

# Project #41 - Make Womb

An investigation of vascular  
adaptation to pregnancy

By Jungwoo Han and Daniel Zang

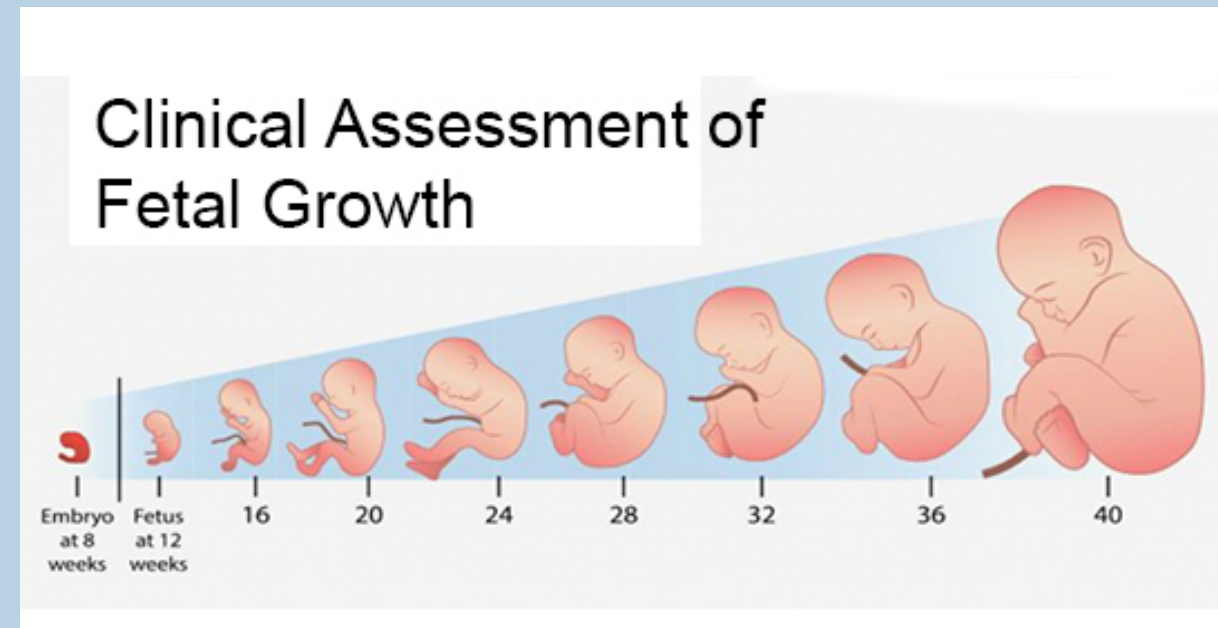
# Healthy Fetal Development

## Factors of Healthy Fetal Growth

- Oxygen and Nutrient
- Blood flow

## Uterine Arteries

- Spiral
- Arcuate
- Radial



Source: <https://www.glowm.com/article/heading/vol-5--surveillance-of-fetal-wellbeing--clinical-assessment-of-fetal-growth/id/411383>



Source: <https://journals.physiology.org/doi/full/10.1152/physiol.00033.2016>

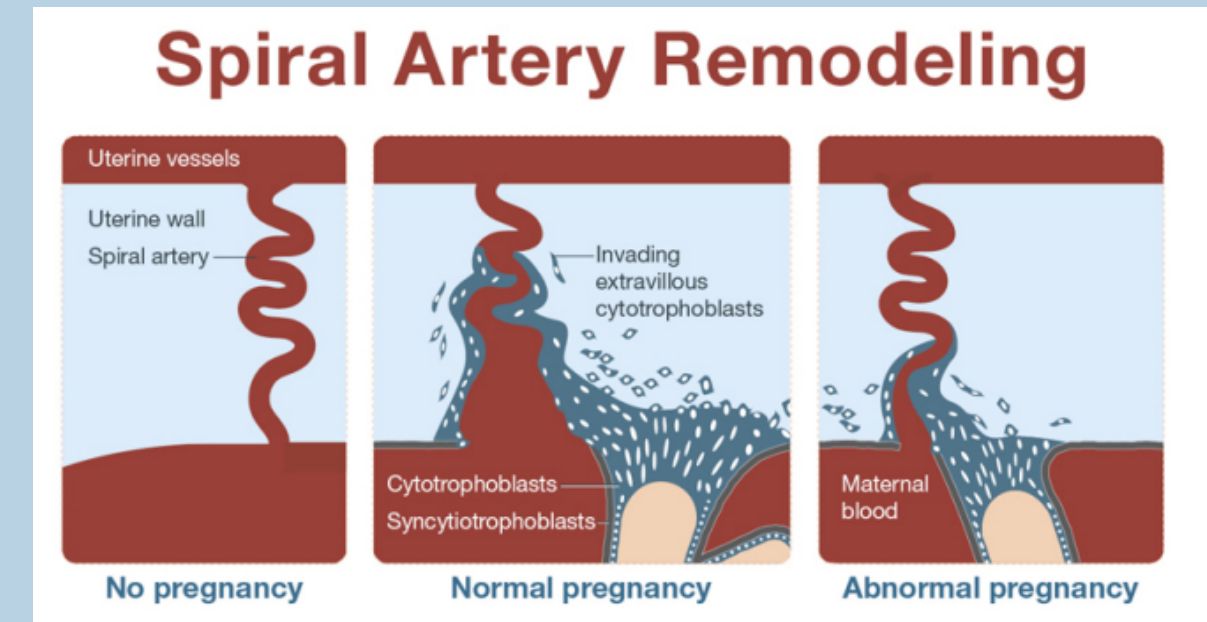
# What is the Problem?

## Fetal Growth Restriction

- Affects approximately 10% of all pregnancies
- Lack of early detection methods
- Can severely impact quality of life

## What can go wrong?

- Inconsistent blood flow
- Improper remodeling of blood arteries

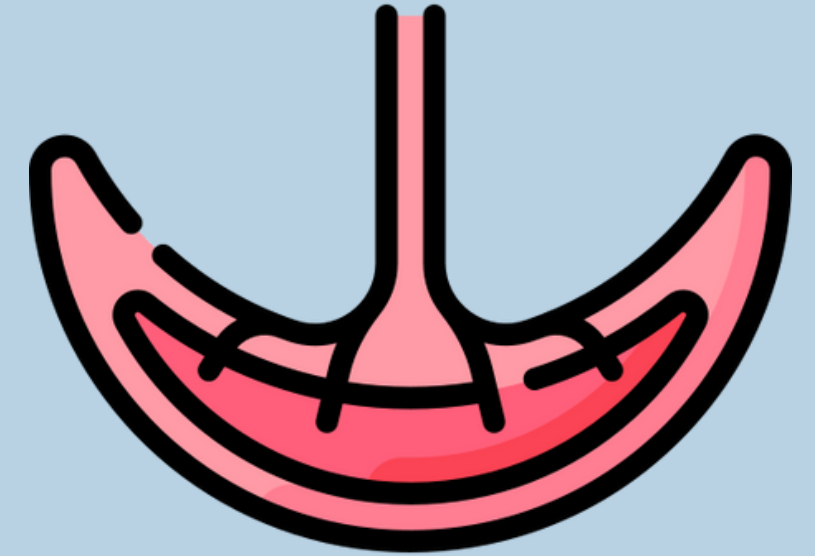


Source: <https://www.nichd.nih.gov/research/supported/human-placenta-project/how-does-placenta-form>

# Background Information

## Boyd Collection

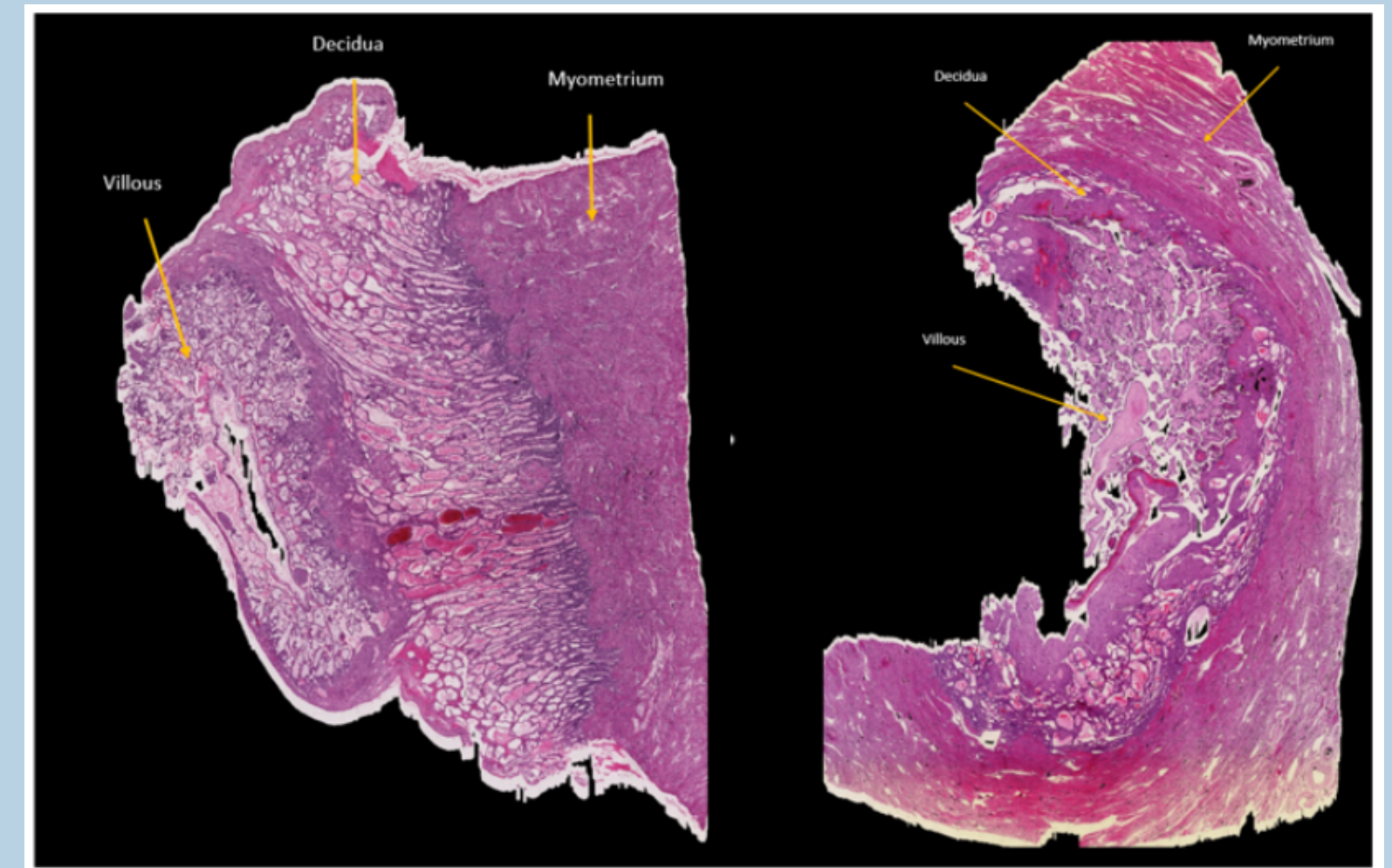
- Developed in 1950s and 1960s
- Two categories of samples
  - placenta-in-situ specimens
  - isolated placental specimens
- Difficulties with working with these specimen



# Background Information

## Placenta Anatomy

- Myometrium
  - Smooth muscular layer with dark red paths that is dense of tissue.
- Decidua
  - Appears pink or red
  - The white areas are tissues with glands.
- Villous
  - Finger-like projections





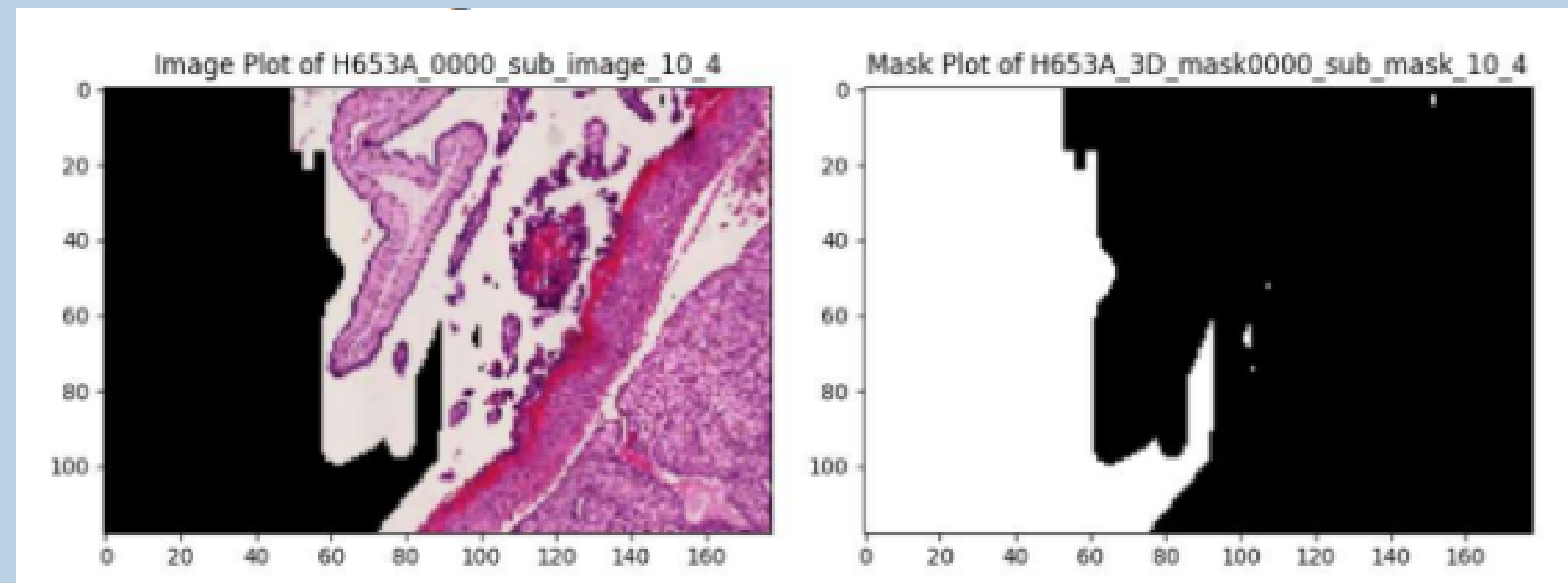
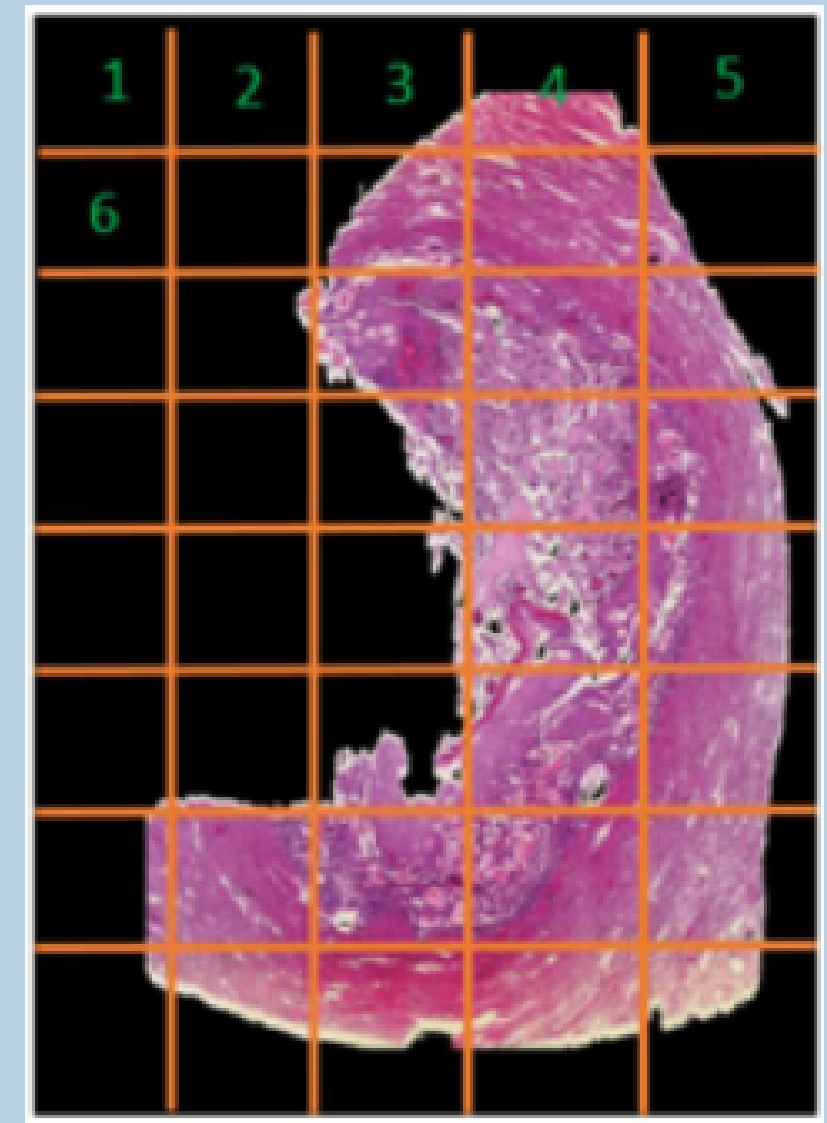
# Two Different Approaches

01. Machine Learning

02. Image Analysis

# Pre-process Images

- Filtering unused images
- Splitting into sub-images
  - 1424 by 2006 pixels
  - 118 pixels height, 178 pixels width
  - 800 -> 2440 Sub-Images
- Remove all black images



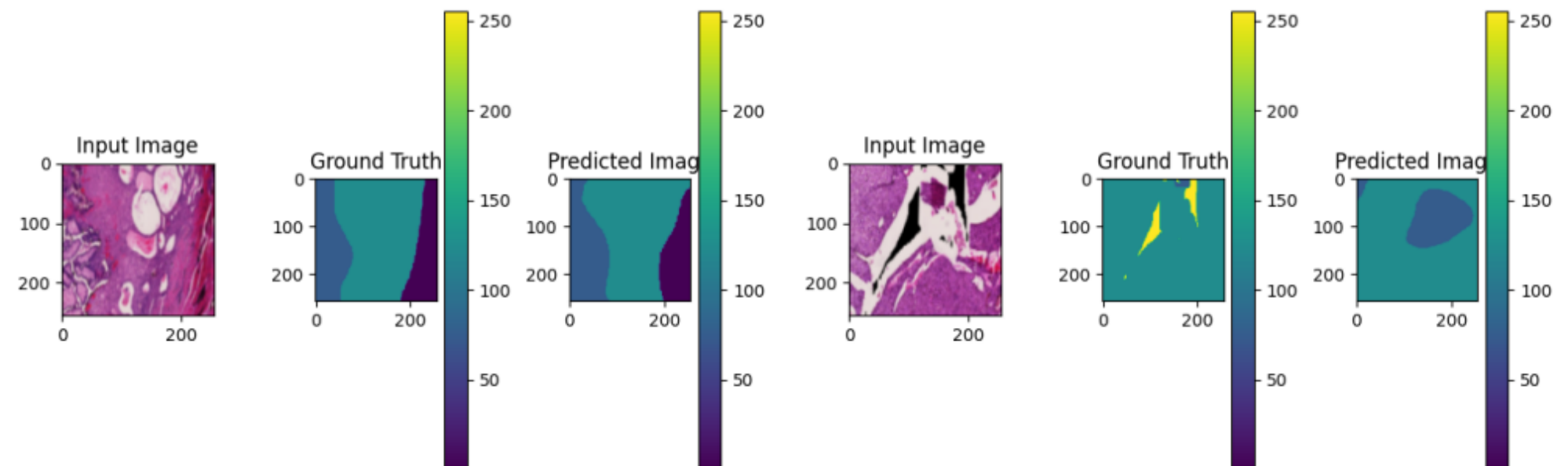
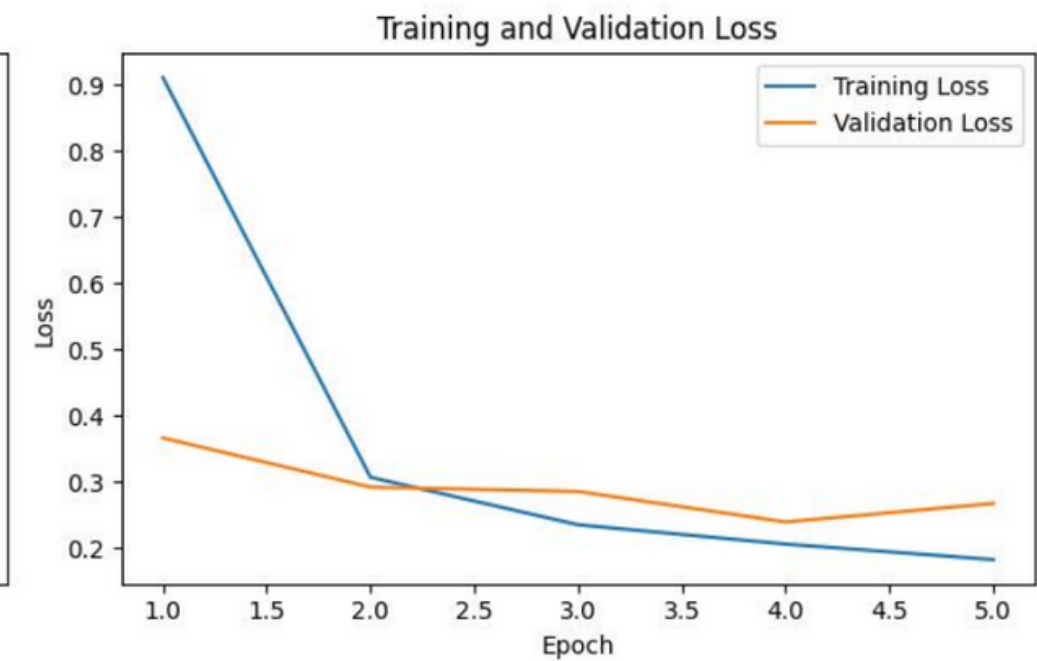
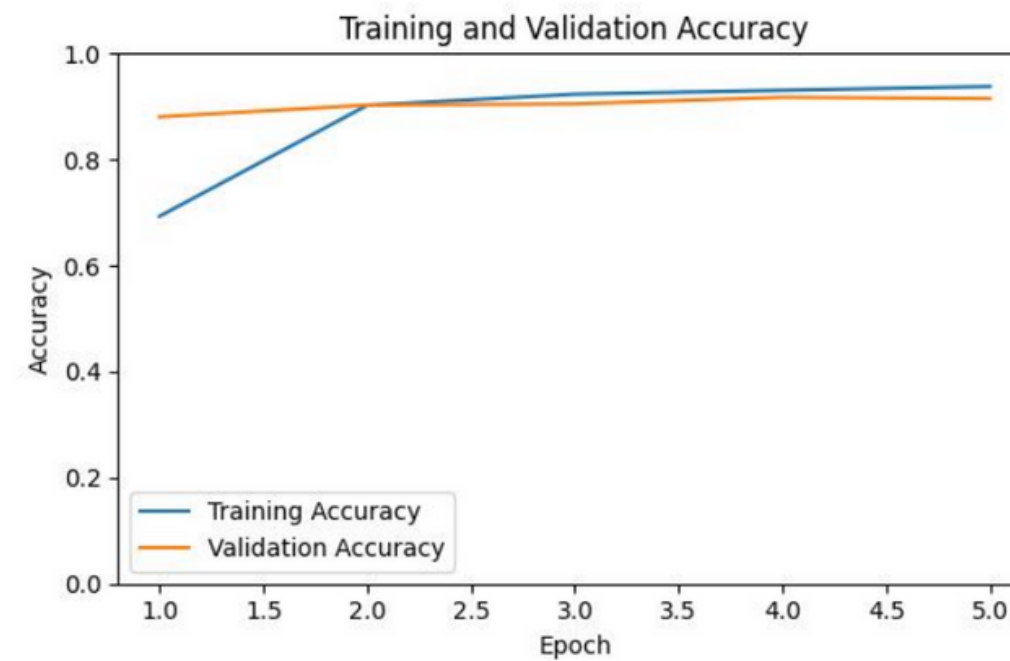
# Machine Learning

- Split images into a train, test, validation set
  - Model Architecture
    - U-Net
  - Model Task
    - Pixel-wise Segmentation
  - Models Trained
  - Optimization
    - Early Callbacks
    - Validation Loss
  - Visualization
- ResNet152V2
  - DenseNet121
  - VGG16
  - VGG19
  - NASNETMobile
  - DenseNet201
  - MobileNetV2



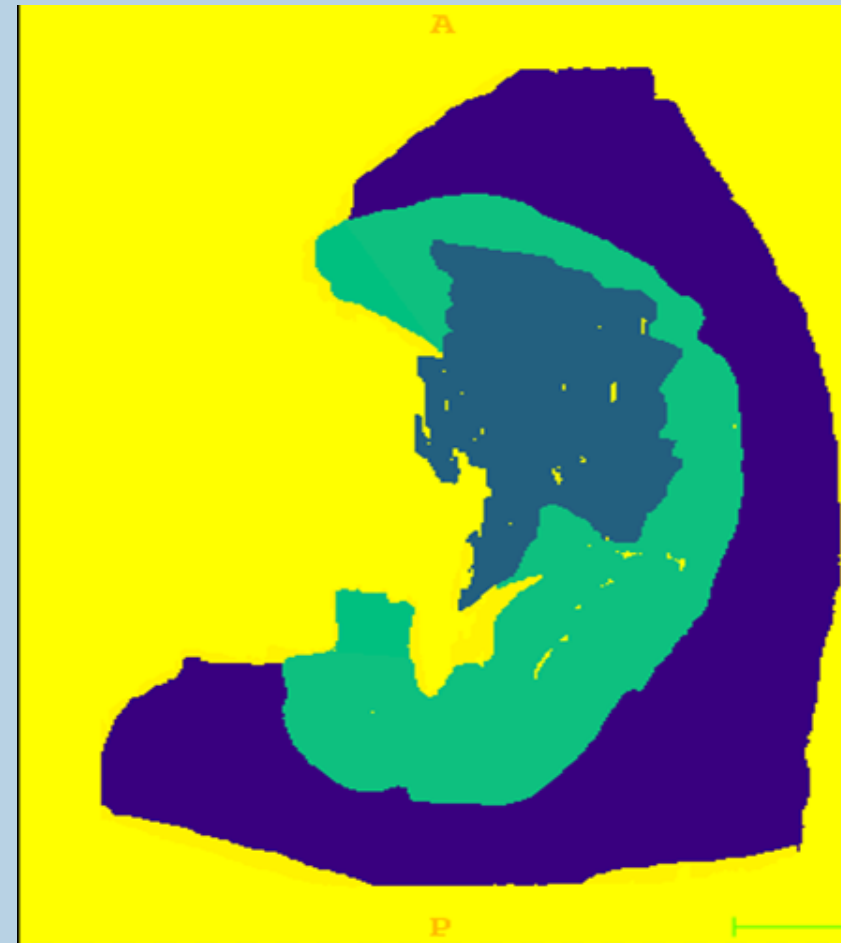
# Machine Learning Results

- Best Model and Performance
  - DenseNet201
  - Acc: 0.9115
  - Loss: 0.2398
  - Valid\_loss: 0.2150
- Optimization
  - Max\_Epochs: 5
  - Validation loss
  - None of the models
  - improved after 5 epochs
- Predictions
  - Good and Bad

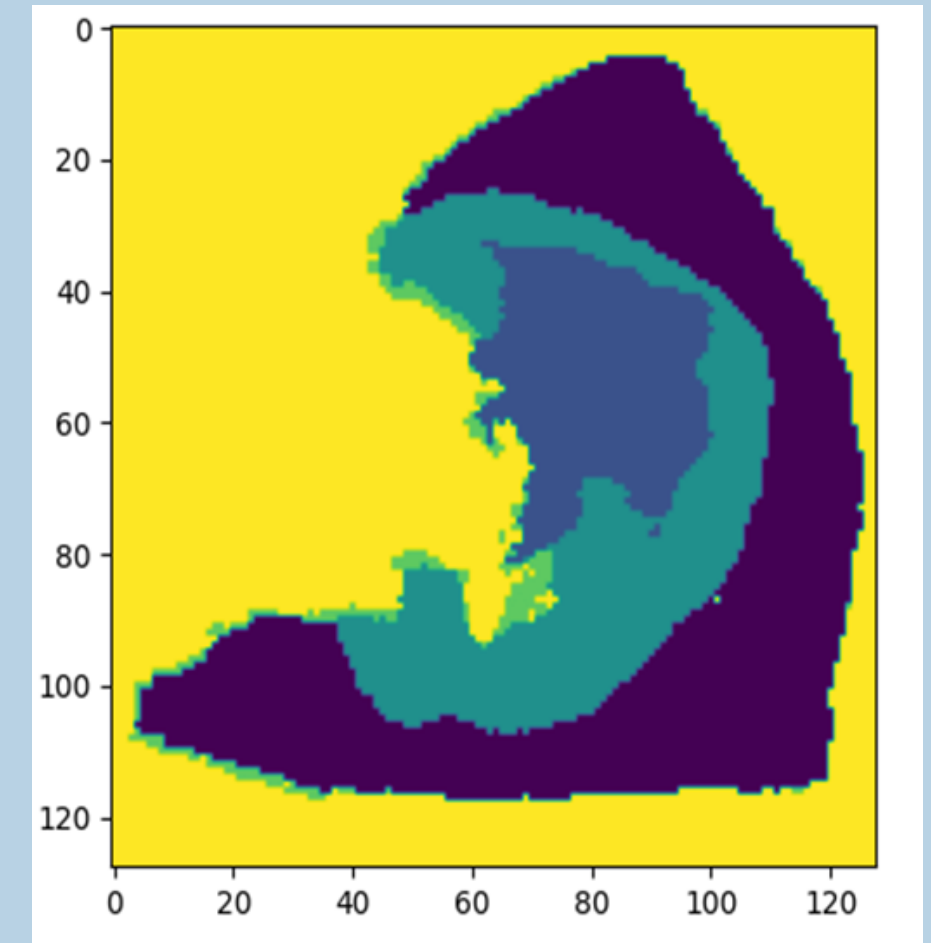


# Model prediction results

- 98% Training accuracy
- 96% Validation accuracy
- 6% Training loss
- 12% Validation loss
- Trained as whole images
- U-Net architecture
- Trained in batches of 4
- 20 training samples
- 5 steps per epoch



Original Mask (Truth)



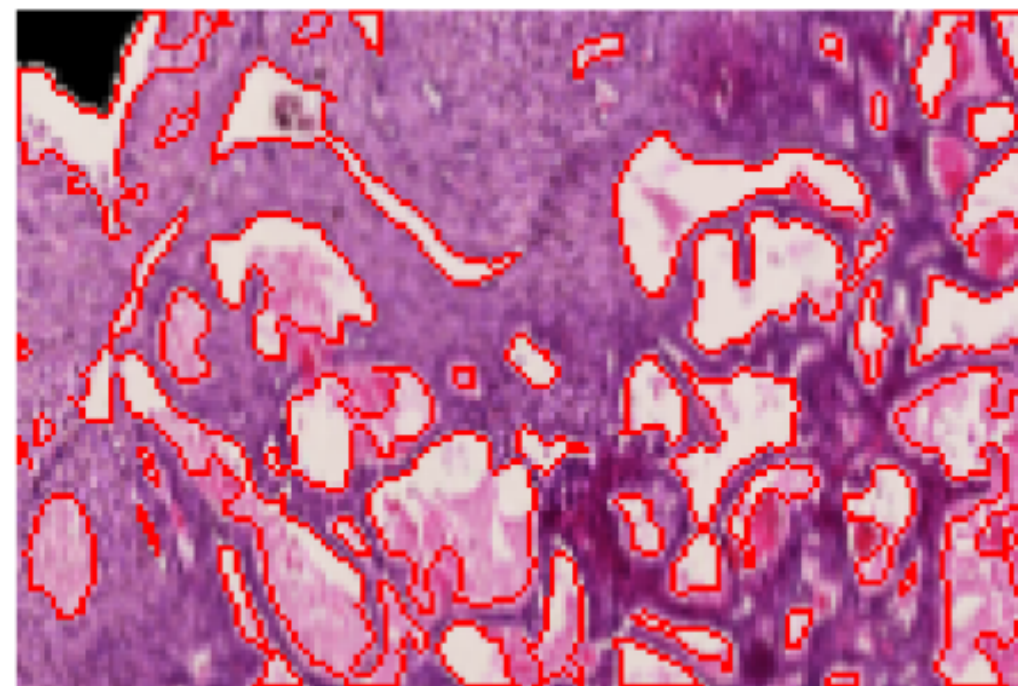
Model prediction

# Image Analysis

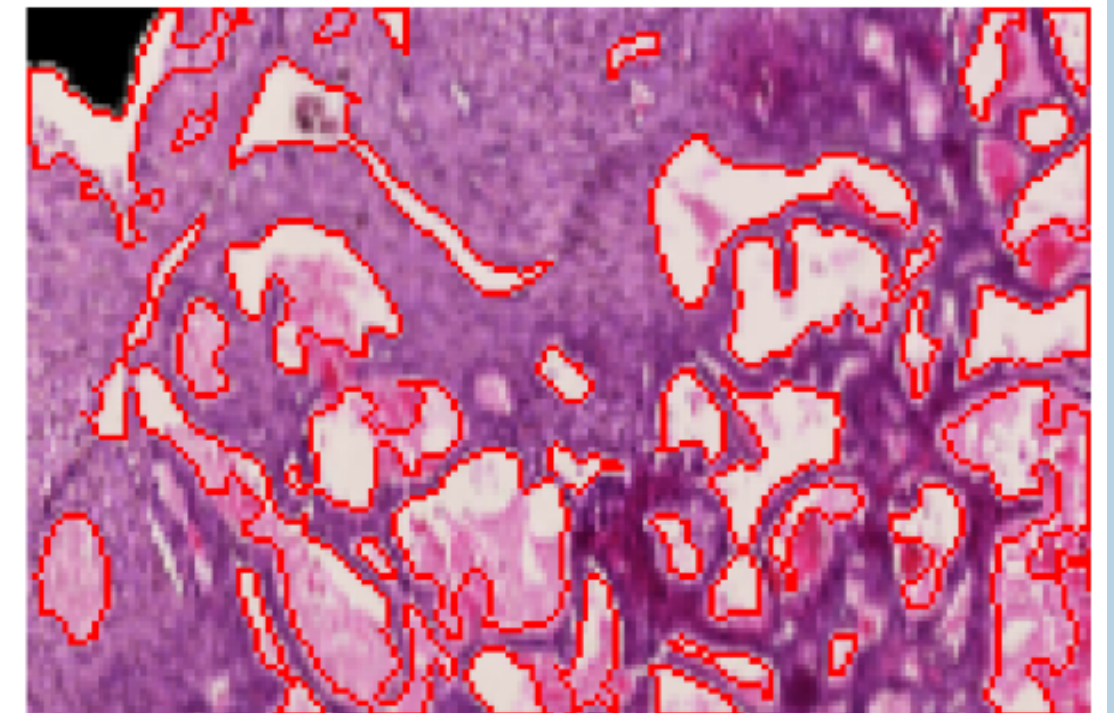
- ImageJ
  - Why it wasn't used
- Python - Sci-kit image analysis
- Edge detection
  - Canny edge detection
  - Sobel filters
- Method
  - Gaussian blur
  - Thresholding
  - Removal of noise
- Drawing edges

# Image Analysis Results

- Parameter choice for Noise removal
- Results
- What could be improved



(a) Weak Noise Remover



(b) Aggressive Noise Remover

# Future Work

- Machine learning
  - More images for more datapoints
  - Images from other gestation weeks
- Image Analysis
  - Incorporate image with edges drawn into a ML model

# Conclusion

- Machine learning
  - Developed a ML model that is able to predict regions of placenta, pixel-wise.
- Image Analysis
  - Developed a script that can identify blood vessels and glands.