



# Medical Image Computing

## Lecture 1

# Waqas Sultani

Assistant Professor, Computer Science Department  
Information Technology University, Lahore

<https://waqassultani.github.io/>



# Who Am I? – Education



- Ph.D. Computer Vision, 2017
  - Center for Research in Computer Vision , University of Central Florida, USA
  - Advisor: Dr. Mubarak Shah
  - 6<sup>th</sup> Best Computer Vision Research Group in US
- MS. Computer Engineering, 2010
  - Perception and Intelligence Lab , Seoul National Unveristy, South Korea
  - Advisor: Jin Young Choi
  - South Korea's No.1 University
- BS, Electrical Engineering, 2006
  - University of Engineering and Technology, Taxila, Pakistan



# Who Am I? – Positions

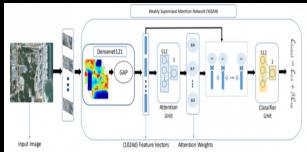


- Assistant Professor, Computer Science , 2018-Present
  - Member of Intelligent Machine Lab
  - Head of MedAI Research Group
  - Currently Supervising around 10 MS students and Co-Supervising 4 PhD Students
- Xerox, Webster, NewYork
  - Computer Vision Summer Intern
  - Worked on Developing Elementray School students monitoring system
  - 2 US patents granted
- Graduate Research Assistant
- Advanced Engineering Organization, Pakistan
  - System Design Engineer.

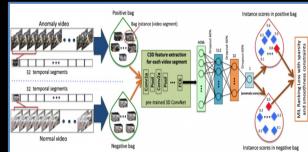


# Research Areas

## Weakly Supervised Classification

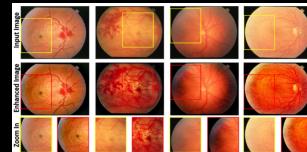


JPR 2020



CVPR 2018

## Medical Image Analysis



MCCAII 2020

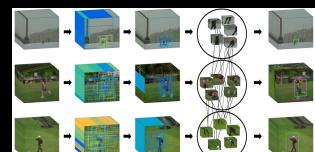


CMB 2021

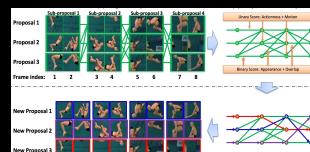
## UAV Analysis



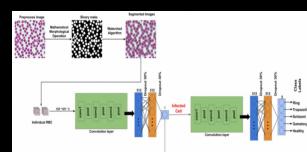
CVPR 2021



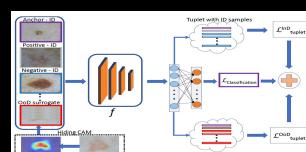
CVIU 2017



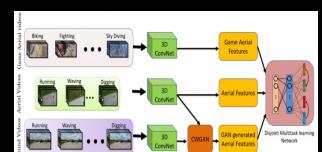
CVIU 2017



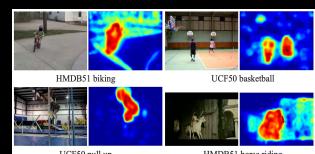
FaceBook AI  
CV4GC Research Grant, 2019



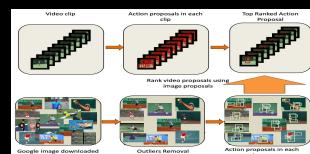
OOD, 2021



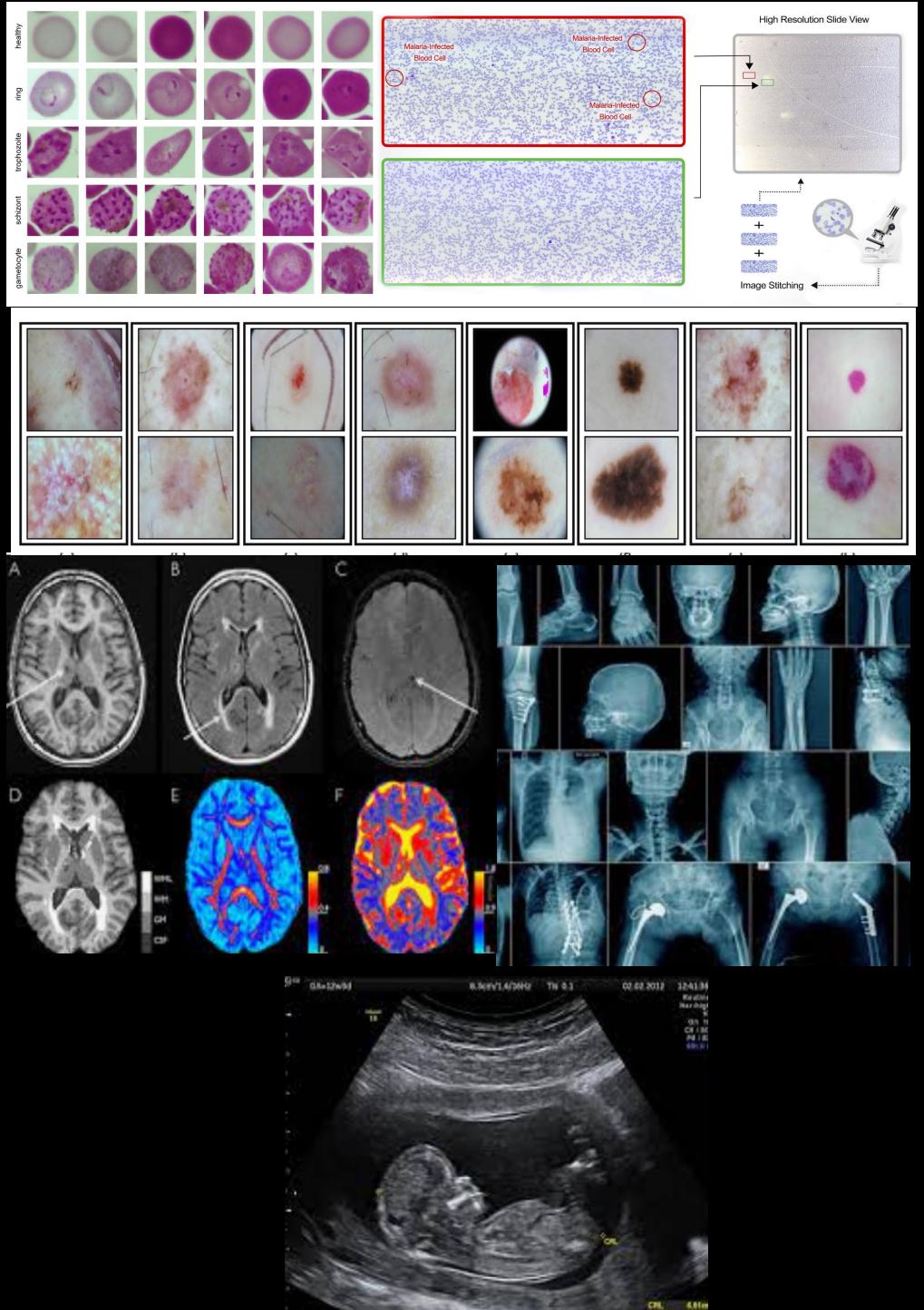
CVIU 2021



CVPR 2014



CVPR 2016



- Lectures
- Wed/Friday 7.15 to 8.45 pm
- Office hours
  - Appointment through email  
Email: [waqas.sultani@itu.edu.pk](mailto:waqas.sultani@itu.edu.pk),  
MIC\_
  - Email of TA: [syed.javed@itu.edu.pk](mailto:syed.javed@itu.edu.pk)

# Course Information

Course work:

Assignments	30
Quizzes	10
Mid term exam	20
Final Exam	20
Project	20
Total	100

You are allowed to verbally discuss the assignments etc. However, you must write the answer completely on your own.

**Do not share written solutions or partial  
solutions with other students.**

# Introduction

- In developing countries, people observe poor health facilities due to three main reasons: unavailability of expensive medical instruments, lack of doctors who can spend sufficient time to analyse the outcome of those instruments and digitized data.
- According to the statistics of World Health Organization, there are 0.58, 0.86, 0.98, and 1.98 physicians available for 1000 people in Bangladesh, India, Pakistan, and China, respectively.
- With the help of automated image analysis techniques, disease diagnosis will be easier/faster, and more accurate.

# Introduction

- Imaging sciences is experiencing a tremendous growth in the World
- The global medical imaging market size was \$33.69 billion in 2019 & is projected to reach \$43.33 billion by 2027, exhibiting a CAGR of 5.1% in the forecast period.
- Products are not easy to get approved

# Introduction

- Biomedical imaging and its analysis are fundamental to (1) understanding, (2) visualizing, and (3) quantifying information.
- This course will mostly focus on analysis of biomedical images, and imaging part will be briefly taught!

Machine Learning/  
Deep learning

Medical Image  
Computing

Computer Vision

Imaging Sciences  
(Radiology etc.)

Image Processing

# Biomedical Images

- (Bio)medical images are different from other pictures
  - They depict distributions of various physical features measured from the human body (or animal).
- Analysis of biomedical images is guided by very specific expectations
  - Automatic detection of tumours, characterizing their types,
  - Measurement of normal/abnormal structures,
  - Visualization of anatomy, surgery guidance, therapy planning,
  - Exploring relationship between clinical, genomic, and imaging based markers

# Conference Journals and Patents

## Conference

- Fixed paper submission deadline
- Fixed review time, Paper will get accepted or rejected in less time
- Single or double blind
- Meeting up
- Collaborations

## Journal

- No Fixed paper submission deadline
- Not fixed review time, Paper may not get accepted or rejected in less time
- Single blind
- No Meeting up

# Conference Journals and Patents

## Patent

- Ideas which can generate Money
- Need to file patent for idea, you need to pay money to get a patent
- If some company use your patented idea, it will pay you the money
- If some company use your patented idea without letting you know, you can go to the court for this.

# Conference and Journals

The top-tier conferences (**double blind**, acceptance rates are below 25%, high quality technical articles):

- **MICCAI** (medical image computing & computer assisted intervention)
  - **IPMI** (Information Processing in Medical Imaging)
  - Other conferences: IEEE ISBI, EMBC and SPIE Med Imaging
  - Clinical Conferences: RSNA (>65.000 attendances), ISMRM, SNM
- 
- The top-tier technical journals:
    - IEEE TMI, TBME, PAMI, and TIP
    - Medical Image Analysis, CMIG, and NeuroImage
  - The top-tier clinical journals relevant to MIC:
    - Radiology, Journal of Nuclear Medicine, AJR, Nature Methods, Nature Medicine, PlosOne, ...

# Examples/Applications

# Automatic Malaria Detection

## ITU Faculty Wins Facebook's CV4GC Research Award

Co-PIs: Dr. Mohsen Ali and Dr. Arif Mehmood

Faculty of Computer Science  
(associated with Intelligent Machine Lab)



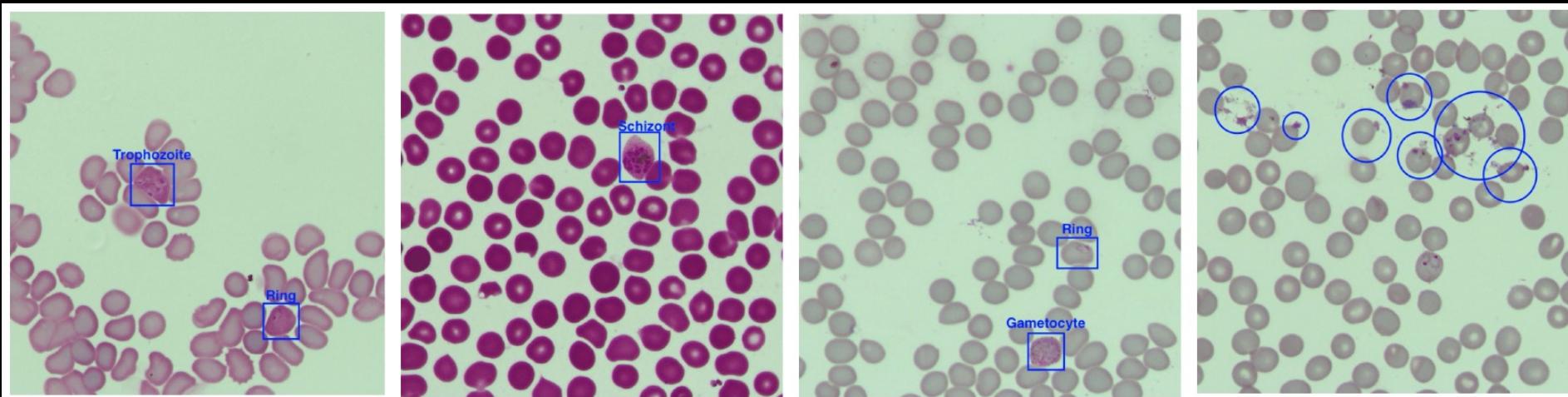
Dr. Waqas Sultani  
Principal Investigator



- There are more than 3,000 species of mosquitoes
- Out of 400 species of the Anopheles mosquito only 60 species carry plasmodium, a parasite that causes malaria
- According to the World Health Organization, only in 2018, 228 million cases of malaria occurred worldwide and there were 405,000 deaths globally due to malaria



- There are more than 3,000 species of mosquitoes
- Out of 400 species of the Anopheles mosquito only 60 species carry plasmodium, a parasite that causes malaria
- According to the World Health Organization, only in 2018, **228 million** cases of malaria occurred worldwide and there were **405,000** deaths globally due to malaria

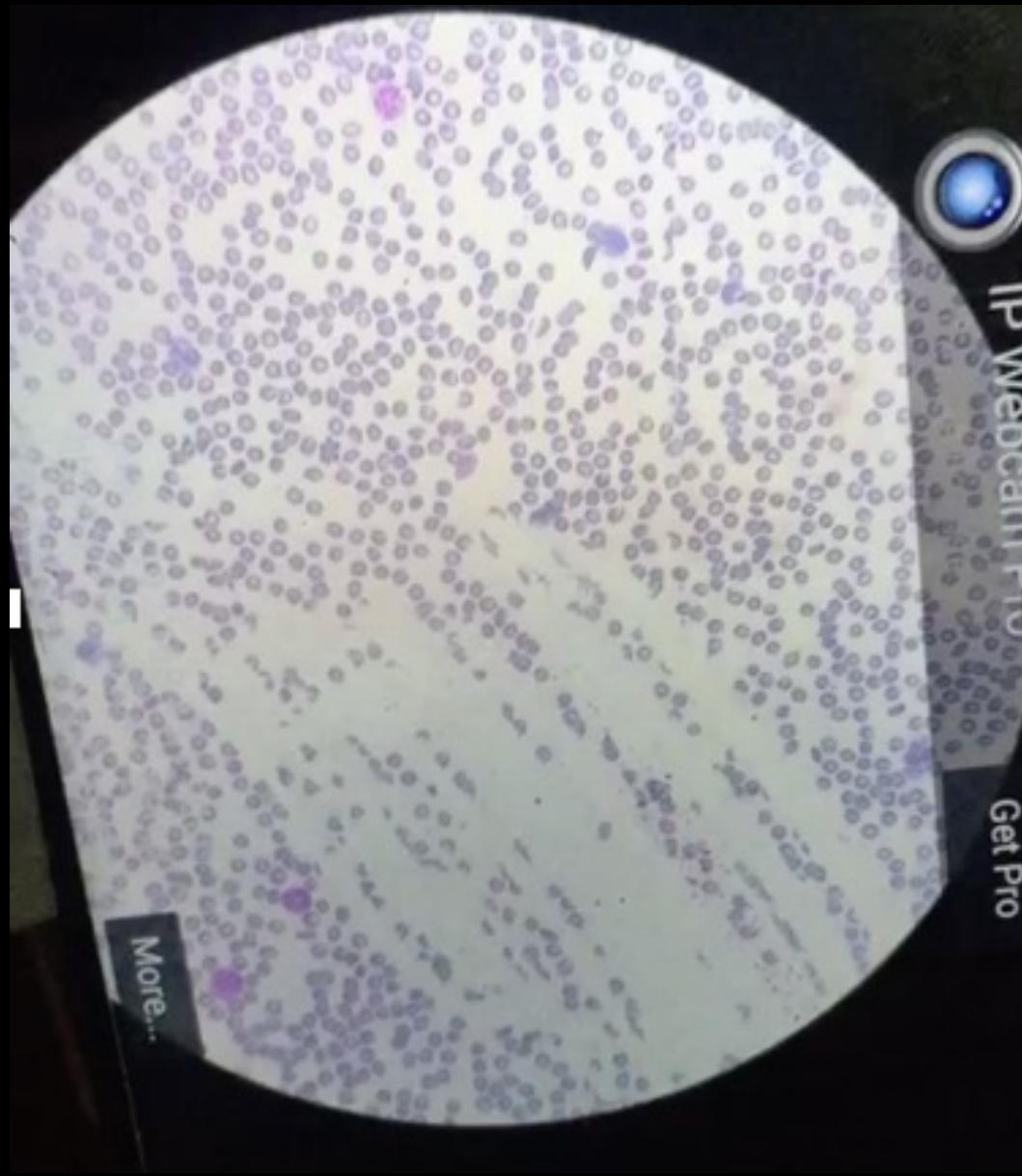




**100x**



More...



400x

IP Webcam Pro

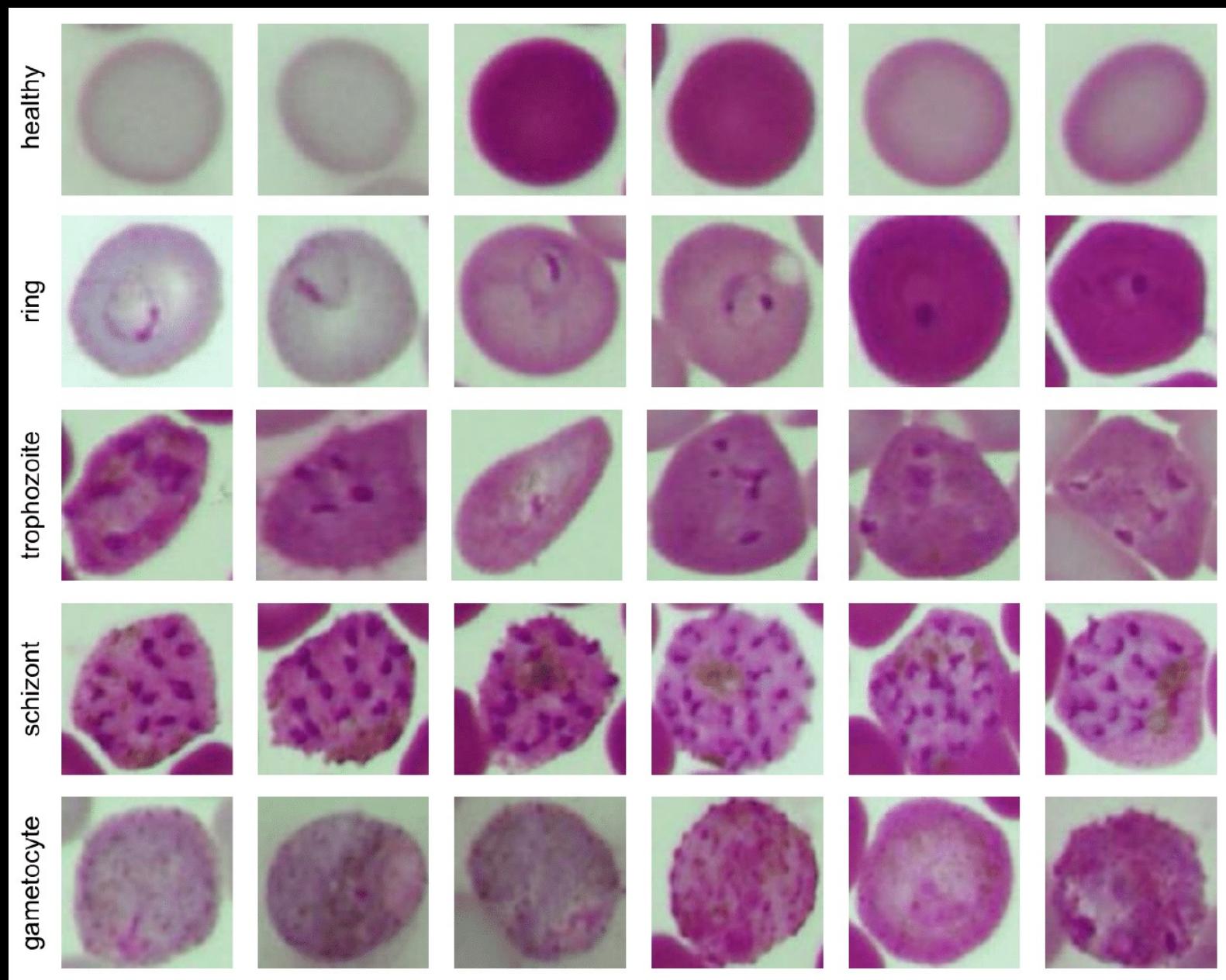
Get Pro

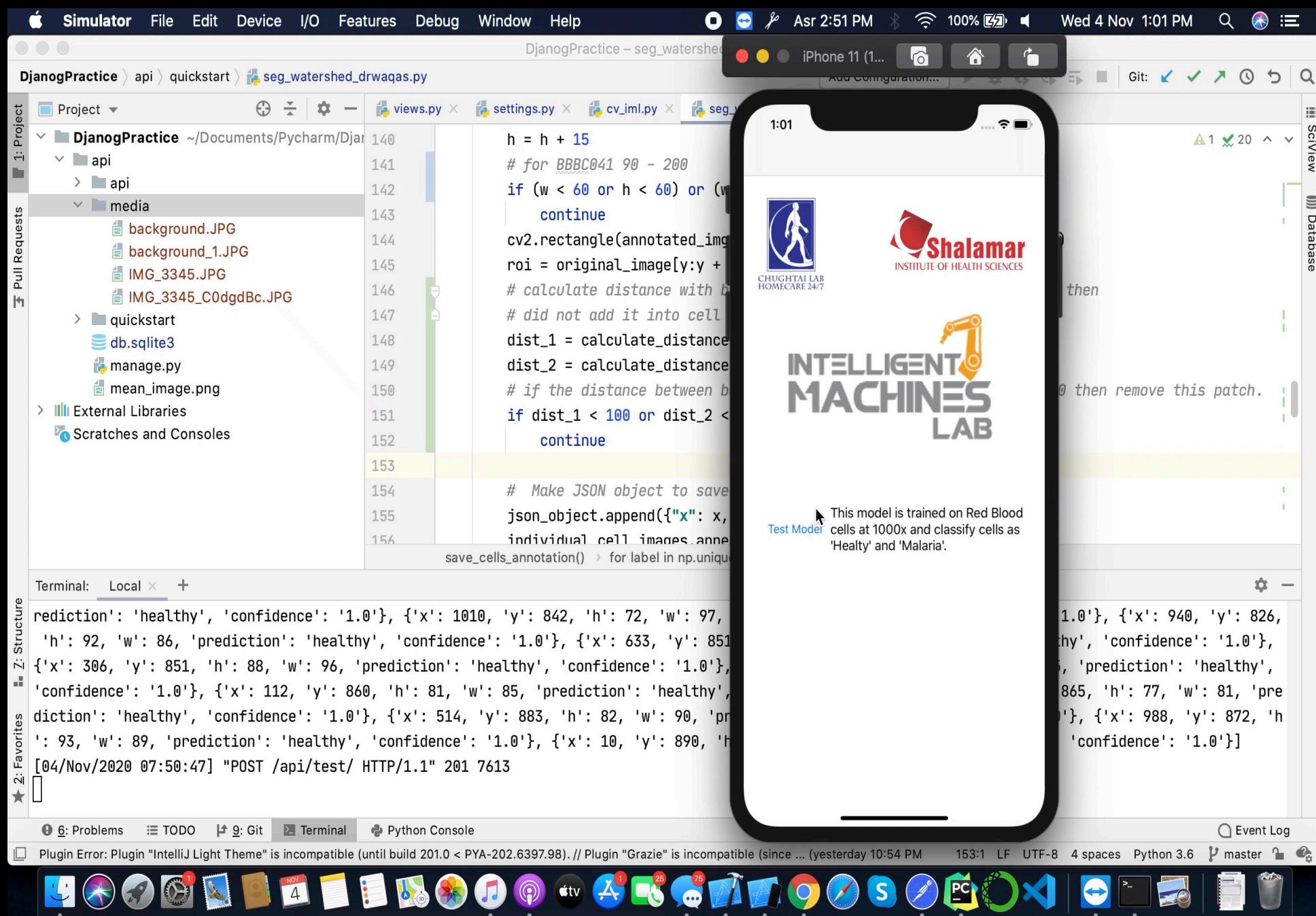
More...

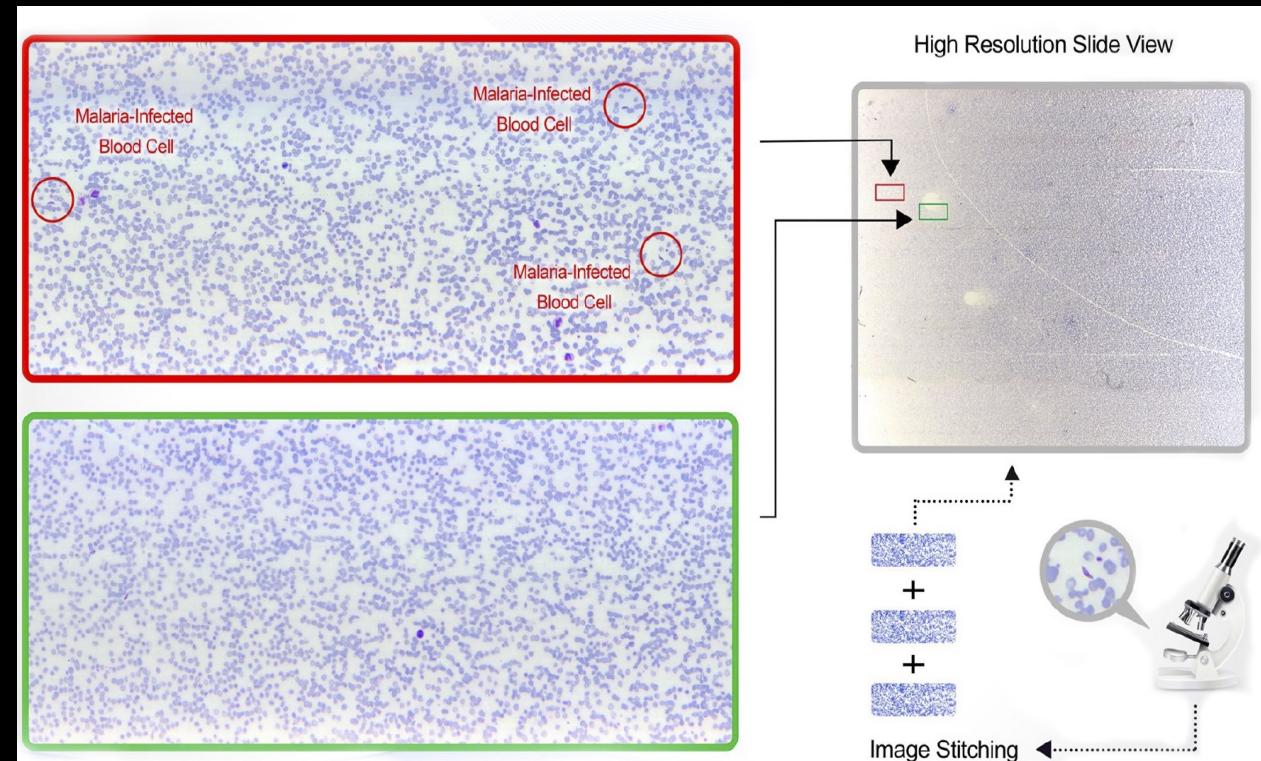
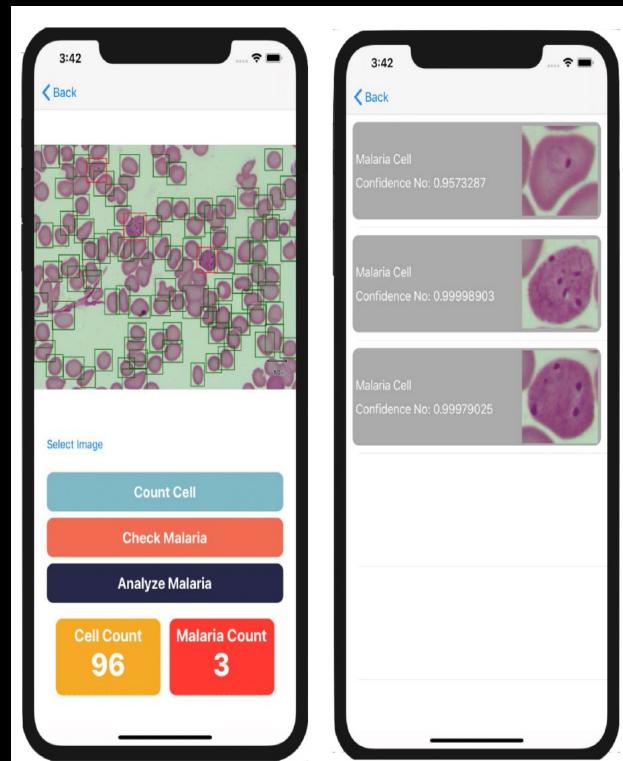


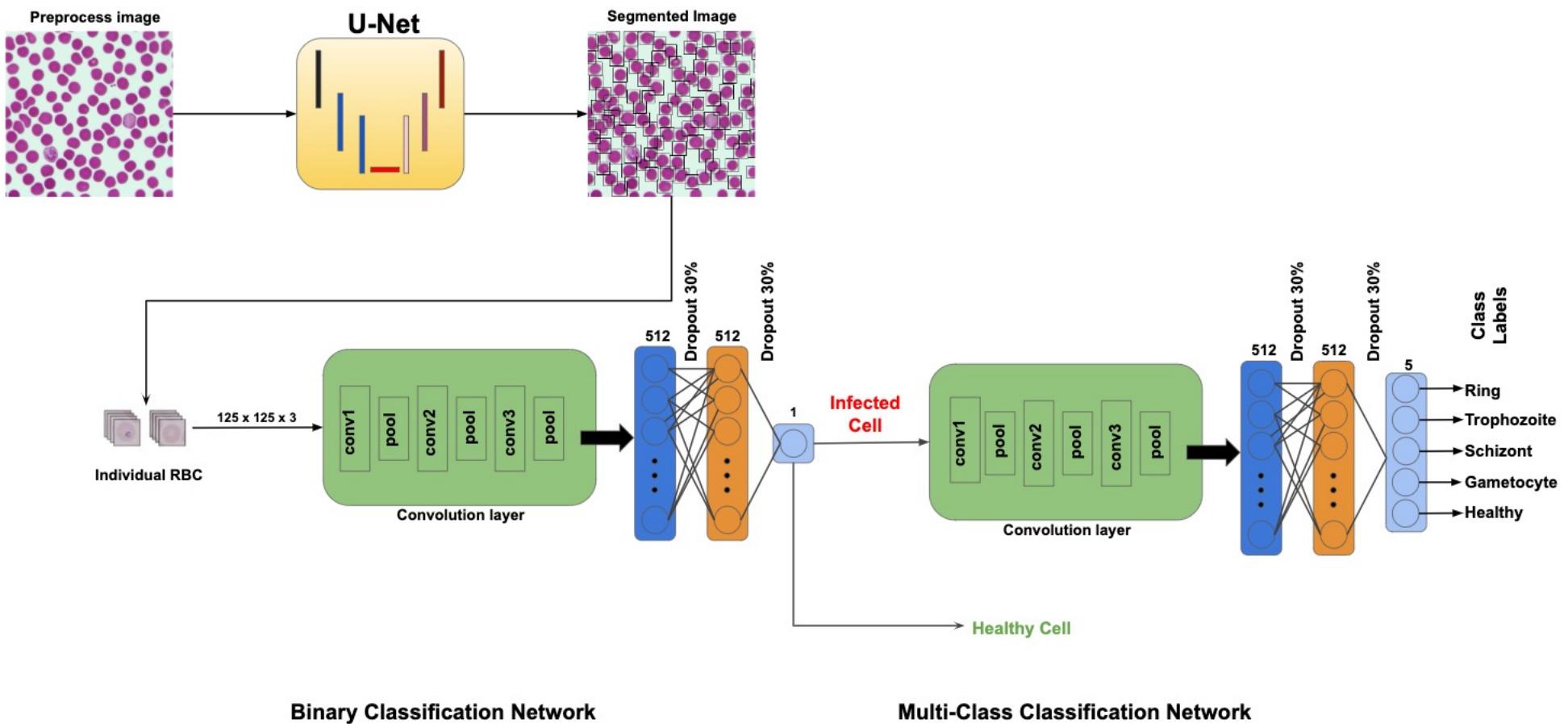
1000x

More...





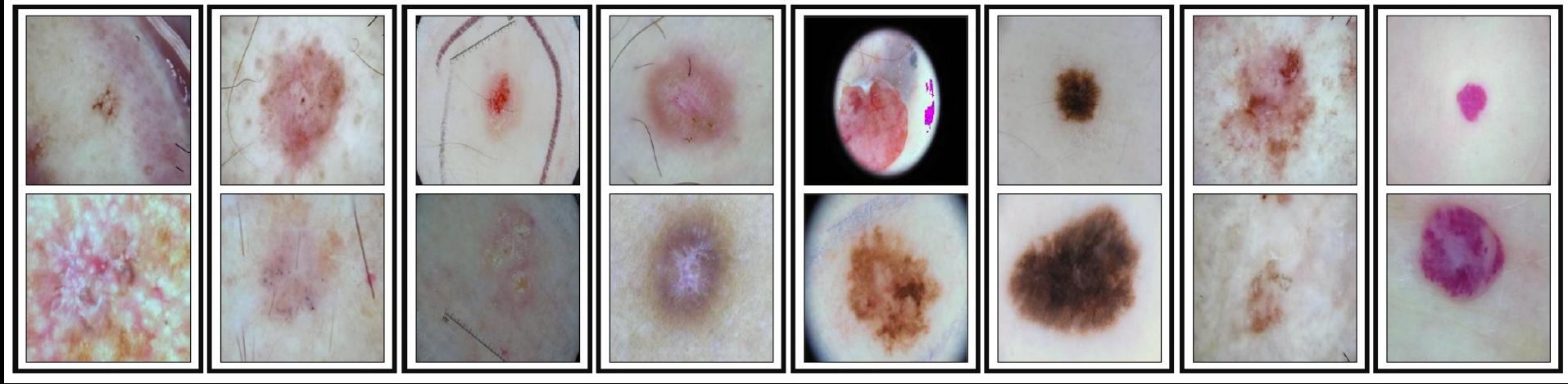




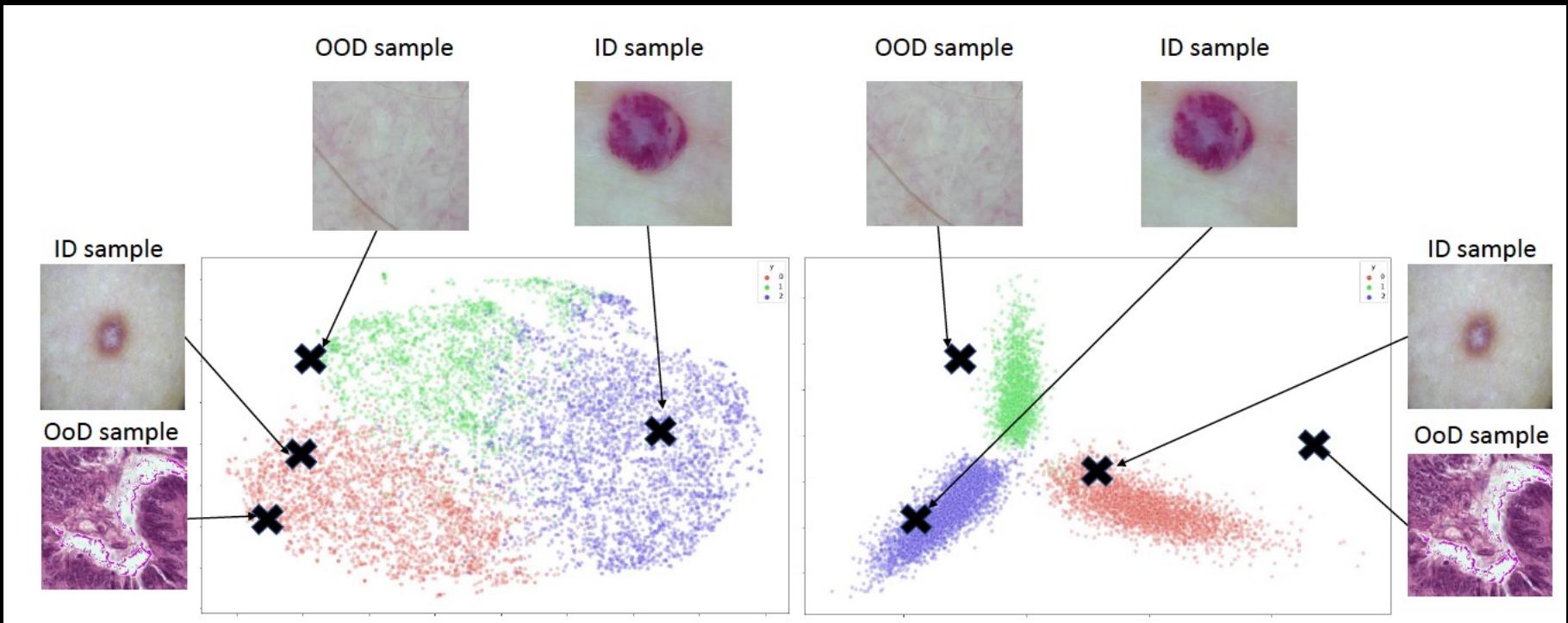
# Out of Distribution Detection in Malaria and Skin Cancer Images

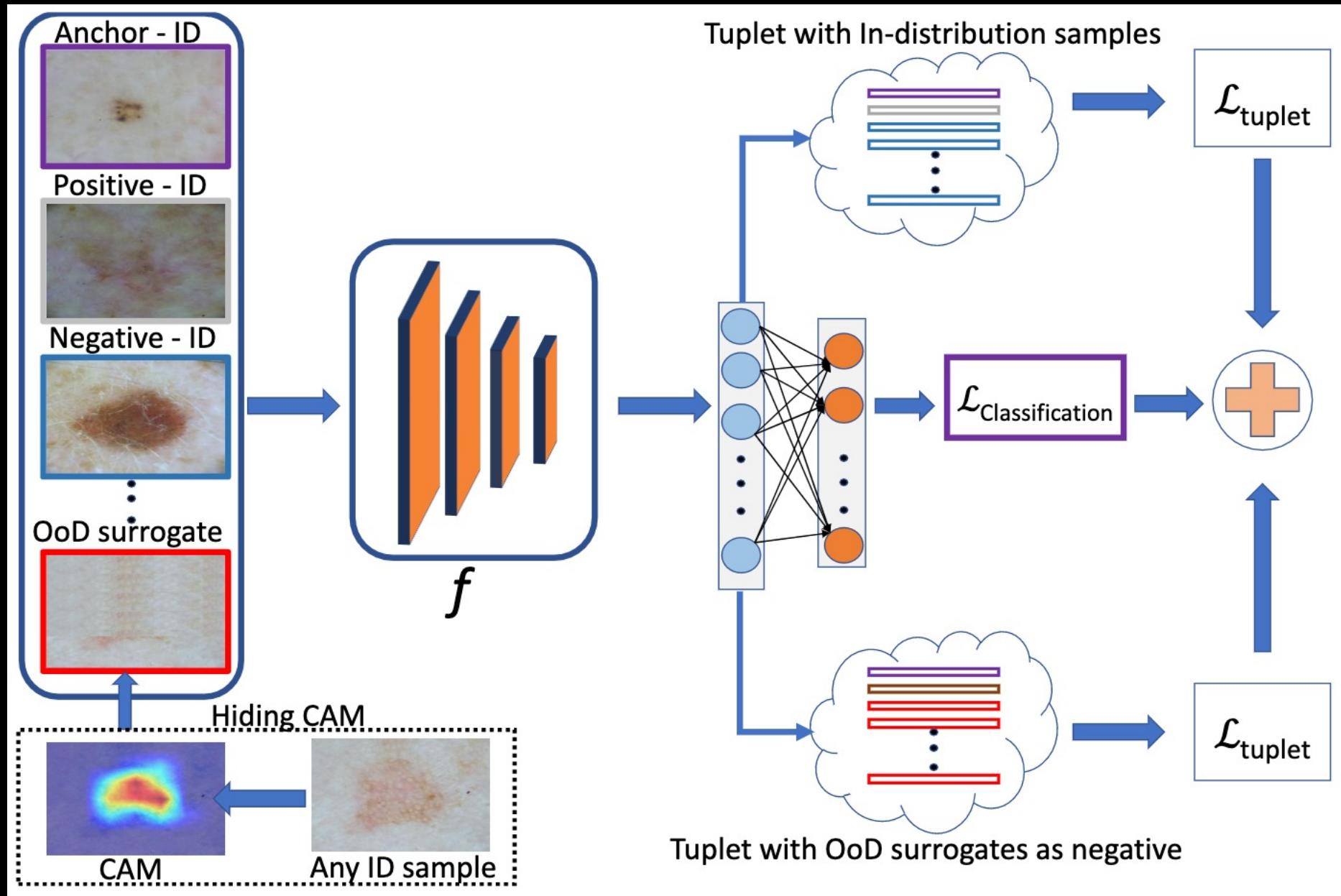
- Skin cancer is one of the most common types of cancer. There are around **1.19 million** new cases of skin cancer only in 2020.
- An early diagnosis, including the detection of cancer and its correct classification, has been correlated to a high rate of overall survival
- The Armed Forces Institute of Pathology (AFIP), Rawalpindi, reports skin cancer to be **the fourth (6.68% of all cancers)** and second **(5.63 of all cancers)** leading cause of cancer in males and females respectively in Northern Pakistan

# Out of Distribution Detection in Skin Cancer Images



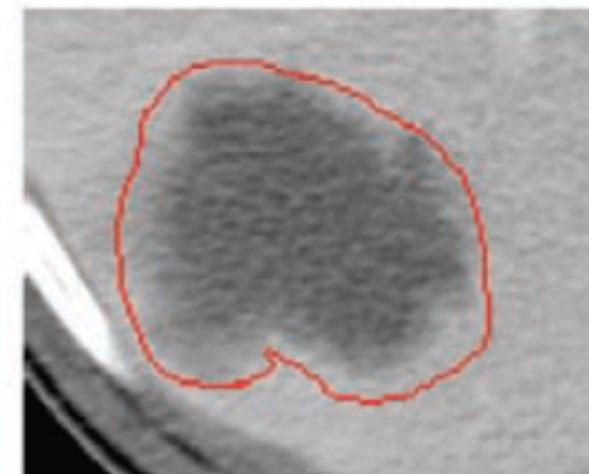
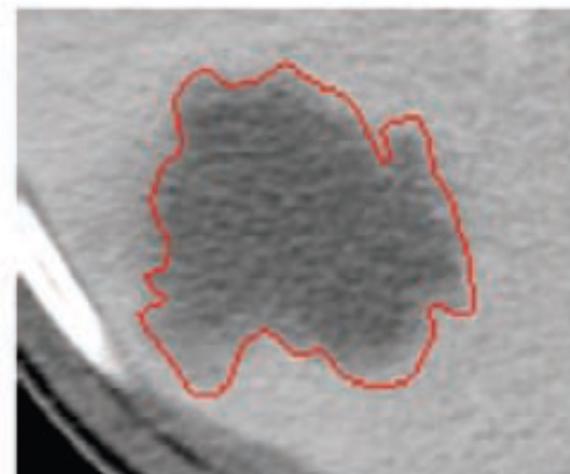
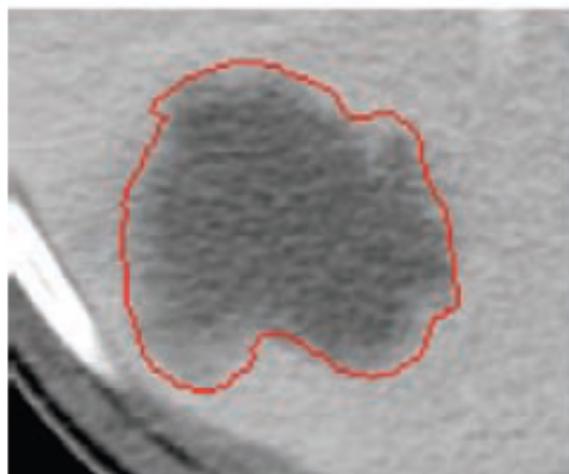
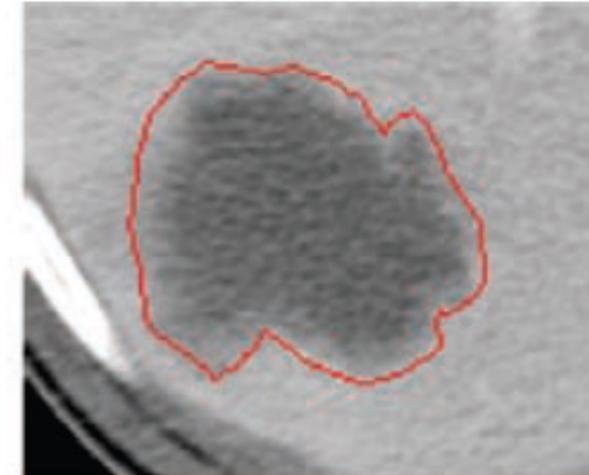
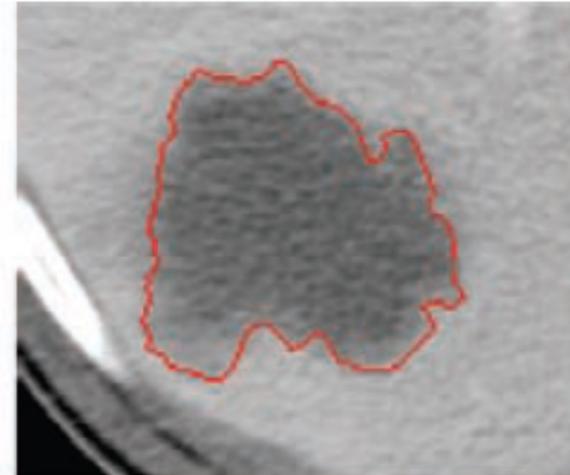
## Skin Cancer Detection





## Observer Variability – Example: Liver lesion

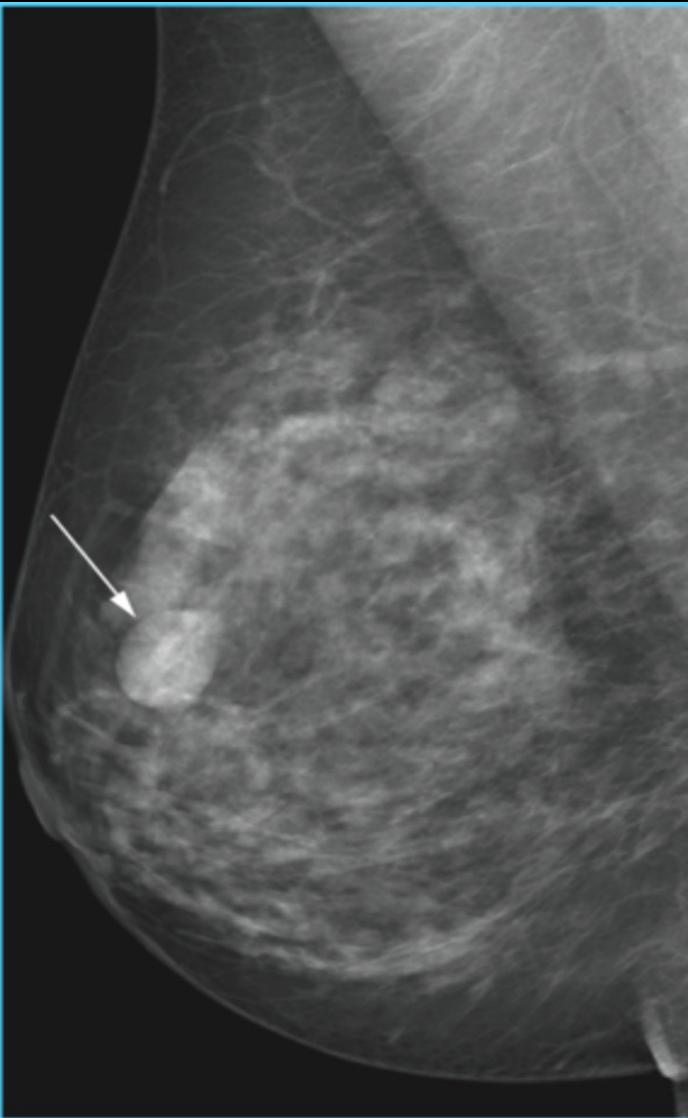
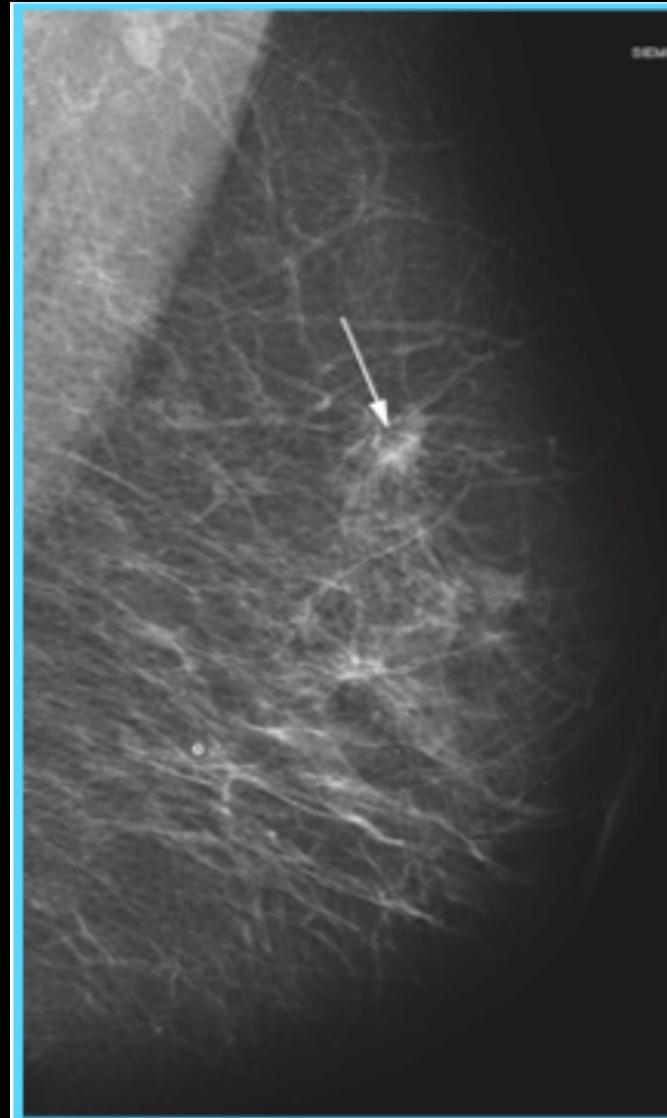
Intra- (one week interval)



# Breast Cancer

- Breast cancer rate in Pakistan highest in Asia
- Almost 99 percent breast cancer patients, if diagnosed at an early stage, are treatable.
- In Pakistan, as many as 36,000 cases of breast cancer among women were reported in 2020 out of which 13,000 women died. “One in every nine women in Pakistan is likely to suffer from breast cancer in her lifetime.”.
- Every woman after the age of 40 years must get her mammography scan done. “Late diagnosis of breast cancers reduces chances of recovery from 1 to 10 percent,”

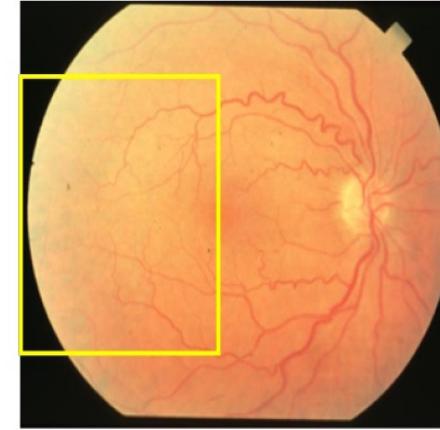
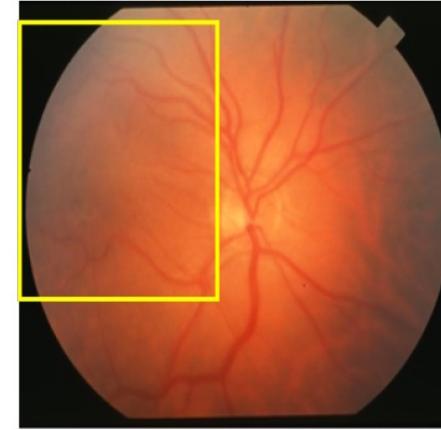
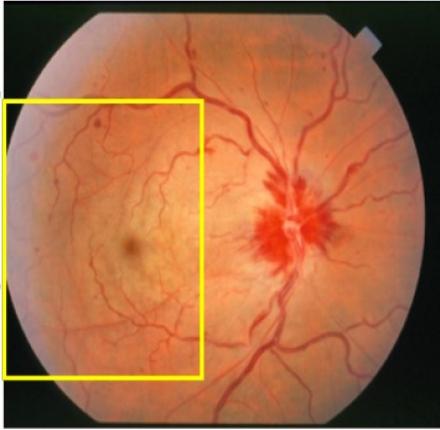
Benign



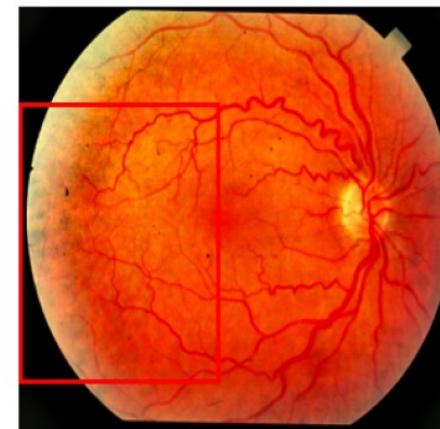
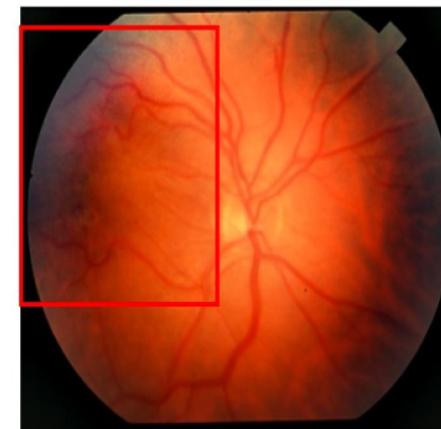
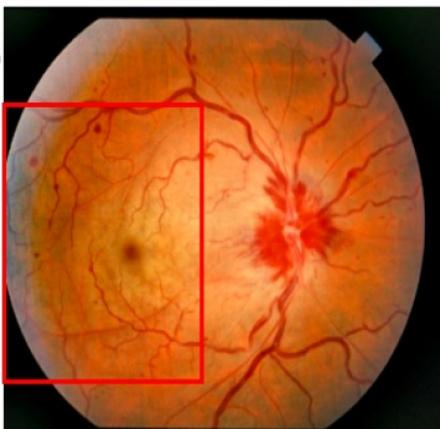
Malignant

# Retinal Image Enhancement

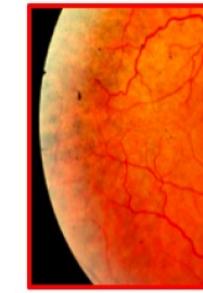
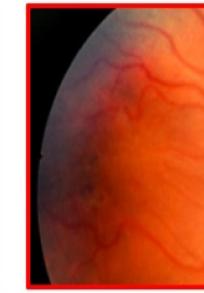
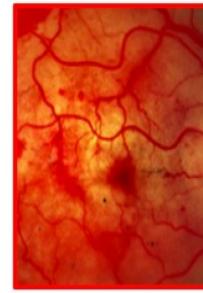
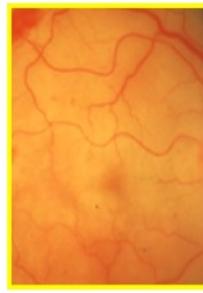
Input Image

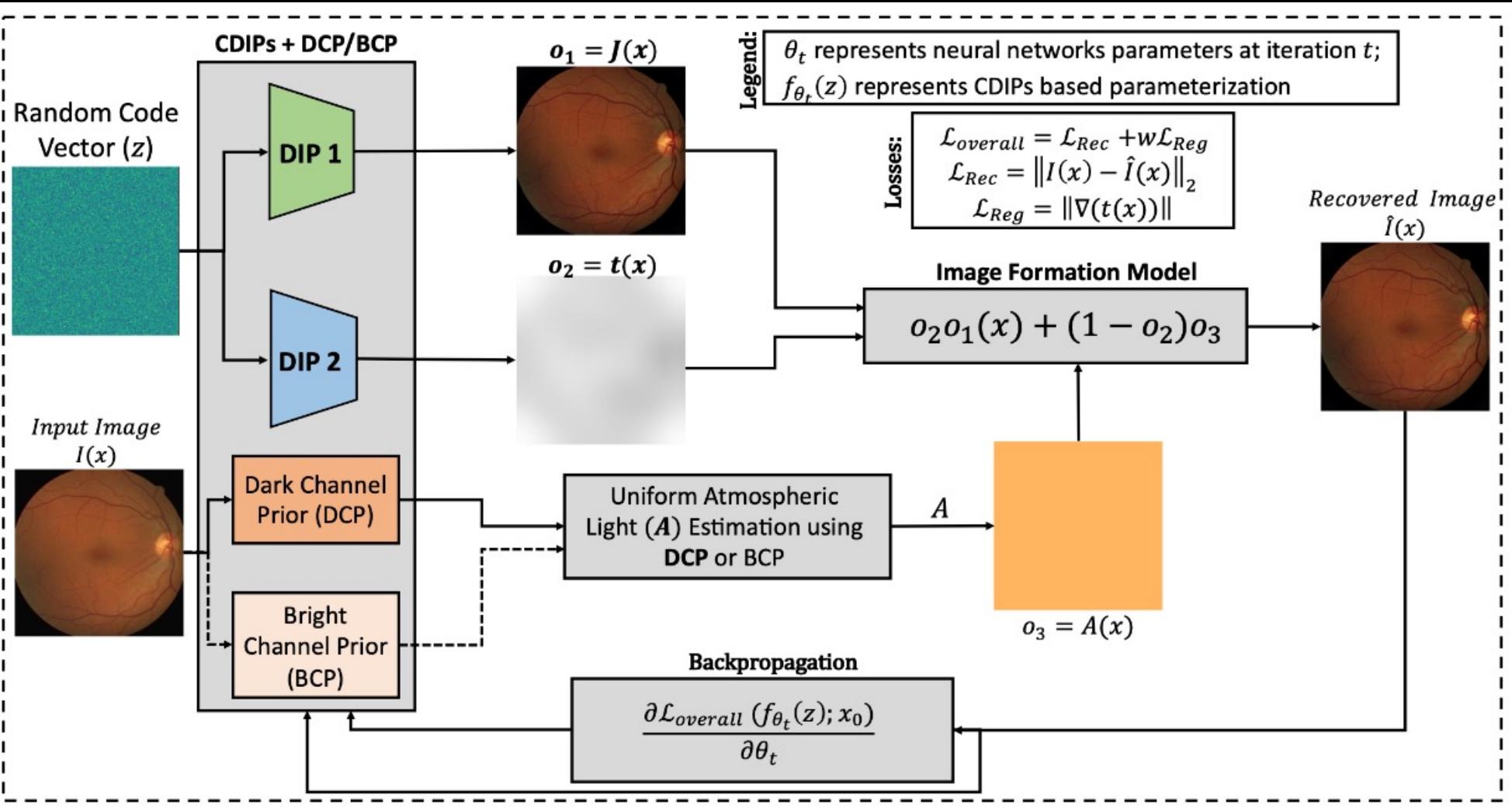


Enhanced Image

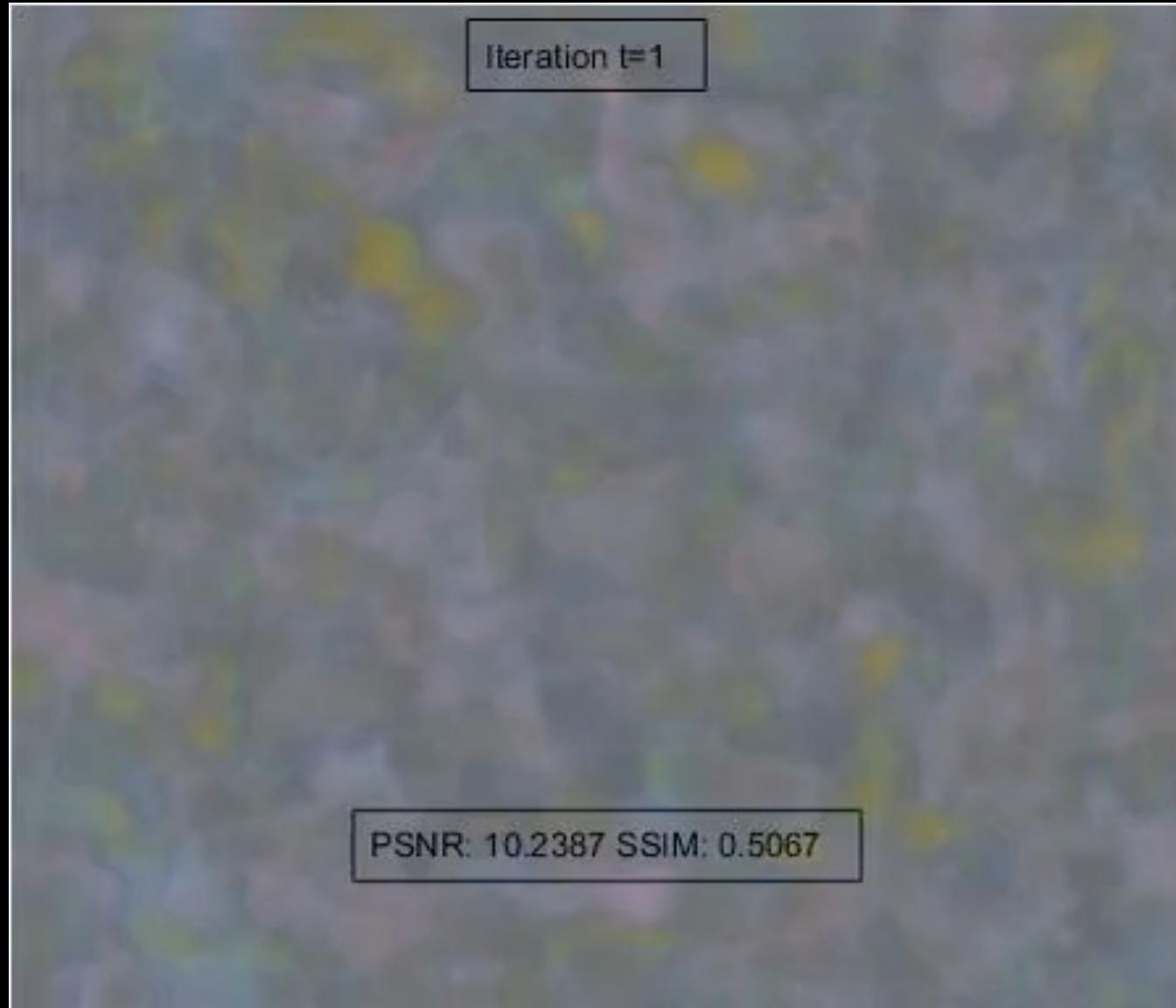


Zoom In

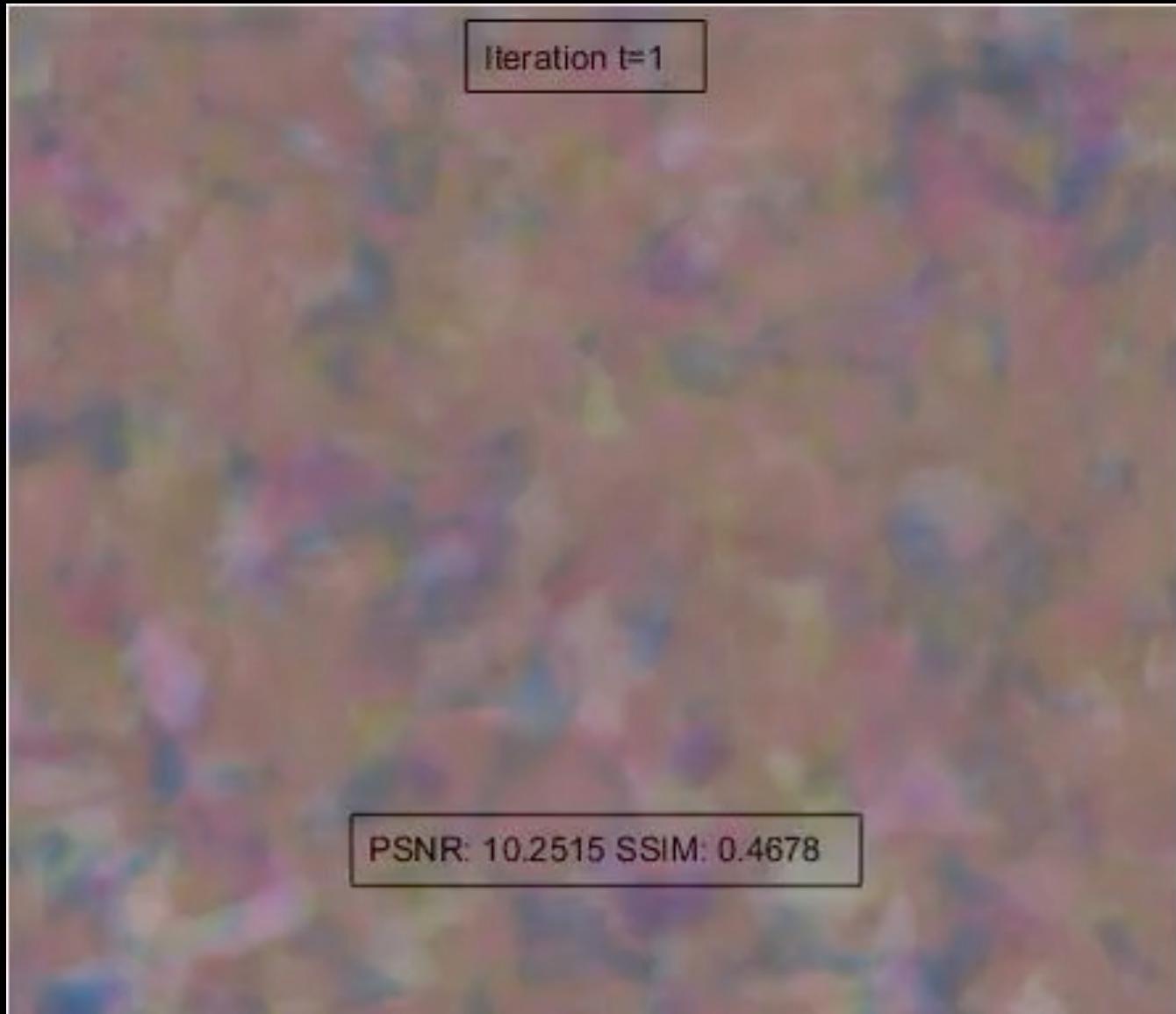




# Retinal Image Enhancement



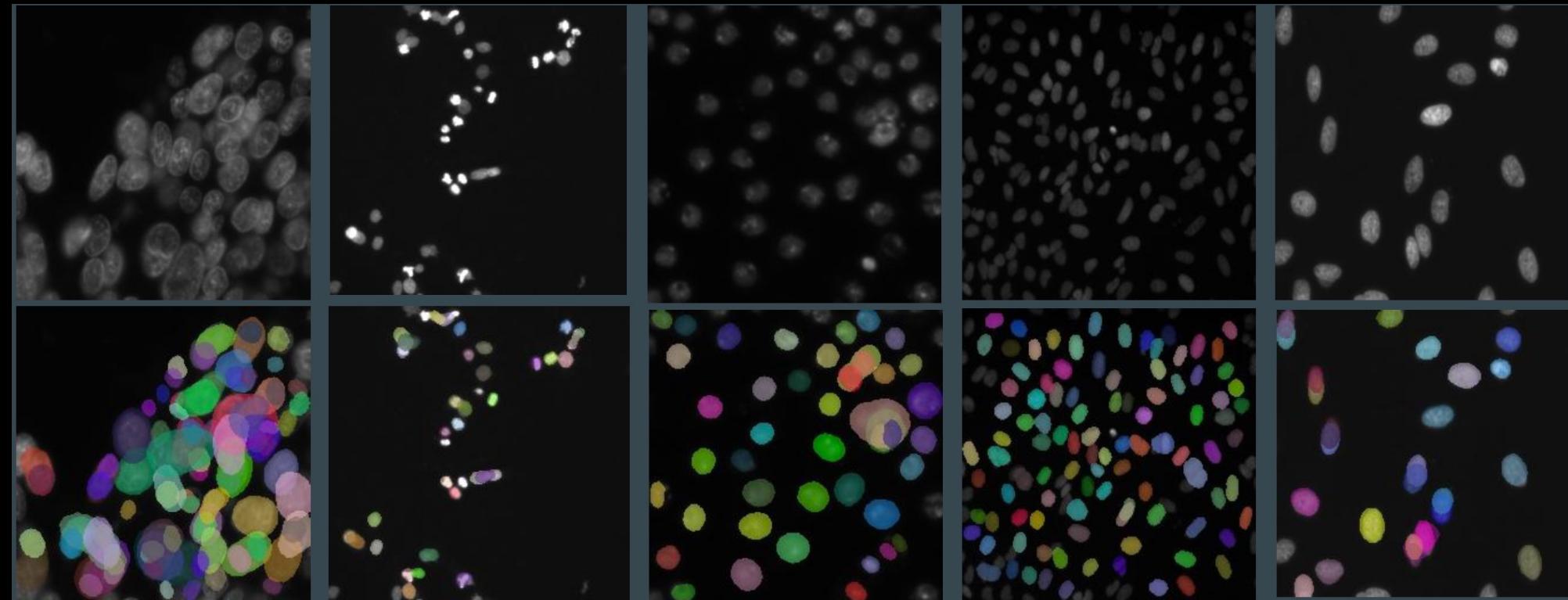
# Retinal Image Enhancement



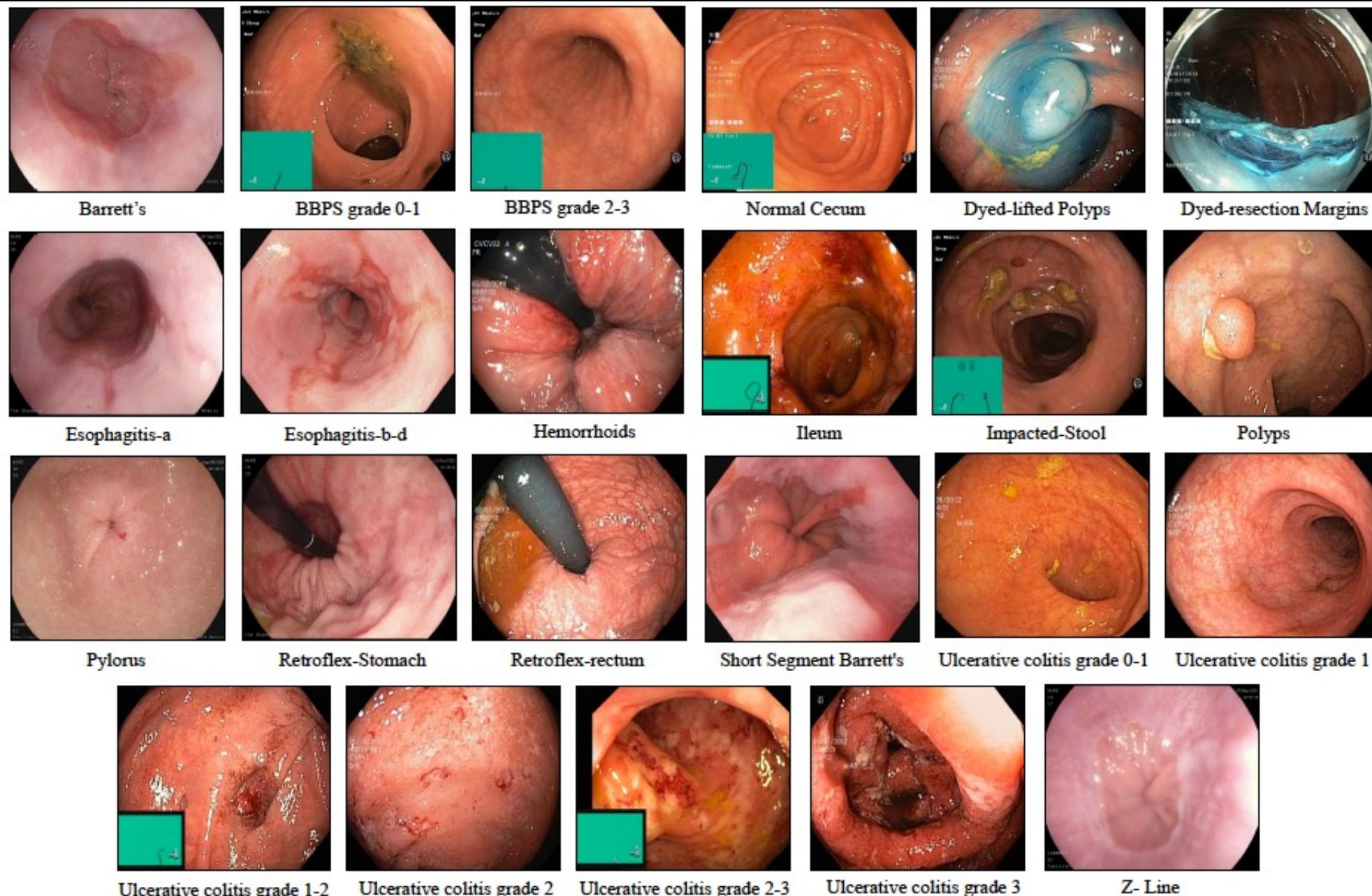
# Retinal Image Enhancement

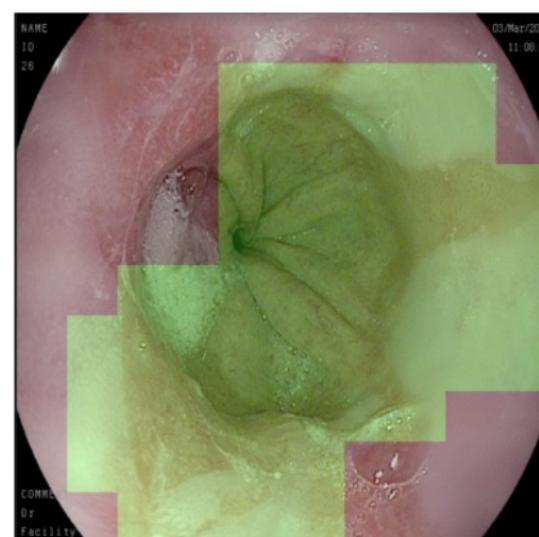
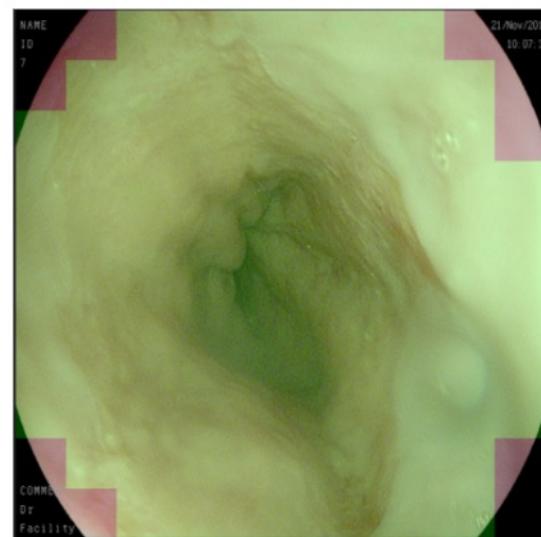
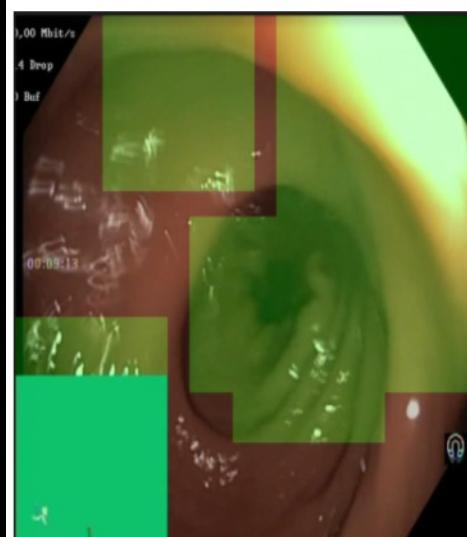
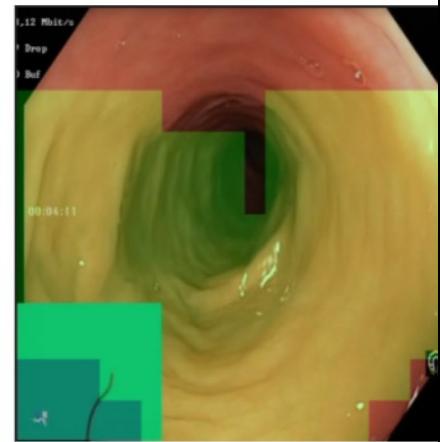
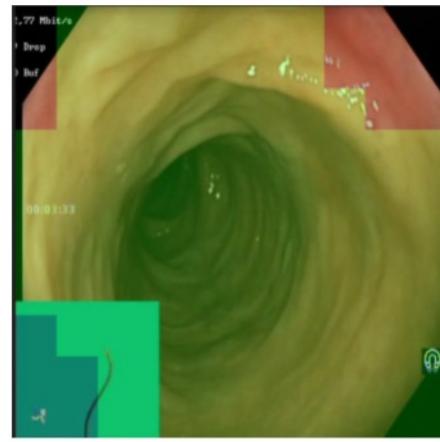
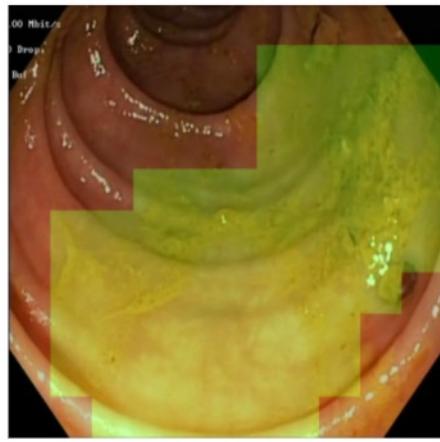
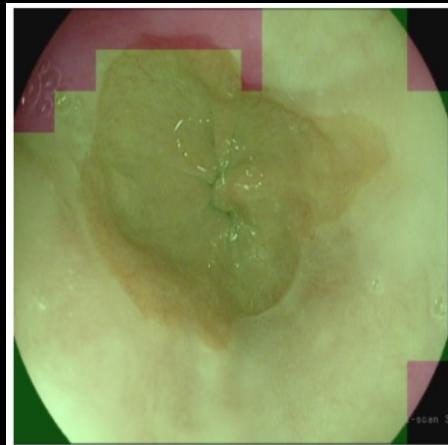


# Microscopic Cell Counting

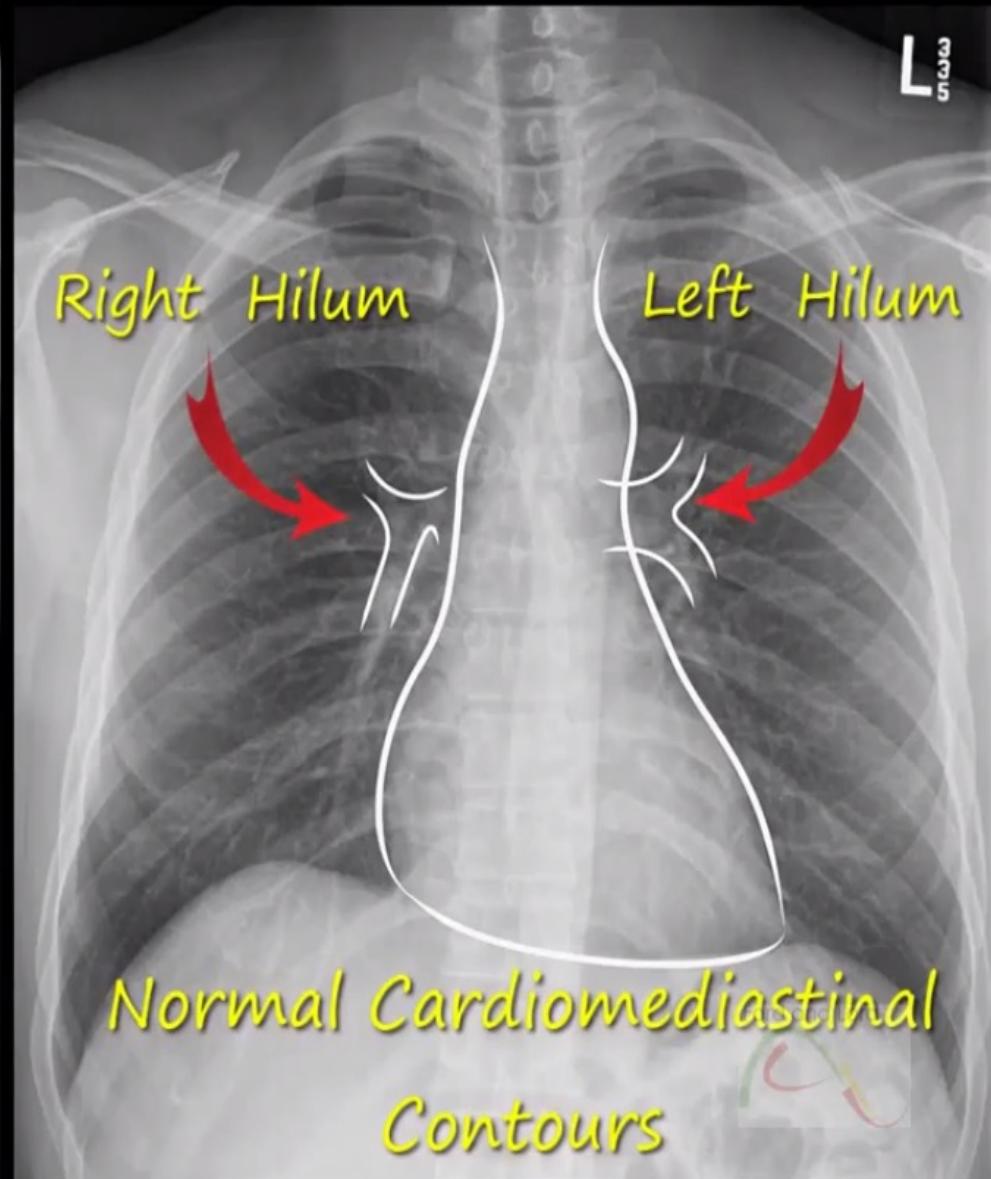
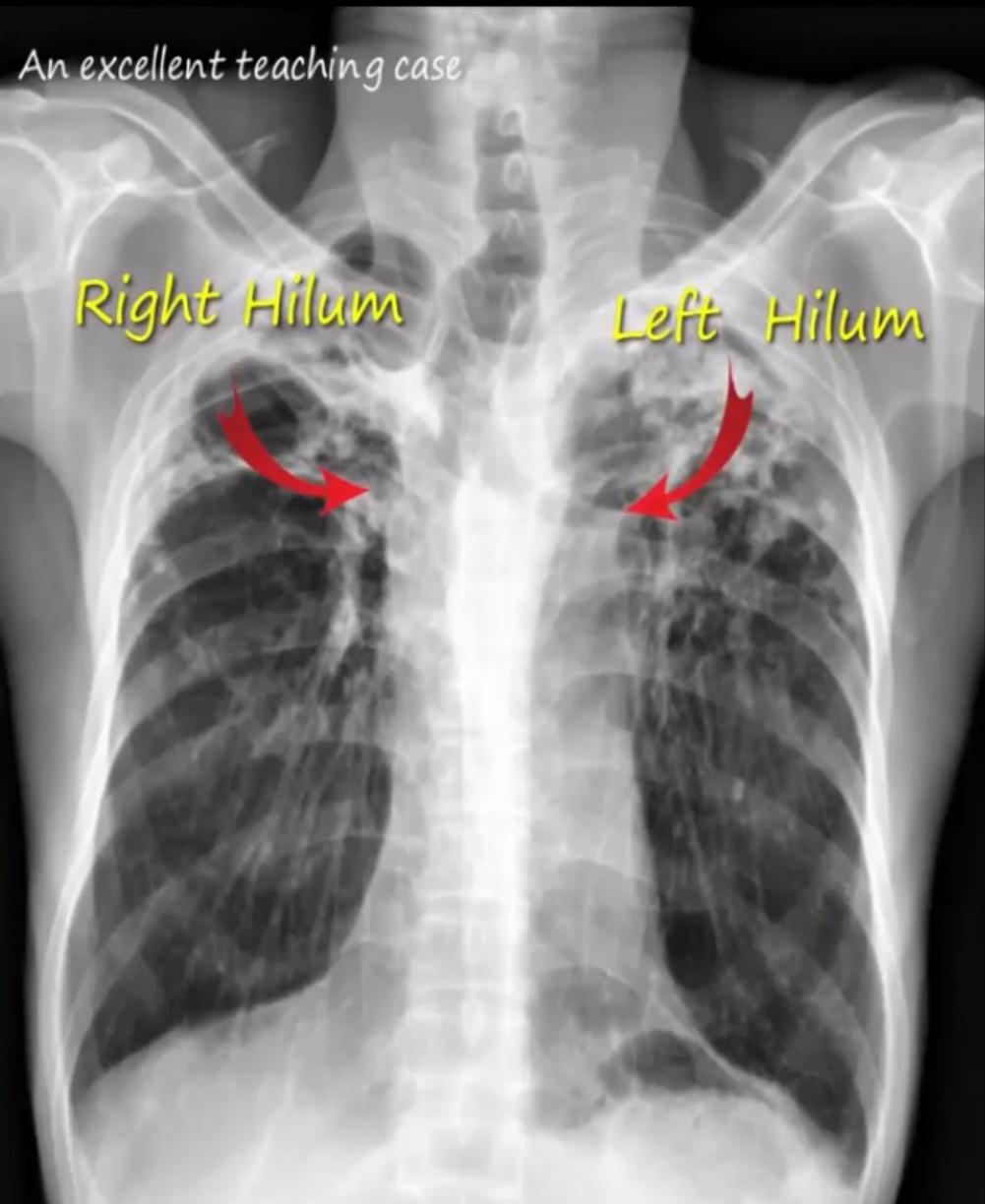


# Endoscopy Images





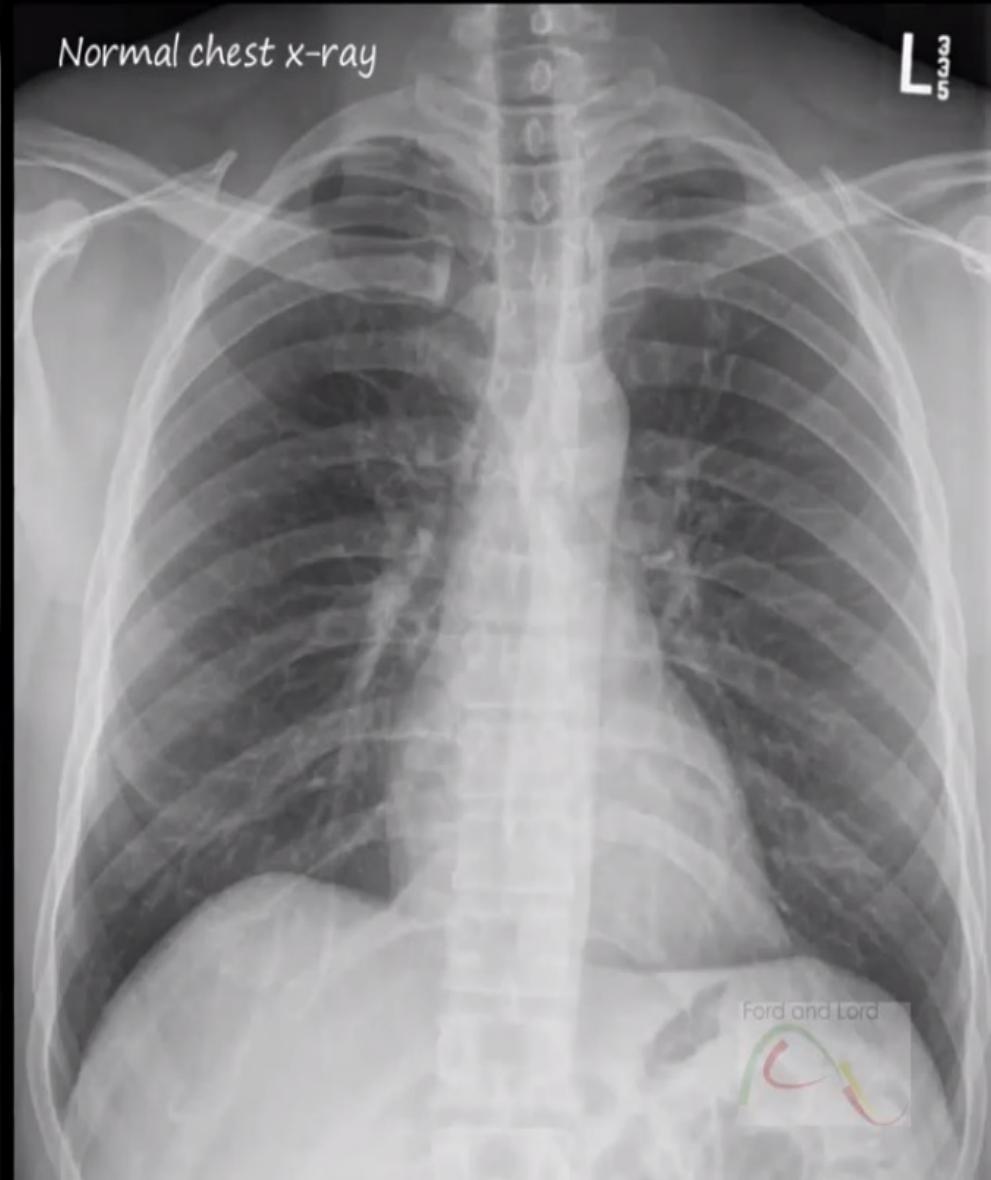
An excellent teaching case



An excellent teaching case



Normal chest x-ray

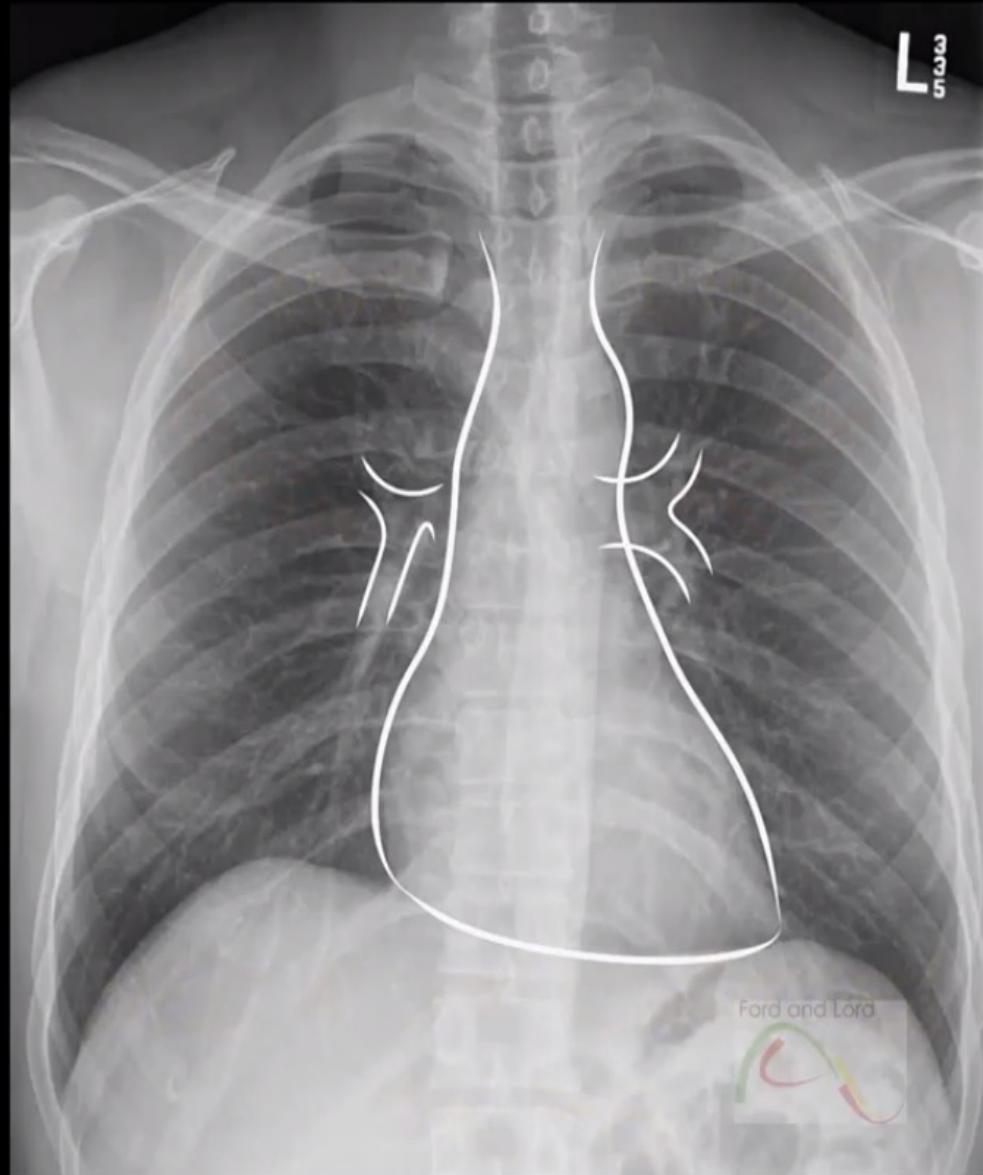
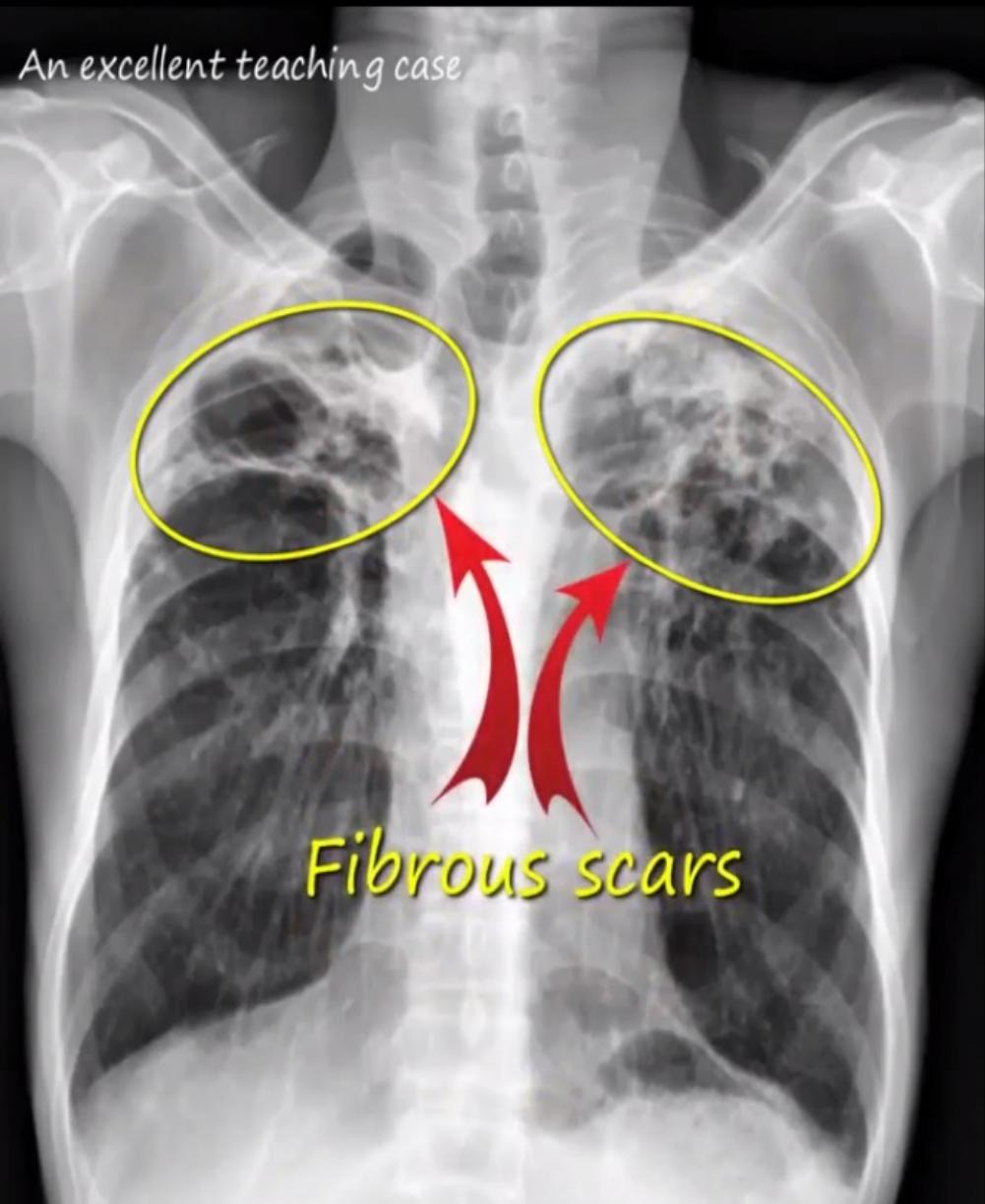


Ford and Lord

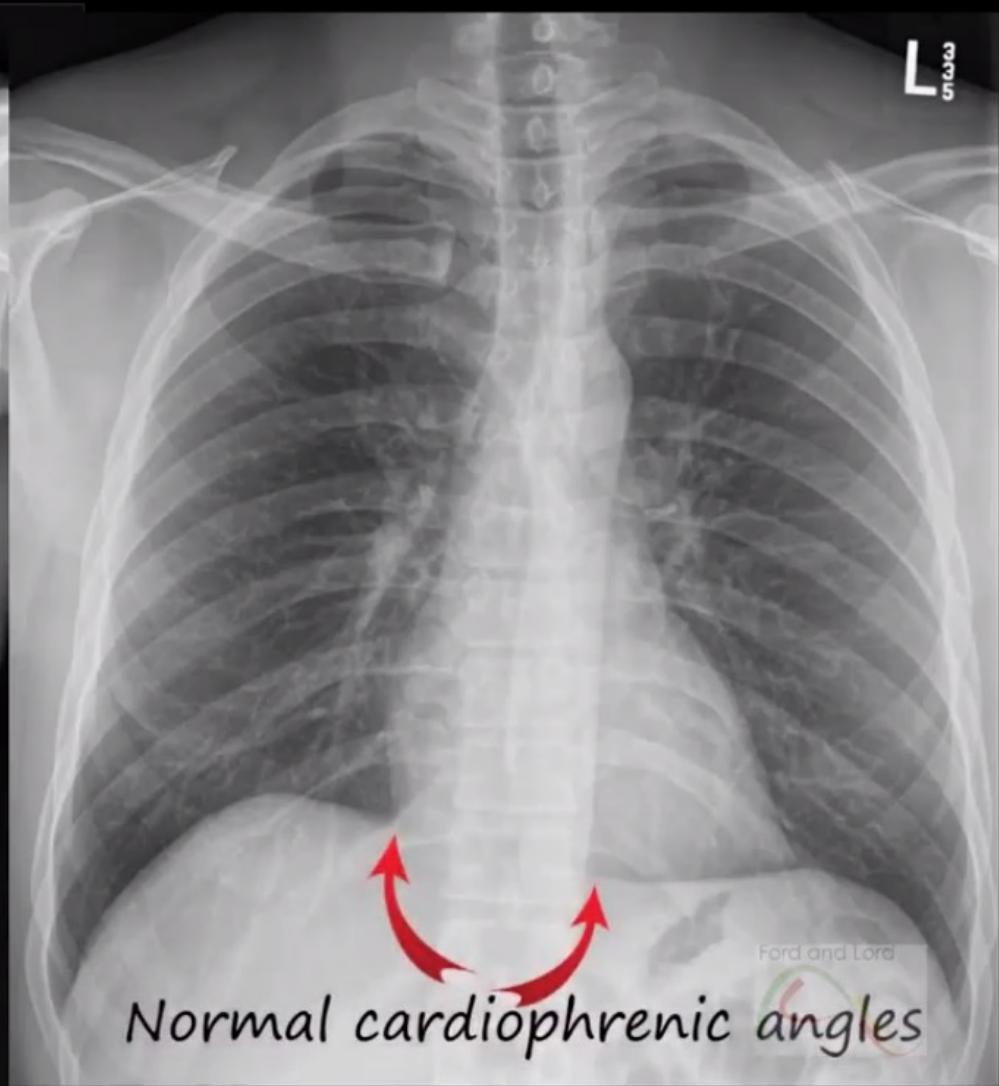
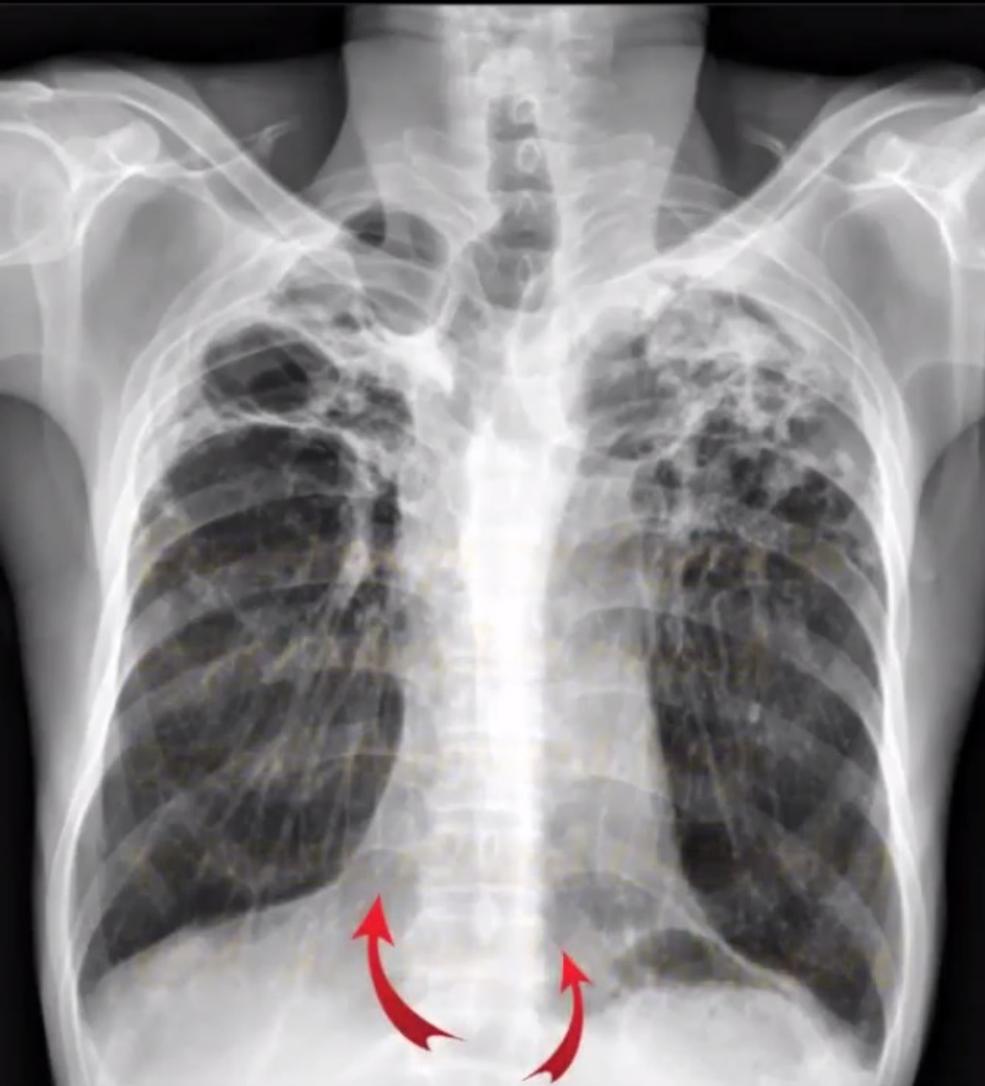


An excellent teaching case

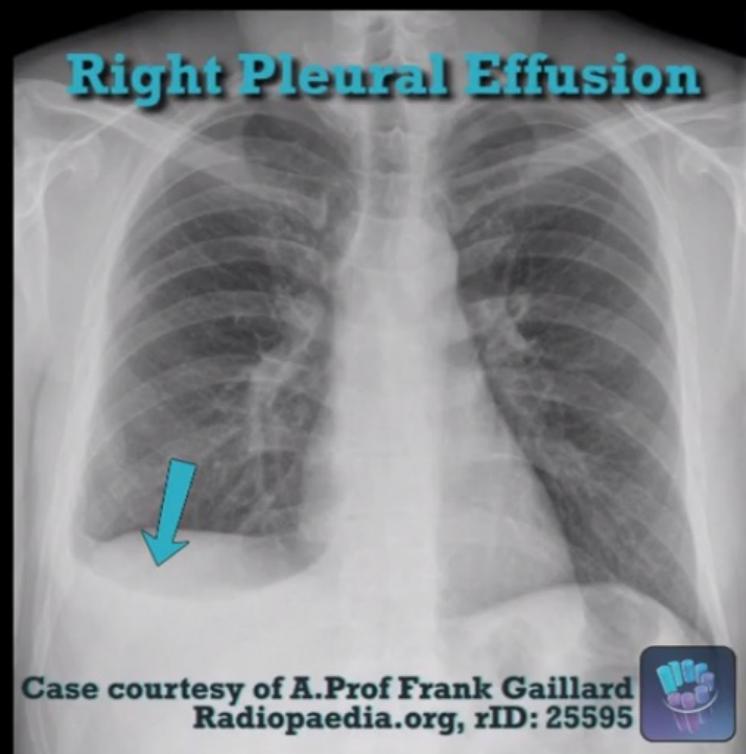
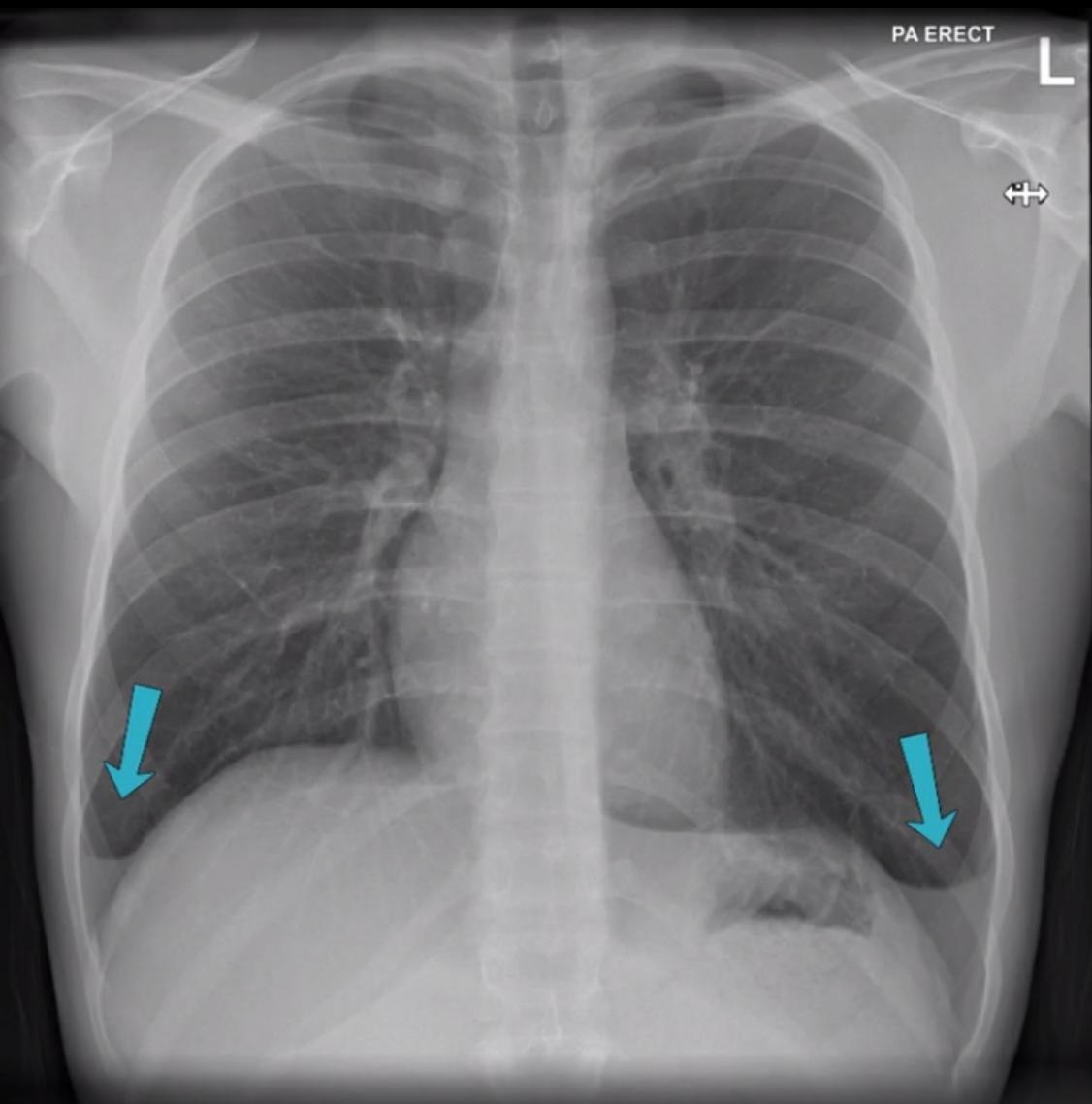
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L<sub>5</sub>

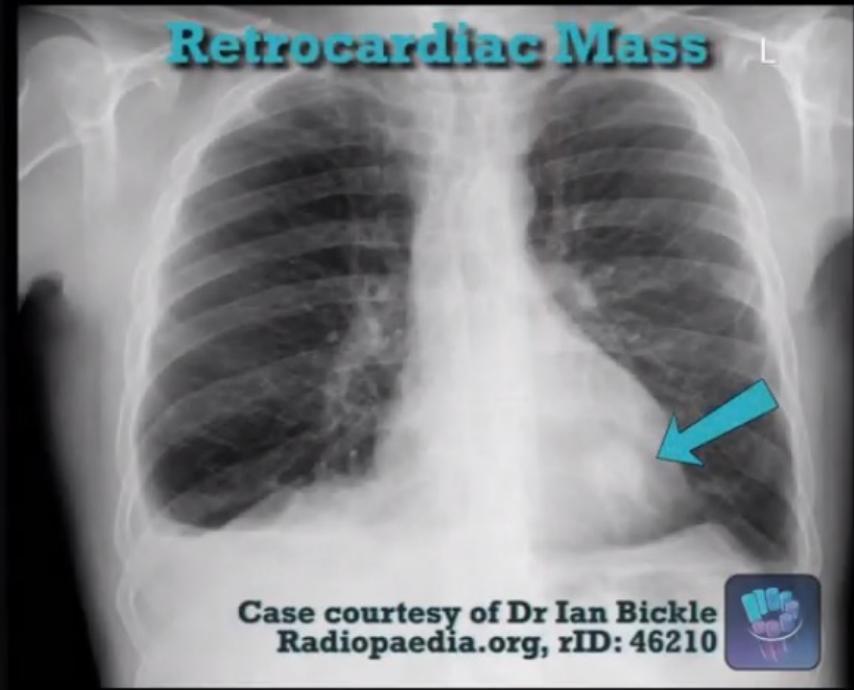
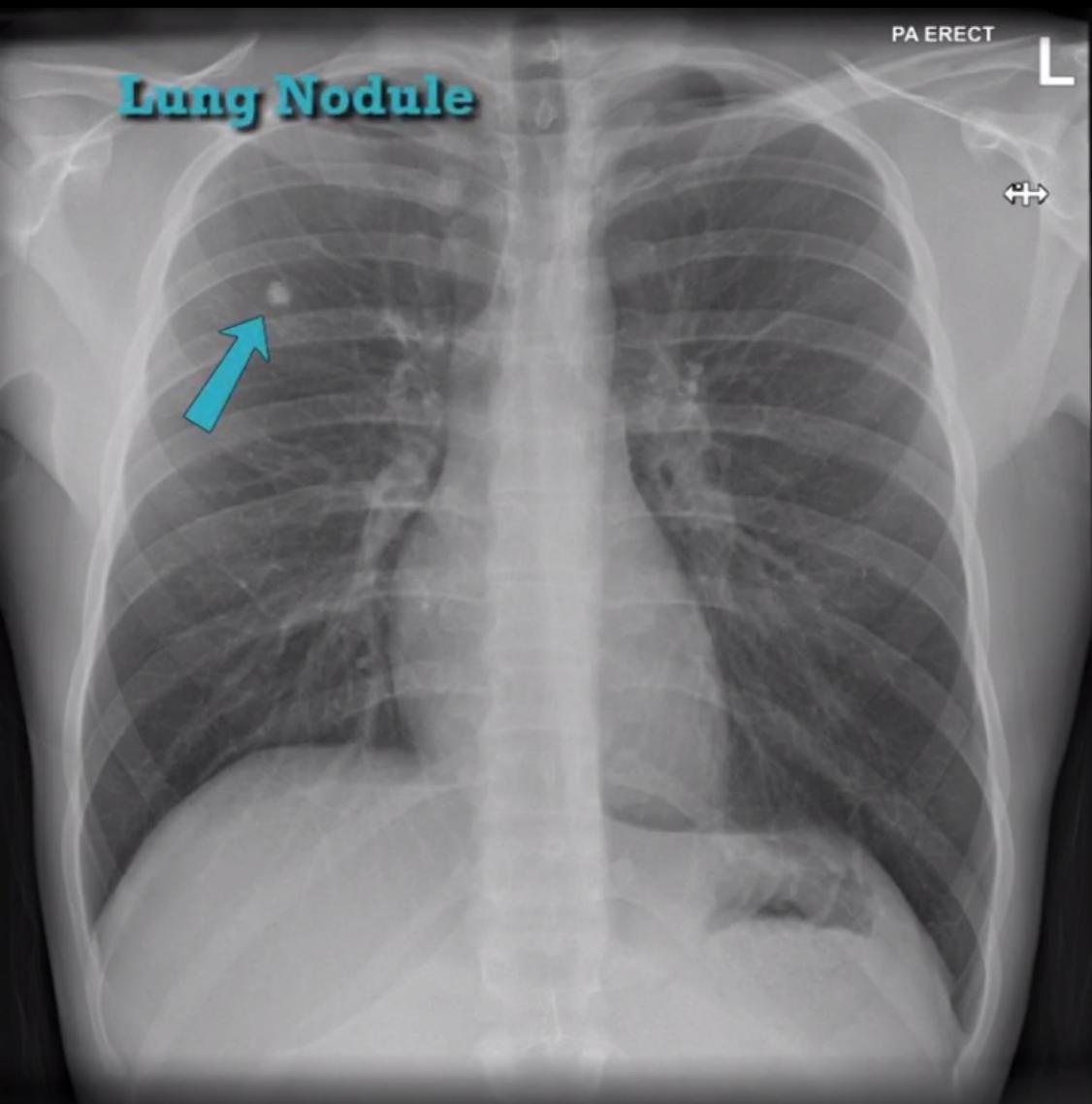


- Fibrous tissues: Any tissue comprised of a network of closely woven small fibres adhering together as bundles in animals and plants.
- Scar tissue refers to thick, fibrous tissues that take the place of healthy ones that have been damaged.



Normal cardiophrenic angles

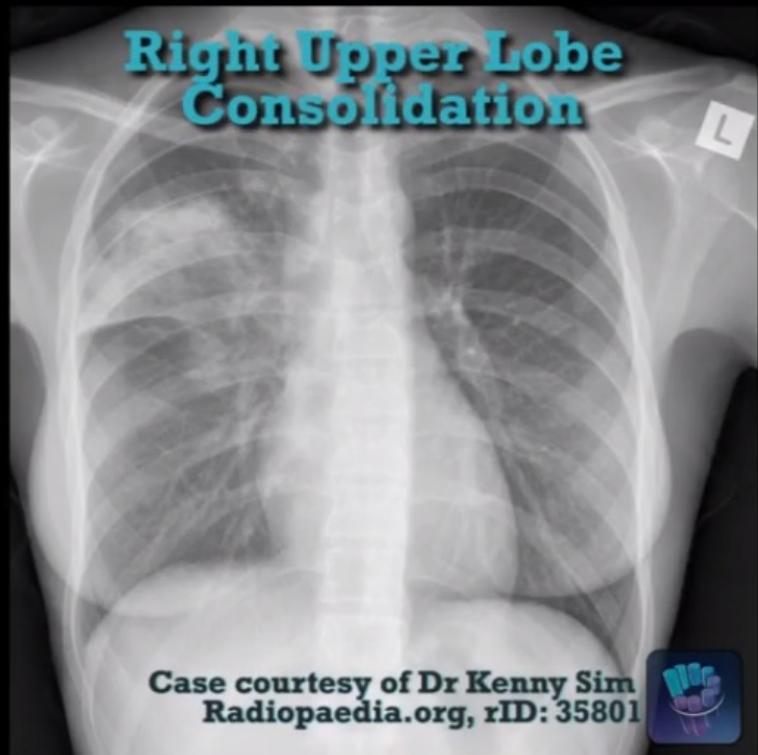
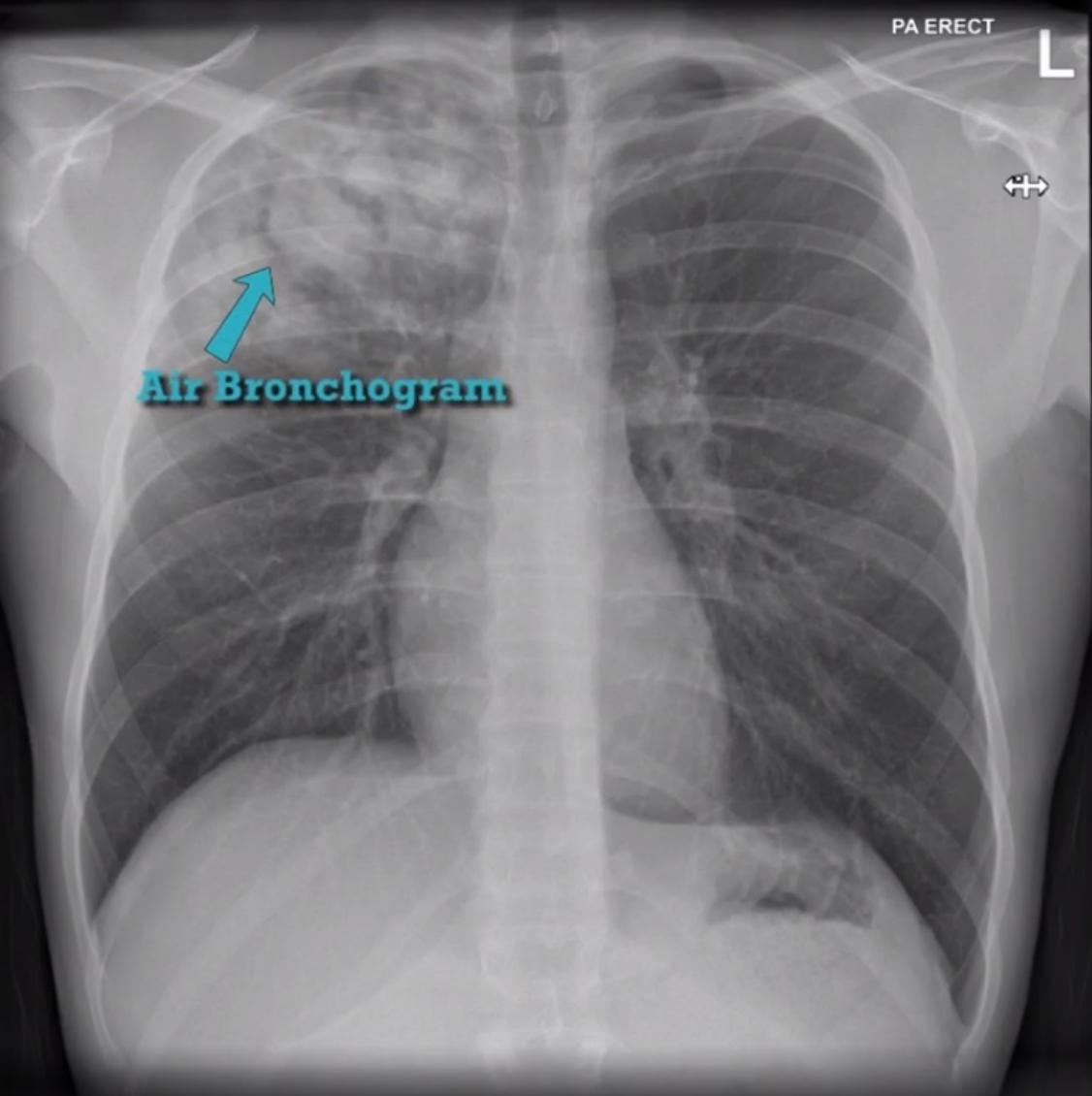




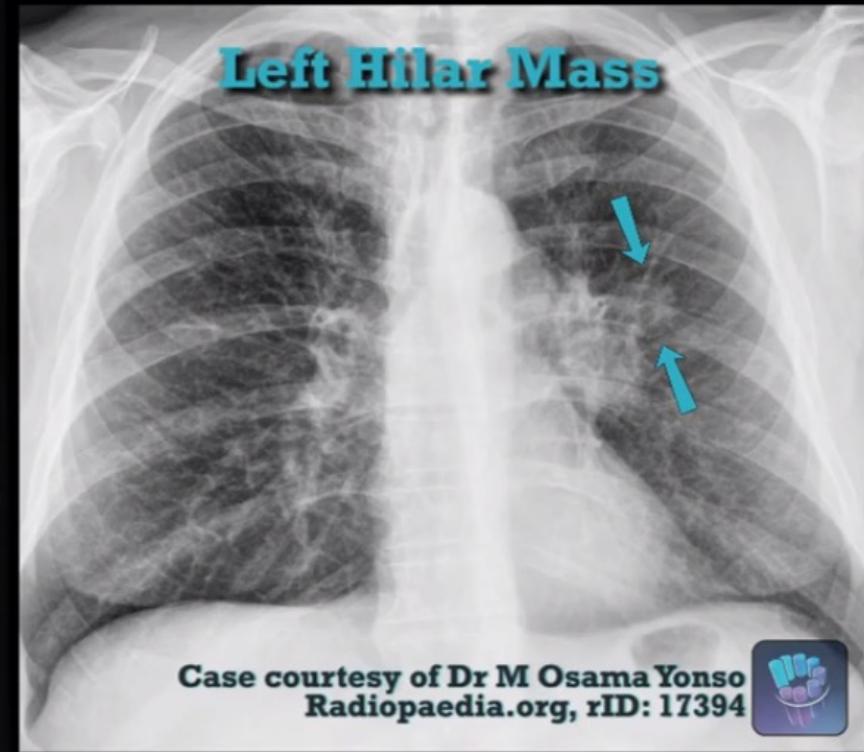
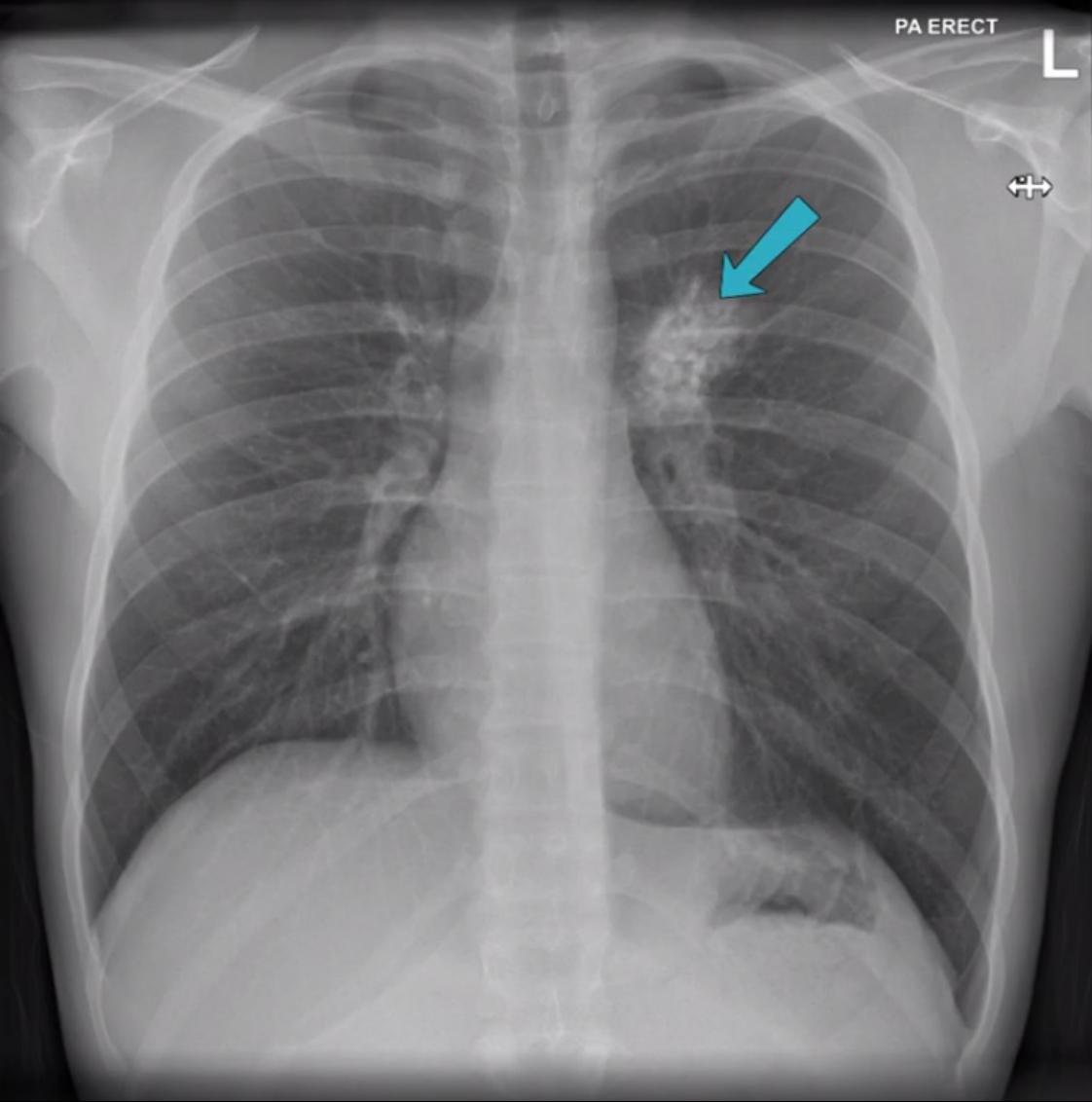
Case courtesy of Dr Ian Bickle  
Radiopaedia.org, rID: 46210



Look for abnormal lesions such as metastases or lung nodules.



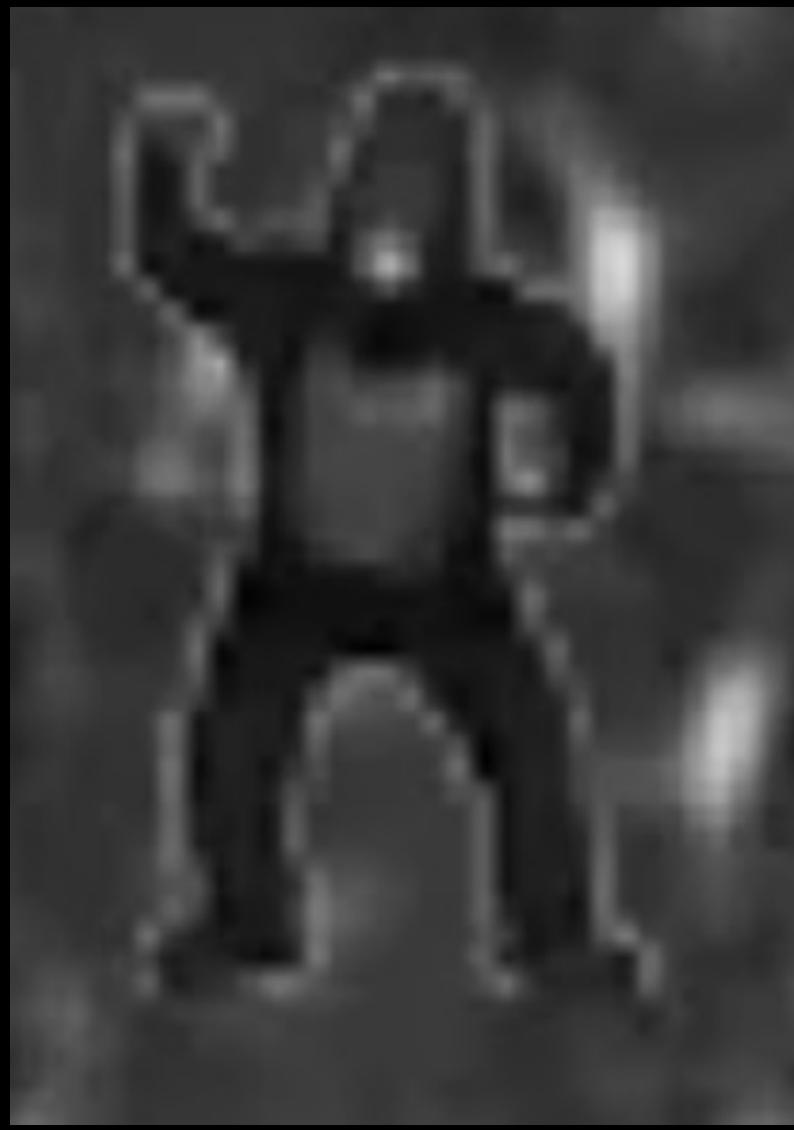
Consolidation or airspace opacification is another common finding and is confirmed by the presence of air bronchograms.

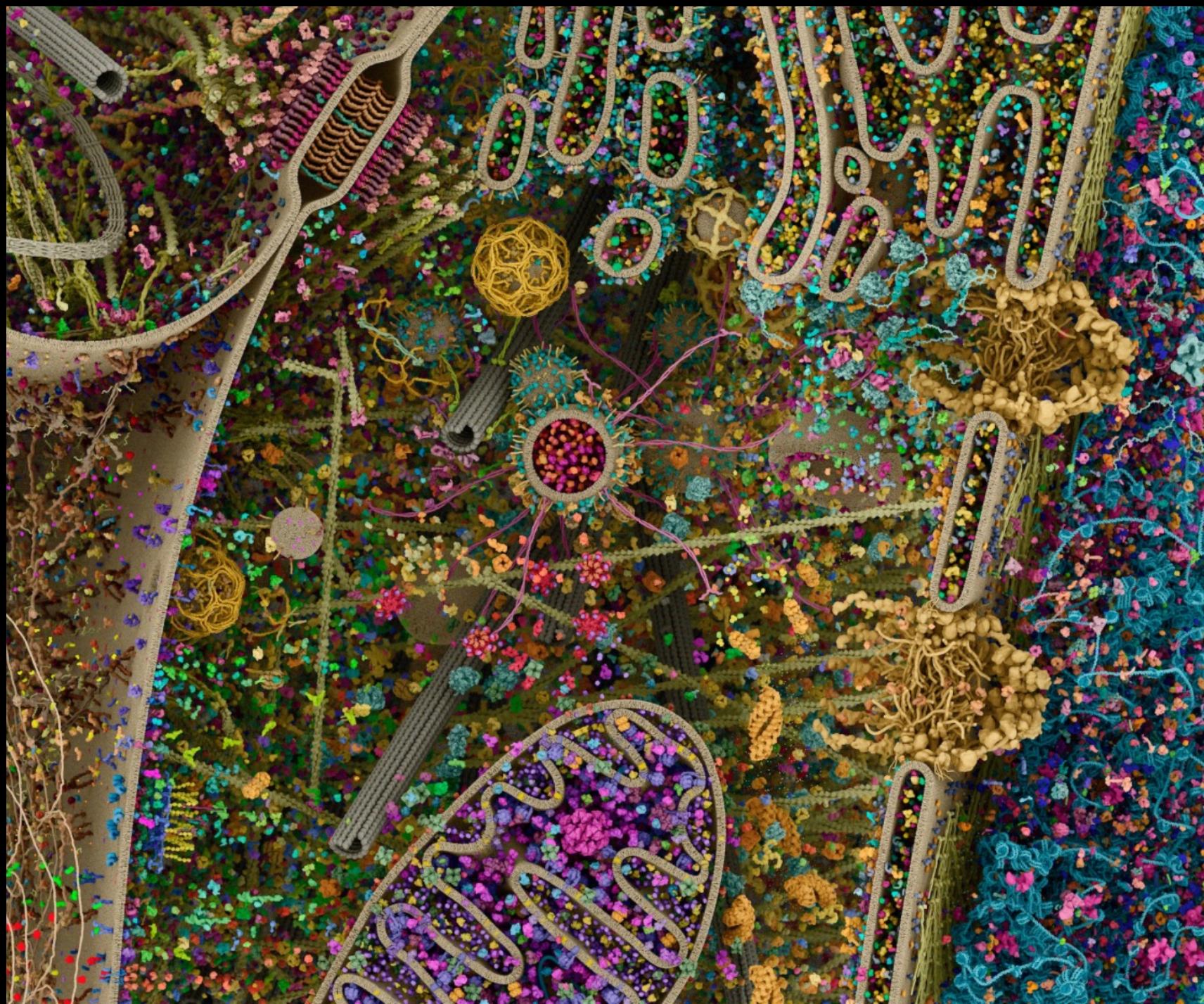


Case courtesy of Dr M Osama Yonso  
Radiopaedia.org, rID: 17394

Particular attention should be paid to the hilar regions as malignancy or enlarged lymph nodes can be overlooked in this area.







# References and Slide Credits

- Jayaram K. Udupa, MIPG of University of Pennsylvania, PA.
- P. Suetens, Fundamentals of Medical Imaging, Cambridge Univ. Press.
- N. Bryan, Intro. to the science of medical imaging, Cambridge Univ. Press.
- CAP 5937 (Fall 2016) Lecture Presentations
- [siemens.com](http://siemens.com)