# Adopting CARE

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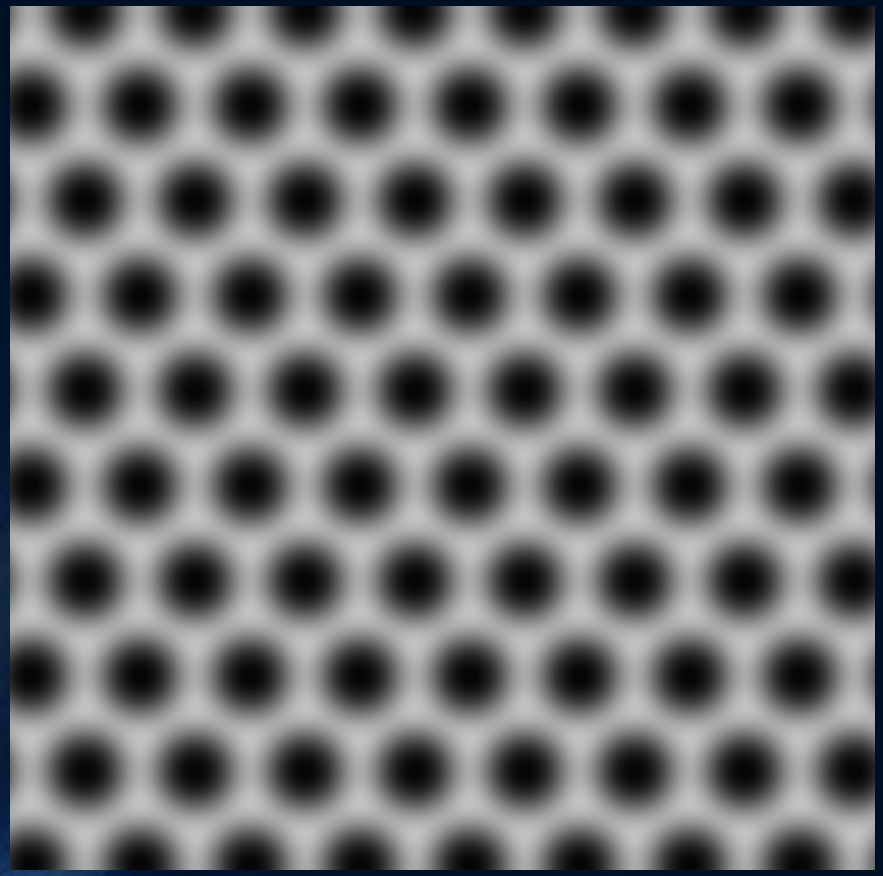
# What is CARE?

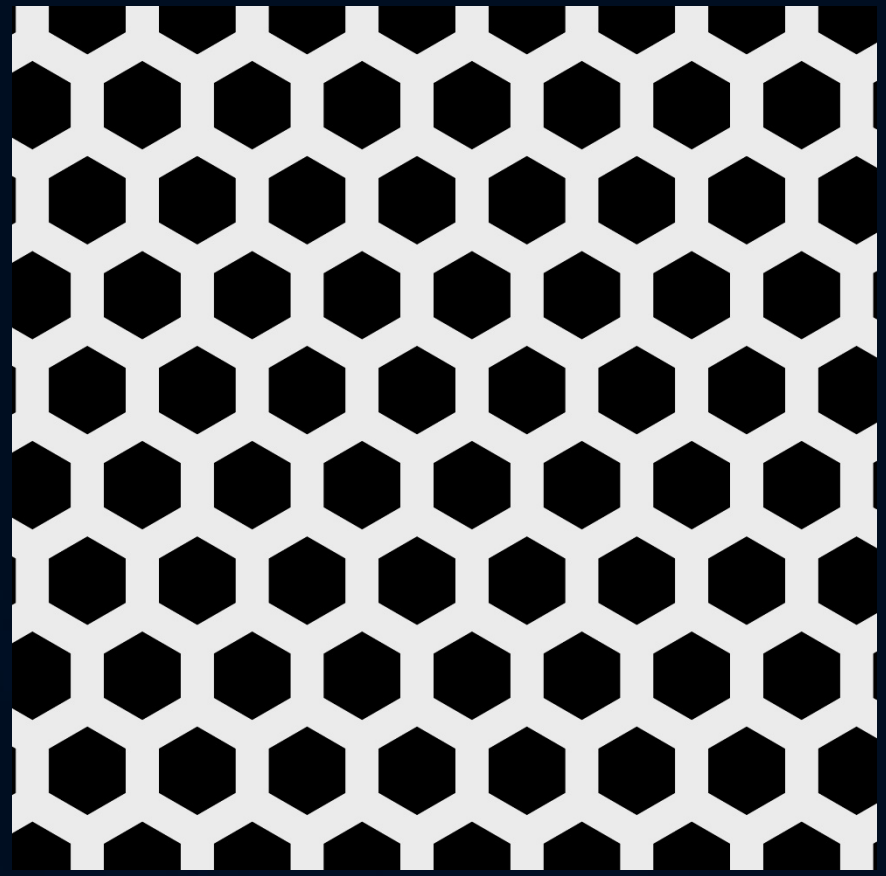
- CARE stands for Content-Aware Image Reconstruction
- Leverages knowledge about what the algorithm is deconvoluting to get better results
- Can be difficult to get an intuitive understanding of how this works without doing it yourself first.

# Imagine this picture of mesh without any blur

If I asked you to draw these circles clearly, you could do it without issue, right?

# Except it isn’t mesh. It’s honeycomb!

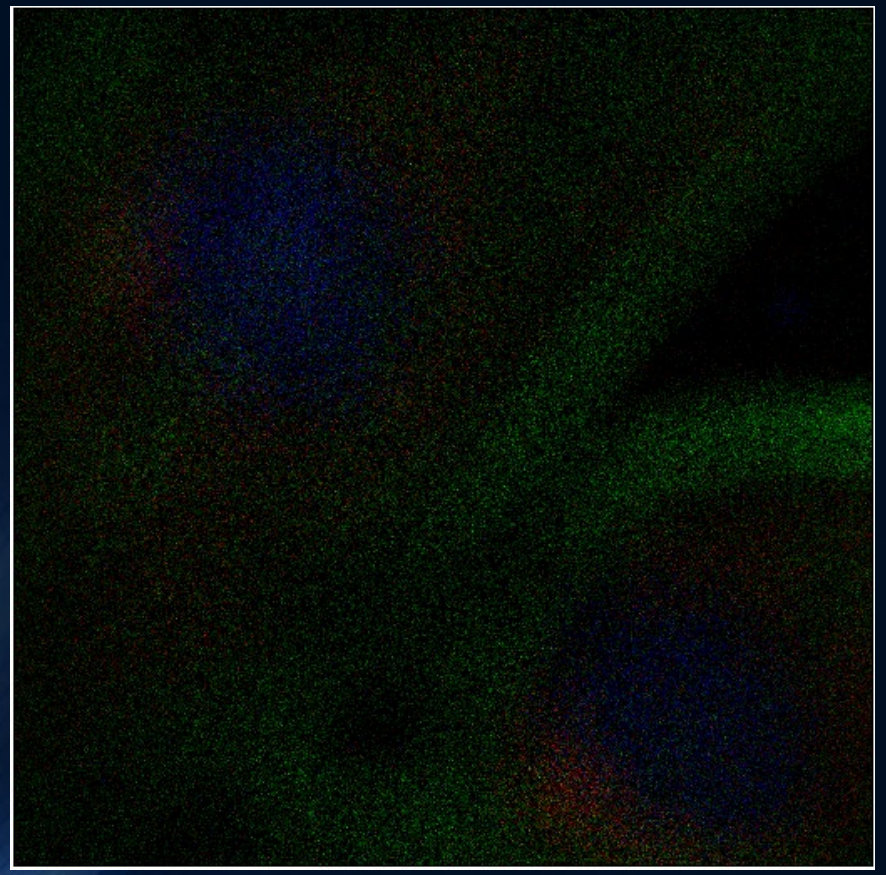


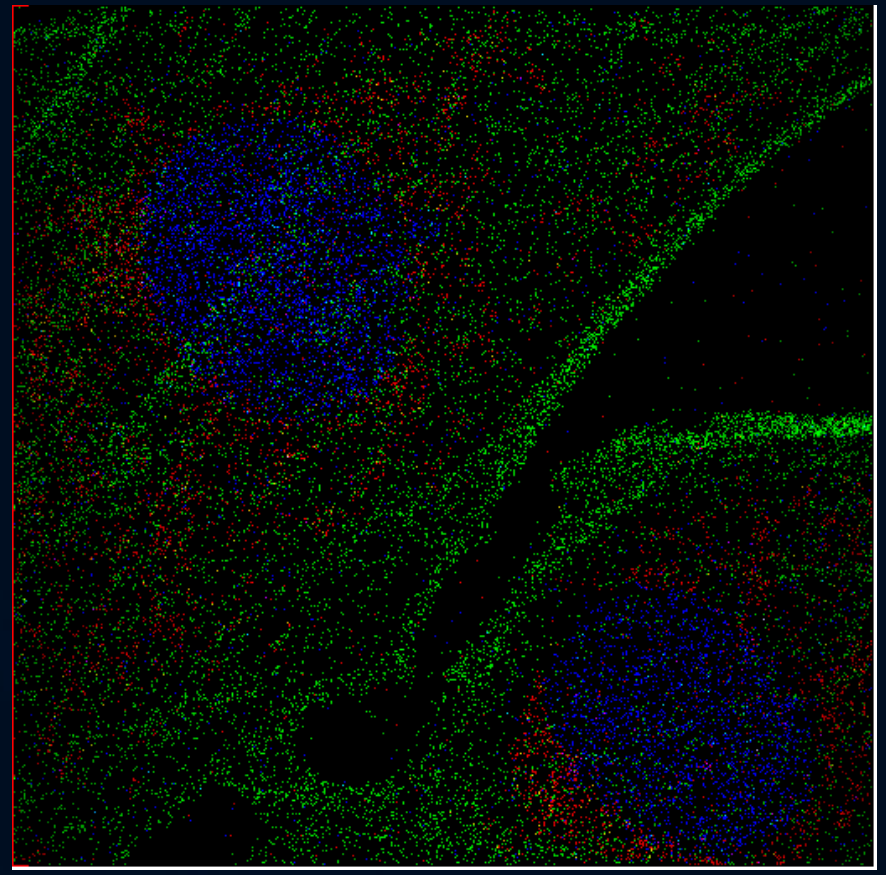


# Why do we need CARE

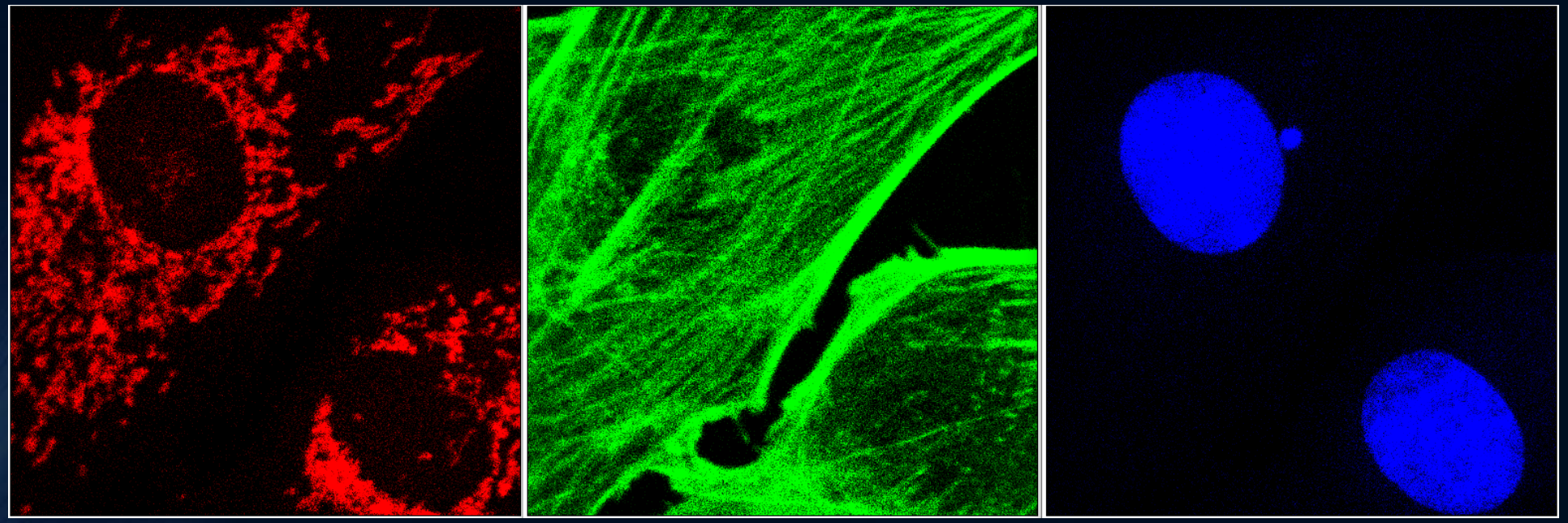
- Biological materials can be very fragile
- Obtaining high signal-to-noise ratio (SNR) images can kill the sample
- May need to make do with lower SNR images
- CARE can solve this problem

# What does high vs. Low SNR mean?





# Layout of Data – RGB Channels



# Two Methods to apply CARE

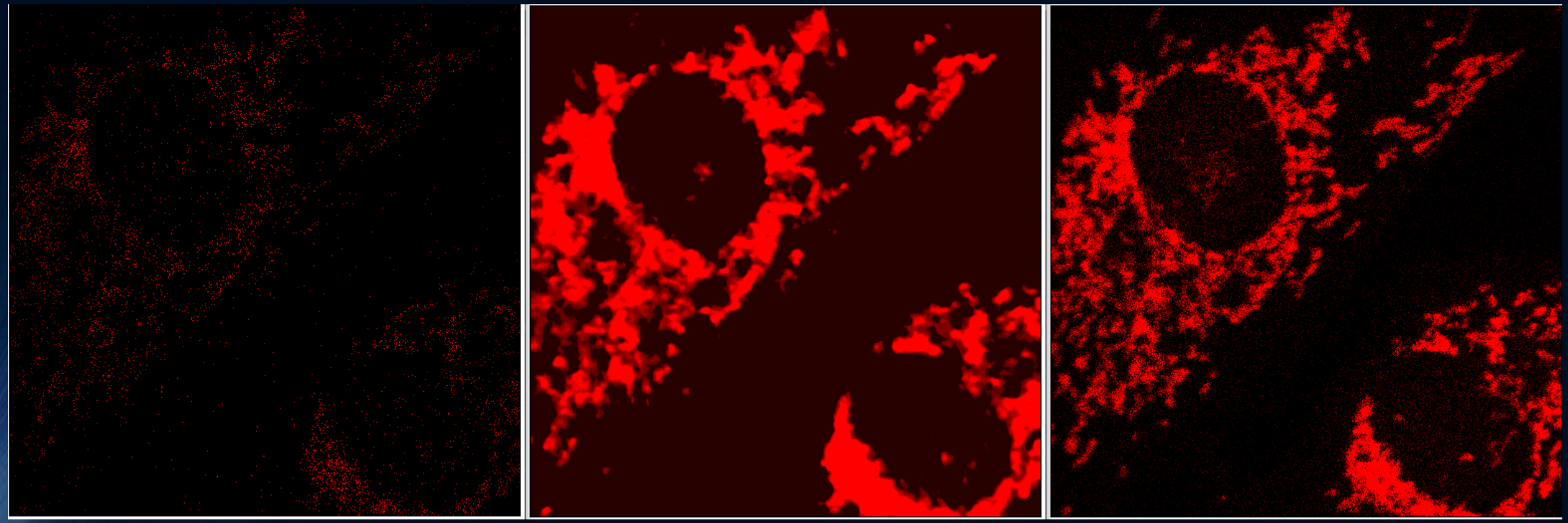
## SINGLE CHANNEL

- Handle one channel at a time
- Train multiple networks
- Combine images afterwards
- No Cross-Channel information

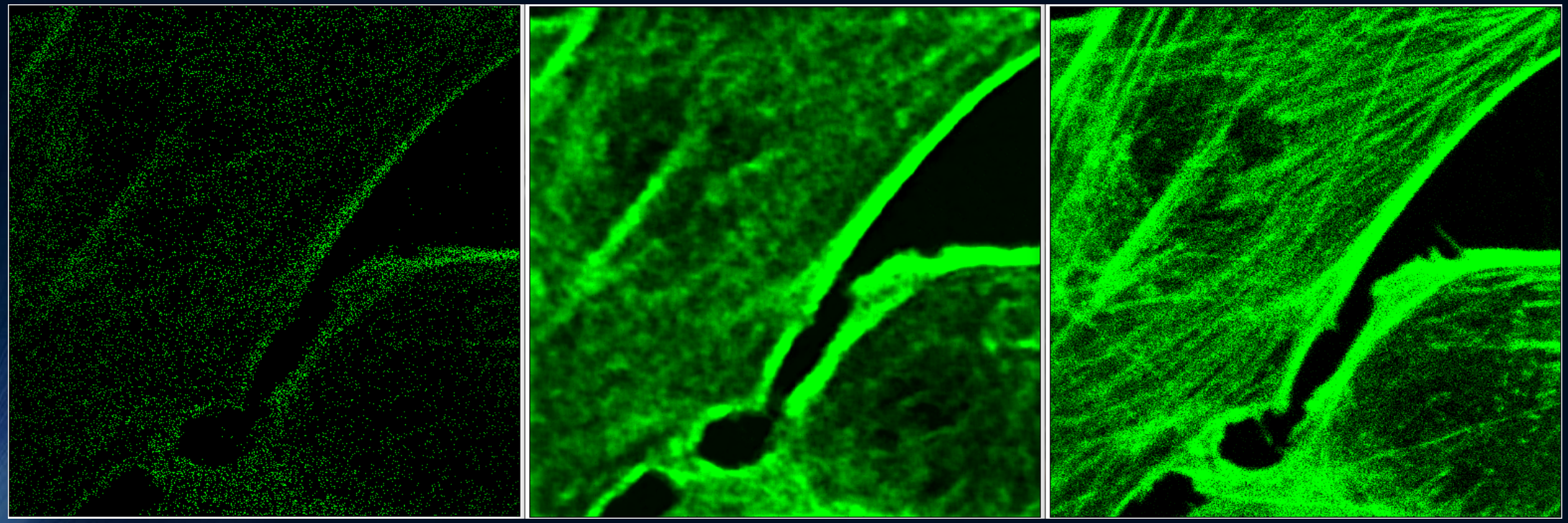
## MULTI CHANNEL

- Handle every channel at once
- Train a single network
- Combine images before
- Cross-Channel information

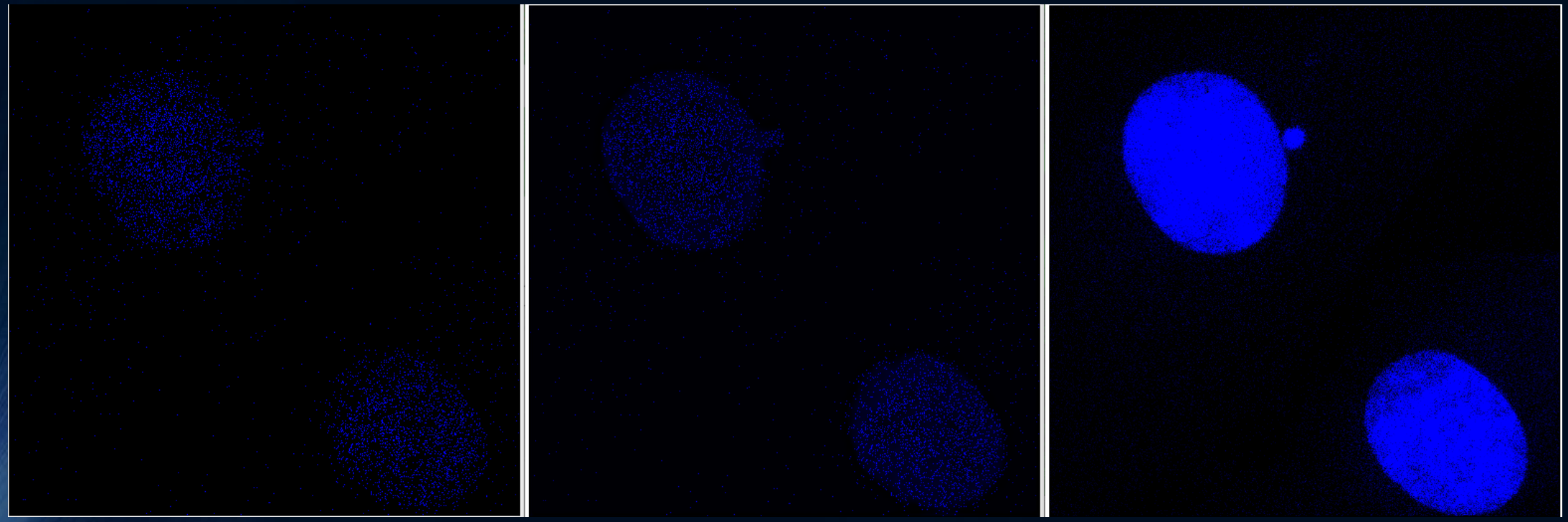
# CARE success on red channel



# CARE success on green channel



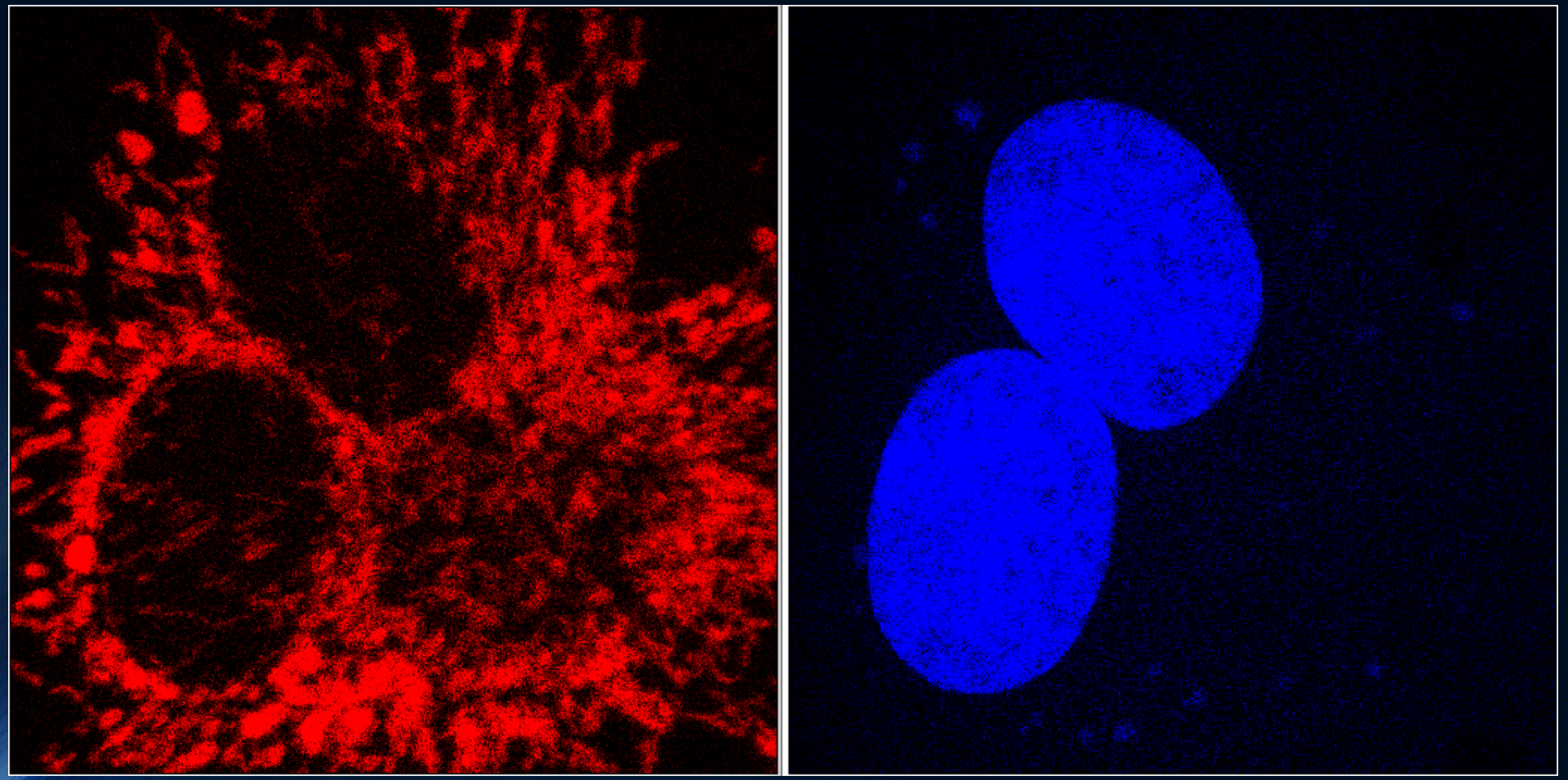
# CARE success on blue channel



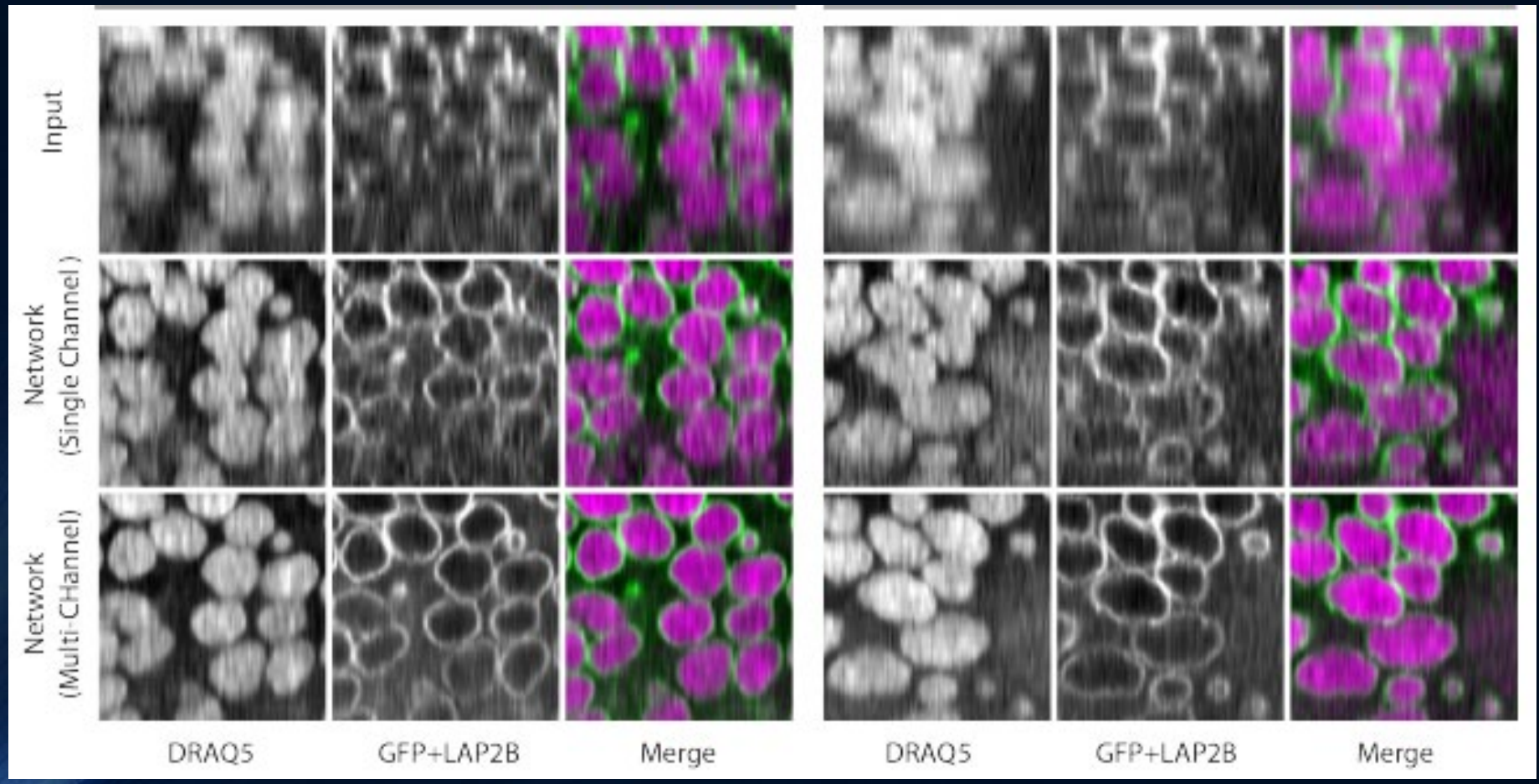
# Multi-Channel Approach

- CARE comes ready to handle multiple channels
- Original paper asserts the beneficial value of cross-channel communication
- Theoretically, CARE should pick up on connections between multiple channels

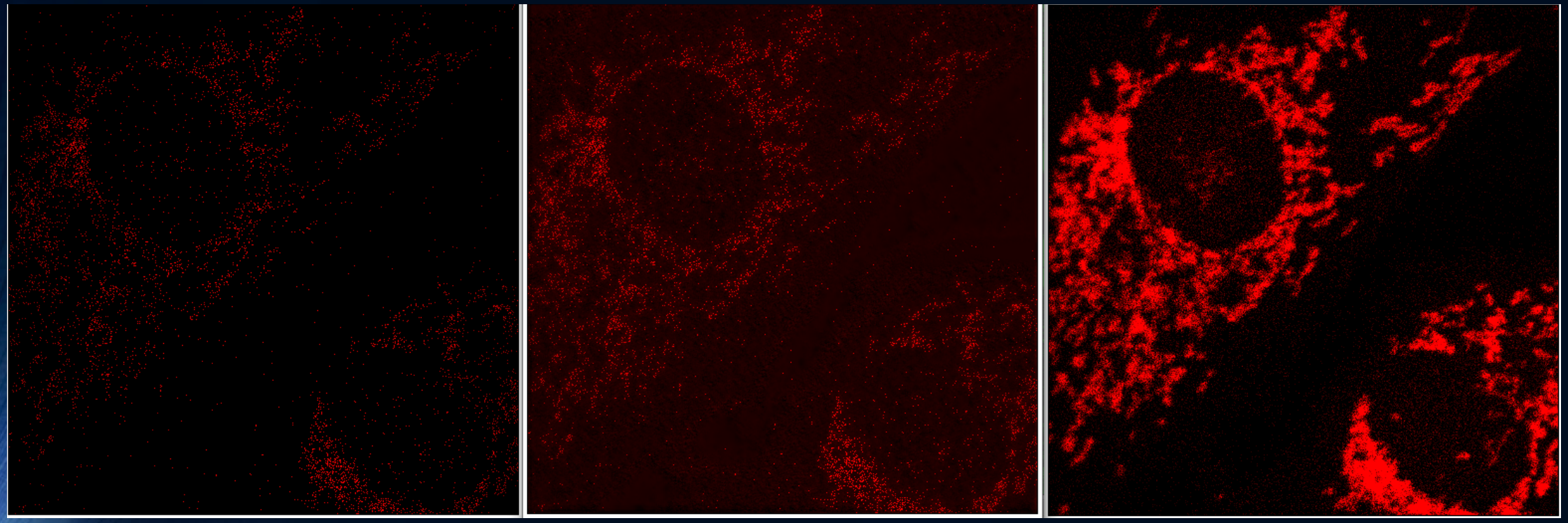
# Example of cross-channel data



# CARE example with cross-channel communication.



# My experience with cross-channel communication



# How badly did it really fail?

- It failed so badly; I cannot visualize the data in any meaningful way
- Loss function of single channel: around .12 - .025
- Loss function of multi channel: 6x10^22
  - The ratio of the loss functions is about the ratio of the volume of a hot air balloon and the sun

# What went wrong?

- Bad cross-channel communication
  - Channels must be closely related
  - Green channel unrelated to Red/Blue channels
- Fundamental misunderstanding of the documentation
  - Isotropic reconstruction of two channels vs deconvolution of multiple channels
  - CARE works with multiple channels, but individual problems

# Understanding the difference

- In the paper's example
  - A single effect
  - Need to remove the "stretch" from the images
  - Both channels offer information for solving that single problem
- In our experiment
  - Multiple different effects
  - Need to treat each phenomenon individually
  - Other channels give unrelated data

# What did we gain?

- Proof CARE works as advertised with new applications
- Exploration into the limits and valid applications of CARE
- Installation experience

# What did I gain?

- Experience working remote
- Experience using TensorFlow and FIJI
- Experience training and preparing data for machine learning
- Deep understanding of how machine learning works

# Difficulties caused by COVID-19

## WHAT WE WANTED TO DO

- Run on St. Jude Hardware
- Get experience with CARE on Linux
- Deep Dive on how CARE works

## HOW WE ADAPTED

- Ran solely on my home PC
- Created an annotated recipe
- Personal study on the structure and process of machine learning

# Conclusion

- Single channel CARE experiment exceeded expectations
  - Training for the pictured results took 20 minutes
  - Prediction took 7 seconds
- CARE is extremely user friendly
  - Out of box examples easily extrapolated into new projects
  - Can be made into a smooth pipeline
- Multi-Channel CARE is not always applicable
  - Understand the problem at hand and change how CARE is applied accordingly

# Sources

- Content-aware image restoration: pushing the limits of fluorescence microscopy
  - By Martin Weigert, Uwe Schmidt, et al.
  - https://doi.org/10.1038/s41592-018-0216-7
    - Original Paper
  - Supplementary fig. 15 used in slide 14
- Honeycomb example images
  - By Alexander Killebrew
  - https://www.linkedin.com/in/alexanderkillebrewdesigns/