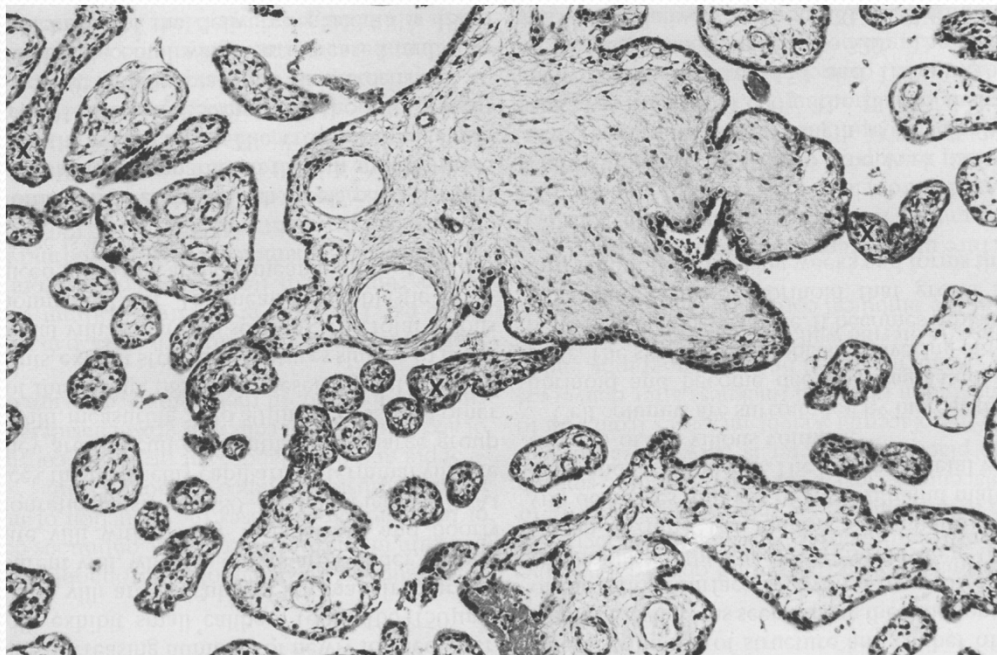


# Placental Maturity Analysis

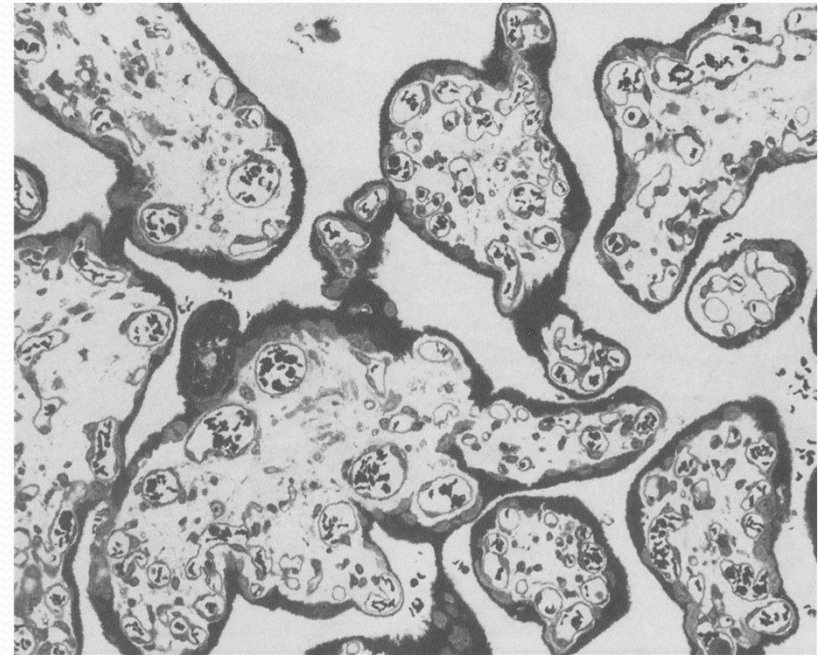
Sarah Grefe, Raymond Ahn, Mariana Reyes, Jose Ruiz

# What's Wrong with this Picture?

## Immaturity



Synchronous Immaturity at 24 Weeks Gestation, Magnified X125

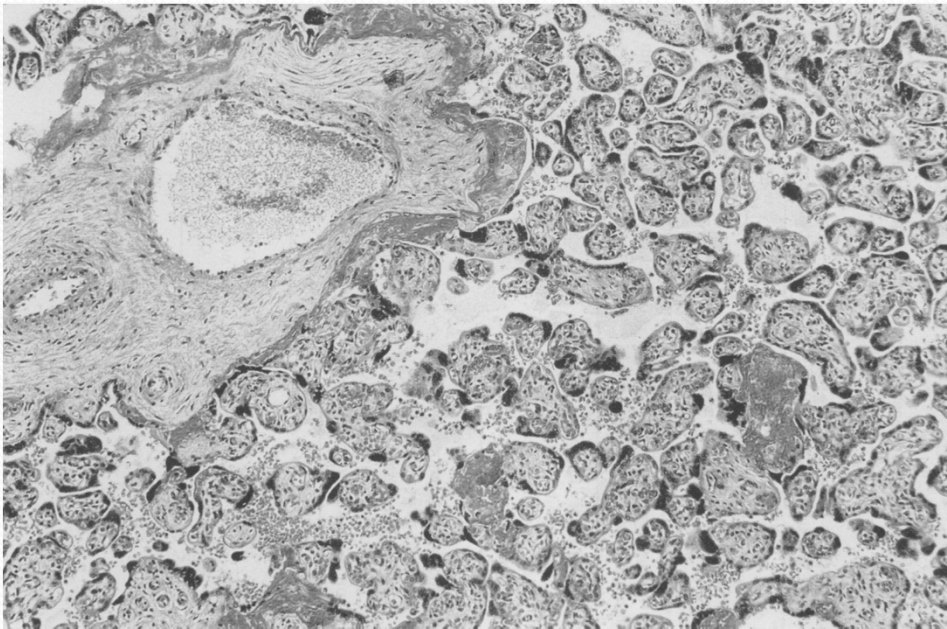


Pathological Immaturity "near-term" (34-37 Weeks Gestation), Magnified X64

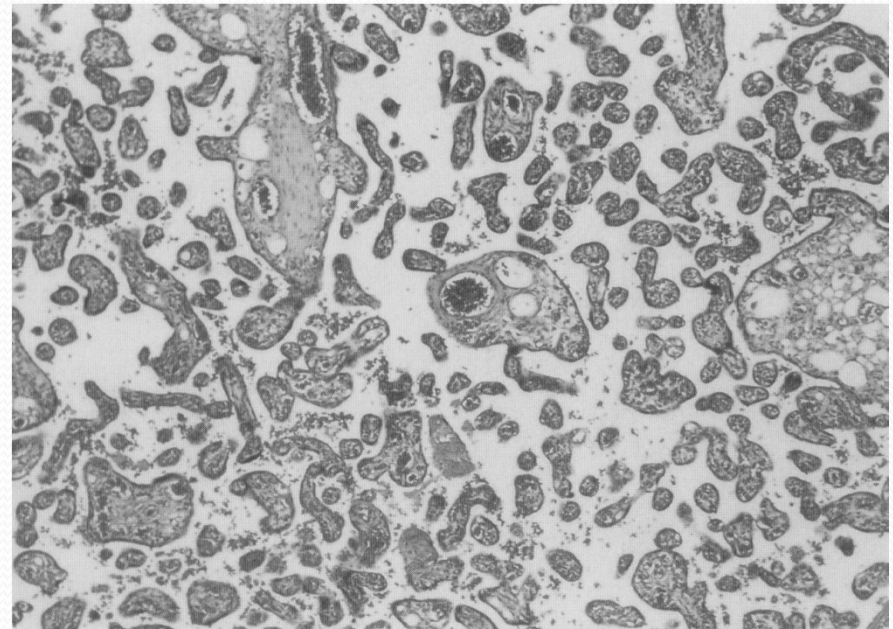
- Meconium contamination, long gestation, high BW, infection, stunted growth

# What's Wrong with this Picture?

## Hypermaturity



Synchronous Maturity at 40 Weeks Gestation, Magnified X125



Pathological Hypermaturity at 29 Weeks Gestation, Magnified X125

- Premature birth, preeclampsia, hypoxia, “inefficiency,” anemia, high altitude

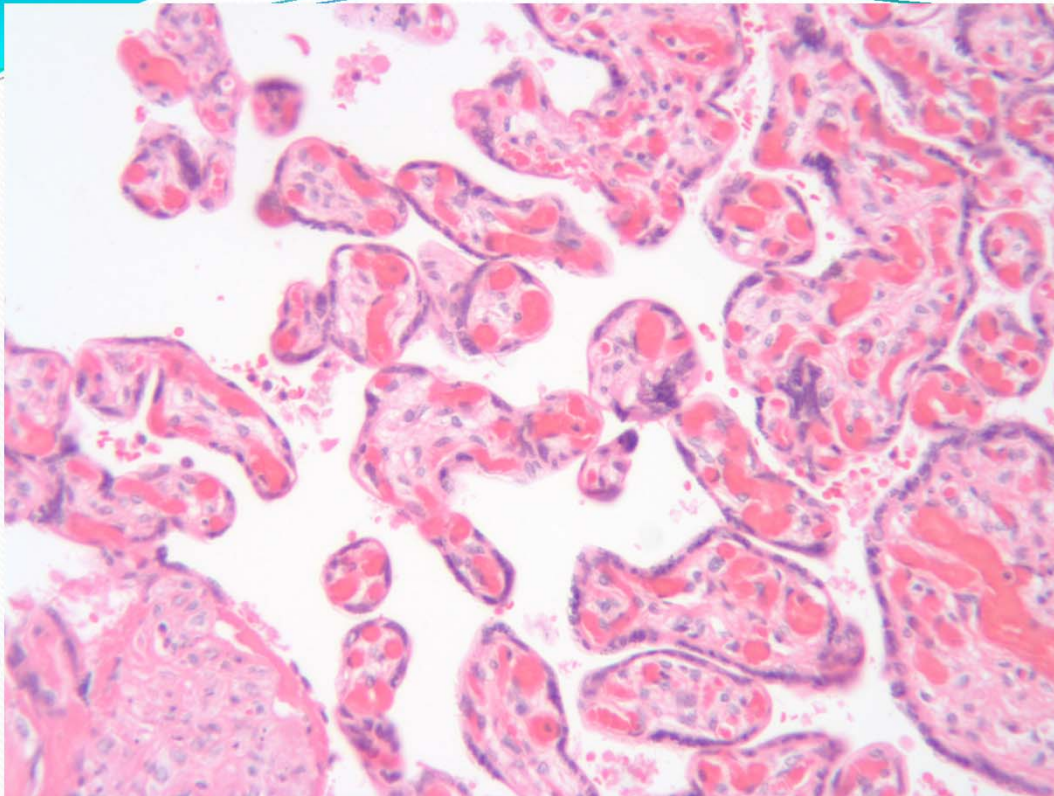


## 4-Phase extraction of PM features:

- Isolate the villi
- Measure the shapes of the villi
- Count the villous blood vessels
- Analyze the data in a meaningful way

# Isolating the Villi

- Isolating the villi requires several considerations of the images
  - First we must consider the cells and blood vessels that lie outside the villi. The problem occurs from the fact that both blood vessels inside and outside the villi are of the same color and separating them by color filtering is impossible
  - The second problem occurs when those vessels are attached by mere pixels to the villi or if those vessels appear in chunks.



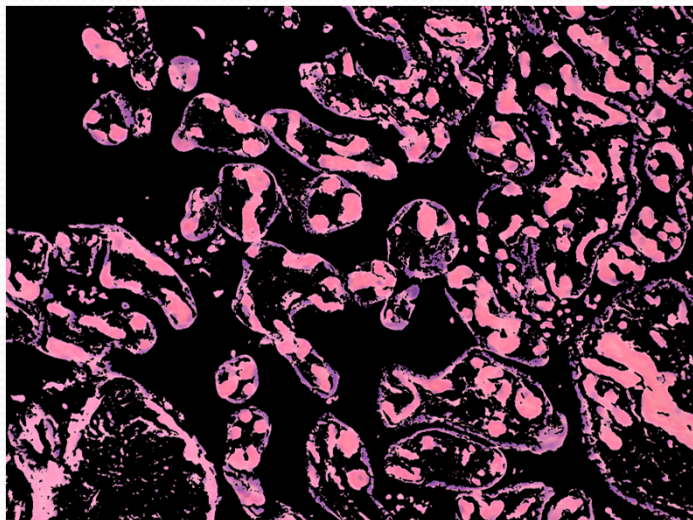
The original image

The first thing we attempted to do was find a way to automate the way the image is segmented by colors.

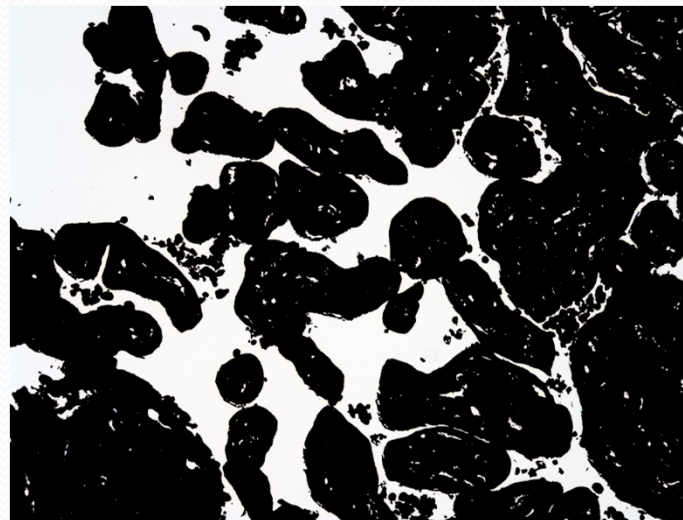
By using a color segmentation technique that relies on k-means via Lab color space transformation we were able to take this image and segment it into its four primary colors: Red, Pink, Blue and White.

Unfortunately, this method causes some problems for us...

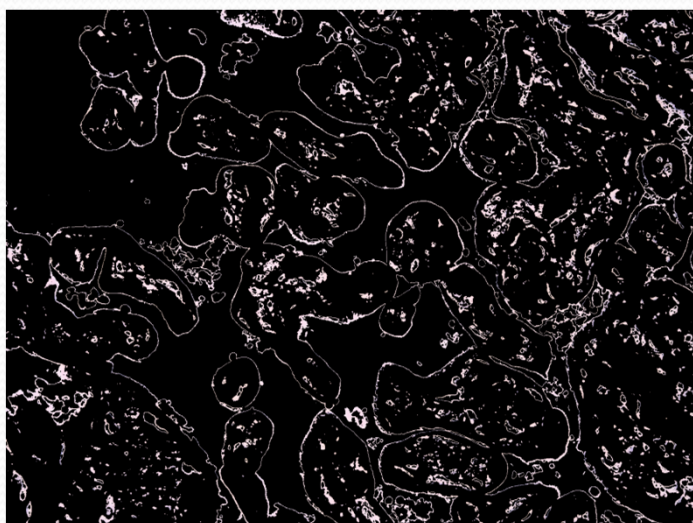
Image segmented by four main colors



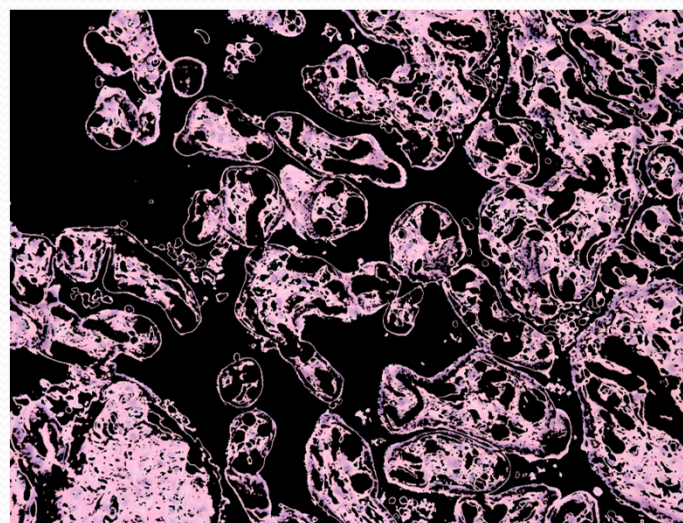
Red



White



Blue

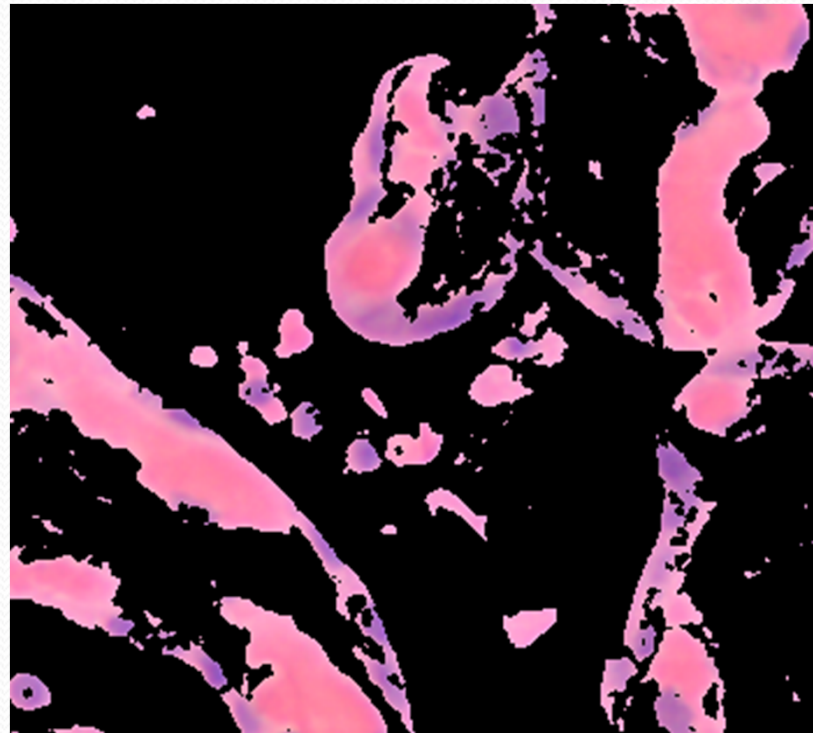
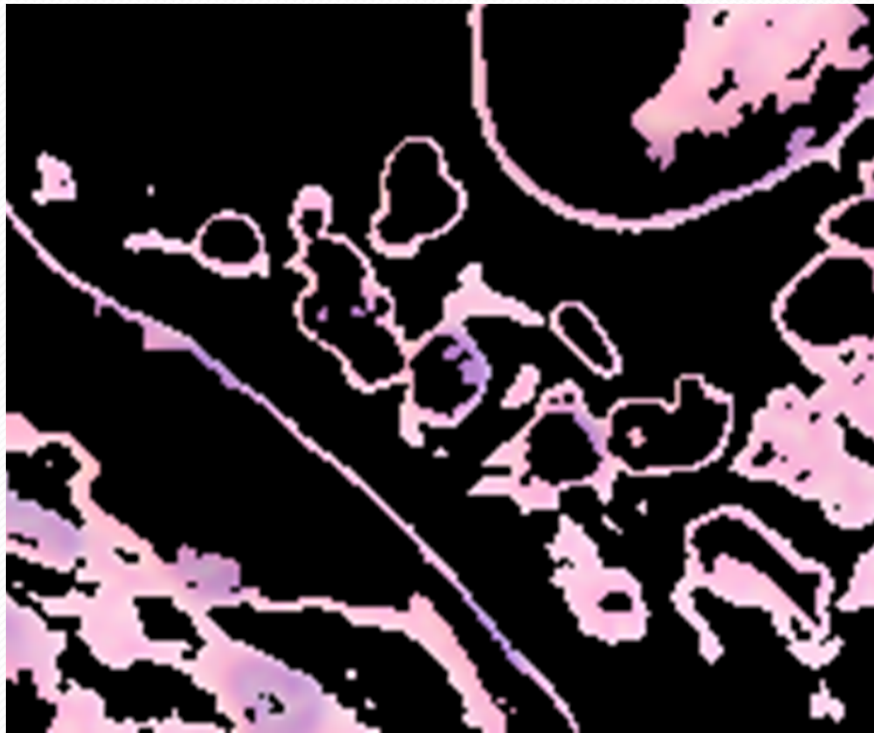


Pink

# Complications

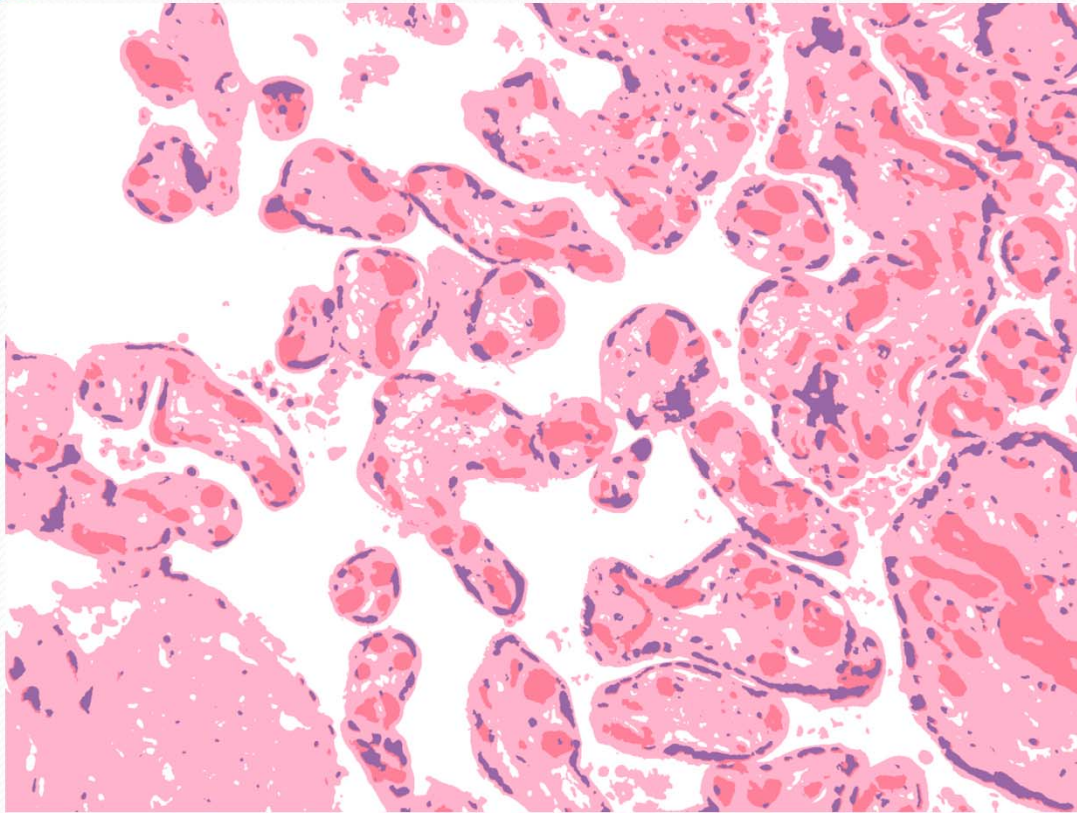
Notice that around the red that we wish to remove from the actual image, there is a ring of pink around it. Because of this it makes making a mask of the pink area difficult, since again, that is something we want to remove from our final image.

Another complication from using this method is that the order in which the colors are segmented are not guaranteed. For this particular image, the order went red, white, blue, pink. But some images the order differs, thus for automation, we cannot rely solely on this method.





## Averaged image



The alternative method is to make the image “cleaner” by making each pixel value to be the same overall value, corresponding to the four main colors.

This is done by manually picking a pixel value that represents pink, red, blue and white. For each pixel, we then take the Euclidean distance

between the pixel and each color value and change it to the color that yields a minimum. Of course, this method has the draw back that we have to manually choose a color.

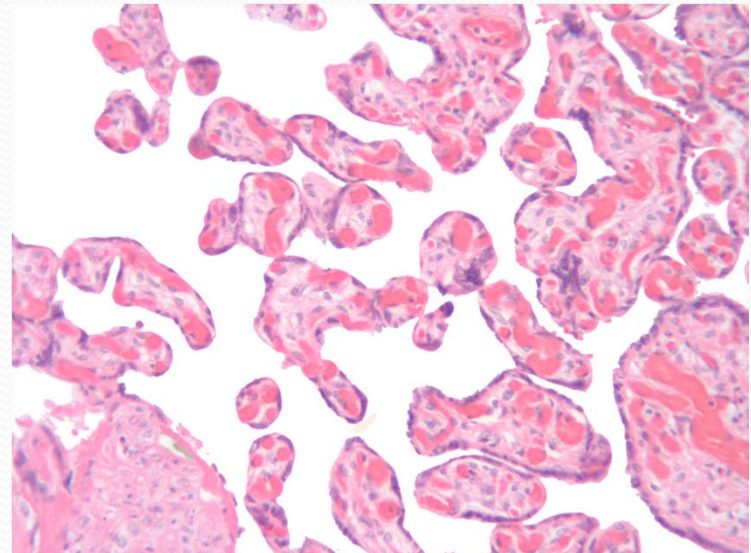
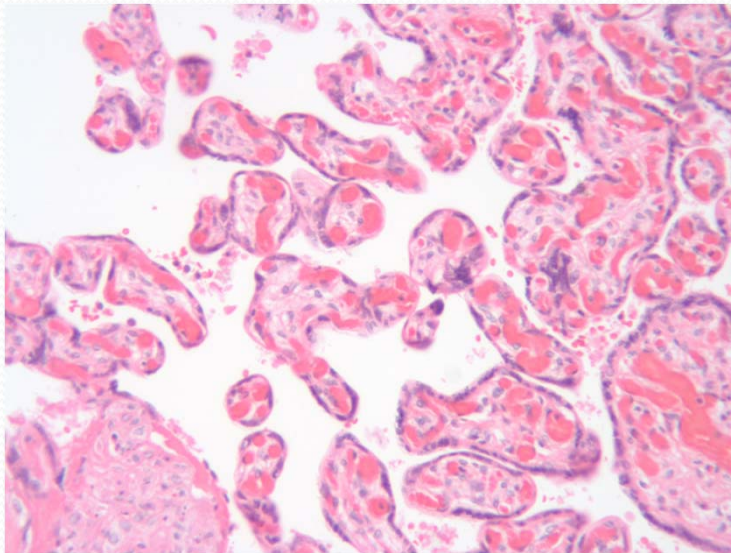
# Problems to fix

- The small ring of pink around the red vessels that lie outside have to be removed.
- An automated way of finding values for pink, red, blue and white pixels.

# End results

In the end, we want our image to go from:

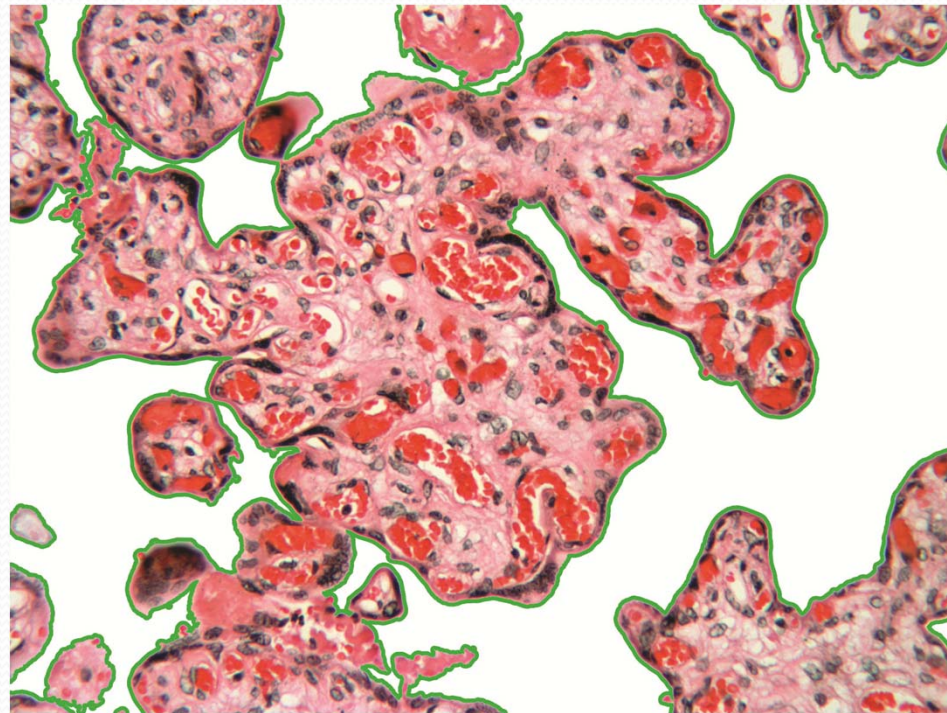
To this:



# Measuring the Villi Shapes

- Measuring the villi shapes will come from calculating the perimeter and area of each color component. Since the true dimensions of the cells are unknown, the perimeter and area will have a pixel dimension.
- These calculations can be done by applying MatLabs perimeter and area calculations to a black and white image.
- In order for the area to have meaning, we will take them as ratios of red to pink, pink to white, and red and pink to white.

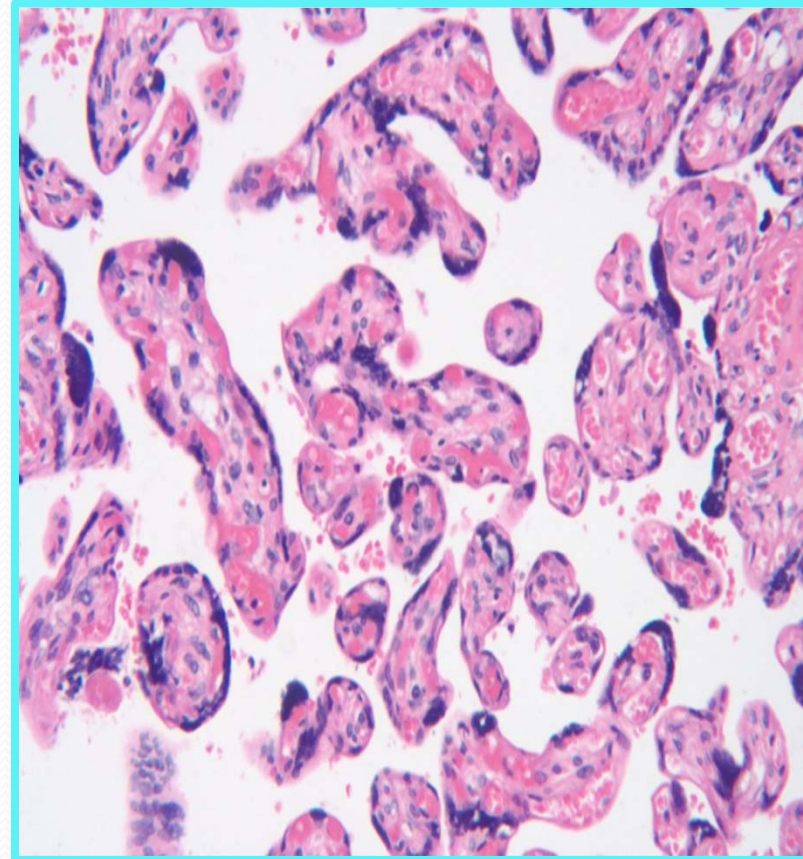
# Area and Perimeter



# Blood Vessel Count

## Work Plan

1. Mark the outline of each blood vessel
2. Segment blood vessels
3. Count the number of blood vessels present after maternal blood cells are deleted



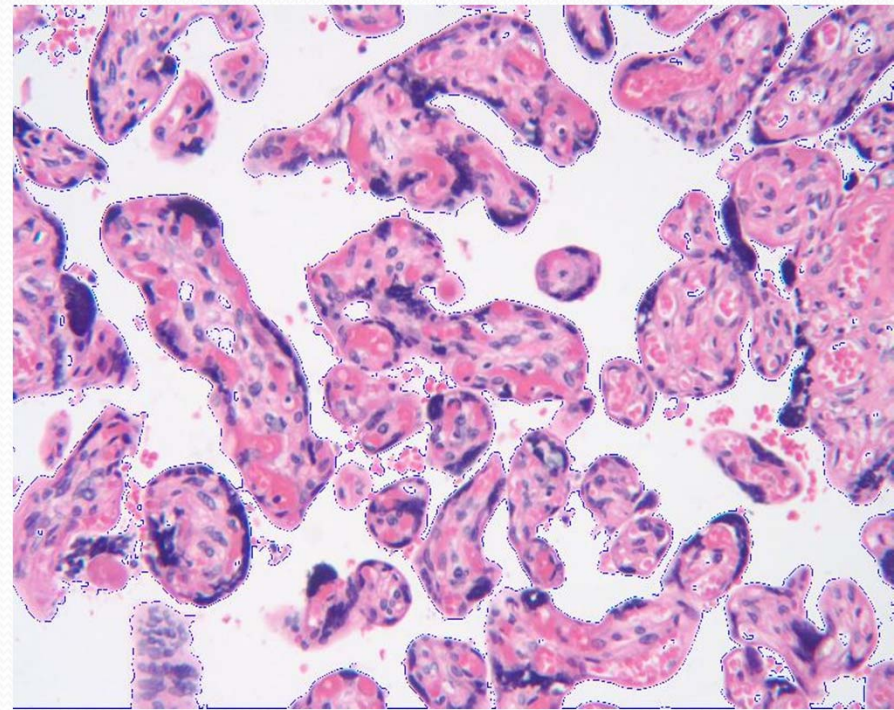
Original

# Blood Vessel Count

- Outline of Blood vessels
  - apply threshold
  - overlay perimeter on the original image



Threshold

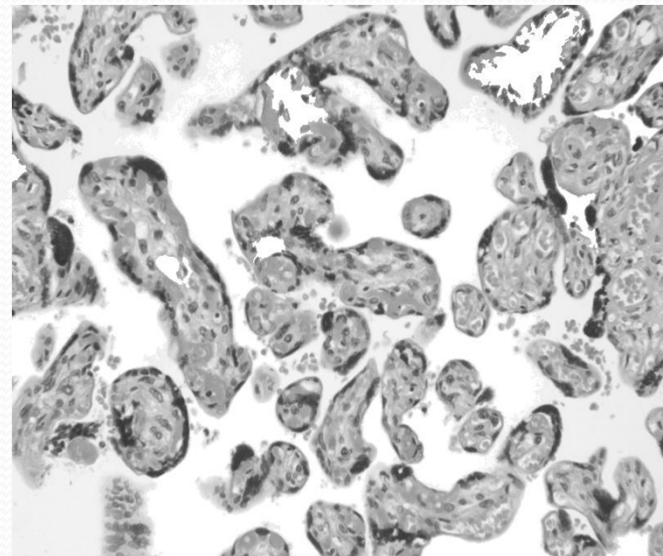
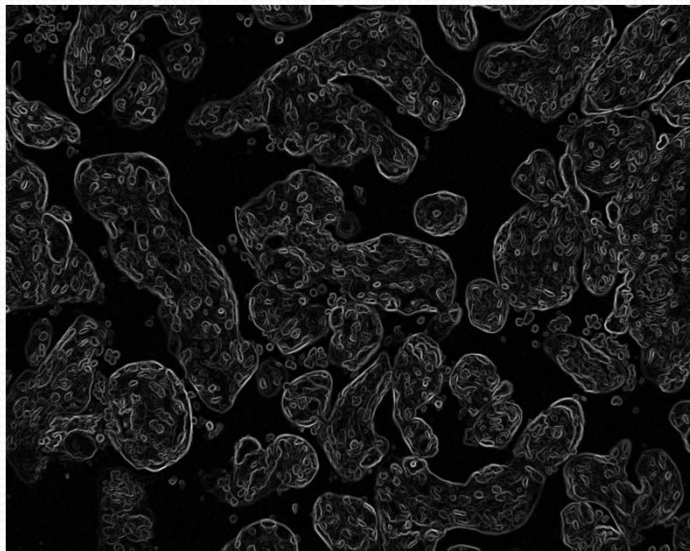


Superimposing perimeter on original

# Blood Vessel Count Cont.

## Marker-Controlled Watershed Segmentation

- Convert to grayscale, compute gradient magnitude and use as segmentation function
- Mark Foreground Objects
  - “opening-by-reconstruction”
  - “closing-by-reconstruction”
  - Obtain foreground markers and superimpose on the original image

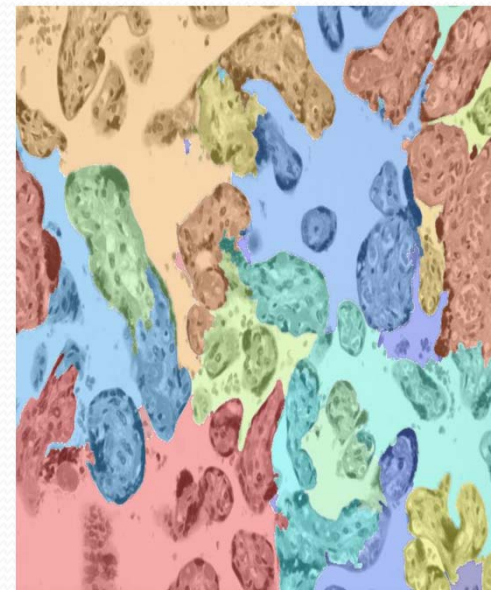
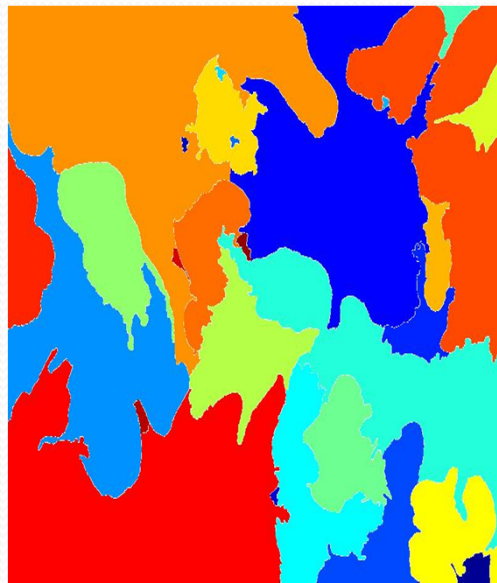
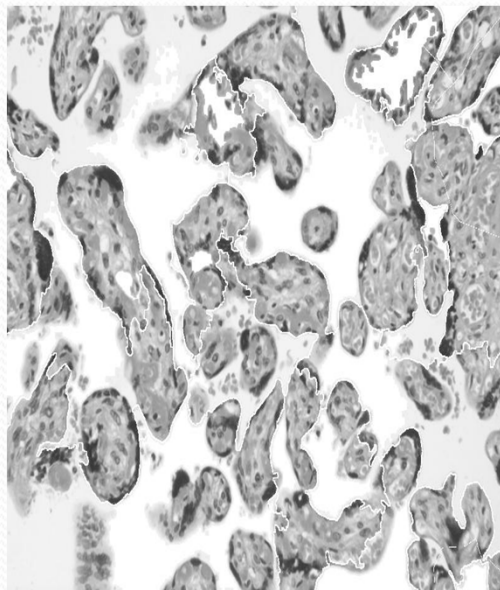


~~Watershed Transform~~



# Blood Vessel Count Cont.

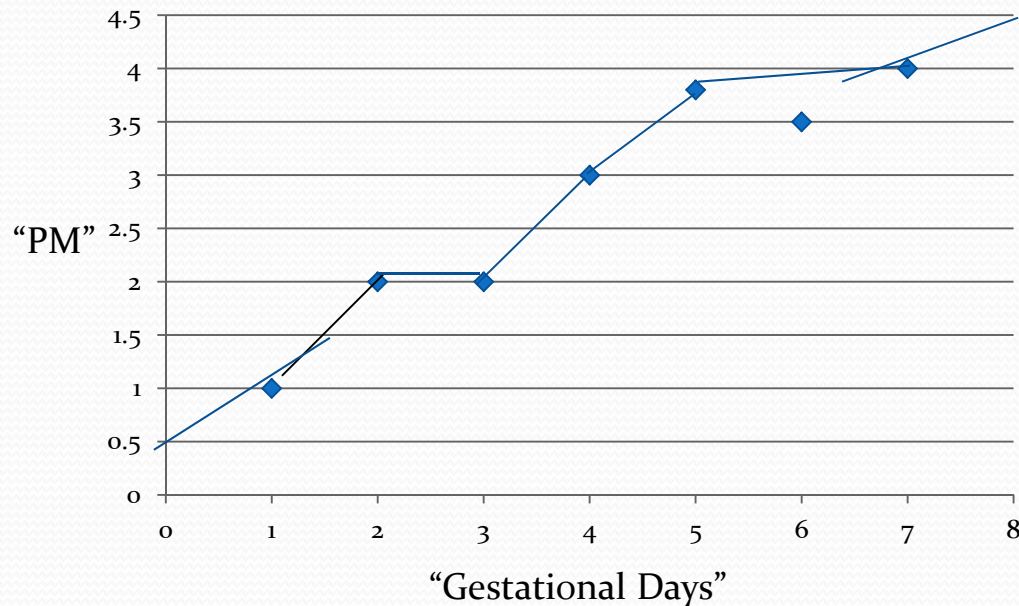
- Compute background markers
- Compute watershed-based transformation
- Superimpose foreground markers, background markers, and segmented boundaries on original image or display the label matrix as a color image or use transparency to superimpose this pseudo-color label matrix on top of the original image



# Data Analysis - Placental Maturity Scale

- Run the isolation, perimeter & area measuring and counting functions on large sample of non-pathological slide images
  - $PM = \#BV/P^2/A$
- Arrange by ascending Gestational Days (GD)
  - Average each variable for same GD
- Each point connected by non-decreasing line segment

# Placental Maturity Scale



- Non-decreasing, slope  $\geq 0$
- Skips points that do not meet condition
- Linear – easily solvable (important in next stage)
- Uses average slope to provide extrapolation at ends

# Placental Maturity Measurement

- Run the isolation, perimeter & area measuring and counting functions on Image X
- Find “height” on PM Scale
  - Solve linear equation for Gestational Day
  - Compare to Image X’s actual gestational days
- Actual/Expected GD Ratio
  - $A/E$  small  $\rightarrow$  Placenta is hypermatured
  - $A/E$  large  $\rightarrow$  Placenta is immature
  - $A/E \approx 1 \rightarrow$  Placenta has developed normally