

Failure Modes: Image Translation

Shalin Mehta,
Computational Microscopy Platform



@mattersOfLight

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Aug 30, 2022

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virtual staining

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[PDF] Emerging advances to transform histopathology using **virtual staining** [PDF] sciencemag.org
Y Rivenson, K de Haan, WD Wallace... - BME ..., 2020 - downloads.spj.science.org
... Here, we discuss how emerging **virtual staining** technologies and machine learning can help to disrupt the standard histopathology workflow and create new avenues for the diagnostic ...
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[HTML] Virtual histological staining of unlabelled tissue-autofluorescence images via deep learning [HTML] nature.com
Y Rivenson, H Wang, Z Wei, K de Haan... - Nature biomedical ..., 2019 - nature.com
... After evaluating the differences in tissue section and **staining** methods, we tested the ability of our **virtual staining** approach in the specialized **staining** histology workflow. We imaged the ...
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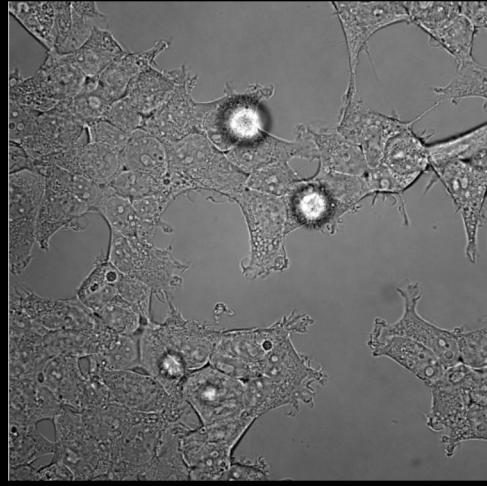
[HTML] Digital synthesis of histological stains using micro-structured and multiplexed **virtual staining** of label-free tissue [HTML] nature.com
Y Zhang, K de Haan, Y Rivenson, J Li, A Delis... - Light: Science & ..., 2020 - nature.com
... 1, we demonstrate a method that can be used to perform **virtual staining** of unlabelled tissue sections using two channels of tissue autofluorescence along with a digital **staining** matrix, ...
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Holographic **virtual staining** of individual biological cells [PDF] pnas.org
YN Nygate, M Levi, SK Mirsky... - Proceedings of the ..., 2020 - National Acad Sciences
... for **virtual staining** ... of **staining** materials, 2) saves time and resources, 3) optimizes inter- and intralab variability, 4) allows concurrent **staining** of different types of cells with multiple **virtual** ...
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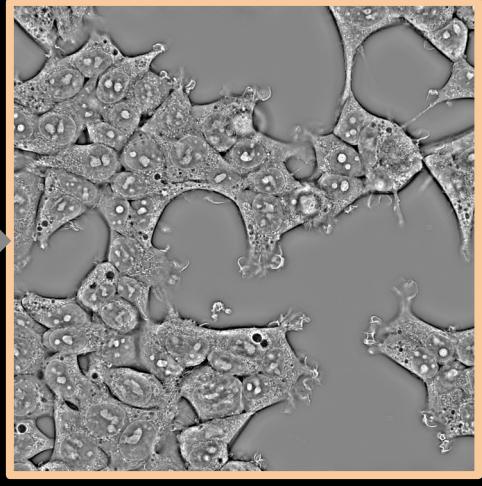
Why haven't biologists adopted virtual staining widely?

Objective

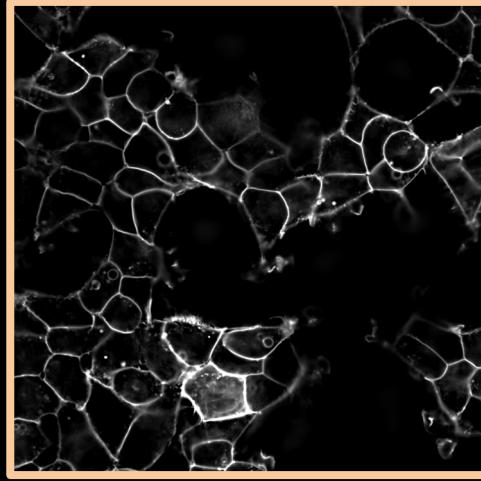
BF



Input
Phase

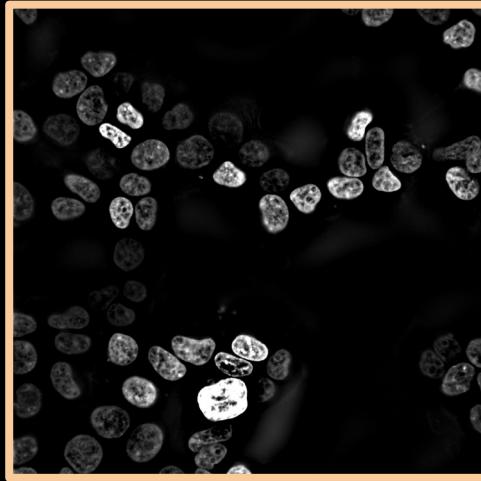
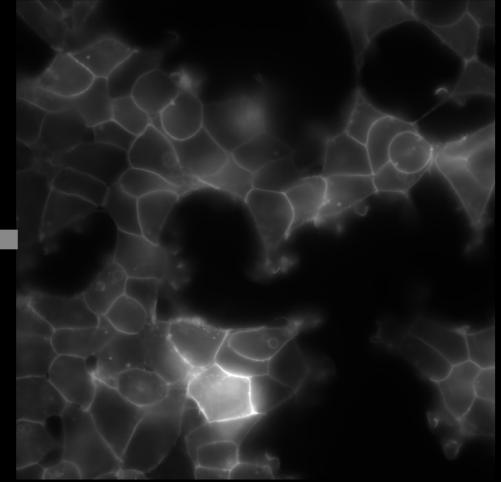


Target
Deconvolved Fluorescence
Channel

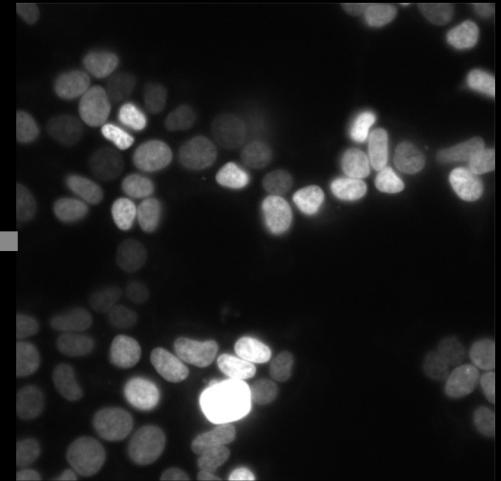


Membrane: I-Caax-mScarlet

Fluorescence Channel



Nucleus: H2B-mIFP



Pipelines

- recOrder
data reconstruction
- microDL
configure U-Nets with yaml files



Johanna



Syuan-Ming

Overview: imaging conditions

magnification

training 63x

test 40x 100x

brightfield exposure time

training 10 ms

test 5 ms

position in well

training centered

test border

aperture diaphragm

training ~17

test 6, 12

cell densities

training dense

test less dense, very dense

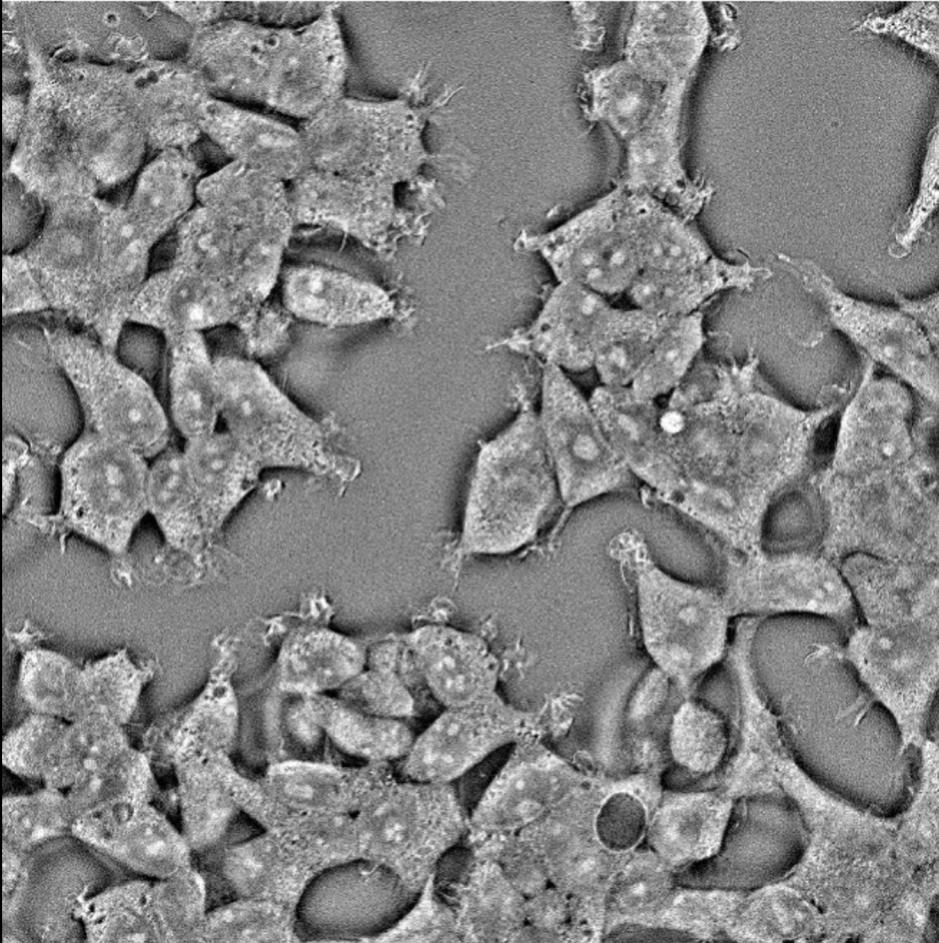
phase reconstruction values

training 1e-3

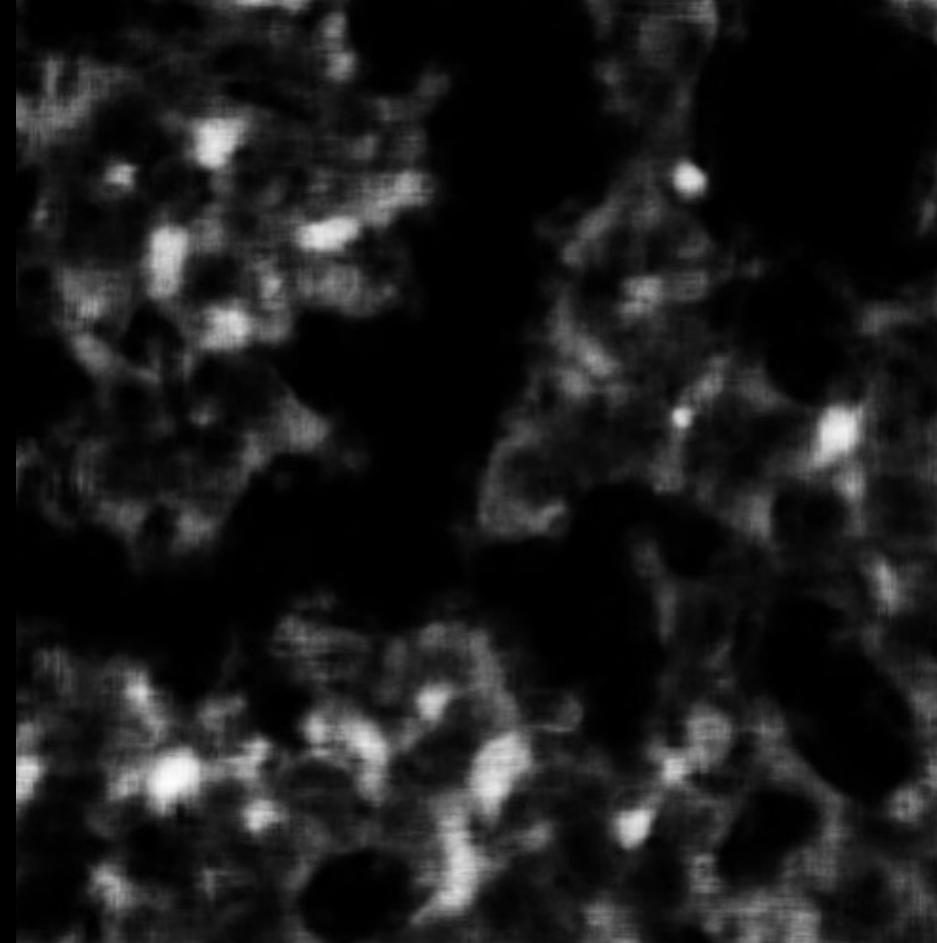
test 1e-2, 5e-3, 5e-4, 1e-4

Models didn't generalize to the simplest perturbation!

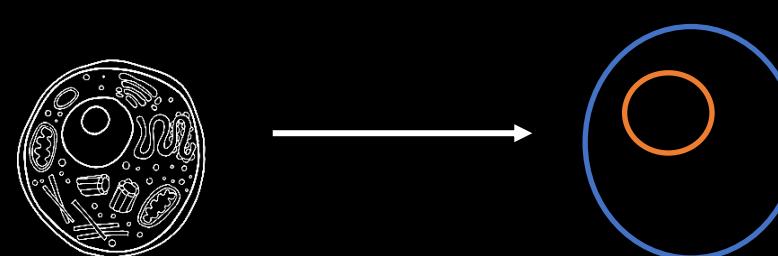
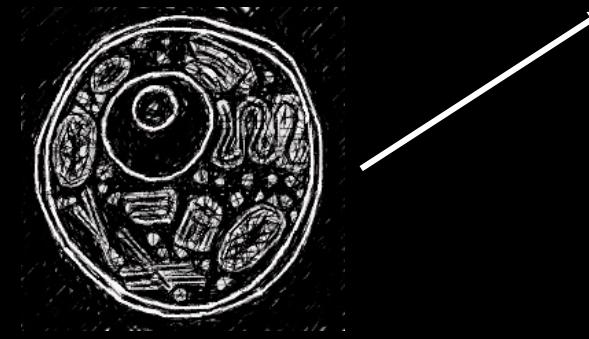
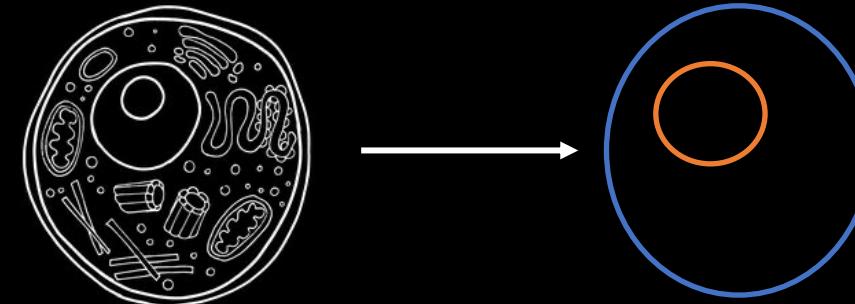
Different noise than training data



Prediction of nuclei

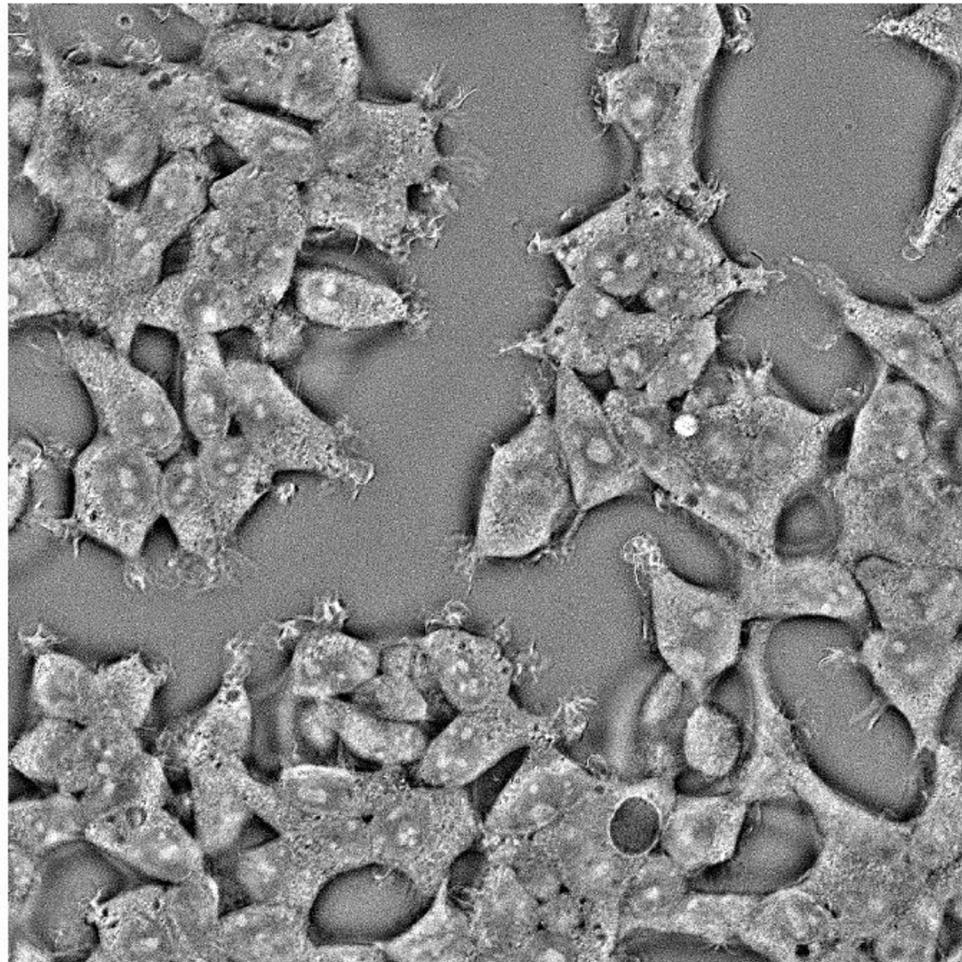


Augmentations to the rescue!

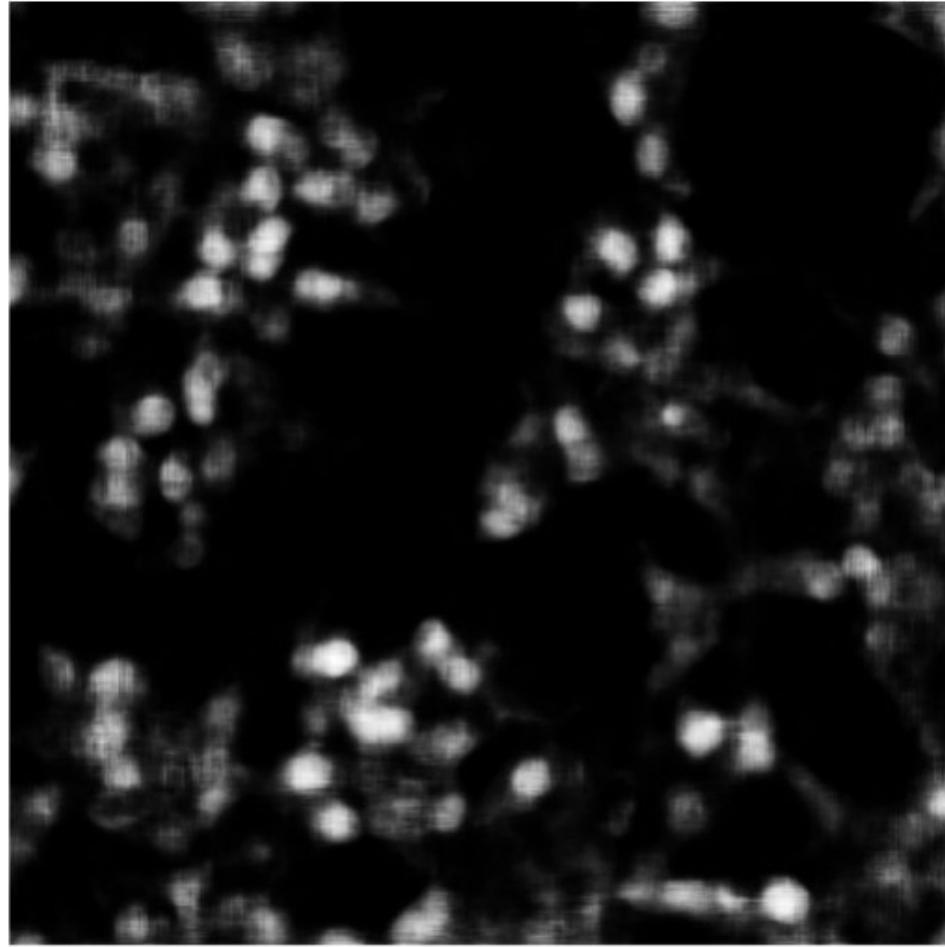


Augmentations to the rescue!

Input



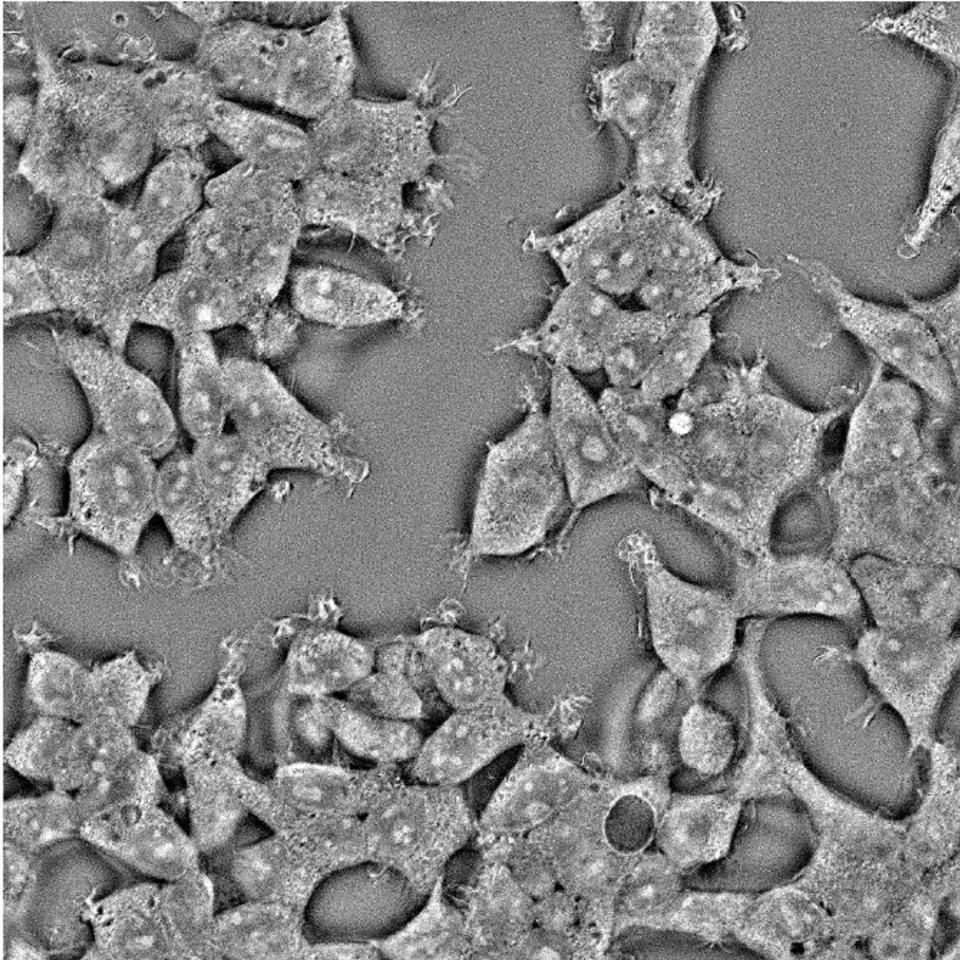
Prediction



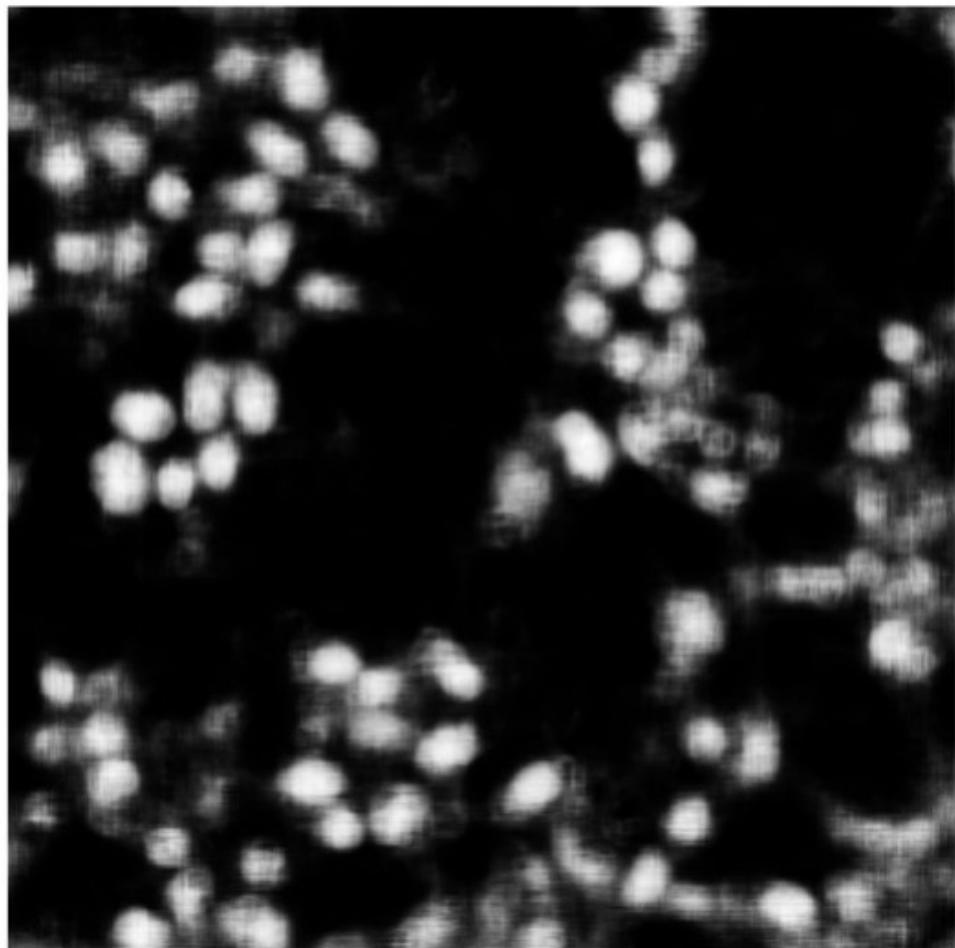
random blur=0.1-10, noise=0-0.4, intensity jitter=0-0.2

heavy data augmentation

Input



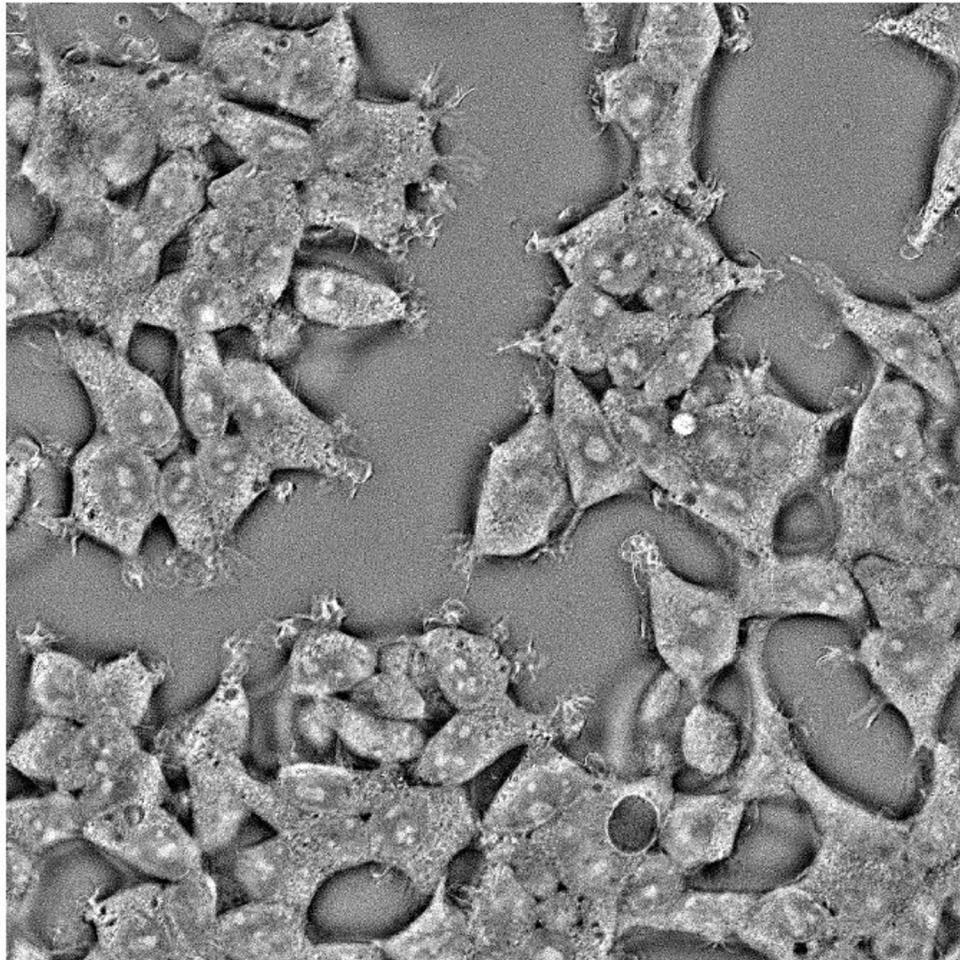
Prediction



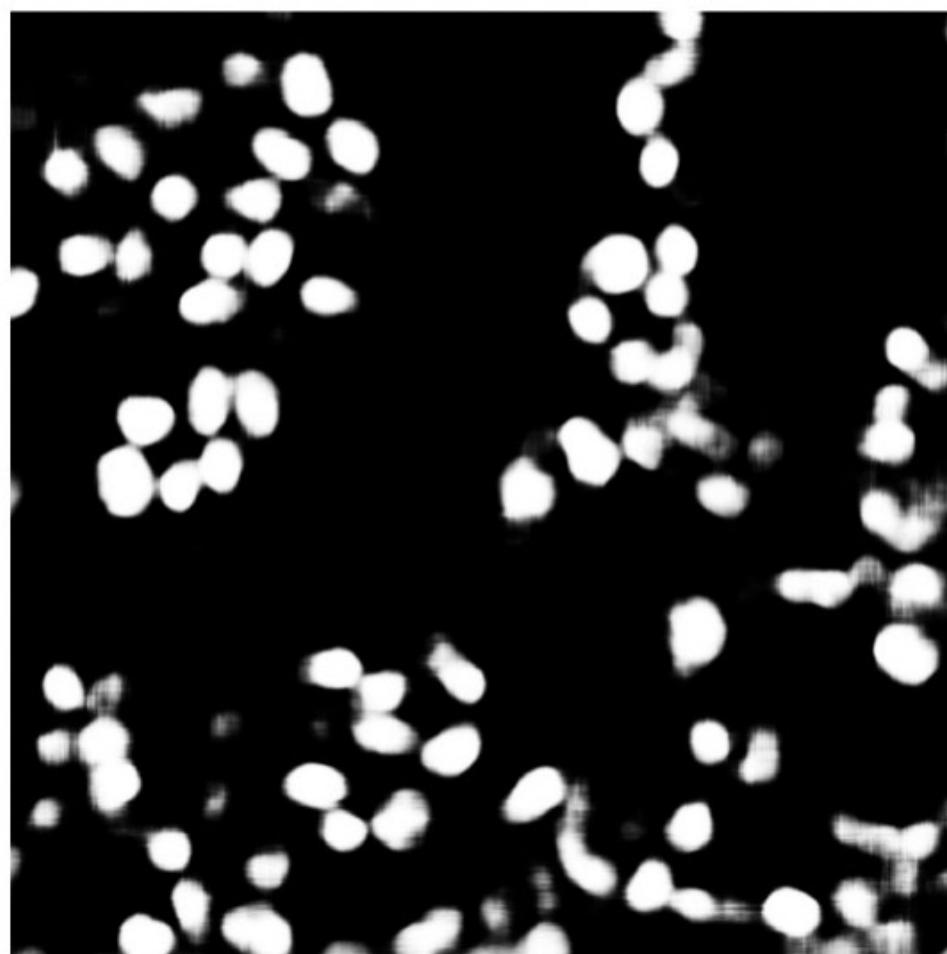
random blur=0.1-10, noise=0-0.4, intensity jitter=0-0.8

Heavy data augmentation + self-training

Input



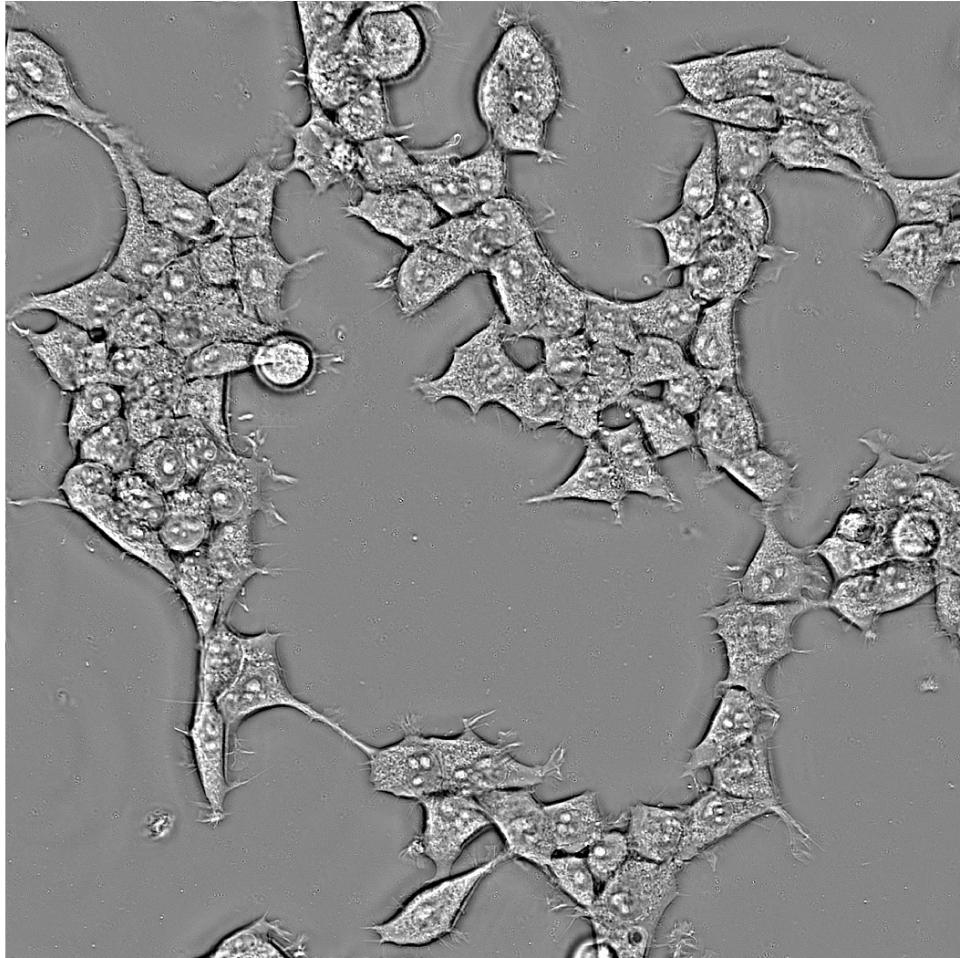
Prediction



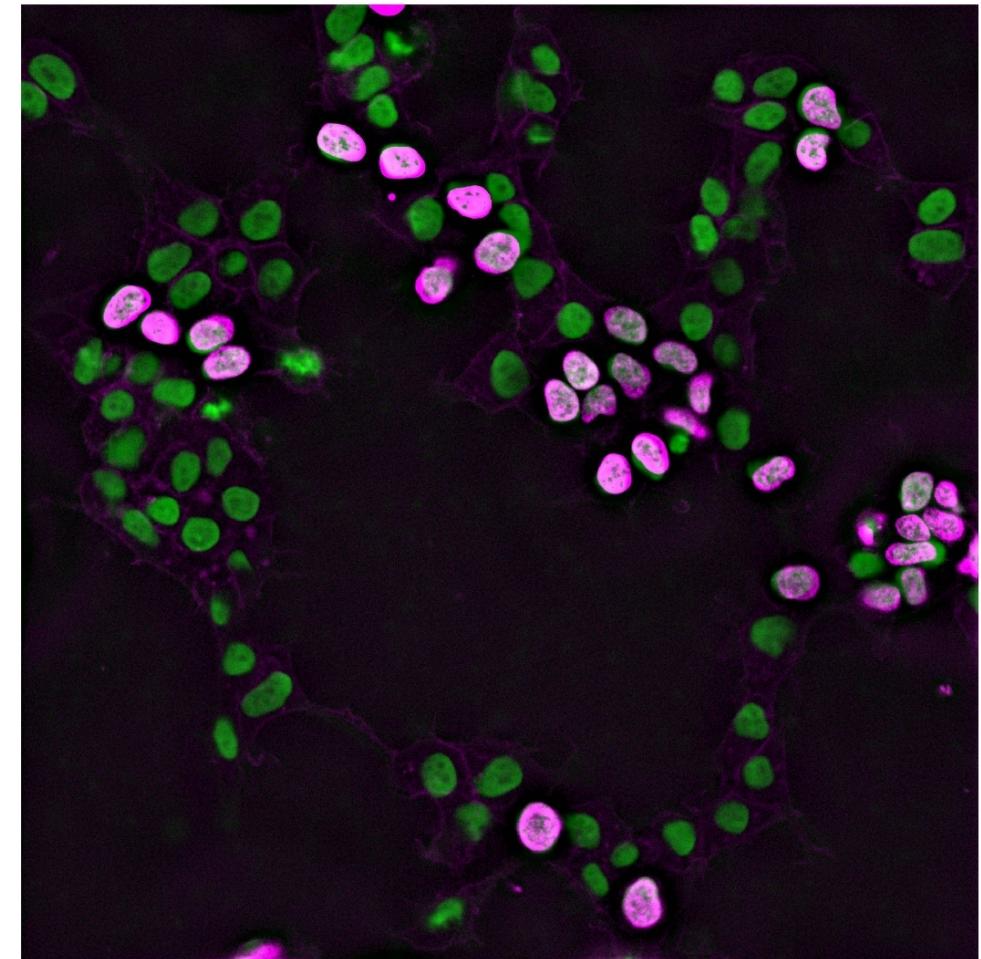
random blur=0.1-10, noise=0-0.4, intensity jitter=0-0.8, after self-training

Rescuing labeling artifacts - nuclei

Input



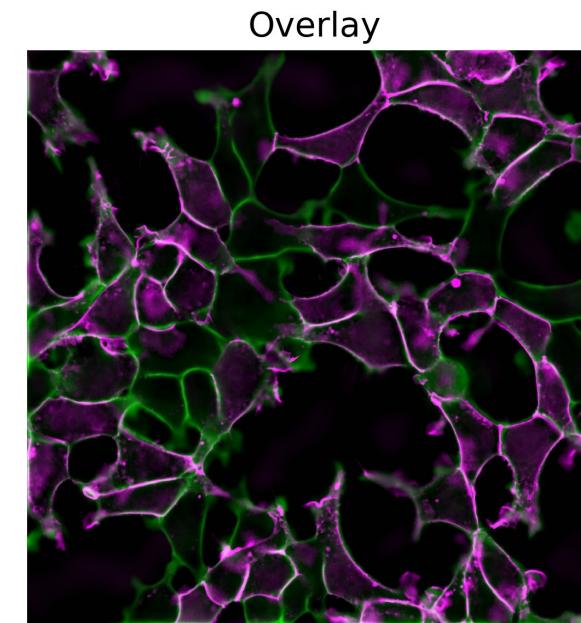
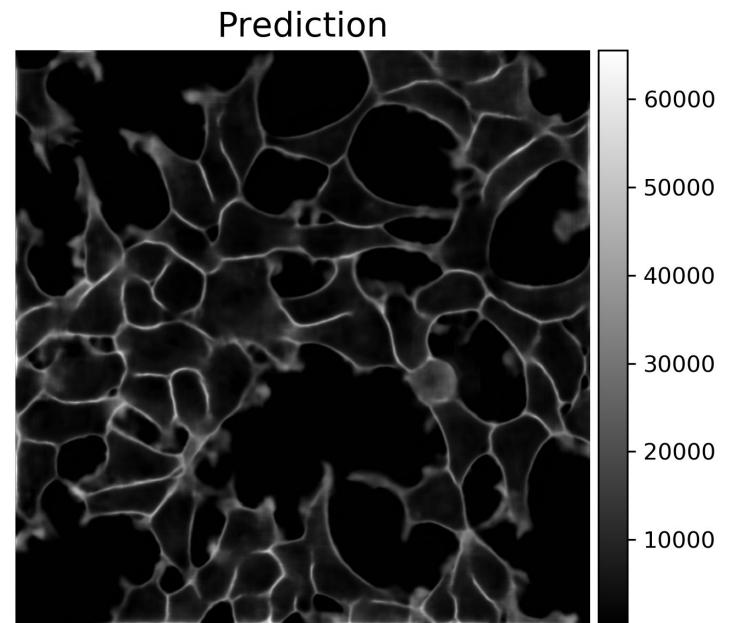
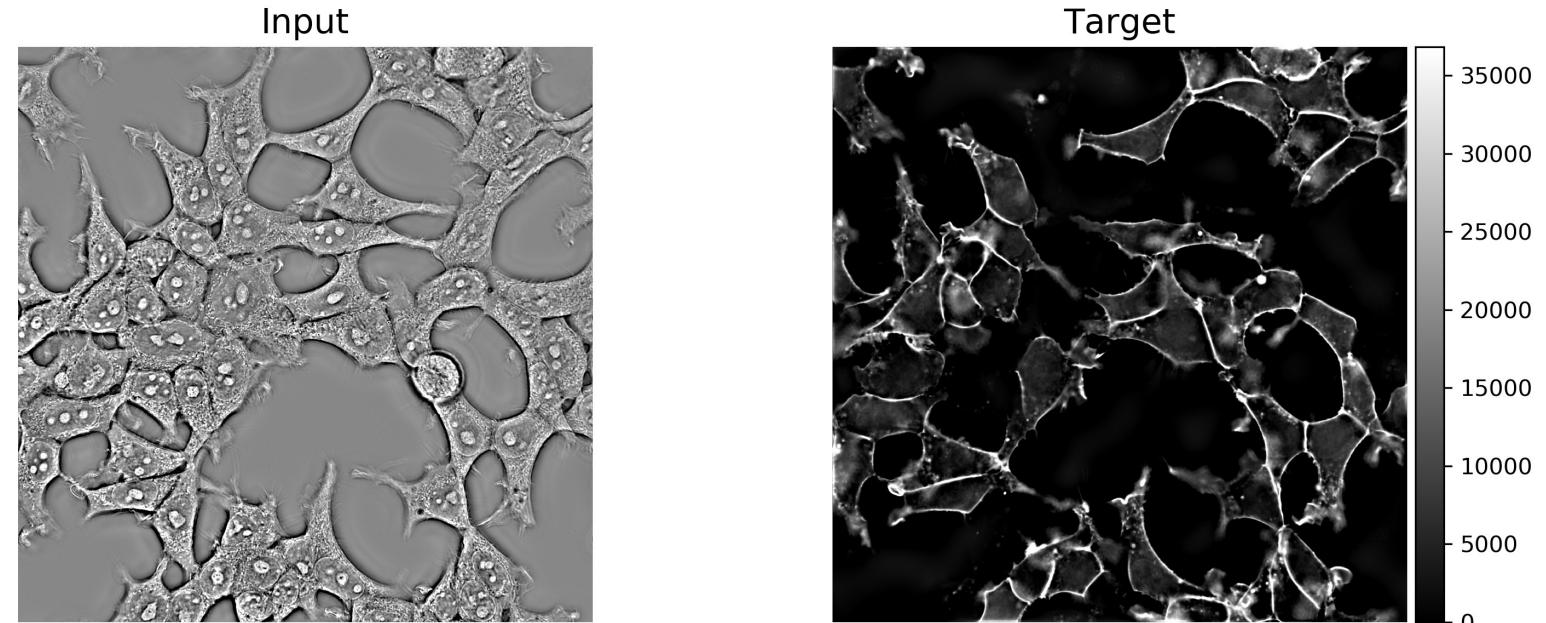
Overlay



Experiment + virtually stained

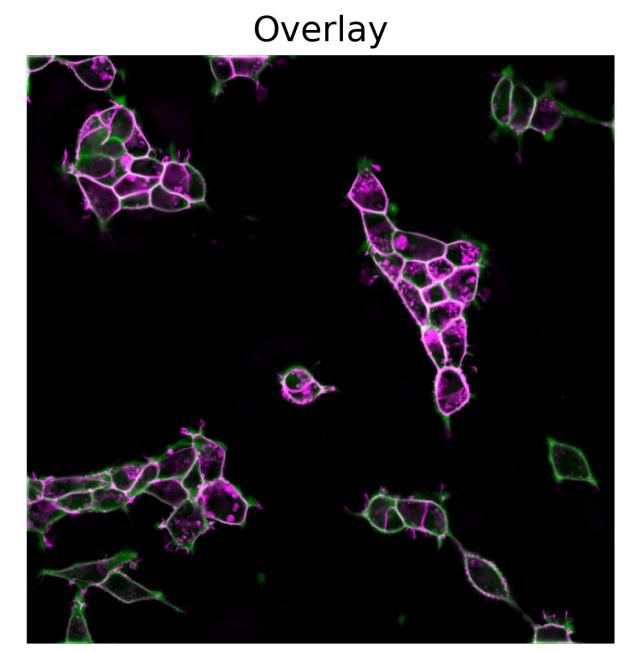
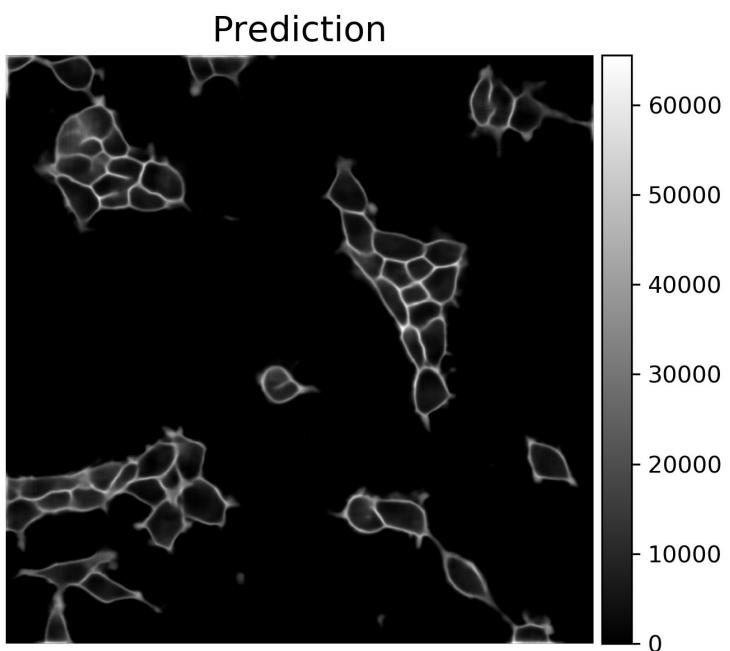
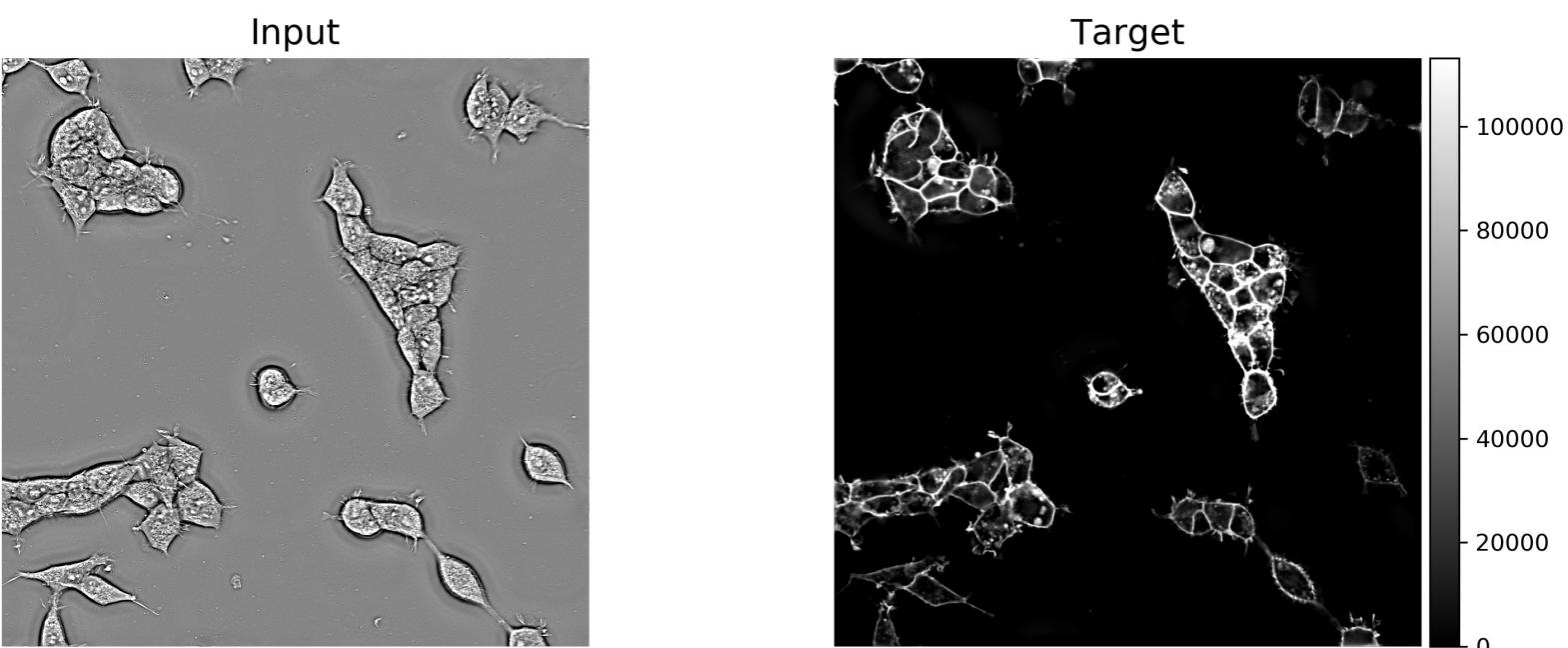
Robust staining of membrane

Membrane prediction
model trained with
data @ 63x mag



Robust staining of membrane

works quite robustly with
data @ 40x mag.



In nutshell

- A common failure mode is imperceptible differences between training data and “application data”.
- In biological experiments, it is often not possible to collect all necessary training data.
- Choosing right augmentations is one strategy to make the model invariant to differences between training and application data, and therefore more generalizable to biological experiments.
- Need more strategies and metrics for generalization!