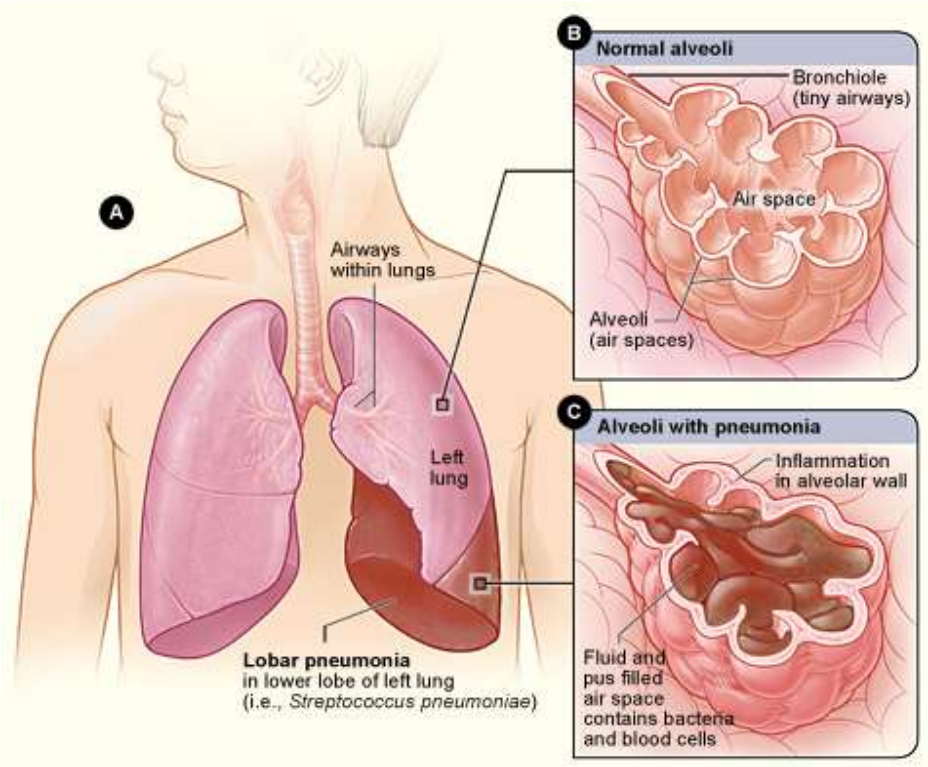
# *Pneumonia Detection on Chest Radiographs using Deep Learning Techniques*

## *Overview*

Pneumonia is an infection in one or both lungs. The infection causes inflammation in the air sacs in your lungs, which are called alveoli. The alveoli fill with fluid or pus, making it difficult to breathe.




Physicians or radiologists perform a physical examination and employ a chest x-ray (CXR) to evaluate and identify pneumonia. The CXR reveals opacity in the affected area.

Dicom original images: - Medical images are stored in a special format called DICOM files (*.dcm). So our initial steps involve examining the DICOM data, extracting metadata from the DICOM files, and visualizing the different characteristics of the DICOM images, categorized according to age and sex.

Dataset - https://drive.google.com/drive/folders/1GYAe8hZB8Si5YSW0akNXBpsELRicE4Hp

## *Installing required packages and libraries*

In [8]:
```
!pip install matplotlib
!pip install pandas
!pip install pydicom
```

```
Requirement already satisfied: matplotlib in d:\anaconda3\envs\pneumonia_set\lib\s
ite-packages (3.7.0)
Requirement already satisfied: pyparsing>=2.3.1 in d:\anaconda3\envs\pneumonia_set
\lib\site-packages (from matplotlib) (3.0.9)
Requirement already satisfied: pillow>=6.2.0 in d:\anaconda3\envs\pneumonia_set\li
b\site-packages (from matplotlib) (9.4.0)
Requirement already satisfied: numpy>=1.20 in d:\anaconda3\envs\pneumonia_set\lib
\site-packages (from matplotlib) (1.24.2)
Requirement already satisfied: kiwisolver>=1.0.1 in d:\anaconda3\envs\pneumonia_se
t\lib\site-packages (from matplotlib) (1.4.4)
Requirement already satisfied: packaging>=20.0 in d:\anaconda3\envs\pneumonia_set
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Requirement already satisfied: importlib-resources>=3.2.0 in d:\anaconda3\envs\pne
umonia_set\lib\site-packages (from matplotlib) (5.12.0)
Requirement already satisfied: python-dateutil>=2.7 in d:\anaconda3\envs\pneumonia
_set\lib\site-packages (from matplotlib) (2.8.2)
Requirement already satisfied: cycler>=0.10 in d:\anaconda3\envs\pneumonia_set\lib
\site-packages (from matplotlib) (0.11.0)
Requirement already satisfied: fonttools>=4.22.0 in d:\anaconda3\envs\pneumonia_se
t\lib\site-packages (from matplotlib) (4.38.0)
Requirement already satisfied: contourpy>=1.0.1 in d:\anaconda3\envs\pneumonia_set
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Requirement already satisfied: zipp>=3.1.0 in d:\anaconda3\envs\pneumonia_set\lib
\site-packages (from importlib-resources>=3.2.0->matplotlib) (3.14.0)
Requirement already satisfied: six>=1.5 in d:\anaconda3\envs\pneumonia_set\lib\sit
e-packages (from python-dateutil>=2.7->matplotlib) (1.16.0)
Requirement already satisfied: pandas in d:\anaconda3\envs\pneumonia_set\lib\site-
packages (1.5.3)
Requirement already satisfied: numpy>=1.20.3 in d:\anaconda3\envs\pneumonia_set\li
b\site-packages (from pandas) (1.24.2)
Requirement already satisfied: python-dateutil>=2.8.1 in d:\anaconda3\envs\pneumon
ia_set\lib\site-packages (from pandas) (2.8.2)
Requirement already satisfied: pytz>=2020.1 in d:\anaconda3\envs\pneumonia_set\lib
\site-packages (from pandas) (2022.7.1)
Requirement already satisfied: six>=1.5 in d:\anaconda3\envs\pneumonia_set\lib\sit
e-packages (from python-dateutil>=2.8.1->pandas) (1.16.0)
Collecting pydicom
  Downloading pydicom-2.3.1-py3-none-any.whl (2.0 MB)
     ---------------------------------------- 2.0/2.0 MB 4.0 MB/s eta 0:00:00
Installing collected packages: pydicom
Successfully installed pydicom-2.3.1
```

In [3]:
```
from matplotlib import pyplot as plt
```

In [4]:
```
import glob, pandas as pd
import matplotlib.pyplot as plt
import pydicom, numpy as np
```

In [5]:
```
#To parse the data
def parse_data(df):
```

```
    extract_box = lambda row: [row['y'], row['x'], row['height'], row['width']]

    parsed = {}
    for n, row in df.iterrows():
        pid = row['patientId']
        if pid not in parsed:
            parsed[pid] = {
                'dicom': "D:\\Pneumonia_Set_Project\\stage_2_train_images\\%s.dcm"
                'label': row['Target'],
                'boxes': []}

        if parsed[pid]['label'] == 1:
            parsed[pid]['boxes'].append(extract_box(row))

    return parsed
```

Reading the data from our csv files

1. stage_2_train.csv - the training set. Contains patientIds and bounding box / target information.
2. stage_2_detailed_class_info.csv - provides detailed information about the type of positive or negative class for each image.

In [6]:
```
df = pd.read_csv("D:\\Pneumonia_Set_Project\\stage_2_train_labels.csv")

patient_class = pd.read_csv("D:\\Pneumonia_Set_Project\\stage_2_detailed_class_info

parsed = parse_data(df)

patientId = df['patientId'][0]
print(parsed[patientId])
print(patient_class.loc[patientId])
```

```
{'dicom': 'D:\\Pneumonia_Set_Project\\stage_2_train_images\\0004cfab-14fd-4e49-80b
a-63a80b6bddd6.dcm', 'label': 0, 'boxes': []}
class    No Lung Opacity / Not Normal
Name: 0004cfab-14fd-4e49-80ba-63a80b6bddd6, dtype: object
```

The above shows that for the first patient, there are no lung opacity and we didn't get any bounding boxes

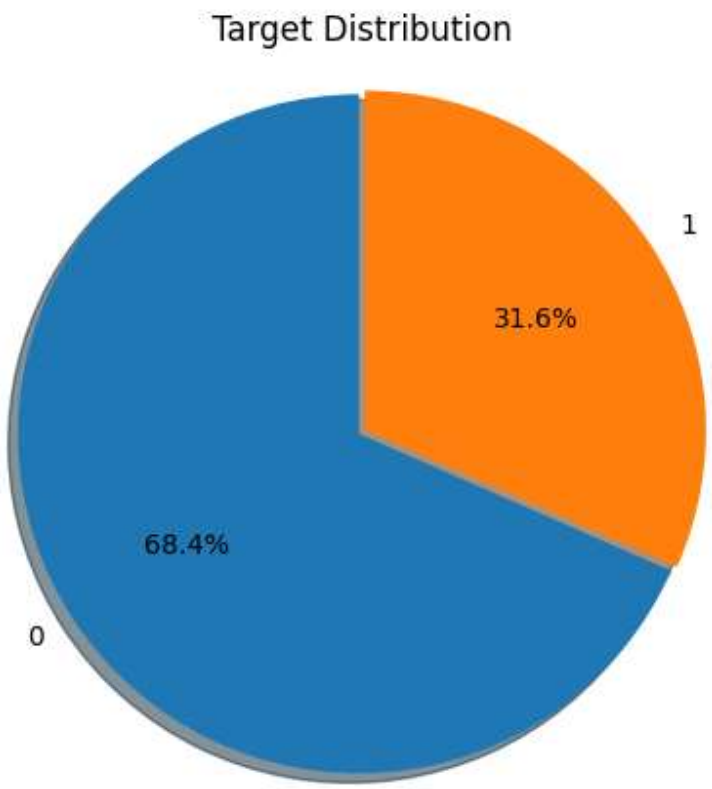
In [7]:
```
df.head(10)
```

Out[7]:

| | patientId | x | y | width | height | Target |
|---|---|---|---|---|---|---|
| **0** | 0004cfab-14fd-4e49-80ba-63a80b6bddd6 | NaN | NaN | NaN | NaN | 0 |
| **1** | 00313ee0-9eaa-42f4-b0ab-c148ed3241cd | NaN | NaN | NaN | NaN | 0 |
| **2** | 00322d4d-1c29-4943-afc9-b6754be640eb | NaN | NaN | NaN | NaN | 0 |
| **3** | 003d8fa0-6bf1-40ed-b54c-ac657f8495c5 | NaN | NaN | NaN | NaN | 0 |
| **4** | 00436515-870c-4b36-a041-de91049b9ab4 | 264.0 | 152.0 | 213.0 | 379.0 | 1 |
| **5** | 00436515-870c-4b36-a041-de91049b9ab4 | 562.0 | 152.0 | 256.0 | 453.0 | 1 |
| **6** | 00569f44-917d-4c86-a842-81832af98c30 | NaN | NaN | NaN | NaN | 0 |
| **7** | 006cec2e-6ce2-4549-bffa-eadfcd1e9970 | NaN | NaN | NaN | NaN | 0 |
| **8** | 00704310-78a8-4b38-8475-49f4573b2dbb | 323.0 | 577.0 | 160.0 | 104.0 | 1 |
| **9** | 00704310-78a8-4b38-8475-49f4573b2dbb | 695.0 | 575.0 | 162.0 | 137.0 | 1 |

In [33]:

```
label_count = df['Target'].value_counts()
explode = (0.01,0.01)

fig1, ax1 = plt.subplots(figsize=(5,5))
ax1.pie(label_count.values, explode=explode, labels=label_count.index, autopct='%1.
        shadow=True, startangle=90)
ax1.axis('equal')
plt.title('Target Distribution')
plt.show()
```



We can see that label '0' is more in number, so before splitting into train-test we need to stratify the data or use some sampling techniques to avoid bias

From the above dataframe, we can see that only for those having Target value as 1, meaning they have pneumonia we have bounding boxes

## *Exploring Patient Class*

In [16]:
```
patient_class.head()
```

Out[16]:

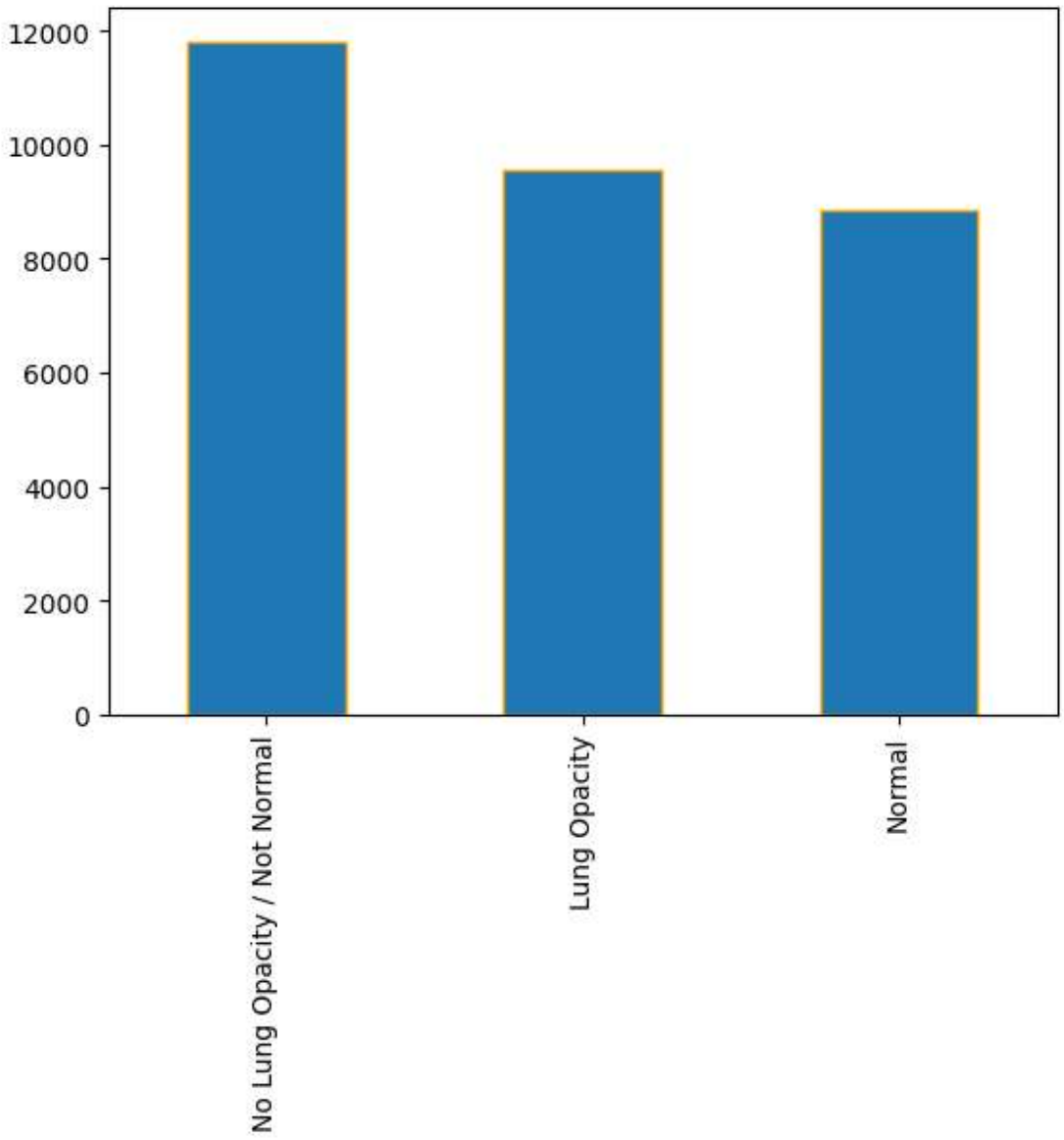
| | class |
|---|---|
| **patientId** | |
| **0004cfab-14fd-4e49-80ba-63a80b6bddd6** | No Lung Opacity / Not Normal |
| **00313ee0-9eaa-42f4-b0ab-c148ed3241cd** | No Lung Opacity / Not Normal |
| **00322d4d-1c29-4943-afc9-b6754be640eb** | No Lung Opacity / Not Normal |
| **003d8fa0-6bf1-40ed-b54c-ac657f8495c5** | Normal |
| **00436515-870c-4b36-a041-de91049b9ab4** | Lung Opacity |

In [17]:
```
print("Number of classes in the dataset :: %i" %  len(patient_class["class"].unique
print("Classes' names are :: %s" % patient_class["class"].unique())
```

```
Number of classes in the dataset :: 3
Classes' names are :: ['No Lung Opacity / Not Normal' 'Normal' 'Lung Opacity']
```

In [18]:
```
class_count = patient_class['class'].value_counts()
class_count.plot.bar( ec="orange")
print(class_count)
```

```
No Lung Opacity / Not Normal    11821
Lung Opacity                     9555
Normal                           8851
Name: class, dtype: int64
```




## *Exploring Patient Details*

In [19]:
```
patientIds = df.drop_duplicates('patientId', keep = 'first').patientId.tolist()
```

In [20]:
```
Sex = []
Age = []
for patientId in patientIds:
    dcm_file = 'D:\\Pneumonia_Set_Project\\stage_2_train_images\\%s.dcm' % patientI
    dcm_data = pydicom.read_file(dcm_file)
    Sex.append(dcm_data.PatientSex)
    Age.append(int(dcm_data.PatientAge))
```

In [23]:
```
patientInfo = pd.DataFrame({'patientId': patientIds, 'patientSex': Sex, 'patientAge
patientInfo.dtypes
```

Out[23]:
```
patientId     object
patientSex    object
patientAge     int64
dtype: object
```

In [24]:
```
patientAge_count = patientInfo['patientAge'].value_counts().sum()
patientSex_count = patientInfo['patientSex'].value_counts().sum()
patient_count = patientInfo['patientId'].value_counts().sum()

print("total number of patientId :: %i" % patient_count )
print("Total number of patients with Non null patientSex :: %i " % patientSex_count
print("Total number of patients with Non null patientAge :: %i " %  patientAge_coun
print("Number of missing values to be imputed for the first field :: %i " % (patien
print("Number of missing values to be imputed for the second field :: %i " % (patie
```

```
total number of patientId :: 26684
Total number of patients with Non null patientSex :: 26684
Total number of patients with Non null patientAge :: 26684
Number of missing values to be imputed for the first field :: 0
Number of missing values to be imputed for the second field :: 0
```

In [26]:
```
patientInfo = patientInfo.set_index('patientId').join(df.set_index('patientId'))[['
patientInfo.reset_index(inplace=True)
patientInfo.head()
```

Out[26]:

| | patientId | patientSex | patientAge | Target |
|---|---|---|---|---|
| **0** | 0004cfab-14fd-4e49-80ba-63a80b6bddd6 | F | 51 | 0 |
| **1** | 000924cf-0f8d-42bd-9158-1af53881a557 | F | 19 | 0 |
| **2** | 000db696-cf54-4385-b10b-6b16fbb3f985 | F | 25 | 1 |
| **3** | 000db696-cf54-4385-b10b-6b16fbb3f985 | F | 25 | 1 |
| **4** | 000fe35a-2649-43d4-b027-e67796d412e0 | M | 40 | 1 |

In [27]:
```
patientInfo.describe()
```

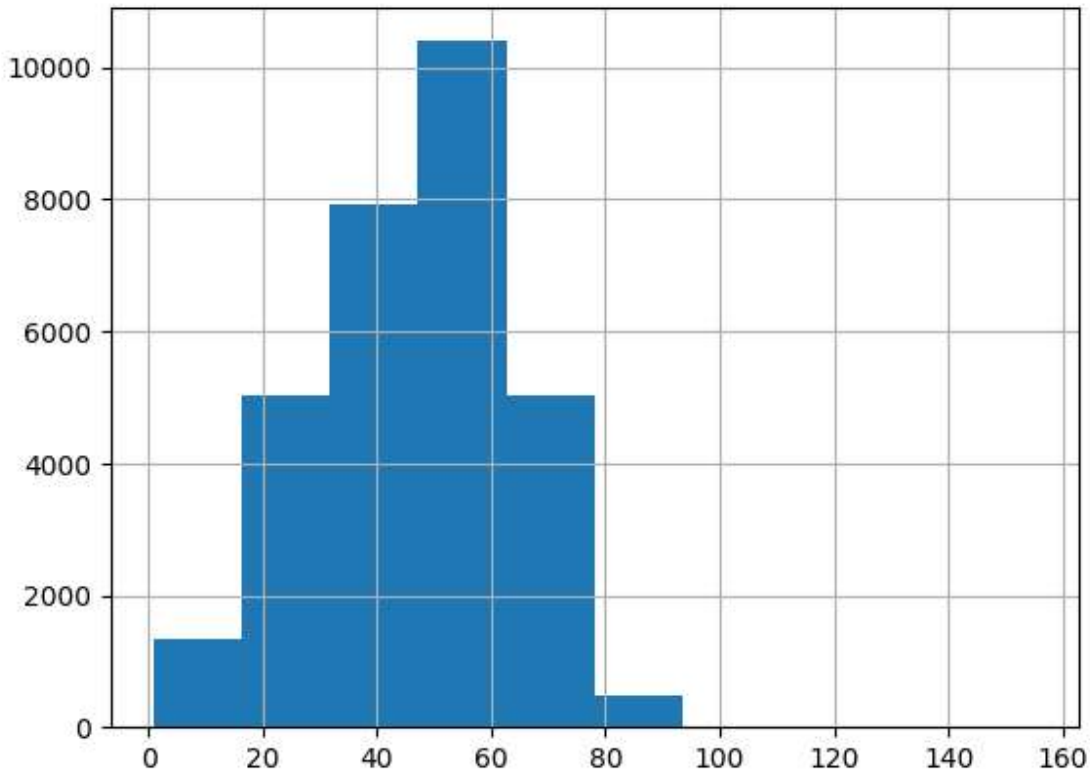
Out[27]:

| | patientAge | Target |
|---|---|---|
| **count** | 30227.000000 | 30227.000000 |
| **mean** | 46.797764 | 0.316108 |
| **std** | 16.892940 | 0.464963 |
| **min** | 1.000000 | 0.000000 |
| **25%** | 34.000000 | 0.000000 |
| **50%** | 49.000000 | 0.000000 |
| **75%** | 59.000000 | 1.000000 |
| **max** | 155.000000 | 1.000000 |

Exploring Age of patients

In [28]:
```
patientInfo['patientAge'].hist()
```

Out[28]:
```
<Axes: >
```




In [29]:
```
patientInfo[patientInfo['patientAge']>=85]['patientAge'].value_counts()
```

Out[29]:
```
86     25
87     20
90     19
85     16
88     12
89      8
91      3
92      2
148     1
151     1
153     1
150     1
155     1
Name: patientAge, dtype: int64
```

We can see that some patient have age more than 100+ and some even ranging to 140+, either these ages are masked or they are some error in data collection

## *Let us visualize the bounding boxes*

In [8]:
```
#Method to draw single patient with bounding box(es) if present
def draw(data):
    # --- Open DICOM file
```

```
    d = pydicom.read_file(data['dicom'])
    im = d.pixel_array

    # --- Convert from single-channel grayscale to 3-channel RGB
    im = np.stack([im] * 3, axis=2)

    # --- Add boxes with random color if present
    for box in data['boxes']:
        rgb = np.floor(np.random.rand(3) * 256).astype('int')
        im = overlay_box(im=im, box=box, rgb=rgb, stroke=6)

    plt.imshow(im, cmap=plt.cm.gist_gray)
    plt.axis('off')

def overlay_box(im, box, rgb, stroke=1):
    # --- Convert coordinates to integers
    box = [int(b) for b in box]

    # --- Extract coordinates
    y1, x1, height, width = box
    y2 = y1 + height
    x2 = x1 + width

    im[y1:y1 + stroke, x1:x2] = rgb
    im[y2:y2 + stroke, x1:x2] = rgb
    im[y1:y2, x1:x1 + stroke] = rgb
    im[y1:y2, x2:x2 + stroke] = rgb

    return im
```

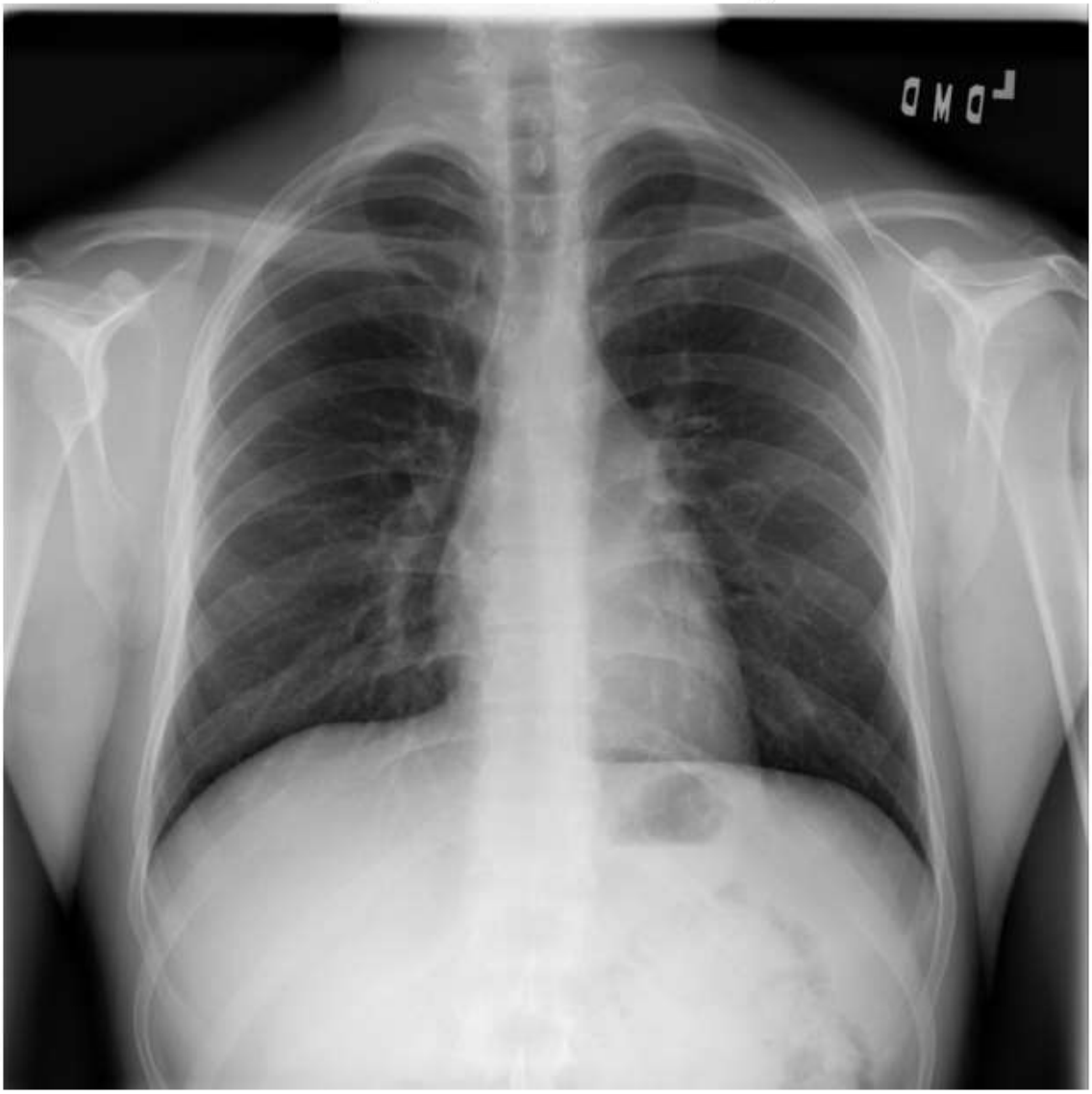
## 1. *Visualizing a normal chest radiograph without any opacities*

In [9]:

```
patientId = df['patientId'][3]
print(patient_class.loc[patientId])

plt.figure(figsize=(10,8))
plt.title("Sample Patient 1 - Normal Image")

draw(parsed[patientId])
```

```
class    Normal
Name: 003d8fa0-6bf1-40ed-b54c-ac657f8495c5, dtype: object
```

Sample Patient 1 - Normal Image

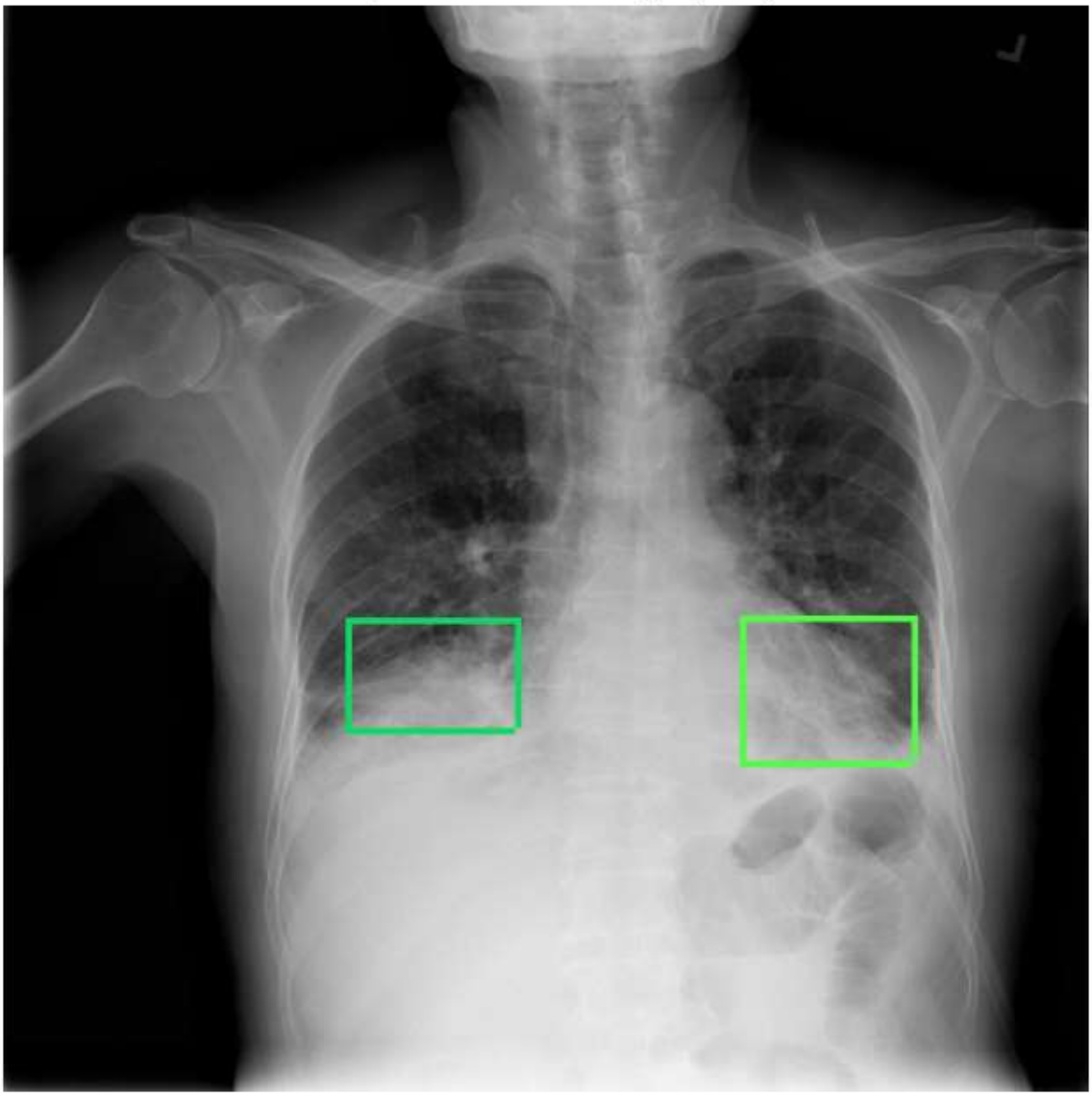


## 2. *Visualizing a Normal Image having opacities*

In [10]:
```
patientId = df['patientId'][8]
print(patient_class.loc[patientId])

plt.figure(figsize=(10,8))
plt.title("Sample Patient 2 - Lung Opacity")

draw(parsed[patientId])
```

```
                                          class
patientId
00704310-78a8-4b38-8475-49f4573b2dbb  Lung Opacity
00704310-78a8-4b38-8475-49f4573b2dbb  Lung Opacity
```

Sample Patient 2 - Lung Opacity



Let us understand the difference between the two pictures and understand what we mean by opacity

Here, in Chest Radiographs :-

- Black = Air
- White = Bone
- Grey = Tissue or Fluid

One thing we should keep in mind is that the left side of the subject is on the right side of the screen by convention.

If any region of the chest X-ray appears whiter than expected, it may indicate an abnormality. Comparing the X-ray images of Sample Patient 1 and Sample Patient 2 reveals that patient 2's lower lung boundary is obstructed by opacities. In Sample Patient 1's X-ray

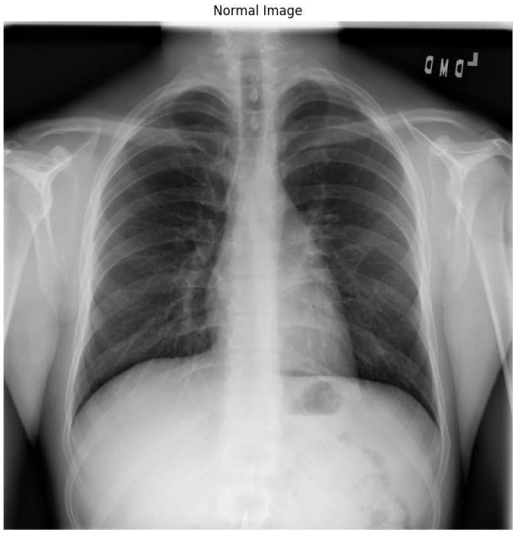
image, a clear distinction can be seen between the black lungs and the tissue beneath, while in Sample Patient 2's image, there is only a blurry appearance.

Usually the lungs are full of air. When someone has pneumonia, the air in the lungs is replaced by other material - fluids, bacteria, immune system cells, etc.

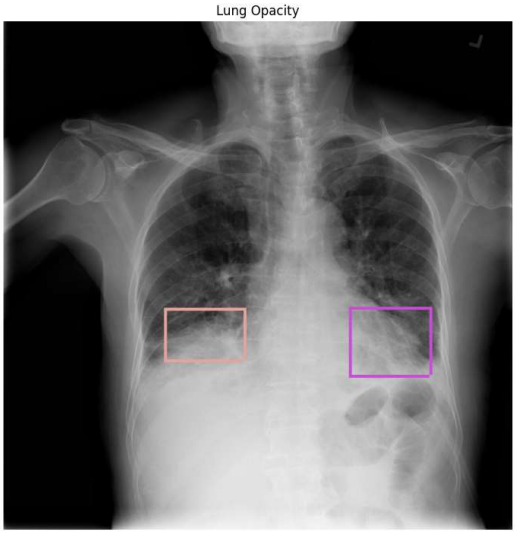
## *To get a better understanding, let us compare few images side by side*

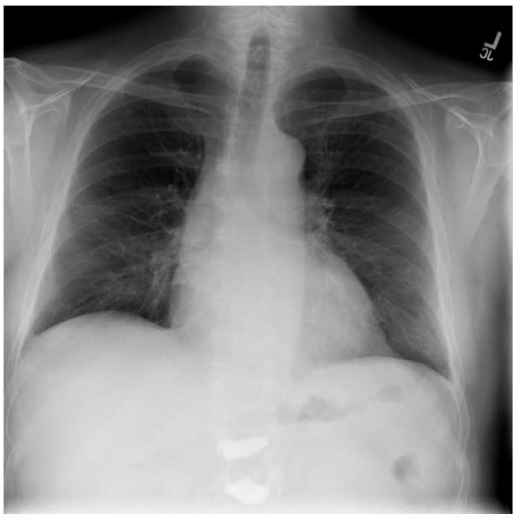
In [11]:
```
plt.figure(figsize=(20, 40))

plt.subplot(421)
plt.title("Normal Image")

draw(parsed[df['patientId'][3]])

plt.subplot(423)
draw(parsed[df['patientId'][11]])

plt.subplot(425)
draw(parsed[df['patientId'][12]])

plt.subplot(427)
draw(parsed[df['patientId'][13]])

plt.subplot(422)
plt.title("Lung Opacity")

draw(parsed[df['patientId'][8]])

plt.subplot(424)
draw(parsed[df['patientId'][16]])

plt.subplot(426)
draw(parsed[df['patientId'][19]])

plt.subplot(428)
draw(parsed[df['patientId'][24]])
```

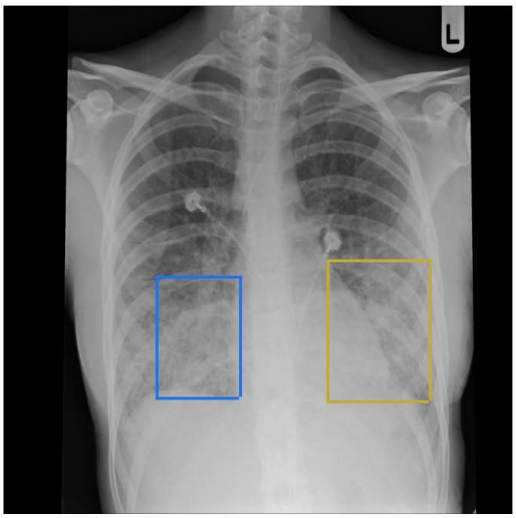
Normal Image

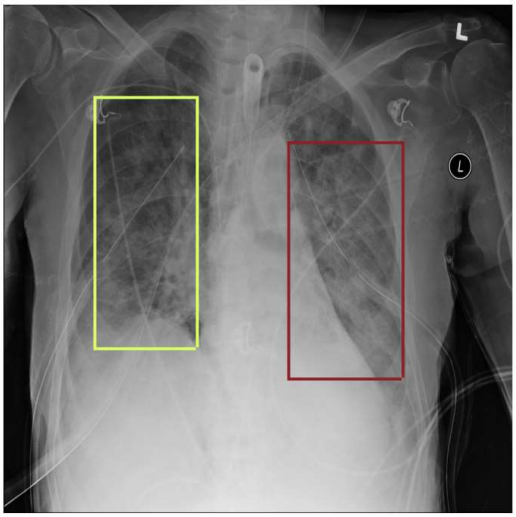


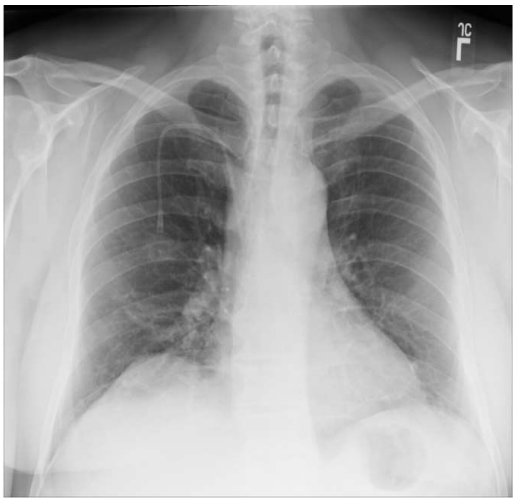
Lung Opacity

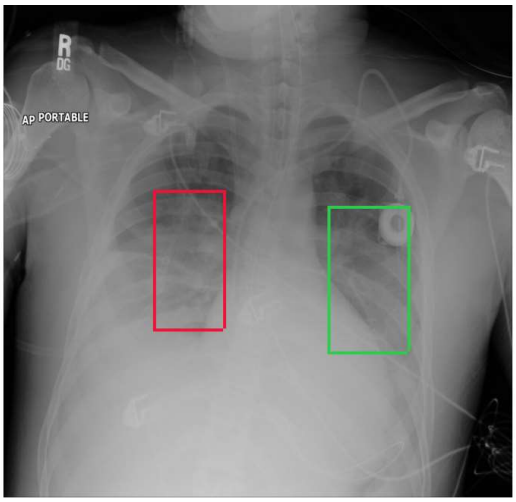










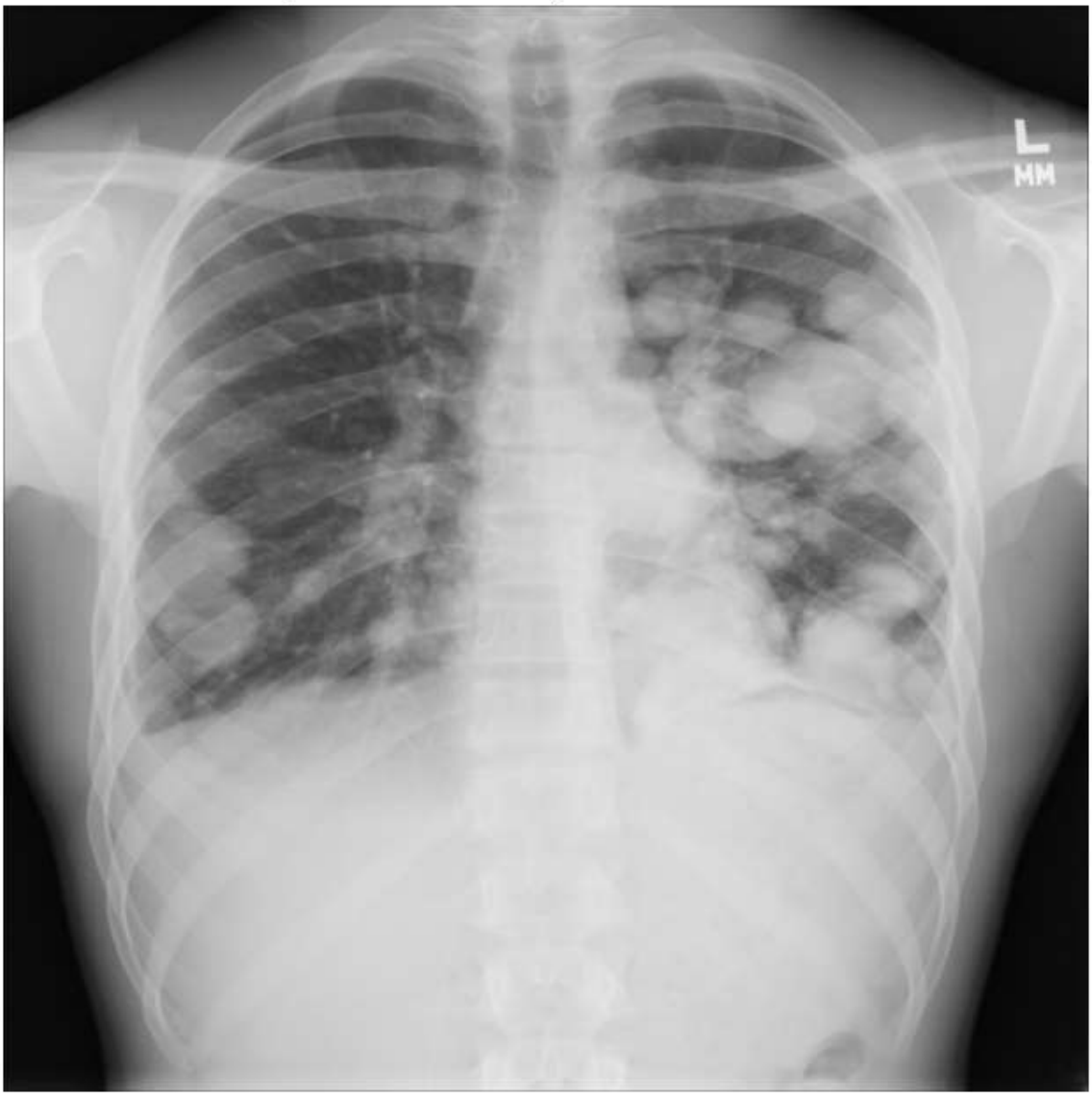



### *We also have one more class i.e No Lung Opacity but also not normal*

In [12]:
```
patientId = df['patientId'][2]
print(patient_class.loc[patientId])

plt.figure(figsize=(10,8))
plt.title("Sample Patient 3 - Lung Nodules and Masses")
draw(parsed[patientId])
```

```
class    No Lung Opacity / Not Normal
Name: 00322d4d-1c29-4943-afc9-b6754be640eb, dtype: object
```

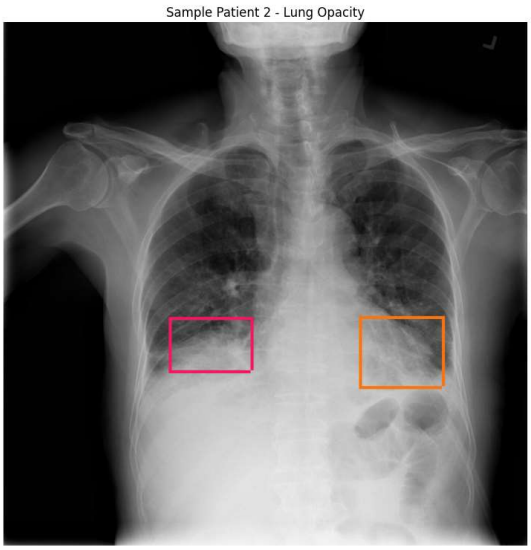
Sample Patient 3 - Lung Nodules and Masses




This is an interesting observation we can see that this patient has a "Target" value of 0 in the "stage_2_train_labels.csv" file, which means he does not have a diagnosis of peumonia.

## *Let us visualize both of these*

In [13]:
```
plt.figure(figsize=(20, 40))

plt.subplot(121)
plt.title("Sample Patient 2 - Lung Opacity")
draw(parsed[df['patientId'][8]])

plt.subplot(122)
plt.title("Sample Patient 3 - Lung Nodules and Masses")
draw(parsed[df['patientId'][2]])
```

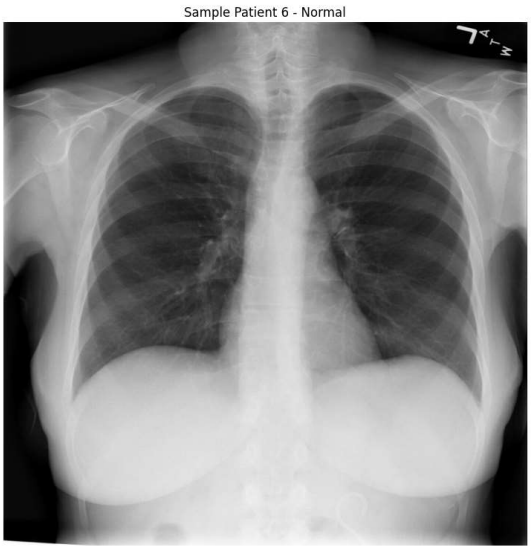


The primary contrast in opacity types between these two patients lies in the appearance and form of the opacities. Patient 3 displays numerous opacities that are circular and well-defined, while Patient 2 exhibits indistinct haziness that obscures the borders of the lungs and heart.

## Let us take a look at another two classes i.e Normal and No lung opacity

In [14]:
```
plt.figure(figsize=(20, 40))

plt.subplot(121)
plt.title("Sample Patient 6 - Normal")
draw(parsed[df['patientId'][59]])
print(patient_class.loc[df['patientId'][59]])

plt.subplot(122)
plt.title("Sample Patient 8 - Increased Vascular Markings + Enlarged Heart")
draw(parsed[df['patientId'][38]])
print(patient_class.loc[df['patientId'][38]])
```

```
class    Normal
Name: 01cc7c75-4498-43ab-b650-5553d0507f76, dtype: object
class    No Lung Opacity / Not Normal
Name: 019e035e-2f82-4c66-a198-57422a27925f, dtype: object
```



Here, we can observe that Patient 8's heart is occupying an excessive amount of space, exceeding the recommended size of no more than half of the chest cavity.

## *White Lung*

While exploring some of the images, I found that there were radiographs containing white lung and these are labelled as '1' meaning the patient have pneumonia. So the question may arise what happened to the lung if there is no lung, some of the poissibilities are stated as below :-

- The lung was removed in a surgery related to pneumonia
- The lung is filled with fluid from pneumonia
- The lung is there but it is surrounded by fluids inside the chest cavity due to pneumonia thus in the chest radiographs caused white lung

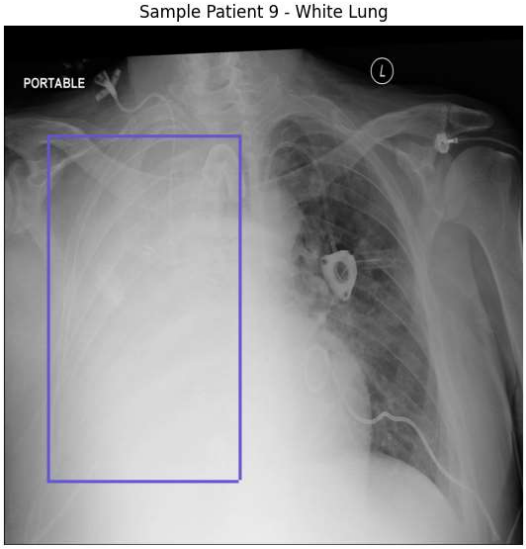
In [15]:
```
plt.figure(figsize=(15, 15))

plt.subplot(221)
plt.title("Sample Patient 6 - Normal")
draw(parsed[df['patientId'][59]])
print(patient_class.loc[df['patientId'][59]])

plt.subplot(222)
plt.title("Sample Patient 9 - White Lung")
draw(parsed['924f4f8b-fc27-4dfd-b5ae-59c40715e150'])
print(patient_class.loc['924f4f8b-fc27-4dfd-b5ae-59c40715e150'])

plt.subplot(223)
plt.title("Sample Patient 10 - White Lung")
draw(parsed['17a5ce04-809a-42ed-9e58-100cfb33de7a'])
print(patient_class.loc['17a5ce04-809a-42ed-9e58-100cfb33de7a'])

plt.subplot(224)
plt.title("Sample Patient 11 - White Lung")
```

```
draw(parsed['9dde630b-1f95-46e6-bcde-117eee4c7283'])
print(patient_class.loc['9dde630b-1f95-46e6-bcde-117eee4c7283'])
```

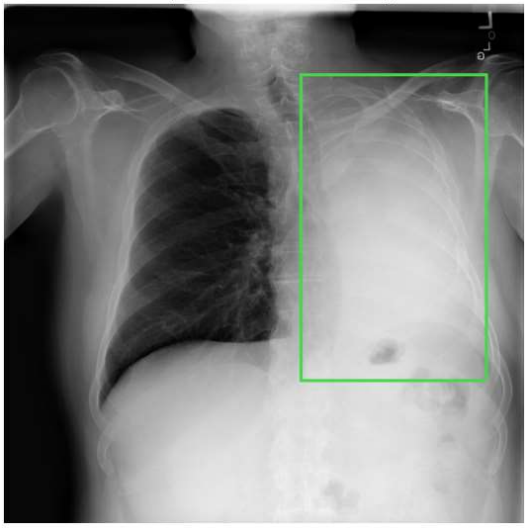
```
class    Normal
Name: 01cc7c75-4498-43ab-b650-5553d0507f76, dtype: object
class    Lung Opacity
Name: 924f4f8b-fc27-4dfd-b5ae-59c40715e150, dtype: object
class    Lung Opacity
Name: 17a5ce04-809a-42ed-9e58-100cfb33de7a, dtype: object
class    Lung Opacity
Name: 9dde630b-1f95-46e6-bcde-117eee4c7283, dtype: object
```

Sample Patient 6 - Normal

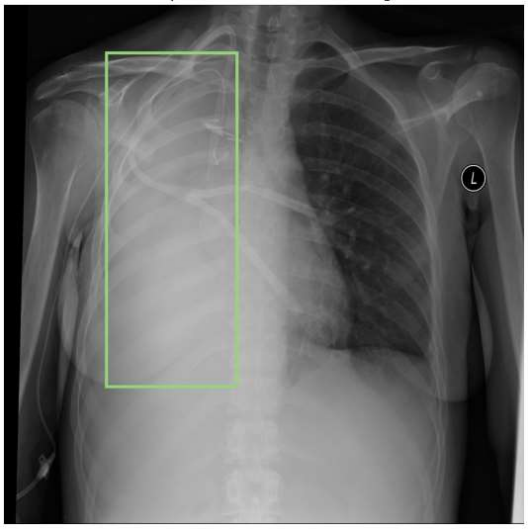
Sample Patient 9 - White Lung




Sample Patient 10 - White Lung



Sample Patient 11 - White Lung



In [ ]:

```
```

In [3]:

```
!python -m pip install -U notebook-as-pdf
!pyppeteer-install
```

```
Collecting notebook-as-pdf
  Using cached notebook_as_pdf-0.5.0-py3-none-any.whl (6.5 kB)
Requirement already satisfied: nbconvert in d:\anaconda3\envs\pneumonia_set\lib\si
te-packages (from notebook-as-pdf) (7.2.9)
Collecting pyppeteer
  Downloading pyppeteer-1.0.2-py3-none-any.whl (83 kB)
     ---------------------------------------- 83.4/83.4 kB 786.4 kB/s eta 0:00:00
Collecting PyPDF2
  Downloading pypdf2-3.0.1-py3-none-any.whl (232 kB)
     ---------------------------------------- 232.6/232.6 kB 2.4 MB/s eta 0:00:00
Requirement already satisfied: bleach in d:\anaconda3\envs\pneumonia_set\lib\site-
packages (from nbconvert->notebook-as-pdf) (6.0.0)
Requirement already satisfied: jinja2>=3.0 in d:\anaconda3\envs\pneumonia_set\lib
\site-packages (from nbconvert->notebook-as-pdf) (3.1.2)
Requirement already satisfied: mistune<3,>=2.0.3 in d:\anaconda3\envs\pneumonia_se
t\lib\site-packages (from nbconvert->notebook-as-pdf) (2.0.5)
Requirement already satisfied: jupyterlab-pygments in d:\anaconda3\envs\pneumonia_
set\lib\site-packages (from nbconvert->notebook-as-pdf) (0.2.2)
Requirement already satisfied: markupsafe>=2.0 in d:\anaconda3\envs\pneumonia_set
\lib\site-packages (from nbconvert->notebook-as-pdf) (2.1.2)
Requirement already satisfied: traitlets>=5.0 in d:\anaconda3\envs\pneumonia_set\l
ib\site-packages (from nbconvert->notebook-as-pdf) (5.9.0)
Requirement already satisfied: packaging in d:\anaconda3\envs\pneumonia_set\lib\si
te-packages (from nbconvert->notebook-as-pdf) (23.0)
Requirement already satisfied: tinycss2 in d:\anaconda3\envs\pneumonia_set\lib\sit
e-packages (from nbconvert->notebook-as-pdf) (1.2.1)
Requirement already satisfied: jupyter-core>=4.7 in d:\anaconda3\envs\pneumonia_se
t\lib\site-packages (from nbconvert->notebook-as-pdf) (5.2.0)
Requirement already satisfied: pygments>=2.4.1 in d:\anaconda3\envs\pneumonia_set
\lib\site-packages (from nbconvert->notebook-as-pdf) (2.14.0)
Requirement already satisfied: defusedxml in d:\anaconda3\envs\pneumonia_set\lib\s
ite-packages (from nbconvert->notebook-as-pdf) (0.7.1)
Requirement already satisfied: importlib-metadata>=3.6 in d:\anaconda3\envs\pneumo
nia_set\lib\site-packages (from nbconvert->notebook-as-pdf) (6.0.0)
Requirement already satisfied: nbformat>=5.1 in d:\anaconda3\envs\pneumonia_set\li
b\site-packages (from nbconvert->notebook-as-pdf) (5.7.3)
Requirement already satisfied: beautifulsoup4 in d:\anaconda3\envs\pneumonia_set\l
ib\site-packages (from nbconvert->notebook-as-pdf) (4.11.2)
Requirement already satisfied: pandocfilters>=1.4.1 in d:\anaconda3\envs\pneumonia
_set\lib\site-packages (from nbconvert->notebook-as-pdf) (1.5.0)
Requirement already satisfied: nbclient>=0.5.0 in d:\anaconda3\envs\pneumonia_set
\lib\site-packages (from nbconvert->notebook-as-pdf) (0.7.2)
Collecting typing_extensions>=3.10.0.0
  Downloading typing_extensions-4.5.0-py3-none-any.whl (27 kB)
Collecting appdirs<2.0.0,>=1.4.3
  Using cached appdirs-1.4.4-py2.py3-none-any.whl (9.6 kB)
Collecting pyee<9.0.0,>=8.1.0
  Using cached pyee-8.2.2-py2.py3-none-any.whl (12 kB)
Requirement already satisfied: certifi>=2021 in d:\anaconda3\envs\pneumonia_set\li
b\site-packages (from pyppeteer->notebook-as-pdf) (2022.12.7)
Collecting websockets<11.0,>=10.0
  Downloading websockets-10.4-cp39-cp39-win_amd64.whl (101 kB)
     ---------------------------------------- 101.4/101.4 kB 162.3 kB/s eta 0:00:00
Collecting urllib3<2.0.0,>=1.25.8
  Downloading urllib3-1.26.14-py2.py3-none-any.whl (140 kB)
     ---------------------------------------- 140.6/140.6 kB 334.4 kB/s eta 0:00:00
```

```
Collecting tqdm<5.0.0,>=4.42.1
  Downloading tqdm-4.64.1-py2.py3-none-any.whl (78 kB)
     ---------------------------------------- 78.5/78.5 kB 334.4 kB/s eta 0:00:00
Requirement already satisfied: zipp>=0.5 in d:\anaconda3\envs\pneumonia_set\lib\si
te-packages (from importlib-metadata>=3.6->nbconvert->notebook-as-pdf) (3.14.0)
Requirement already satisfied: platformdirs>=2.5 in d:\anaconda3\envs\pneumonia_se
t\lib\site-packages (from jupyter-core>=4.7->nbconvert->notebook-as-pdf) (3.0.0)
Requirement already satisfied: pywin32>=1.0 in d:\anaconda3\envs\pneumonia_set\lib
\site-packages (from jupyter-core>=4.7->nbconvert->notebook-as-pdf) (305)
Requirement already satisfied: jupyter-client>=6.1.12 in d:\anaconda3\envs\pneumon
ia_set\lib\site-packages (from nbclient>=0.5.0->nbconvert->notebook-as-pdf) (8.0.
3)
Requirement already satisfied: jsonschema>=2.6 in d:\anaconda3\envs\pneumonia_set
\lib\site-packages (from nbformat>=5.1->nbconvert->notebook-as-pdf) (4.17.3)
Requirement already satisfied: fastjsonschema in d:\anaconda3\envs\pneumonia_set\l
ib\site-packages (from nbformat>=5.1->nbconvert->notebook-as-pdf) (2.16.2)
Requirement already satisfied: colorama in d:\anaconda3\envs\pneumonia_set\lib\sit
e-packages (from tqdm<5.0.0,>=4.42.1->pyppeteer->notebook-as-pdf) (0.4.6)
Requirement already satisfied: soupsieve>1.2 in d:\anaconda3\envs\pneumonia_set\li
b\site-packages (from beautifulsoup4->nbconvert->notebook-as-pdf) (2.4)
Requirement already satisfied: six>=1.9.0 in d:\anaconda3\envs\pneumonia_set\lib\s
ite-packages (from bleach->nbconvert->notebook-as-pdf) (1.16.0)
Requirement already satisfied: webencodings in d:\anaconda3\envs\pneumonia_set\lib
\site-packages (from bleach->nbconvert->notebook-as-pdf) (0.5.1)
Requirement already satisfied: attrs>=17.4.0 in d:\anaconda3\envs\pneumonia_set\li
b\site-packages (from jsonschema>=2.6->nbformat>=5.1->nbconvert->notebook-as-pdf)
(22.2.0)
Requirement already satisfied: pyrsistent!=0.17.0,!=0.17.1,!=0.17.2,>=0.14.0 in
d:\anaconda3\envs\pneumonia_set\lib\site-packages (from jsonschema>=2.6->nbformat>
=5.1->nbconvert->notebook-as-pdf) (0.19.3)
Requirement already satisfied: tornado>=6.2 in d:\anaconda3\envs\pneumonia_set\lib
\site-packages (from jupyter-client>=6.1.12->nbclient>=0.5.0->nbconvert->notebook-
as-pdf) (6.2)
Requirement already satisfied: python-dateutil>=2.8.2 in d:\anaconda3\envs\pneumon
ia_set\lib\site-packages (from jupyter-client>=6.1.12->nbclient>=0.5.0->nbconvert-
>notebook-as-pdf) (2.8.2)
Requirement already satisfied: pyzmq>=23.0 in d:\anaconda3\envs\pneumonia_set\lib
\site-packages (from jupyter-client>=6.1.12->nbclient>=0.5.0->nbconvert->notebook-
as-pdf) (25.0.0)
Installing collected packages: pyee, appdirs, websockets, urllib3, typing_extensio
ns, tqdm, pyppeteer, PyPDF2, notebook-as-pdf
Successfully installed PyPDF2-3.0.1 appdirs-1.4.4 notebook-as-pdf-0.5.0 pyee-8.2.2
pyppeteer-1.0.2 tqdm-4.64.1 typing_extensions-4.5.0 urllib3-1.26.14 websockets-10.
4
chromium is already installed.
```

In [ ]: