In [1]:
```
# Import the necessary packages
import numpy as np
import random
import timeit
import sys
import matplotlib.pyplot as plt
```

In [2]:
```
class SOM(object):

    def __init__(self, X_len = 100, y_len=100, epochs=20, sigma_init=1, alpha=
0.8, seed=42):
      """ SOM Network
      Parameter:
      ----------
      X_len: 100 for the Grid along X-axis (this represent neurons)
      y_len: 100 for the Grid along y-axis (this represent neurons)
      epochs: Default(20)
              Number of Iteration to run
      sigma_init = Default (1)
                   Value of Sigma to be given
      alpha: Default (0.8)
             Initial value of alpha
      seed: Default (42)
            seed for Random state
      """
        self.X_len = X_len
        self.y_len = y_len
        self.epochs = epochs
        self.sigma_init = sigma_init
        self.alpha = alpha
        self.beta = 1000
        self.random = np.random.RandomState(seed)

    def color_selection(self, n):
      """ Initialization of the network parameters for 100 * 100 grid
      Parameter:
      ----------
      n: 3 represent number the RGB value in the network.

      Attributes:
      --------
      color: Random initialized value of dimension 100 * 100 * 3
      """
        color = np.random.random((self.X_len, self.y_len, n))
        return color

    def distance(self, vector_1, vector_2):
      """ Distance function
      Parameter:
      ----------
      vector_1: 1st vector to find the distance to
      vector_2: 2nd vector to find the distance from
      Attributes:
      -----------
      return the distance between two vectors.
      """
        return np.linalg.norm(vector_1 - vector_2)
```

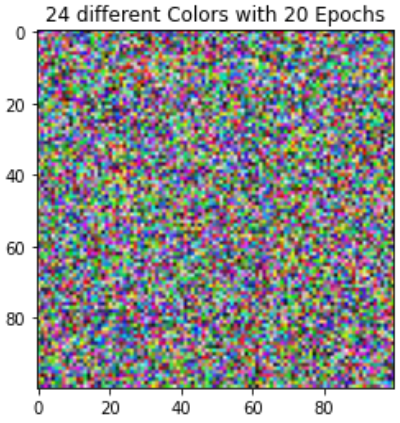
In [ ]:
```
def index_position(self, index):
    """ index_position :
    Parameter:
    ----------
    index: Index of Node
    Attributes:
    -----------
    position_array: Return the position from the array.
    """
    index_X_len = index//self.X_len
    index_y_len = index % self.y_len
    position_array = np.array([index_X_len, index_y_len])
    return position_array

def index_weight(self, index):
      """ index_weight:
      Parameter:
      ----------
      index: Index of the Node
      Attributes:
      -----------
      Returns the weight using the index.
      """
        index_X_len = index//self.X_len
        index_y_len = index%self.y_len
        return self.color[index_X_len][index_y_len]

def plot_color(self):
    """ Plot for the  Data
    """
    sys.stderr.write("Visualization With {0} iteration of\
    {1}*{2} SOM Network".format(self.epochs, self.X_len, self.y_len))
    sys.stderr.flush()
    plt.title('24 different Colors with {0} Epochs'.format(self.epochs))
    plt.imshow(self.color)
```

In [ ]:
```
def train(self):
      """ Train Function for the Network
      """

        init_time = timeit.default_timer()
        self.random
        n = 3
        self.color = self.color_selection(n)
        color_size = 24
        train_data = np.array([[255,255,0], [154,205,50], [255,215,0], [184,13
4,11],\
        [0,100,0], [0,128,0], [0,255,0], [34,139,34], [255,0,0], [220,20,60],
[139,0,0],\
        [165,42,42], [0,0,255], [0,0,205], [0,0,139], [0,0,128], [255,20,147],
[255,105,180],\
        [255,182,193], [255,192,203], [0,128,128], [0,139,139], [47,79,79], [3
2,178,170]])
        train_data = train_data/255

        # Iterate for the Epochs
        for t in range(1, self.epochs+1):
            sys.stderr.write("\nEpoch: {0}".format(t))
            sys.stderr.flush()
            # Iterate for all the Colors in One Epoch
            for index_a in range(len(train_data)):
                self.current_input_vector = train_data[index_a]
                distance_list = []
                # update the index for each node for each color
                for index_i in range(self.X_len * self.y_len):
                    index_X_len = index_i // self.X_len
                    index_y_len = index_i % self.X_len
                    dist = self.distance(self.current_input_vector,\
                     self.color[index_X_len][index_y_len])
                    distance_list.append(dist)
                minimum_distance = distance_list.index(min(distance_list))
                sigma_k = self.sigma_init * np.exp(-t/self.beta)
                alpha_k = self.alpha * np.exp(-t/self.beta)
                # Update the weights for the Network
                for node in range(self.X_len * self.y_len):
                    if self.distance(self.index_position(node),\
                     self.index_position(minimum_distance)) < sigma_k:
                        d_i = self.distance(self.index_position\
                        (minimum_distance), self.index_position(node))
                        theta_t = np.exp(-d_i *d_i/(2*sigma_k*sigma_k))
                        current_X = node//self.X_len
                        current_y = node% self.X_len
                        self.color[current_X][current_y] = \
                        self.color[current_X][current_y] \
                        + alpha_k*theta_t* (self.current_input_vector -\
                        self.color[current_X][current_y])

        # Final Time for the Runtime of the train function
        final_time = timeit.default_timer()
        sys.stderr.write("\n Training Time is {0:.3f} seconds,\
        with {1} iteration in {2} * {3} grid of Neurons in the SOM Network".for
mat((final_time - init_time),\
        self.epochs, self.X_len, self.y_len))
        sys.stderr.flush()
```

Analysis for 20 Epochs, Sigma = 1

In [3]:
```
# Initialize the Network with Epoch = 20, Sigma = 1
som = SOM(epochs = 20, sigma_init= 1)
som.train()
som.plot_color()
```

```
Epoch: 1
Epoch: 2
Epoch: 3
Epoch: 4
Epoch: 5
Epoch: 6
Epoch: 7
Epoch: 8
Epoch: 9
Epoch: 10
Epoch: 11
Epoch: 12
Epoch: 13
Epoch: 14
Epoch: 15
Epoch: 16
Epoch: 17
Epoch: 18
Epoch: 19
Epoch: 20
 Training Time is 79.519 seconds, with 20 iteration in 100 * 100 grid of Neuron
s in the SOM NetworkVisualization With 20 iteration of 100*100 SOM Network
```



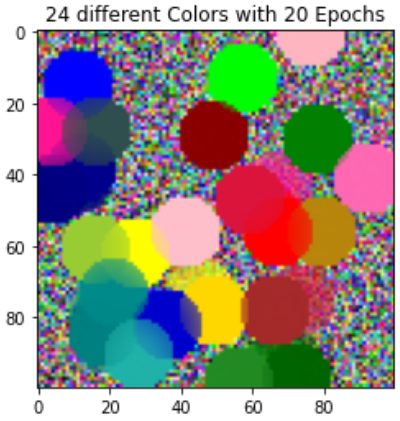
Analysis:

The plot above is generated for 20 Epochs with sigma value as 1. As we can see in the image that the colors are randomly spread over the 100*100 grid and the size of each color is very small. The overall time taken to run 20 epochs with sigma = 1 is around 79.519 seconds for the SOM Network.

Analysis for 20 Epochs, Sigma = 10

In [4]:
```
# Initialize the Network with Epoch = 20, Sigma = 10
som = SOM(epochs = 20, sigma_init = 10)
som.train()
som.plot_color()
```

```
Epoch: 1
Epoch: 2
Epoch: 3
Epoch: 4
Epoch: 5
Epoch: 6
Epoch: 7
Epoch: 8
Epoch: 9
Epoch: 10
Epoch: 11
Epoch: 12
Epoch: 13
Epoch: 14
Epoch: 15
Epoch: 16
Epoch: 17
Epoch: 18
Epoch: 19
Epoch: 20
 Training Time is 82.526 seconds, with 20 iteration in 100 * 100 grid of Neuron
s in the SOM NetworkVisualization With 20 iteration of 100*100 SOM Network
```



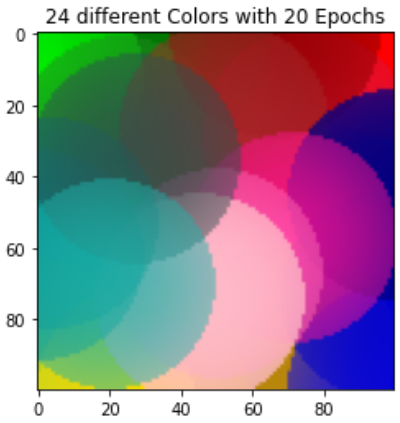
Analysis:

The plot above is generated for 20 Epochs with sigma value as 10. As we can see in the image that the colors are randomly spread over the 100*100 grid and the colors are shown in the circles. It has all the 24 colors on the grid as compared to sigma = 1 which didn't have any color. The overall time taken to run 20 epochs with signma = 10 is around 82.526 seconds for the SOM Network.

Analysis for 20 Epochs, Sigma = 30

In [5]:
```
# Initialize the Network with Epoch = 20, Sigma = 30
som = SOM(epochs = 20, sigma_init = 30)
som.train()
som.plot_color()
```

```
Epoch: 1
Epoch: 2
Epoch: 3
Epoch: 4
Epoch: 5
Epoch: 6
Epoch: 7
Epoch: 8
Epoch: 9
Epoch: 10
Epoch: 11
Epoch: 12
Epoch: 13
Epoch: 14
Epoch: 15
Epoch: 16
Epoch: 17
Epoch: 18
Epoch: 19
Epoch: 20
 Training Time is 99.424 seconds, with 20 iteration in 100 * 100 grid of Neuron
s in the SOM NetworkVisualization With 20 iteration of 100*100 SOM Network
```



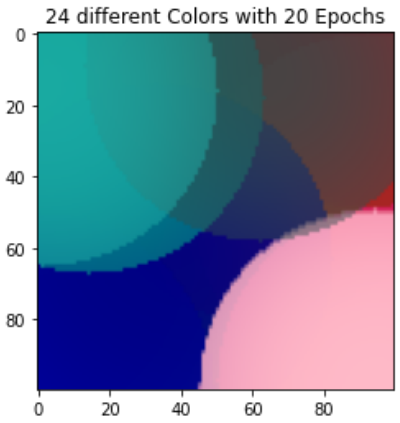
Analysis:

The plot above is generated for 20 Epochs with sigma value as 30. As we can see in the image that the colors are randomly spread over the 100*100 grid and the colors are shown in the circles. The circles for the 24 colors on the grid is larger in diameter than that of sigma = 10 as the spread for the color using the parameter sigma = 30 increases the diameter of the color circles. The overall time taken to run 20 epochs with signma = 30 is around 99.424 seconds for the SOM Network.

Analysis for 20 Epochs, Sigma = 50

In [6]:
```
# Initialize the Network with Epoch = 20, Sigma = 50
som = SOM(epochs = 20, sigma_init = 50)
som.train()
som.plot_color()
```

```
Epoch: 1
Epoch: 2
Epoch: 3
Epoch: 4
Epoch: 5
Epoch: 6
Epoch: 7
Epoch: 8
Epoch: 9
Epoch: 10
Epoch: 11
Epoch: 12
Epoch: 13
Epoch: 14
Epoch: 15
Epoch: 16
Epoch: 17
Epoch: 18
Epoch: 19
Epoch: 20
 Training Time is 115.916 seconds, with 20 iteration in 100 * 100 grid of Neuro
ns in the SOM NetworkVisualization With 20 iteration of 100*100 SOM Network
```



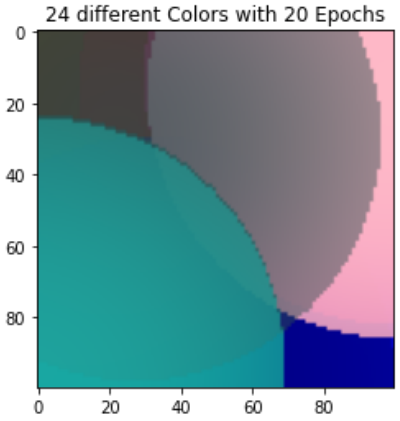
Analysis:

The plot above is generated for 20 Epochs with sigma value as 50. As we can see in the image that the colors are randomly spread over the 100*100 grid and the colors are shown in the circles. The circles for some of the colors on the grid is large enough to be out of the grid. The diameter of each color is larger than that of sigma = 30 as the spread for the color using the parameter sigma = 50 increases the diameter of the color circles. The overall time taken to run 20 epochs with sigma = 50 is around 115.916 seconds for the SOM Network.

Analysis for 20 Epochs, Sigma = 70

In [7]:
```
# Initialize the Network with Epoch = 20, Sigma = 70
som = SOM(epochs = 20, sigma_init = 70)
som.train()
som.plot_color()
```

```
Epoch: 1
Epoch: 2
Epoch: 3
Epoch: 4
Epoch: 5
Epoch: 6
Epoch: 7
Epoch: 8
Epoch: 9
Epoch: 10
Epoch: 11
Epoch: 12
Epoch: 13
Epoch: 14
Epoch: 15
Epoch: 16
Epoch: 17
Epoch: 18
Epoch: 19
Epoch: 20
 Training Time is 133.354 seconds, with 20 iteration in 100 * 100 grid of Neuro
ns in the SOM NetworkVisualization With 20 iteration of 100*100 SOM Network
```



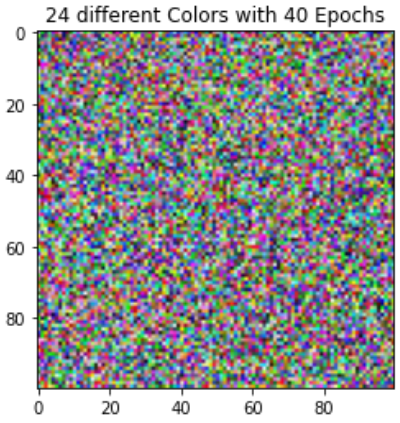
Analysis:

The plot above is generated for 20 Epochs with sigma value as 70. As we can see in the image that the colors are randomly spread over the 100*100 grid and the colors are shown in the circles. The circles for some of the colors on the grid is large enough to be out of the grid. In addition, only few colors are present on the grid when sigma = 70. The diameter of each color is larger than that of sigma = 50 as the spread for the color using the parameter sigma = 70 increases the diameter of the color circles. The overall time taken to run 20 epochs with sigma = 70 is around 133.354 seconds for the SOM Network.

Analysis for 40 Epochs, Sigma = 1

In [8]:
```
# Initialize the Network with Epoch = 40, Sigma = 1
som = SOM(epochs = 40, sigma_init = 1)
som.train()
som.plot_color()
```

```
Epoch: 1
Epoch: 2
Epoch: 3
Epoch: 4
Epoch: 5
Epoch: 6
Epoch: 7
Epoch: 8
Epoch: 9
Epoch: 10
Epoch: 11
Epoch: 12
Epoch: 13
Epoch: 14
Epoch: 15
Epoch: 16
Epoch: 17
Epoch: 18
Epoch: 19
Epoch: 20
Epoch: 21
Epoch: 22
Epoch: 23
Epoch: 24
Epoch: 25
Epoch: 26
Epoch: 27
Epoch: 28
Epoch: 29
Epoch: 30
Epoch: 31
Epoch: 32
Epoch: 33
Epoch: 34
Epoch: 35
Epoch: 36
Epoch: 37
Epoch: 38
Epoch: 39
Epoch: 40
 Training Time is 160.346 seconds, with 40 iteration in 100 * 100 grid of Neuro
ns in the SOM NetworkVisualization With 40 iteration of 100*100 SOM Network
```



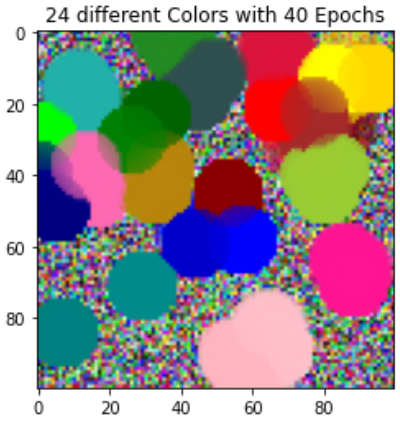
Analysis:

The plot above is generated for 40 Epochs with sigma value as 1. As we can see in the image that the colors are randomly spread over the 100*100 grid. This image is similar to the one obtained from 20 epochs with sigma = 1. The overall time taken to run 40 epochs with sigma = 1 is around 160.346 seconds for the SOM Network.

Analysis for 40 Epochs, Sigma = 10

In [9]:
```
# Initialize the Network with Epoch = 40, Sigma = 10
som = SOM(epochs = 40, sigma_init = 10)
som.train()
som.plot_color()
```

```
Epoch: 1
Epoch: 2
Epoch: 3
Epoch: 4
Epoch: 5
Epoch: 6
Epoch: 7
Epoch: 8
Epoch: 9
Epoch: 10
Epoch: 11
Epoch: 12
Epoch: 13
Epoch: 14
Epoch: 15
Epoch: 16
Epoch: 17
Epoch: 18
Epoch: 19
Epoch: 20
Epoch: 21
Epoch: 22
Epoch: 23
Epoch: 24
Epoch: 25
Epoch: 26
Epoch: 27
Epoch: 28
Epoch: 29
Epoch: 30
Epoch: 31
Epoch: 32
Epoch: 33
Epoch: 34
Epoch: 35
Epoch: 36
Epoch: 37
Epoch: 38
Epoch: 39
Epoch: 40
 Training Time is 162.699 seconds, with 40 iteration in 100 * 100 grid of Neuro
ns in the SOM NetworkVisualization With 40 iteration of 100*100 SOM Network
```



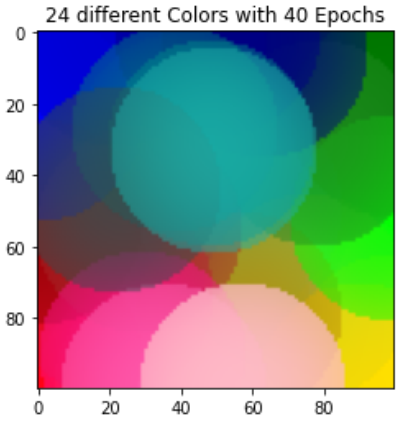
Analysis:

The plot above is generated for 40 Epochs with sigma value as 10. As we can see in the image that all the colors are randomly spread over the 100*100 grid and the colors are shown in the circles. The circles for some of the colors on the grid is small and it looks similar to the one obtained for epoch = 20, sigma = 10. The above grid has all the colors in the image. The overall time taken to run 40 epochs with sigma = 10 is around 162.699 seconds for the SOM Network.

Analysis for 40 Epochs, Sigma = 30

In [10]:
```
# Initialize the Network with Epoch = 40, Sigma = 30
som = SOM(epochs = 40, sigma_init = 30)
som.train()
som.plot_color()
```

```
Epoch: 1
Epoch: 2
Epoch: 3
Epoch: 4
Epoch: 5
Epoch: 6
Epoch: 7
Epoch: 8
Epoch: 9
Epoch: 10
Epoch: 11
Epoch: 12
Epoch: 13
Epoch: 14
Epoch: 15
Epoch: 16
Epoch: 17
Epoch: 18
Epoch: 19
Epoch: 20
Epoch: 21
Epoch: 22
Epoch: 23
Epoch: 24
Epoch: 25
Epoch: 26
Epoch: 27
Epoch: 28
Epoch: 29
Epoch: 30
Epoch: 31
Epoch: 32
Epoch: 33
Epoch: 34
Epoch: 35
Epoch: 36
Epoch: 37
Epoch: 38
Epoch: 39
Epoch: 40
 Training Time is 191.176 seconds, with 40 iteration in 100 * 100 grid of Neuro
ns in the SOM NetworkVisualization With 40 iteration of 100*100 SOM Network
```



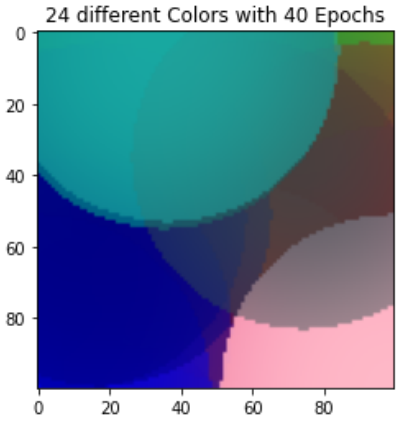
Analysis:

The plot above is generated for 40 Epochs with sigma value as 30. As we can see in the image that some of the colors are randomly spread over the 100*100 grid and the colors are shown in the circles. Some of the colors in the image is not fully visible as the diameter of the circle gets large enough to be out of the grid. The circles for the colors on the grid is larger than that of the image obtained from epoch = 40, sigma = 10 and it looks similar to the one obtained for epoch = 20, sigma = 30. The overall time taken to run 40 epochs with sigma = 30 is around 191.176 seconds for the SOM Network.

Analysis for 40 Epochs, Sigma = 50

In [11]:
```
# Initialize the Network with Epoch = 40, Sigma = 50
som = SOM(epochs = 40, sigma_init = 50)
som.train()
som.plot_color()
```

```
Epoch: 1
Epoch: 2
Epoch: 3
Epoch: 4
Epoch: 5
Epoch: 6
Epoch: 7
Epoch: 8
Epoch: 9
Epoch: 10
Epoch: 11
Epoch: 12
Epoch: 13
Epoch: 14
Epoch: 15
Epoch: 16
Epoch: 17
Epoch: 18
Epoch: 19
Epoch: 20
Epoch: 21
Epoch: 22
Epoch: 23
Epoch: 24
Epoch: 25
Epoch: 26
Epoch: 27
Epoch: 28
Epoch: 29
Epoch: 30
Epoch: 31
Epoch: 32
Epoch: 33
Epoch: 34
Epoch: 35
Epoch: 36
Epoch: 37
Epoch: 38
Epoch: 39
Epoch: 40
 Training Time is 229.593 seconds, with 40 iteration in 100 * 100 grid of Neuro
ns in the SOM NetworkVisualization With 40 iteration of 100*100 SOM Network
```



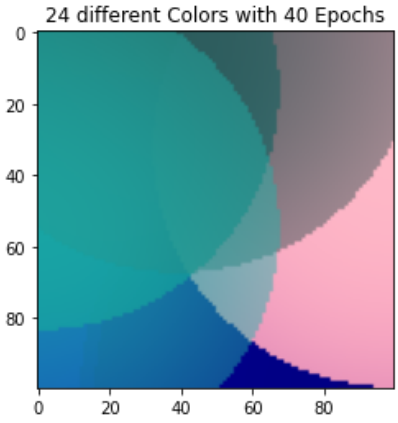
Analysis:

The plot above is generated for 40 Epochs with sigma value as 50. As we can see in the image that few of the colors are randomly spread over the 100*100 grid and the colors are shown in the circles. Some of the colors in the image is not visible as the diameter of the circle gets large enough to be out of the grid. The circles for the colors on the grid is larger than that of the image obtained from epoch = 40, sigma = 30 and it looks similar to the one obtained for epoch = 20, sigma = 50. The overall time taken to run 40 epochs with sigma = 50 is around 229.593 seconds for the SOM Network.

Analysis for 40 Epochs, Sigma = 70

In [12]:
```
# Initialize the Network with Epoch = 40, Sigma = 70
som = SOM(epochs = 40, sigma_init = 70)
som.train()
som.plot_color()
```

```
Epoch: 1
Epoch: 2
Epoch: 3
Epoch: 4
Epoch: 5
Epoch: 6
Epoch: 7
Epoch: 8
Epoch: 9
Epoch: 10
Epoch: 11
Epoch: 12
Epoch: 13
Epoch: 14
Epoch: 15
Epoch: 16
Epoch: 17
Epoch: 18
Epoch: 19
Epoch: 20
Epoch: 21
Epoch: 22
Epoch: 23
Epoch: 24
Epoch: 25
Epoch: 26
Epoch: 27
Epoch: 28
Epoch: 29
Epoch: 30
Epoch: 31
Epoch: 32
Epoch: 33
Epoch: 34
Epoch: 35
Epoch: 36
Epoch: 37
Epoch: 38
Epoch: 39
Epoch: 40
 Training Time is 260.830 seconds, with 40 iteration in 100 * 100 grid of Neuro
ns in the SOM NetworkVisualization With 40 iteration of 100*100 SOM Network
```



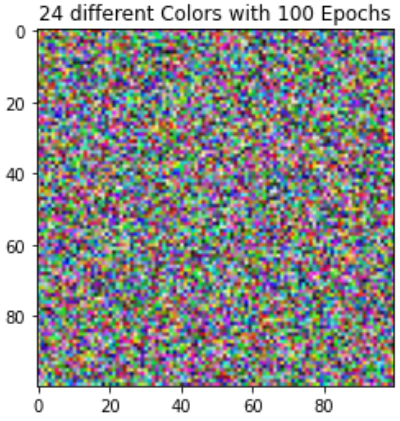
Analysis:

The plot above is generated for 40 Epochs with sigma value as 70. As we can see in the image that few of the colors are randomly spread over the 100*100 grid and the colors are shown in the semi-circles. Some of the colors in the image is not visible as the diameter of the circle gets large enough to be out of the grid. The circles for the colors on the grid is larger than that of the image obtained from epoch = 40, sigma = 50 and it looks similar to the one obtained for epoch = 20, sigma = 70. The overall time taken to run 40 epochs with sigma = 70 is around 260.830 seconds for the SOM Network.

Analysis for 100 Epochs, Sigma = 1

In [13]:
```
# Initialize the Network with Epoch = 100, Sigma = 1
som = SOM(epochs = 100, sigma_init = 1)
som.train()
som.plot_color()
```

```
Epoch: 1
Epoch: 2
Epoch: 3
Epoch: 4
Epoch: 5
Epoch: 6
Epoch: 7
Epoch: 8
Epoch: 9
Epoch: 10
Epoch: 11
Epoch: 12
Epoch: 13
Epoch: 14
Epoch: 15
Epoch: 16
Epoch: 17
Epoch: 18
Epoch: 19
Epoch: 20
Epoch: 21
Epoch: 22
Epoch: 23
Epoch: 24
Epoch: 25
Epoch: 26
Epoch: 27
Epoch: 28
Epoch: 29
Epoch: 30
Epoch: 31
Epoch: 32
Epoch: 33
Epoch: 34
Epoch: 35
Epoch: 36
Epoch: 37
Epoch: 38
Epoch: 39
Epoch: 40
Epoch: 41
Epoch: 42
Epoch: 43
Epoch: 44
Epoch: 45
Epoch: 46
Epoch: 47
Epoch: 48
Epoch: 49
Epoch: 50
Epoch: 51
Epoch: 52
Epoch: 53
Epoch: 54
Epoch: 55
Epoch: 56
Epoch: 57
Epoch: 58
Epoch: 59
Epoch: 60
Epoch: 61
Epoch: 62
Epoch: 63
```



Analysis:

The plot above is generated for 100 Epochs with sigma value as 1. As we can see in the image that the colors are randomly spread over the 100*100 grid. This image is similar to the one obtained from 40 epochs with sigma = 1. The overall time taken to run 100 epochs with sigma = 1 is around 399.324 seconds for the SOM Network.

Analysis for 100 Epochs, Sigma = 10

In [14]:
```
# Initialize the Network with Epoch = 100, Sigma = 10
som = SOM(epochs = 100, sigma_init = 10)
som.train()
som.plot_color()
```

```
Epoch: 1
Epoch: 2
Epoch: 3
Epoch: 4
Epoch: 5
Epoch: 6
Epoch: 7
Epoch: 8
Epoch: 9
Epoch: 10
Epoch: 11
Epoch: 12
Epoch: 13
Epoch: 14
Epoch: 15
Epoch: 16
Epoch: 17
Epoch: 18
Epoch: 19
Epoch: 20
Epoch: 21
Epoch: 22
Epoch: 23
Epoch: 24
Epoch: 25
Epoch: 26
Epoch: 27
Epoch: 28
Epoch: 29
Epoch: 30
Epoch: 31
Epoch: 32
Epoch: 33
Epoch: 34
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Epoch: 37
Epoch: 38
Epoch: 39
Epoch: 40
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Epoch: 51
Epoch: 52
Epoch: 53
Epoch: 54
Epoch: 55
Epoch: 56
Epoch: 57
Epoch: 58
Epoch: 59
Epoch: 60
Epoch: 61
Epoch: 62
Epoch: 63
```

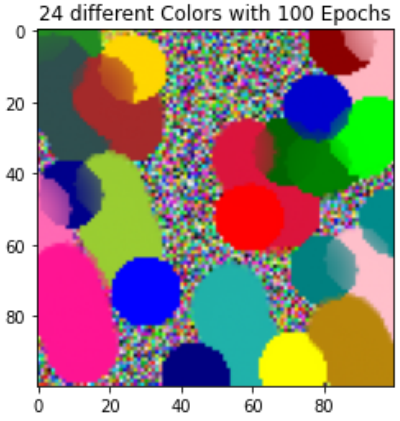

Analysis:

The plot above is generated for 100 Epochs with sigma value as 10. As we can see in the image that the colors are randomly spread over the 100*100 grid. In the grid almost all the colors are present in the form of circles and the colors overlap one another as seen in the image. The image is an improvement on sigma = 1 as in that image there were no colors with circles. The overall time taken to run 100 epochs with sigma = 10 is around 411.856 seconds for the SOM Network.

Analysis for 100 Epochs, Sigma = 30

In [15]:
```
# Initialize the Network with Epoch = 100, Sigma = 30
som = SOM(epochs = 100, sigma_init = 30)
som.train()
som.plot_color()
```

```
Epoch: 1
Epoch: 2
Epoch: 3
Epoch: 4
Epoch: 5
Epoch: 6
Epoch: 7
Epoch: 8
Epoch: 9
Epoch: 10
Epoch: 11
Epoch: 12
Epoch: 13
Epoch: 14
Epoch: 15
Epoch: 16
Epoch: 17
Epoch: 18
Epoch: 19
Epoch: 20
Epoch: 21
Epoch: 22
Epoch: 23
Epoch: 24
Epoch: 25
Epoch: 26
Epoch: 27
Epoch: 28
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Epoch: 30
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Epoch: 52
Epoch: 53
Epoch: 54
Epoch: 55
Epoch: 56
Epoch: 57
Epoch: 58
Epoch: 59
Epoch: 60
Epoch: 61
Epoch: 62
Epoch: 63
```

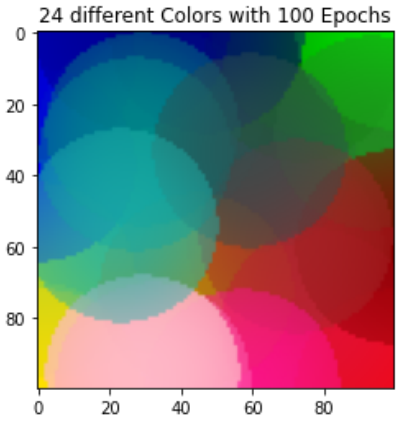

Analysis:

The plot above is generated for 100 Epochs with sigma value as 30. As we can see in the image that the colors are randomly spread over the 100*100 grid. In the grid almost all the colors are present in the form of circles and the colors overlap one another as seen in the image. The diameter of the colors are larger than that of the image shown for epoch = 100, sigma = 10. Some colors are out of the grid as the diameter of the circle is increased by the parameter sigma. The overlap is higher than that of the image obtained from sigma = 10. The overall time taken to run 100 epochs with sigma = 30 is around 477.331 seconds for the SOM Network.

Analysis for 100 Epochs, Sigma = 50

In [16]:
```
# Initialize the Network with Epoch = 100, Sigma = 50
som = SOM(epochs = 100, sigma_init = 50)
som.train()
som.plot_color()
```

```
Epoch: 1
Epoch: 2
Epoch: 3
Epoch: 4
Epoch: 5
Epoch: 6
Epoch: 7
Epoch: 8
Epoch: 9
Epoch: 10
Epoch: 11
Epoch: 12
Epoch: 13
Epoch: 14
Epoch: 15
Epoch: 16
Epoch: 17
Epoch: 18
Epoch: 19
Epoch: 20
Epoch: 21
Epoch: 22
Epoch: 23
Epoch: 24
Epoch: 25
Epoch: 26
Epoch: 27
Epoch: 28
Epoch: 29
Epoch: 30
Epoch: 31
Epoch: 32
Epoch: 33
Epoch: 34
Epoch: 35
Epoch: 36
Epoch: 37
Epoch: 38
Epoch: 39
Epoch: 40
Epoch: 41
Epoch: 42
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Epoch: 44
Epoch: 45
Epoch: 46
Epoch: 47
Epoch: 48
Epoch: 49
Epoch: 50
Epoch: 51
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Epoch: 53
Epoch: 54
Epoch: 55
Epoch: 56
Epoch: 57
Epoch: 58
Epoch: 59
Epoch: 60
Epoch: 61
Epoch: 62
Epoch: 63
```

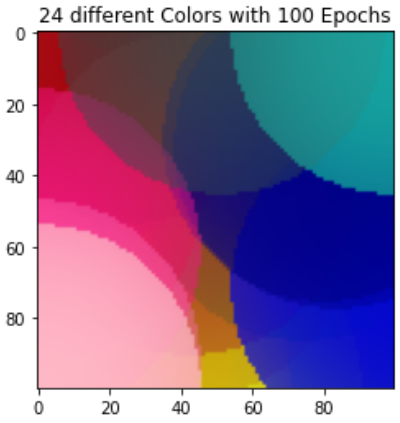

Analysis:

The plot above is generated for 100 Epochs with sigma value as 50. As we can see in the image that the colors are randomly spread over the 100*100 grid. The diameter of the colors are larger than that of the image shown for epoch = 100, sigma = 30. Some colors are out of the grid as the diameter of the circle is increased by the parameter sigma. The overlap is even higher than that of the image obtained from sigma = 30. The overall time taken to run 100 epochs with sigma = 50 is around 565.076 seconds for the SOM Network.

Analysis for 100 Epochs, Sigma = 70

In [17]:
```
# Initialize the Network with Epoch = 100, Sigma = 70
som = SOM(epochs = 100, sigma_init = 70)
som.train()
som.plot_color()
```

```
Epoch: 1
Epoch: 2
Epoch: 3
Epoch: 4
Epoch: 5
Epoch: 6
Epoch: 7
Epoch: 8
Epoch: 9
Epoch: 10
Epoch: 11
Epoch: 12
Epoch: 13
Epoch: 14
Epoch: 15
Epoch: 16
Epoch: 17
Epoch: 18
Epoch: 19
Epoch: 20
Epoch: 21
Epoch: 22
Epoch: 23
Epoch: 24
Epoch: 25
Epoch: 26
Epoch: 27
Epoch: 28
Epoch: 29
Epoch: 30
Epoch: 31
Epoch: 32
Epoch: 33
Epoch: 34
Epoch: 35
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Epoch: 52
Epoch: 53
Epoch: 54
Epoch: 55
Epoch: 56
Epoch: 57
Epoch: 58
Epoch: 59
Epoch: 60
Epoch: 61
Epoch: 62
Epoch: 63
```

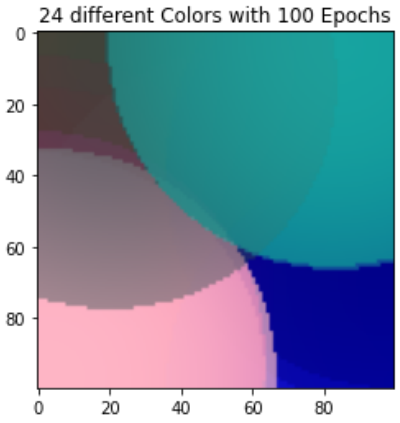

Analysis:

The plot above is generated for 100 Epochs with sigma value as 70. As we can see in the image that the colors are randomly spread over the 100*100 grid. The diameter of the colors are larger than that of the image shown for epoch = 100, sigma = 50. Only a few of the colors are present in the grid with overlaps, the diameter of the circles of the color is higher than that in the image of epoch = 100, sigma = 50. The overlap is more when compared to that of the image obtained from sigma = 50. The overall time taken to run 100 epochs with sigma = 70 is around 656.926 seconds for the SOM Network.

Analysis for 1000 Epochs, Sigma = 1

In [18]:
```
# Initialize the Network with Epoch = 1000, Sigma = 1
som = SOM(epochs = 1000, sigma_init = 1)
som.train()
som.plot_color()
```

```
Epoch: 1
Epoch: 2
Epoch: 3
Epoch: 4
Epoch: 5
Epoch: 6
Epoch: 7
Epoch: 8
Epoch: 9
Epoch: 10
Epoch: 11
Epoch: 12
Epoch: 13
Epoch: 14
Epoch: 15
Epoch: 16
Epoch: 17
Epoch: 18
Epoch: 19
Epoch: 20
Epoch: 21
Epoch: 22
Epoch: 23
Epoch: 24
Epoch: 25
Epoch: 26
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Epoch: 35
Epoch: 36
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Epoch: 52
Epoch: 53
Epoch: 54
Epoch: 55
Epoch: 56
Epoch: 57
Epoch: 58
Epoch: 59
Epoch: 60
Epoch: 61
Epoch: 62
Epoch: 63
```

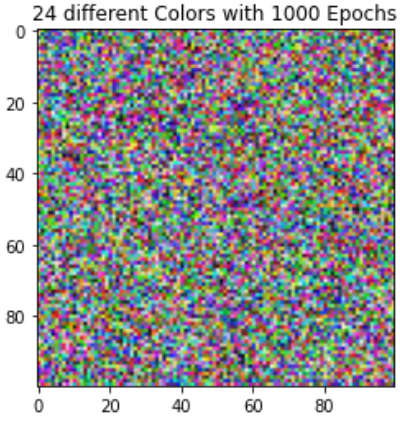

Analysis:

The plot above is generated for 1000 Epochs with sigma value as 1. As we can see in the image that the colors are randomly spread over the 100*100 grid. This image is similar to the one obtained from 100 epochs with sigma = 1. However, we can slightly observe groups of the colors in the image which is not very clear. The overall time taken to run 1000 epochs with sigma = 1 is around 4039.061 seconds for the SOM Network.

Analysis for 1000 Epochs, Sigma = 10

In [19]:
```
# Initialize the Network with Epoch = 1000, Sigma = 10
som = SOM(epochs = 1000, sigma_init = 10)
som.train()
som.plot_color()
```

```
Epoch: 1
Epoch: 2
Epoch: 3
Epoch: 4
Epoch: 5
Epoch: 6
Epoch: 7
Epoch: 8
Epoch: 9
Epoch: 10
Epoch: 11
Epoch: 12
Epoch: 13
Epoch: 14
Epoch: 15
Epoch: 16
Epoch: 17
Epoch: 18
Epoch: 19
Epoch: 20
Epoch: 21
Epoch: 22
Epoch: 23
Epoch: 24
Epoch: 25
Epoch: 26
Epoch: 27
Epoch: 28
Epoch: 29
Epoch: 30
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Epoch: 47
Epoch: 48
Epoch: 49
Epoch: 50
Epoch: 51
Epoch: 52
Epoch: 53
Epoch: 54
Epoch: 55
Epoch: 56
Epoch: 57
Epoch: 58
Epoch: 59
Epoch: 60
Epoch: 61
Epoch: 62
Epoch: 63
```

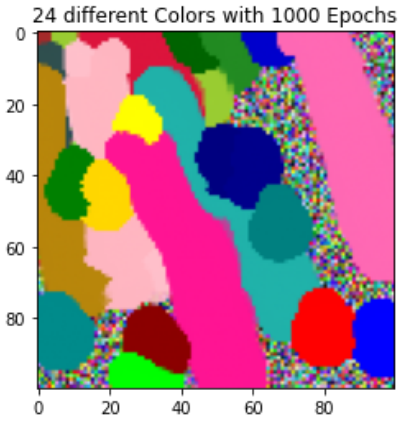

Analysis:

The plot above is generated for 1000 Epochs with sigma value as 10. As we can see in the image that the colors are randomly spread over the 100*100 grid. In the grid the shape of the color chages and there is an overlap among the colors. The image is an improvement on sigma = 1 as in that image there were no large group of colors. This image is very different from what we have obtained so far among all the Epochs with different sigma parameters. The overall time taken to run 1000 epochs with sigma = 10 is around 4018.774 seconds for the SOM Network.

Analysis for 1000 Epochs, Sigma = 30

In [20]:
```
# Initialize the Network with Epoch = 1000, Sigma = 30
som = SOM(epochs = 1000, sigma_init = 30)
som.train()
som.plot_color()
```

```
Epoch: 1
Epoch: 2
Epoch: 3
Epoch: 4
Epoch: 5
Epoch: 6
Epoch: 7
Epoch: 8
Epoch: 9
Epoch: 10
Epoch: 11
Epoch: 12
Epoch: 13
Epoch: 14
Epoch: 15
Epoch: 16
Epoch: 17
Epoch: 18
Epoch: 19
Epoch: 20
Epoch: 21
Epoch: 22
Epoch: 23
Epoch: 24
Epoch: 25
Epoch: 26
Epoch: 27
Epoch: 28
Epoch: 29
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Epoch: 54
Epoch: 55
Epoch: 56
Epoch: 57
Epoch: 58
Epoch: 59
Epoch: 60
Epoch: 61
Epoch: 62
Epoch: 63
```

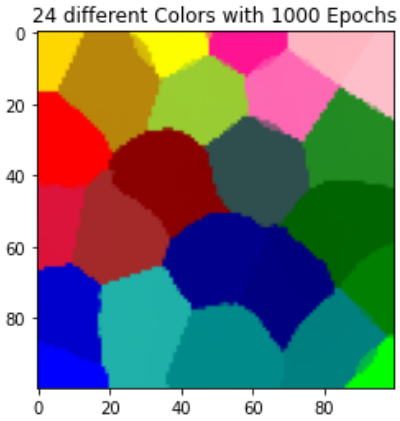

Analysis:

The plot above is generated for 1000 Epochs with sigma value as 30. The image is completely different from other Epochs with different sigma parameters. The image looks like a color map without any overlaps with clear distinct boundaries. Here all the 24 colors are present with boundaries, which has not been observed in the other epochs. From the image it is clear that in the network there are 24 winners which represent each of the color and thus the distinct boundary is observed in the image. It is also clear that the network has converged for the number of colors which it can represent effectively for all the training data. This image can be used for color coding the maps along with other applications. The overall time taken to run 1000 epochs with sigma = 30 is around 4353.286 seconds for the SOM Network.

Analysis for 1000 Epochs, Sigma = 50

In [21]:
```
# Initialize the Network with Epoch = 1000, Sigma = 50
som = SOM(epochs = 1000, sigma_init = 50)
som.train()
som.plot_color()
```

```
Epoch: 1
Epoch: 2
Epoch: 3
Epoch: 4
Epoch: 5
Epoch: 6
Epoch: 7
Epoch: 8
Epoch: 9
Epoch: 10
Epoch: 11
Epoch: 12
Epoch: 13
Epoch: 14
Epoch: 15
Epoch: 16
Epoch: 17
Epoch: 18
Epoch: 19
Epoch: 20
Epoch: 21
Epoch: 22
Epoch: 23
Epoch: 24
Epoch: 25
Epoch: 26
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Epoch: 28
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Epoch: 52
Epoch: 53
Epoch: 54
Epoch: 55
Epoch: 56
Epoch: 57
Epoch: 58
Epoch: 59
Epoch: 60
Epoch: 61
Epoch: 62
Epoch: 63
```

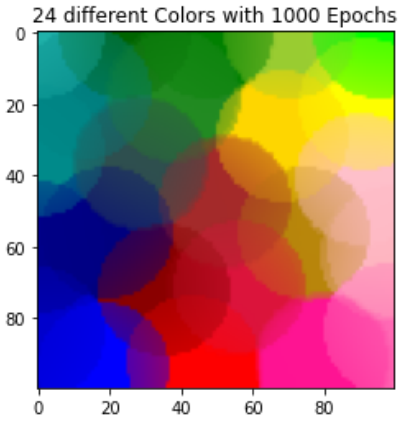

Analysis:

The plot above is generated for 1000 Epochs with sigma value as 50. As we can see in the image that the colors are randomly spread over the 100*100 grid. Some colors are out of the grid as the diameter of the circle is increased by the parameter sigma. The overlap is present in the image which was not the case in the image obtained by epoch = 1000, sigma = 30. The overall time taken to run 1000 epochs with sigma = 50 is around 4850.507 seconds for the SOM Network.

Analysis for 1000 Epochs, Sigma = 70

In [22]:
```
# Initialize the Network with Epoch = 1000, Sigma = 70
som = SOM(epochs = 1000, sigma_init = 70)
som.train()
som.plot_color()
```

```
Epoch: 1
Epoch: 2
Epoch: 3
Epoch: 4
Epoch: 5
Epoch: 6
Epoch: 7
Epoch: 8
Epoch: 9
Epoch: 10
Epoch: 11
Epoch: 12
Epoch: 13
Epoch: 14
Epoch: 15
Epoch: 16
Epoch: 17
Epoch: 18
Epoch: 19
Epoch: 20
Epoch: 21
Epoch: 22
Epoch: 23
Epoch: 24
Epoch: 25
Epoch: 26
Epoch: 27
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Epoch: 31
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Epoch: 40
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Epoch: 54
Epoch: 55
Epoch: 56
Epoch: 57
Epoch: 58
Epoch: 59
Epoch: 60
Epoch: 61
Epoch: 62
Epoch: 63
```

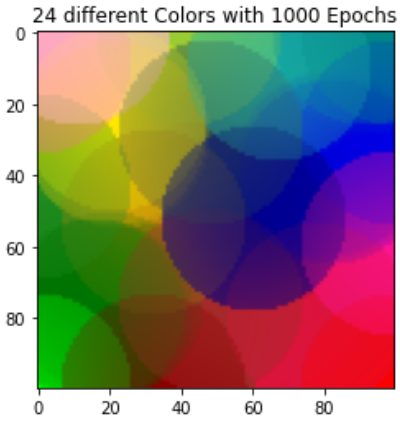

Analysis:

The plot above is generated for 1000 Epochs with sigma value as 70. As we can see in the image that the colors are randomly spread over the 100*100 grid. Some colors are even out of the grid as the diameter of the circle is increased by the parameter sigma. The overlap is present in the image which was not the case in the image obtained by epoch = 1000, sigma = 30. The diameter of each color is larger than that of the image obtained from epoch = 1000, sigma = 50. The overall time taken to run 1000 epochs with sigma = 70 is around 5382.946 seconds for the SOM Network.