Importing Libraries

In [24]:

```
import numpy as np
import pandas as pd
import os
import tensorflow as tf
from tensorflow.keras import Sequential
from keras.layers import Conv2D, MaxPooling2D, Activation, Dropout, Flatte
from keras.callbacks import EarlyStopping
from sklearn.model_selection import train_test_split
from tensorflow.keras.preprocessing.image import ImageDataGenerator
import matplotlib.pyplot as plt
from tensorflow.keras.applications.resnet50 import ResNet50
from tensorflow.keras.applications.efficientnet import EfficientNetB2
from sklearn.metrics import classification_report,confusion_matrix
import seaborn as sns
import cv2
import pprint
import datetime
import warnings
warnings.filterwarnings('ignore')
```

In [29]:

```
parasited_paths = '/content/cell_images/Parasitized'
uninfected_paths = '/content/cell_images/Uninfected'
```

In [32]:

```
parasitized_cell_path_prefix = '/content/cell_images/Parasitized'
uninfected_cell_path_prefix = '/content/cell_images/Uninfected'
```

In [33]:

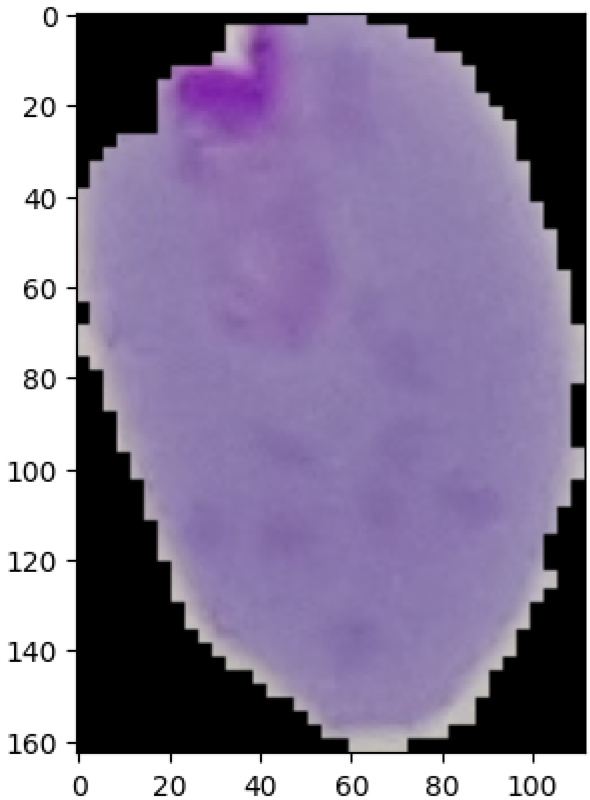
```
parasited_paths = [os.path.join(parasitized_cell_path_prefix, i) for i in
uninfected_paths = [os.path.join(uninfected_cell_path_prefix, i) for i in


pprint.pprint(parasited_paths[:3])
pprint.pprint(uninfected_paths[:3])
```

```
['/content/cell_images/Parasitized/C132P93ThinF_IMG_20151004_152505_cell
_140.png',
 '/content/cell_images/Parasitized/C66P27N_ThinF_IMG_20150818_163419_cel
l_205.png',
 '/content/cell_images/Parasitized/C89P50ThinF_IMG_20150820_162300_cell_
210.png']
['/content/cell_images/Uninfected/C98P59ThinF_IMG_20150917_153801_cell_1
27.png',
 '/content/cell_images/Uninfected/C86P47ThinF_IMG_20150820_124943_cell_7
8.png',
 '/content/cell_images/Uninfected/C146P107ThinF_IMG_20151018_140044_cell
_142.png']
```

In [35]:

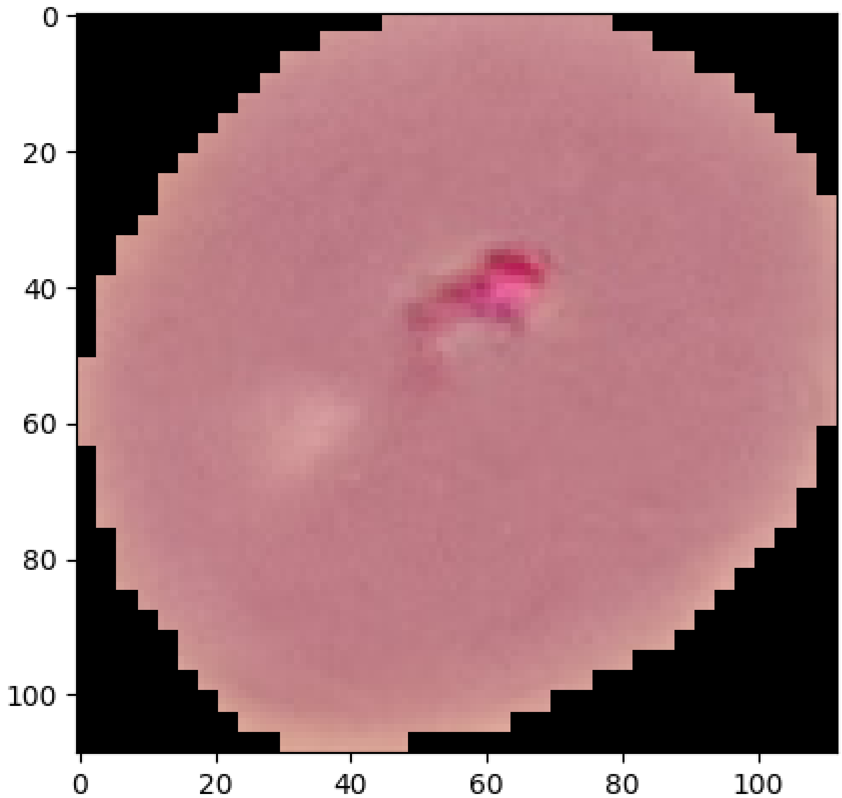
```python
print(plt.imread(parasited_paths[5]).shape)
plt.imshow(plt.imread(parasited_paths[5]));
```

(163, 112, 3)



In [36]:

```
plt.imshow(plt.imread(uninfected_paths[5]));
```



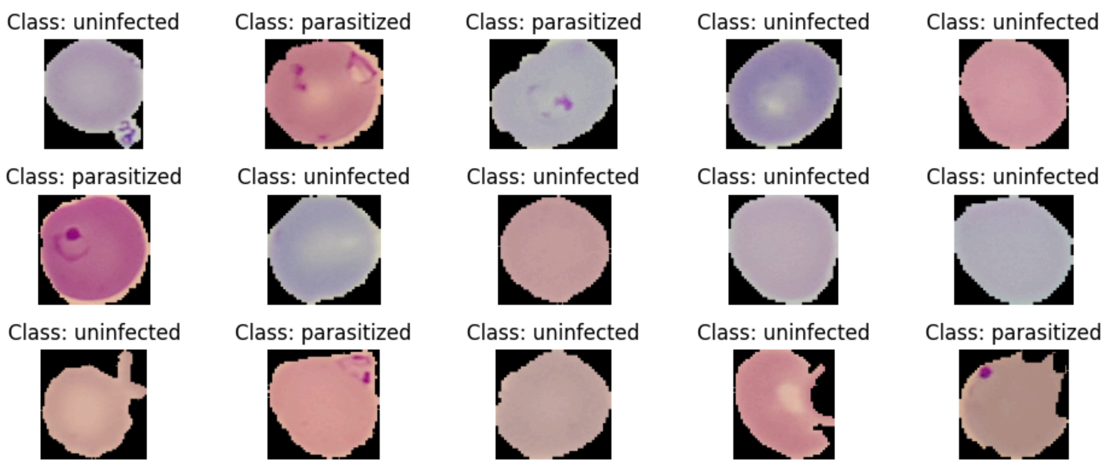
In [37]:

```
# Create a DataFrame from full_paths of images
df_parasited = pd.DataFrame({'filename': parasited_paths, 'class': 'parasi
df_uninfected = pd.DataFrame({'filename': uninfected_paths, 'class': 'unir

# Concatenate the two DataFrames
df = pd.concat([df_parasited, df_uninfected], ignore_index=True)

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

# Split the DataFrame into training and testing sets
train_df, test_df = train_test_split(df, test_size=0.1, random_state=42)

# Display a sample of the training and testing sets
print("Length of train Set: ", len(train_df))
print("Training set:")
print(train_df.head())
print("\nLength of test Set: ", len(test_df))
print("Testing set:")
print(test_df.head())
```

```
Length of train Set:  24804
Training set:
                                               filename        class
23886  /content/cell_images/Uninfected/C96P57ThinF_IM...   uninfected
19633  /content/cell_images/Parasitized/C184P145ThinF...  parasitized
17781  /content/cell_images/Parasitized/C136P97ThinF_...  parasitized
19612  /content/cell_images/Parasitized/C176P137NThin...  parasitized
13033  /content/cell_images/Uninfected/C104P65ThinF_I...   uninfected

Length of test Set:  2756
Testing set:
                                               filename        class
2476   /content/cell_images/Uninfected/C102P63ThinF_I...   uninfected
7809   /content/cell_images/Parasitized/C68P29N_ThinF...  parasitized
18968  /content/cell_images/Uninfected/C117P78ThinF_I...   uninfected
10810  /content/cell_images/Parasitized/C176P137NThin...  parasitized
13698  /content/cell_images/Parasitized/C46P7ThinF_IM...  parasitized
```

In [38]:

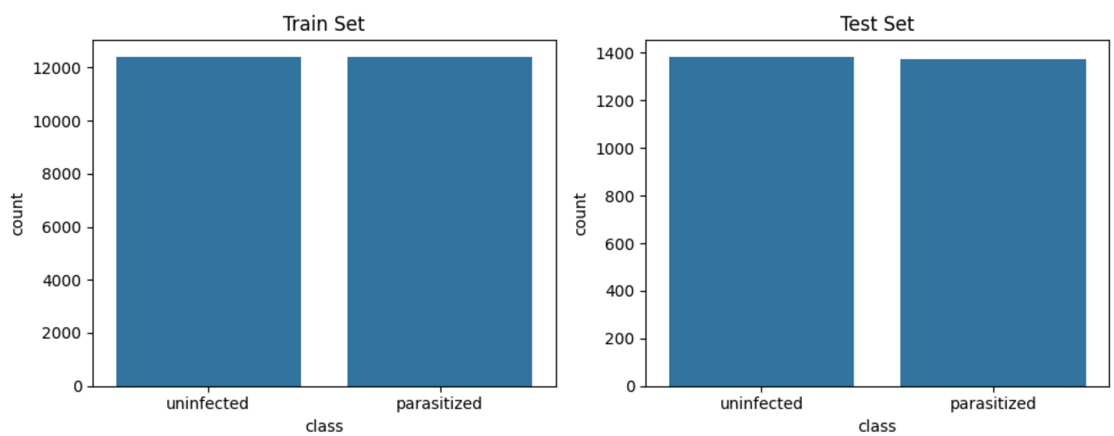
```python
# Create a subplot with 3 rows and 5 columns
fig, axes = plt.subplots(nrows=3, ncols=5, figsize=(10, 4))
axes = axes.flatten()

# Plotting images
for i in range(15):
    ax = axes[i]

    sample_observation = train_df.sample()
    sample_path = sample_observation['filename'].iloc[0]

    image = plt.imread(sample_path)

    ax.imshow(image)
    ax.set_title(f"Class: {sample_observation['class'].iloc[0]}")
    ax.axis('off')

plt.tight_layout()
plt.show()
```



In [39]:

```python
print(f"Train set, Uninfected Images: {len(train_df[train_df['class']=='ur
print(f"Train set, Parasitized Images: {len(train_df[train_df['class']=='p
print(f"Test set, Uninfected Images: {len(test_df[test_df['class']=='uninf
print(f"Test set, Parasitized Images: {len(test_df[test_df['class']=='para

fig,axes = plt.subplots(1, 2, figsize=(10,4))
sns.countplot(x=train_df['class'], ax=axes[0])
axes[0].set_title('Train Set')
sns.countplot(x=test_df['class'], ax=axes[1])
axes[1].set_title('Test Set')
plt.tight_layout()
plt.show()
```

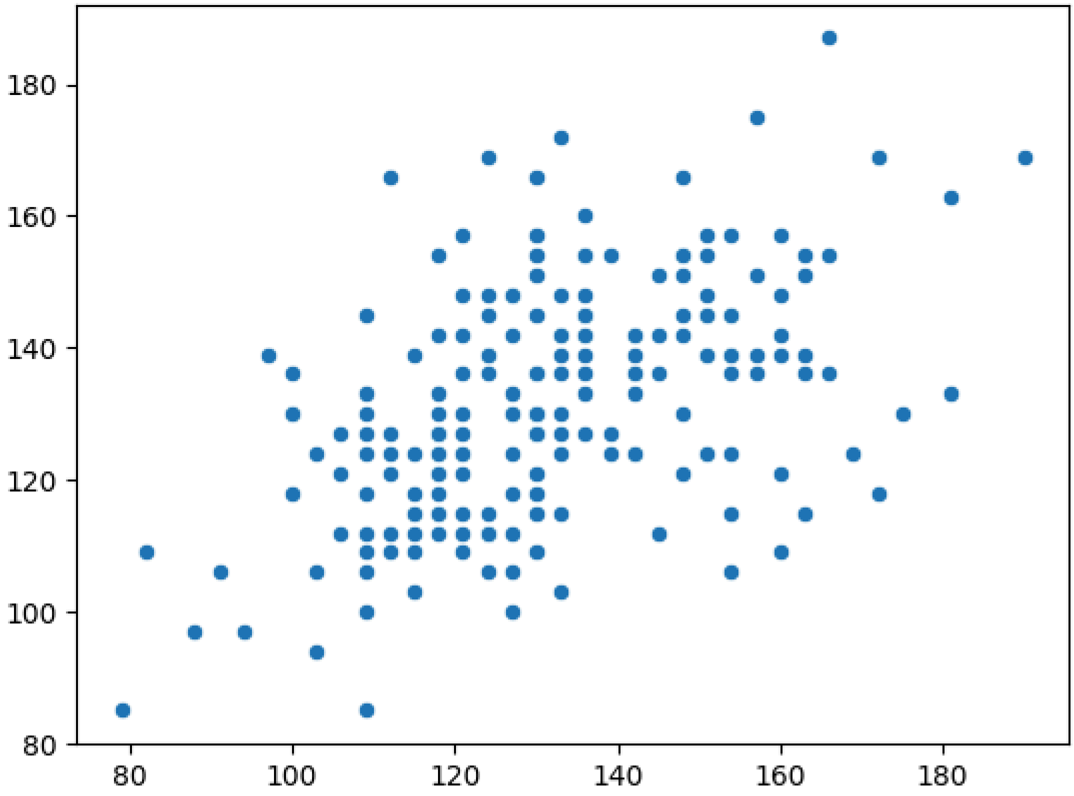
```
Train set, Uninfected Images: 12396
Train set, Parasitized Images: 12408
Test set, Uninfected Images: 1384
Test set, Parasitized Images: 1372
```



In [40]:

```python
# random 200 images

random_images_paths = train_df.sample(200)['filename']
x = []
y = []
c = []
max_rgb = []
min_rgb = []

for image_path in random_images_paths:
    image = plt.imread(image_path)

    max_rgb.append(image.max())
    min_rgb.append(image.min())

    d1, d2, channels = image.shape
    x.append(d1)
    y.append(d2)
    c.append(channels)
```

In [41]:
```
sns.scatterplot(x=x,y=y);
```



In [42]:
```
print(np.mean(x),'--', np.mean(y))
```

```
131.98 -- 131.92
```

In [43]:
```
print(f"Unique Channels: {set(c)}")
```

```
Unique Channels: {3}
```

In [45]:
```
batch_size = 64
image_shape = (135,135,3)
target_size = (135,135)
```

In [46]:
```python
# train set (divided into train and validation set: validation set will be

train_image_data_generator = ImageDataGenerator(
    rotation_range=20,
    width_shift_range=0.10,
    height_shift_range=0.10,
    shear_range=0.1,
    zoom_range=0.1,
    horizontal_flip=True,
    fill_mode='nearest',
    validation_split=0.2
)

# Separate generators for training and validation
train_generator = train_image_data_generator.flow_from_dataframe(
    dataframe=train_df,
    x_col='filename',
    y_col='class',
    target_size=target_size,
    color_mode='rgb',
    batch_size=batch_size,
    class_mode='binary',
    shuffle=False,
    seed=42,
    subset='training'
)

validation_generator = train_image_data_generator.flow_from_dataframe(
    dataframe=train_df,
    x_col='filename',
    y_col='class',
    target_size=target_size,
    color_mode='rgb',
    batch_size=batch_size,
    class_mode='binary',
    shuffle=False,
    seed=42,
    subset='validation'
)
```

```
Found 19842 validated image filenames belonging to 2 classes.
Found 4960 validated image filenames belonging to 2 classes.
```

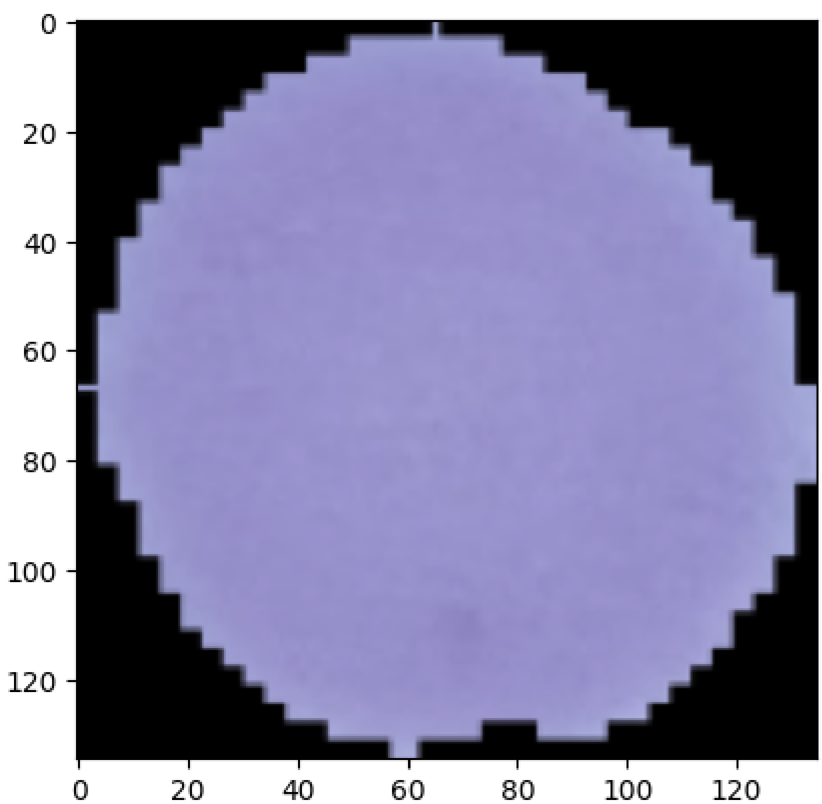
In [47]:
```python
print(train_generator.class_indices)
print(validation_generator.class_indices)
print(len(train_generator))
print(len(validation_generator))
```

```
{'parasitized': 0, 'uninfected': 1}
{'parasitized': 0, 'uninfected': 1}
311
78
```

In [48]:
```python
x_test = test_df.copy()
test_images = x_test['filename']
test_labels = x_test['class']

loaded_images = []

for path in test_images:
    img = cv2.imread(path)
    resized_img = cv2.resize(img, dsize=target_size, interpolation=cv2.INT
    loaded_images.append(resized_img)
```

In [49]:
```python
print(f"loaded_images {len(loaded_images)} qty np.arrays [images] in a lis
print(f"test_images {len(test_images)} of {type(test_images)}")
print(f"test_labels {len(test_labels)} of {type(test_labels)}")
print(f"Shape of an image from Test Set: {loaded_images[42].shape}")

plt.imshow(loaded_images[42])
plt.show()
```

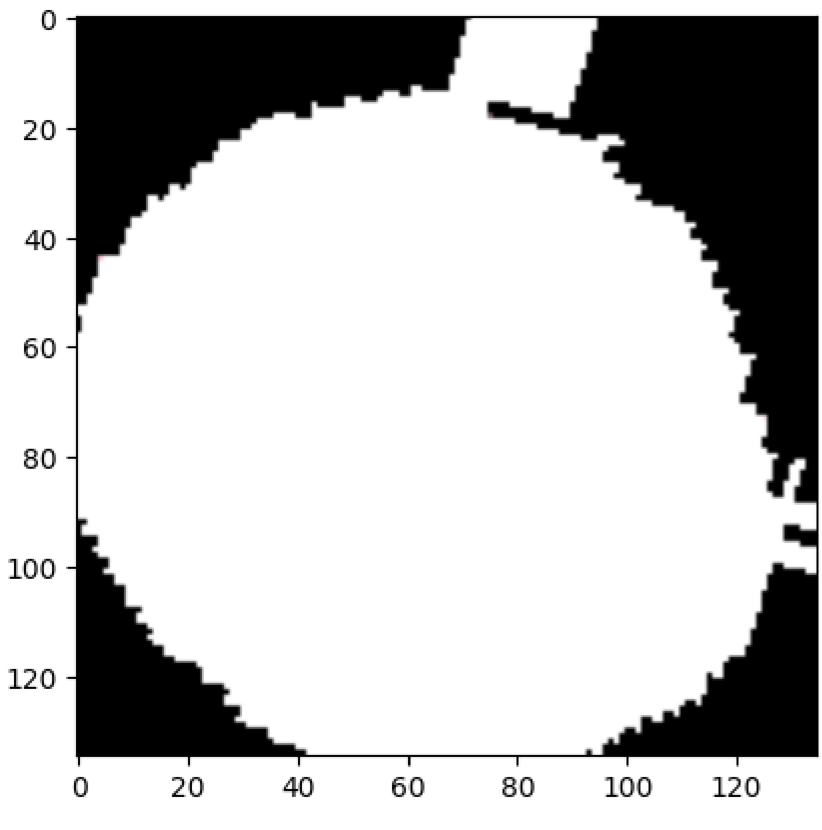
```
loaded_images 2756 qty np.arrays [images] in a list
test_images 2756 of <class 'pandas.core.series.Series'>
test_labels 2756 of <class 'pandas.core.series.Series'>
Shape of an image from Test Set: (135, 135, 3)
```



In [51]:

```
augmented_img = next(train_generator)[0][0]  # batch_size=1
print(augmented_img.shape)

# image saving
filename = "augmented_image.jpg"
path = f"/content/working{filename}"

from PIL import Image
img = Image.fromarray(augmented_img.astype('uint8'))
img.save(path)

print(f"Image saved as: {path}")

# image
plt.imshow(augmented_img)
plt.show()
```

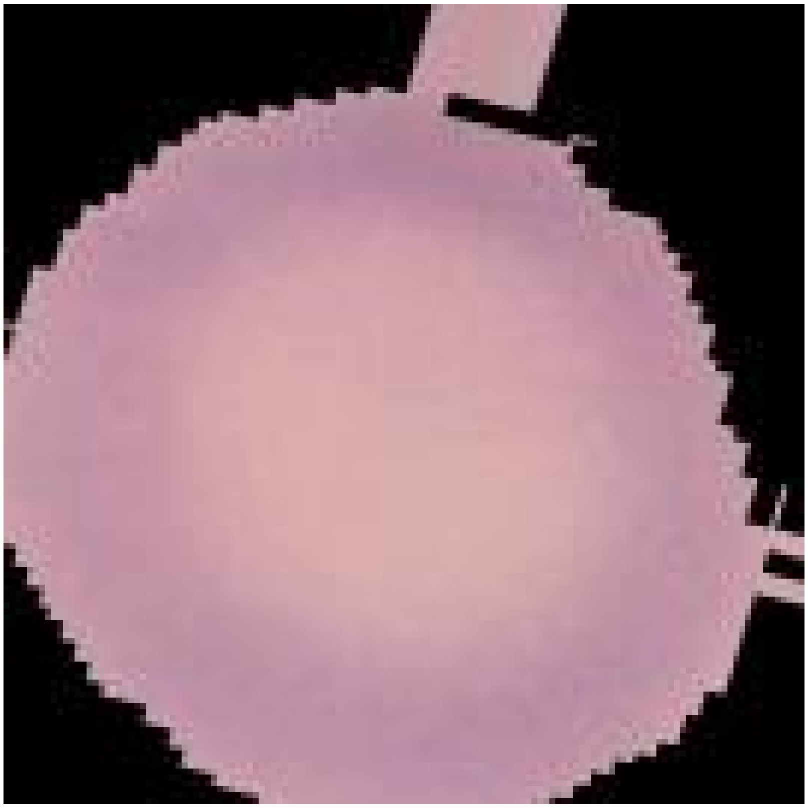
```
WARNING:matplotlib.image:Clipping input data to the valid range for imsh
ow with RGB data ([0..1] for floats or [0..255] for integers).

(135, 135, 3)
Image saved as: /content/workingaugmented_image.jpg
```



In [52]:

```
from IPython.display import Image
image_path = '/content/workingaugmented_image.jpg'
Image(filename=image_path, width=400)
```

Out[52]:



In [53]:

```
# number of batches for model training
print(len(train_generator))
print(len(validation_generator))
```

```
311
78
```

Customized CNN Model

In [54]:

```
model = Sequential()

model.add(Conv2D(filters=64, kernel_size=(3,3),input_shape=image_shape, pa
model.add(MaxPooling2D(pool_size=(2, 2)))

model.add(Conv2D(filters=128, kernel_size=(3,3), padding='same', activatic
model.add(MaxPooling2D(pool_size=(2, 2)))

model.add(Conv2D(filters=128, kernel_size=(3,3), padding='same', activatic
model.add(MaxPooling2D(pool_size=(2, 2)))

model.add(Conv2D(filters=128, kernel_size=(3,3), padding='same', activatic
model.add(MaxPooling2D(pool_size=(2, 2)))

model.add(Conv2D(filters=64, kernel_size=(3,3), padding='same', activatior
model.add(MaxPooling2D(pool_size=(2, 2)))

model.add(Flatten())

model.add(Dense(256))
model.add(Activation('relu'))
model.add(Dropout(0.5))
model.add(Dense(128))
model.add(Activation('relu'))
model.add(Dropout(0.25))
model.add(Dense(1))
model.add(Activation('sigmoid'))

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

model.summary()
```

```
Model: "sequential_1"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 conv2d_3 (Conv2D)           (None, 135, 135, 64)      1792

 max_pooling2d_3 (MaxPoolin  (None, 67, 67, 64)        0
 g2D)

 conv2d_4 (Conv2D)           (None, 67, 67, 128)       73856

 max_pooling2d_4 (MaxPoolin  (None, 33, 33, 128)       0
 g2D)

 conv2d_5 (Conv2D)           (None, 33, 33, 128)       147584

 max_pooling2d_5 (MaxPoolin  (None, 16, 16, 128)       0
 g2D)

 conv2d_6 (Conv2D)           (None, 16, 16, 128)       147584

 max_pooling2d_6 (MaxPoolin  (None, 8, 8, 128)         0
 g2D)

 conv2d_7 (Conv2D)           (None, 8, 8, 64)          73792

 max_pooling2d_7 (MaxPoolin  (None, 4, 4, 64)          0
 g2D)

 flatten_1 (Flatten)         (None, 1024)              0

 dense_1 (Dense)             (None, 256)               262400

 activation (Activation)     (None, 256)               0

 dropout_3 (Dropout)         (None, 256)               0

 dense_2 (Dense)             (None, 128)               32896

 activation_1 (Activation)   (None, 128)               0

 dropout_4 (Dropout)         (None, 128)               0

 dense_3 (Dense)             (None, 1)                 129

 activation_2 (Activation)   (None, 1)                 0

=================================================================
Total params: 740033 (2.82 MB)
Trainable params: 740033 (2.82 MB)
Non-trainable params: 0 (0.00 Byte)
_________________________________________________________________
```

In [55]:

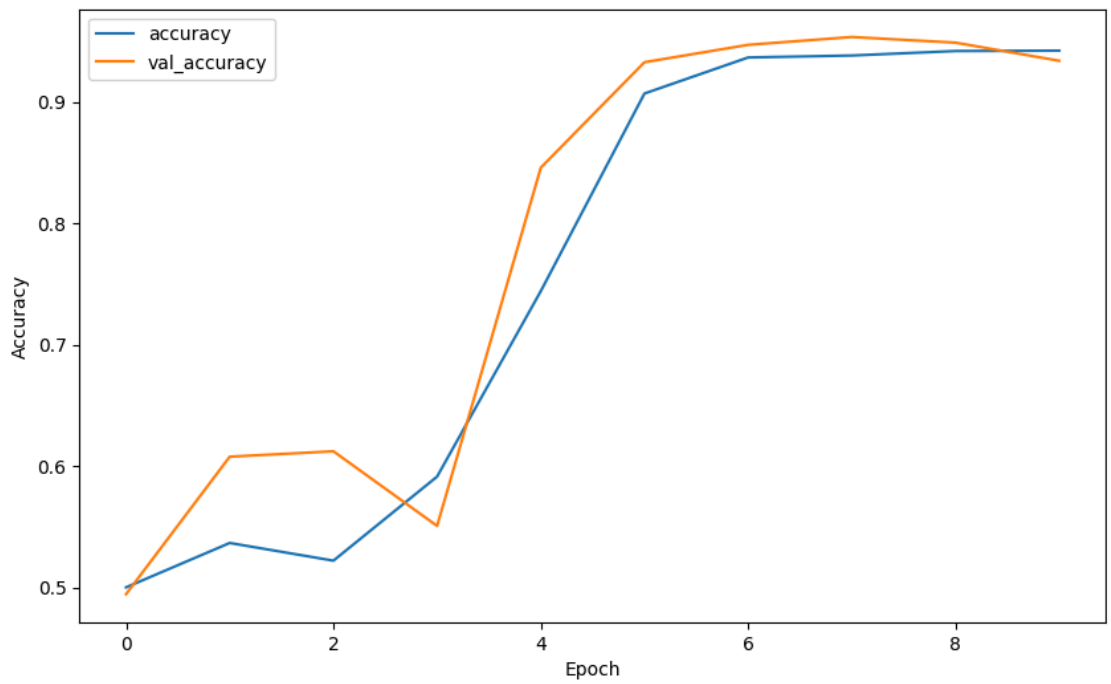
```
results = model.fit(
    train_generator,
    steps_per_epoch= 50,
    epochs=10,
    validation_data=validation_generator,
    batch_size=batch_size
)
```

```
Epoch 1/10
50/50 [==============================] - 52s 944ms/step - loss: 1.3986 -
accuracy: 0.5000 - val_loss: 0.6946 - val_accuracy: 0.4944
Epoch 2/10
50/50 [==============================] - 46s 934ms/step - loss: 0.6919 -
accuracy: 0.5366 - val_loss: 0.6740 - val_accuracy: 0.6077
Epoch 3/10
50/50 [==============================] - 46s 927ms/step - loss: 0.6944 -
accuracy: 0.5220 - val_loss: 0.6835 - val_accuracy: 0.6121
Epoch 4/10
50/50 [==============================] - 59s 1s/step - loss: 0.6777 - ac
curacy: 0.5913 - val_loss: 0.6753 - val_accuracy: 0.5506
Epoch 5/10
50/50 [==============================] - 45s 914ms/step - loss: 0.5353 -
accuracy: 0.7441 - val_loss: 0.4264 - val_accuracy: 0.8458
Epoch 6/10
50/50 [==============================] - 47s 942ms/step - loss: 0.2996 -
accuracy: 0.9069 - val_loss: 0.2268 - val_accuracy: 0.9327
Epoch 7/10
50/50 [==============================] - 47s 942ms/step - loss: 0.2272 -
accuracy: 0.9366 - val_loss: 0.1670 - val_accuracy: 0.9470
Epoch 8/10
50/50 [==============================] - 45s 910ms/step - loss: 0.2000 -
accuracy: 0.9382 - val_loss: 0.1800 - val_accuracy: 0.9534
Epoch 9/10
50/50 [==============================] - 64s 1s/step - loss: 0.2078 - ac
curacy: 0.9419 - val_loss: 0.1668 - val_accuracy: 0.9488
Epoch 10/10
50/50 [==============================] - 46s 936ms/step - loss: 0.1923 -
accuracy: 0.9422 - val_loss: 0.1735 - val_accuracy: 0.9339
```

In [56]:

```
# Model Summary
summary = pd.DataFrame(model.history.history)
print(summary.head())
print('\n','-'*100)

plt.figure(figsize=(10,6))
plt.plot(summary.accuracy, label="accuracy")
plt.plot(summary.val_accuracy, label="val_accuracy")
plt.legend(loc="upper left")
plt.ylabel("Accuracy")
plt.xlabel("Epoch")
plt.show()
```

```
       loss  accuracy  val_loss  val_accuracy
0  1.398588  0.500000  0.694593      0.494355
1  0.691860  0.536563  0.674035      0.607661
2  0.694408  0.521989  0.683479      0.612097
3  0.677735  0.591250  0.675311      0.550605
4  0.535333  0.744062  0.426410      0.845766

 ---------------------------------------------------------------------------------------------------
```



In [57]:

```
# Model Evaluation on Test Set

# Convert the list of loaded images to a numpy array
test_images_array = np.array(loaded_images)

# Make predictions using the model
predictions = model.predict(test_images_array)

# Convert the predictions to binary labels
predicted_labels = np.round(predictions).flatten().astype(int)

# Convert the actual labels from strings to integers
actual_labels = (test_labels == 'uninfected').astype(int)

# Calculate accuracy
accuracy = np.mean(predicted_labels == actual_labels)

print(f"Accuracy score is {accuracy}")
```

```
87/87 [==============================] - 1s 13ms/step
Accuracy score is 0.9368650217706821
```

ResNet50

In [58]:

```
base_model = ResNet50(
    weights='imagenet',
    include_top=False,
    input_shape= image_shape
)

# Freezing the convolutional layers
for layer in base_model.layers:
    layer.trainable = False

# Resnet50
model = Sequential()
model.add(base_model)

model.add(Flatten())

model.add(Dense(256))
model.add(Activation('relu'))
model.add(Dropout(0.5))
model.add(Dense(1))
model.add(Activation('sigmoid'))

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

model.summary()
```

```
Downloading data from https://storage.googleapis.com/tensorflow/keras-applications/resnet/resnet50_weights_tf_dim_ordering_tf_kernels_notop.h5 (https://storage.googleapis.com/tensorflow/keras-applications/resnet/resnet50_weights_tf_dim_ordering_tf_kernels_notop.h5)
94765736/94765736 [==============================] - 5s 0us/step
Model: "sequential_2"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 resnet50 (Functional)       (None, 5, 5, 2048)        23587712

 flatten_2 (Flatten)         (None, 51200)             0

 dense_4 (Dense)             (None, 256)               13107456

 activation_3 (Activation)   (None, 256)               0

 dropout_5 (Dropout)         (None, 256)               0

 dense_5 (Dense)             (None, 1)                 257

 activation_4 (Activation)   (None, 1)                 0

=================================================================
Total params: 36695425 (139.98 MB)
Trainable params: 13107713 (50.00 MB)
Non-trainable params: 23587712 (89.98 MB)
_________________________________________________________________
```

In [59]:

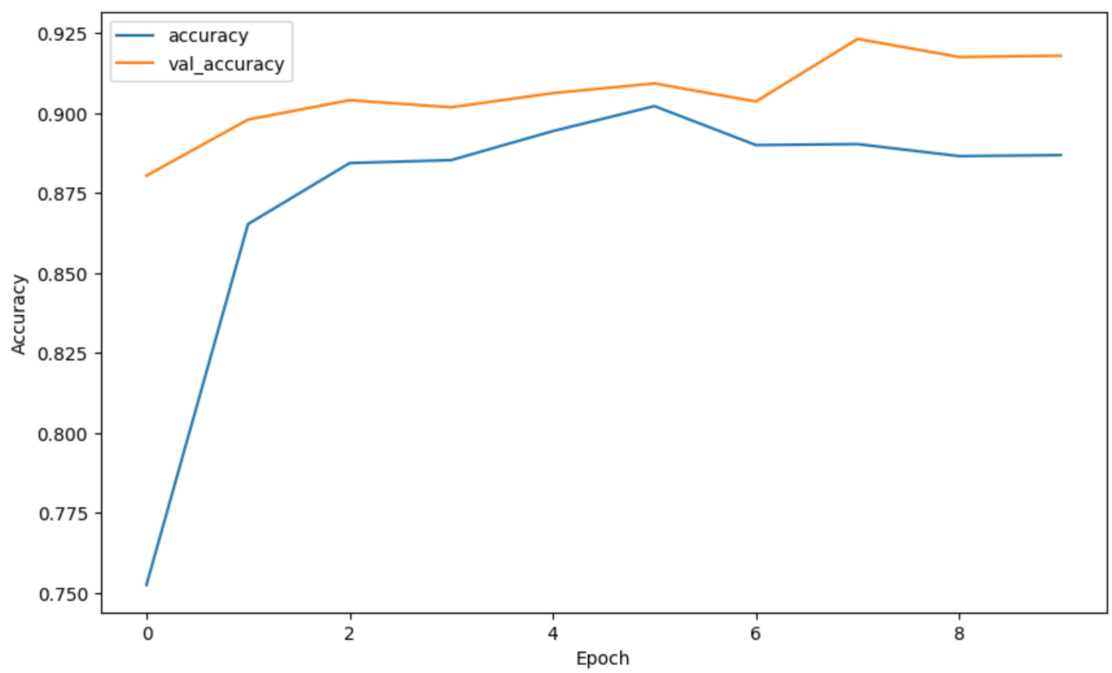
```
results = model.fit(
    train_generator,
    steps_per_epoch= 50,
    epochs=10,
    validation_data=validation_generator,
    batch_size=batch_size
)
```

```
Epoch 1/10
50/50 [==============================] - 56s 1s/step - loss: 3.2423 - ac
curacy: 0.7525 - val_loss: 0.2904 - val_accuracy: 0.8804
Epoch 2/10
50/50 [==============================] - 48s 978ms/step - loss: 0.3433 -
accuracy: 0.8653 - val_loss: 0.2466 - val_accuracy: 0.8980
Epoch 3/10
50/50 [==============================] - 48s 980ms/step - loss: 0.2964 -
accuracy: 0.8844 - val_loss: 0.2377 - val_accuracy: 0.9040
Epoch 4/10
50/50 [==============================] - 47s 960ms/step - loss: 0.2916 -
accuracy: 0.8853 - val_loss: 0.2359 - val_accuracy: 0.9018
Epoch 5/10
50/50 [==============================] - 49s 985ms/step - loss: 0.2730 -
accuracy: 0.8944 - val_loss: 0.2282 - val_accuracy: 0.9062
Epoch 6/10
50/50 [==============================] - 48s 979ms/step - loss: 0.2502 -
accuracy: 0.9022 - val_loss: 0.2182 - val_accuracy: 0.9093
Epoch 7/10
50/50 [==============================] - 51s 1s/step - loss: 0.2629 - ac
curacy: 0.8900 - val_loss: 0.2286 - val_accuracy: 0.9036
Epoch 8/10
50/50 [==============================] - 50s 1s/step - loss: 0.2780 - ac
curacy: 0.8903 - val_loss: 0.2112 - val_accuracy: 0.9232
Epoch 9/10
50/50 [==============================] - 50s 1s/step - loss: 0.2968 - ac
curacy: 0.8866 - val_loss: 0.2133 - val_accuracy: 0.9175
Epoch 10/10
50/50 [==============================] - 55s 1s/step - loss: 0.2912 - ac
curacy: 0.8869 - val_loss: 0.2056 - val_accuracy: 0.9179
```

In [60]:

```
# Model Summary
summary = pd.DataFrame(model.history.history)
print(summary.head())
print('\n','-'*100)

plt.figure(figsize=(10,6))
plt.plot(summary.accuracy, label="accuracy")
plt.plot(summary.val_accuracy, label="val_accuracy")
plt.legend(loc="upper left")
plt.ylabel("Accuracy")
plt.xlabel("Epoch")
plt.show()
```

```
       loss  accuracy  val_loss  val_accuracy
0  3.242338  0.752500  0.290421      0.880444
1  0.343266  0.865313  0.246554      0.897984
2  0.296380  0.884375  0.237661      0.904032
3  0.291592  0.885312  0.235941      0.901815
4  0.273016  0.894375  0.228157      0.906250

 ----------------------------------------------------------------------
----------------------------
```



In [61]:

```python
# Model Evaluation on Test Set

# Convert the list of loaded images to a numpy array
test_images_array = np.array(loaded_images)

# Make predictions using the model
predictions = model.predict(test_images_array)

# Convert the predictions to binary labels
predicted_labels = np.round(predictions).flatten().astype(int)

# Convert the actual labels from strings to integers
actual_labels = (test_labels == 'uninfected').astype(int)

# Calculate accuracy
accuracy = np.mean(predicted_labels == actual_labels)

print(f"Accuracy score is {accuracy}")
```

```
87/87 [==============================] - 6s 55ms/step
Accuracy score is 0.8940493468795355
```

EfficientNetB2

In [62]:

```
base_model = EfficientNetB2(
    weights='imagenet',
    include_top=False,
    input_shape= image_shape
)

# Freezing the convolutional layers
for layer in base_model.layers:
    layer.trainable = False

# EfficientNetB2
model = Sequential()
model.add(base_model)

model.add(Flatten())

model.add(Dense(256))
model.add(Activation('relu'))
model.add(Dropout(0.5))
model.add(Dense(1))
model.add(Activation('sigmoid'))

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

model.summary()
```

```
Downloading data from https://storage.googleapis.com/keras-applications/efficientnetb2_notop.h5 (https://storage.googleapis.com/keras-applications/efficientnetb2_notop.h5)
31790344/31790344 [==============================] - 2s 0us/step
Model: "sequential_3"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 efficientnetb2 (Functional  (None, 5, 5, 1408)        7768569
 )

 flatten_3 (Flatten)         (None, 35200)             0

 dense_6 (Dense)             (None, 256)               9011456

 activation_5 (Activation)   (None, 256)               0

 dropout_6 (Dropout)         (None, 256)               0

 dense_7 (Dense)             (None, 1)                 257

 activation_6 (Activation)   (None, 1)                 0

=================================================================
Total params: 16780282 (64.01 MB)
Trainable params: 9011713 (34.38 MB)
Non-trainable params: 7768569 (29.63 MB)
_________________________________________________________________
```

In [63]:

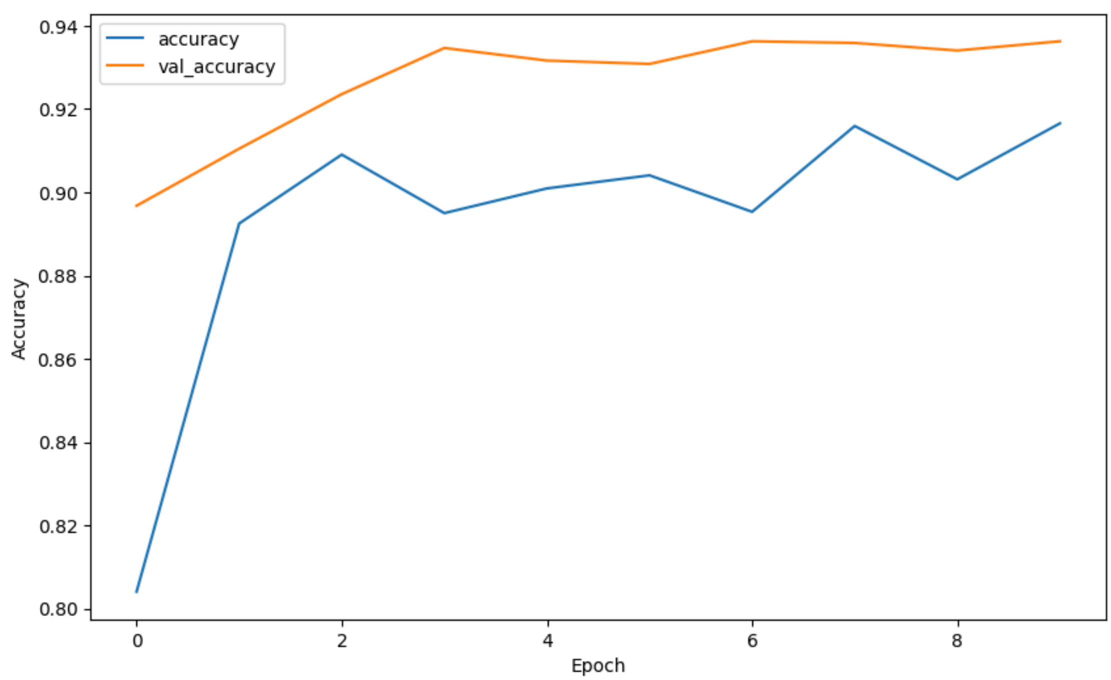
```python
results = model.fit(
    train_generator,
    steps_per_epoch= 50,
    epochs=10,
    validation_data=validation_generator,
    batch_size=batch_size
)
```

```
Epoch 1/10
50/50 [==============================] - 65s 1s/step - loss: 1.4847 - ac
curacy: 0.8041 - val_loss: 0.2560 - val_accuracy: 0.8968
Epoch 2/10
50/50 [==============================] - 50s 1s/step - loss: 0.2783 - ac
curacy: 0.8925 - val_loss: 0.2332 - val_accuracy: 0.9105
Epoch 3/10
50/50 [==============================] - 49s 988ms/step - loss: 0.2464 -
accuracy: 0.9091 - val_loss: 0.2124 - val_accuracy: 0.9236
Epoch 4/10
50/50 [==============================] - 59s 1s/step - loss: 0.2810 - ac
curacy: 0.8950 - val_loss: 0.1891 - val_accuracy: 0.9347
Epoch 5/10
50/50 [==============================] - 52s 1s/step - loss: 0.2454 - ac
curacy: 0.9009 - val_loss: 0.1847 - val_accuracy: 0.9317
Epoch 6/10
50/50 [==============================] - 48s 961ms/step - loss: 0.2373 -
accuracy: 0.9041 - val_loss: 0.1864 - val_accuracy: 0.9308
Epoch 7/10
50/50 [==============================] - 52s 1s/step - loss: 0.2577 - ac
curacy: 0.8953 - val_loss: 0.1781 - val_accuracy: 0.9363
Epoch 8/10
50/50 [==============================] - 49s 992ms/step - loss: 0.2265 -
accuracy: 0.9159 - val_loss: 0.1879 - val_accuracy: 0.9359
Epoch 9/10
50/50 [==============================] - 59s 1s/step - loss: 0.2533 - ac
curacy: 0.9031 - val_loss: 0.1737 - val_accuracy: 0.9341
Epoch 10/10
50/50 [==============================] - 47s 947ms/step - loss: 0.2214 -
accuracy: 0.9166 - val_loss: 0.1785 - val_accuracy: 0.9363
```

In [64]:

```
# Model Summary
summary = pd.DataFrame(model.history.history)
print(summary.head())
print('\n','-'*100)

plt.figure(figsize=(10,6))
plt.plot(summary.accuracy, label="accuracy")
plt.plot(summary.val_accuracy, label="val_accuracy")
plt.legend(loc="upper left")
plt.ylabel("Accuracy")
plt.xlabel("Epoch")
plt.show()
```

```
       loss  accuracy  val_loss  val_accuracy
0  1.484711  0.804062  0.255994      0.896774
1  0.278332  0.892500  0.233218      0.910484
2  0.246357  0.909063  0.212419      0.923589
3  0.280967  0.895000  0.189122      0.934677
4  0.245388  0.900937  0.184667      0.931653

 ----------------------------------------------------------------------
----------------------------
```



In [65]:

```python
# Model Evaluation on Test Set

# Convert the list of loaded images to a numpy array
test_images_array = np.array(loaded_images)

# Make predictions using the model
predictions = model.predict(test_images_array)

# Convert the predictions to binary labels
predicted_labels = np.round(predictions).flatten().astype(int)

# Convert the actual labels from strings to integers
actual_labels = (test_labels == 'uninfected').astype(int)

# Accuracy
accuracy = np.mean(predicted_labels == actual_labels)

print(f"Accuracy score is {accuracy}")
```

```
87/87 [==============================] - 6s 50ms/step
Accuracy score is 0.9437590711175616
```