

Image Display, Histograms, Brightness and Contrast

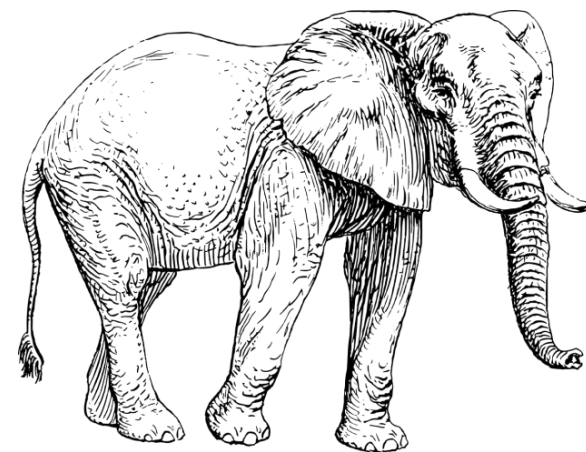
Image Processing & Analysis for Life Scientist

Olivier Burri, Romain Guiet & Arne Seitz

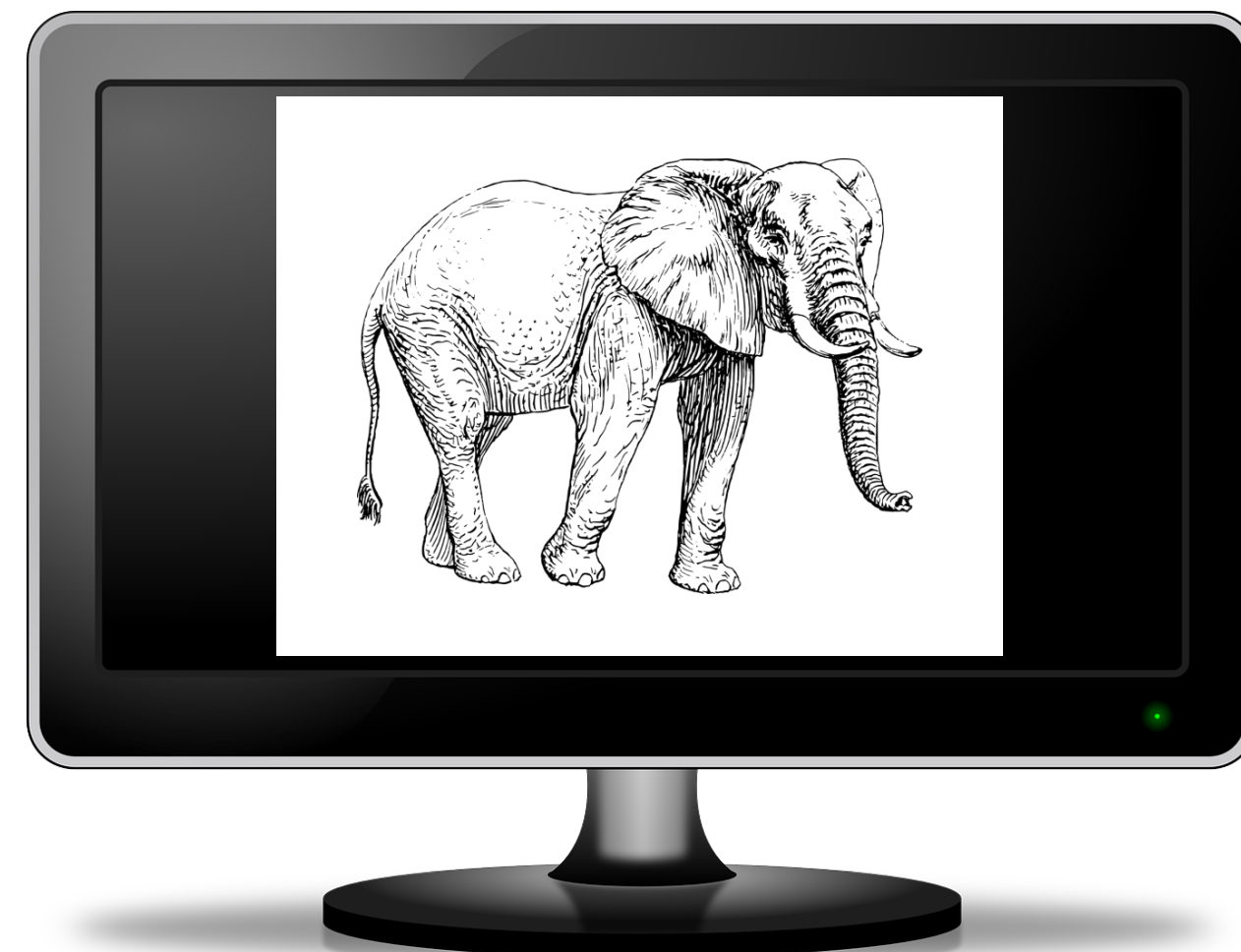
Displaying Images

- Representing Image Data
 - 2D Images
 - Histograms
- Basic Image Display Adjustment
 - Adjusting Brightness and Contrast
- Image Saturation

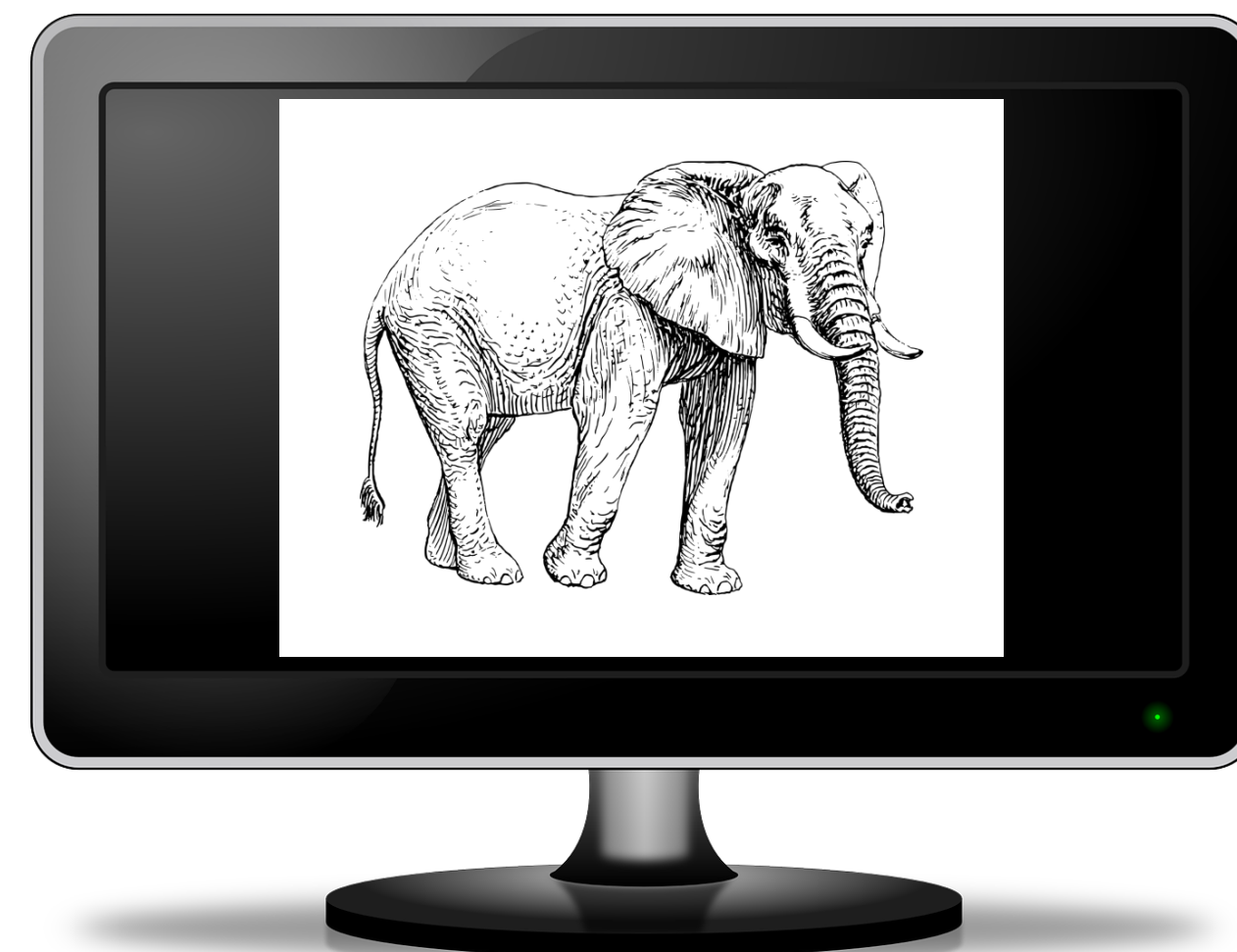
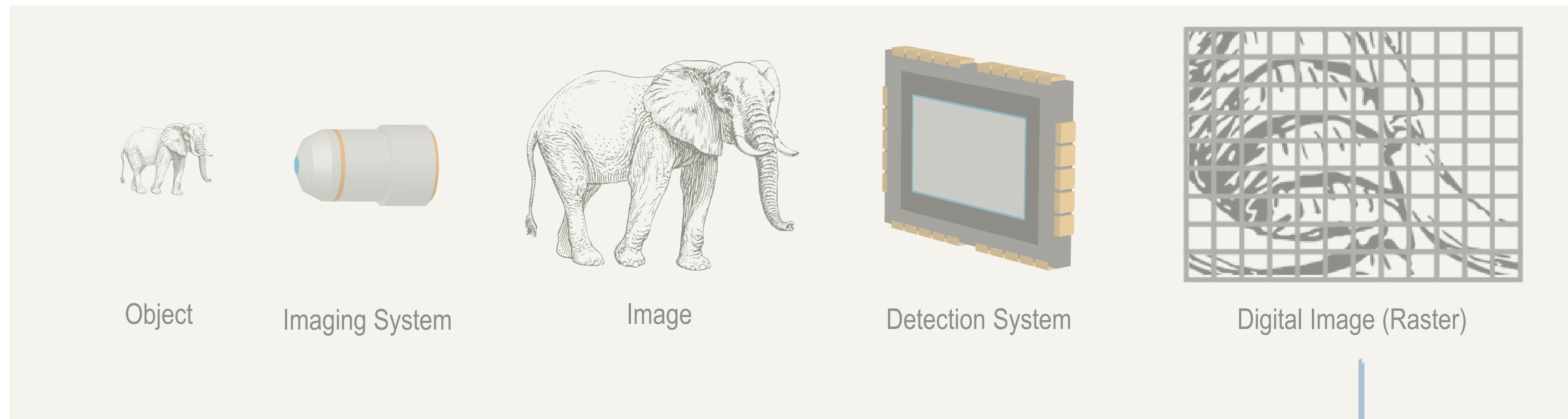
How A Digital Image Reaches Your Eyes



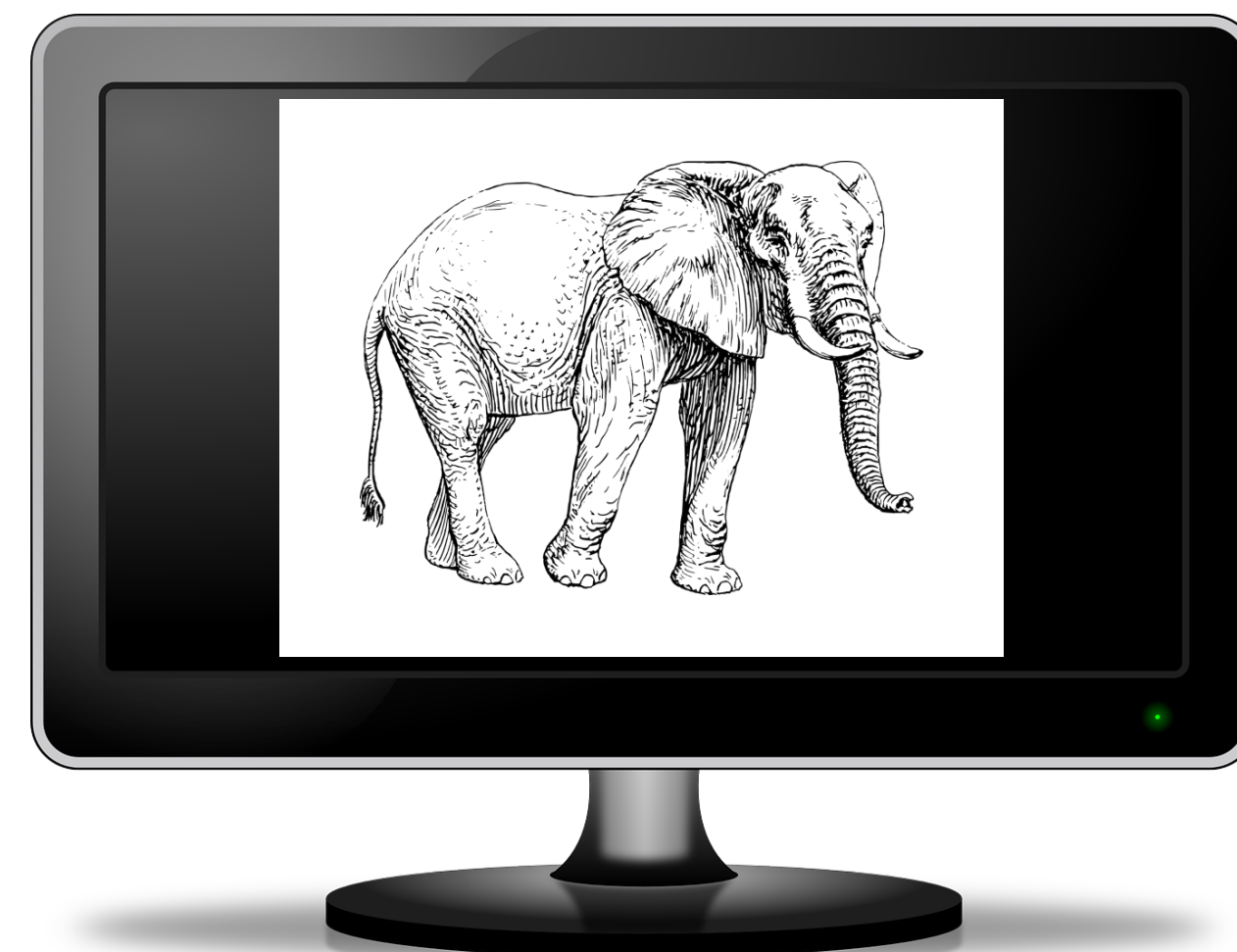
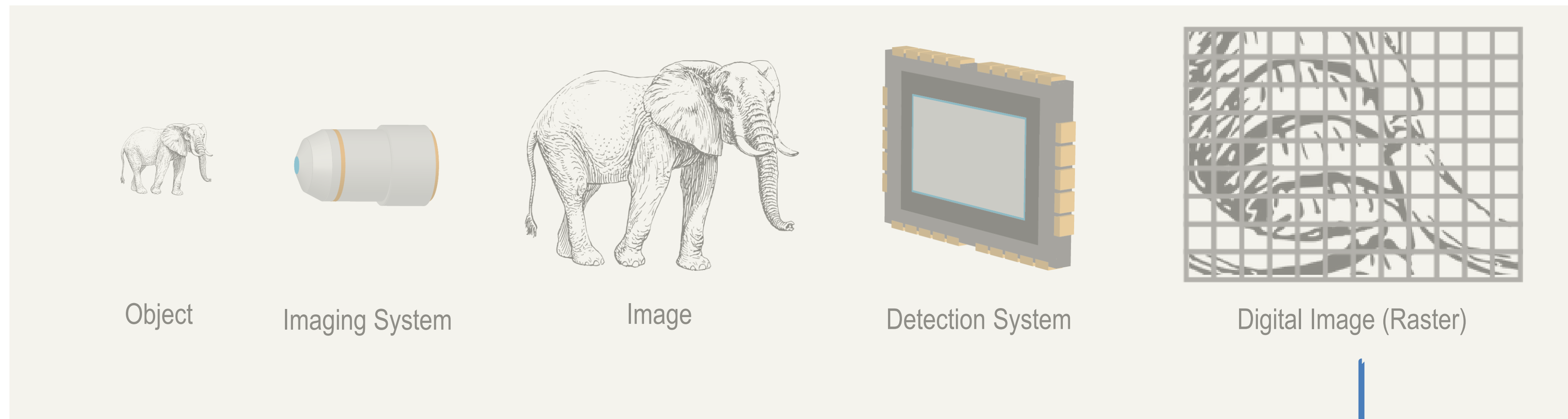
How A Digital Image Reaches Your Eyes



How A Digital Image Reaches Your Eyes



How A Digital Image Reaches Your Eyes

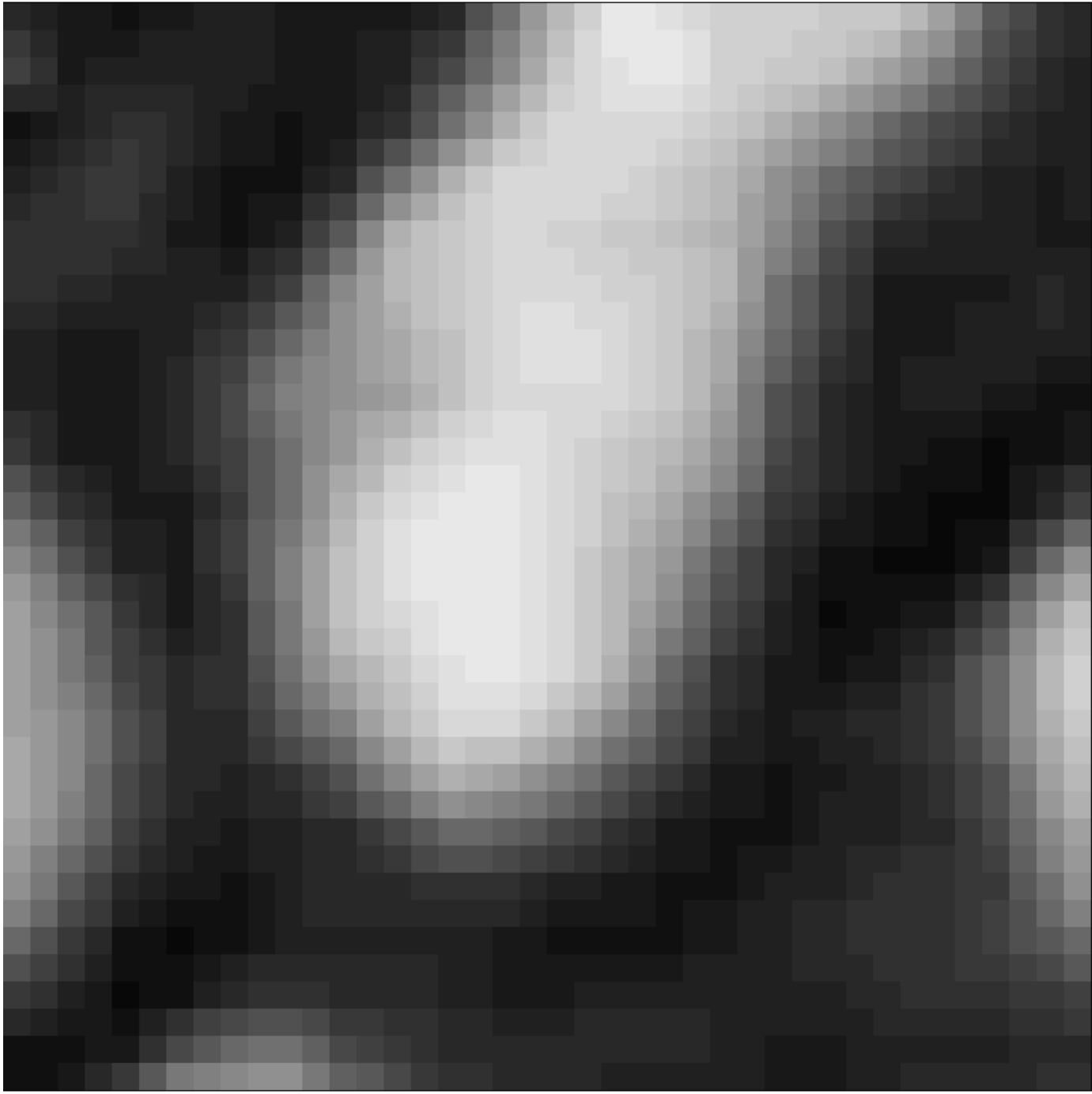
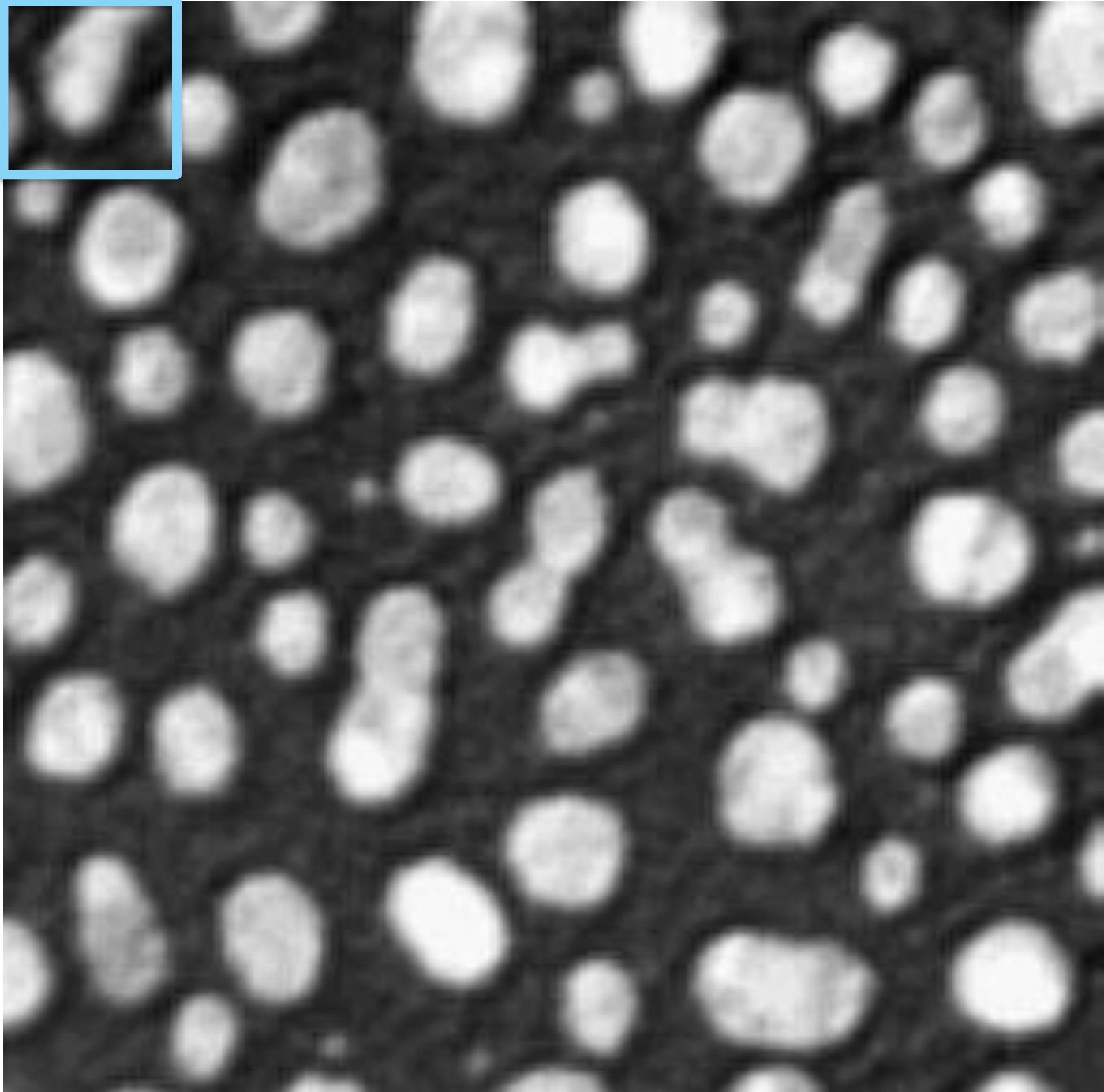


$$I(u, v) \Rightarrow I(u', v')$$

Pixel Intensity value(s)
e.g. 0...255

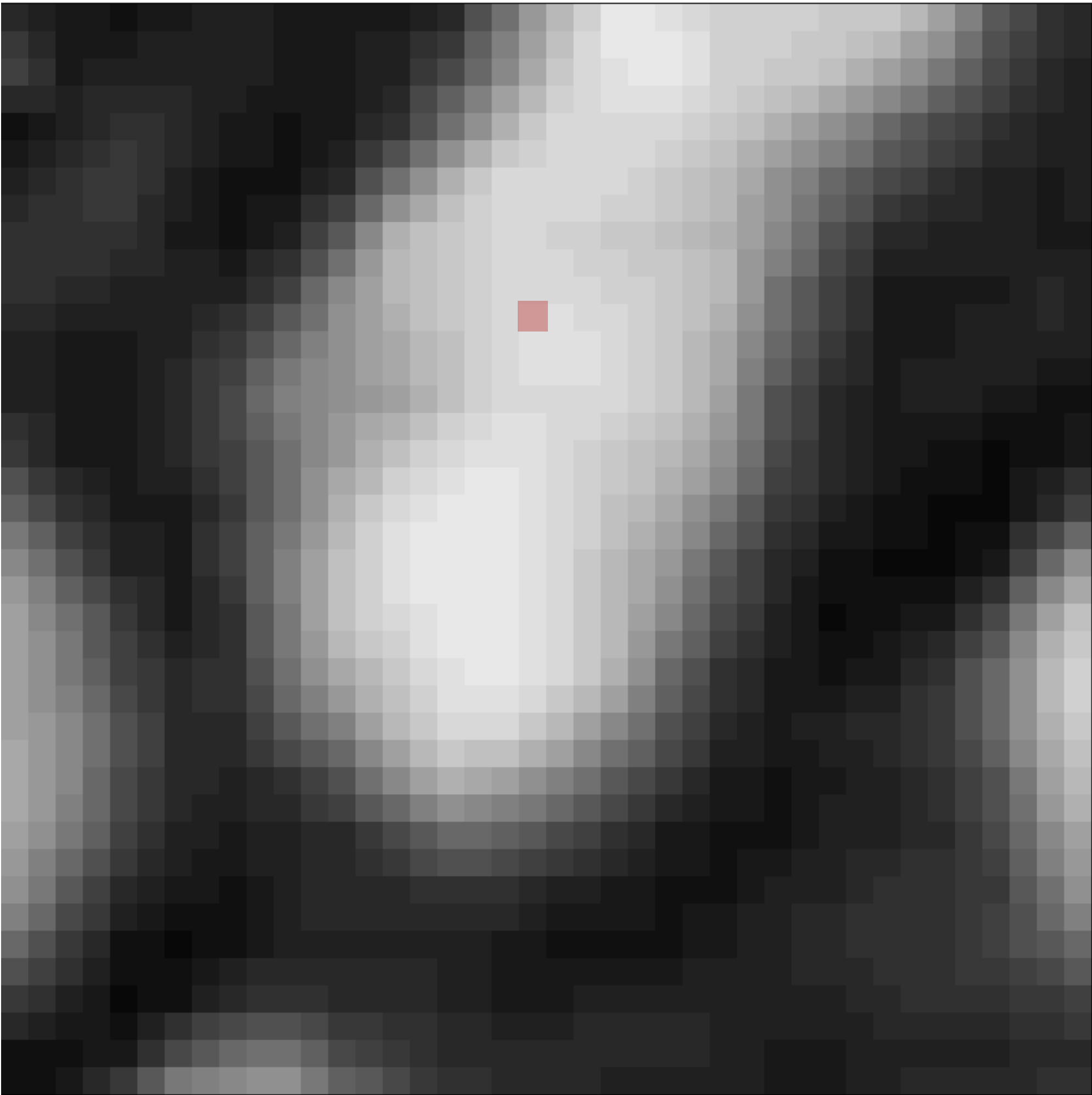
Screen luminosity value(s)

2D Data Arrays



| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|-----|-----|-----|-----|----|----|----|----|----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 40 | 32 | 24 | 24 | 16 | 24 | 24 | 32 | 32 | 32 | 24 | 24 | 24 | 24 | 24 | 32 | 40 | 80 | 112 | 152 | 184 | 208 | 232 | 232 | 224 | 216 | 208 | 208 | 208 | 200 | 200 | 200 | 184 | 160 | 128 | 88 | 72 | 48 | 40 | 24 | 24 | | |
| 56 | 40 | 24 | 24 | 24 | 32 | 32 | 32 | 32 | 32 | 32 | 24 | 24 | 24 | 32 | 32 | 48 | 56 | 96 | 128 | 160 | 192 | 216 | 232 | 232 | 232 | 224 | 208 | 208 | 208 | 200 | 192 | 184 | 160 | 144 | 112 | 80 | 64 | 48 | 40 | 24 | 24 | |
| 64 | 48 | 24 | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 24 | 24 | 24 | 32 | 32 | 56 | 72 | 104 | 136 | 168 | 200 | 216 | 224 | 232 | 232 | 224 | 208 | 208 | 200 | 200 | 192 | 176 | 160 | 144 | 120 | 96 | 72 | 56 | 40 | 32 | 24 | 24 |
| 40 | 40 | 32 | 40 | 40 | 40 | 40 | 32 | 32 | 24 | 24 | 24 | 24 | 32 | 40 | 72 | 96 | 128 | 160 | 184 | 208 | 216 | 224 | 224 | 224 | 216 | 208 | 200 | 192 | 184 | 168 | 152 | 136 | 120 | 96 | 80 | 64 | 48 | 40 | 32 | 32 | 32 | |
| 16 | 24 | 32 | 40 | 48 | 48 | 40 | 32 | 24 | 24 | 16 | 24 | 24 | 40 | 48 | 80 | 112 | 144 | 176 | 200 | 216 | 216 | 216 | 216 | 216 | 208 | 200 | 192 | 176 | 160 | 144 | 128 | 104 | 88 | 72 | 64 | 48 | 40 | 32 | 32 | 32 | 32 | |
| 24 | 32 | 40 | 48 | 56 | 48 | 40 | 32 | 24 | 24 | 16 | 24 | 32 | 56 | 80 | 112 | 144 | 176 | 200 | 208 | 216 | 216 | 216 | 216 | 208 | 200 | 192 | 176 | 160 | 144 | 128 | 112 | 88 | 80 | 64 | 56 | 40 | 40 | 32 | 32 | 32 | 32 | |
| 32 | 40 | 48 | 56 | 56 | 48 | 32 | 24 | 16 | 16 | 32 | 40 | 80 | 112 | 144 | 176 | 200 | 216 | 216 | 216 | 216 | 216 | 216 | 208 | 200 | 192 | 184 | 168 | 144 | 128 | 104 | 88 | 72 | 64 | 48 | 40 | 32 | 32 | 24 | 32 | 32 | 32 | |
| 40 | 48 | 48 | 56 | 56 | 40 | 32 | 24 | 16 | 24 | 24 | 48 | 64 | 104 | 144 | 168 | 192 | 208 | 216 | 216 | 216 | 216 | 208 | 208 | 200 | 192 | 184 | 160 | 144 | 120 | 96 | 80 | 56 | 48 | 40 | 40 | 32 | 32 | 24 | 32 | 32 | 32 | |
| 48 | 48 | 48 | 48 | 48 | 40 | 24 | 24 | 16 | 24 | 32 | 64 | 88 | 136 | 176 | 192 | 200 | 208 | 216 | 216 | 208 | 208 | 200 | 200 | 192 | 184 | 176 | 160 | 136 | 112 | 80 | 64 | 40 | 40 | 32 | 32 | 32 | 32 | 24 | 24 | 24 | 24 | |
| 48 | 48 | 48 | 48 | 40 | 40 | 32 | 32 | 24 | 40 | 48 | 80 | 112 | 152 | 184 | 192 | 200 | 208 | 216 | 216 | 216 | 208 | 208 | 200 | 200 | 192 | 184 | 152 | 128 | 104 | 72 | 56 | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 24 | 24 | |
| 48 | 48 | 40 | 40 | 32 | 32 | 32 | 32 | 32 | 48 | 64 | 104 | 136 | 160 | 184 | 192 | 200 | 208 | 216 | 216 | 216 | 208 | 208 | 200 | 192 | 184 | 152 | 112 | 88 | 64 | 48 | 24 | 24 | 24 | 24 | 32 | 40 | 32 | 24 | 24 | 24 | 24 | |
| 40 | 40 | 32 | 32 | 32 | 32 | 32 | 40 | 48 | 64 | 88 | 112 | 144 | 160 | 176 | 192 | 200 | 208 | 216 | 224 | 224 | 216 | 216 | 208 | 200 | 192 | 176 | 144 | 112 | 88 | 64 | 48 | 24 | 24 | 24 | 32 | 32 | 32 | 40 | 32 | 24 | 24 | 24 |
| 32 | 32 | 24 | 24 | 24 | 32 | 32 | 48 | 56 | 80 | 104 | 128 | 144 | 160 | 168 | 184 | 192 | 208 | 216 | 224 | 224 | 224 | 216 | 208 | 200 | 184 | 168 | 136 | 104 | 80 | 56 | 40 | 24 | 24 | 24 | 32 | 32 | 32 | 32 | 32 | 24 | 24 | 24 |
| 32 | 32 | 24 | 24 | 24 | 32 | 40 | 56 | 64 | 96 | 120 | 136 | 144 | 160 | 168 | 184 | 192 | 208 | 216 | 224 | 224 | 224 | 216 | 208 | 200 | 184 | 168 | 128 | 96 | 72 | 48 | 40 | 24 | 32 | 32 | 32 | 32 | 32 | 24 | 24 | 24 | 24 | |
| 32 | 32 | 24 | 24 | 24 | 32 | 40 | 56 | 72 | 104 | 128 | 136 | 144 | 152 | 160 | 176 | 192 | 208 | 216 | 216 | 216 | 216 | 208 | 200 | 184 | 160 | 120 | 80 | 64 | 40 | 32 | 24 | 32 | 32 | 32 | 24 | 24 | 16 | 16 | 16 | 16 | 16 | |
| 48 | 40 | 24 | 24 | 24 | 32 | 40 | 56 | 72 | 96 | 120 | 136 | 152 | 168 | 176 | 192 | 208 | 216 | 224 | 224 | 216 | 216 | 208 | 200 | 192 | 176 | 152 | 120 | 80 | 64 | 40 | 32 | 24 | 24 | 24 | 16 | 16 | 16 | 24 | 24 | 24 | 24 | |
| 56 | 40 | 24 | 24 | 24 | 32 | 40 | 56 | 64 | 88 | 112 | 136 | 152 | 176 | 192 | 208 | 216 | 224 | 224 | 224 | 216 | 208 | 200 | 192 | 184 | 168 | 144 | 112 | 72 | 56 | 40 | 32 | 24 | 24 | 16 | 16 | 8 | 16 | 16 | 24 | 32 | 40 | |
| 80 | 56 | 40 | 32 | 24 | 32 | 32 | 48 | 64 | 88 | 112 | 144 | 168 | 184 | 208 | 216 | 224 | 232 | 232 | 224 | 216 | 208 | 200 | 192 | 176 | 160 | 136 | 104 | 64 | 56 | 40 | 32 | 24 | 16 | 16 | 16 | 8 | 24 | 32 | 48 | 56 | 72 | |
| 96 | 72 | 48 | 40 | 24 | 24 | 24 | 40 | 56 | 88 | 112 | 144 | 176 | 200 | 216 | 224 | 232 | 232 | 232 | 224 | 216 | 208 | 192 | 184 | 168 | 144 | 120 | 88 | 56 | 48 | 32 | 24 | 16 | 16 | 8 | 8 | 8 | 24 | 40 | 64 | 80 | 104 | |
| 120 | 96 | 64 | 48 | 32 | 32 | 24 | 48 | 64 | 96 | 120 | 152 | 184 | 208 | 224 | 232 | 232 | 232 | 232 | 224 | 216 | 208 | 192 | 176 | 160 | 136 | 104 | 80 | 48 | 40 | 24 | 24 | 16 | 16 | 8 | 16 | 16 | 48 | 72 | 104 | 136 | 152 | |
| 136 | 112 | 80 | 56 | 32 | 32 | 24 | 48 | 64 | 96 | 128 | 160 | 192 | 208 | 224 | 232 | 232 | 232 | 232 | 224 | 216 | 208 | 192 | 176 | 160 | 136 | 104 | 80 | 40 | 32 | 16 | 16 | 8 | 8 | 8 | 16 | 24 | 64 | 104 | 144 | 184 | 200 | |
| 152 | 128 | 96 | 72 | 48 | 40 | 24 | 40 | 56 | 96 | 128 | 160 | 192 | 208 | 224 | 232 | 232 | 232 | 232 | 224 | 216 | 200 | 184 | 168 | 144 | 112 | 80 | 64 | 40 | 24 | 16 | 16 | 16 | 16 | 16 | 16 | 32 | 48 | 96 | 136 | 168 | 200 | |
| 160 | 136 | 112 | 88 | 56 | 40 | 24 | 40 | 48 | 88 | 120 | 160 | 192 | 208 | 216 | 224 | 232 | 232 | 232 | 224 | 216 | 200 | 184 | 160 | 136 | 104 | 72 | 56 | 32 | 24 | 8 | 16 | 16 | 16 | 24 | 32 | 40 | 64 | 88 | 136 | 176 | 200 | 224 |
| 160 | 144 | 120 | 88 | 64 | 48 | 32 | 40 | 48 | 88 | 120 | 152 | 184 | 200 | 208 | 224 | 232 | 232 | 232 | 224 | 216 | 200 | 184 | 152 | 120 | 96 | 64 | 48 | 32 | 24 | 16 | 24 | 24 | 40 | 64 | 88 | 136 | 176 | 200 | 224 | 232 | | |
| 160 | 144 | 120 | 96 | 64 | 56 | 40 | 48 | 48 | 80 | 112 | 144 | 168 | 184 | 200 | 216 | 224 | 232 | 232 | 224 | 216 | 200 | 176 | 144 | 104 | 80 | 48 | 40 | 24 | 24 | 16 | 24 | 24 | 40 | 48 | 80 | 104 | 144 | 184 | 208 | 224 | 232 | |
| 160 | 144 | 128 | 104 | 72 | 56 | 40 | 48 | 48 | 72 | 104 | 128 | 152 | 176 | 192 | 208 | 224 | 224 | 224 | 216 | 200 | 184 | 160 | 128 | 96 | 72 | 48 | 40 | 24 | 24 | 24 | 32 | 32 | 48 | 56 | 80 | 104 | 144 | 184 | 208 | 224 | 232 | |
| 160 | 152 | 136 | 112 | 80 | 64 | 40 | 40 | 64 | 88 | 112 | 128 | 160 | 184 | 200 | 216 | 216 | 200 | 184 | 160 | 136 | 112 | 80 | 64 | 40 | 32 | 24 | 32 | 32 | 40 | 40 | 48 | 56 | 80 | 104 | 144 | 176 | 200 | 224 | 224 | 224 | | |
| 168 | 152 | 136 | 112 | 80 | 64 | 40 | 40 | 56 | 72 | 88 | 104 | 136 | 160 | 184 | 200 | 192 | 176 | 160 | 136 | 112 | 96 | 72 | 56 | 32 | 32 | 24 | 24 | 32 | 32 | 40 | 40 | 48 | 56 | 72 | 96 | 136 | 168 | 192 | 216 | 216 | | |
| 168 | 152 | 136 | 104 | 72 | 56 | 40 | 40 | 32 | 40 | 48 | 64 | 80 | 112 | 136 | 160 | 176 | 168 | 160 | 144 | 128 | 112 | 88 | 72 | 56 | 40 | 24 | 24 | 16 | 24 | 24 | 32 | 32 | 40 | 48 | 64 | 80 | 120 | 160 | 184 | 200 | 208 | |
| 168 | 152 | 128 | 104 | 72 | 56 | 40 | 32 | 32 | 40 | 40 | 56 | 64 | 88 | 104 | 128 | 144 | 136 | 128 | 120 | 104 | 88 | 72 | 56 | 40 | 32 | 24 | 24 | 16 | 24 | 32 | 32 | 32 | 40 | 48 | 64 | 80 | 112 | 152 | 176 | 192 | 200 | |
| 160 | 144 | 120 | 96 | 64 | 48 | 32 | 32 | 24 | 32 | 32 | 40 | 40 | 56 | 72 | 88 | 104 | 104 | 96 | 88 | 72 | 64 | 48 | 40 | 24 | 24 | 16 | 16 | 16 | 24 | 32 | 32 | 40 | 40 | 56 | 72 | 104 | 136 | 160 | 184 | 200 | | |
| 152 | 128 | 104 | 80 | 56 | 40 | 32 | 24 | 24 | 32 | 32 | 40 | 40 | 48 | 56 | 72 | 80 | 80 | 72 | 64 | 56 | 48 | 40 | 32 | 24 | 24 | 16 | 24 | 24 | 32 | 32 | 40 | 40 | 48 | 56 | 64 | 96 | 128 | 152 | 176 | 192 | | |
| 144 | 120 | 88 | 64 | 40 | 32 | 24 | 24 | 16 | 24 | 32 | 40 | 40 | 40 | 48 | 48 | 48 | 48 | 40 | 32 | 32 | 24 | 24 | 32 | 32 | 24 | 16 | 16 | 24 | 32 | 32 | 40 | 48 | 48 | 48 | 56 | 56 | 88 | 112 | 144 | 168 | 184 | |
| 128 | 104 | 72 | 56 | 32 | 24 | 16 | 16 | 16 | 24 | 32 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 32 | 24 | 24 | 24 | 24 | 16 | 24 | 24 | 32 | 32 | 40 | 40 | 48 | 48 | 48 | 48 | 56 | 64 | 80 | 104 | 128 | 144 | 160 | |
| 104 | 80 | 56 | 40 | 16 | 16 | 8 | 16 | 16 | 24 | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 24 | 24 | 16 | 16 | 16 | 16 | 16 | 16 | 24 | 24 | 32 | 32 | 40 | 40 | 48 | 48 | 48 | 48 | 56 | 64 | 80 | 88 | 104 | 120 | 136 |
| 80 | 64 | 48 | 32 | 16 | 16 | 16 | 24 | 32 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 32 | 32 | 24 | 24 | 24 | 24 | 24 | 24 | 32 | 32 | 32 | 32 | 40 | 40 | 40 | 48 | 48 | 48 | 56 | 56 | 64 | 72 | 88 | 96 | 11 |

2D Data Arrays

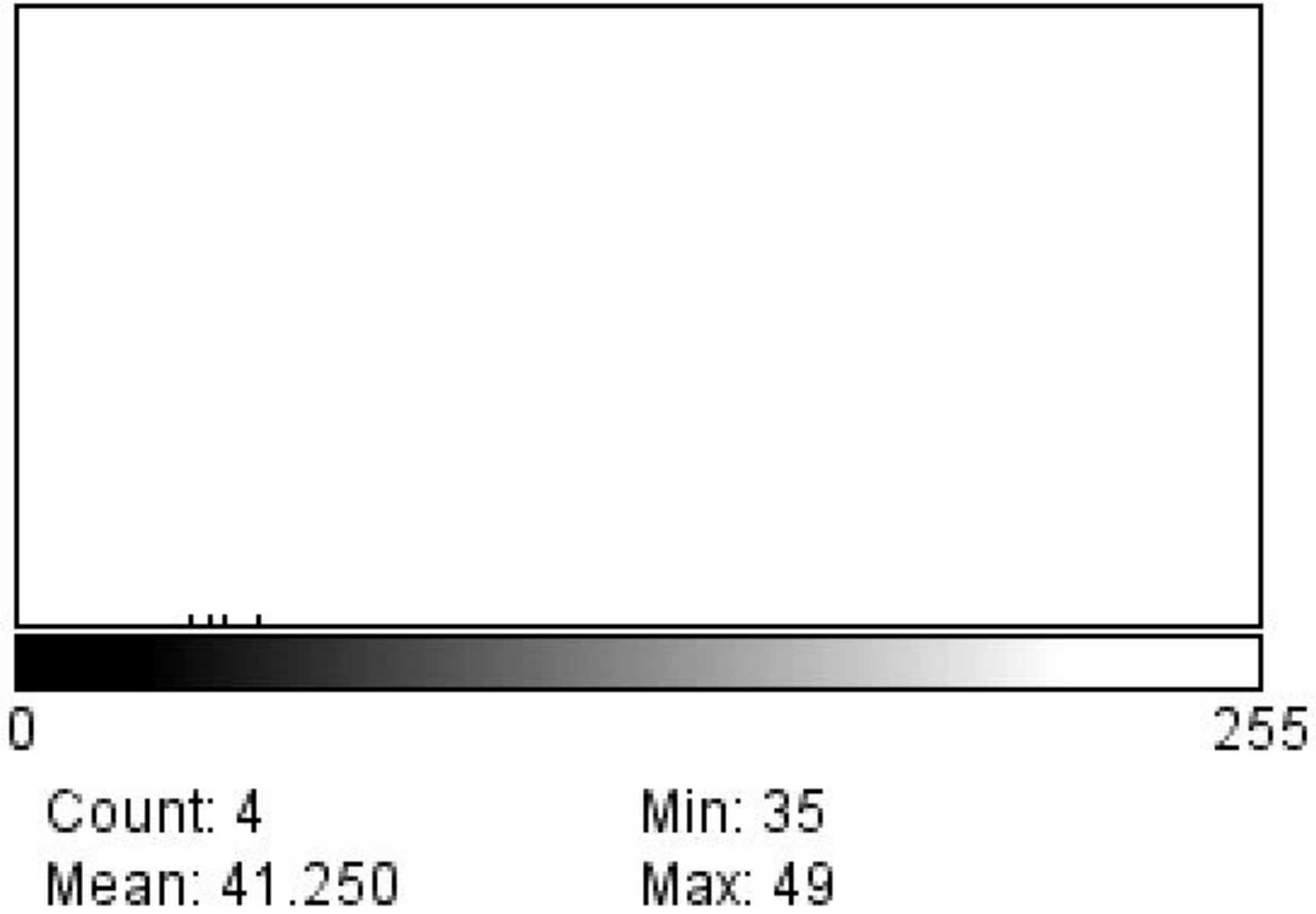
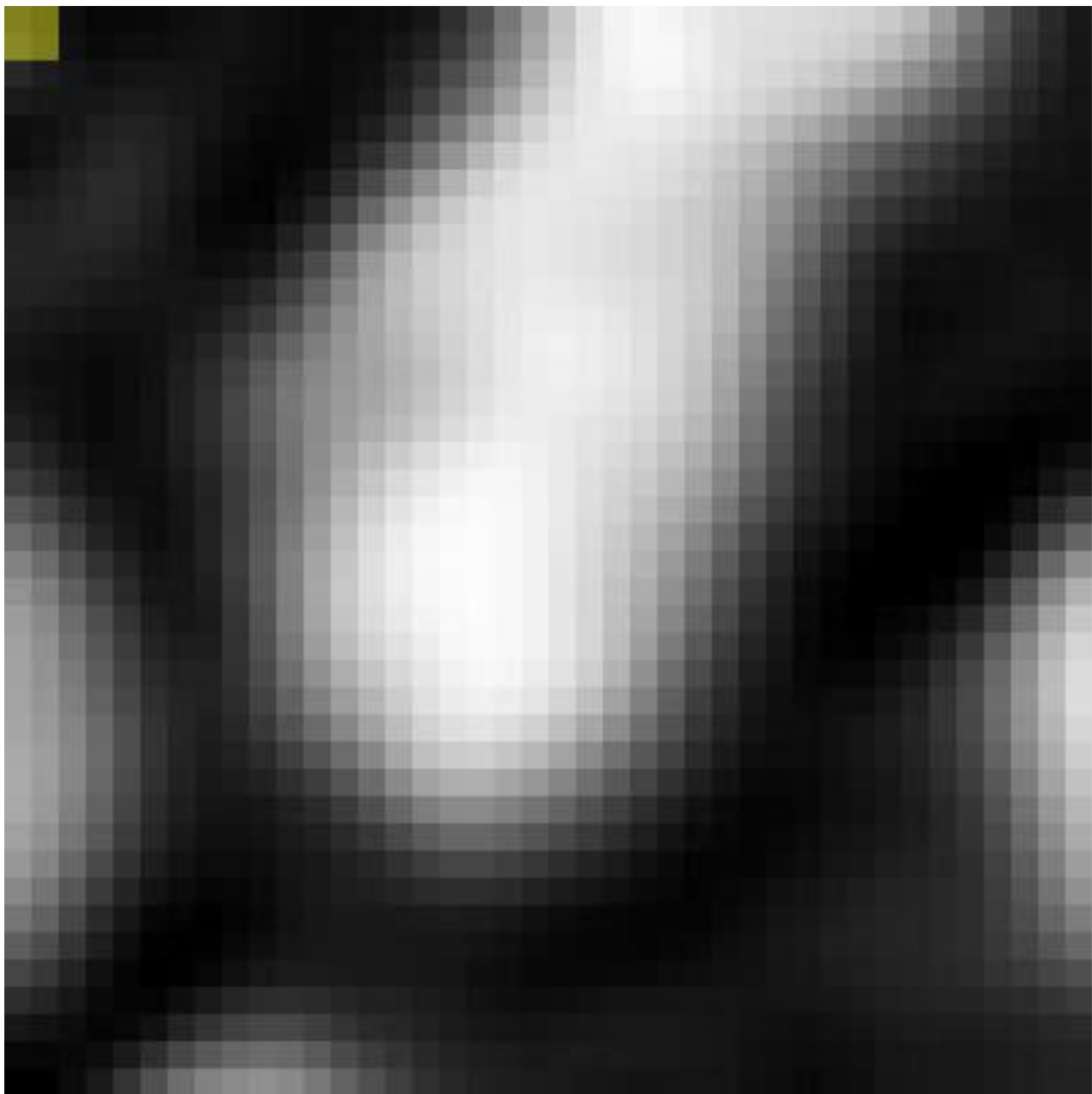
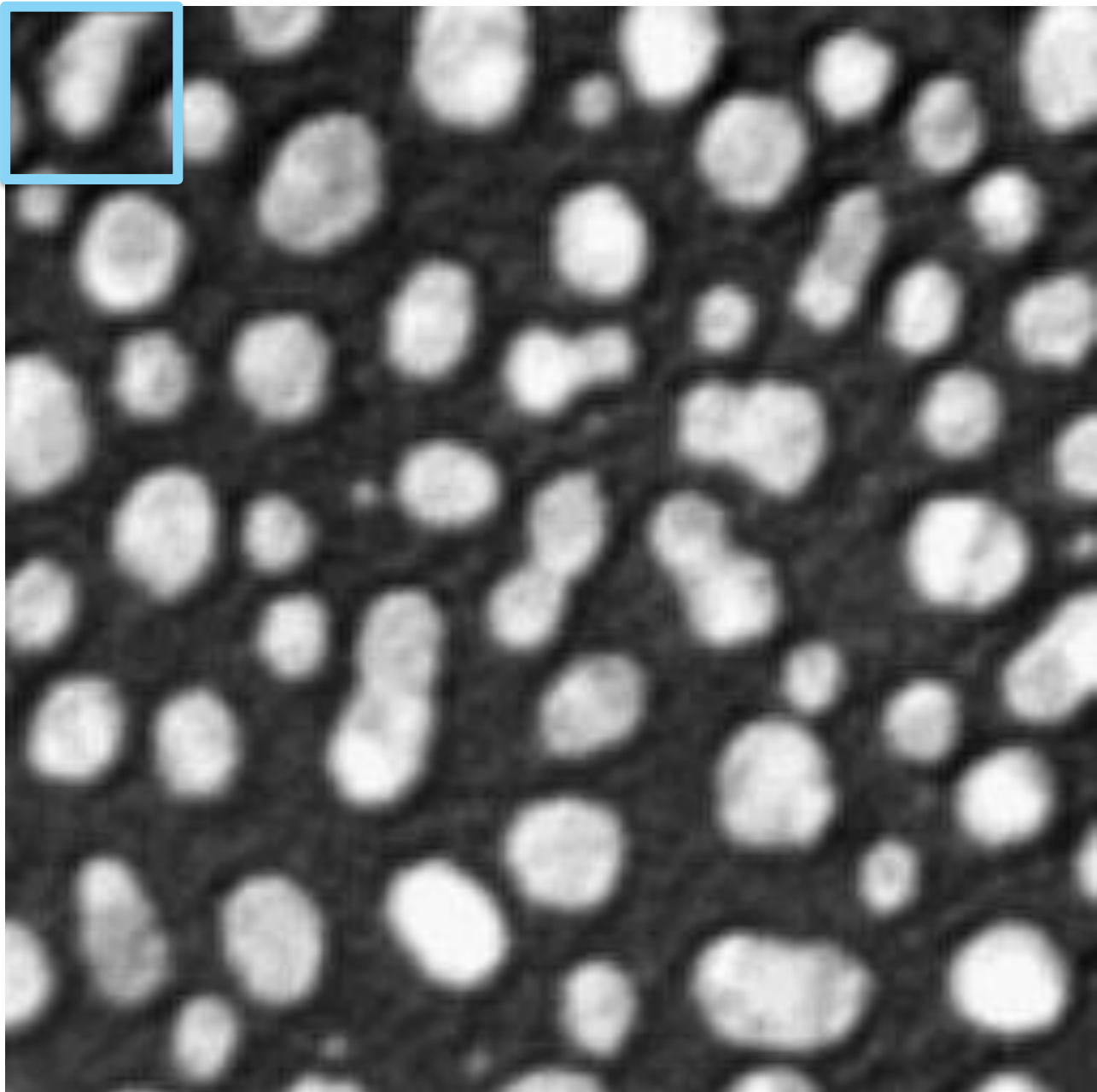


| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
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| 40 | 40 | 32 | 40 | 40 | 40 | 40 | 32 | 32 | 24 | 24 | 24 | 24 | 32 | 40 | 72 | 96 | 128 | 160 | 184 | 208 | 216 | 224 | 224 | 216 | 208 | 200 | 192 | 184 | 168 | 152 | 136 | 120 | 96 | 80 | 64 | 48 | 40 | 32 | 32 | 32 | | |
| 16 | 24 | 32 | 40 | 48 | 48 | 40 | 32 | 24 | 24 | 16 | 24 | 24 | 40 | 48 | 80 | 112 | 144 | 176 | 200 | 216 | 216 | 216 | 216 | 216 | 208 | 200 | 192 | 176 | 160 | 144 | 128 | 104 | 88 | 72 | 64 | 48 | 40 | 32 | 32 | 32 | 32 | |
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| 32 | 40 | 48 | 56 | 56 | 48 | 32 | 24 | 16 | 16 | 16 | 32 | 40 | 80 | 112 | 144 | 176 | 200 | 216 | 216 | 216 | 216 | 216 | 208 | 200 | 192 | 184 | 168 | 144 | 128 | 104 | 88 | 72 | 64 | 48 | 40 | 32 | 32 | 24 | 32 | 32 | 32 | |
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| 32 | 32 | 24 | 24 | 24 | 32 | 40 | 56 | 64 | 96 | 120 | 136 | 144 | 160 | 168 | 184 | 192 | 208 | 216 | 224 | 224 | 224 | 216 | 208 | 200 | 184 | 168 | 128 | 96 | 72 | 48 | 40 | 24 | 32 | 32 | 32 | 32 | 24 | 24 | 24 | 24 | | |
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| 136 | 112 | 80 | 56 | 32 | 32 | 24 | 48 | 64 | 96 | 128 | 160 | 192 | 208 | 224 | 232 | 232 | 232 | 232 | 224 | 216 | 200 | 184 | 168 | 152 | 120 | 88 | 64 | 40 | 32 | 16 | 16 | 8 | 8 | 8 | 16 | 24 | 64 | 104 | 144 | 184 | 200 | |
| 152 | 128 | 96 | 72 | 48 | 40 | 24 | 40 | 56 | 96 | 128 | 160 | 192 | 208 | 224 | 232 | 232 | 232 | 232 | 224 | 216 | 200 | 184 | 168 | 144 | 112 | 80 | 64 | 40 | 24 | 16 | 16 | 16 | 16 | 16 | 32 | 48 | 96 | 136 | 168 | 200 | 216 | |
| 160 | 136 | 112 | 88 | 56 | 40 | 24 | 40 | 48 | 88 | 120 | 160 | 192 | 208 | 216 | 224 | 232 | 232 | 232 | 224 | 216 | 200 | 184 | 160 | 136 | 104 | 72 | 56 | 32 | 24 | 8 | 16 | 16 | 24 | 24 | 48 | 72 | 120 | 160 | 192 | 216 | 232 | |
| 160 | 144 | 120 | 88 | 64 | 48 | 32 | 40 | 48 | 88 | 120 | 152 | 184 | 200 | 208 | 224 | 232 | 232 | 232 | 224 | 216 | 200 | 184 | 152 | 120 | 96 | 64 | 48 | 32 | 24 | 16 | 16 | 24 | 32 | 40 | 64 | 88 | 136 | 176 | 200 | 224 | 232 | |
| 160 | 144 | 120 | 96 | 64 | 56 | 40 | 48 | 48 | 80 | 112 | 144 | 168 | 184 | 200 | 216 | 224 | 232 | 232 | 224 | 216 | 200 | 176 | 144 | 104 | 80 | 48 | 40 | 24 | 24 | 16 | 24 | 24 | 40 | 48 | 80 | 104 | 144 | 184 | 208 | 224 | 232 | |
| 160 | 144 | 128 | 104 | 72 | 56 | 40 | 48 | 48 | 72 | 104 | 128 | 152 | 176 | 192 | 208 | 224 | 224 | 224 | 216 | 200 | 184 | 160 | 128 | 96 | 72 | 48 | 40 | 24 | 24 | 24 | 32 | 32 | 48 | 56 | 80 | 104 | 144 | 184 | 208 | 224 | 232 | |
| 160 | 152 | 136 | 112 | 80 | 64 | 40 | 40 | 40 | 64 | 88 | 112 | 128 | 160 | 184 | 200 | 216 | 216 | 216 | 200 | 184 | 160 | 136 | 112 | 80 | 64 | 40 | 32 | 24 | 32 | 32 | 40 | 40 | 48 | 56 | 80 | 104 | 144 | 176 | 200 | 224 | 224 | |
| 168 | 152 | 136 | 112 | 80 | 64 | 40 | 40 | 40 | 56 | 72 | 88 | 104 | 136 | 160 | 184 | 200 | 192 | 192 | 176 | 160 | 136 | 112 | 96 | 72 | 56 | 32 | 32 | 24 | 24 | 32 | 32 | 40 | 48 | 56 | 72 | 96 | 136 | 168 | 192 | 216 | 216 | |
| 168 | 152 | 136 | 104 | 72 | 56 | 40 | 40 | 32 | 40 | 48 | 64 | 80 | 112 | 136 | 160 | 176 | 168 | 160 | 144 | 128 | 112 | 88 | 72 | 56 | 40 | 24 | 24 | 16 | 24 | 24 | 32 | 32 | 40 | 48 | 64 | 80 | 120 | 160 | 184 | 200 | 208 | |
| 168 | 152 | 128 | 104 | 72 | 56 | 40 | 32 | 32 | 40 | 40 | 56 | 64 | 88 | 104 | 128 | 144 | 136 | 128 | 120 | 104 | 88 | 72 | 56 | 40 | 32 | 24 | 24 | 16 | 24 | 32 | 32 | 32 | 40 | 48 | 64 | 80 | 112 | 152 | 176 | 192 | 200 | |
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| 152 | 128 | 104 | 80 | 56 | 40 | 32 | 24 | 24 | 32 | 32 | 40 | 40 | 48 | 56 | 72 | 80 | 80 | 72 | 64 | 56 | 48 | 40 | 32 | 24 | 24 | 16 | 24 | 24 | 32 | 32 | 40 | 40 | 48 | 48 | 56 | 64 | 96 | 128 | 152 | 176 | 192 | |
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| 128 | 104 | 72 | 56 | 32 | 24 | 16 | 16 | 16 | 24 | 32 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 32 | 24 | 24 | 24 | 24 | 16 | 24 | 24 | 32 | 32 | 40 | 40 | 48 | 48 | 48 | 48 | 56 | 64 | 80 | 104 | 128 | 144 | 160 | |
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| 80 | 64 | 48 | 32 | 16 | 16 | 16 | 24 | 32 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 32 | 32 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 32 | 32 | 32 | 32 | 40 | 40 | 40 | 48 | 48 | 48 | 56 | 56 | 64 | 72 | 88 | 96 | 112 | |
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| 40 | 32 | 24 | 24 | 16 | 32 | 48 | 64 | 72 | 80 | 80 | 72 | 56 | 56 | 48 | 48 | 40 | 40 | 32 | 32 | 32 | 40 | 40 | 40 | 40 | 40 | 32 | 32 | 32 | 32 | 32 | 40 | 40 | 40 | 40 | 40 | 40 | 48 | 48 | 56 | 56 | 64 | |
| 16 | 16 | 16 | 24 | 24 | 48 | 72 | 88 | 104 | 112 | 112 | 96 | 72 | 64 | 56 | 48 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 32 | 32 | 24 | 24 | 24 | 32 | 32 | 32 | 32 | 3 | | | | | | | |

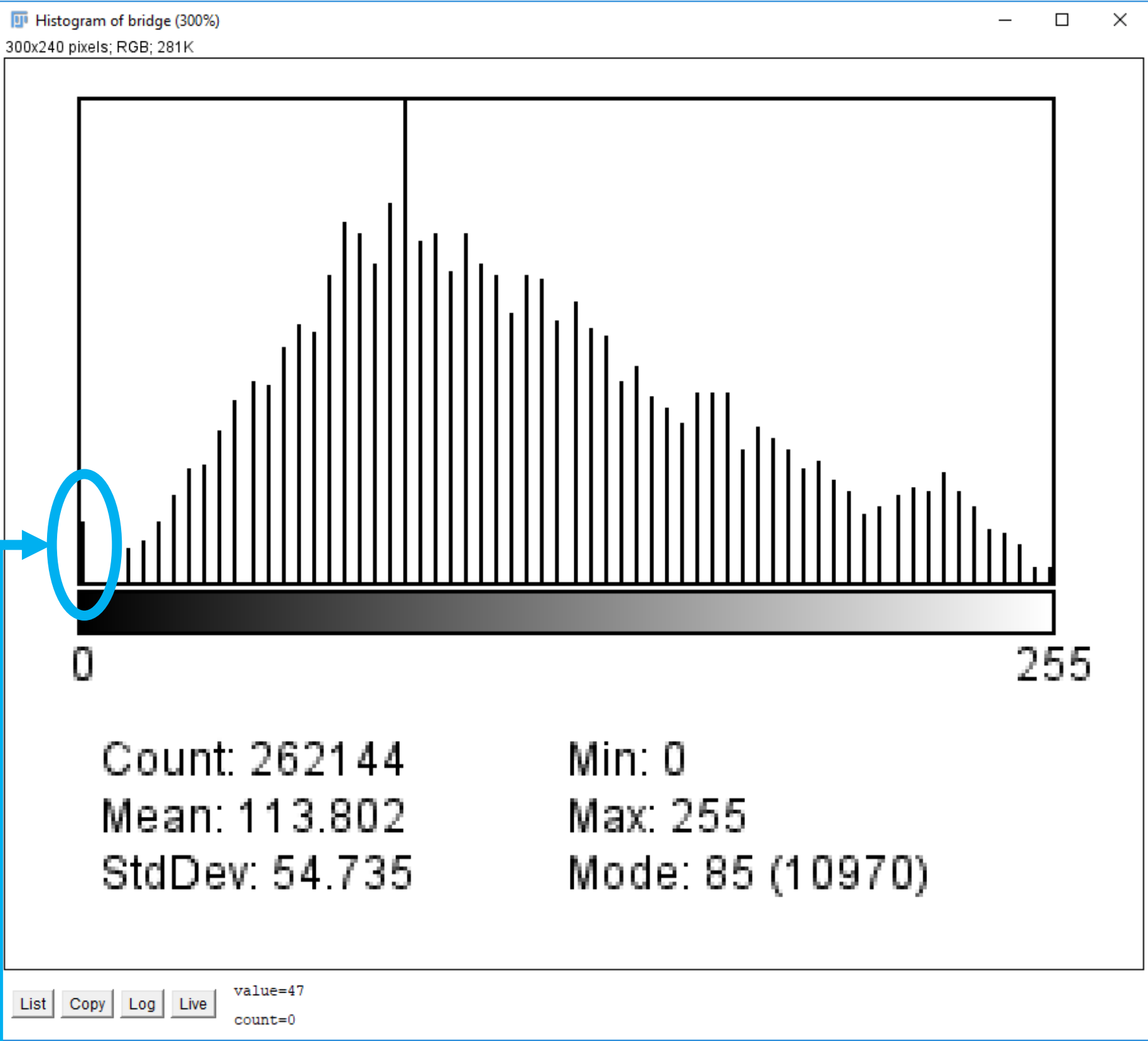
Getting Data From Your Image

- Image Histograms

Image Histogram

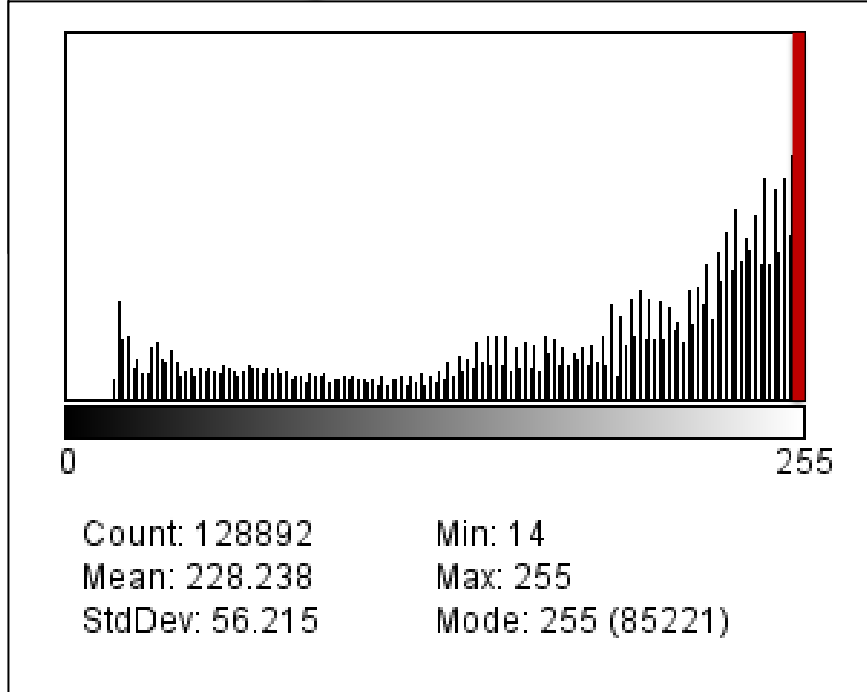
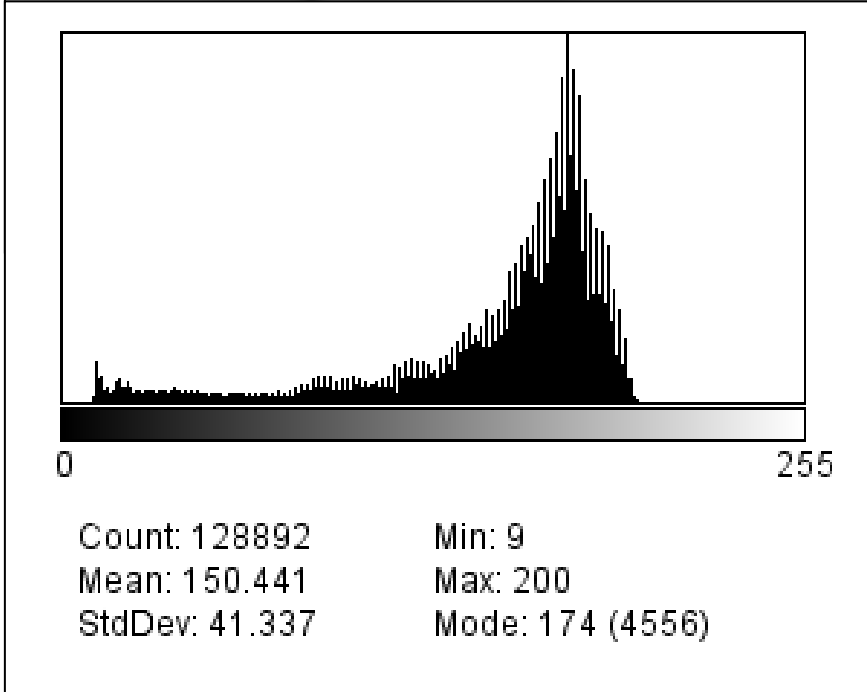
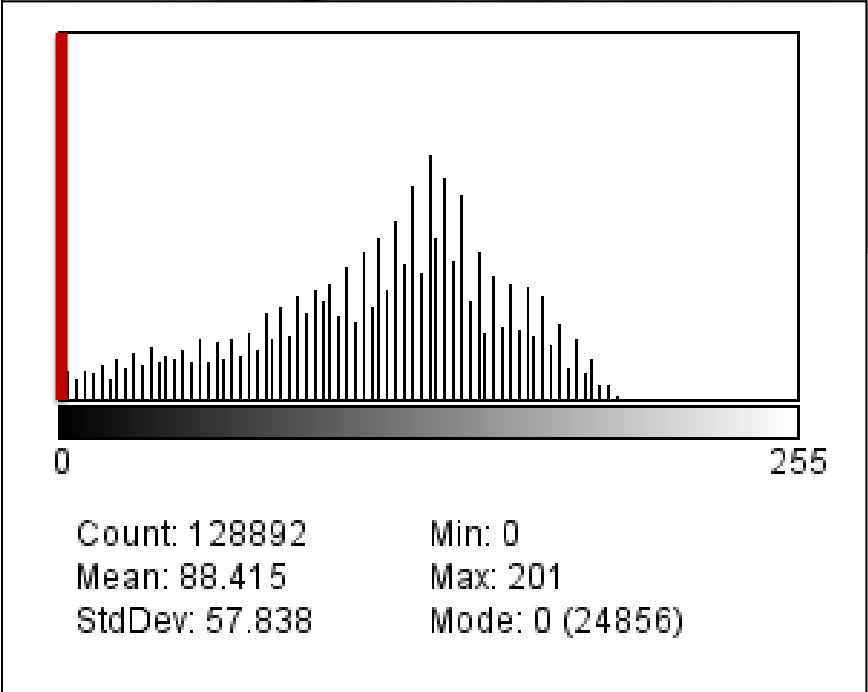
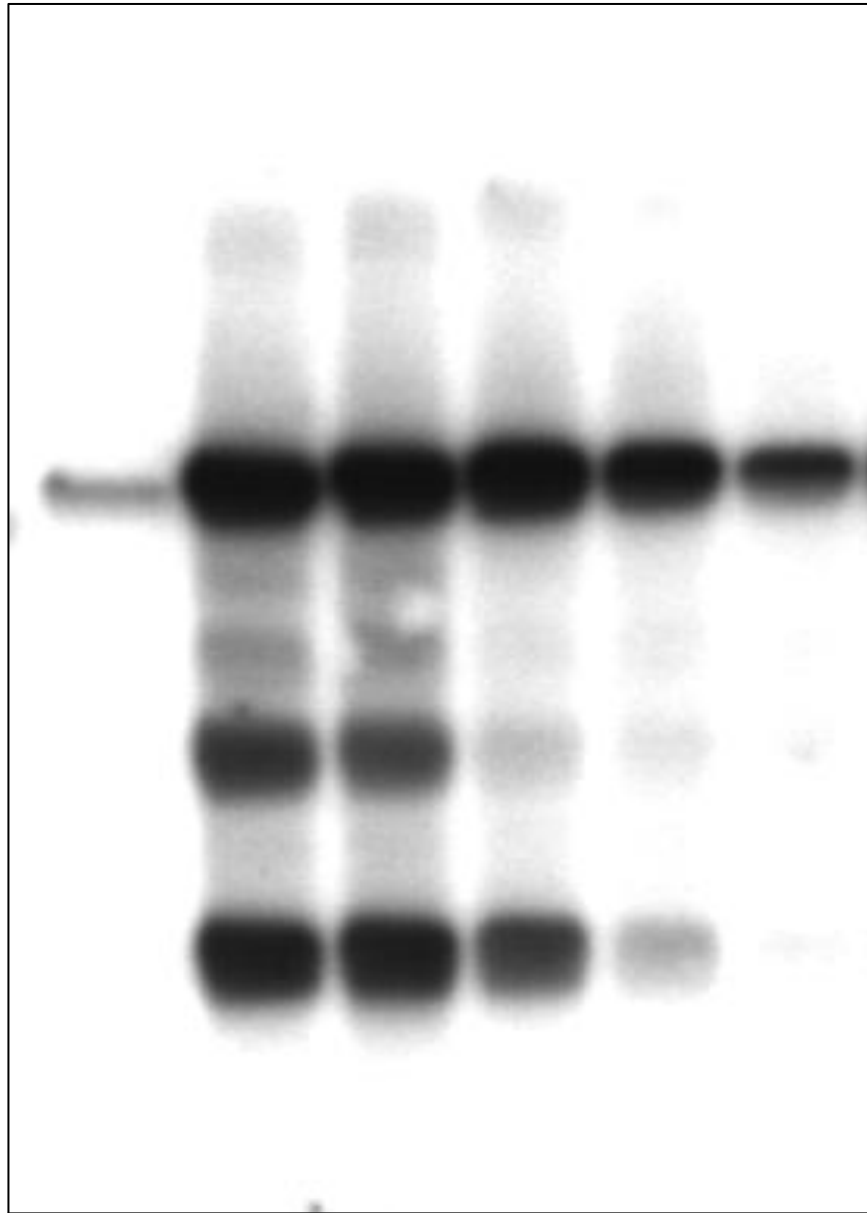
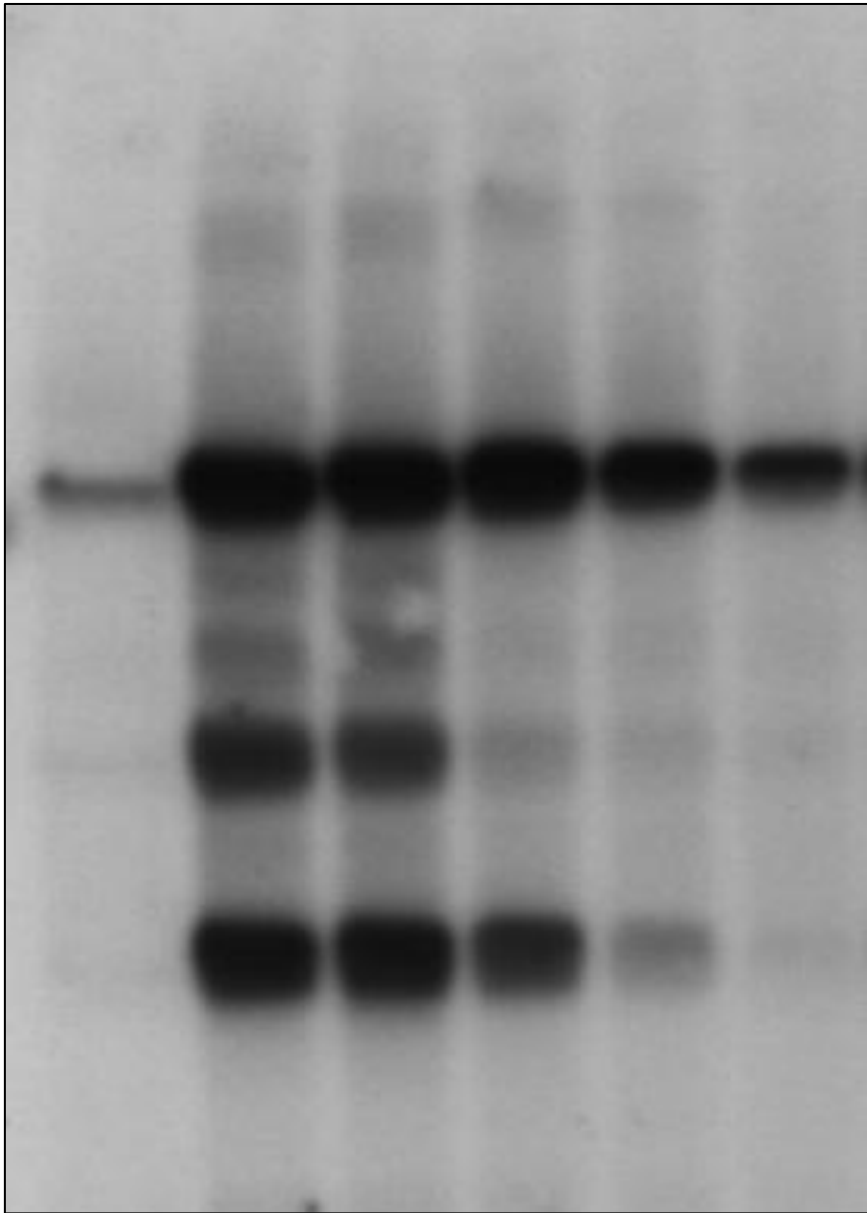
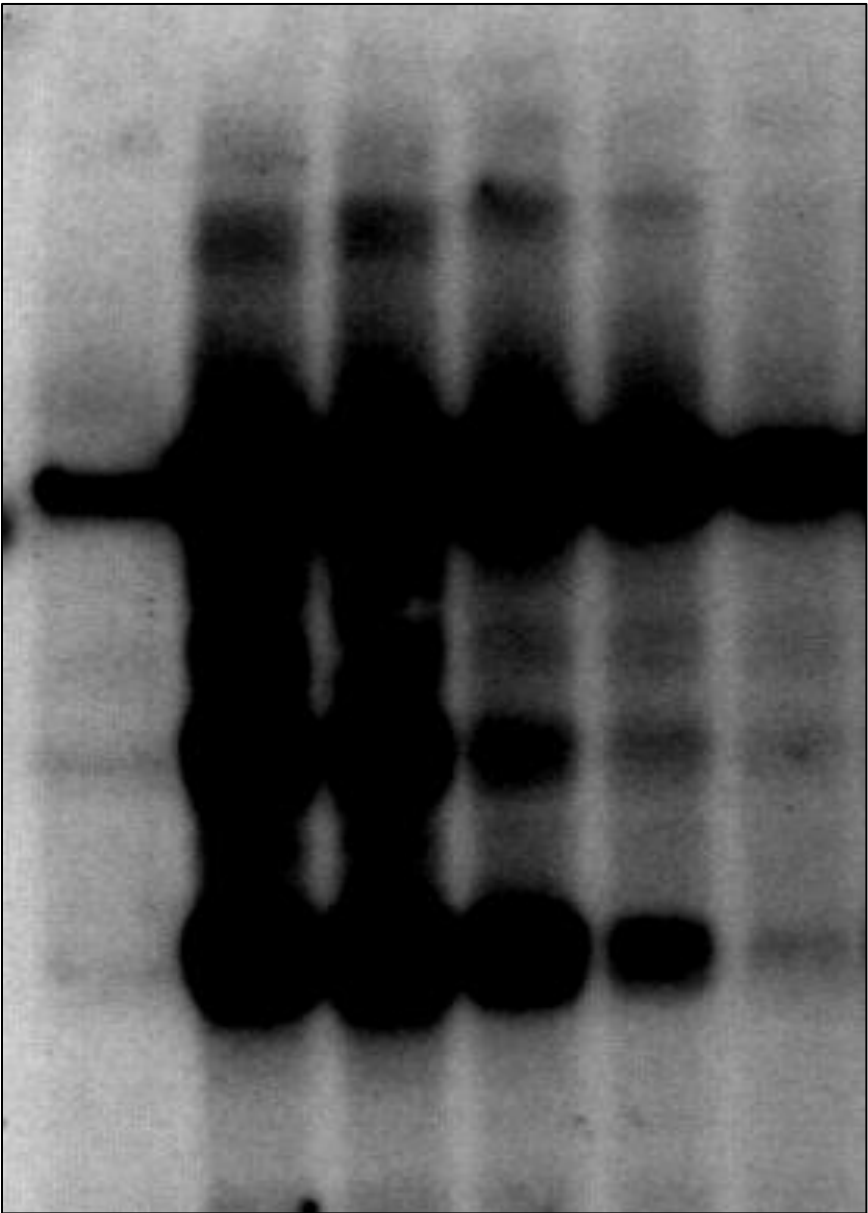


Histograms



Analyze > Histogram

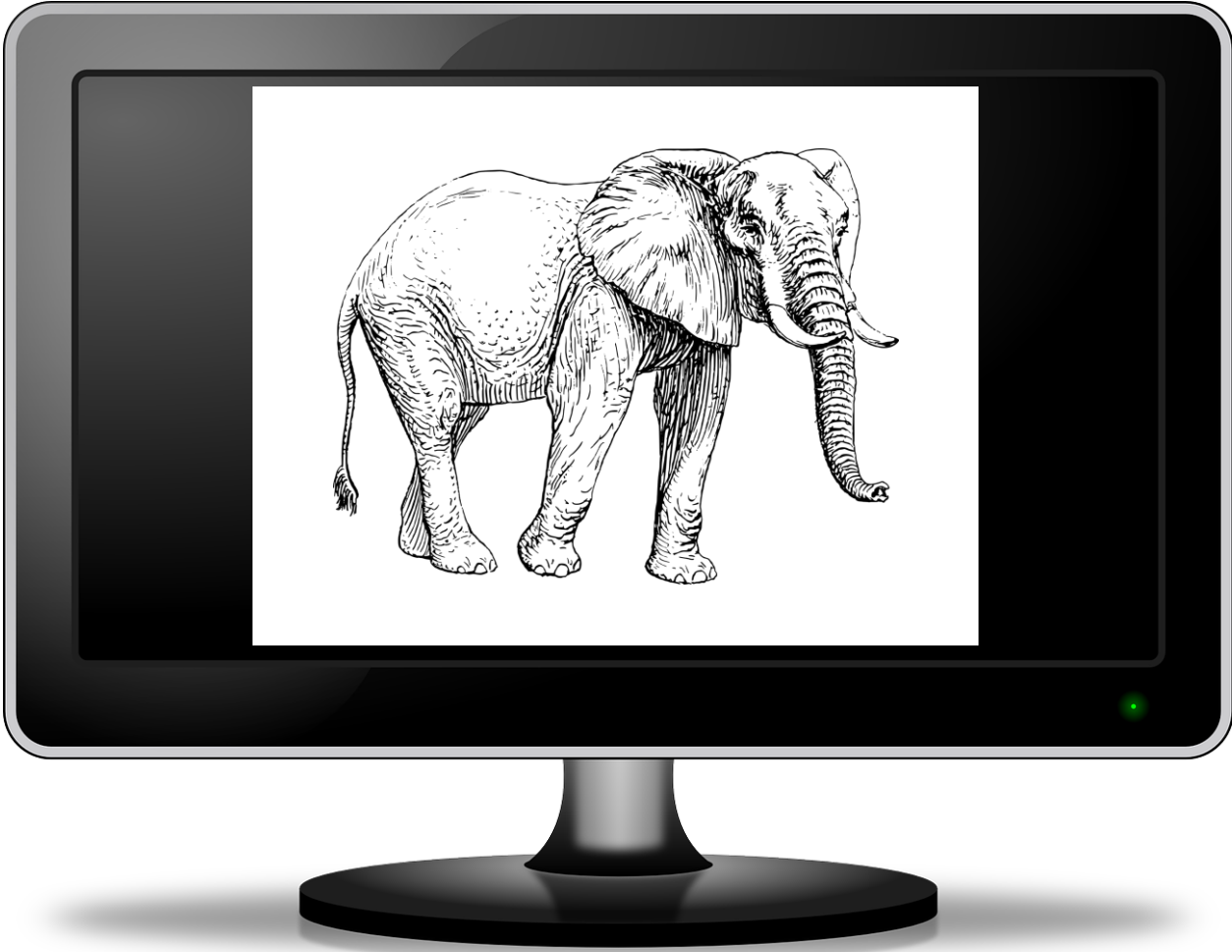
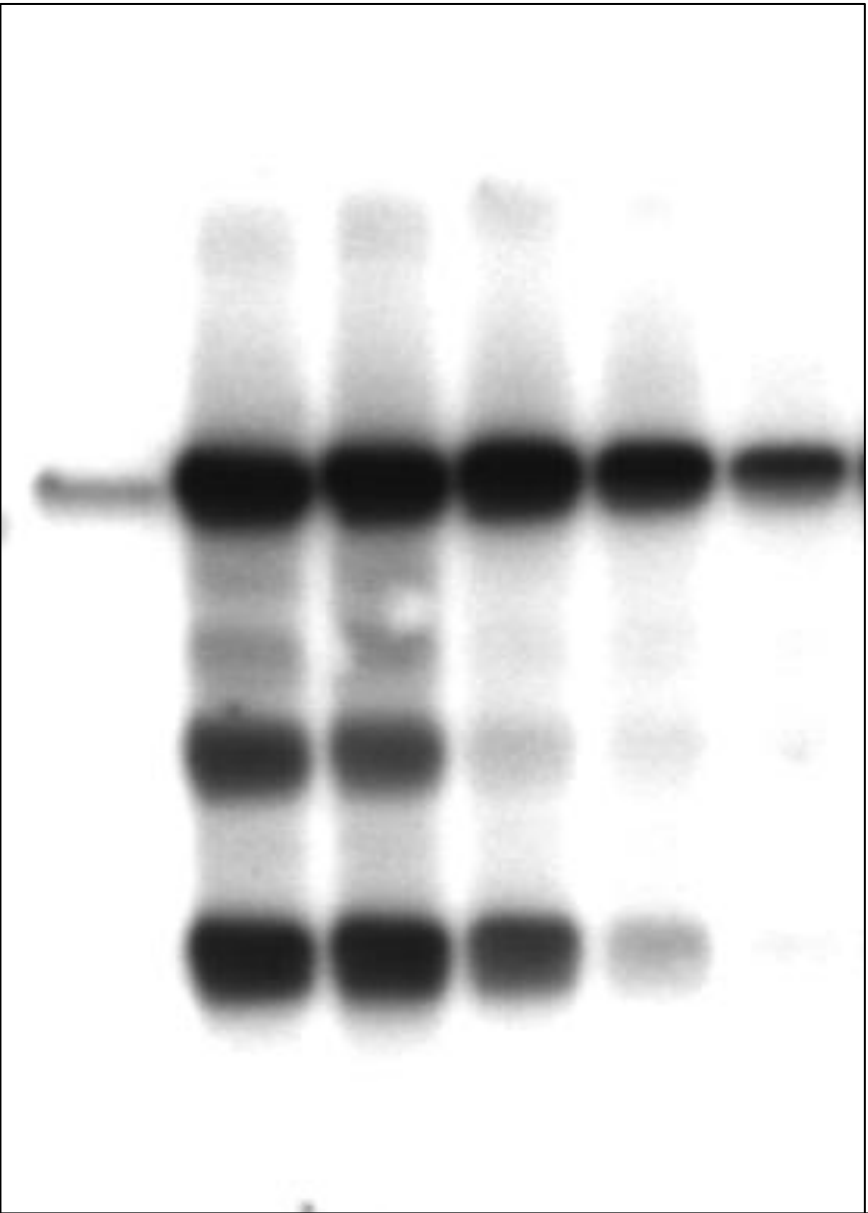
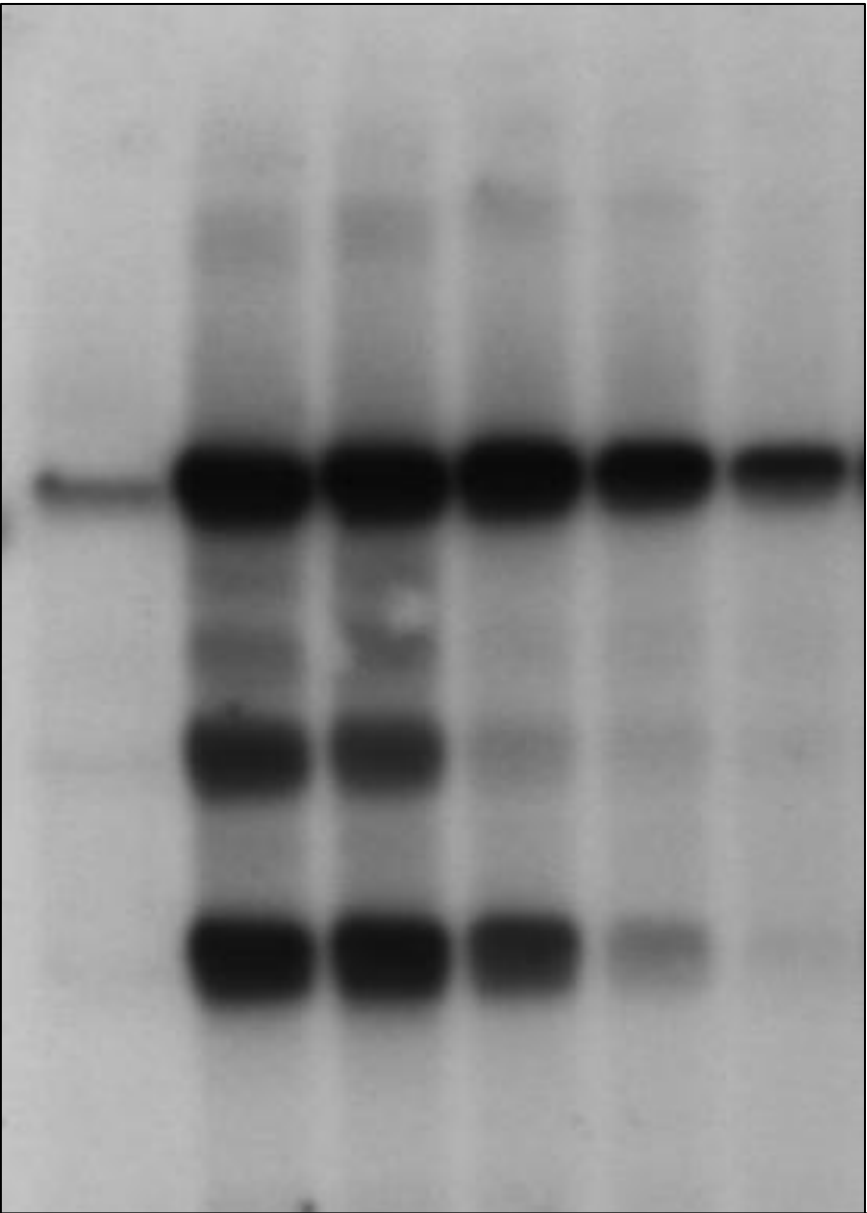
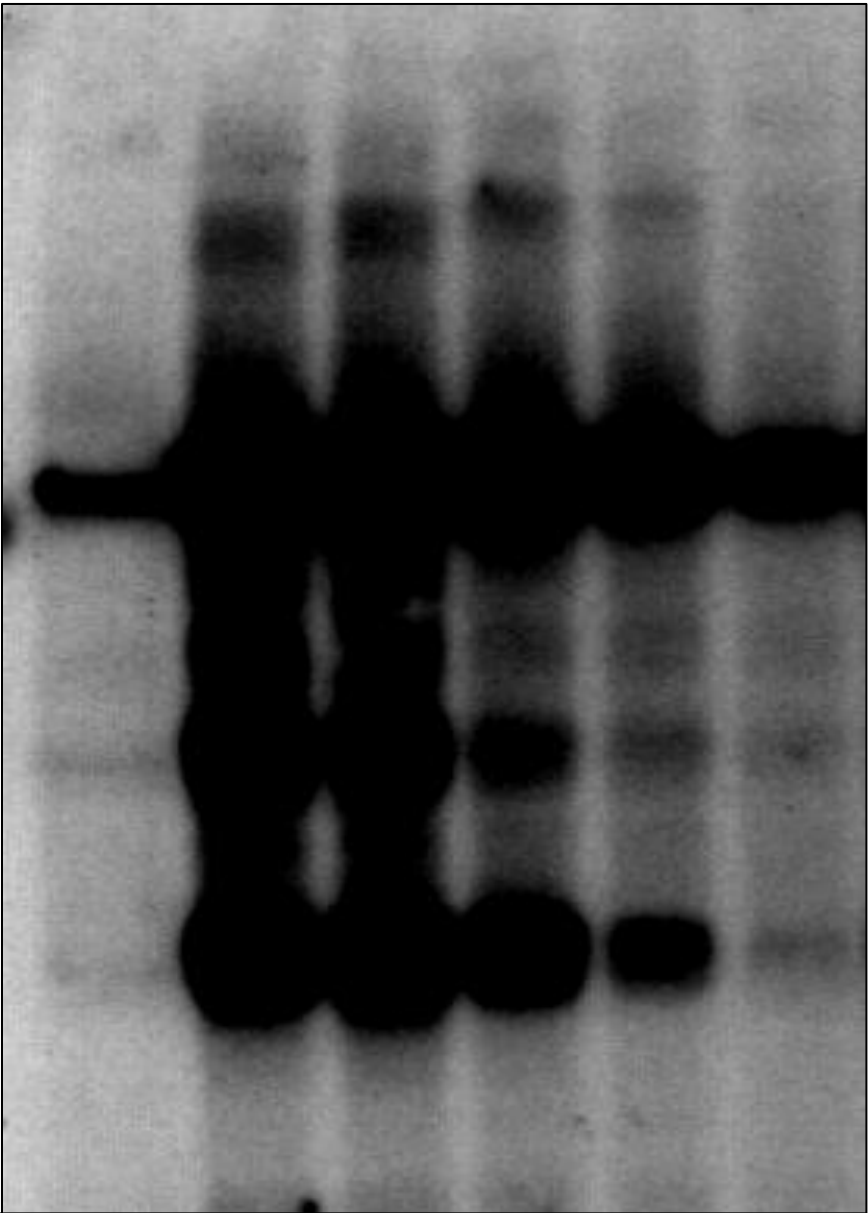
Artifact: Image Saturation



Saturation

Is an irreversible loss of information
Cannot be fixed post-acquisition

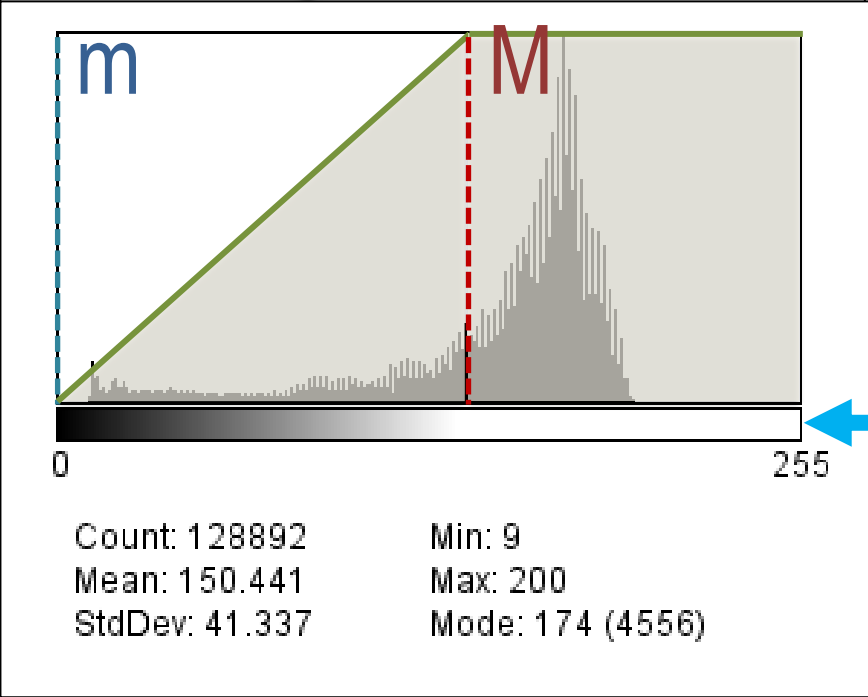
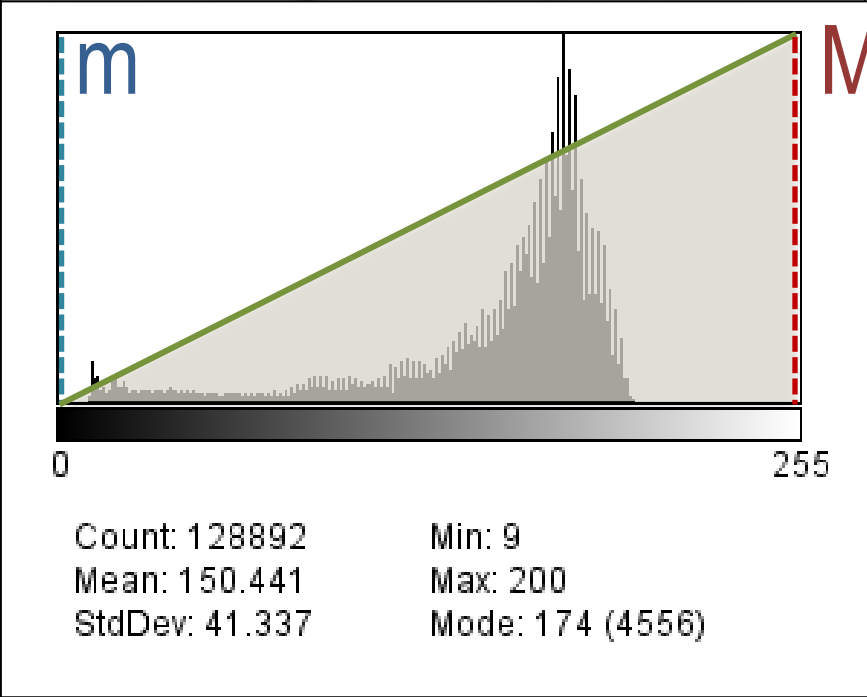
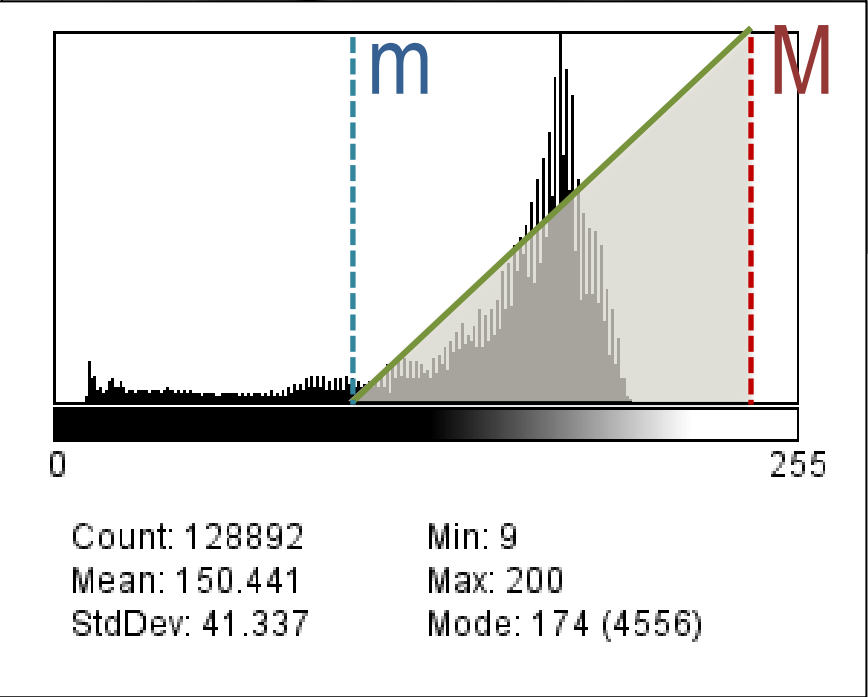
Brightness & Contrast (And Min & Max)



$$I(u, v) \Rightarrow I(u', v')$$

Pixel Intensity value(s)
e.g. 0...255

Screen luminosity value(s)



Brightness & Contrast (And Min & Max)

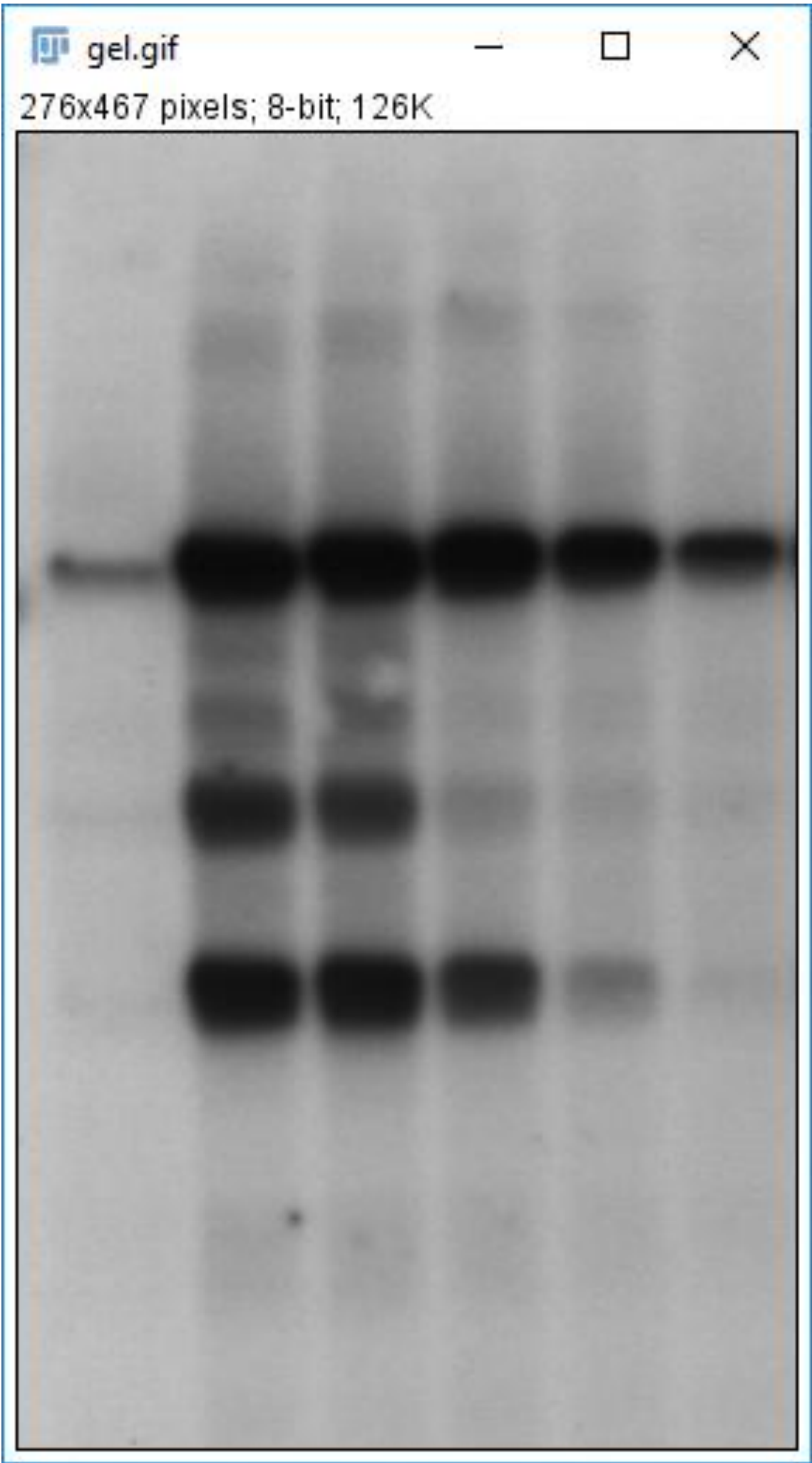
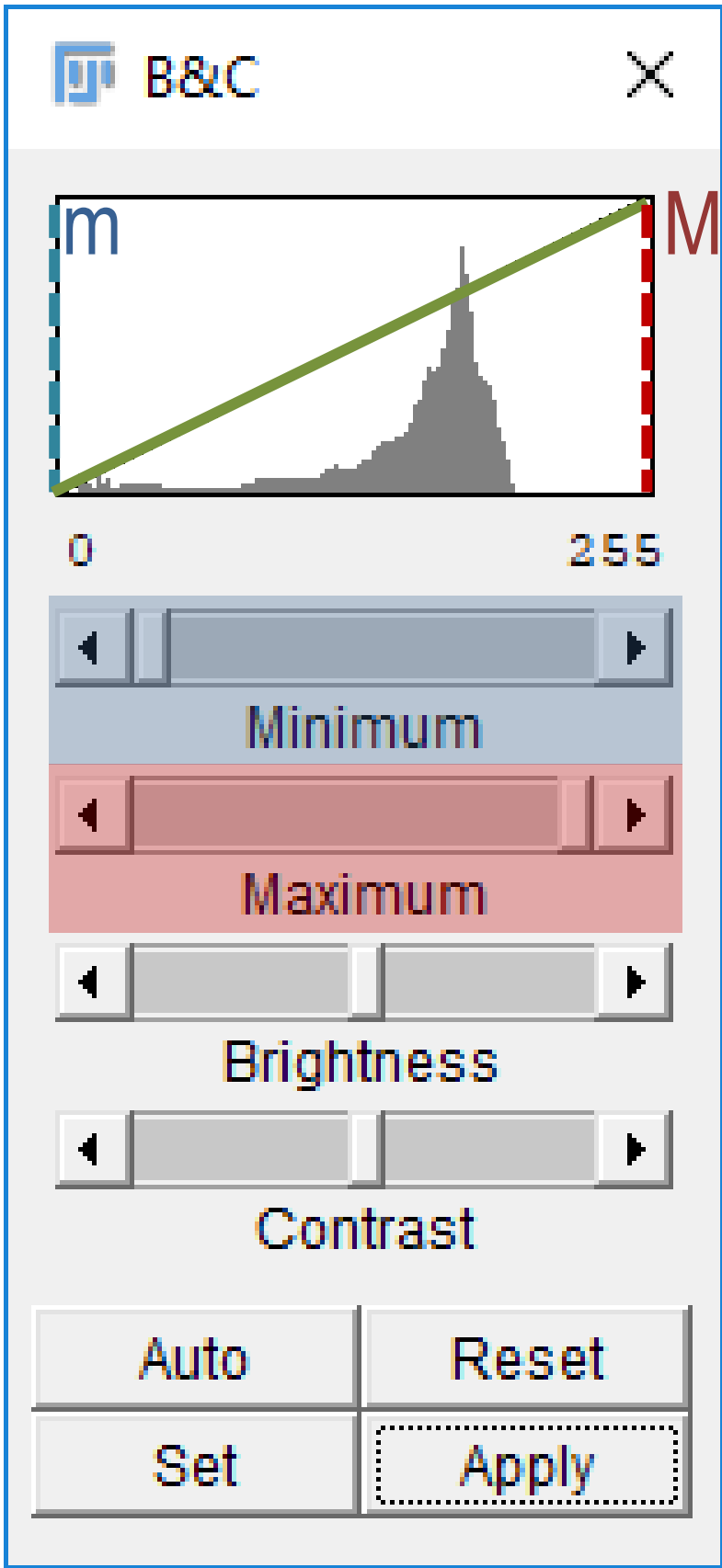
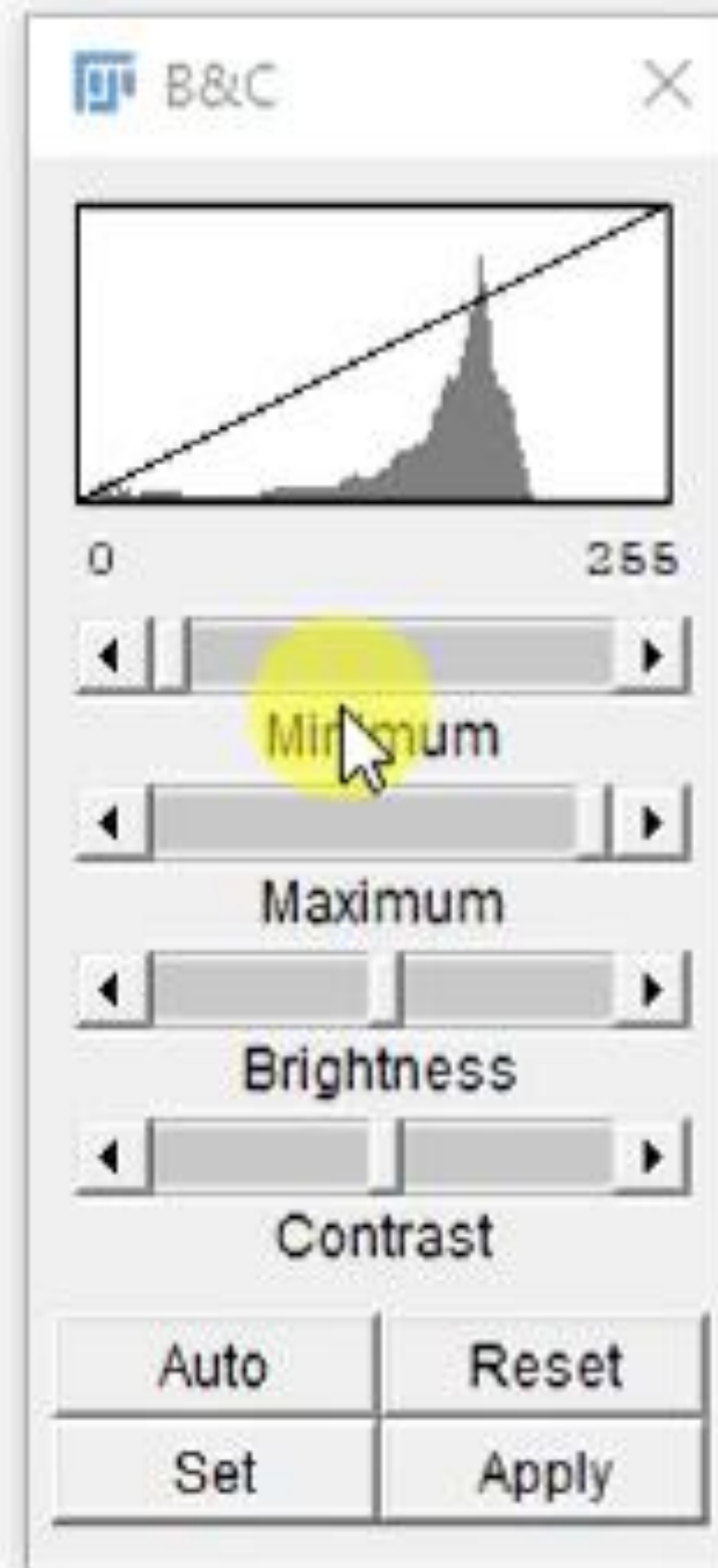


Image > Adjust >
Brightness & Contrast

Brightness and Contrast in Fiji



- Images are represented by their intensities
- Histograms allow for quantitative data to be extracted
- How to adjust brightness and contrast
- Careful of image saturation

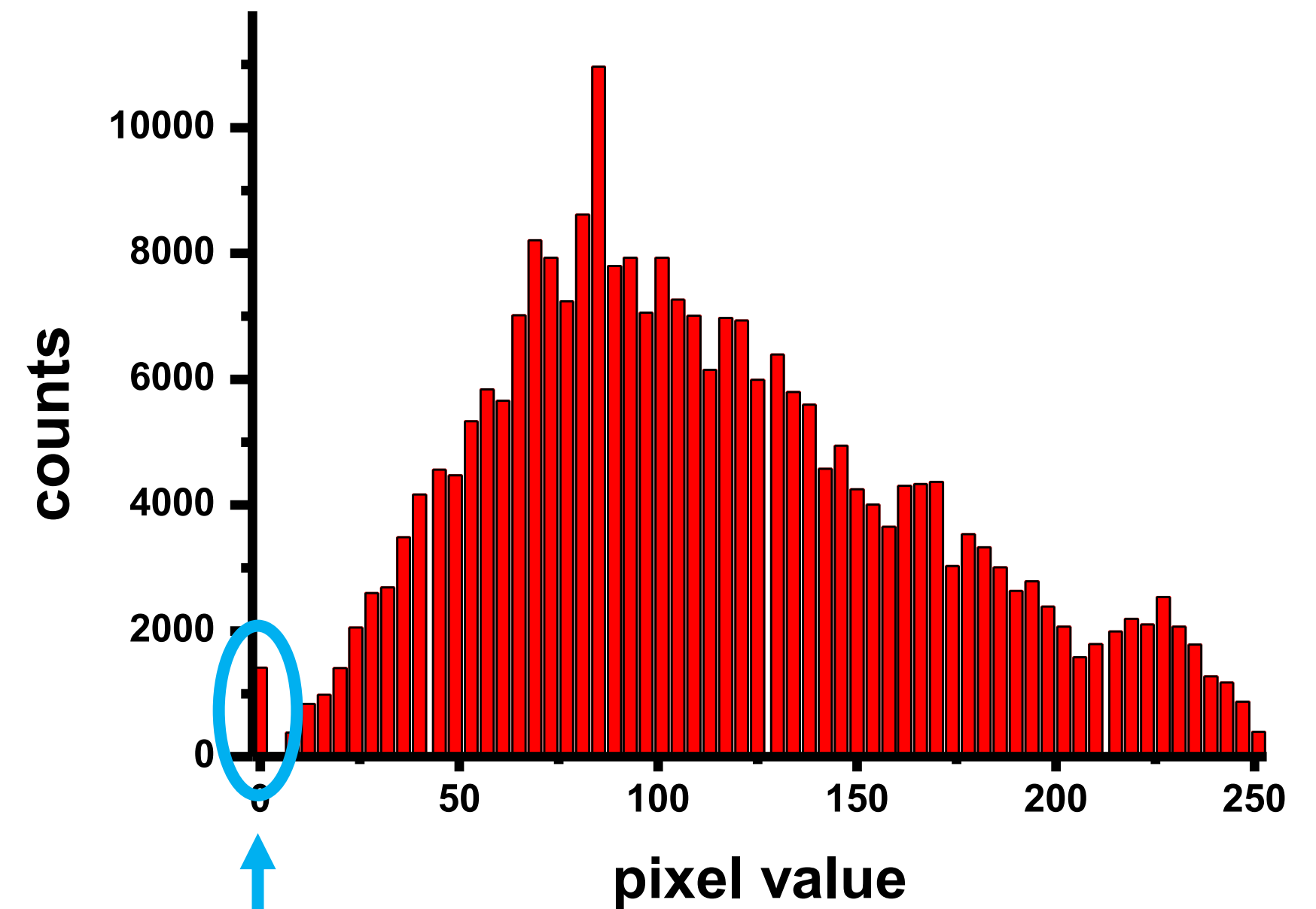
END, Nothing after this



Histograms

Definition

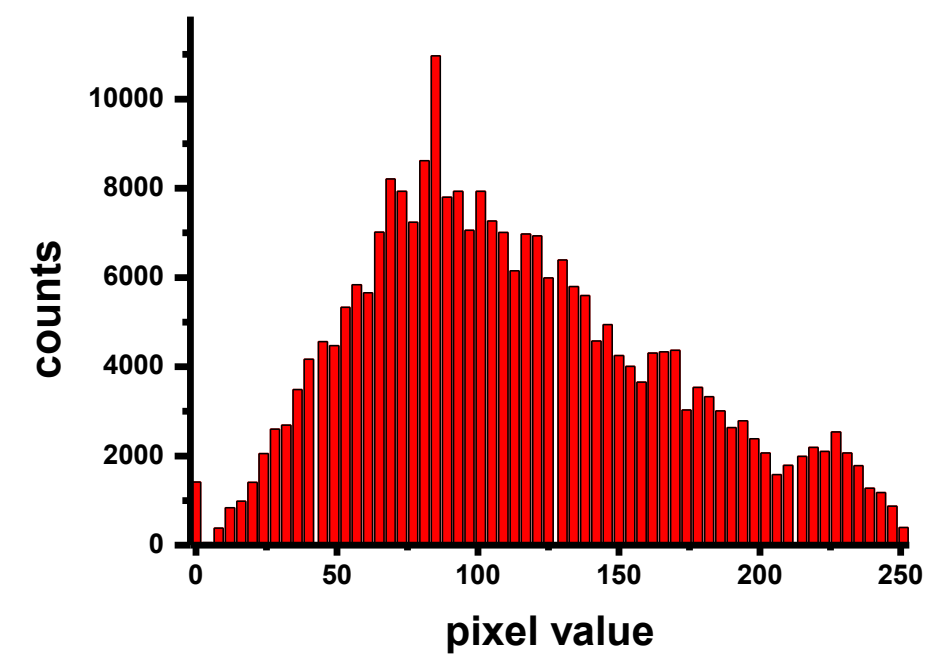
A **histogram** represents the distribution of intensity values of all pixels in an image, rather than their spatial distribution.



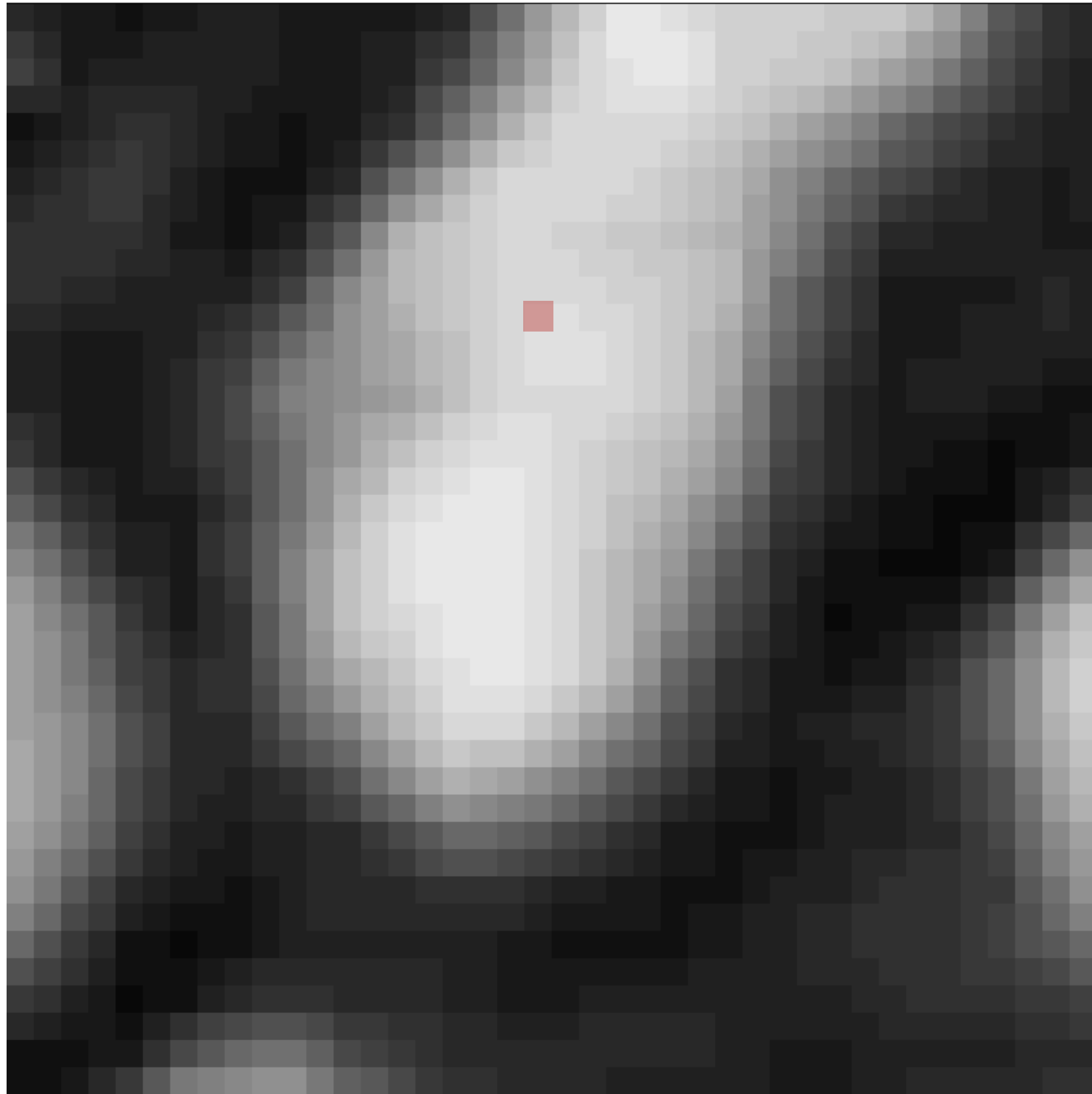
Histograms

Definition

A **histogram** represents the distribution of intensity values of all pixels in an image, rather than their spatial distribution.



2D Data Arrays



Definition

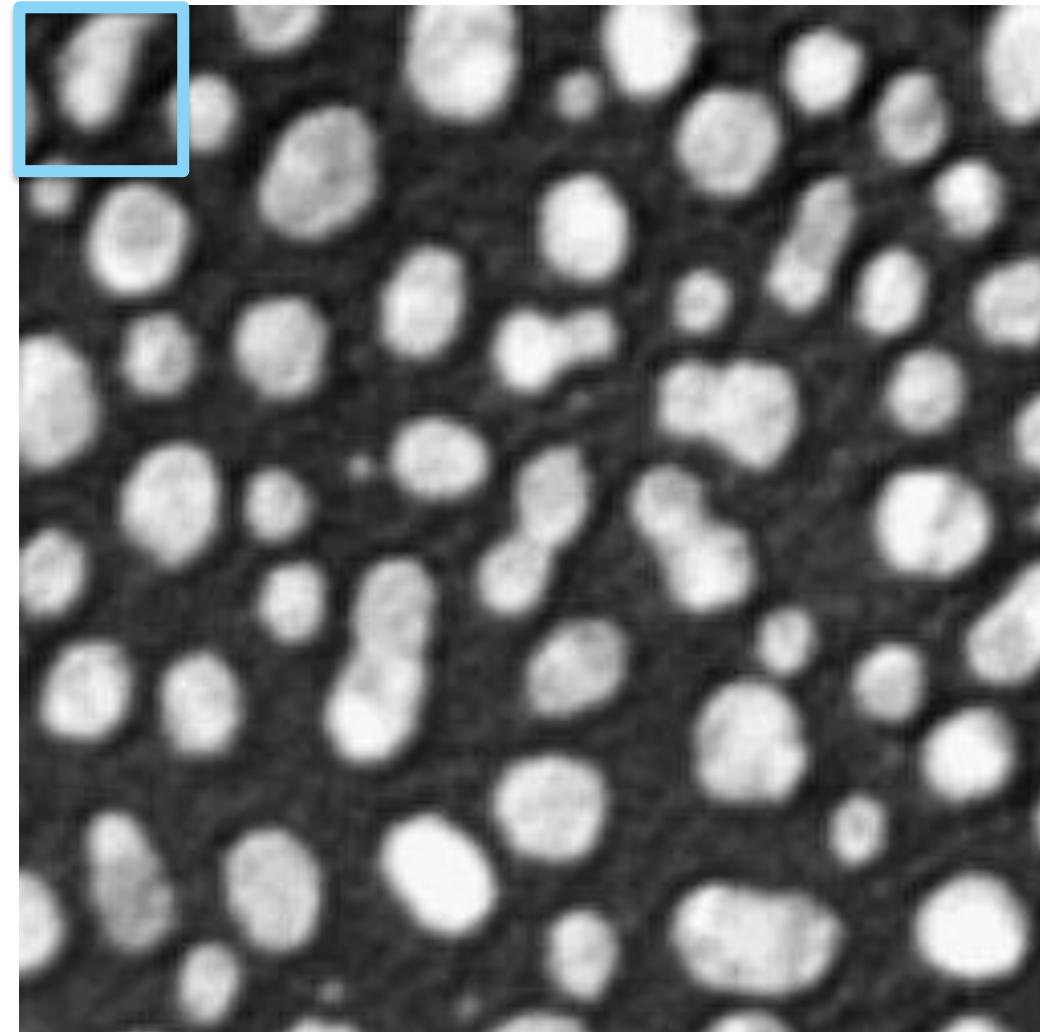
A **pixel** is the smallest unit of a digital image or graphic that can be displayed and represented on a digital display device.

A pixel **is the basic logical unit in digital graphics**. Pixels are combined to form a complete image, video, text or any visible thing on a computer display.

A pixel is also known as a **picture element**.

$$I(u, v)$$

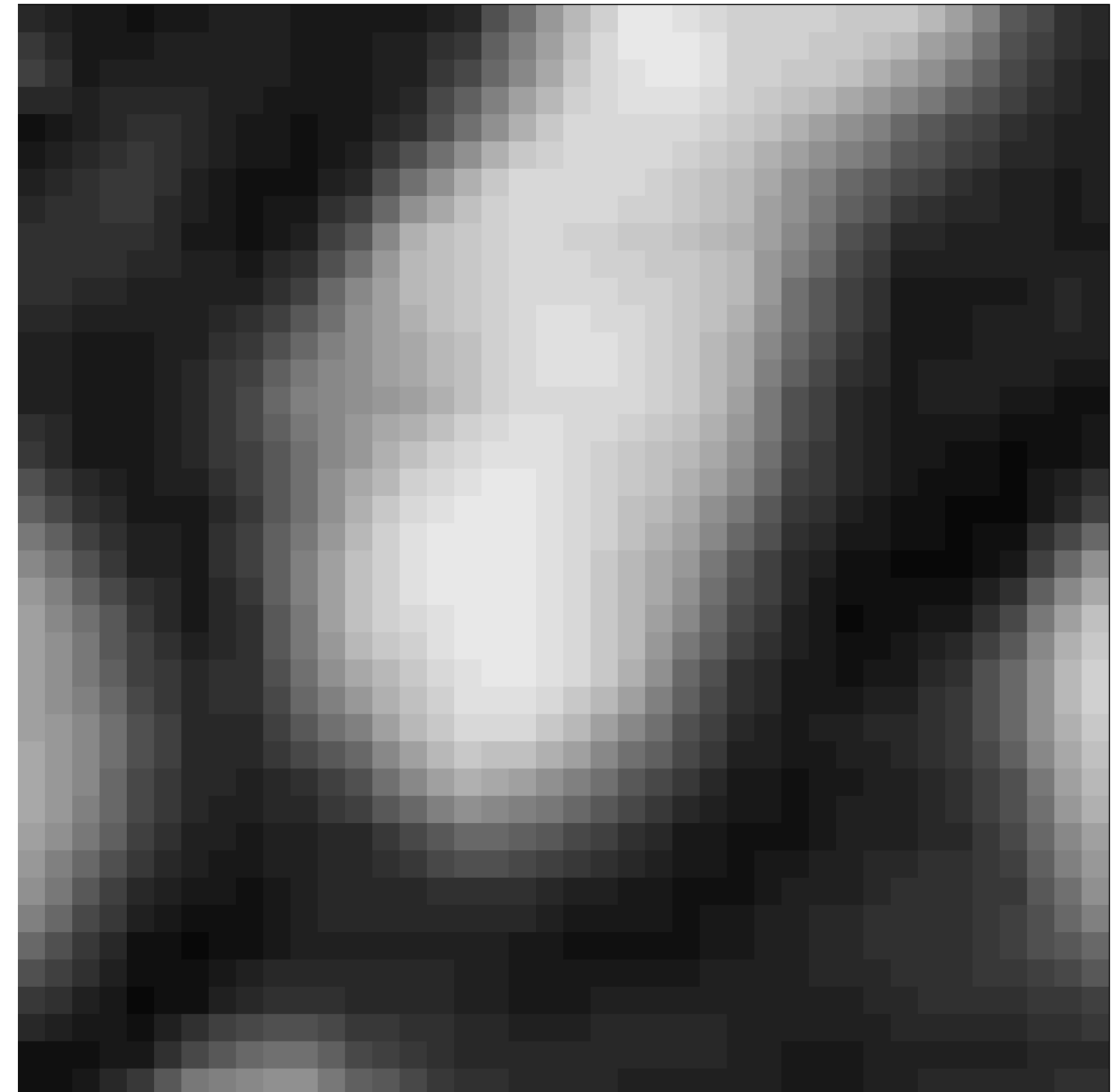
2D Images



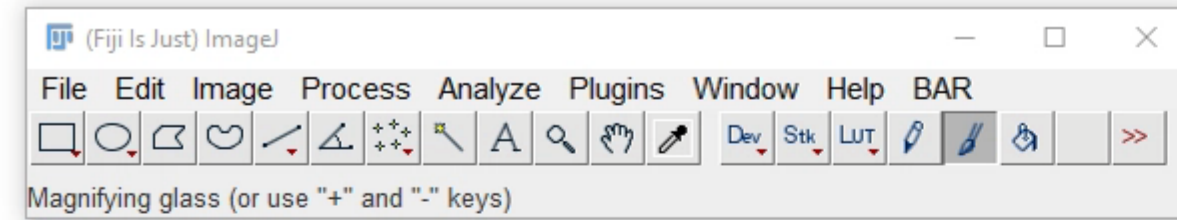
A Pixel Is *Not* A Little Square,
A Pixel Is *Not* A Little Square,
A Pixel Is *Not* A Little Square!
(And a Voxel is *Not* A Little Cube)

Technical Memo 6

Alvy Ray Smith
July 17, 1995



Images Are Discrete Numbers



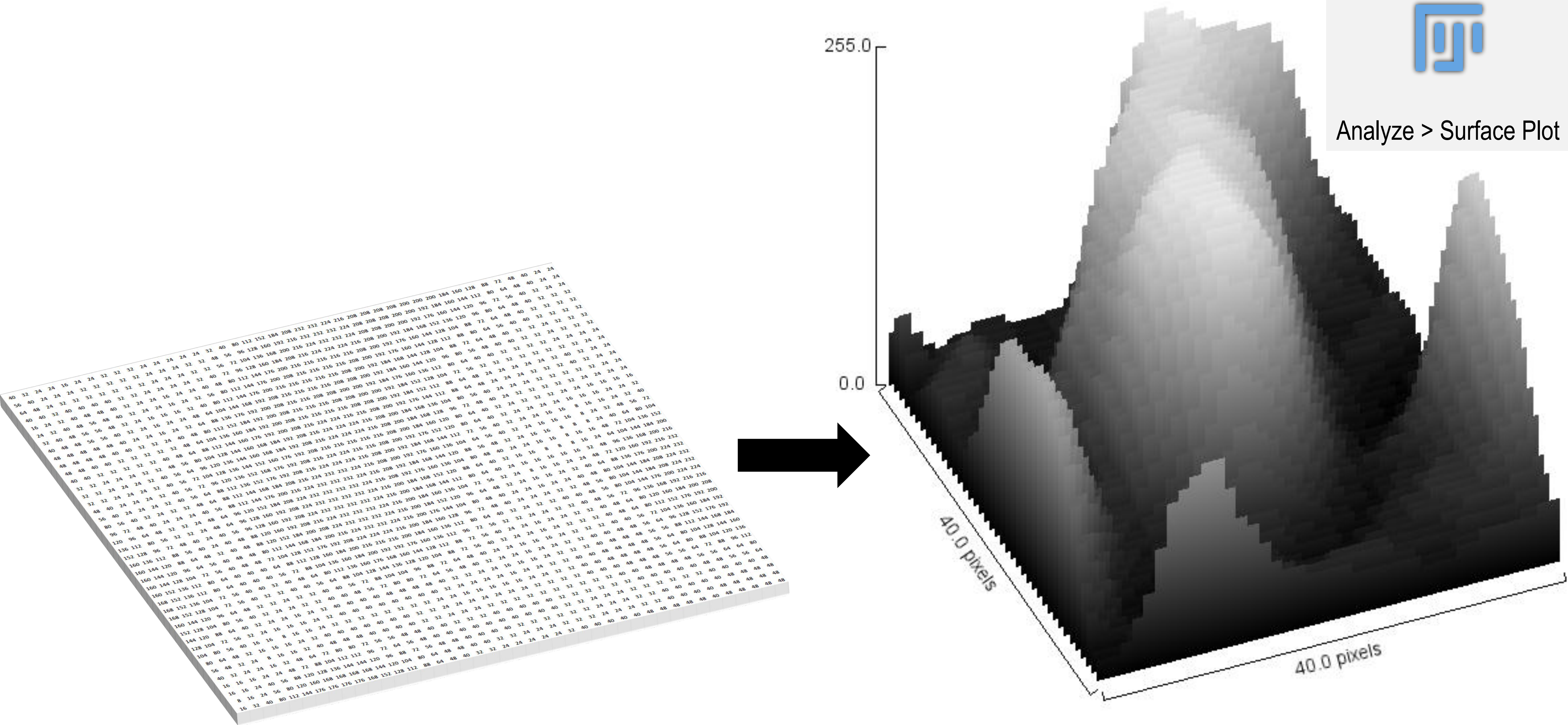
Exercise:

1. Make a new image using
File → New → Image...
And these settings
2. Click OK
3. Draw on it using the Pen tool
4. Use
File → Save As → Text Image...
5. Open image in text editor

2D Surfaces

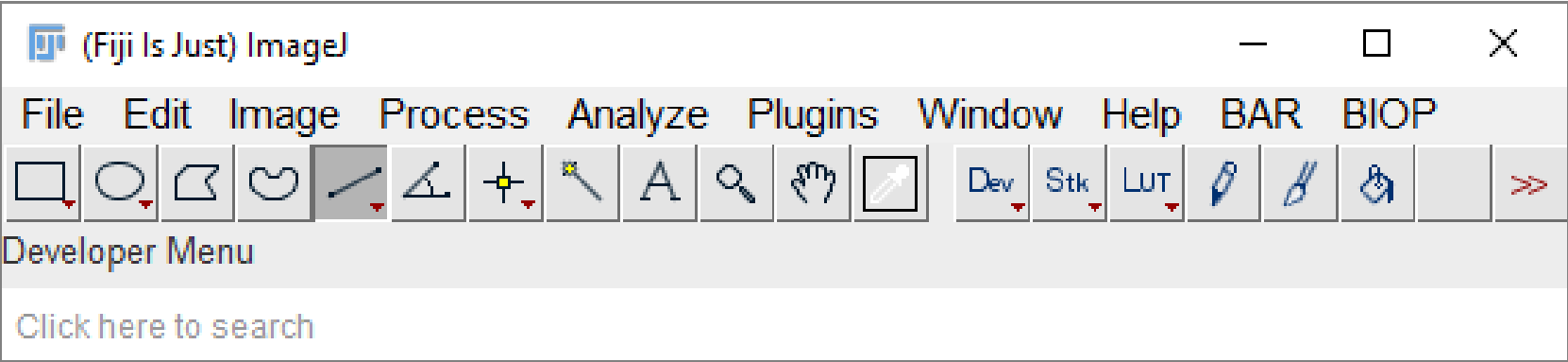


Analyze > Surface Plot

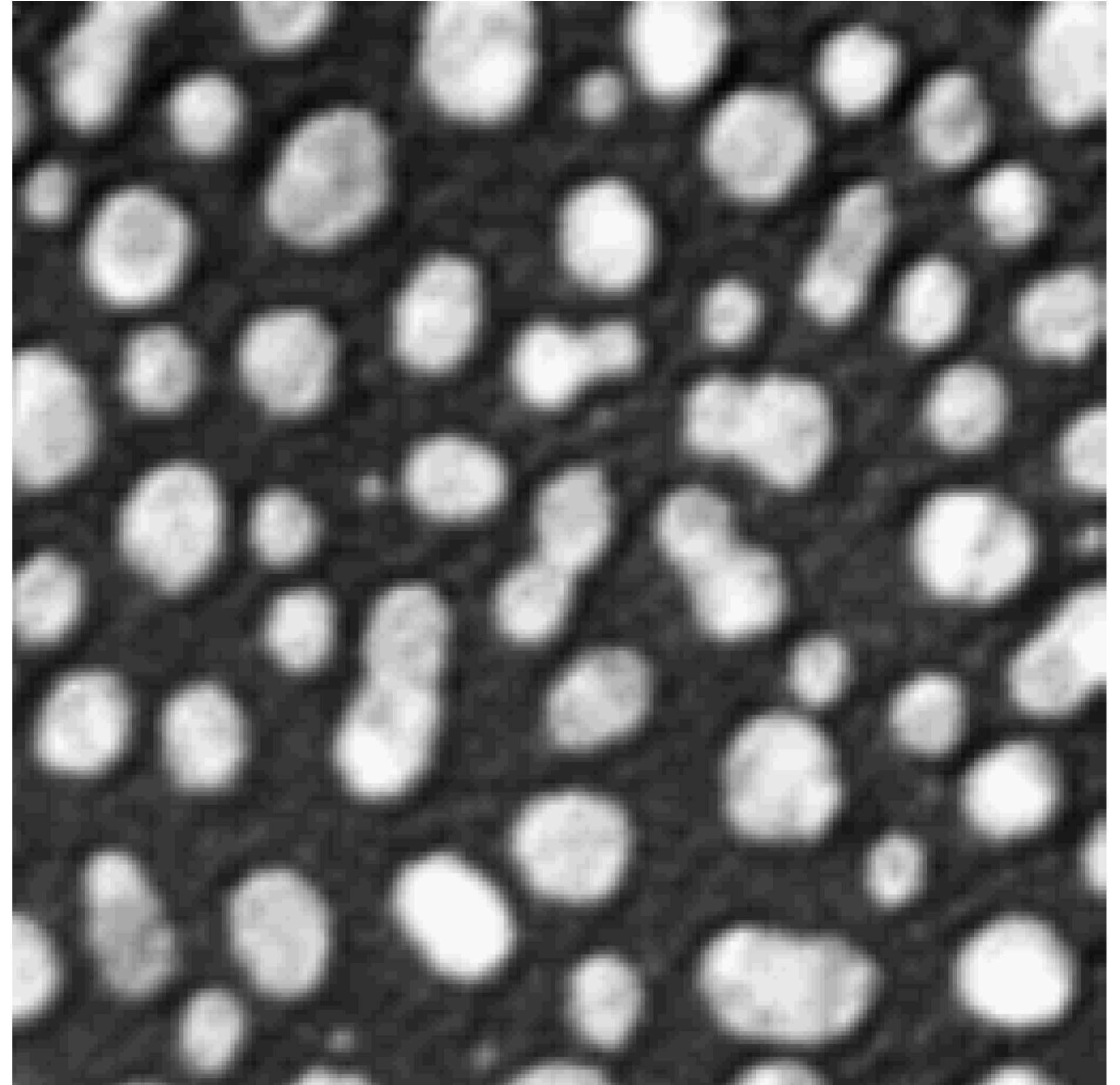


Fiji - Benefits

- Java



A Lot Of Data



256x254 pixels = 65'024 data points

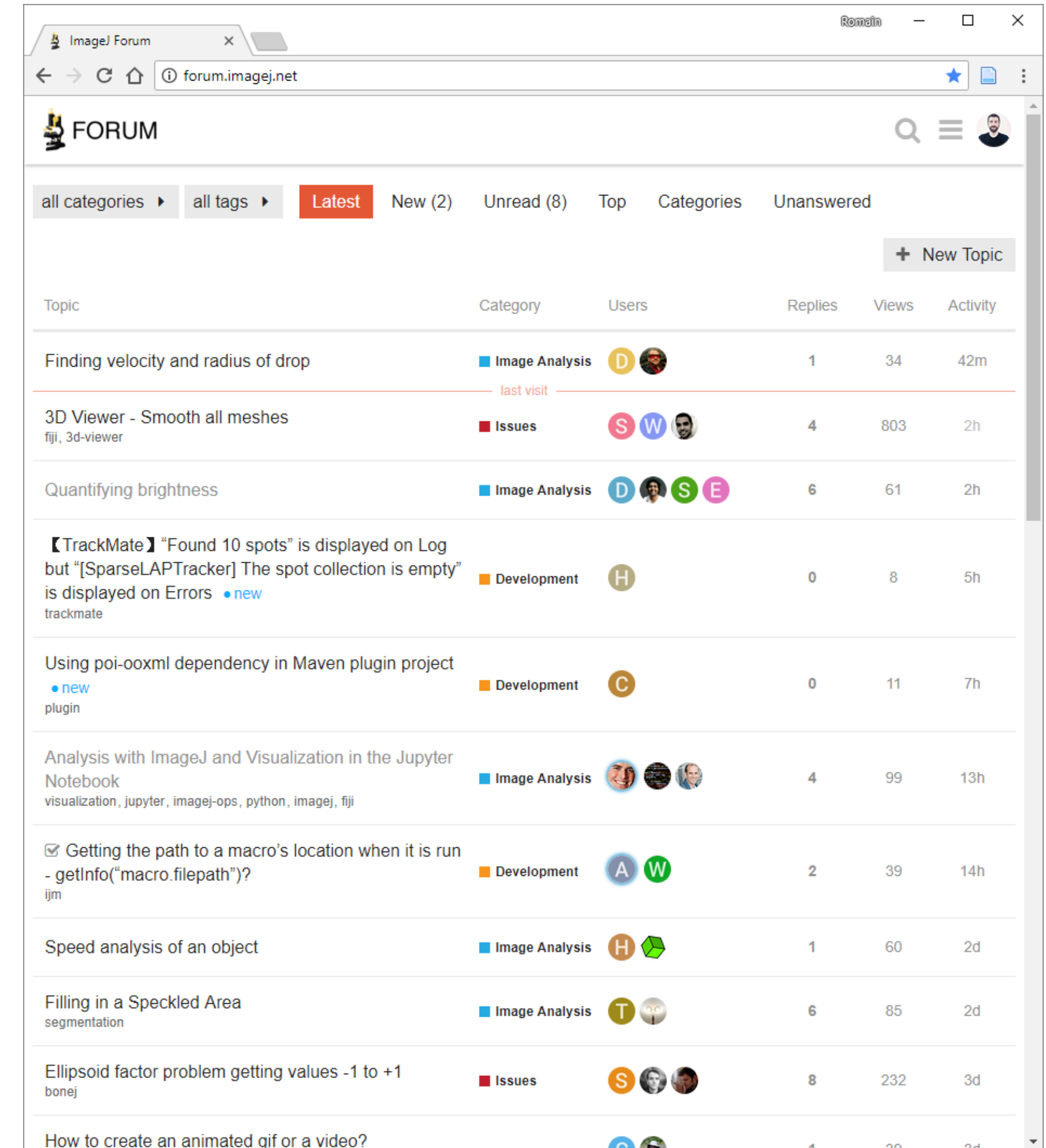
Fiji - Benefits

- Java
- Large community
 - 1000 plugins
 - Documentation, tutorials



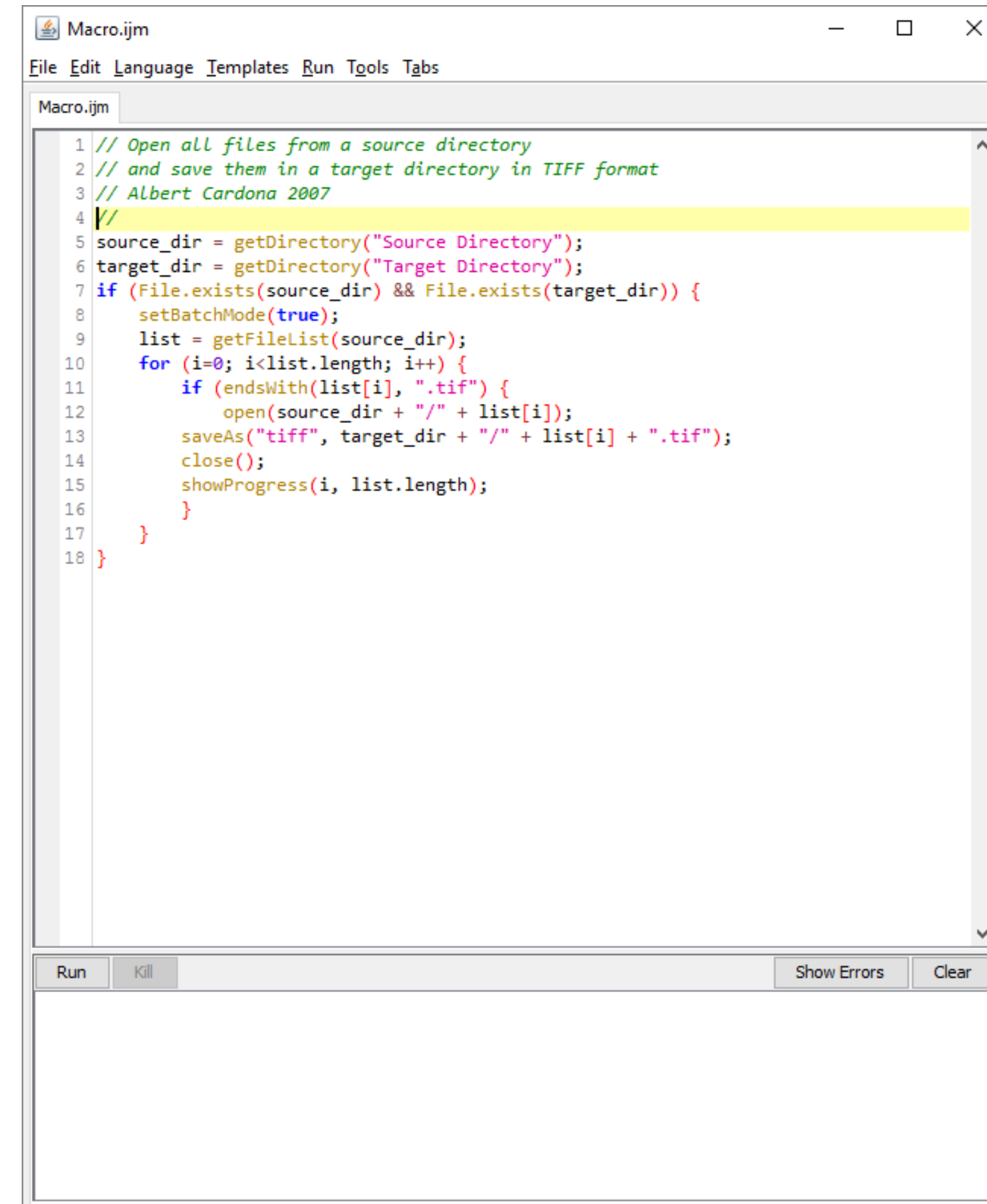
Fiji - Benefits

- Java
- Large community
 - 1000 plugins
 - Documentation, tutorials
 - Forum



Fiji - Benefits

- Java
- Large community
 - 1000 plugins
 - Documentation, tutorials
 - Forum
 - Easy Scripting using “macro language”

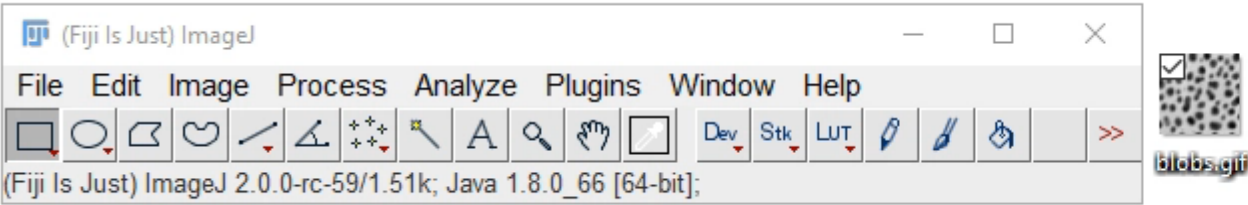


The screenshot shows the 'Macro.ijm' window in Fiji. The menu bar includes File, Edit, Language, Templates, Run, Tools, and Tabs. The macro script is as follows:

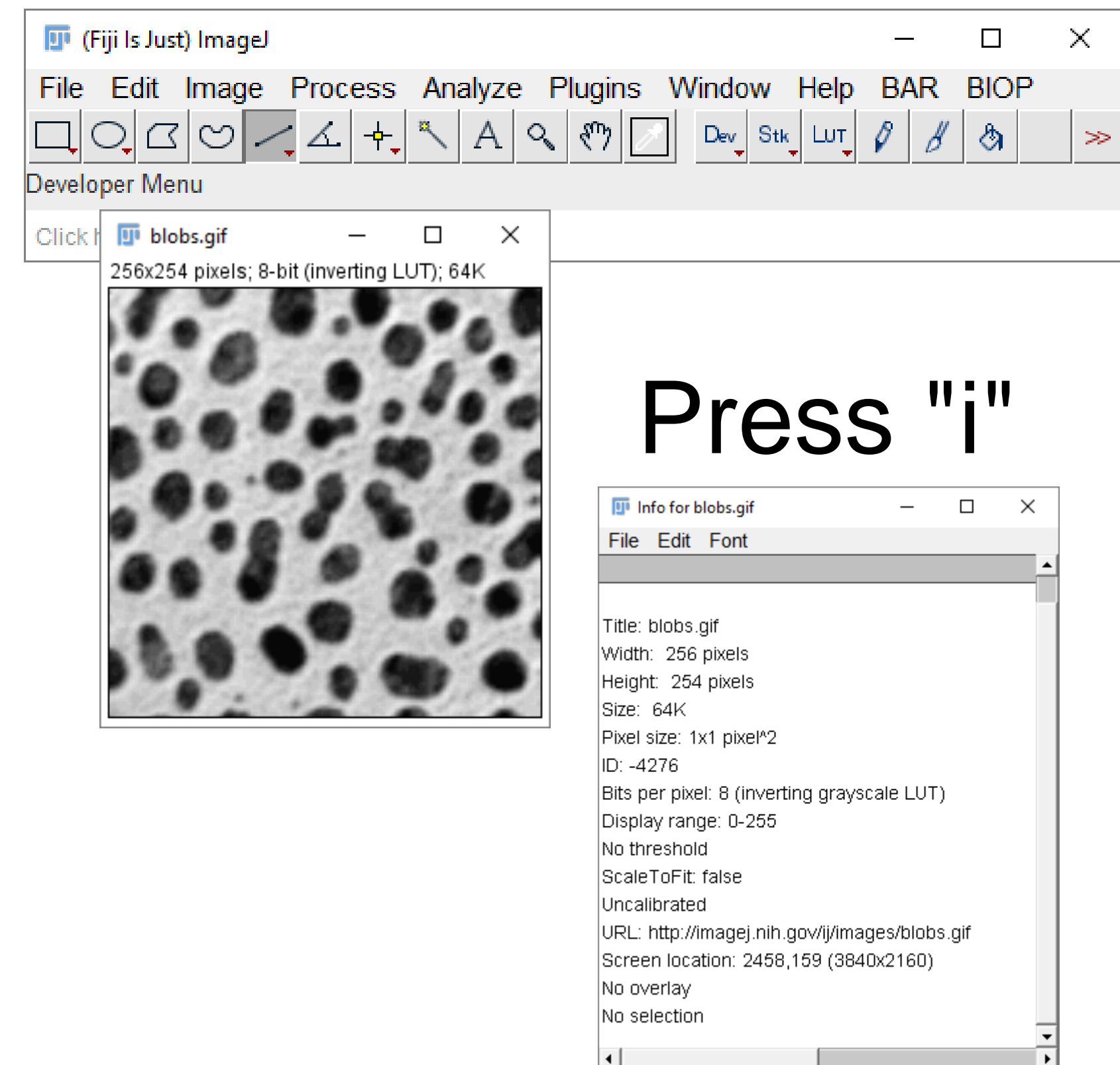
```
1 // Open all files from a source directory
2 // and save them in a target directory in TIFF format
3 // Albert Cardona 2007
4 //
5 source_dir = getDirectory("Source Directory");
6 target_dir = getDirectory("Target Directory");
7 if (File.exists(source_dir) && File.exists(target_dir)) {
8     setBatchMode(true);
9     list = getFileList(source_dir);
10    for (i=0; i<list.length; i++) {
11        if (endsWith(list[i], ".tif") {
12            open(source_dir + "/" + list[i]);
13            saveAs("tiff", target_dir + "/" + list[i] + ".tif");
14            close();
15            showProgress(i, list.length);
16        }
17    }
18 }
```

At the bottom of the window, there are buttons for 'Run', 'Kill', 'Show Errors', and 'Clear'.

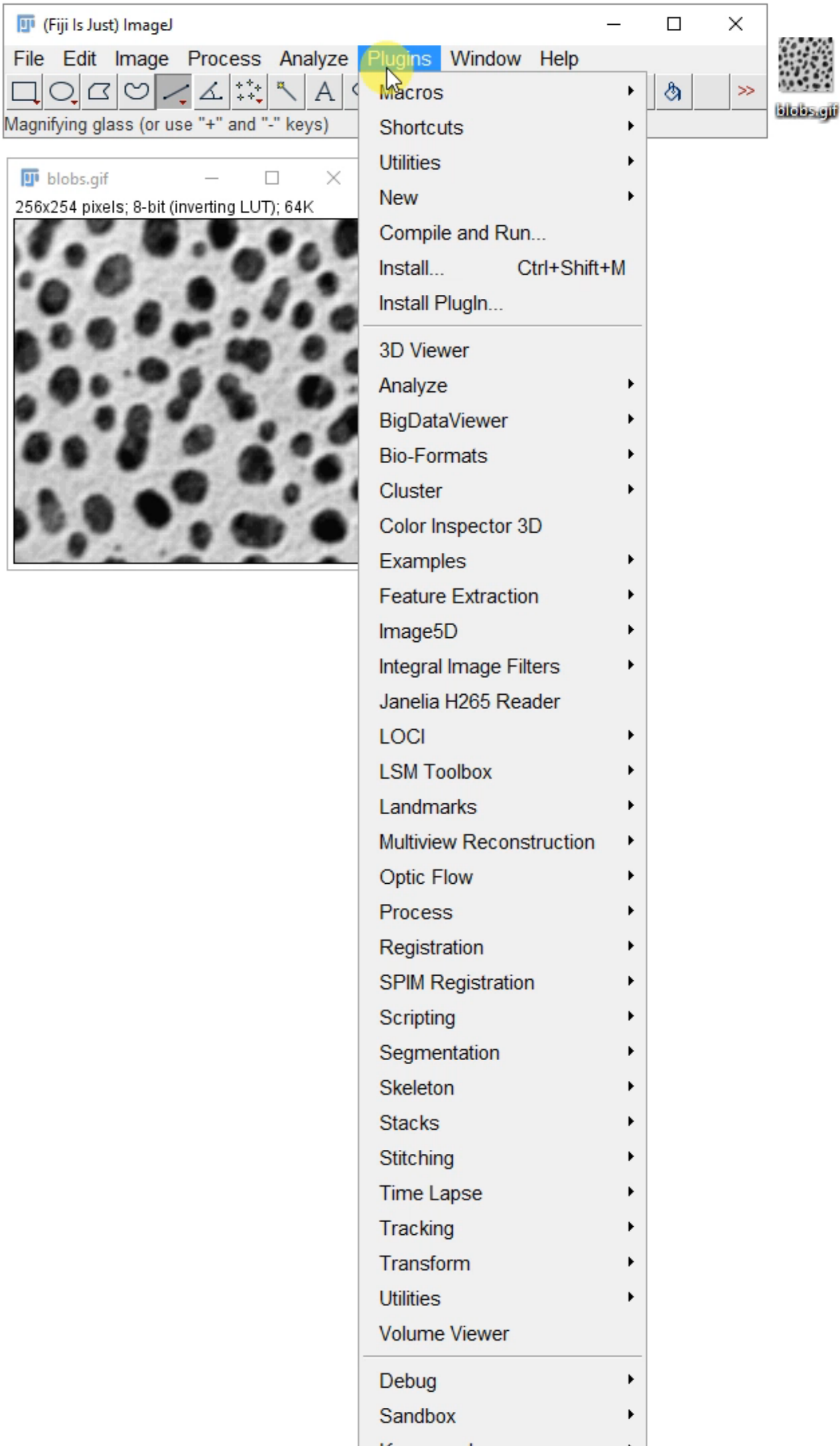
Fiji - First use



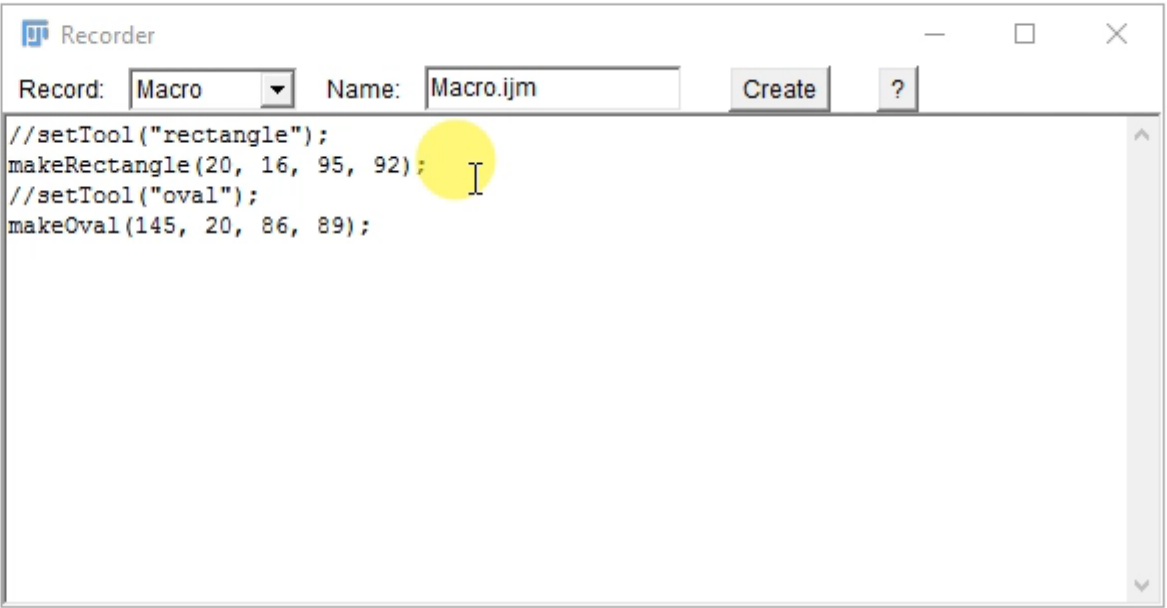
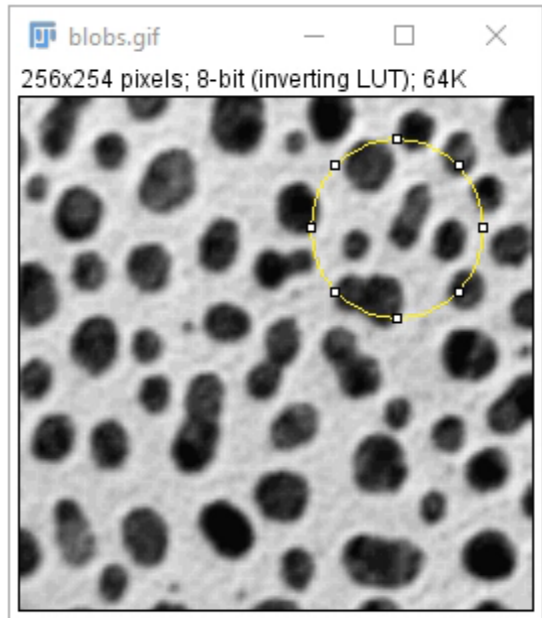
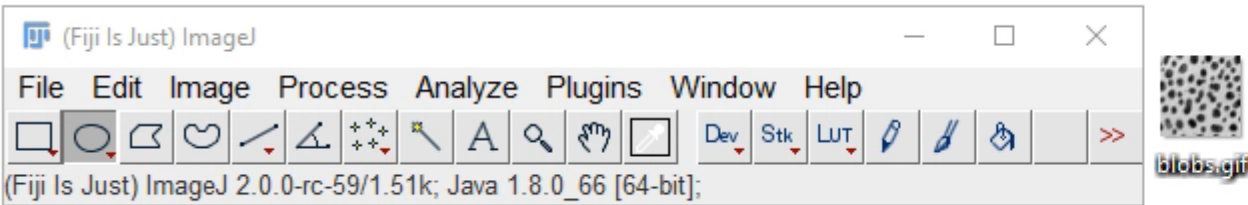
- Pixel Size, bit depth, ...



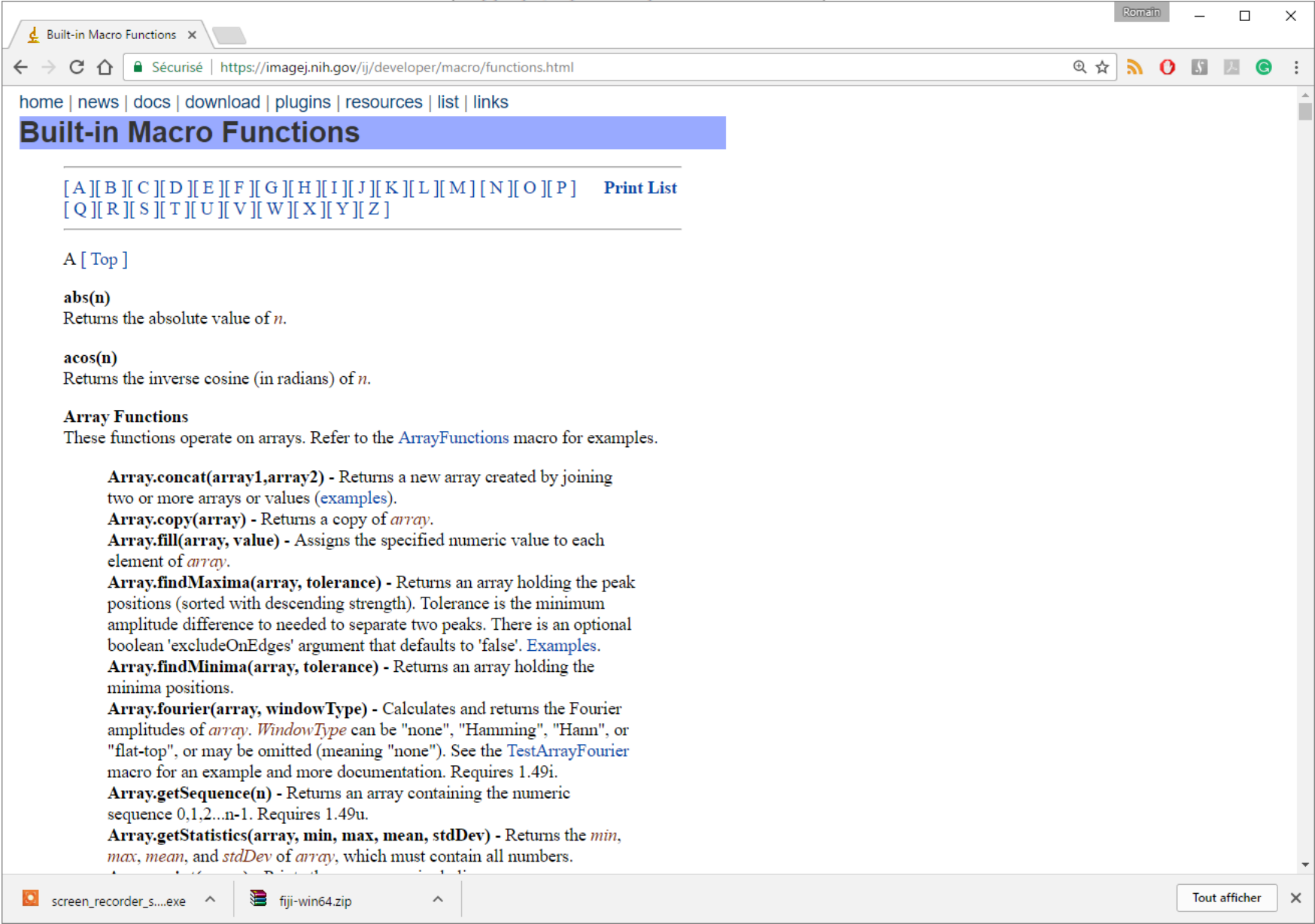
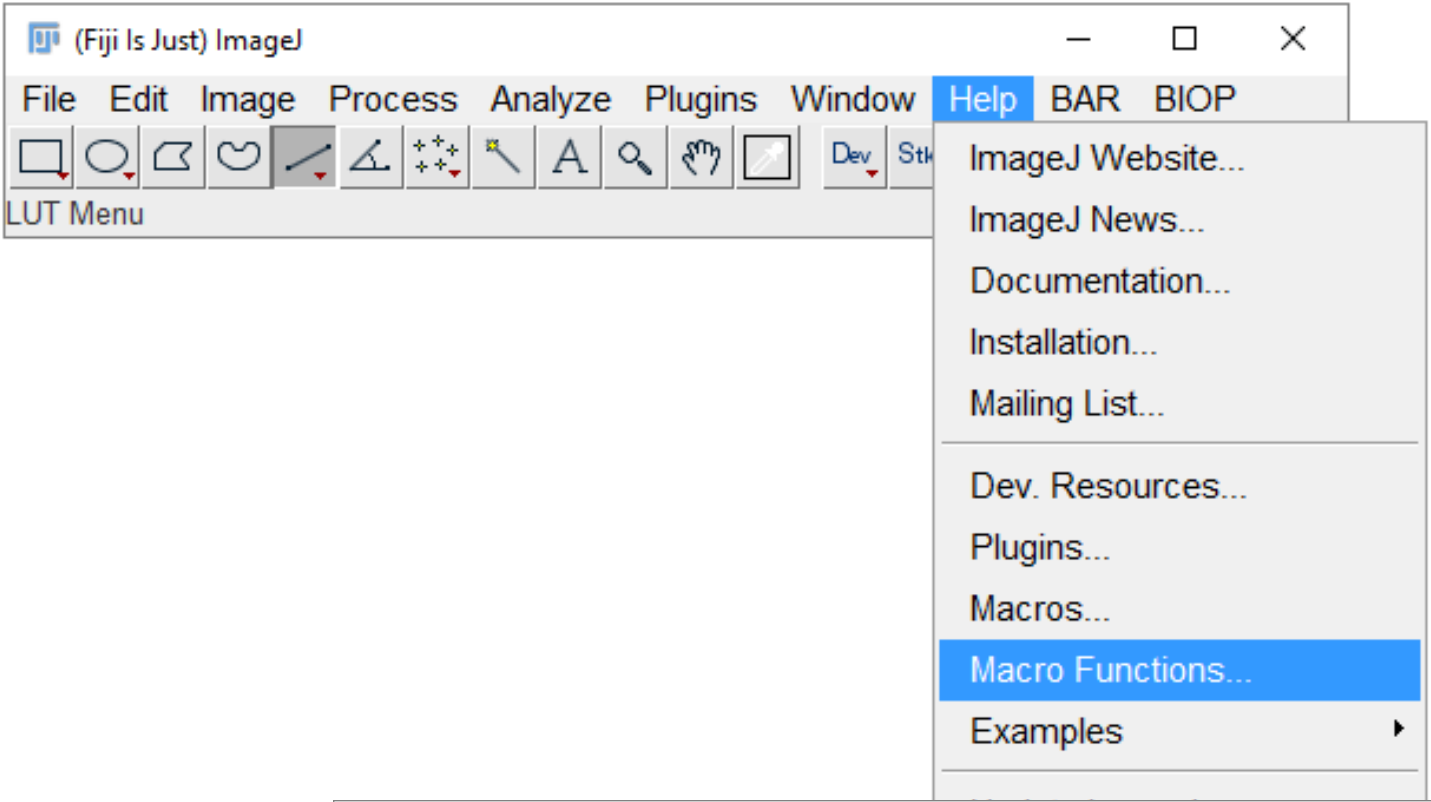
Fiji - Recorder



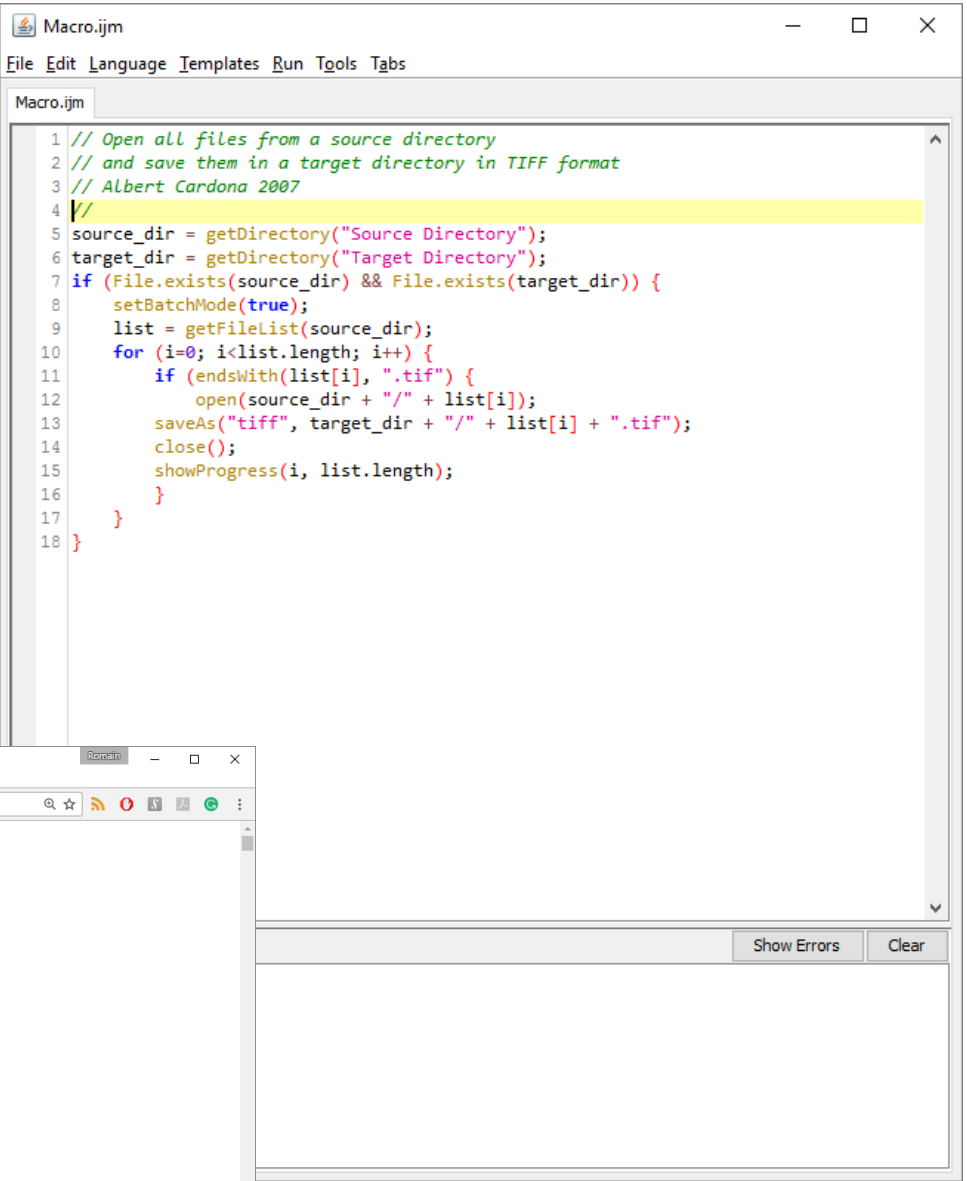
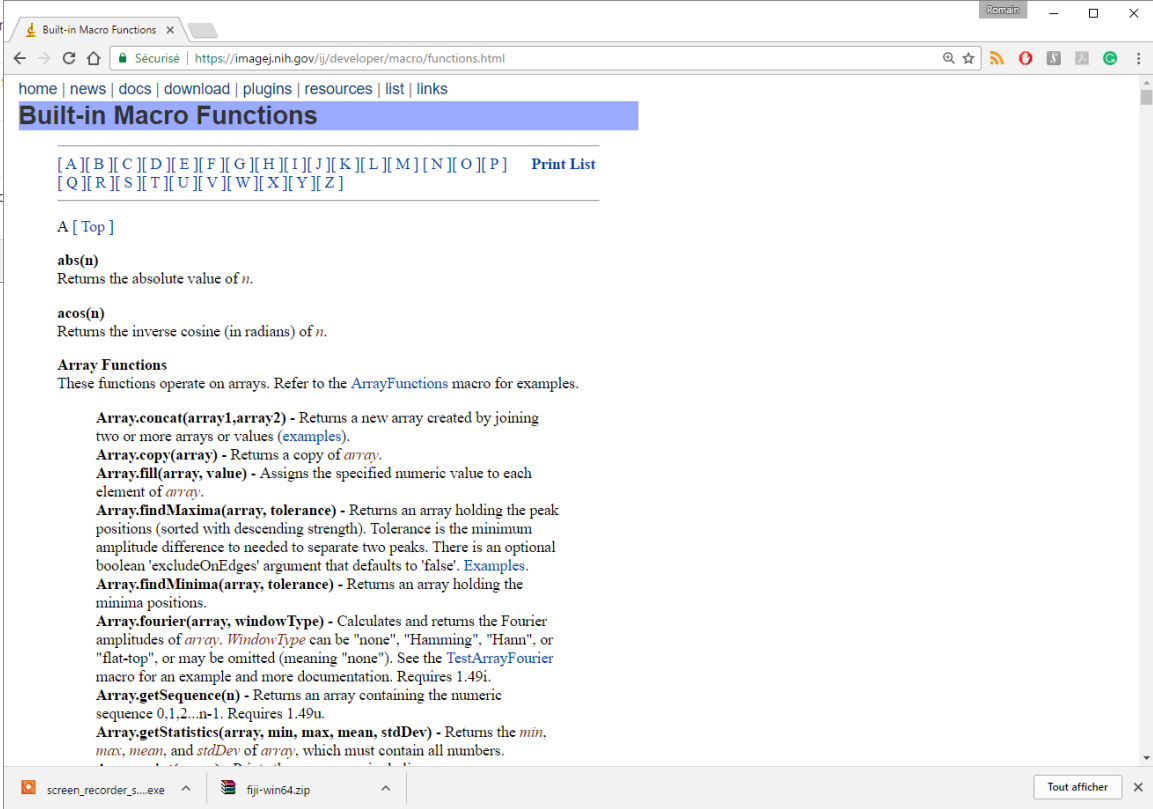
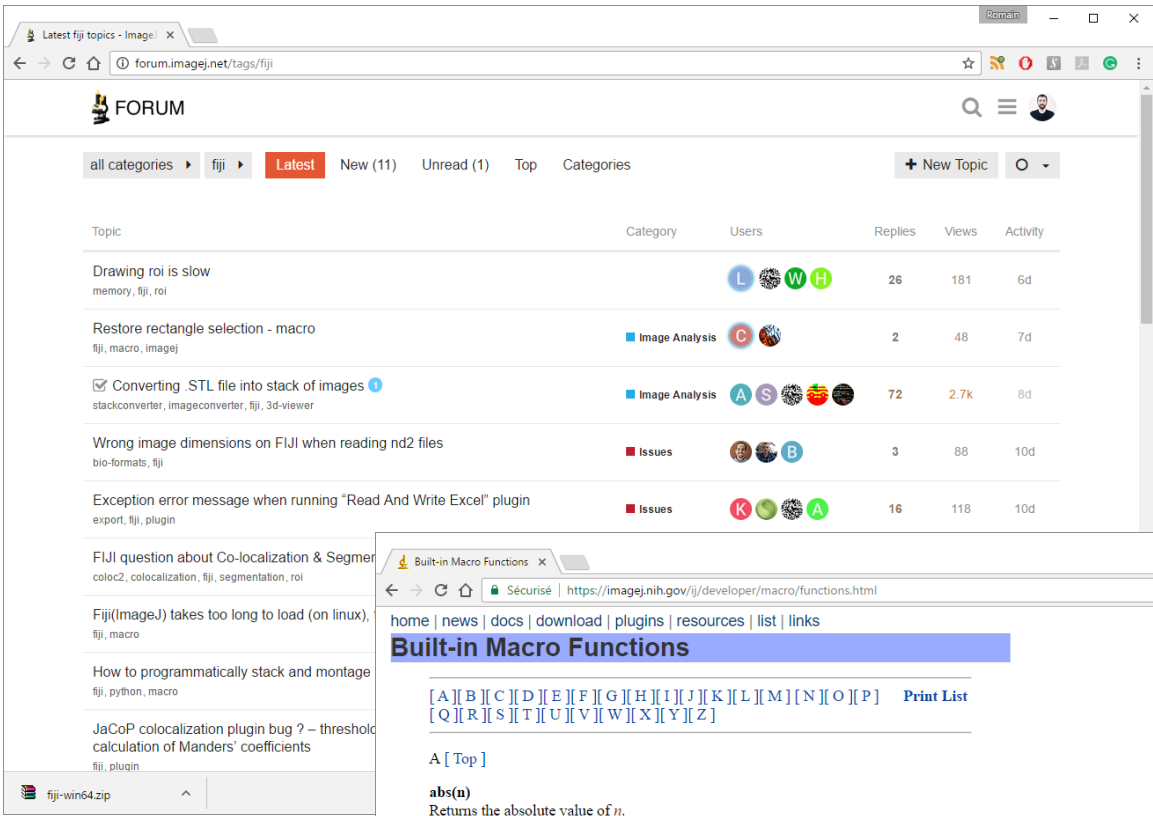
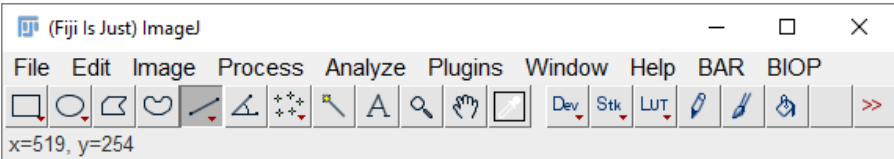
Fiji - Create a Macro



Fiji - Create a Macro



Conclusion

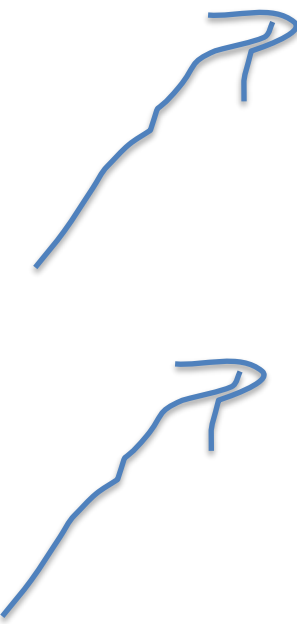


Sample => Explanations (Split shot)

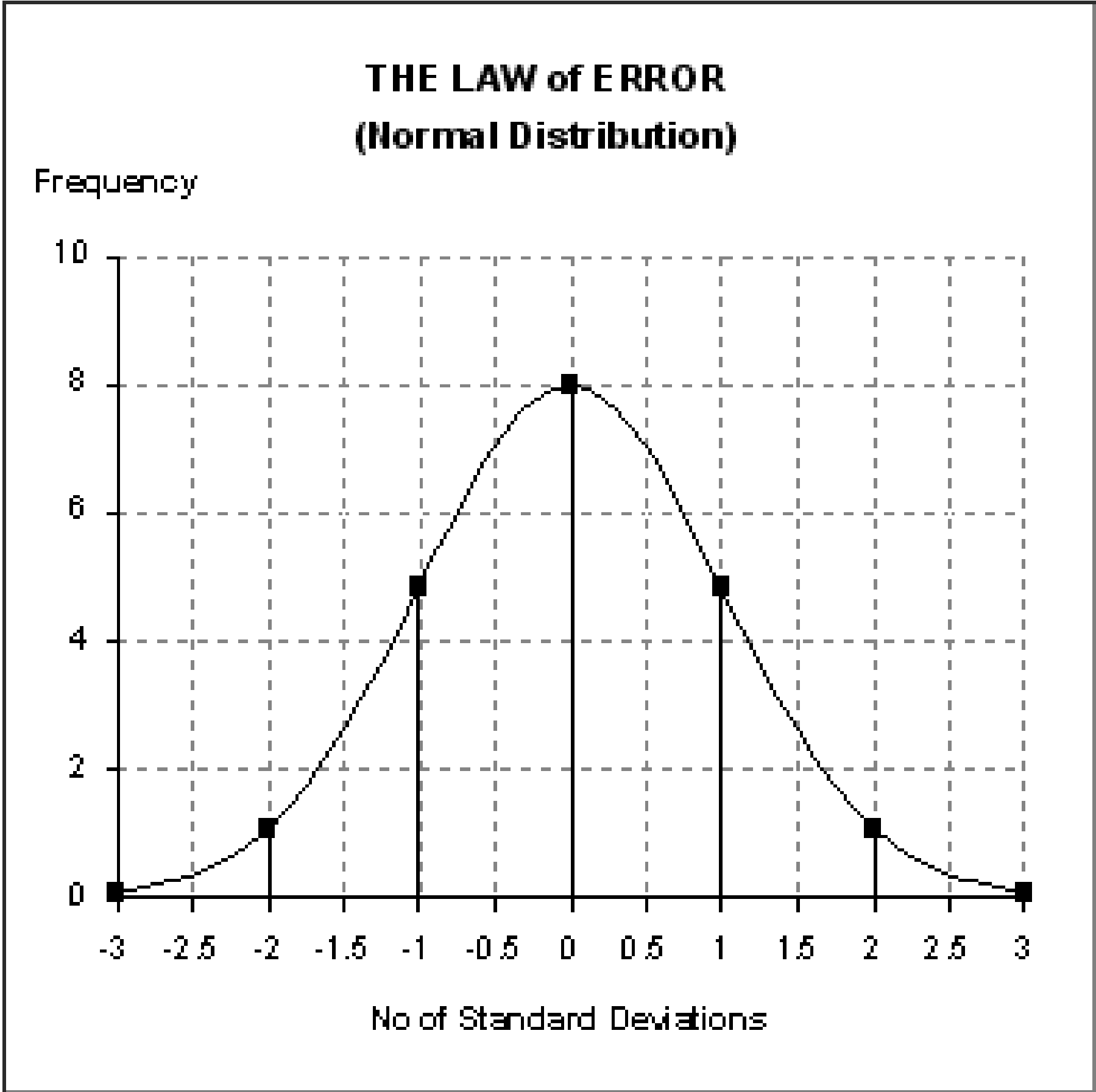


- Referring and explaining
- Split Shot with professor profile
 - Look at the iMac (screen placed on the side of the camera)
 - This will result in a 2/3 shot that gives the impression that the teacher is looking at the content.
- For Bullets and Video
 - Use this shot when commenting static content (an image, graphics, a schema) or a video

Sample => Complementary representations

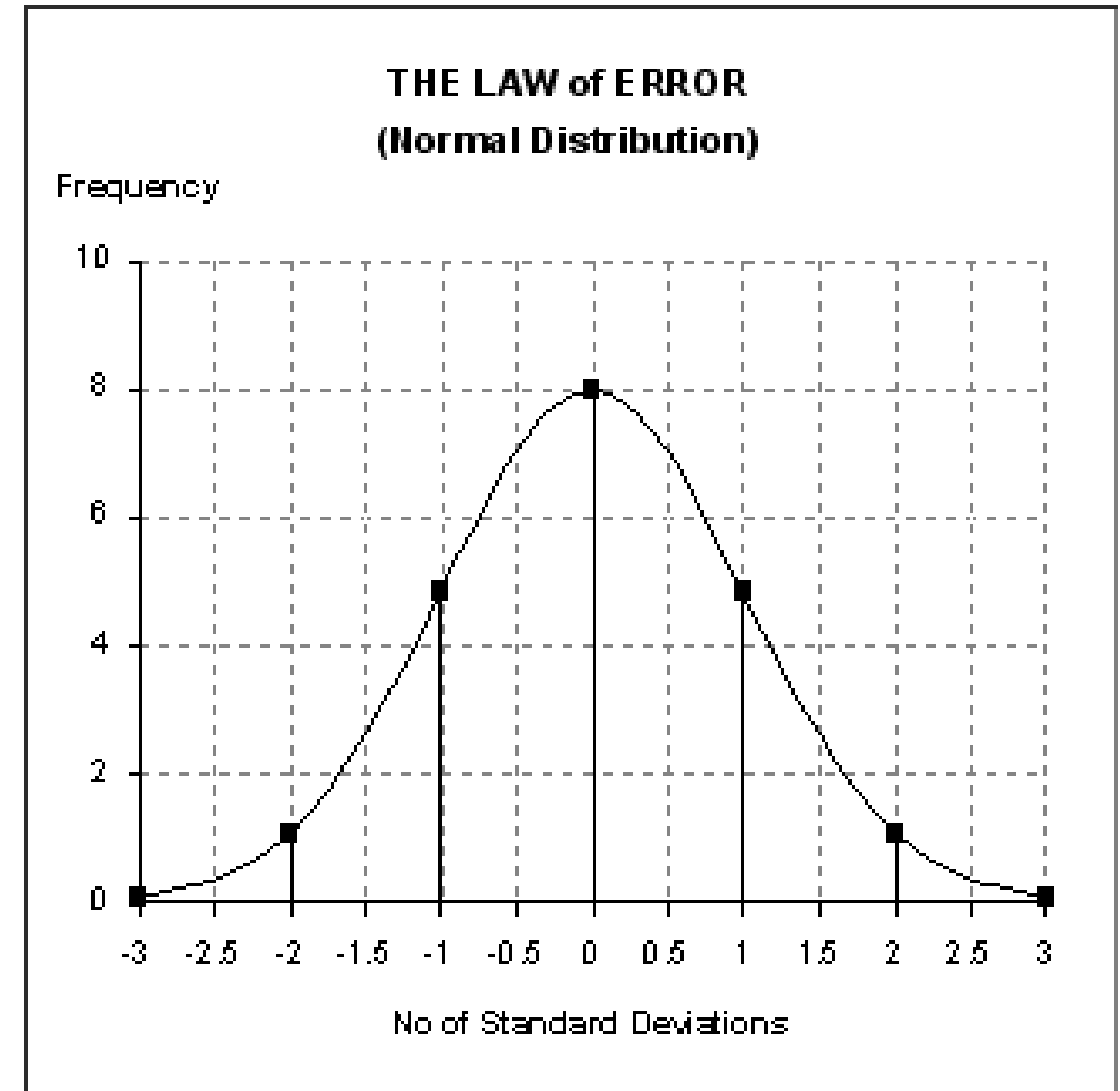


| | |
|------------|---|
| Notation | $\mathcal{N}(\mu, \Sigma)$ |
| Parameters | $\mu \in \mathbb{R}^k$ — location $\Sigma \in \mathbb{R}^{k \times k}$ — covariance (nonnegative-definite matrix) |
| Support | $x \in \mu + \text{span}(\Sigma) \subseteq \mathbb{R}^k$ |
| PDF | $ 2\pi \Sigma ^{-\frac{1}{2}} e^{-\frac{1}{2}(\mathbf{x}-\mu)'\Sigma^{-1}(\mathbf{x}-\mu)}$, exists only when Σ is positive-definite |
| CDF | (no analytic expression) |
| Mean | μ |
| Mode | μ |
| Variance | Σ |
| Entropy | $\frac{1}{2} \ln 2\pi e \Sigma $ |
| MGF | $\exp\left(\mu' t + \frac{1}{2} t' \Sigma t\right)$ |
| CF | $\exp\left(i \mu' t - \frac{1}{2} t' \Sigma t\right)$ |

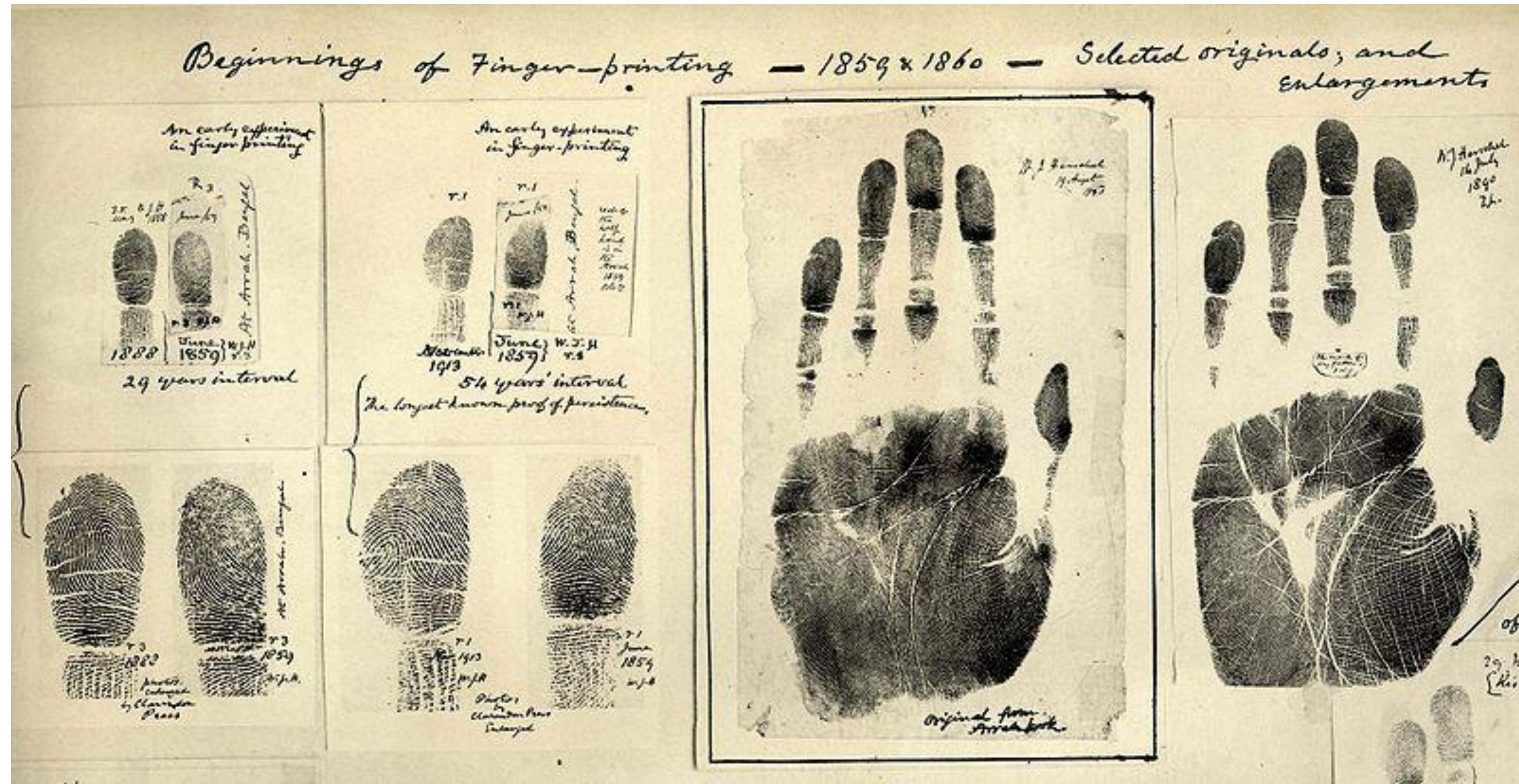


Sample => Handwriting and reference (Split shot)

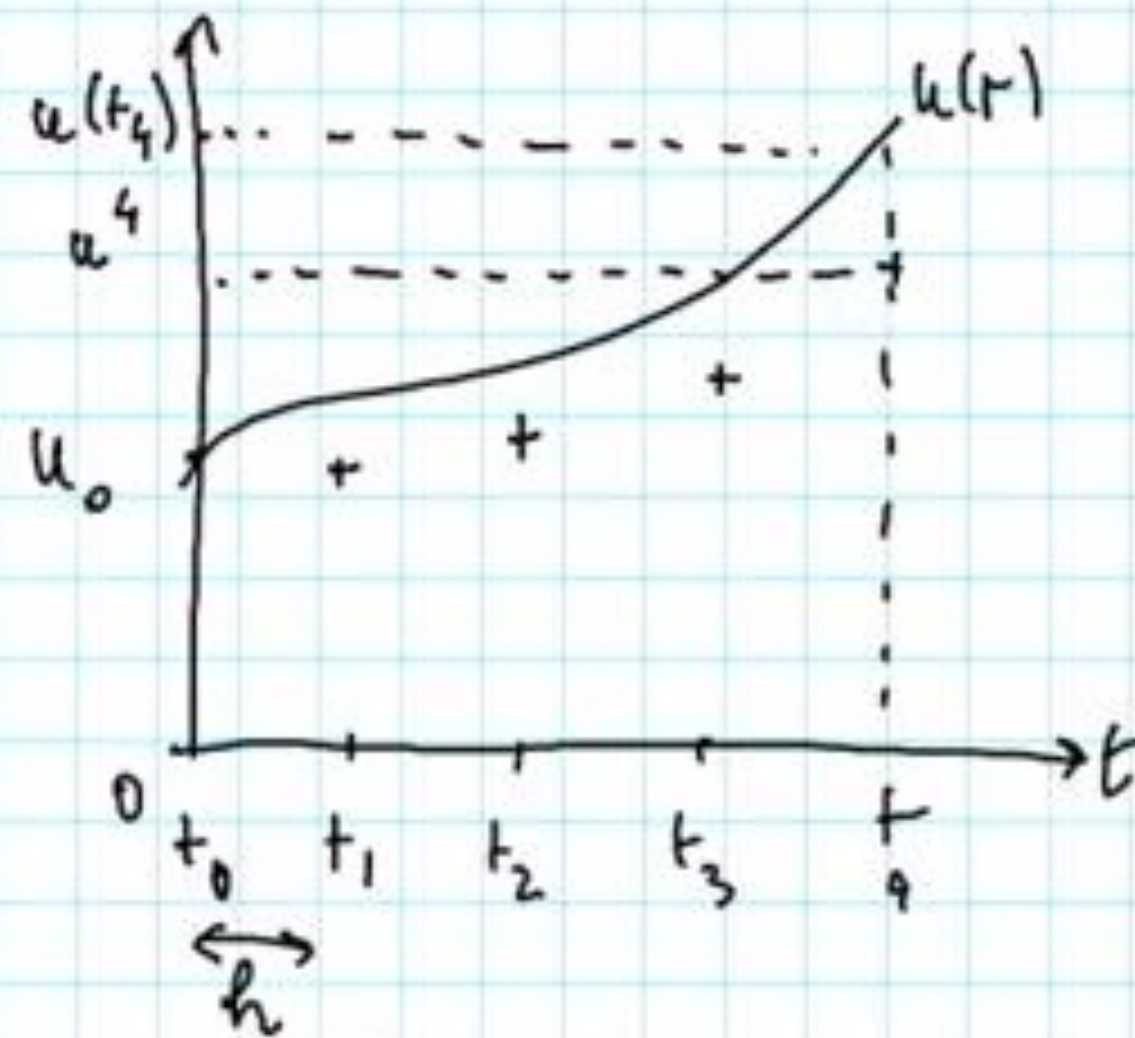
$$\exp\left(\mu't + \frac{1}{2} t' \Sigma t\right)$$



Sample => Wide Content, picture or video



Sample => Handwritten Content (Full shot)



origine? on écrit l'éq. diff. temps t_n : $\dot{u}(t_n) = f(u(t_n), t_n)$ on utilise une formule de diff. finies pour approcher $\dot{u}(t_n)$ chap 2

$$\frac{u(t_{n+1}) - u(t_n)}{h} = f(u(t_n), t_n) + O(h) \text{ on remplace } u(t_n) \text{ par } u^n$$

avantage: schéma explicite: $u^{n+1} = u^n + h f(u^n, t_n)$ facile à programmer

inconven

$t_n = nh$ $n=0, 1, 2, \dots$ Calculer u^n de $u(t_n)$

A partir de $u^0 = u_0$ on va calculer u^1, u^2, \dots, u^{n+1} } méthode de marche en temps.

Schéma d'Euler progressif: $\frac{u^{n+1} - u^n}{h} = f(u^n, t_n)$

- Try to **avoid this**
- This is a layout that you would use if you have long text in bullets
 - But this might be **difficult to read**
 - And loses a lot of white space
- The best use of this template is to use it to present images or videos
 - The layout allows to have a title, logo, page number around the content.
 - Another advantage compared to the Blank Page Layout is that the content placed in a box:
 - Will be replaced and sized when you change the layout for the slide
 - Will survive the transition to another template in the future.

Graphical elements

Texte Arial Narrow Bold

Texte Arial Narrow

Texte Arial Narrow Bold couleur



Texte Arial Narrow Bold

