

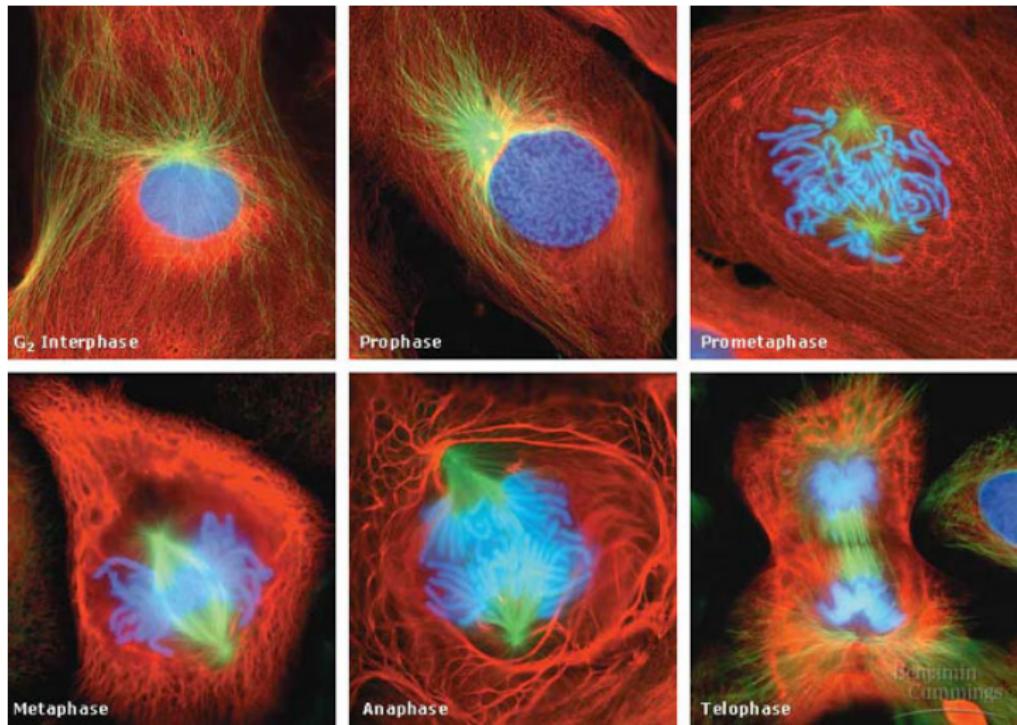
# Student Performance on BIOL12

## Lab Module 3, Part 2

Kyle Morrison

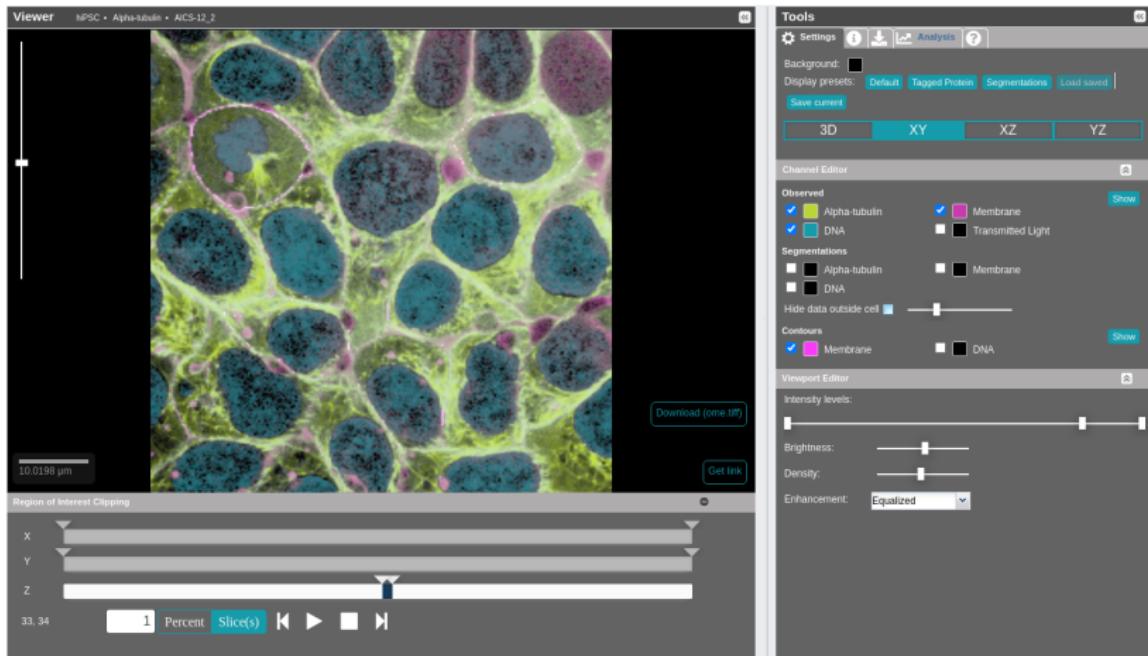
06/22/20

# Refresher: Stages of Mitosis



Retrieved from <https://bitesizebio.com>. Species unknown, but illustrates the point.

# Lab Module 3 - Using the Allen Institute 3D Cell Viewer



- ▶ Across 50 images, tally hIPSCs in Interphase and in each stage of mitosis.
- ▶ Don't count cells not fully in view.
- ▶ Do count cells in telophase as *one* cell.

# Lab Module 3 - Using the Allen Institute 3D Cell Viewer

Image Identity	Interphase	Prophase	Prometaphase	Metaphase	Anaphase	Telophase	Number of dividing cells to look for: Hints:
Image 1							2
Image 2							1
Image 3							4
Image 4							3
Image 5							1
Image 6							4
Image 7							1
Image 8							1
Image 9							Look a DNA channel separately. Scroll through Z stack with tubulin selected.
Image 10							1
Image 11							1
Image 12							2
Image 13							Look a DNA channel separately. Scroll through Z stack with tubulin selected.
Image 14							2
Image 15							2
Image 16							4
Image 17							Scroll through the Z stack with tubulin selected. Scroll through the Z stack with tubulin selected.
Image 18							2
Image 19							5
Image 20							Scroll through the Z stack with tubulin and DNA selected. Scroll through the Z stack with tubulin selected.
Image 21							3
Image 22							Scroll through the Z stack with tubulin and DNA selected.
Image 23							2
Image 24							1
Image 25							Look a DNA channel separately. Scroll through Z stack with tubulin selected.
Image 26							5
Image 27							Look a DNA channel separately. Scroll through Z stack with tubulin selected.
Image 28							2
Image 29							Look a DNA channel separately. Scroll through Z stack with tubulin selected.
Image 30							2
Image 31							Look a DNA channel separately. Scroll through Z stack with tubulin selected.
Image 32							2
Image 33							Look a DNA channel separately. Scroll through Z stack with tubulin selected.
Image 34							1
Image 35							1
Image 36							2
Image 37							2
Image 38							2
Image 39							3
Image 40							Look a DNA channel separately. Scroll through Z stack with tubulin selected.
Image 41							2
Image 42							1
Image 43							1
Image 44							Look through the Z stack with tubulin and DNA selected.
Image 45							1
Image 46							1
Image 47							1
Image 48							1
Image 49							1
Image 50							1

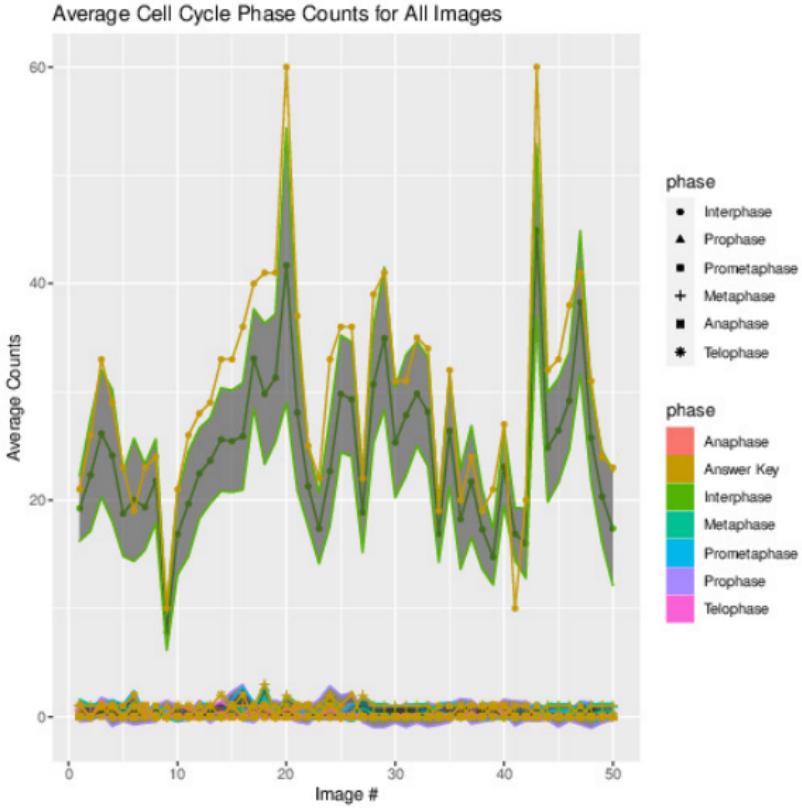
	Total Count	Percentage of Total Cells	Percentage in Total Dividing Cells
Interphase			
Prophase			
Prometaphase			
Metaphase			
Anaphase			
Telophase			
Total cells			
Total dividing cells			

## Analysis Methodology

1. Aggregate all usable student data ( $n = 82$ ).
2. Plot the average counts (with standard deviations) vs cell cycle phase for each image (50 bar charts!).
3. Plot overall average counts (with standard deviations) vs cell cycle phase.
4. Plot average residual magnitude (how far off the answer key were the students?) vs image number for each cell cycle phase.
5. Examine images students were the most off on.

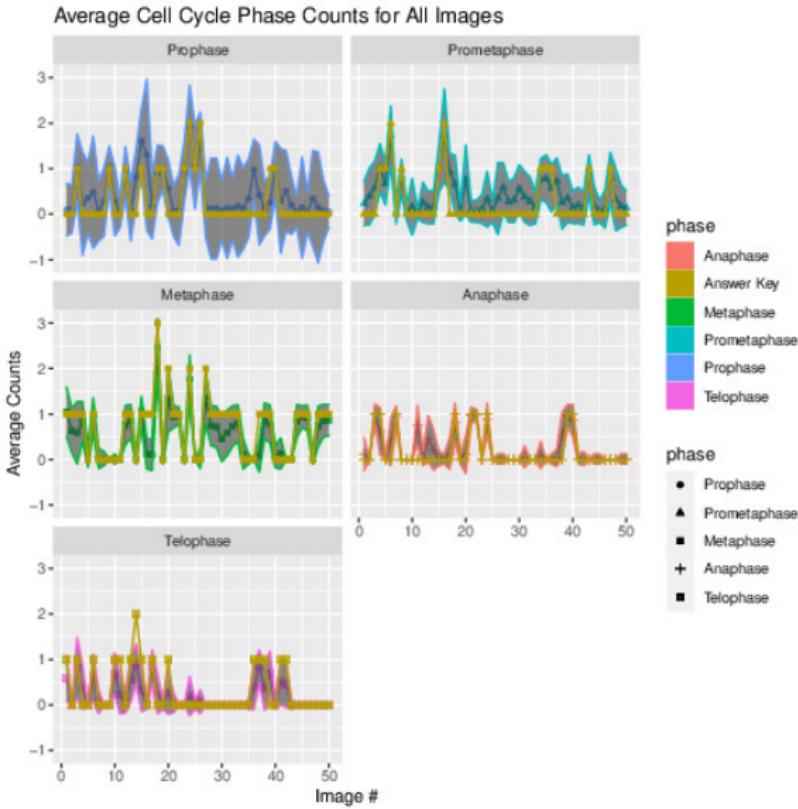
# Overall Average Counts (All Phases)

- ▶ Yellow Line - Answer Key values.
- ▶ Students were more conservative in identifying Interphase.



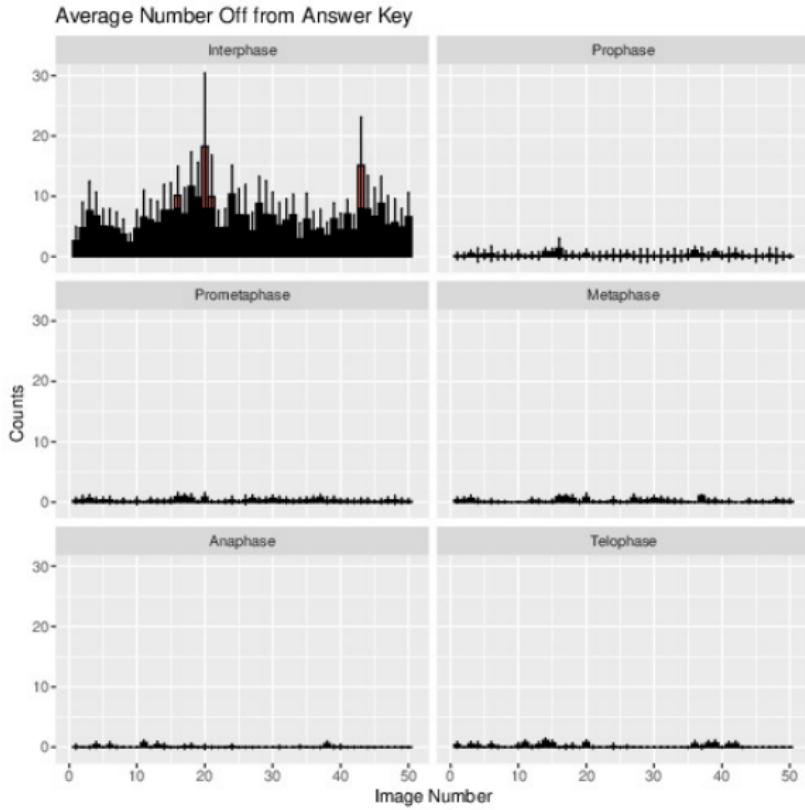
# Overall Average Counts (Mitotic Phases)

- ▶ Yellow Line - Answer Key values.
- ▶ Students didn't get worse as the assignment went on (cool!).
- ▶ Prophase and Prometaphase have the most false positives.
- ▶ Metaphase and Prometaphase are often confused (compare averages around Image 30).



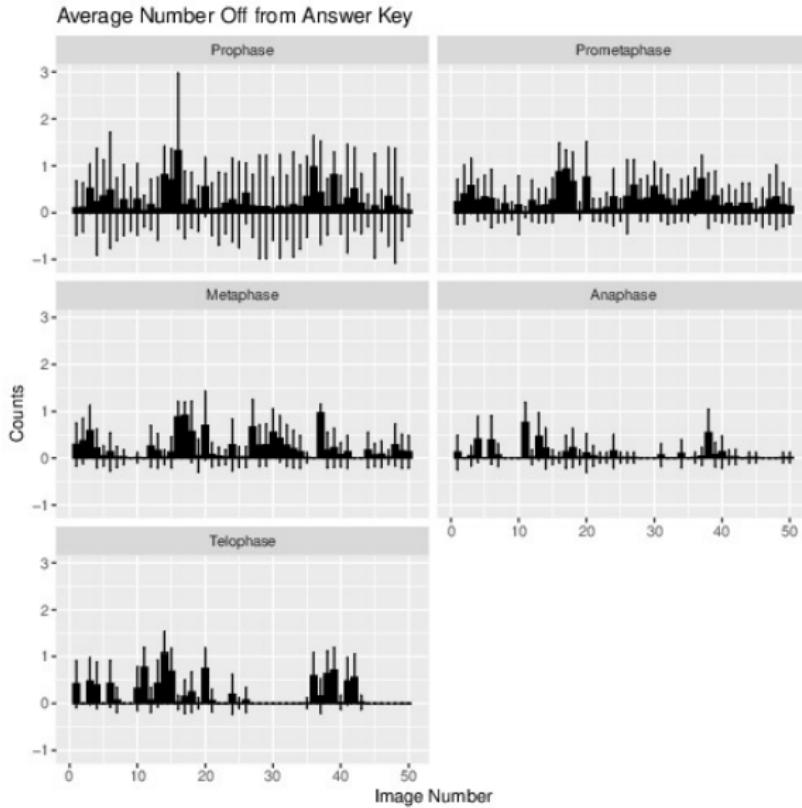
# Overall Residual Magnitude (All Phases)

- ▶ Again, lots of variability in Interphase, particularly at Image 20 (more on this later).



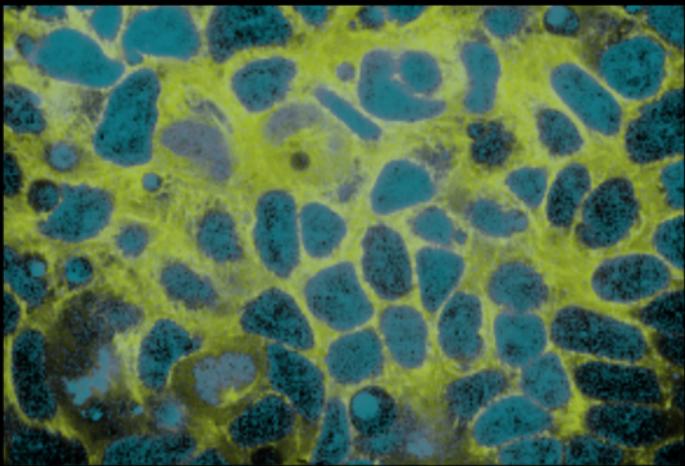
# Overall Residual Magnitude (Mitotic Phases)

- ▶ Unsurprisingly, Prophase has the largest standard deviations.
- ▶ Anaphase is the phase the students did the best on.
- ▶ 4 bars around Image 15 are almost identical for Prometaphase and Metaphase, further evidence students are mixing them up (more on this later).



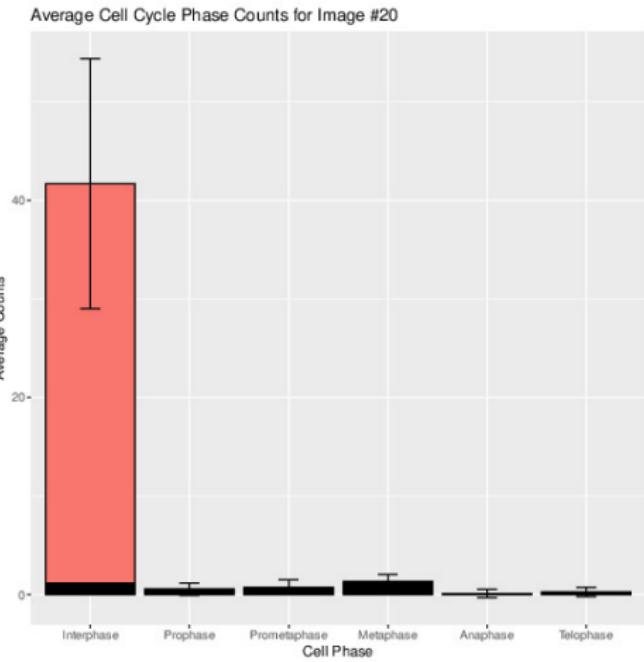
## Hardest Images: Interphase (Image 20)

- ▶ Looks like it might've given the students trouble just because there are a LOT of cells in view.



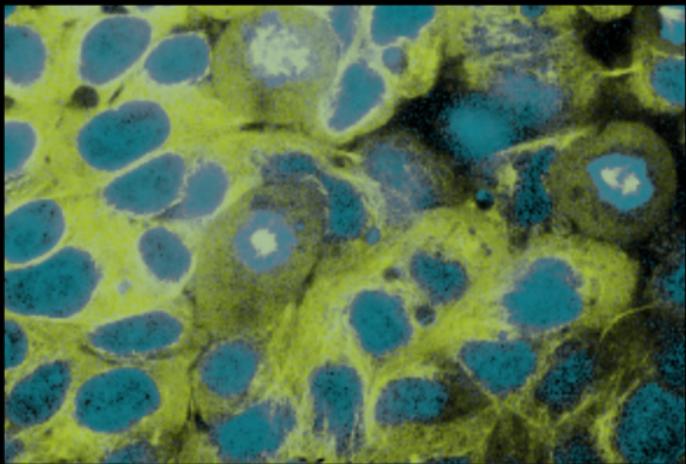
# Hardest Images: Interphase (Image 20)

- ▶ Looks like it might've given the students trouble just because there are a LOT of cells in view.



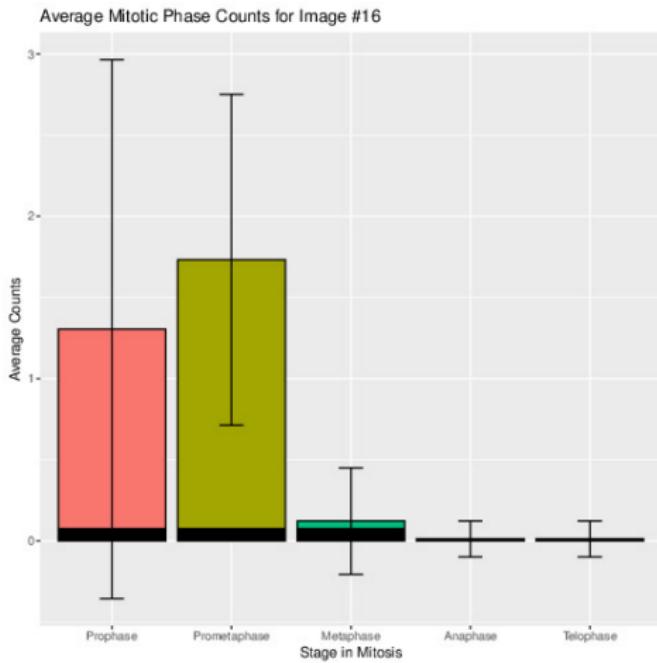
## Hardest Images: Prophase (Image 16)

- ▶ The answer key missed identifying the Prophase on the right, and the students might have picked up on this one, missed it, identified the Prometaphase as Prophase, or some combination.



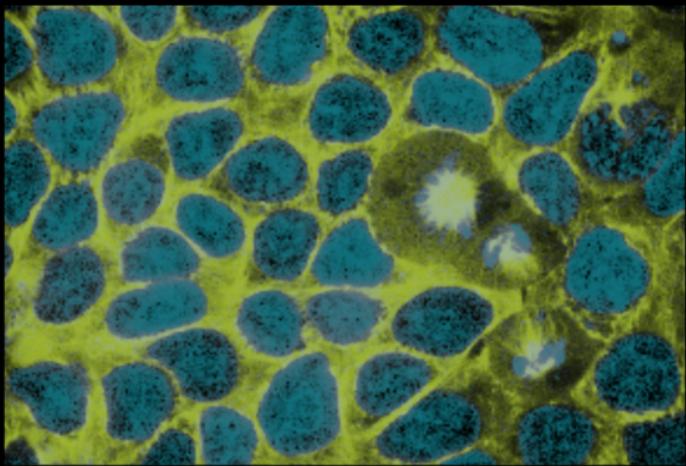
# Hardest Images: Prophase (Image 16)

- ▶ Looks more like misclassification based on the raw data, given both vary a lot here.



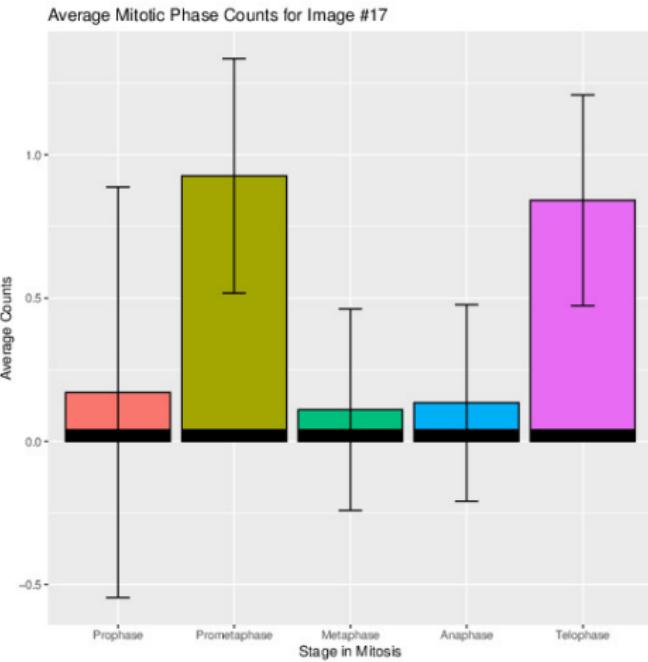
## Hardest Images: Prometaphase (Image 17)

- ▶ The answer key says Metaphase, but this looks like Prometaphase, which is presumably what the students said.



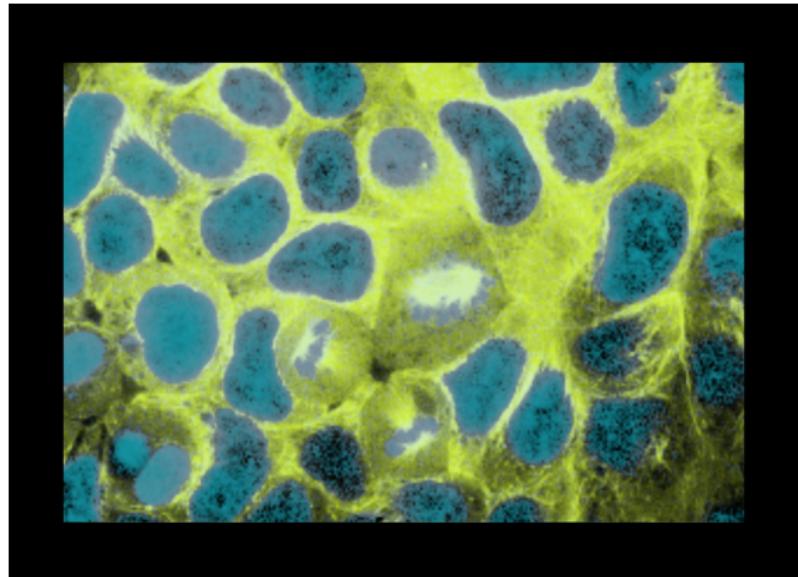
# Hardest Images: Prometaphase (Image 17)

- ▶ Looking at the raw data, it's not clear what happened. Perhaps Anaphase and Telophase mixups combined with Prophase/Prometaphase/Metaphase mixups?



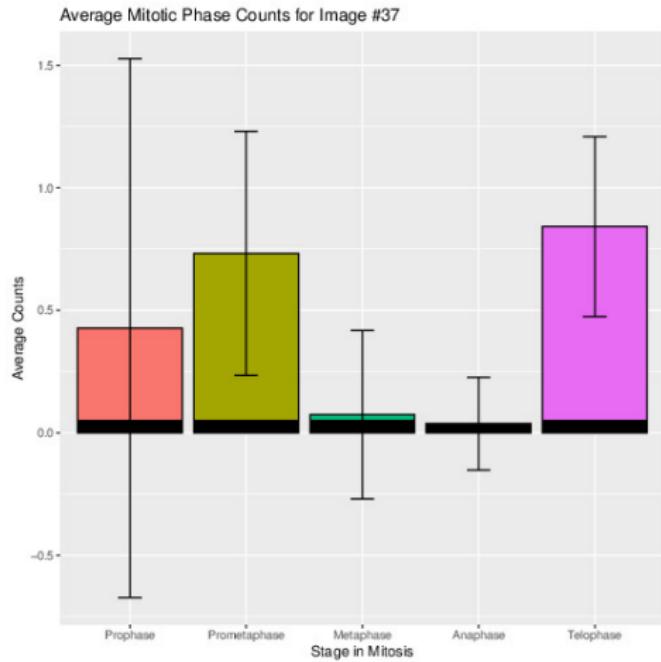
## Hardest Images: Metaphase (Image 37)

- ▶ The answer key says Metaphase, but this looks like Prometaphase, which is presumably what the students said. The middle cell does look like it could be late prophase, though, with more like two yellow blobs than one.



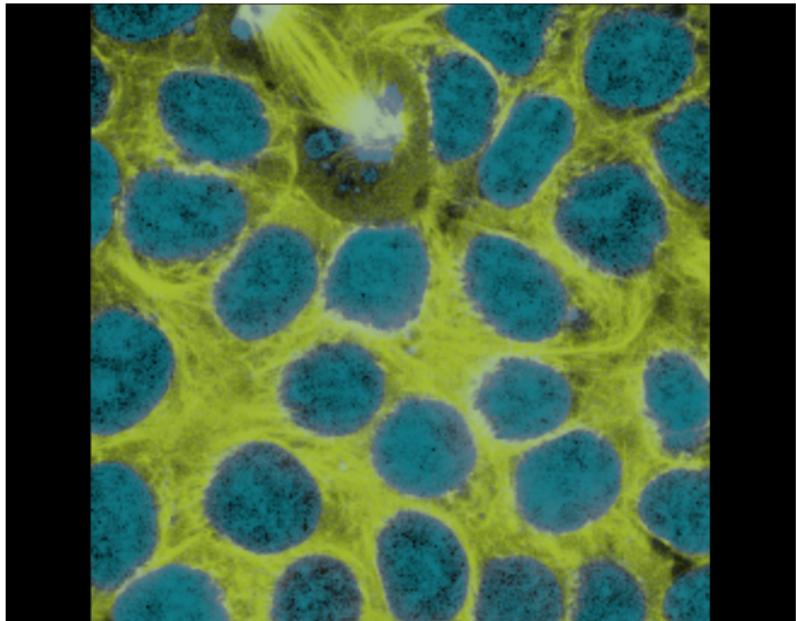
# Hardest Images: Metaphase (Image 37)

- ▶ Looks like the students called Prometaphase and Prophase a lot, which matches what the image looks like. Also some mixups of Anaphase/Telophase for good measure.



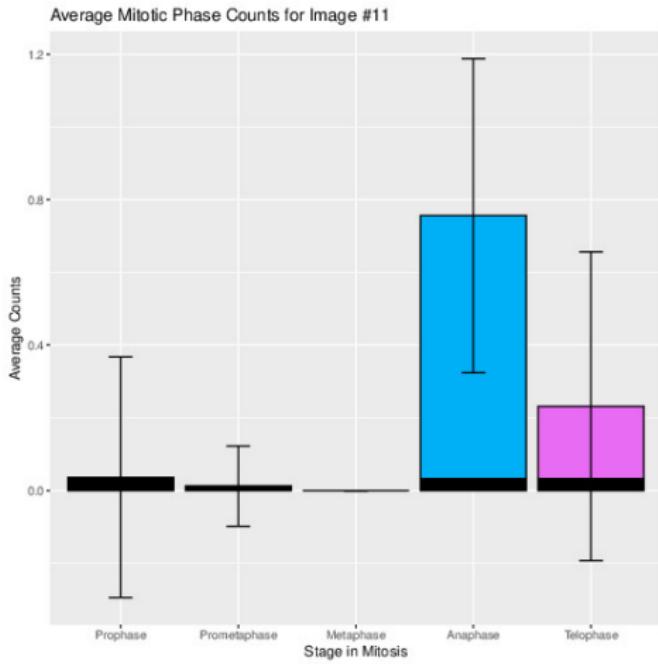
## Hardest Images: Anaphase (Image 11)

- ▶ Looks like a classic case of “Anaphase or Telophase?”



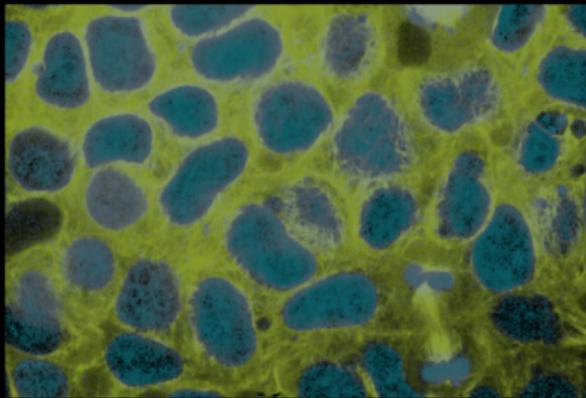
# Hardest Images: Anaphase (Image 11)

► Yup.



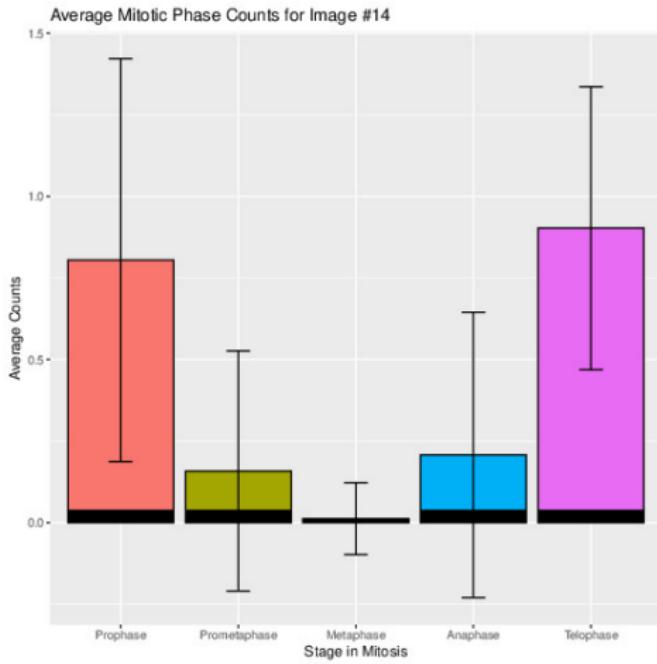
## Hardest Images: Telophase (Image 14)

- ▶ Looks like a classic case of “Anaphase or Telophase?”
- ▶ Perhaps the cell on the far right that has a bright yellow spot is prophase-like?



# Hardest Images: Telophase (Image 14)

- ▶ Yup.
- ▶ The data supports the idea that the students thought at least something in here was prophase (the answer key disagrees).



## Overall Results

- ▶ Students were more conservative in identifying Interphase.
- ▶ By difference from the answer key (residual magnitude), visual inspection, and my experience grading, the order of rising difficulty:  
Anaphase, Telophase, Metaphase, Prometaphase, Prophase.
- ▶ Interphase was “technically” the most difficult, but I’d chalk this up to being more stringent with counting than to misclassifying Interphase as, say, Prophase.
- ▶ Even lab staff, experienced and new, can go back and forth on “proper” labeling. Real images  $\neq$  diagrams.