Import packages

In [92]:
```
%matplotlib inline
import pandas as pd
from pandas.api.types import is_numeric_dtype
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns

from sklearn.metrics import roc_curve, roc_auc_score, accuracy_score, precision_score, r
ecall_score, classification_report
from sklearn.decomposition import PCA
from sklearn.preprocessing import StandardScaler, LabelEncoder

# Metrics
from sklearn.metrics import precision_score, recall_score, log_loss, accuracy_score, f1_
score, confusion_matrix
```

Load the dataset

In [93]:
```
path='https://raw.githubusercontent.com/charlenelau-github/Mushroom-Classification/maste
r/agaricus-lepiota.data'
missing_values = ["n/a", "na", "-", ""]
df = pd.read_csv(path, na_values = missing_values, header=None)
df.head(n=10)
```

Out[93]:

	0	1	2	3	4	5	6	7	8	9	...	13	14	15	16	17	18	19	20	21	22
0	p	x	s	n	t	p	f	c	n	k	...	s	w	w	p	w	o	p	k	s	u
1	e	x	s	y	t	a	f	c	b	k	...	s	w	w	p	w	o	p	n	n	g
2	e	b	s	w	t	l	f	c	b	n	...	s	w	w	p	w	o	p	n	n	m
3	p	x	y	w	t	p	f	c	n	n	...	s	w	w	p	w	o	p	k	s	u
4	e	x	s	g	f	n	f	w	b	k	...	s	w	w	p	w	o	e	n	a	g
5	e	x	y	y	t	a	f	c	b	n	...	s	w	w	p	w	o	p	k	n	g
6	e	b	s	w	t	a	f	c	b	g	...	s	w	w	p	w	o	p	k	n	m
7	e	b	y	w	t	l	f	c	b	n	...	s	w	w	p	w	o	p	n	s	m
8	p	x	y	w	t	p	f	c	n	p	...	s	w	w	p	w	o	p	k	v	g
9	e	b	s	y	t	a	f	c	b	g	...	s	w	w	p	w	o	p	k	s	m

10 rows × 23 columns

Data Preprocessing

Dealing with missing values

In [94]:
```
# Check for missing values
df.isnull().sum()
```

Out[94]:
```
0     0
1     0
2     0
3     0
4     0
5     0
6     0
7     0
8     0
9     0
10    0
11    0
12    0
13    0
14    0
15    0
16    0
17    0
18    0
19    0
20    0
21    0
22    0
dtype: int64
```

No missing values.

Data Visualization

In [96]:
```
df.describe()
```

Out[96]:

	0	1	2	3	4	5	6	7	8	9	...	13	14	15	16	17
count	8124	8124	8124	8124	8124	8124	8124	8124	8124	8124	...	8124	8124	8124	8124	8124
unique	2	6	4	10	2	9	2	2	2	12	...	4	9	9	1	4
top	e	x	y	n	f	n	f	c	b	b	...	s	w	w	p	w
freq	4208	3656	3244	2284	4748	3528	7914	6812	5612	1728	...	4936	4464	4384	8124	7924

4 rows × 23 columns

In [97]:
```
df.groupby(df[0]).size()
```

Out[97]:
```
0
e    4208
p    3916
dtype: int64
```

In [98]:
```
# 4208 edible cases vs 3925 poisonous cases. More or less balanced. Class imbalance will
not become an issue.
```

In [99]:
```
df=df.apply(LabelEncoder().fit_transform)
df.info()
```

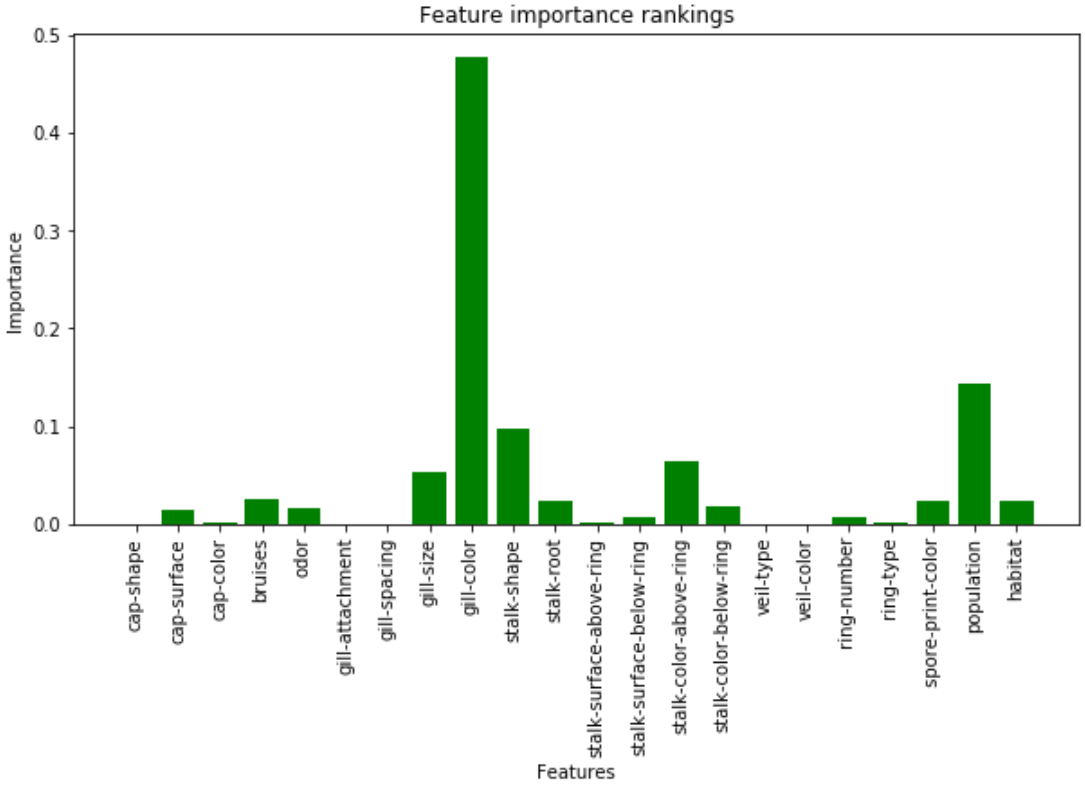
```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 8124 entries, 0 to 8123
Data columns (total 23 columns):
0     8124 non-null int64
1     8124 non-null int64
2     8124 non-null int64
3     8124 non-null int64
4     8124 non-null int64
5     8124 non-null int64
6     8124 non-null int64
7     8124 non-null int64
8     8124 non-null int64
9     8124 non-null int64
10    8124 non-null int64
11    8124 non-null int64
12    8124 non-null int64
13    8124 non-null int64
14    8124 non-null int64
15    8124 non-null int64
16    8124 non-null int64
17    8124 non-null int64
18    8124 non-null int64
19    8124 non-null int64
20    8124 non-null int64
21    8124 non-null int64
22    8124 non-null int64
dtypes: int64(23)
memory usage: 1.4 MB
```

In [100]:
```
#Choose 22 predictor variables
X = df.iloc[:,1:23]
#Set column one as target variable
Y = df.iloc[:,0]
```

Feature Importance

In [101]:
```
features = ['cap-shape', 'cap-surface', 'cap-color', 'bruises', 'odor',
            'gill-attachment', 'gill-spacing','gill-size', 'gill-color', 'stalk-shape',
            'stalk-root', 'stalk-surface-above-ring', 'stalk-surface-below-ring',  'stal
k-color-above-ring', 'stalk-color-below-ring',
            'veil-type', 'veil-color', ' ring-number',' ring-type', ' spore-print-color'
,
            'population','habitat']
```

In [106]:
```
# Feature importance using XGBoost feature selection
from xgboost import XGBClassifier
model = XGBClassifier(n_estimators=500)
model.fit(X, Y)
feature_importance = model.feature_importances_
indices= np.argsort(feature_importance)
plt.figure(figsize=(10, 5))
plt.bar(range(len(feature_importance)), feature_importance, align='center', color ="G")
plt.xticks(range(len(feature_importance)), features, rotation='vertical')
plt.title('Feature importance rankings')
plt.ylabel('Importance')
plt.xlabel('Features')
plt.show()
```



In [105]:
```
table = pd.DataFrame(model.feature_importances_, columns=['weights'], index=features)
table = table.sort_values(by ='weights', ascending=False)
table
```

Out[105]:

	weights
gill-color	0.478012
population	0.143534
stalk-shape	0.097710
stalk-color-above-ring	0.063925
gill-size	0.053242
bruises	0.026120
habitat	0.023842
stalk-root	0.023567
spore-print-color	0.022758
stalk-color-below-ring	0.017927
odor	0.015328
cap-surface	0.014461
ring-number	0.007542
stalk-surface-below-ring	0.007219
cap-color	0.001744
ring-type	0.001670
stalk-surface-above-ring	0.001126
gill-spacing	0.000201
cap-shape	0.000074
veil-color	0.000000
veil-type	0.000000
gill-attachment	0.000000

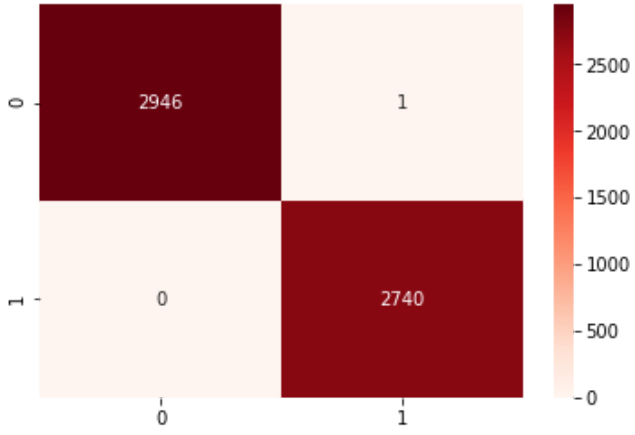
In [108]:
```
#Order of importances : 9, 21, 10, 14, 8, 4, 22, 11, 20, 15, 5, 2, 18, 12, 7, 1, 17, 16,
6
```

Modeling

In [68]:
```
def evaluate_metrics(X_train, Y_train, X_test, Y_test, model):

    model.fit(X_train, Y_train)

    predictions_proba = model.predict_proba(X_test)
    predictions = model.predict(X_test)

    log_loss_score = log_loss(Y_test, predictions_proba)
    training = model.score(X_train, Y_train)
    accuracy = accuracy_score(Y_test, predictions)

    print('Log loss: %.4f' % log_loss_score)
    print ('Training accuracy: %.4f' % training)
    print('Model accuracy: %.4f' % accuracy)
    print(classification_report(Y_test, predictions))
    sns.heatmap(data=confusion_matrix(Y_test, predictions), xticklabels=np.unique(Y_test
), yticklabels=np.unique(Y_test),
            annot=True, fmt='d', cmap="Reds")
```

In [111]:
```
from sklearn.ensemble import RandomForestClassifier
from sklearn.cross_validation import train_test_split
X_train, X_test, Y_train, Y_test = train_test_split(X, Y, test_size=0.7)
model = RandomForestClassifier()
evaluate_metrics(X_train, Y_train, X_test, Y_test, model)
```

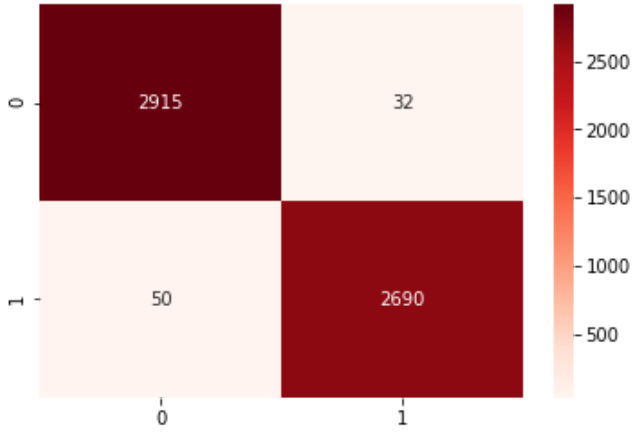
```
Log loss: 0.0022
Training accuracy: 1.0000
Model accuracy: 0.9998
             precision    recall  f1-score   support

          0       1.00      1.00      1.00      2947
          1       1.00      1.00      1.00      2740

avg / total       1.00      1.00      1.00      5687
```



In [112]:
```
xgb_params = {'learning_rate': 0.003,
              'max_depth': 5,
              'subsample': 0.9,
              'colsample_bytree': 0.9,
              'objective': 'binary:logistic',
              'silent': 1,
              'n_estimators':100,
              'gamma':1,
              'min_child_weight':4}
model = XGBClassifier(**xgb_params, seed = 10)
evaluate_metrics(X_train, Y_train, X_test, Y_test, model)
```

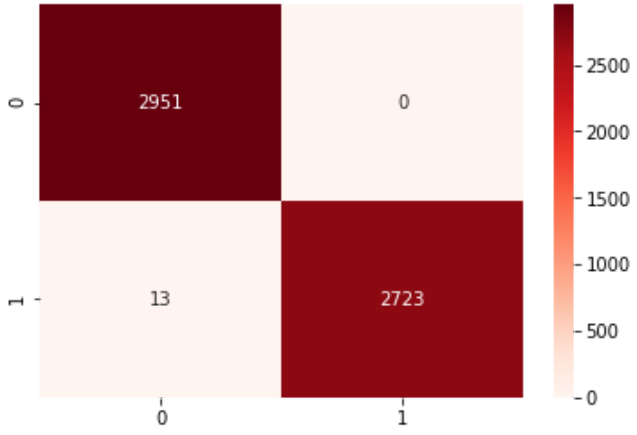
```
C:\Users\cyine\Anaconda3\lib\site-packages\sklearn\preprocessing\label.py:151: DeprecationWarning: The truth value of an empty array is ambiguous. Returning False, but in future this will result in an error. Use `array.size > 0` to check that an array is not empty.
  if diff:
C:\Users\cyine\Anaconda3\lib\site-packages\sklearn\preprocessing\label.py:151: DeprecationWarning: The truth value of an empty array is ambiguous. Returning False, but in future this will result in an error. Use `array.size > 0` to check that an array is not empty.
  if diff:
```

```
Log loss: 0.4818
Training accuracy: 0.9860
Model accuracy: 0.9856
             precision    recall  f1-score   support

          0       0.98      0.99      0.99      2947
          1       0.99      0.98      0.98      2740

avg / total       0.99      0.99      0.99      5687
```



In [128]:
```
X2=df[[9, 21, 10, 14, 8, 4, 22, 11, 20, 15, 5, 2, 18, 12, 7, 1, 17, 16, 6]]
X_train, X_test, Y_train, Y_test = train_test_split(X2, Y, test_size=0.7)
xgb_params = {'learning_rate': 0.1,
              'max_depth': 5,
              'subsample': 0.9,
              'colsample_bytree': 0.9,
              'objective': 'binary:logistic',
              'silent': 1,
              'n_estimators':100,
              'gamma':1,
              'min_child_weight':4}
model = XGBClassifier(**xgb_params, seed = 10)
evaluate_metrics(X_train, Y_train, X_test, Y_test, model)
```

```
C:\Users\cyine\Anaconda3\lib\site-packages\sklearn\preprocessing\label.py:151: DeprecationWarning: The truth value of an empty array is ambiguous. Returning False, but in future this will result in an error. Use `array.size > 0` to check that an array is not empty.
  if diff:
C:\Users\cyine\Anaconda3\lib\site-packages\sklearn\preprocessing\label.py:151: DeprecationWarning: The truth value of an empty array is ambiguous. Returning False, but in future this will result in an error. Use `array.size > 0` to check that an array is not empty.
  if diff:

Log loss: 0.0129
Training accuracy: 0.9988
Model accuracy: 0.9977
             precision    recall  f1-score   support

          0       1.00      1.00      1.00      2951
          1       1.00      1.00      1.00      2736

avg / total       1.00      1.00      1.00      5687
```



In [127]:
```
from sklearn.ensemble import RandomForestClassifier
from sklearn.cross_validation import train_test_split
X3=df[[9, 21, 10, 14, 8, 4, 22, 11, 20, 15, 5, 2, 18, 12, 7, 1, 17]]
X_train, X_test, Y_train, Y_test = train_test_split(X3, Y, test_size=0.7)
model = RandomForestClassifier()
evaluate_metrics(X_train, Y_train, X_test, Y_test, model)
```

```
Log loss: 0.0039
Training accuracy: 1.0000
Model accuracy: 0.9986
             precision    recall  f1-score   support

          0       1.00      1.00      1.00      2976
          1       1.00      1.00      1.00      2711

avg / total       1.00      1.00      1.00      5687
```