Import Libraries

In [1]:
```
import numpy as np
import sklearn
from sklearn import svm
from sklearn.neighbors import KNeighborsClassifier
from sklearn import tree
import pandas as pd
import matplotlib.pyplot as plt
from pandas.plotting import scatter_matrix
from sklearn.decomposition import PCA as sklearnPCA
from sklearn.decomposition import FastICA
from sklearn.externals.six import StringIO
from sklearn.svm import SVC
from IPython.display import Image
from sklearn.model_selection import train_test_split
from sklearn import svm
from sklearn.tree import export_graphviz
import graphviz
import pydotplus
from pydotplus import graphviz
from sklearn.preprocessing import MinMaxScaler
from sklearn.tree import export_graphviz
import warnings
warnings.filterwarnings('ignore')
```

Data Reading and Cleaning

In [2]:
```
df=pd.read_csv("phl_hec_all_confirmed.csv", error_bad_lines=False)
df=df[["P. Name","P. Mass (EU)","P. Radius (EU)","P. Density (EU)","P. Gravity (EU)","P. Esc Vel (EU)","P. SFlux Mean
 (EU)","P. Teq Mean (K)","P. Surf Press (EU)","P. Period (days)","P. Sem Major Axis (AU)","P. Mean Distance (AU)","P. E
ccentricity","S. Mass (SU)","S. Radius (SU)","S. Teff (K)","S. Luminosity (SU)","S. [Fe/H]","S. Hab Zone Min (AU)","S.
 Hab Zone Max (AU)","P. Habitable Class"]]
df=df.dropna()
df.head()
```

```
b'Skipping line 3742: expected 68 fields, saw 69\nSkipping line 3743: expected 68 fields, saw 69\n'
```

Out[2]:

	P. Name	P. Mass (EU)	P. Radius (EU)	P. Density (EU)	P. Gravity (EU)	P. Esc Vel (EU)	P. SFlux Mean (EU)	P. Teq Mean (K)	P. Surf Press (EU)	P. Period (days)	...	P. Mean Distance (AU)	P. Eccentricity	S. Mass (SU)	S. Radius (SU)	S. Teff (K)
17	4 Uma b	2257.37	11.67	1.42	16.57	13.91	163.7823	877.3	3205.8	269.30	...	0.78	0.43	1.23	18.11	4415.0
19	7 CMa b	782.13	11.44	0.52	5.98	8.27	0.6887656	230.0	408.7	796.00	...	1.88	0.22	1.52	2.30	4792.0
20	8 Umi b	476.91	10.92	0.37	4.00	6.61	202.5754	960.5	174.8	93.40	...	0.49	0.06	1.80	9.90	4847.4
21	11 Com b	6168.04	10.98	4.66	51.15	23.70	101.1515	799.7	28729.5	326.03	...	1.26	0.23	2.70	19.00	4742.0
23	11 UMi b	3338.37	11.54	2.17	25.05	17.00	78.07546	756.4	7242.6	516.22	...	1.54	0.08	1.80	24.08	4340.0

5 rows × 21 columns

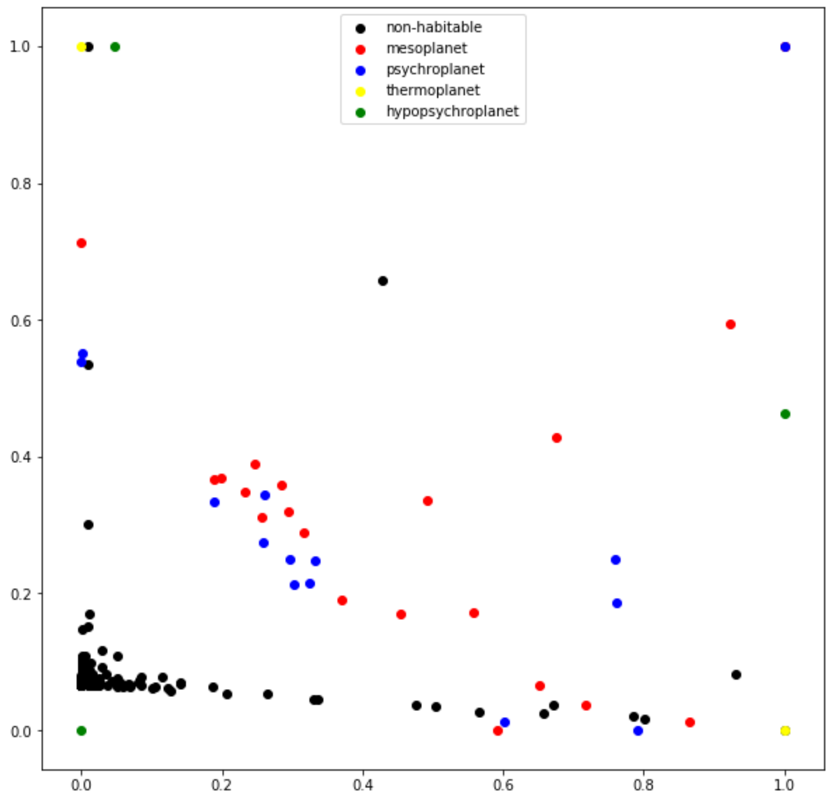
In [3]:
```
df.columns
```

Out[3]:
```
Index(['P. Name', 'P. Mass (EU)', 'P. Radius (EU)', 'P. Density (EU)',
       'P. Gravity (EU)', 'P. Esc Vel (EU)', 'P. SFlux Mean (EU)',
       'P. Teq Mean (K)', 'P. Surf Press (EU)', 'P. Period (days)',
       'P. Sem Major Axis (AU)', 'P. Mean Distance (AU)', 'P. Eccentricity',
       'S. Mass (SU)', 'S. Radius (SU)', 'S. Teff (K)', 'S. Luminosity (SU)',
       'S. [Fe/H]', 'S. Hab Zone Min (AU)', 'S. Hab Zone Max (AU)',
       'P. Habitable Class'],
      dtype='object')
```

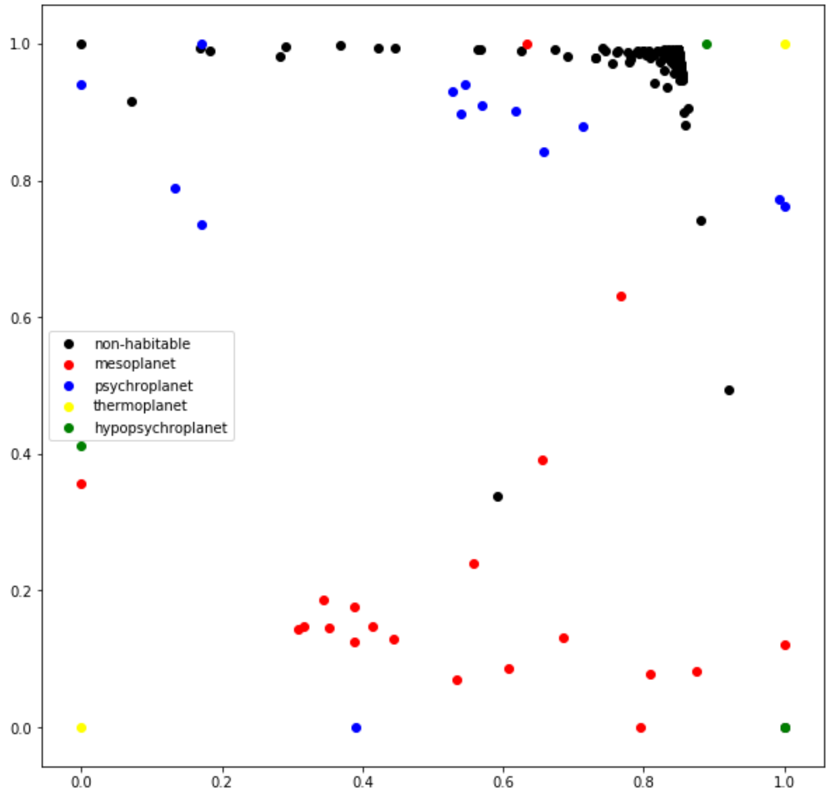
Visualize Data by Reducing Dimensionality

In [4]:
```
labels=df["P. Habitable Class"].unique().tolist()
colors=["black","red","blue","yellow","green"]
plt.figure(figsize=(10,10))
for x in range(len(labels)):
    data=df[df["P. Habitable Class"]==labels[x]]
    print(labels[x]+":"+str(len(data)))
    data=data[["P. Mass (EU)","P. Radius (EU)","P. Density (EU)","P. Gravity (EU)","P. Esc Vel (EU)","P. SFlux Mean (E
U)","P. Teq Mean (K)","P. Surf Press (EU)","P. Period (days)","P. Sem Major Axis (AU)","P. Mean Distance (AU)","P. Ecce
ntricity","S. Mass (SU)","S. Radius (SU)","S. Teff (K)","S. Luminosity (SU)","S. [Fe/H]","S. Hab Zone Min (AU)","S. Hab
 Zone Max (AU)"]]
    pca = sklearnPCA(n_components=2,random_state=0)
    reduced = pd.DataFrame(pca.fit_transform(data))
    reduced= (reduced - reduced.min())/(reduced.max() - reduced.min())
    plt.scatter(reduced[0], reduced[1], label=labels[x], c=colors[x])

plt.legend()
plt.show()
```

```
non-habitable:2065
mesoplanet:20
psychroplanet:14
thermoplanet:2
hypopsychroplanet:3
```



In [5]:
```
labels=df["P. Habitable Class"].unique().tolist()
colors=["black","red","blue","yellow","green"]
plt.figure(figsize=(10,10))
for x in range(len(labels)):
    data=df[df["P. Habitable Class"]==labels[x]]
    data=data[["P. Mass (EU)","P. Radius (EU)","P. Density (EU)","P. Gravity (EU)","P. Esc Vel (EU)","P. SFlux Mean (EU)","P. Teq Mean (K)","P. Surf Press (EU)","P. Period (days)","P. Sem Major Axis (AU)","P. Mean Distance (AU)","P. Eccentricity","S. Mass (SU)","S. Radius (SU)","S. Teff (K)","S. Luminosity (SU)","S. [Fe/H]","S. Hab Zone Min (AU)","S. Hab Zone Max (AU)"]]
    ica = FastICA(n_components=2,max_iter=1000,random_state=0)
    reduced = pd.DataFrame(ica.fit_transform(data))
    reduced= (reduced - reduced.min())/(reduced.max() - reduced.min())
    plt.scatter(reduced[0], reduced[1], label=labels[x], c=colors[x])

plt.legend()
plt.show()
```



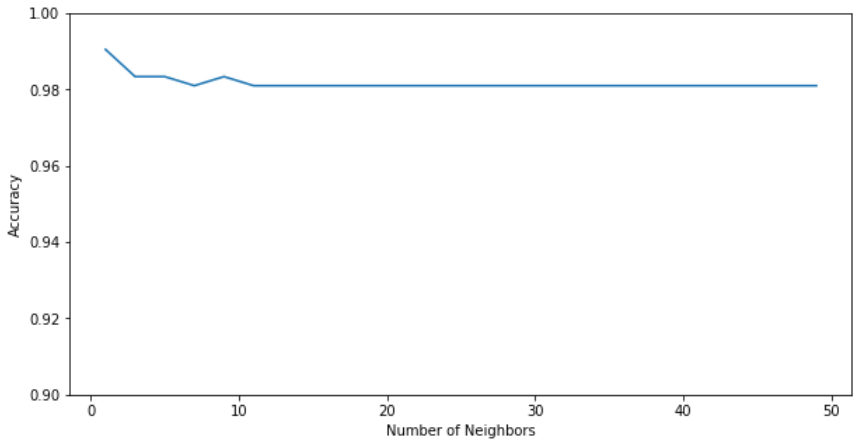
K-Nearest Neighbor

Find Optimal Number of Neighbors

With Normalization

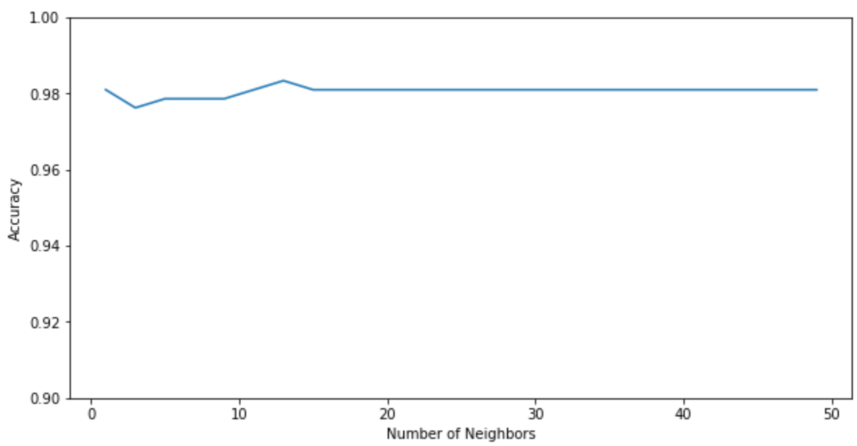
In [6]:

```
features=["P. Mass (EU)","P. Radius (EU)","P. Density (EU)","P. Gravity (EU)","P. Esc Vel (EU)","P. SFlux Mean (EU)",
"P. Teq Mean (K)","P. Surf Press (EU)","P. Period (days)","P. Sem Major Axis (AU)","P. Mean Distance (AU)","P. Eccentri
city","S. Mass (SU)","S. Radius (SU)","S. Teff (K)","S. Luminosity (SU)","S. [Fe/H]","S. Hab Zone Min (AU)","S. Hab Zon
e Max (AU)"]
label=["P. Habitable Class"]
x=df[features]
y=df[label]
train_data, test_data, train_lbl, test_lbl = train_test_split(x,y, test_size=.20, random_state=0,stratify=y)
plotx=[]
ploty=[]
for x in range(1,51,2):
    neigh = KNeighborsClassifier(n_neighbors=x)
    neigh.fit(train_data, train_lbl)
    acc=neigh.score(test_data,test_lbl)
    plotx.append(x)
    ploty.append(acc)
    #print("Accuracy at "+str(x)+" neighbors:"+str(acc))
plt.figure(figsize=(10,5))
plt.ylim(0.9,1)
plt.plot(plotx,ploty)
plt.ylabel('Accuracy');
plt.xlabel('Number of Neighbors');
plt.show()
```



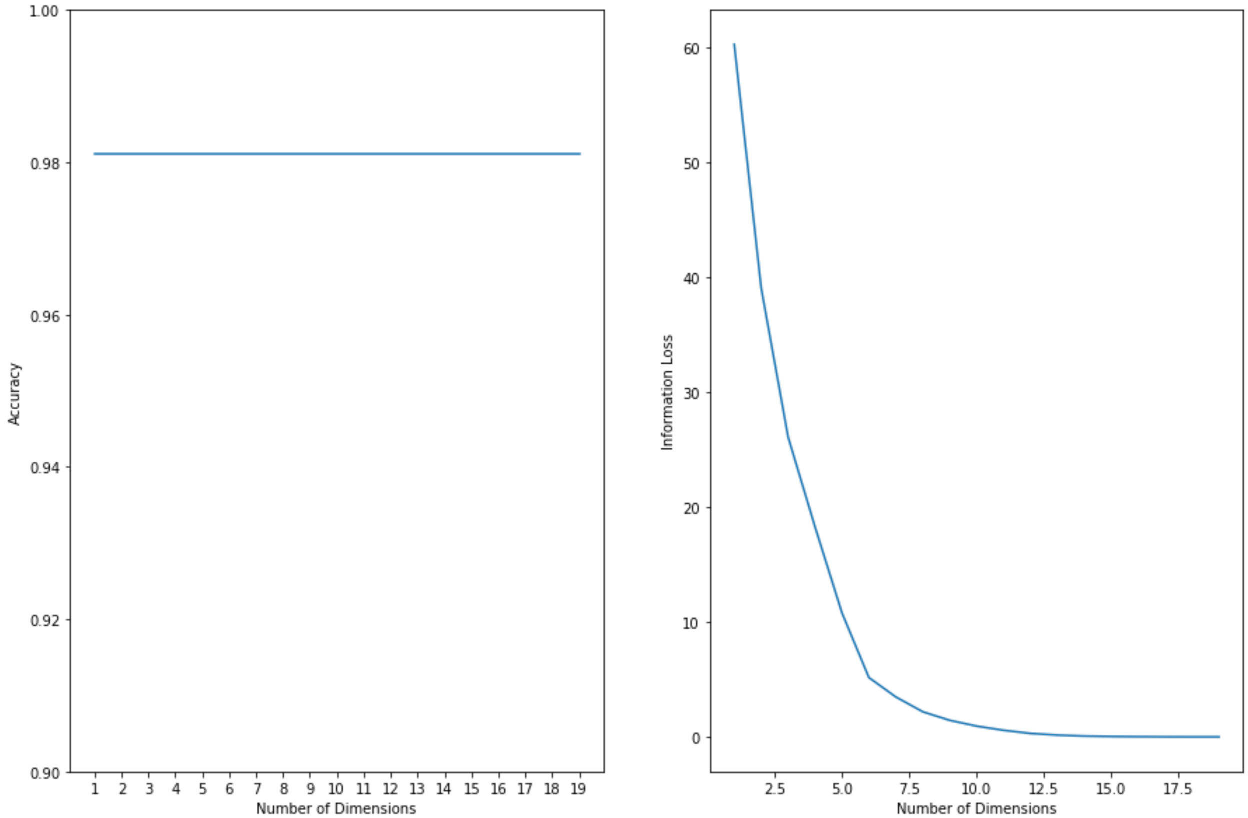
Without Normalization

In [7]:
```
features=["P. Mass (EU)","P. Radius (EU)","P. Density (EU)","P. Gravity (EU)","P. Esc Vel (EU)","P. SFlux Mean (EU)",
"P. Teq Mean (K)","P. Surf Press (EU)","P. Period (days)","P. Sem Major Axis (AU)","P. Mean Distance (AU)","P. Eccentri
city","S. Mass (SU)","S. Radius (SU)","S. Teff (K)","S. Luminosity (SU)","S. [Fe/H]","S. Hab Zone Min (AU)","S. Hab Zon
e Max (AU)"]
label=["P. Habitable Class"]
x=df[features]
y=df[label]
scaler = MinMaxScaler()
x=scaler.fit_transform(x)
train_data, test_data, train_lbl, test_lbl = train_test_split(x,y, test_size=.20, random_state=0,stratify=y)
plotx=[]
ploty=[]
for x in range(1,51,2):
    neigh = KNeighborsClassifier(n_neighbors=x)
    neigh.fit(train_data, train_lbl)
    acc=neigh.score(test_data,test_lbl)
    plotx.append(x)
    ploty.append(acc)
    #print("Accuracy at "+str(x)+" neighbors:"+str(acc))
plt.figure(figsize=(10,5))
plt.ylim(0.9,1)
plt.plot(plotx,ploty)
plt.ylabel('Accuracy');
plt.xlabel('Number of Neighbors');
plt.show()
```



Preventing Curse of Dimensionality

In [8]:
```
plotx=[]
ploty=[]
dimensionx=[]
dimensiony=[]
for x in range(1,len(features)+1):
    neigh = KNeighborsClassifier(n_neighbors=20)
    data = df[features]
    scaler = MinMaxScaler()
    data=scaler.fit_transform(data)
    pca = sklearnPCA(n_components=x,random_state=0)
    data = pd.DataFrame(pca.fit_transform(data))
    loss=(1-sum(pca.explained_variance_ratio_))*100
    #print("Information Loss at "+str(x)+" dimensions:"+str(loss))
    y=df[label]
    train_data, test_data, train_lbl, test_lbl = train_test_split(data,y, test_size=.20, random_state=0,stratify=y)
    neigh.fit(train_data, train_lbl)
    acc=neigh.score(test_data,test_lbl)
    plotx.append(x)
    ploty.append(acc)
    dimensionx.append(x)
    dimensiony.append(loss)
    #print("Accuracy at "+str(x)+" neighbors:"+str(acc))
plt.figure(figsize=(15,10))
plt.subplot(1,2,1)
plt.xticks(range(0,20))
plt.ylim(.9,1)
plt.plot(plotx,ploty)
plt.ylabel('Accuracy');
plt.xlabel('Number of Dimensions');
plt.subplot(1,2,2)
plt.plot(dimensionx,dimensiony)
plt.ylabel('Information Loss');
plt.xlabel('Number of Dimensions');
plt.show()
print(ploty[15])
```




```
0.9809976247030879
```

Support Vector Machines

In [9]:
```
kernels=[]
accuracy=[]
```

In [10]:
```
x=df[features]
y=df[label]
scaler = MinMaxScaler()
x=scaler.fit_transform(x)
train_data, test_data, train_lbl, test_lbl = train_test_split(x,y, test_size=.20, random_state=0,stratify=y)
clf = SVC(random_state=0,kernel="rbf",gamma=.7)
clf.fit(train_data, train_lbl)
acc=clf.score(test_data,test_lbl)
accuracy.append(acc)
kernels.append("RBF Kernel")
print(acc)
```

```
0.9809976247030879
```

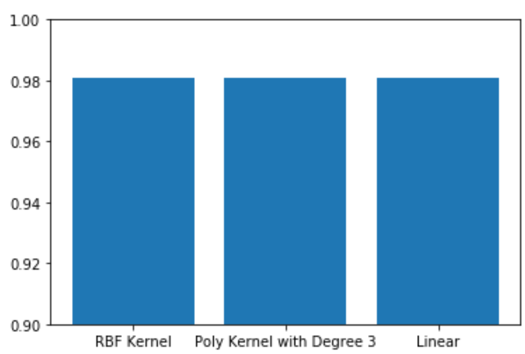
In [11]:
```
x=df[features]
y=df[label]
scaler = MinMaxScaler()
x=scaler.fit_transform(x)
train_data, test_data, train_lbl, test_lbl = train_test_split(x,y, test_size=.20, random_state=0,stratify=y)
clf = SVC(random_state=0,kernel="poly")
clf.fit(train_data, train_lbl)
acc=clf.score(test_data,test_lbl)
kernels.append("Poly Kernel with Degree 3")
accuracy.append(acc)
print(acc)
```

```
0.9809976247030879
```

In [12]:
```
x=df[features]
y=df[label]
scaler = MinMaxScaler()
x=scaler.fit_transform(x)
train_data, test_data, train_lbl, test_lbl = train_test_split(x,y, test_size=.20, random_state=0,stratify=y)
clf = SVC(random_state=0,kernel="linear")
clf.fit(train_data, train_lbl)
acc=clf.score(test_data,test_lbl)
kernels.append("Linear")
accuracy.append(acc)
print(acc)
```

```
0.9809976247030879
```

In [13]:
```
plt.figure()
plt.bar(kernels,accuracy)
plt.ylim(.9,1)
plt.show()
print(accuracy)
```




```
[0.9809976247030879, 0.9809976247030879, 0.9809976247030879]
```

Decision Trees

In [14]:
```
x=df[features]
y=df[label]
train_data, test_data, train_lbl, test_lbl = train_test_split(x,y, test_size=.20, random_state=0,stratify=y)
clf = tree.DecisionTreeClassifier(random_state=0)
clf = clf.fit(train_data, train_lbl)
clf.score(test_data,test_lbl)
```

Out[14]:
```
0.995249406175772
```

In [15]:
```
graph = pydotplus.graph_from_dot_data(tree.export_graphviz(clf,feature_names = features,class_names = labels))
Image(graph.create_png())
```

Out[15]: