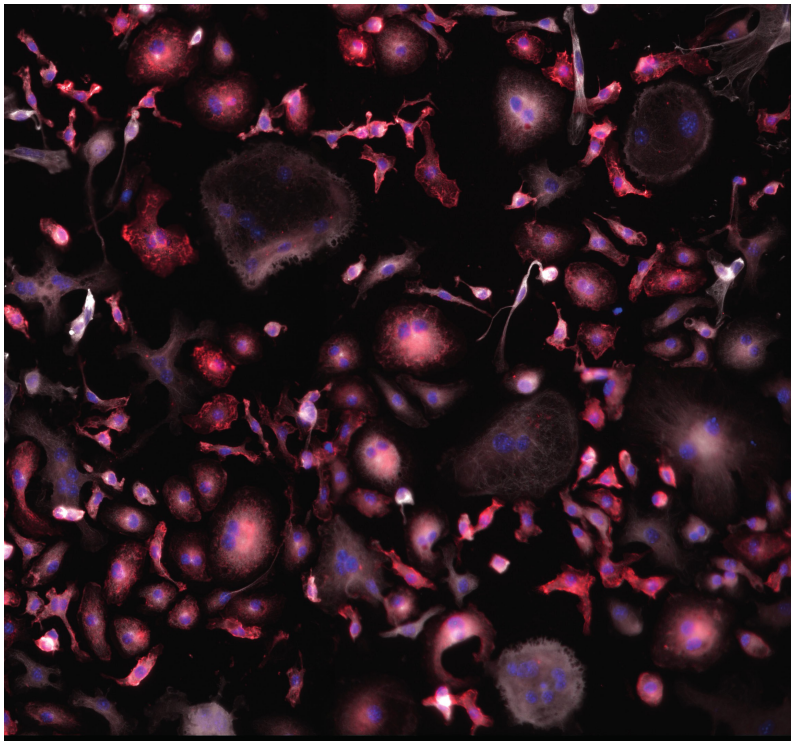
Automated Characterization of Osteoclasts via Image Processing Methods



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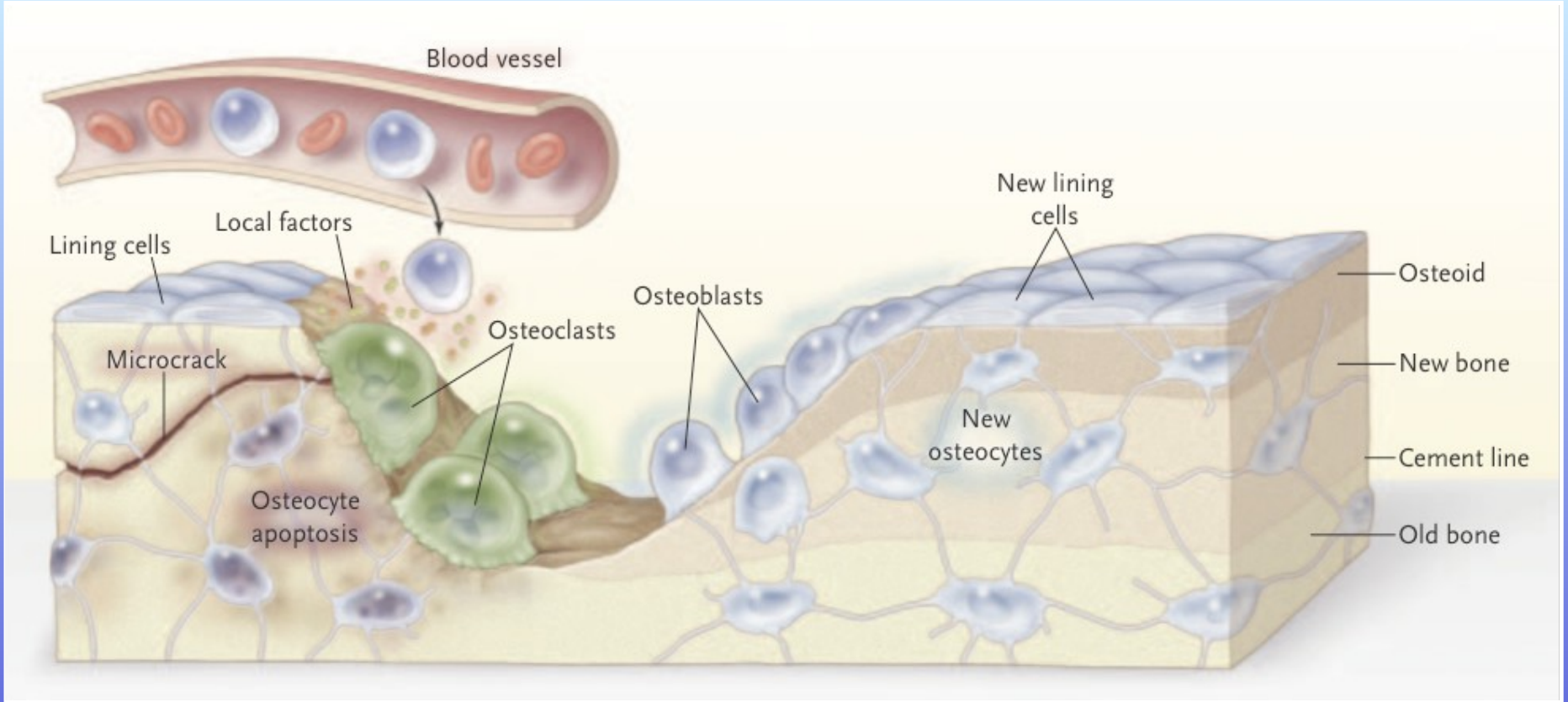
Background



Bone is continually being resorbed and replaced to repair microdamage, adapt to changing mechanical loads, and to enable calcium homeostasis.

Osteoclasts are bone-resorbing cells in marrow whose pathology is implied in osteoporosis & rheumatoid arthritis. Osteoporosis is the most common bone disease and is characterized by loss of bone mineral density (BMD) and deterioration of bone microarchitecture.

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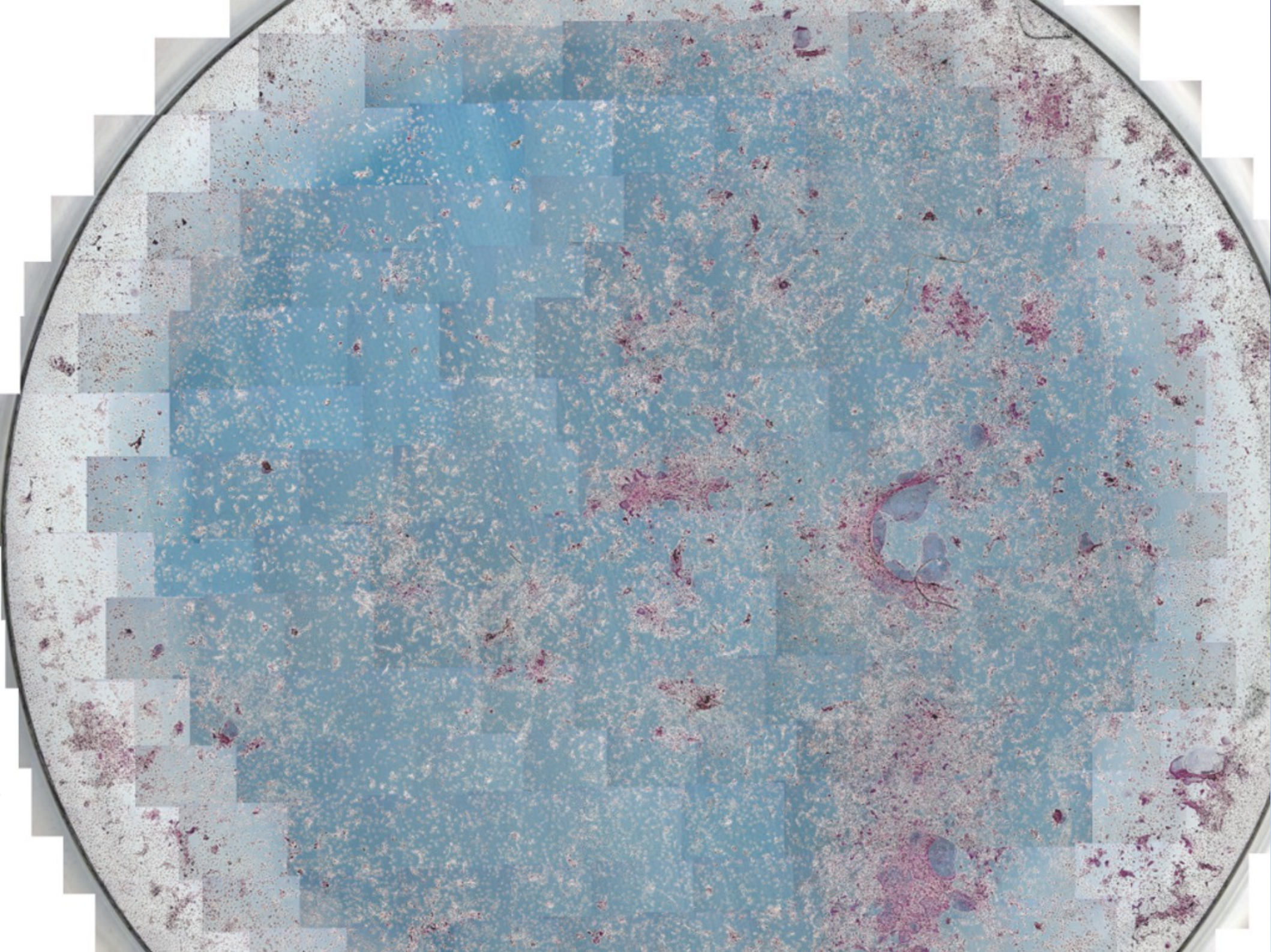
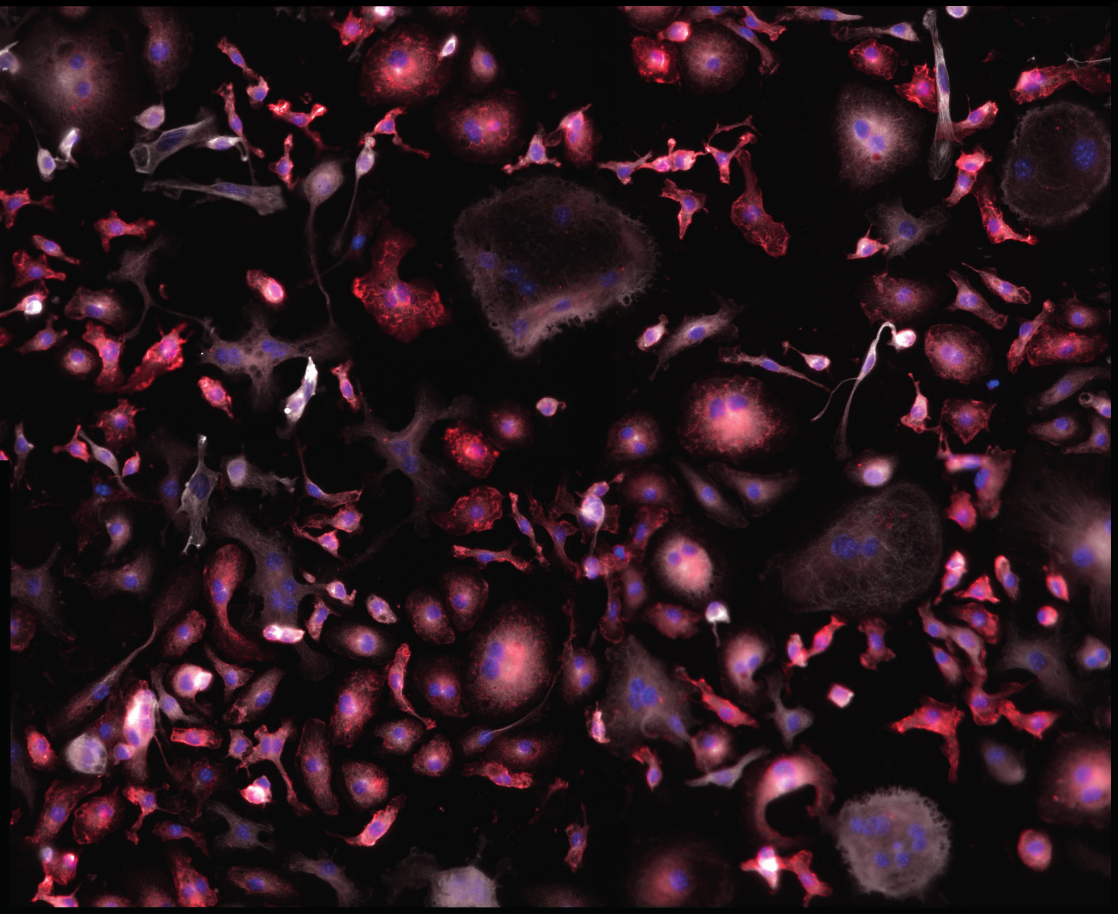
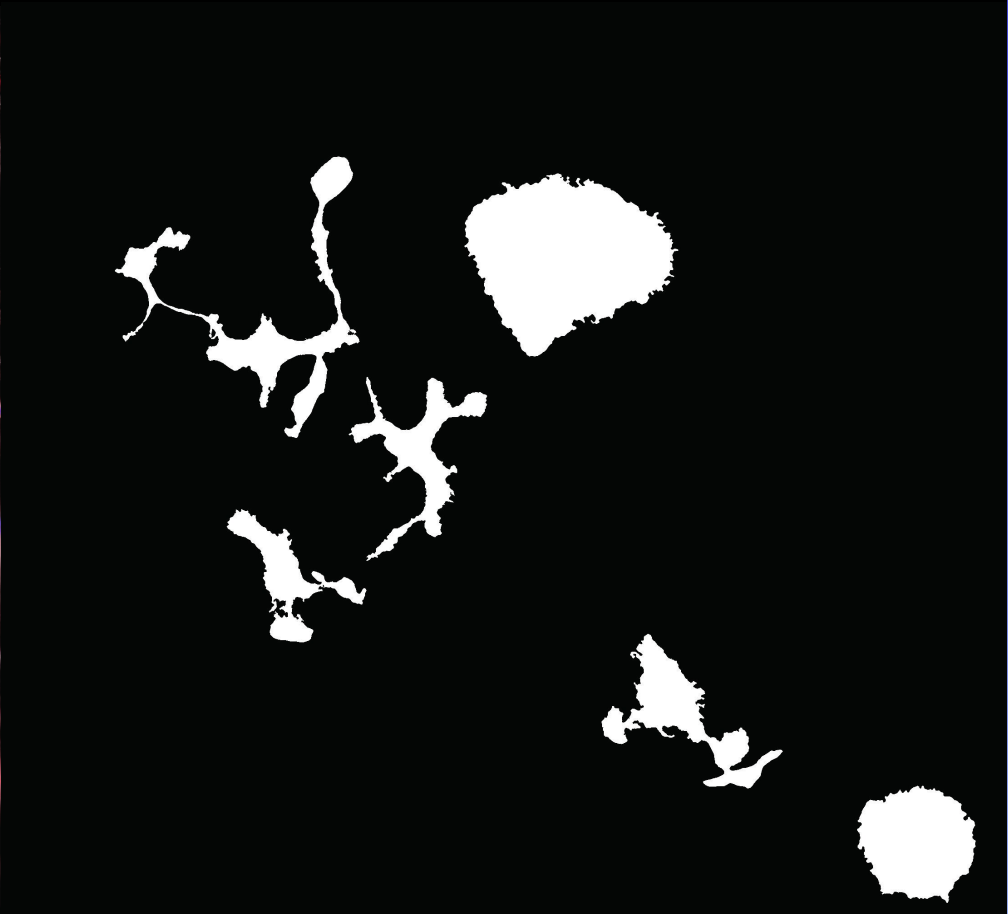


Proposed Method - Staining



Base image

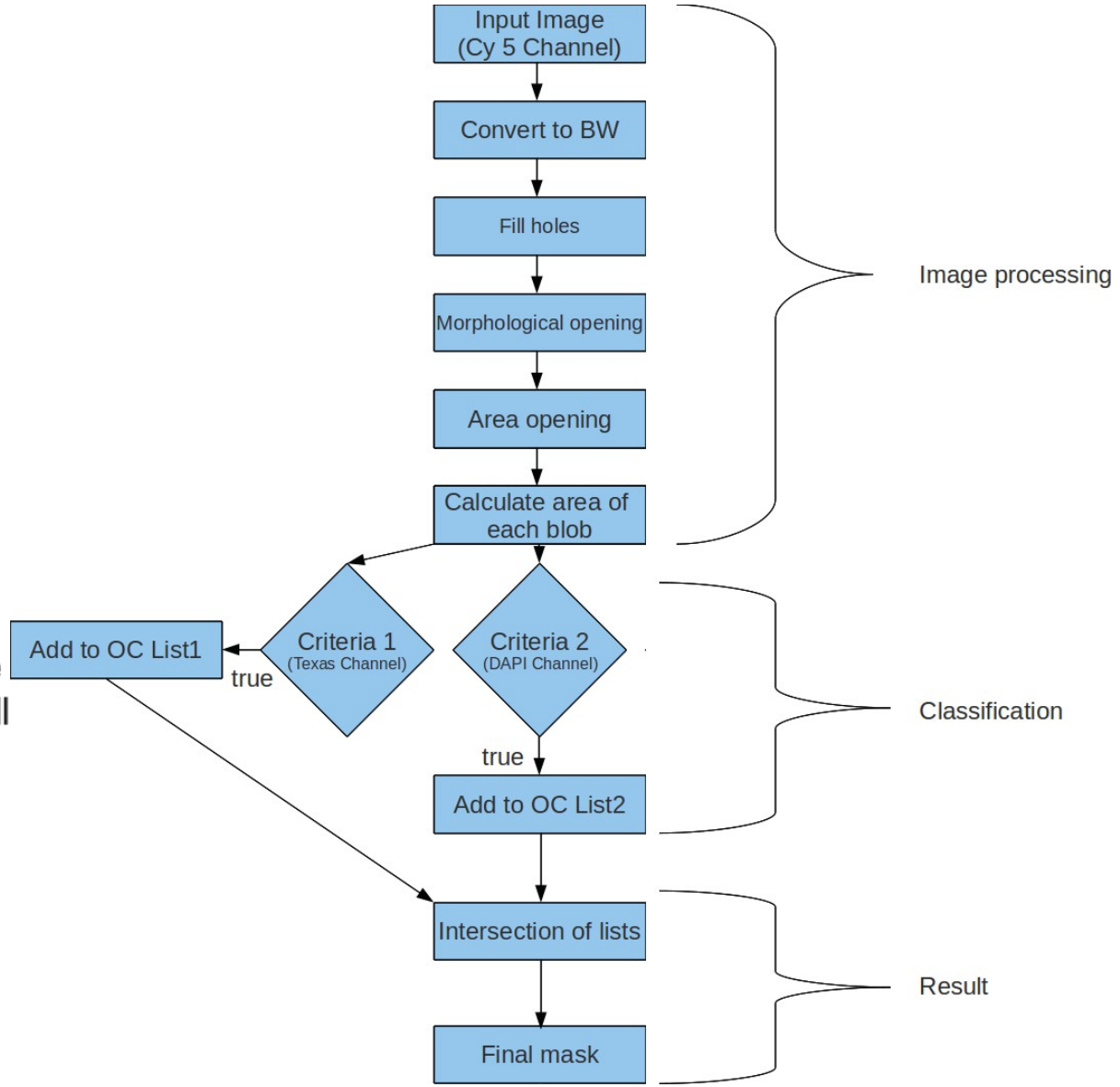


Algorithm output

Methods (Staining)

- cell: alpha-tubulin & calcitonin receptor (white)
- nuclei: DAPI (blue)
- precursor/non-osteoclast: F4/80 macrophage marker (red)

Proposed Method - Algorithm



- Criterion 1 computes the ratio of the macrophage marker inside the cell versus the total area of the cell

$$\frac{amount(macrophage\ marker)}{area\ of\ cell} < T_1$$

- Criterion 2 counts the amount of DAPI staining inside the cell

$$amount(DAPI) > T_2$$

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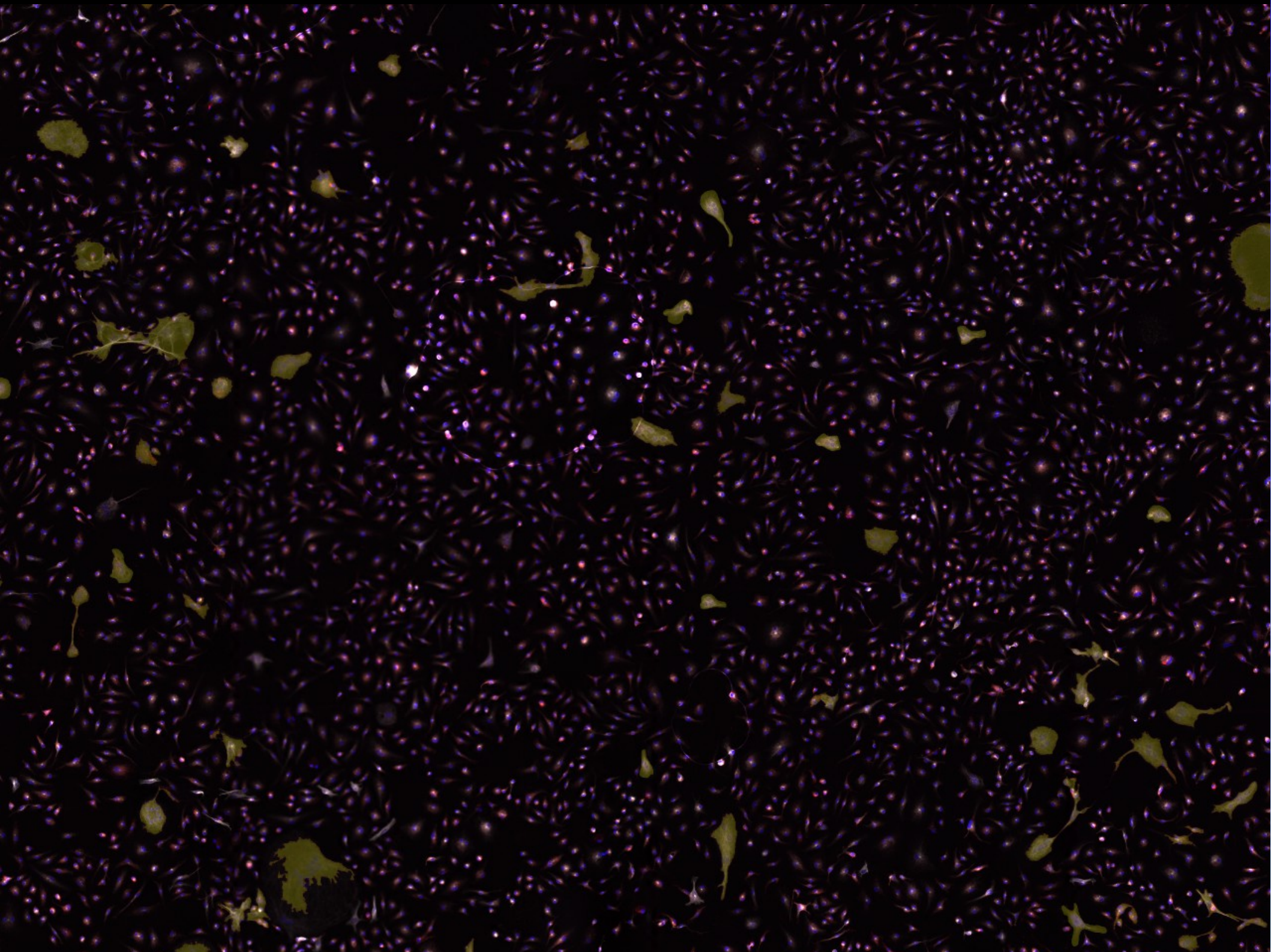
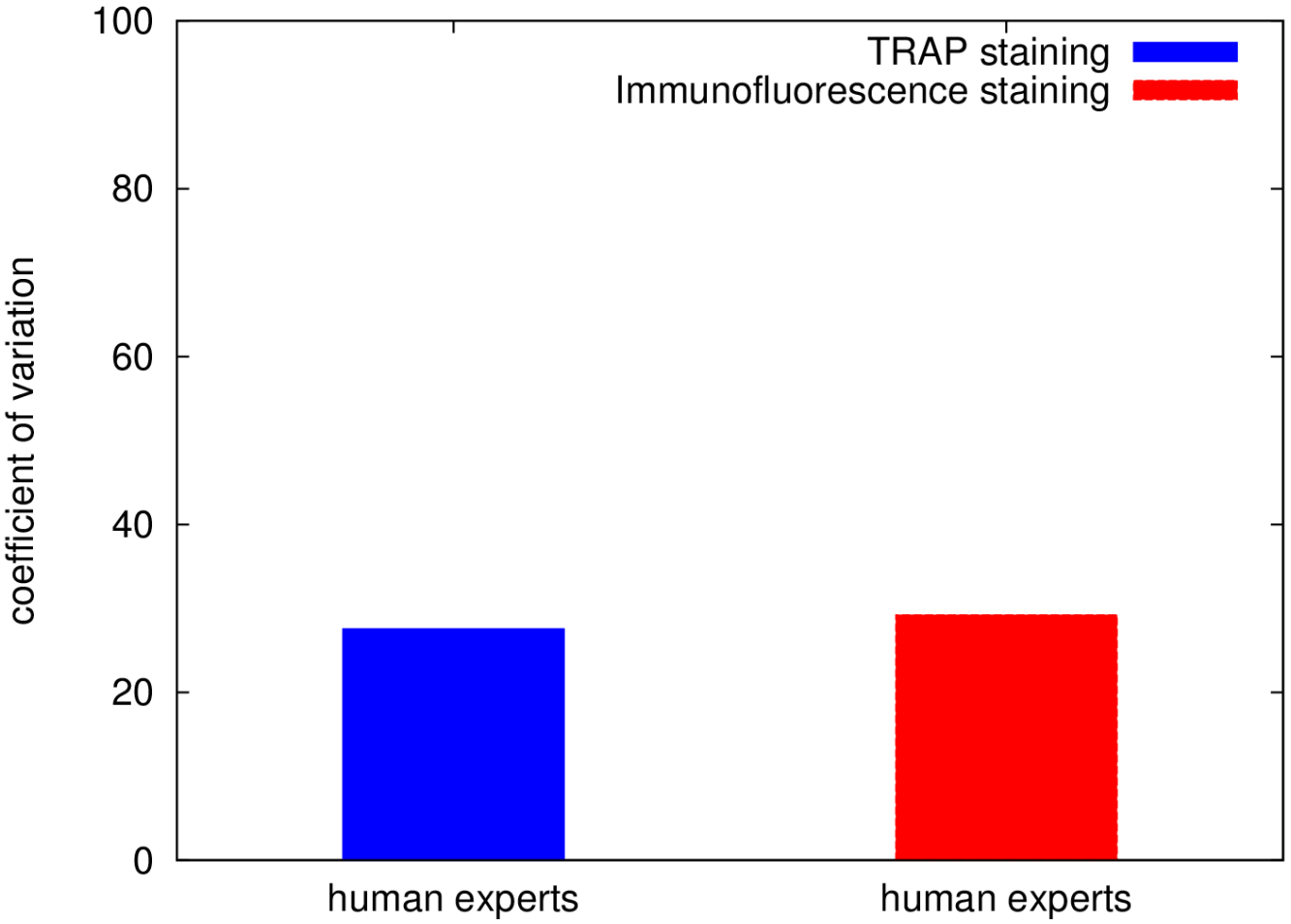


TRAP vs. Immunofluorescence



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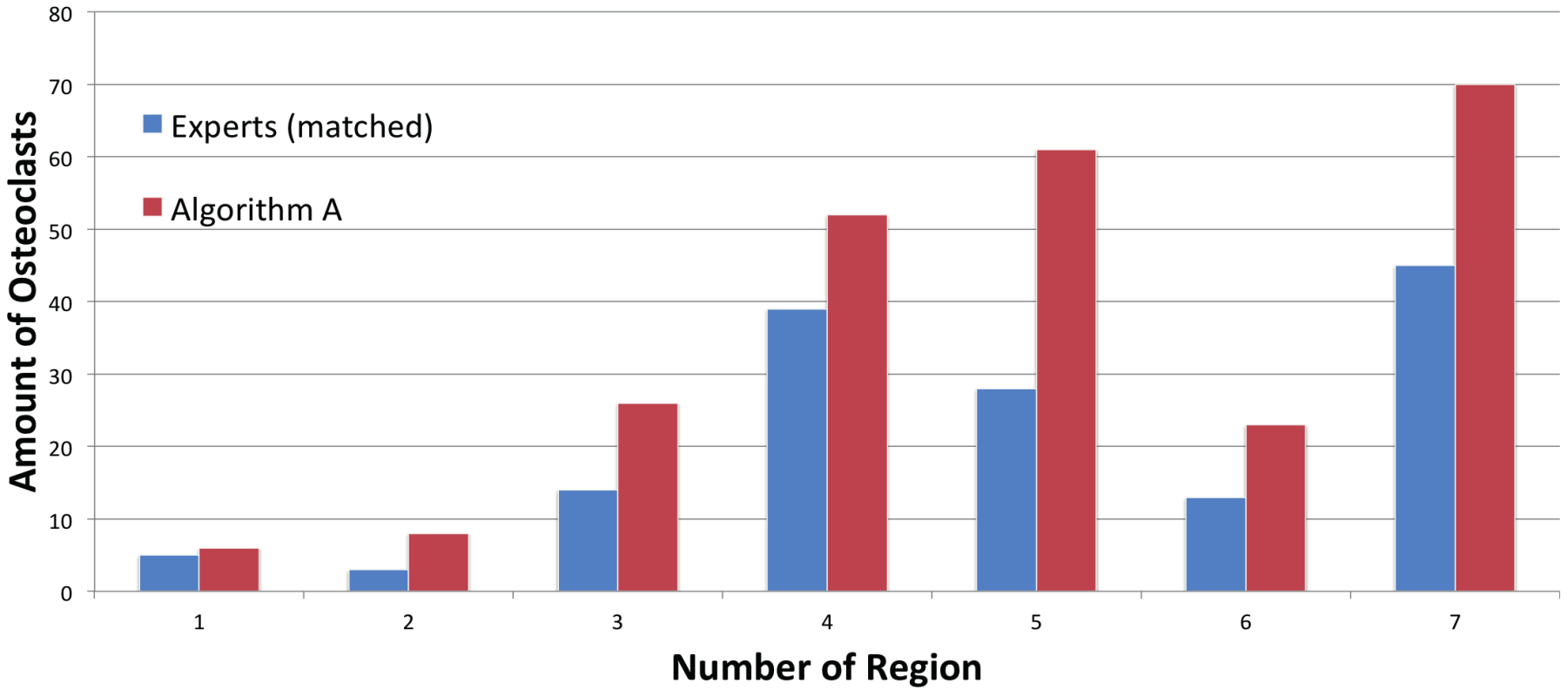
Proposed Method vs. Experts



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Conclusion

TRAP-staining and manual counting of osteoclasts (most common)

+ very fast (tissue to staining ~ 15min)
– only the number of osteoclasts is obtained
– counts differ stochastically and systematically between individuals (high variation coefficient)
– no additional proteins can be measured

Immunofluorescence staining and automated analysis (prop. method)

+ pixelwise identification of osteoclasts (full shape and type of each cell) enables powerful analytics, e.g. mean and standard deviation of protein expression normalized by cell, cell area, cell circumference, ...
+ additional proteins can be measured
+ fully consistent repeatable results due to automated image analysis
– preparation of tissue takes longer (~ days)

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