In [1]:

```
import pandas as pd
import numpy as np
import os
import matplotlib.pyplot as plt
from pathlib import Path as path
%matplotlib inline

from tensorflow.keras.preprocessing.image import ImageDataGenerator
from tensorflow.keras.applications.mobilenet_v2 import preprocess_input

from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Dense,Conv2D,MaxPool2D,Flatten,Dropout, BatchNormaliz
ation

from sklearn.metrics import precision_score, recall_score, accuracy_score, confusion_matr
ix, f1_score,classification_report
from sklearn.preprocessing import LabelEncoder
```

In [2]:

```
from google.colab import drive
drive.mount("/content/drive")
```

```
Mounted at /content/drive
```

Read The Data

In [3]:

```
pneumonia_path = path(r"/content/drive/MyDrive/Chest X_Ray/train/PNEUMONIA")
```

In [4]:

```
pneumonia_images = os.listdir(r"/content/drive/MyDrive/Chest X_Ray/train/PNEUMONIA")
```

In [5]:

```
len(pneumonia_images)
```

Out[5]:

```
3875
```

In [6]:

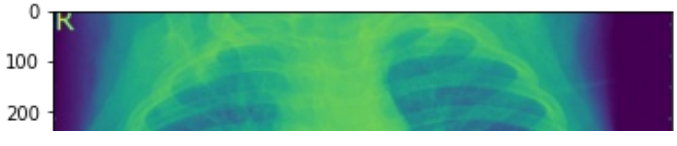
```
pneumonia_filepaths = [str(pneumonia_path) + '/' + img_path for img_path in pneumonia_ima
ges]
pneumonia_filepaths=pneumonia_filepaths[:2000]
len(pneumonia_filepaths)
```

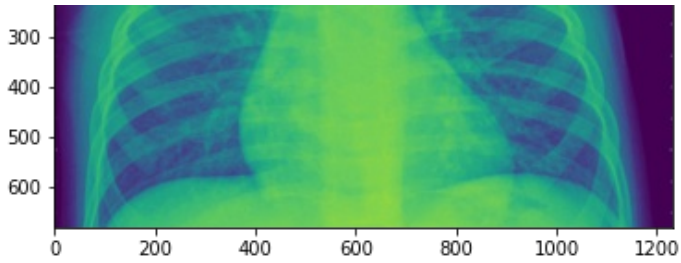
Out[6]:

```
2000
```

In [7]:

```
# all images file paths
img = plt.imread(pneumonia_filepaths[8])
plt.imshow(img)
plt.show()
```





In [8]:

```
normal_path = path(r"/content/drive/MyDrive/Chest X_Ray/train/NORMAL")
normal_images = os.listdir(r"/content/drive/MyDrive/Chest X_Ray/train/NORMAL")
```

In [9]:

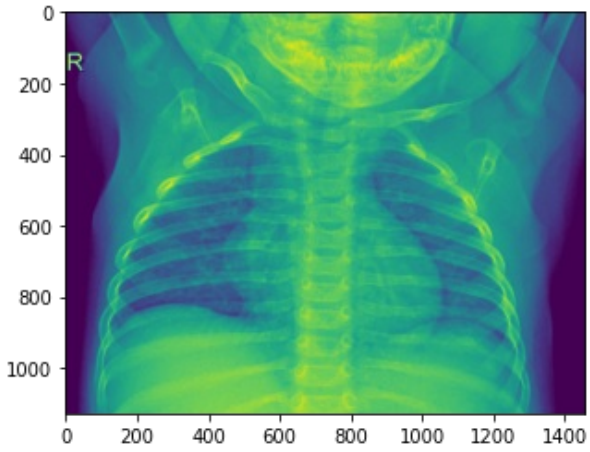
```
len(normal_images)
```

Out[9]:

```
1341
```

In [10]:

```
img = plt.imread(str(normal_path)+'/'+normal_images[10])
plt.imshow(img)
plt.show()
```

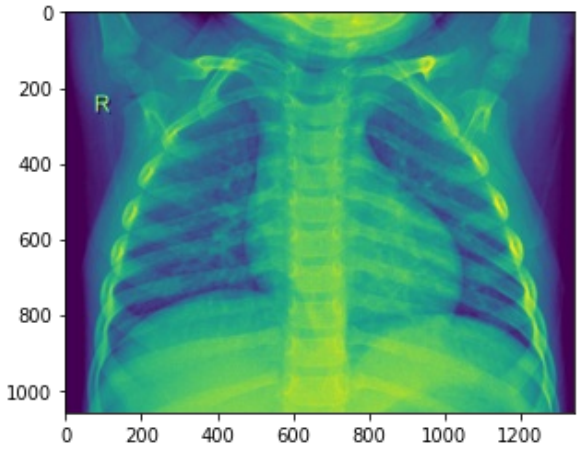


In [11]:

```
normal_filespaths = [str(normal_path) + '/' + img_path for img_path in normal_images]
#normal_filespaths=normal_filespaths[500:1000]
```

In [12]:

```
img = plt.imread(normal_filespaths[2])
plt.imshow(img)
plt.show()
```



Pre_Processing

In [13]:

```
def proc_img(filepath):
    """ Create a DataFrame with the filepath and the labels of the pictures
    """
    labels = list(map(lambda x: os.path.split(os.path.split(x)[0])[1], filepath))

    filepath = pd.Series(filepath, name='Filepath').astype(str)
    labels = pd.Series(labels, name='Label')

    # Concatenate filepaths and labels
    df = pd.concat([filepath, labels], axis=1)

    # Shuffle the DataFrame and reset index
    df = df.sample(frac=1).reset_index(drop = True)

    return df
```

In [14]:

```
pneumonia_df = proc_img(pneumonia_filepaths)
pneumonia_df.head(1)
```

Out[14]:

	Filepath	Label
0	/content/drive/MyDrive/Chest X_Ray/train/PNEUM...	PNEUMONIA

In [15]:

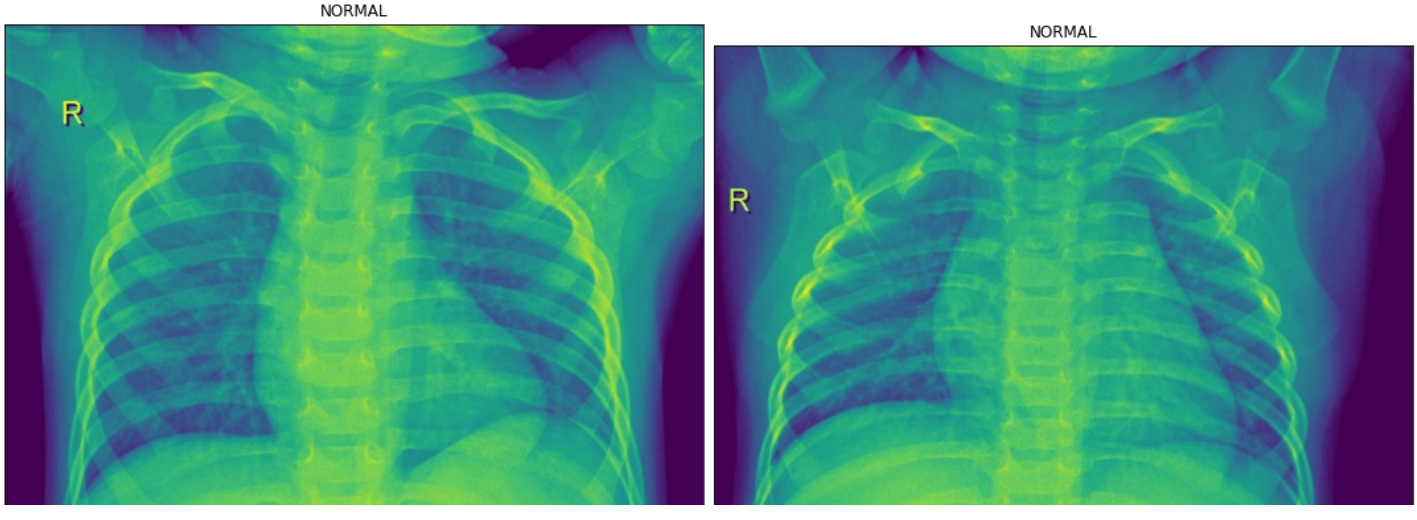
```
normal_df = proc_img(normal_filespaths)
normal_df.head(1)
```

Out[15]:

	Filepath	Label
0	/content/drive/MyDrive/Chest X_Ray/train/NORMA...	NORMAL

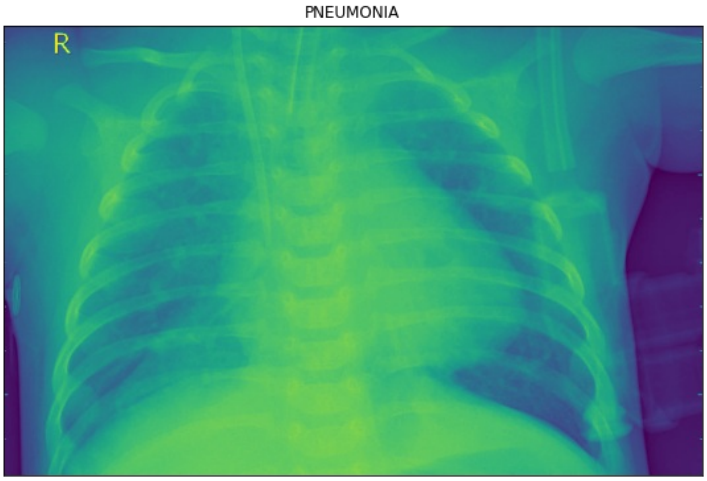
In [16]:

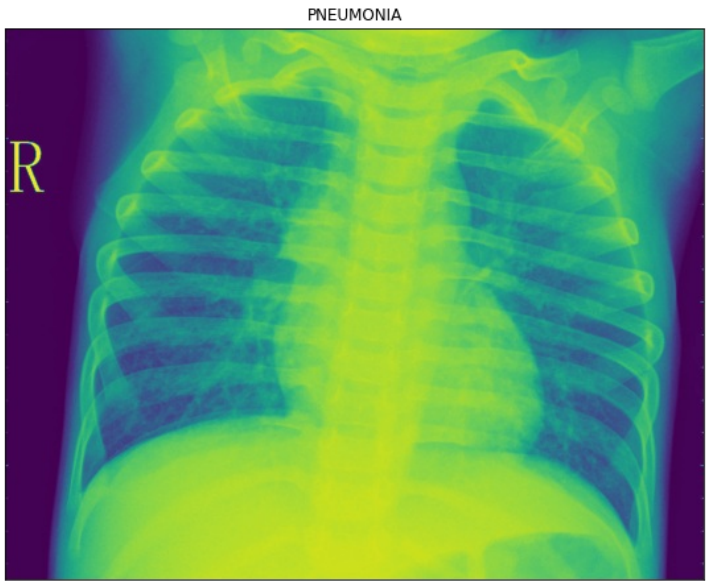
```
# Display 2 picture of the Normal dataset
fig, axes = plt.subplots(nrows=1, ncols=2, figsize=(15, 7),
                         subplot_kw={'xticks': [], 'yticks': []})
for i, ax in enumerate(axes.flat):
    ax.imshow(plt.imread(normal_df.Filepath[i]))
    ax.set_title(normal_df.Label[i])
plt.tight_layout(pad=0.5)
plt.show()
```




In [17]:

```
# Display 2 picture of the Pneumonia dataset
fig, axes = plt.subplots(nrows=1, ncols=2, figsize=(15, 7),
                         subplot_kw={'xticks': [], 'yticks': []})
for i, ax in enumerate(axes.flat):
    ax.imshow(plt.imread(pneumonia_df.Filepath[i]))
    ax.set_title(pneumonia_df.Label[i])
plt.tight_layout(pad=0.5)
plt.show()
```





In [18]:

```
# Concat the two data frame(pneumonia and normal)
pneumonia_normal_data = pd.concat([pneumonia_df, normal_df], axis=0)
```

In [19]:

```
pneumonia_normal_data.sample(10)
```

Out[19]:

	Filepath	Label
312	**/content/drive/MyDrive/Chest X_Ray/train/PNEUM...**	**PNEUMONIA**
91	**/content/drive/MyDrive/Chest X_Ray/train/PNEUM...**	**PNEUMONIA**
87	**/content/drive/MyDrive/Chest X_Ray/train/PNEUM...**	**PNEUMONIA**
442	**/content/drive/MyDrive/Chest X_Ray/train/PNEUM...**	**PNEUMONIA**
1314	**/content/drive/MyDrive/Chest X_Ray/train/PNEUM...**	**PNEUMONIA**
348	**/content/drive/MyDrive/Chest X_Ray/train/PNEUM...**	**PNEUMONIA**
325	**/content/drive/MyDrive/Chest X_Ray/train/PNEUM...**	**PNEUMONIA**
429	**/content/drive/MyDrive/Chest X_Ray/train/PNEUM...**	**PNEUMONIA**
669	**/content/drive/MyDrive/Chest X_Ray/train/NORMA...**	**NORMAL**
291	**/content/drive/MyDrive/Chest X_Ray/train/PNEUM...**	**PNEUMONIA**

In [20]:

```
pneumonia_normal_data.shape
```

Out[20]:

```
(3341, 2)
```

In [21]:

```
pneumonia_normal_data['Label'].value_counts()
```

Out[21]:

```
PNEUMONIA    2000
NORMAL       1341
Name: Label, dtype: int64
```

Train Test Split

In [22]:

```
# Take a .2 sample from the data frame
int(len(pneumonia_normal_data) * 0.25)     #  num of test images
```

Out[22]:

```
835
```

In [23]:

```
# Test_dataframe
test_data = pneumonia_normal_data.sample(n=450,random_state=42)
test_data.Label.value_counts()
```

Out[23]:

```
PNEUMONIA    304
NORMAL       146
Name: Label, dtype: int64
```

In [24]:

```
# Find Rows in df Which Are Not Available in test_df
train_data = pneumonia_normal_data.merge(test_data, how = 'outer' ,indicator=True).loc[l
ambda x : x['_merge']=='left_only']
```

In [25]:

```
train_data.Label.value_counts()
```

Out[25]:

```
PNEUMONIA    1696
NORMAL       1195
Name: Label, dtype: int64
```

In [26]:

```
len(train_data.Label)
```

Out[26]:

```
2891
```

Image Generator

In [27]:

```
# Train generator
train_generator = ImageDataGenerator(
    preprocessing_function= preprocess_input,
    rescale=1./255
)


train_images = train_generator.flow_from_dataframe(
```

```
    dataframe=train_data,
    x_col='Filepath',
    y_col='Label',
    target_size=(120, 120),
    color_mode='grayscale',
    class_mode='categorical',
    batch_size=32,
    shuffle=True,
    seed=0,
    subset='training',
    rotation_range=30,
    zoom_range=0.15,
    width_shift_range=0.2,
    height_shift_range=0.2,
    shear_range=0.15,
    horizontal_flip=True,
    fill_mode="nearest"
)
```

```
Found 2891 validated image filenames belonging to 2 classes.
```

In [28]:

```
# Test generator
test_generator = ImageDataGenerator(
    preprocessing_function= preprocess_input,
    rescale=1./255
)


test_images = test_generator.flow_from_dataframe(
    dataframe=test_data,
    x_col='Filepath',
    y_col='Label',
    target_size=(120, 120),
    color_mode='grayscale',
    class_mode='categorical',
    batch_size=32,
    shuffle=True,
    seed=0,
    subset='training',
    rotation_range=30,
    zoom_range=0.15,
    width_shift_range=0.2,
    height_shift_range=0.2,
    shear_range=0.15,
    horizontal_flip=True,
    fill_mode="nearest"
)
```

```
Found 450 validated image filenames belonging to 2 classes.
```

Model

In [29]:

```
model= Sequential()

model.add(Conv2D(kernel_size=(3,3), filters=32, activation='relu', input_shape=(120,120,
1,)))
model.add(Conv2D(filters=30,kernel_size = (3,3),activation='relu'))
model.add(Dropout(0.4))

model.add(MaxPool2D(2,2))
model.add(Conv2D(filters=30,kernel_size = (3,3),activation='relu'))
model.add(Dropout(0.3))
model.add(MaxPool2D(2,2))
model.add(Conv2D(filters=30,kernel_size = (3,3),activation='relu'))
model.add(Dropout(0.4))
model.add(Flatten())
```

```
model.add(Dense(128,activation='relu'))
model.add(Dropout(.2))
model.add(Dense(64,activation='relu'))
model.add(Dense(2,activation = 'softmax'))   # the output layer
```

In [30]:

```
model.compile(loss = 'categorical_crossentropy', optimizer ='adam', metrics= ['accuracy'
])
```

Model Summary

In [31]:

```
model.summary()
```

```
Model: "sequential"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
conv2d (Conv2D)              (None, 118, 118, 32)      320
_________________________________________________________________
conv2d_1 (Conv2D)            (None, 116, 116, 30)      8670
_________________________________________________________________
dropout (Dropout)            (None, 116, 116, 30)      0
_________________________________________________________________
max_pooling2d (MaxPooling2D) (None, 58, 58, 30)        0
_________________________________________________________________
conv2d_2 (Conv2D)            (None, 56, 56, 30)        8130
_________________________________________________________________
dropout_1 (Dropout)          (None, 56, 56, 30)        0
_________________________________________________________________
max_pooling2d_1 (MaxPooling2 (None, 28, 28, 30)        0
_________________________________________________________________
conv2d_3 (Conv2D)            (None, 26, 26, 30)        8130
_________________________________________________________________
dropout_2 (Dropout)          (None, 26, 26, 30)        0
_________________________________________________________________
flatten (Flatten)            (None, 20280)             0
_________________________________________________________________
dense (Dense)                (None, 128)               2595968
_________________________________________________________________
dropout_3 (Dropout)          (None, 128)               0
_________________________________________________________________
dense_1 (Dense)              (None, 64)                8256
_________________________________________________________________
dense_2 (Dense)              (None, 2)                 130
=================================================================
Total params: 2,629,604
Trainable params: 2,629,604
Non-trainable params: 0
_________________________________________________________________
```

Early Stop

In [32]:

```
from tensorflow.keras.callbacks import EarlyStopping
early_stop = EarlyStopping(monitor='val_loss', patience=2, restore_best_weights=True)
```

In [33]:

```
model.fit(train_images, epochs = 6 , validation_data = test_images, verbose=1, callbacks
=early_stop)
```

```
Epoch 1/6
91/91 [==============================] - 732s 8s/step - loss: 0.6845 - accuracy: 0.5866 -
val_loss: 0.6682 - val_accuracy: 0.6756
Epoch 2/6
```

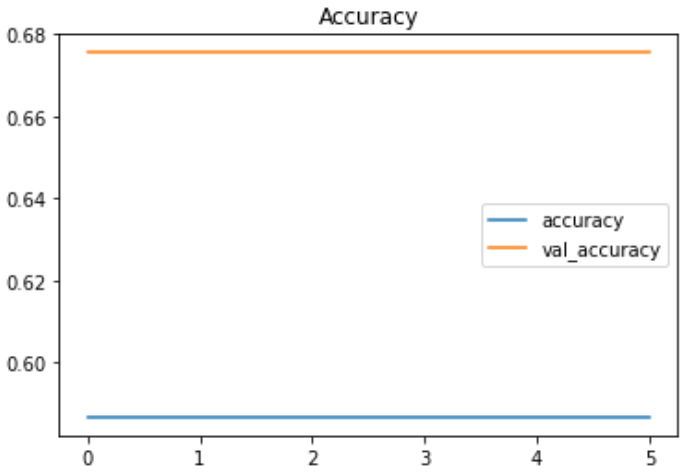
```
91/91 [==============================] - 166s 2s/step - loss: 0.6804 - accuracy: 0.5866 -
val_loss: 0.6442 - val_accuracy: 0.6756
Epoch 3/6
91/91 [==============================] - 167s 2s/step - loss: 0.6799 - accuracy: 0.5866 -
val_loss: 0.6557 - val_accuracy: 0.6756
Epoch 4/6
91/91 [==============================] - 169s 2s/step - loss: 0.6777 - accuracy: 0.5866 -
val_loss: 0.6355 - val_accuracy: 0.6756
Epoch 5/6
91/91 [==============================] - 169s 2s/step - loss: 0.6796 - accuracy: 0.5866 -
val_loss: 0.6493 - val_accuracy: 0.6756
Epoch 6/6
91/91 [==============================] - 169s 2s/step - loss: 0.6785 - accuracy: 0.5866 -
val_loss: 0.6467 - val_accuracy: 0.6756
```

Out[33]:

```
<keras.callbacks.History at 0x7f08d018f410>
```

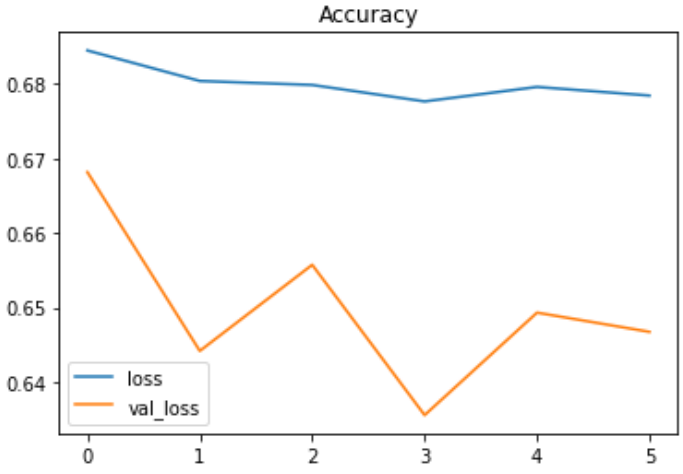
In [34]:

```
pd.DataFrame(model.history.history)[['accuracy','val_accuracy']].plot()
plt.title("Accuracy")
plt.show()
```



In [35]:

```
pd.DataFrame(model.history.history)[['loss','val_loss']].plot()
plt.title("Accuracy")
plt.show()
```



Prediction

In [36]:

```
test_data.head()
```

Out[36]:

	Filepath	Label
479	/content/drive/MyDrive/Chest X_Ray/train/PNEUM...	PNEUMONIA
78	/content/drive/MyDrive/Chest X_Ray/train/NORMA...	NORMAL
705	/content/drive/MyDrive/Chest X_Ray/train/PNEUM...	PNEUMONIA
1330	/content/drive/MyDrive/Chest X_Ray/train/PNEUM...	PNEUMONIA
1606	/content/drive/MyDrive/Chest X_Ray/train/PNEUM...	PNEUMONIA

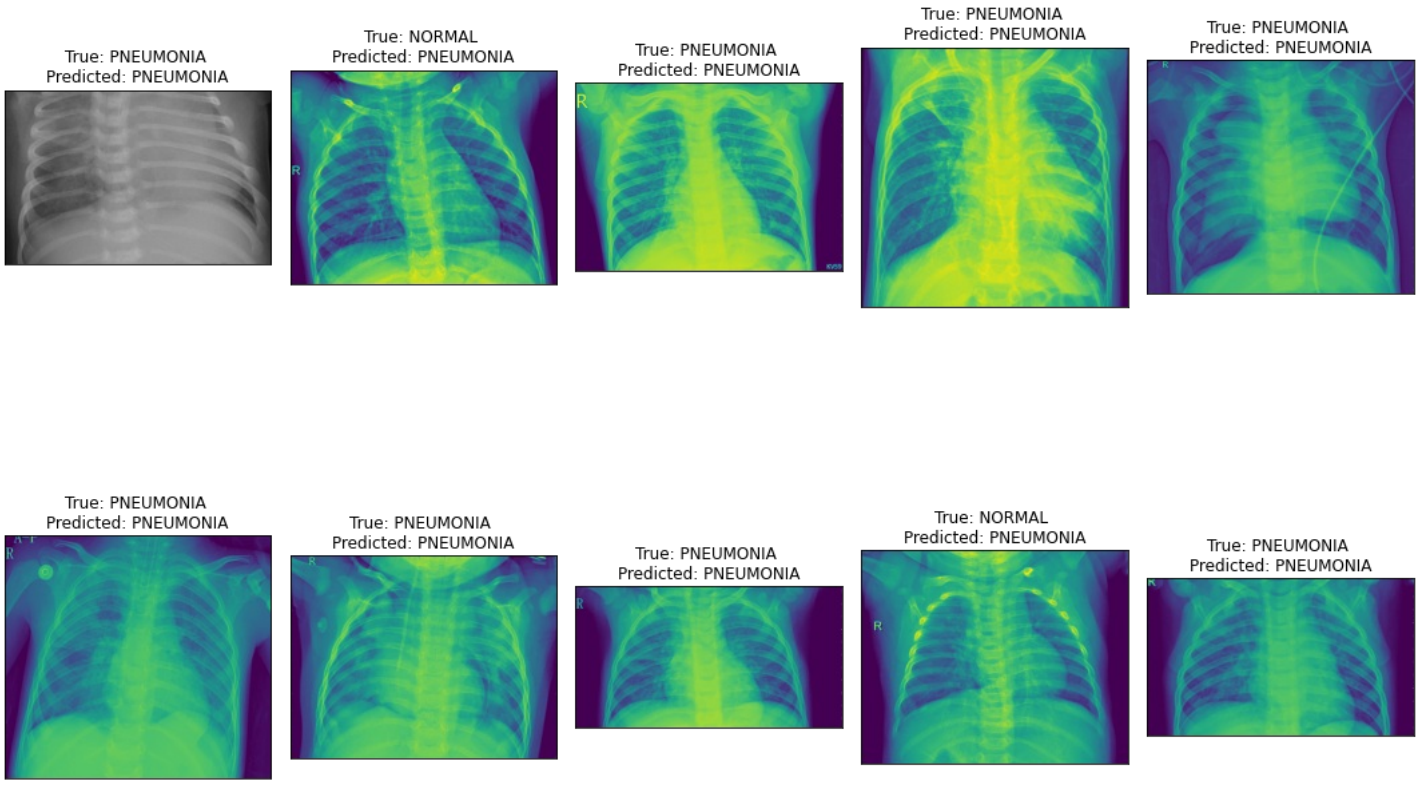
In [37]:

```
# Predict the label of the test_images
pred = model.predict(test_images)
pred = np.argmax(pred,axis=1)

# Map the label
labels = (train_images.class_indices)
labels = dict((v,k) for k,v in labels.items())
pred = [labels[k] for k in pred]

# Display the result
print(f'The first 5 predictions: {pred[:5]}')
```

```
The first 5 predictions: ['PNEUMONIA', 'PNEUMONIA', 'PNEUMONIA', 'PNEUMONIA', 'PNEUMONIA'
]
```

In [38]:

```
# Display 10 picture of the dataset with their labels
fig, axes = plt.subplots(nrows=2, ncols=5, figsize=(15, 12),
                         subplot_kw={'xticks': [], 'yticks': []})

for i, ax in enumerate(axes.flat):
    ax.imshow(plt.imread(test_data.Filepath.iloc[i]))
    ax.set_title(f"True: {test_data.Label.iloc[i].split('_')[0]} \nPredicted: {pred[i].s
plit('_')[0]}")
plt.tight_layout()
plt.show()
```



In [39]:

```
le = LabelEncoder()
# le.fit_transform(df[column])
```

```
test_labels = le.fit_transform(test_data.Label)
pred = le.fit_transform(pred)
```

In [40]:

```
confusion_matrix = pd.crosstab(test_labels, pred, rownames=['Actual'], colnames=['Predicted'], margins = True)
confusion_matrix
```

Out[40]:

Predicted	0	All
Actual		
0	146	146
1	304	304
All	450	450

Im_Balanced Data

In [41]:

```
import imblearn
from imblearn.under_sampling import RandomUnderSampler
```

```
/usr/local/lib/python3.7/dist-packages/sklearn/externals/six.py:31: FutureWarning: The module is deprecated in version 0.21 and will be removed in version 0.23 since we've dropped support for Python 2.7. Please rely on the official version of six (https://pypi.org/project/six/).
  "(https://pypi.org/project/six/).", FutureWarning)
/usr/local/lib/python3.7/dist-packages/sklearn/utils/deprecation.py:144: FutureWarning: The sklearn.neighbors.base module is  deprecated in version 0.22 and will be removed in version 0.24. The corresponding classes / functions should instead be imported from sklearn.neighbors. Anything that cannot be imported from sklearn.neighbors is now part of the private API.
  warnings.warn(message, FutureWarning)
```

under-sample model

In [42]:

```
# reduce the majority rows to be equals the miniority one
undersample = RandomUnderSampler(sampling_strategy='majority')
```

In [43]:

```
pneumonia_normal_data.head()
```

Out[43]:

	Filepath	Label
0	/content/drive/MyDrive/Chest X_Ray/train/PNEUM...	PNEUMONIA
1	/content/drive/MyDrive/Chest X_Ray/train/PNEUM...	PNEUMONIA
2	/content/drive/MyDrive/Chest X_Ray/train/PNEUM...	PNEUMONIA
3	/content/drive/MyDrive/Chest X_Ray/train/PNEUM...	PNEUMONIA
4	/content/drive/MyDrive/Chest X_Ray/train/PNEUM...	PNEUMONIA

In [44]:

```
X = pneumonia_normal_data.iloc[:, :1].values
```

In [45]:

In [45]:

```
X.shape
```

Out[45]:

```
(3341, 1)
```

In [46]:

```
y = pneumonia_normal_data.iloc[:, 1]
```

In [47]:

```
X, y = undersample.fit_resample(X, y)
```

```
/usr/local/lib/python3.7/dist-packages/sklearn/utils/deprecation.py:87: FutureWarning: Fu
nction safe_indexing is deprecated; safe_indexing is deprecated in version 0.22 and will
be removed in version 0.24.
  warnings.warn(msg, category=FutureWarning)
```

In [48]:

```
X[1]
```

Out[48]:

```
array(['/content/drive/MyDrive/Chest X_Ray/train/NORMAL/IM-0729-0001.jpeg'],
      dtype=object)
```

In [49]:

```
X.shape
```

Out[49]:

```
(2682, 1)
```

In [50]:

```
y[1]
```

Out[50]:

```
'NORMAL'
```

In [51]:

```
y.shape
```

Out[51]:

```
(2682,)
```

In [52]:

```
# Data Frame must be 1-D
X = X.reshape((2682, ))
```

In [53]:

```
# to check
from collections import Counter
```

In [54]:

```
print(Counter(y))
```

```
Counter({'NORMAL': 1341, 'PNEUMONIA': 1341})
```

In [55]:

```
balanced_df = pd.DataFrame({'Filepath': X, 'Label': y})
```

In [56]:

```
balanced_df.head()
```

Out[56]:

	Filepath	Label
0	/content/drive/MyDrive/Chest X_Ray/train/NORMA...	NORMAL
1	/content/drive/MyDrive/Chest X_Ray/train/NORMA...	NORMAL
2	/content/drive/MyDrive/Chest X_Ray/train/NORMA...	NORMAL
3	/content/drive/MyDrive/Chest X_Ray/train/NORMA...	NORMAL
4	/content/drive/MyDrive/Chest X_Ray/train/NORMA...	NORMAL

In [57]:

```
balanced_df.Label.value_counts()
```

Out[57]:

```
PNEUMONIA    1341
NORMAL       1341
Name: Label, dtype: int64
```

In [58]:

```
balanced_df.duplicated().sum()
```

Out[58]:

```
0
```

Train Test Split

In [59]:

```
# Take a .2 sample from the data frame
int(len(balanced_df) * 0.2)     #  >> num of test images
```

Out[59]:

```
536
```

In [60]:

```
# Test_df
test_df = balanced_df.sample(n=184,random_state=42)
test_df.Label.value_counts()
```

Out[60]:

```
PNEUMONIA    93
NORMAL       91
Name: Label, dtype: int64
```

In [61]:

```
# Find Rows in balanced_df Which Are Not Available in test_df
train_df = balanced_df.merge(test_df, how = 'outer' ,indicator=True).loc[lambda x : x['_
merge']=='left_only']
```

In [62]:

```
train_df.Label.value_counts()
```

Out[62]:

```
NORMAL       1250
PNEUMONIA    1248
Name: Label, dtype: int64
```

In [63]:

```
# Image Generator
```

In [64]:

```
# Train generator
train_generator = ImageDataGenerator(
    preprocessing_function= preprocess_input,
    rescale=1./255
)


train_images = train_generator.flow_from_dataframe(
    dataframe=train_df,
    x_col='Filepath',
    y_col='Label',
    target_size=(120, 120),
    color_mode='grayscale',
    class_mode='categorical',
    batch_size=32,
    shuffle=True,
    seed=0,
    subset='training',
    rotation_range=30,
    zoom_range=0.15,
    width_shift_range=0.2,
    height_shift_range=0.2,
    shear_range=0.15,
    horizontal_flip=True,
    fill_mode="nearest"
)
```

```
Found 2498 validated image filenames belonging to 2 classes.
```

In [65]:

```
# Test generator
test_generator = ImageDataGenerator(
    preprocessing_function= preprocess_input,
    rescale=1./255
)


test_images = test_generator.flow_from_dataframe(
    dataframe=test_df,
    x_col='Filepath',
    y_col='Label',
    target_size=(120, 120),
    color_mode='grayscale',
    class_mode='categorical',
    batch_size=32,
    shuffle=True,
    seed=0,
    subset='training',
    rotation_range=30,
    zoom_range=0.15,
    width_shift_range=0.2,
    height_shift_range=0.2,
    shear_range=0.15,
    horizontal_flip=True,
    fill_mode="nearest"
)
```

```
Found 184 validated image filenames belonging to 2 classes.
```

Model

In [66]:

In [66]:

```
model= Sequential()

model.add(Conv2D(kernel_size=(3,3), filters=32, activation='relu', input_shape=(120,120,
1,)))
model.add(Conv2D(filters=30,kernel_size = (3,3),activation='relu'))

model.add(MaxPool2D(2,2))
model.add(Conv2D(filters=32,kernel_size = (3,3),activation='relu'))

model.add(MaxPool2D(2,2))
model.add(Conv2D(filters=32,kernel_size = (3,3),activation='relu'))

model.add(Flatten())

model.add(Dense(256,activation='relu'))
model.add(Dense(64,activation='relu'))
model.add(Dense(32,activation='relu'))
model.add(Dense(2,activation = 'softmax'))   # the output layer
```

In [67]:

```
model.compile(loss = 'categorical_crossentropy', optimizer ='adam', metrics= ['accuracy'
])
```

Model Summary

In [68]:

```
model.summary()
```

```
Model: "sequential_1"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
conv2d_4 (Conv2D)            (None, 118, 118, 32)      320
_________________________________________________________________
conv2d_5 (Conv2D)            (None, 116, 116, 30)      8670
_________________________________________________________________
max_pooling2d_2 (MaxPooling2 (None, 58, 58, 30)        0
_________________________________________________________________
conv2d_6 (Conv2D)            (None, 56, 56, 32)        8672
_________________________________________________________________
max_pooling2d_3 (MaxPooling2 (None, 28, 28, 32)        0
_________________________________________________________________
conv2d_7 (Conv2D)            (None, 26, 26, 32)        9248
_________________________________________________________________
flatten_1 (Flatten)          (None, 21632)             0
_________________________________________________________________
dense_3 (Dense)              (None, 256)               5538048
_________________________________________________________________
dense_4 (Dense)              (None, 64)                16448
_________________________________________________________________
dense_5 (Dense)              (None, 32)                2080
_________________________________________________________________
dense_6 (Dense)              (None, 2)                 66
=================================================================
Total params: 5,583,552
Trainable params: 5,583,552
Non-trainable params: 0
_________________________________________________________________
```

Early Stop

In [69]:

```
early_stop = EarlyStopping(monitor='val_loss', patience=2, restore_best_weights=True)
```

In [70]:

```
model.fit(train_images, epochs = 30 , validation_data = test_images, verbose=1, callbacks=early_stop)
```

```
Epoch 1/30
79/79 [==============================] - 138s 2s/step - loss: 0.6934 - accuracy: 0.4984 - val_loss: 0.6932 - val_accuracy: 0.4946
Epoch 2/30
79/79 [==============================] - 135s 2s/step - loss: 0.6933 - accuracy: 0.4828 - val_loss: 0.6933 - val_accuracy: 0.4946
Epoch 3/30
79/79 [==============================] - 135s 2s/step - loss: 0.6932 - accuracy: 0.4956 - val_loss: 0.6931 - val_accuracy: 0.4946
Epoch 4/30
79/79 [==============================] - 135s 2s/step - loss: 0.6933 - accuracy: 0.4924 - val_loss: 0.6932 - val_accuracy: 0.4946
Epoch 5/30
79/79 [==============================] - 134s 2s/step - loss: 0.6933 - accuracy: 0.5004 - val_loss: 0.6931 - val_accuracy: 0.5054
Epoch 6/30
79/79 [==============================] - 134s 2s/step - loss: 0.6932 - accuracy: 0.4996 - val_loss: 0.6931 - val_accuracy: 0.5054
Epoch 7/30
79/79 [==============================] - 133s 2s/step - loss: 0.6932 - accuracy: 0.4868 - val_loss: 0.6931 - val_accuracy: 0.5054
Epoch 8/30
79/79 [==============================] - 133s 2s/step - loss: 0.6932 - accuracy: 0.4996 - val_loss: 0.6931 - val_accuracy: 0.5054
Epoch 9/30
79/79 [==============================] - 134s 2s/step - loss: 0.6932 - accuracy: 0.4996 - val_loss: 0.6931 - val_accuracy: 0.5054
Epoch 10/30
79/79 [==============================] - 134s 2s/step - loss: 0.6932 - accuracy: 0.4980 - val_loss: 0.6932 - val_accuracy: 0.4946
```

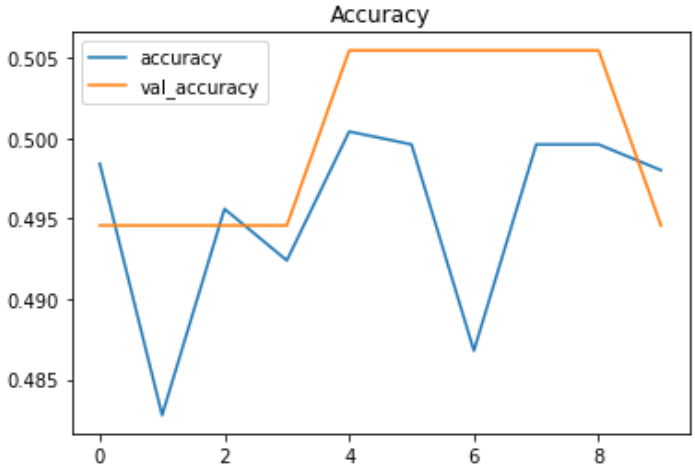
Out[70]:

```
<keras.callbacks.History at 0x7f08c7126fd0>
```

Visualize the output

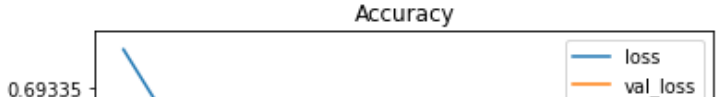
In [71]:

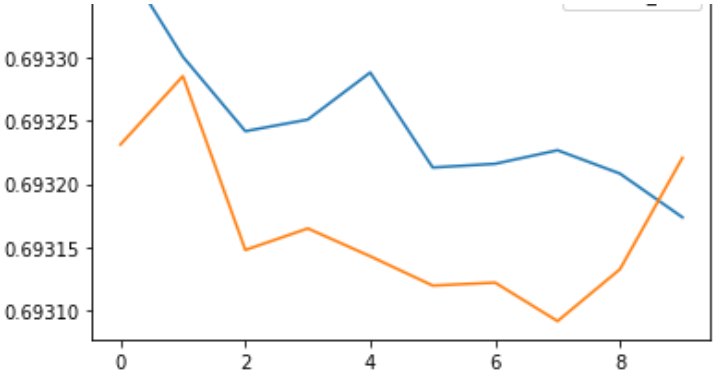
```
pd.DataFrame(model.history.history)[['accuracy','val_accuracy']].plot()
plt.title("Accuracy")
plt.show()
```



In [72]:

```
pd.DataFrame(model.history.history)[['loss','val_loss']].plot()
plt.title("Accuracy")
plt.show()
```





Prediction

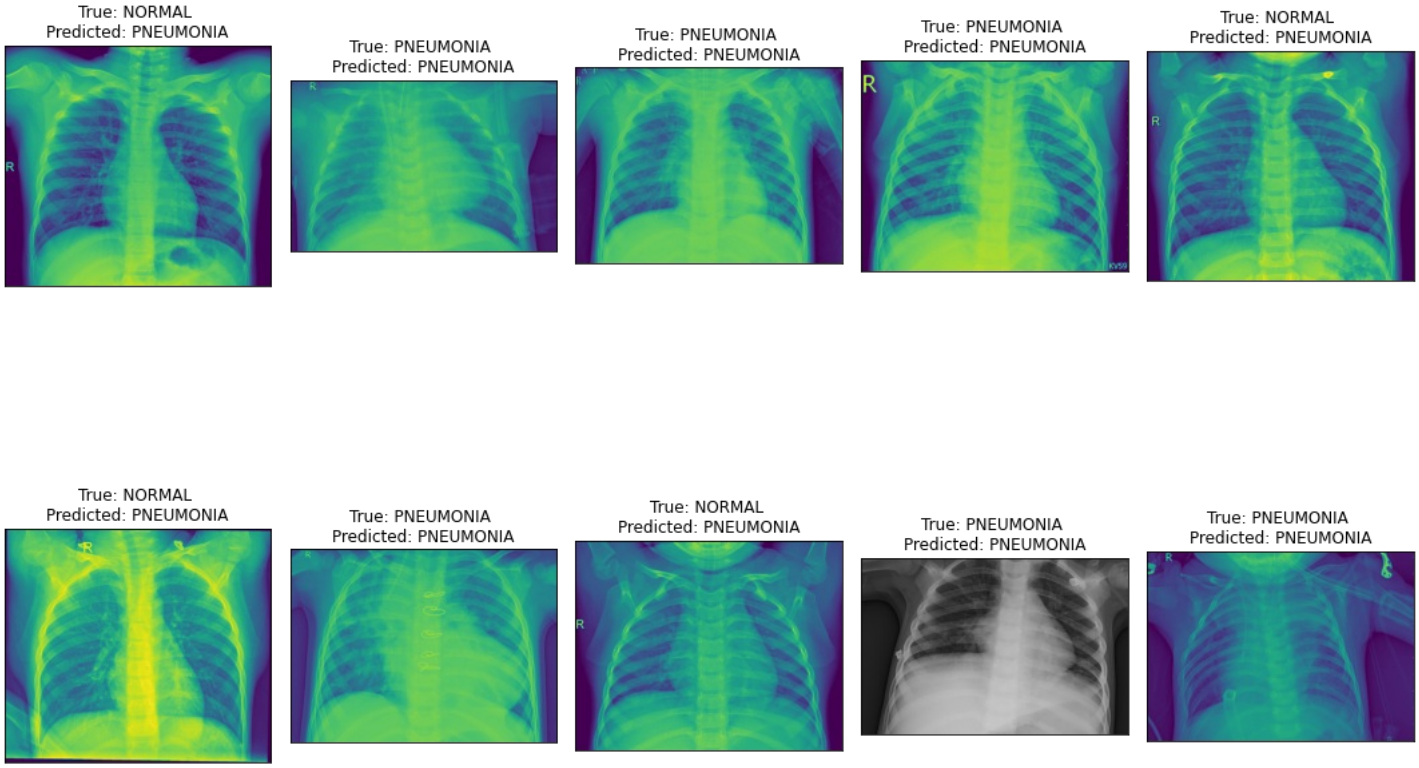
In [73]:

```
# Predict the label of the test_images
pred = model.predict(test_images)
pred = np.argmax(pred,axis=1)

# Map the label
labels = (train_images.class_indices)
labels = dict((v,k) for k,v in labels.items())
pred = [labels[k] for k in pred]

# Display the result
print(f'The first 5 predictions: {pred[:5]}')
```

```
The first 5 predictions: ['PNEUMONIA', 'PNEUMONIA', 'PNEUMONIA', 'PNEUMONIA', 'PNEUMONIA'
]
```

In [74]:

```
# Display 5 picture of the dataset with their labels
fig, axes = plt.subplots(nrows=2, ncols=5, figsize=(15, 12),
                         subplot_kw={'xticks': [], 'yticks': []})

for i, ax in enumerate(axes.flat):
    ax.imshow( plt.imread(test_df.Filepath.iloc[i]))
    ax.set_title(f"True: {test_df.Label.iloc[i].split('_')[0]} \nPredicted: {pred[i].spli
t('_')[0]}")
plt.tight_layout()
plt.show()
```



In [75]:

```
from sklearn.metrics import accuracy_score
y_test = list(test_df.Label)
acc = accuracy_score(y_test,pred)
print(f'Accuracy on the test set: {acc * 100:.2f}%')
```

```
Accuracy on the test set: 50.54%
```

Apply Equalize_Histogram

In [76]:

```
import cv2 as cv
```

In [77]:

```
def LoadImages(column):
    path_list = []
    for i in range(len(column)):
        try:
            path_list.append(cv.resize(cv.imread(column.loc[i], 0), (150, 150)))
        except:
            continue

    return np.array(path_list)
```

In [78]:

```
test_images = []
test_images = LoadImages(test_df.Filepath)
```

In [79]:

```
train_images = []
train_images = LoadImages(train_df.Filepath)
```

In [80]:

```
train_images.shape
```

Out[80]:

```
(2331, 150, 150)
```

In [81]:

```
test_images.shape
```

Out[81]:

```
(14, 150, 150)
```

In [82]:

```
from skimage.exposure import equalize_hist
from skimage import color
from tensorflow.keras.utils import to_categorical
```

In [83]:

```
for i in range(train_images.shape[0]):
    train_images[i] = equalize_hist(train_images[i])
```

In [84]:

```
for i in range(test_images.shape[0]):
    test_images[i] = equalize_hist(test_images[i])
```

In [85]:

```
from sklearn.preprocessing import LabelEncoder
```

In [86]:

```
def label_encoding(column,df):
    le = LabelEncoder()
    df[column] = le.fit_transform(df[column])
```

In [87]:

```
label_encoding('Label', train_df)
label_encoding('Label', test_df)
```

In [88]:

```
y_train = []
for i in range(len(train_df)):
    try:
        y_train.append(train_df.Label.loc[i])
    except:
        continue
```

In [89]:

```
y_train = np.array(y_train)
y_train.shape
```

Out[89]:

```
(2331,)
```

In [90]:

```
y_train = to_categorical(y_train, 2)
```

In [91]:

```
y_test = []
for i in range(len(test_df)):
    try:
        y_test.append(test_df.Label.loc[i])
    except:
        continue
```

In [92]:

```
y_test = np.array(y_test)
y_test.shape
```

Out[92]:

```
(14,)
```

In [93]:

```
y_test = to_categorical(y_test, 2)
```

In [94]:

```
X_train = train_images.reshape(train_images.shape[0], 150, 150, 1)
X_test = test_images.reshape(test_images.shape[0], 150, 150, 1)
```

In [95]:

```
# X_train = X_train / 255.0
# X_test = X_test / 255.0
```

In [96]:

```
X_train.shape
```

Out[96]:

```
(2331, 150, 150, 1)
```

In [97]:

```
X_test.shape
```

Out[97]:

```
(14, 150, 150, 1)
```

In [98]:

```
y_train.shape
```

Out[98]:

```
(2331, 2)
```

In [99]:

```
y_test.shape
```

Out[99]:

```
(14, 2)
```

In [100]:

```
from tensorflow.keras.layers import AveragePooling2D
```

Model

In [101]:

```
model= Sequential()

model.add(Conv2D(kernel_size=(3,3), filters=32, activation='relu', input_shape=(150,150,
1)))
model.add(Conv2D(filters=30,kernel_size = (3,3),activation='relu'))

model.add(Conv2D(filters=30,kernel_size = (3,3),activation='relu'))

model.add(AveragePooling2D(4,4))
model.add(Conv2D(filters=30,kernel_size = (3,3),activation='relu'))

model.add(Flatten())

model.add(Dense(256,activation='relu'))
model.add(Dense(128,activation='relu'))

model.add(Dense(2,activation = 'softmax'))  # the output layer
```

In [102]:

```
model.compile(loss = 'categorical_crossentropy', optimizer ='adam', metrics= ['accuracy'
])
```

In [103]:

```
model.summary()
```

```
Model: "sequential_2"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
conv2d_8 (Conv2D)            (None, 148, 148, 32)      320
_________________________________________________________________
conv2d_9 (Conv2D)            (None, 146, 146, 30)      8670
```

```
_________________________________________________________________
conv2d_10 (Conv2D)           (None, 144, 144, 30)      8130
_________________________________________________________________
average_pooling2d (AveragePo (None, 36, 36, 30)        0
_________________________________________________________________
conv2d_11 (Conv2D)           (None, 34, 34, 30)        8130
_________________________________________________________________
flatten_2 (Flatten)          (None, 34680)             0
_________________________________________________________________
dense_7 (Dense)              (None, 256)               8878336
_________________________________________________________________
dense_8 (Dense)              (None, 128)               32896
_________________________________________________________________
dense_9 (Dense)              (None, 2)                 258
=================================================================
Total params: 8,936,740
Trainable params: 8,936,740
Non-trainable params: 0
_________________________________________________________________
```

In [104]:

```
early_stop = EarlyStopping(monitor='val_loss', patience=1, restore_best_weights=True)
```

In [105]:

```
model.fit(x = X_train, y = y_train, epochs = 10, verbose=1)
```

```
Epoch 1/10
73/73 [==============================] - 216s 3s/step - loss: 0.4541 - accuracy: 0.7881
Epoch 2/10
73/73 [==============================] - 214s 3s/step - loss: 0.2928 - accuracy: 0.8713
Epoch 3/10
73/73 [==============================] - 217s 3s/step - loss: 0.2372 - accuracy: 0.8893
Epoch 4/10
73/73 [==============================] - 214s 3s/step - loss: 0.2085 - accuracy: 0.9146
Epoch 5/10
73/73 [==============================] - 214s 3s/step - loss: 0.1837 - accuracy: 0.9181
Epoch 6/10
73/73 [==============================] - 214s 3s/step - loss: 0.1554 - accuracy: 0.9322
Epoch 7/10
73/73 [==============================] - 214s 3s/step - loss: 0.1473 - accuracy: 0.9344
Epoch 8/10
73/73 [==============================] - 213s 3s/step - loss: 0.1326 - accuracy: 0.9442
Epoch 9/10
73/73 [==============================] - 213s 3s/step - loss: 0.1358 - accuracy: 0.9429
Epoch 10/10
73/73 [==============================] - 214s 3s/step - loss: 0.1156 - accuracy: 0.9468
```

Out[105]:

```
<keras.callbacks.History at 0x7f08c6f9d510>
```

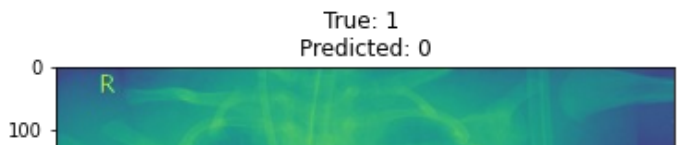
Predict

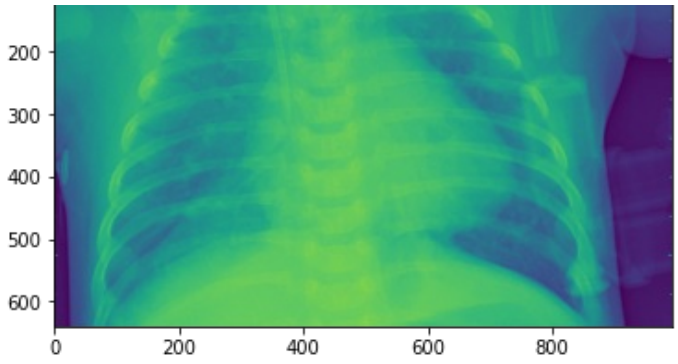
In [106]:

```
# Predict the label of the test_images
pred = model.predict(X_test)
pred = np.argmax(pred,axis=1)
```

In [107]:

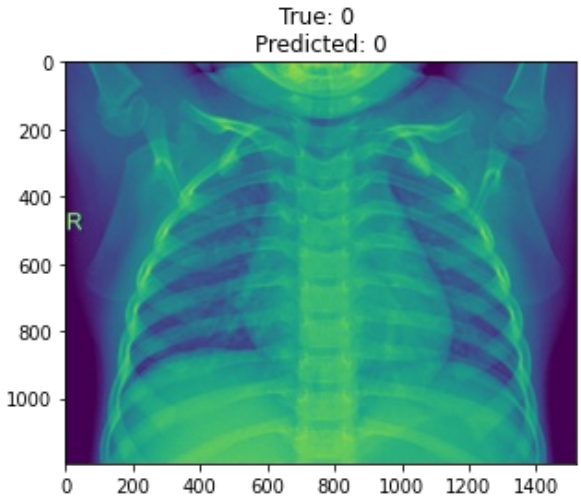
```
plt.imshow(plt.imread(test_df.Filepath.iloc[1]))
plt.title(f"True: {test_df.Label.iloc[1]} \nPredicted: {pred[1]}")
plt.show()
```





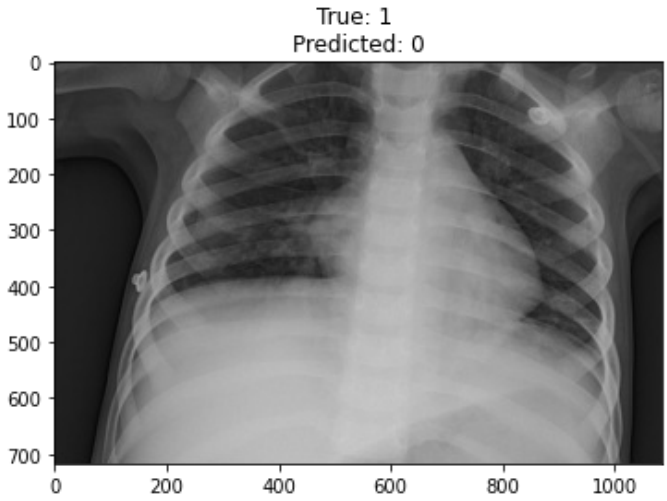
In [108]:

```
plt.imshow(plt.imread(test_df.Filepath.iloc[7]))
plt.title(f"True: {test_df.Label.iloc[7]} \nPredicted: {pred[7]}")
plt.show()
```



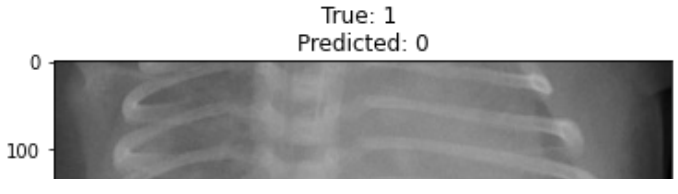
In [109]:

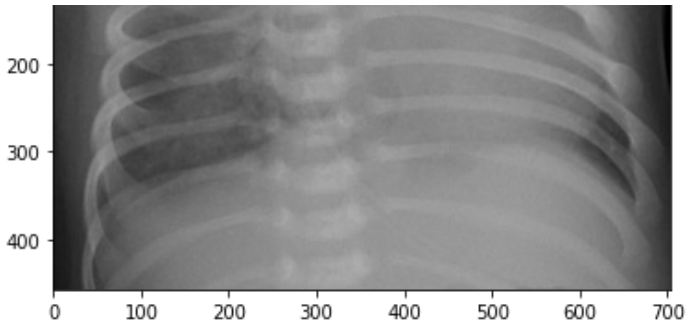
```
plt.imshow(plt.imread(test_df.Filepath.iloc[8]))
plt.title(f"True: {test_df.Label.iloc[8]} \nPredicted: {pred[8]}")
plt.show()
```



In [111]:

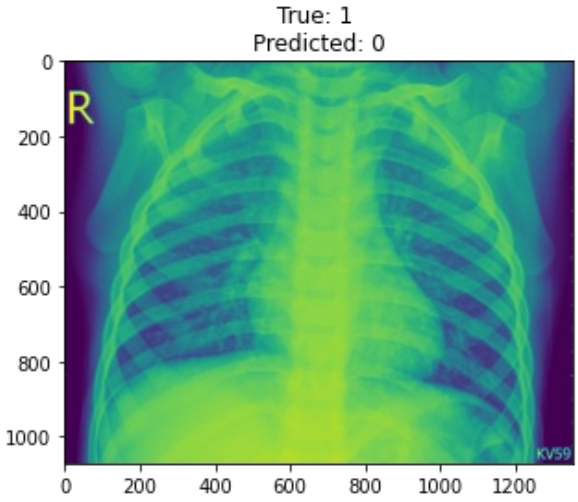
```
plt.imshow(plt.imread(test_df.Filepath.iloc[15]))
plt.title(f"True: {test_df.Label.iloc[15]} \nPredicted: {pred[1]}")
plt.show()
```





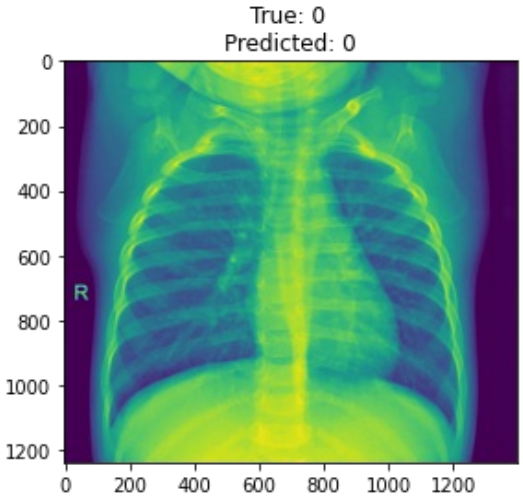
In [112]:

```
plt.imshow(plt.imread(test_df.Filepath.iloc[3]))
plt.title(f"True: {test_df.Label.iloc[3]} \nPredicted: {pred[3]}")
plt.show()
```



In [114]:

```
plt.imshow(plt.imread(test_df.Filepath.iloc[23]))
plt.title(f"True: {test_df.Label.iloc[23]} \nPredicted: {pred[2]}")
plt.show()
```



In [ ]: