Team: X-Ray Vision Group Members:

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In [ ]:
```
from pathlib import Path
from PIL import Image
import pandas as pd
import json
import os
from collections import namedtuple
import matplotlib.pyplot as plt
from torch.utils import data
from torch.utils.data import Dataset, DataLoader
import torchvision.transforms as T
from torchvision.io import read_image
import torchvision.transforms as T
import re
```

Pre-Processing & Summary Stats

In [ ]:
```
# Getting the Path where the x-ray images are stored
current_dir = Path.cwd()

# Get the parent directory of the current file
parent_dir = current_dir.parent

# Join the parent directory with the name of the adjacent folder
data_path = parent_dir.joinpath('/chest_xray')

# Alternative Variable with data directory
alt_directory = '/Users/rubengallardo/Documents/GitHub/Spring_2024/ml_projec
os.listdir(alt_directory)
```

Out[ ]:
```
['.DS_Store', 'test', 'chest_xray', '__MACOSX', 'train', 'val']
```

In [ ]:
```
Image_Stats = namedtuple('Image_Stats', ["split", "label", "sick_type", "wid

METRICS = ["widths", "heights", "pixels_sq", "ratios", "channels"]

def compile_stats(data_path):
    tup_list = []
    sum_stats = {}
    for folder_l1 in os.listdir(data_path):
        #iterating through test, train, and val
        if folder_l1 in ('.DS_Store', '__MACOSX'):
            continue
        fl1 = os.path.join(data_path, folder_l1)

        # checking if it is a folder
```

```
        if not os.path.isdir(fl1):
            continue
        sum_stats[folder_l1] = {}
        for folder_l2 in os.listdir(fl1):
            #iterating through Normal and Pnemonia
            if folder_l2 == '.DS_Store':
                continue
            fl2 = os.path.join(fl1, folder_l2)
            if not os.path.isdir(fl2):
                continue
            sum_stats[folder_l1][folder_l2] = {}

            for filename in os.listdir(fl2):
                #iterating through images
                if filename == '.DS_Store':
                    continue
                f = os.path.join(fl2, filename)
                # checking if it is a file
                if not os.path.isfile(f):
                    continue


                image_obj = Image.open(f)

                #initializing empty lists of summary statistics
                for m in METRICS:
                    sum_stats[folder_l1][folder_l2][m] = sum_stats[folder_l1

                #fillin in the summary statistics
                sum_stats[folder_l1][folder_l2]["widths"].append(image_obj.w
                sum_stats[folder_l1][folder_l2]["heights"].append(image_obj.

                #calculating square pixels
                square_pixels = int(image_obj.height) * int(image_obj.width)
                sum_stats[folder_l1][folder_l2]["pixels_sq"].append(square_p

                ratio = int(image_obj.width)/int(image_obj.height)
                sum_stats[folder_l1][folder_l2]["ratios"].append(ratio)

                #counting the number of layers/ channels
                channels = image_obj.getbands()
                sum_stats[folder_l1][folder_l2]["channels"].append(len(chanr

                img_label = 1 if folder_l2 == 'PNEUMONIA' else 0

                # Checking if the Label is Bacteria or Virus
                if folder_l2 == 'PNEUMONIA':
                    str_path = str(filename)
                    if re.search("virus", str_path):
                        sick = "Virus"
                    else:
                        sick = "Bacteria"
                else:
                    sick = "Normal"

                tup = Image_Stats(folder_l1, img_label, sick, image_obj.widt
```

```
                tup_list.append(tup)

                del image_obj

    return sum_stats, tup_list
```

In [ ]:
```
dic, tup_list = compile_stats(alt_directory)
df = pd.DataFrame(tup_list)
df["ratio"].mean()

# Verify DataFrame
df.head(10)
```

Out[ ]:

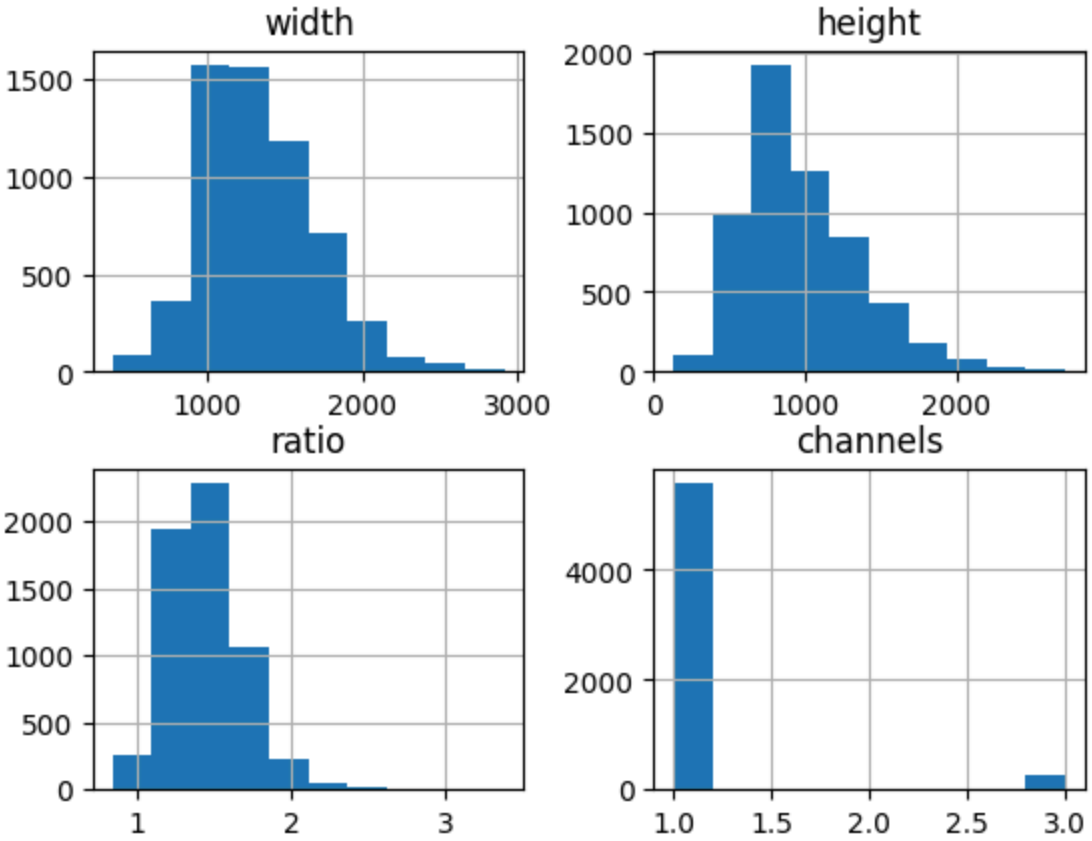
	split	label	sick_type	width	height	pixels_sq	ratio	channels	
0	test	1	Bacteria	1120	808	904960	1.386139	1	person147_bac
1	test	1	Bacteria	1040	696	723840	1.494253	1	person100_bac
2	test	1	Bacteria	1016	544	552704	1.867647	1	person78_bac
3	test	1	Bacteria	976	608	593408	1.605263	1	person124_bac
4	test	1	Virus	1168	768	897024	1.520833	1	person1647_v
5	test	1	Virus	952	520	495040	1.830769	1	person1675_v
6	test	1	Bacteria	1280	1000	1280000	1.280000	1	person89_bac
7	test	1	Virus	1552	1016	1576832	1.527559	1	person35
8	test	1	Bacteria	984	520	511680	1.892308	1	person122_bac
9	test	1	Bacteria	1072	608	651776	1.763158	1	person119_bac

In [ ]:
```
#Presenting the averages for each summary statistic.

df[["width", "height", "ratio", "channels"]].mean()
```

Out[ ]:
```
width       1327.880806
height       970.689037
ratio          1.442986
channels       1.096653
dtype: float64
```

In [ ]:
```
# Ploting the distributing of each summary statistic.
df[["width", "height", "ratio", "channels"]].hist()
```

Out[ ]:
```
array([[<Axes: title={'center': 'width'}>,
        <Axes: title={'center': 'height'}>],
       [<Axes: title={'center': 'ratio'}>,
        <Axes: title={'center': 'channels'}>]], dtype=object)
```



Based on these summary statistics the vast majority of images are landscape, meaning that the width is longer than the height. Almost all the images have only one channel, meaning they are in greyscale, but it appears 283 images have three channels meaning their data is held in rgb.

In [ ]:
```
df_channels = df[["channels"]]
df_channels[df[["channels"]]==3].count()
```

Out[ ]:
```
channels    283
dtype: int64
```

Image Transformations

We implemented a custom Dataset class based on this PyTorch documentation. This class will help us do our image augmentations later on.

In [ ]:
```
# Custom PyTorch Image Dataset Class
# Code Resource: https://pytorch.org/tutorials/beginner/basics/data_tutorial

class CustomImageDataset(Dataset):
    def __init__(self, df, img_dir_path, transform=None):
        """
        df (pandas df): pandas dataframe
        img_dir_path: directory path to your images
        transform: Compose (a PyTorch Class) that strings together several
```

```
        transform functions (e.g. data augmentation steps)
        """
        self.img_labels = df
        self.img_dir = img_dir_path
        self.transform = transform

    def __len__(self):
        """
        Returns: (int) length of your dataset
        """
        return len(self.img_labels)

    def __getitem__(self, idx):
        """
        Loads and returns your sample (the image and the label) at the
        specified index

        Parameter: idx (int): index of interest

        Returns: image, label
        """
        img_path = os.path.join(self.img_labels.iloc[idx, -1])
        image = Image.open(img_path).convert('RGB')
        label = self.img_labels.iloc[idx, 1]

        # Image Transformation
        if self.transform:
            image = self.transform(image)

        # Returns augmented and/or normalized image with label
        # Label = 1 if pneumonia and label = 0 if normal
        return image, label
```

In [ ]:

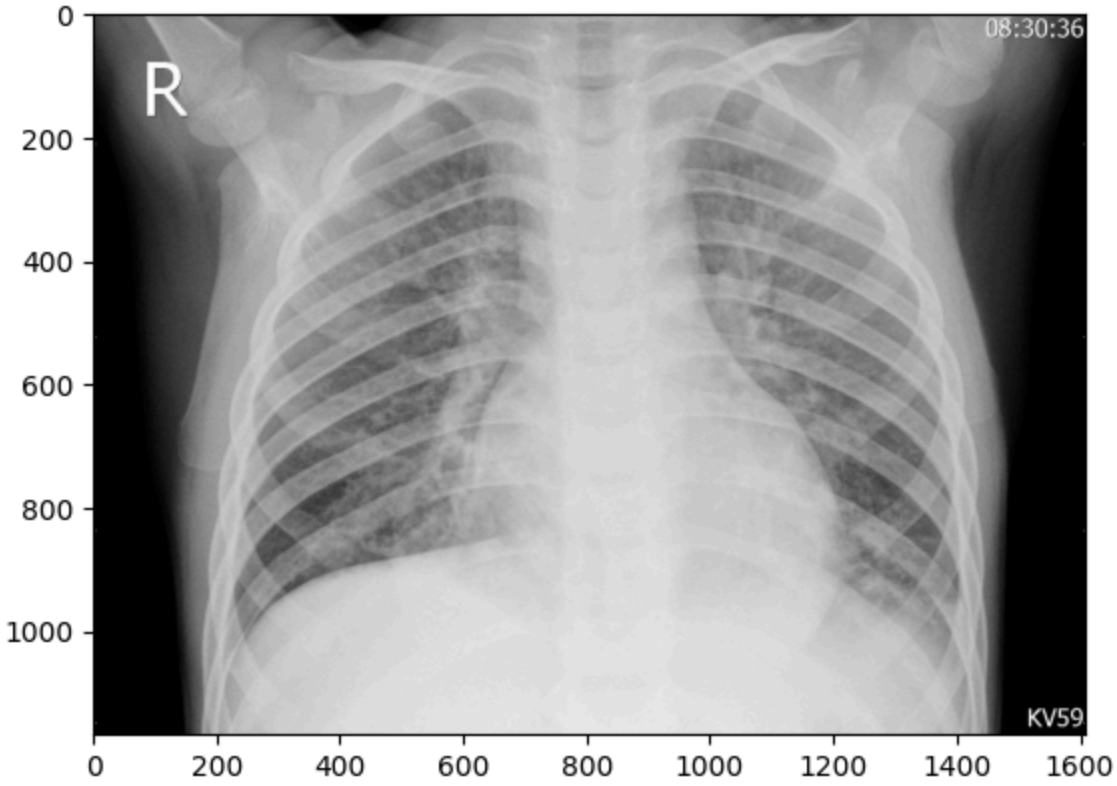
```
# Augmentation for Training Data
augmentations = T.Compose([
    T.Resize((256, 256)),
    T.RandomHorizontalFlip(p=0.5),  # Horizontal flip with prob of 0.5
    T.RandomVerticalFlip(p=0.5),    # Vertical flip with prob of 0.5
    T.RandomResizedCrop(size=(256, 256), scale=(0.8, 1.0), ratio=(0.75, 1.33
    T.RandomAffine(degrees=0, translate=(0.1, 0.1)),  # Shifts image horizor
    T.ColorJitter(brightness=0.2, contrast=0.2),  # Randomly changes brightr
    T.RandomRotation(degrees=10), # Random rotation
    T.ToTensor()  # Convert images to tensors
])

# Normalization for Validation and Test datasets
normalizations = T.Compose([
    T.Resize((256, 256)),
    T.ToTensor()
])
```

Normalization and Augmentation Examples

For data augmentation, we conducted a literature scan of data augmentation methods used in medical image deep learning, with a focus on studies that use chest X-ray images. We identified horizontal flipping, rescaling, shifting, rotation, brightness and contrast changes to be the most common methods that also make sense to our study. We implemented them as a starting point, keeping in mind they are hyperparameters we can revisit and readjust later depending on model performance.

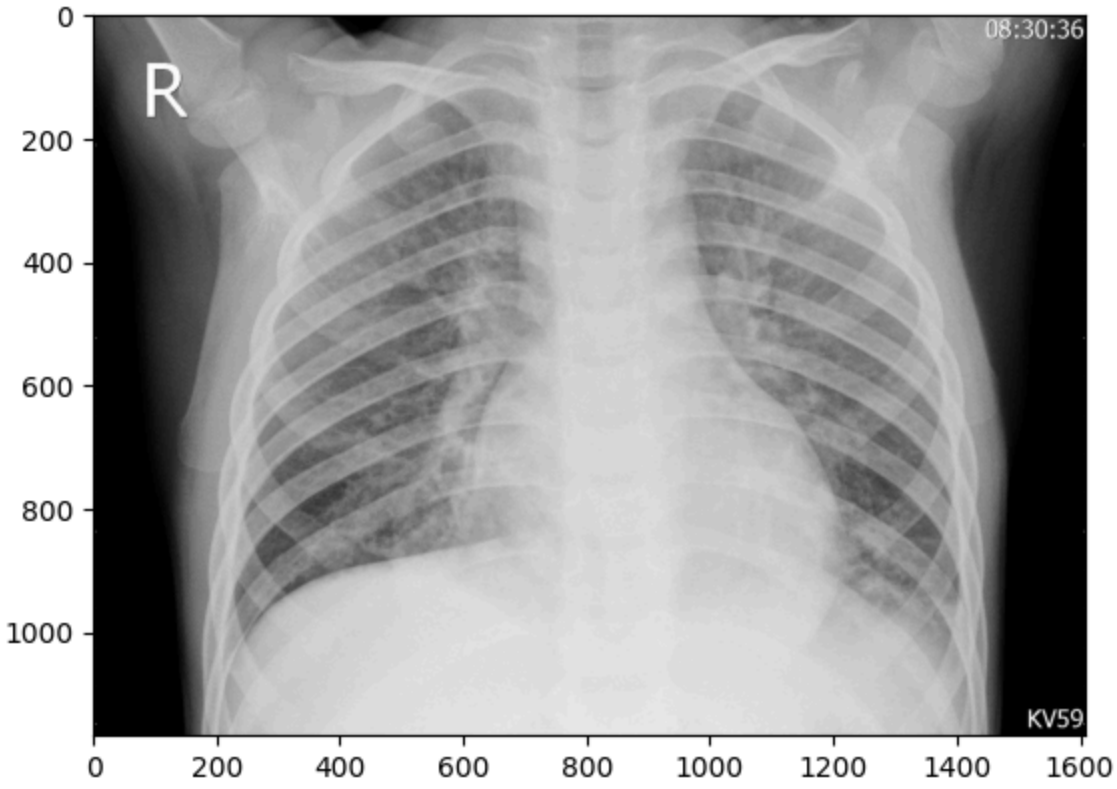
Original Sample Image

In [ ]:
```
# Random Horizontal Flip
image = read_image(alt_directory + '/train/PNEUMONIA/person141_virus_287.jpe

image = image.squeeze() # Remove the channel dimension because it's grayscal
plt.imshow(image, cmap='grey')
plt.show()
```



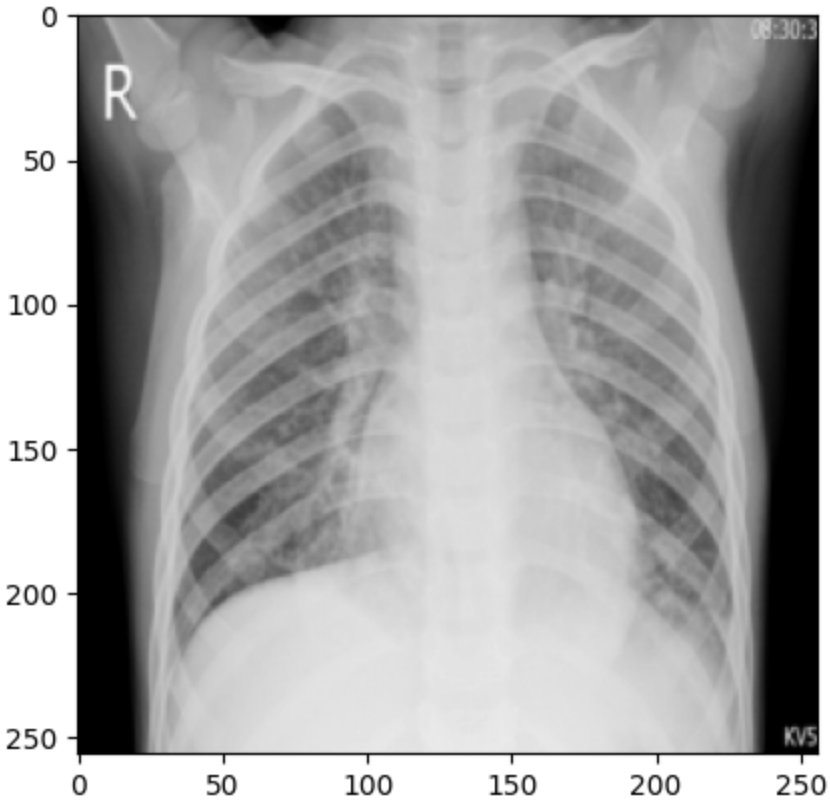
Random Horizonal Flip

In [ ]:
```
# Random Horizontal Flip with probability of 0.5
image = T.RandomHorizontalFlip(p=0.5)(image)

image = image.squeeze() # Remove the channel dimension because it's grayscal
plt.imshow(image, cmap='grey')
plt.show()
```



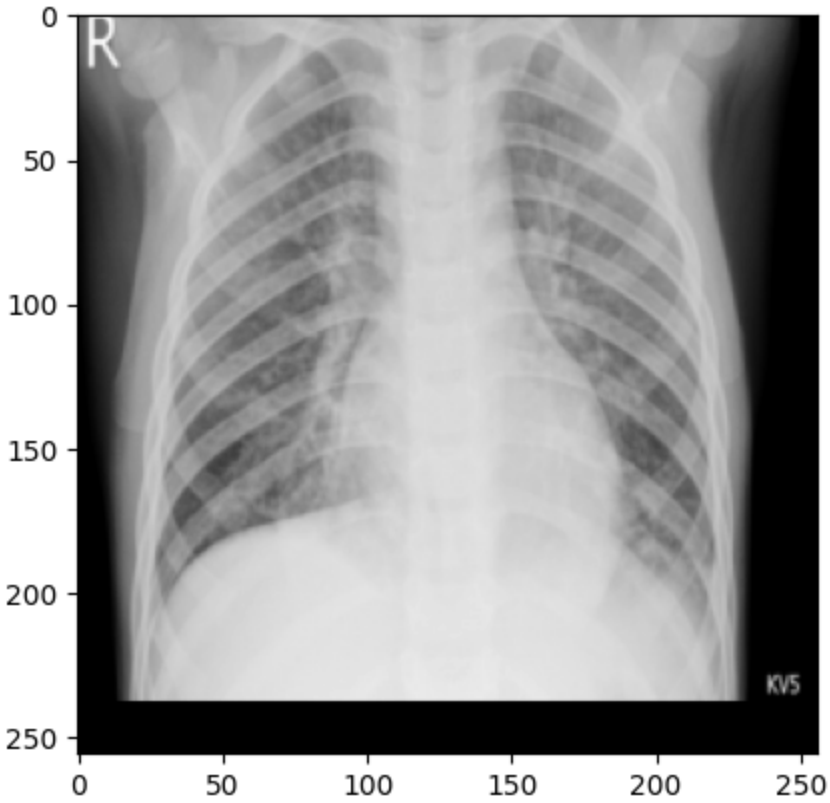
Rescaling

In [ ]:
```
# Add a batch dimension
image = image.unsqueeze(0)  # Reshape from (C, H, W) to (1, C, H, W)

# Rescaling
image = T.RandomResizedCrop(size=(256, 256), scale=(0.8, 1.0), ratio=(0.75,

# Remove the batch dimension for displaying
image = image.squeeze(0)

# Display the image
plt.imshow(image.squeeze(), cmap='grey')
plt.show()
```



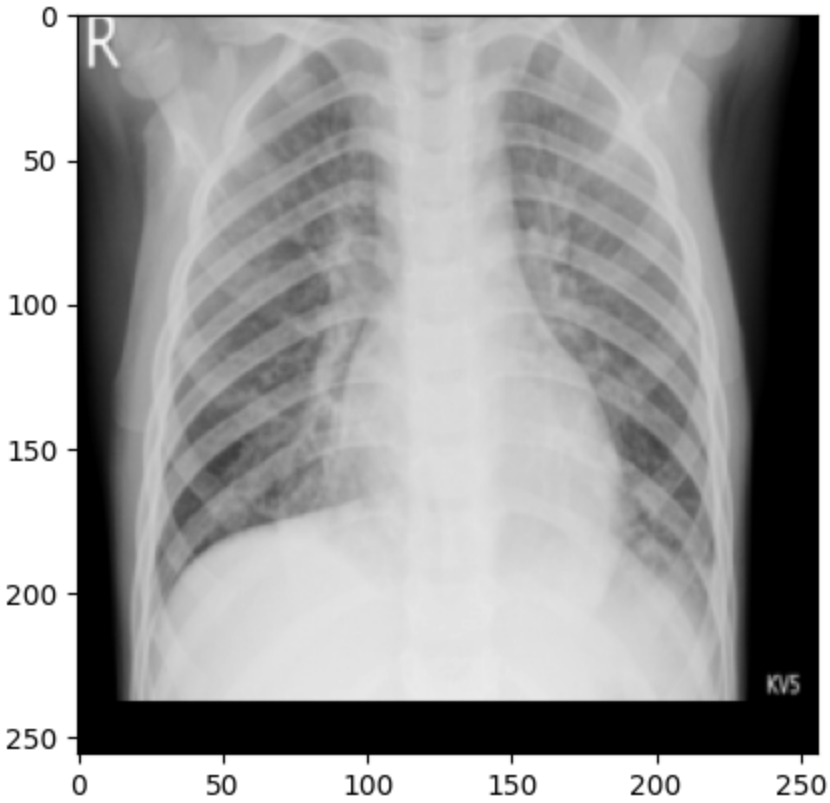
Random Shifting

In [ ]:
```
# Add a batch dimension
image = image.unsqueeze(0)  # Reshape from (C, H, W) to (1, C, H, W)

# Shifts image horizontally or vertically by 10%
image = T.RandomAffine(degrees=0, translate=(0.1, 0.1))(image)

# Remove the batch dimension for displaying
image = image.squeeze()

plt.imshow(image, cmap='grey')
plt.show()
```



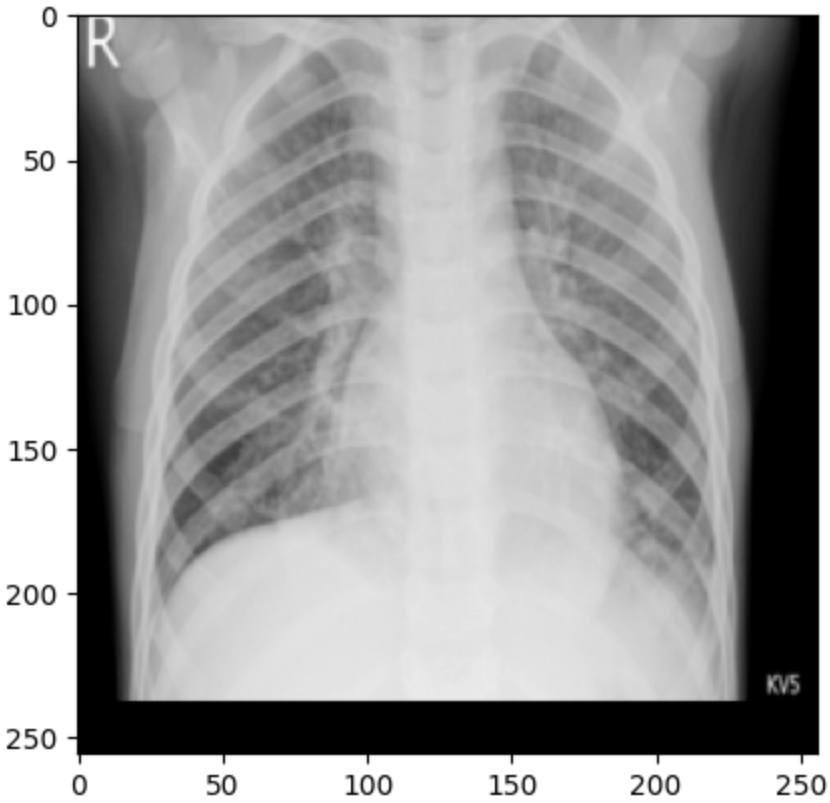
Random Changes to Brightness & Contrast

In [ ]:
```
# Add a batch dimension
image = image.unsqueeze(0)  # Reshape from (C, H, W) to (1, C, H, W)

# Randomly changes brightness and contrast
T.ColorJitter(brightness=0.2, contrast=0.2)(image)

# Remove the batch dimension for displaying
image = image.squeeze()  # Now image is (C, H, W) again

plt.imshow(image, cmap='grey')
plt.show()
```



Random Rotation

In [ ]:
```
# Add a batch dimension
image = image.unsqueeze(0)  # Reshape from (C, H, W) to (1, C, H, W)

# Randomly changes brightness and contrast
T.RandomRotation(degrees=10)(image)

# Remove the batch dimension for displaying
image = image.squeeze()  # Now image is (C, H, W) again

plt.imshow(image, cmap='grey')
plt.show()
```



Create Separate DataFrames & Summary of Labels

After extracting the summary statistics of our images and storing them in a DataFrame, we prepared the data for the DataLoader by separating out the summary statistic into a training, test, and validation DataFrame. We also created a table that shows how many images fall into the normal or pneumonia group for each dataset.

In [ ]:
```
# Creating a separate DataFrame for each dataset
test_df = df.loc[df.loc[:, 'split'] == 'test']
train_df = df.loc[df.loc[:, 'split']=='train']
val_df = df.loc[df.loc[:, 'split'] == 'val']

# Count the occurrences of each label
train_counts = train_df['label'].value_counts().sort_index()
val_counts = val_df['label'].value_counts().sort_index()
test_counts = test_df['label'].value_counts().sort_index()

# Prepare Data for summary table
summary_data = {
    'Normal': [train_counts.get(0, 0), val_counts.get(0, 0), test_counts.get
    'Pneumonia': [train_counts.get(1, 0), val_counts.get(1, 0), test_counts.
}

# Create a summary table
```

```
summary_df = pd.DataFrame(summary_data, index=['Train', 'Validation', 'Test'
summary_df
```

Out[ ]:

	Normal	Pneumonia
Train	1341	3875
Validation	8	8
Test	234	390

Data Loader

Based on this PyTorch documentation, we passed each dataset to a DataLoader. As the documentation states, this will help us pass random mini-batches of the data to our model.

In [ ]:
```
# Defining path for each dataset
test_dir = os.path.join(alt_directory, 'test')
train_dir = os.path.join(alt_directory, 'train')
val_dir = os.path.join(alt_directory, 'val')

# Creating a CustomImageDataset object for each dataset
training_data = CustomImageDataset(train_df, test_dir, augmentations)
val_data = CustomImageDataset(val_df, train_dir, normalizations)
test_data = CustomImageDataset(test_df, val_dir, normalizations)

# Source: https://pytorch.org/tutorials/beginner/basics/data_tutorial.html#c
train_dataloader = DataLoader(training_data, batch_size=64, shuffle=True)
val_dataloader = DataLoader(val_data, batch_size=64, shuffle=True)
test_dataloader = DataLoader(test_data, batch_size=64, shuffle=True)
```

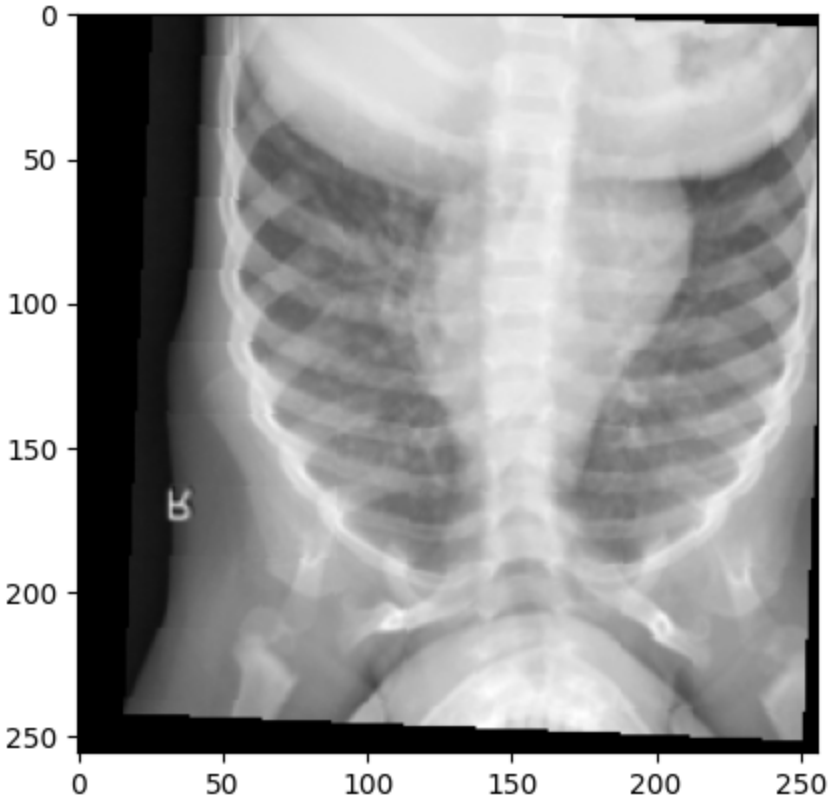
Iterate through Training DataLoader

To validate that our Data Loader is working, we are displaying one image from a mini-batch below with the code below. Most of the code below comes from the PyTorch documentation here.

In [ ]:
```
# Code Source: https://pytorch.org/tutorials/beginner/basics/data_tutorial.h

# Display image and label.
train_features, train_labels = next(iter(train_dataloader))
print(f"Feature batch shape: {train_features.size()}")
print(f"Labels batch shape: {train_labels.size()}")

img = train_features[21].squeeze() # Change the index (0 to 63) to display a
label = train_labels[1] # [0] for Normal & [1] for Pneumonia

img = img.permute(1, 2, 0)  # Change the shape to (256, 256, 3)
plt.imshow(img)
```

```
plt.show()
print(f"Label: {label}")
```

```
Feature batch shape: torch.Size([64, 3, 256, 256])
Labels batch shape: torch.Size([64])
```




```
Label: 0
```