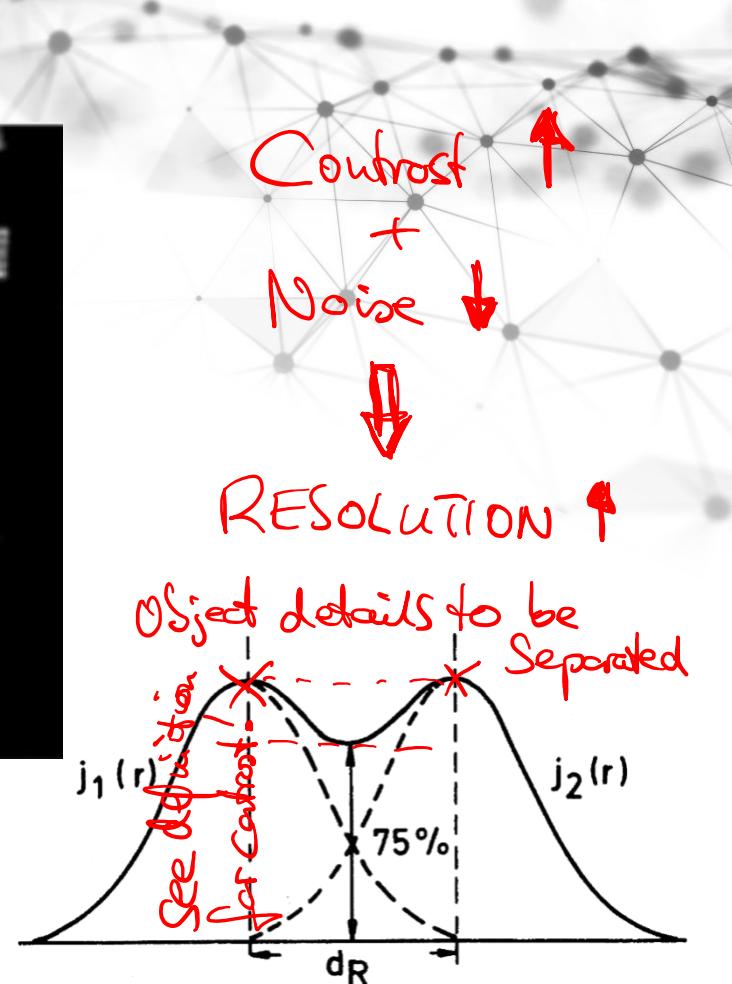
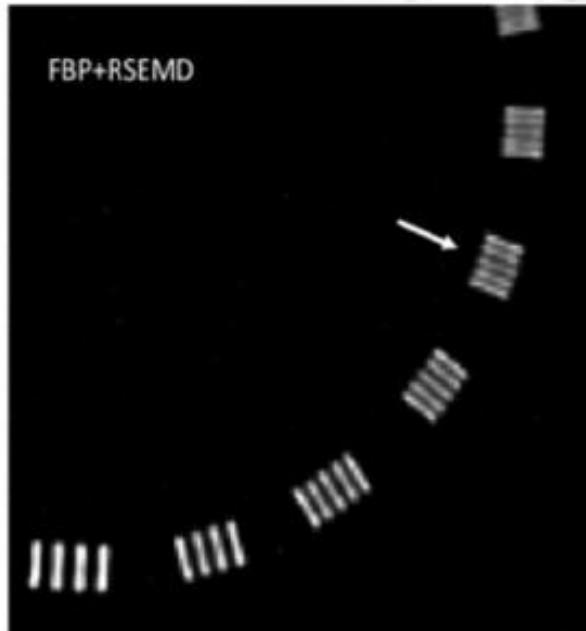
# Histogram manipulation (multichannel data)



# Contrast ( $\leftrightarrow$ Noise) $\leftrightarrow$ Resolution



<https://www.phantomlab.com/catphan-500>



L. Reimer, Scanning Electron Microscopy (p. 53)

# Take-home messages

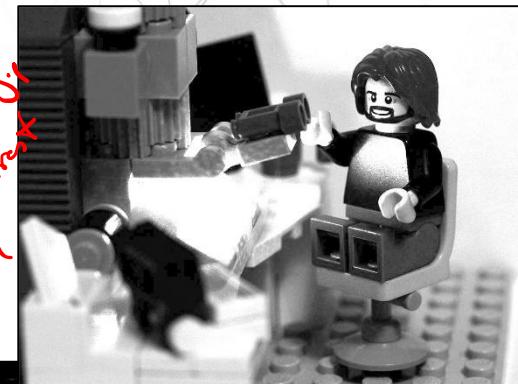
Enhance Contrast !



Contrast ↑  
+  
Noise ↓ → RESOLUTION ↑



Saturation -  
applicable, e.g.  
for edge contrast  
in SEx



Avoid (over-)  
Saturation