

## Hands-on Assignment

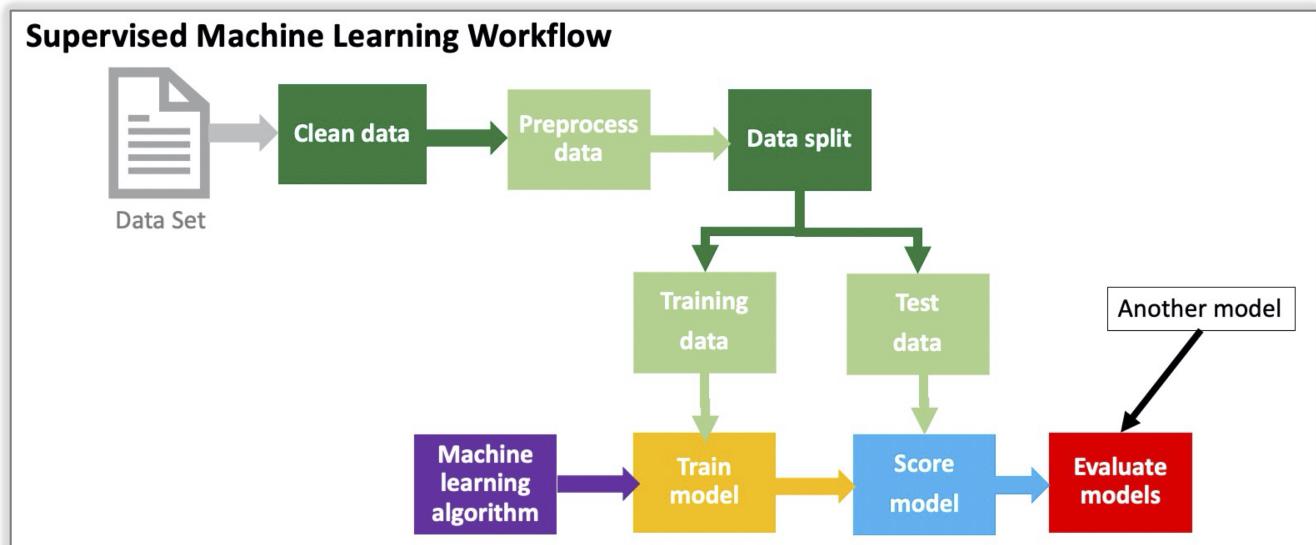
Complete the following two sections on Supervised Machine Learning:

- Linear Regression
- Logistic Regression

### Linear and Logistic Regression

#### Part 1: Linear Regression

#### Machine Learning Supervised Linear Regression



- You can see in the workflow; supervised learning starts with the data set. Remember, since it is supervised, the data is labeled. Then there is some data preprocessing (cleaning) to be done. Next, you will declare your input (X/Independent variables) and output (Target Variable/Dependent or Y) NumPy Arrays. Then the data is split into a testing and training set. Then you will build and train the model, use the model for predictions, and evaluate/validate the model. So let's begin!.

#### STEP 1: Import Libraries

- import pandas and numpy libraries

- import scatter\_matrix from pandas.plotting
- import LinearRegression from sklearn.linear\_model
- import train\_test\_split, KFold, and cross\_val\_score from sklearn.model\_selection
- import matplotlib
- import seaborn

```
In [1]: import pandas as pd
import numpy as np
from pandas.plotting import scatter_matrix
from sklearn.linear_model import LinearRegression
from sklearn.model_selection import train_test_split
from sklearn.model_selection import KFold
from sklearn.model_selection import cross_val_score
import seaborn as sns
sns.set(color_codes=True)
import matplotlib.pyplot as plt
```

## WORKFLOW: DATA SET

### STEP 2: Read data description and Load the Data

- Read the description of the dataset listed below
- Dataset is provided in the module and assignment. It is called housing\_boston.csv.
- Load the data into Pandas dataframe called df
- View the first five rows of the dataframe

### Description of Boston Housing Dataset

- CRIM: This is the per capita crime rate by town
- ZN: This is the proportion of residential land zoned for lots larger than 25,000 sq. ft.
- INDUS: This is the proportion of non-retail business acres per town.
- CHAS: This is the Charles River dummy variable (this is equal to 1 if tract bounds river; 0 otherwise)
- NOX: This is the concentration of the nitric oxide (parts per 10 million)
- RM: This is the average number of rooms per dwelling
- AGE: This is the proportion of owner-occupied units built prior to 1940
- DIS: This is the weighted distances to five Boston employment centers
- RAD: This is the index of accessibility to radial highways
- TAX: This is the full-value property-tax rate per 10,000 dollars
- PTRATIO: This is the pupil-teacher ratio by town
- AA: This is calculated as  $1000(AA - 0.63)^2$ , where AA is the proportion of people of African American descent by town
- LSTAT: This is the percentage lower status of the population
- MEDV: This is the median value of owner-occupied homes in \$1000s

```
In [2]: # Specify the location of the dataset.
housingfile = 'housing_boston.csv'
```

```
In [3]: # Load the data into a Pandas DataFrame
df = pd.read_csv(housingfile, header=None)
```

```
In [4]: df.head()
```

Out[4]:

	0	1	2	3	4	5	6	7	8	9	10	11	12	13
0	0.00632	18.0	2.31	0	0.538	6.575	65.2	4.0900	1	296	15.3	396.90	4.98	24.0
1	0.02731	0.0	7.07	0	0.469	6.421	78.9	4.9671	2	242	17.8	396.90	9.14	21.6
2	0.02729	0.0	7.07	0	0.469	7.185	61.1	4.9671	2	242	17.8	392.83	4.03	34.7
3	0.03237	0.0	2.18	0	0.458	6.998	45.8	6.0622	3	222	18.7	394.63	2.94	33.4
4	0.06905	0.0	2.18	0	0.458	7.147	54.2	6.0622	3	222	18.7	396.90	5.33	36.2

## STEP 3: Give names to the columns since there are no headers

- Give the following names to the columns: 'CRIM', 'ZN', 'INDUS', 'CHAS', 'NOX', 'RM', 'AGE', 'DIS', 'RAD', 'TAX', 'PTRATIO', 'AA', 'LSTAT', 'MEDV'
- Verify columns names were added
- View the first five rows of the dataframe

In [5]:

```
#give names to the columns
col_names = ['CRIM', 'ZN', 'INDUS', 'CHAS', 'NOX', 'RM', 'AGE', 'DIS', 'RAD', 'TAX', 'PTRATIO', 'AA', 'LSTAT', 'MEDV']
```

In [6]:

```
# Let's check to see if the column names were added
df.columns = col_names
```

In [7]:

```
# Look at the first 5 rows of data
df.head()
```

Out[7]:

	CRIM	ZN	INDUS	CHAS	NOX	RM	AGE	DIS	RAD	TAX	PTRATIO	AA	LSTAT	MEDV
0	0.00632	18.0	2.31	0	0.538	6.575	65.2	4.0900	1	296	15.3	396.90	4.98	24.0
1	0.02731	0.0	7.07	0	0.469	6.421	78.9	4.9671	2	242	17.8	396.90	9.14	21.6
2	0.02729	0.0	7.07	0	0.469	7.185	61.1	4.9671	2	242	17.8	392.83	4.03	34.7
3	0.03237	0.0	2.18	0	0.458	6.998	45.8	6.0622	3	222	18.7	394.63	2.94	33.4
4	0.06905	0.0	2.18	0	0.458	7.147	54.2	6.0622	3	222	18.7	396.90	5.33	36.2

## WORKFLOW: Clean and Preprocess the Dataset

### STEP 4: Clean the data

- Find and Mark Missing Values
- If there are no missing data points, then proceed to Step 5.

In [8]:

```
# We see there are no missing data points
df.isnull().sum()
```

Out[8]:

CRIM	0
ZN	0
INDUS	0
CHAS	0
NOX	0

```
RM      0
AGE     0
DIS     0
RAD     0
TAX     0
PTRATIO 0
AA      0
LSTAT   0
MEDV   0
dtype: int64
```

## STEP 5: Performing the Exploratory Data Analysis (EDA)

- Print a count of the number of rows (observations) and columns (variables)
- Print the data types of all variables
- Print a summary statistics of the data

```
In [9]: # Get the number of records/rows and the number of variables/columns
print(df.shape)

(452, 14)
```

```
In [10]: # Get the data types of all variables
print(df.dtypes)
```

```
CRIM      float64
ZN        float64
INDUS    float64
CHAS      int64
NOX       float64
RM        float64
AGE       float64
DIS       float64
RAD       int64
TAX       int64
PTRATIO   float64
AA        float64
LSTAT    float64
MEDV    float64
dtype: object
```

```
In [11]: # Obtain the summary statistics of the data
print(df.describe())
```

	CRIM	ZN	INDUS	CHAS	NOX	RM	\
count	452.000000	452.000000	452.000000	452.000000	452.000000	452.000000	
mean	1.420825	12.721239	10.304889	0.077434	0.540816	6.343538	
std	2.495894	24.326032	6.797103	0.267574	0.113816	0.666808	
min	0.006320	0.000000	0.460000	0.000000	0.385000	3.561000	
25%	0.069875	0.000000	4.930000	0.000000	0.447000	5.926750	
50%	0.191030	0.000000	8.140000	0.000000	0.519000	6.229000	
75%	1.211460	20.000000	18.100000	0.000000	0.605000	6.635000	
max	9.966540	100.000000	27.740000	1.000000	0.871000	8.780000	

	AGE	DIS	RAD	TAX	PTRATIO	AA	\
count	452.000000	452.000000	452.000000	452.000000	452.000000	452.000000	
mean	65.557965	4.043570	7.823009	377.442478	18.247124	369.826504	
std	28.127025	2.090492	7.543494	151.327573	2.200064	68.554439	
min	2.900000	1.129600	1.000000	187.000000	12.600000	0.320000	
25%	40.950000	2.354750	4.000000	276.750000	16.800000	377.717500	
50%	71.800000	3.550400	5.000000	307.000000	18.600000	392.080000	
75%	91.625000	5.401100	7.000000	411.000000	20.200000	396.157500	
max	100.000000	12.126500	24.000000	711.000000	22.000000	396.900000	

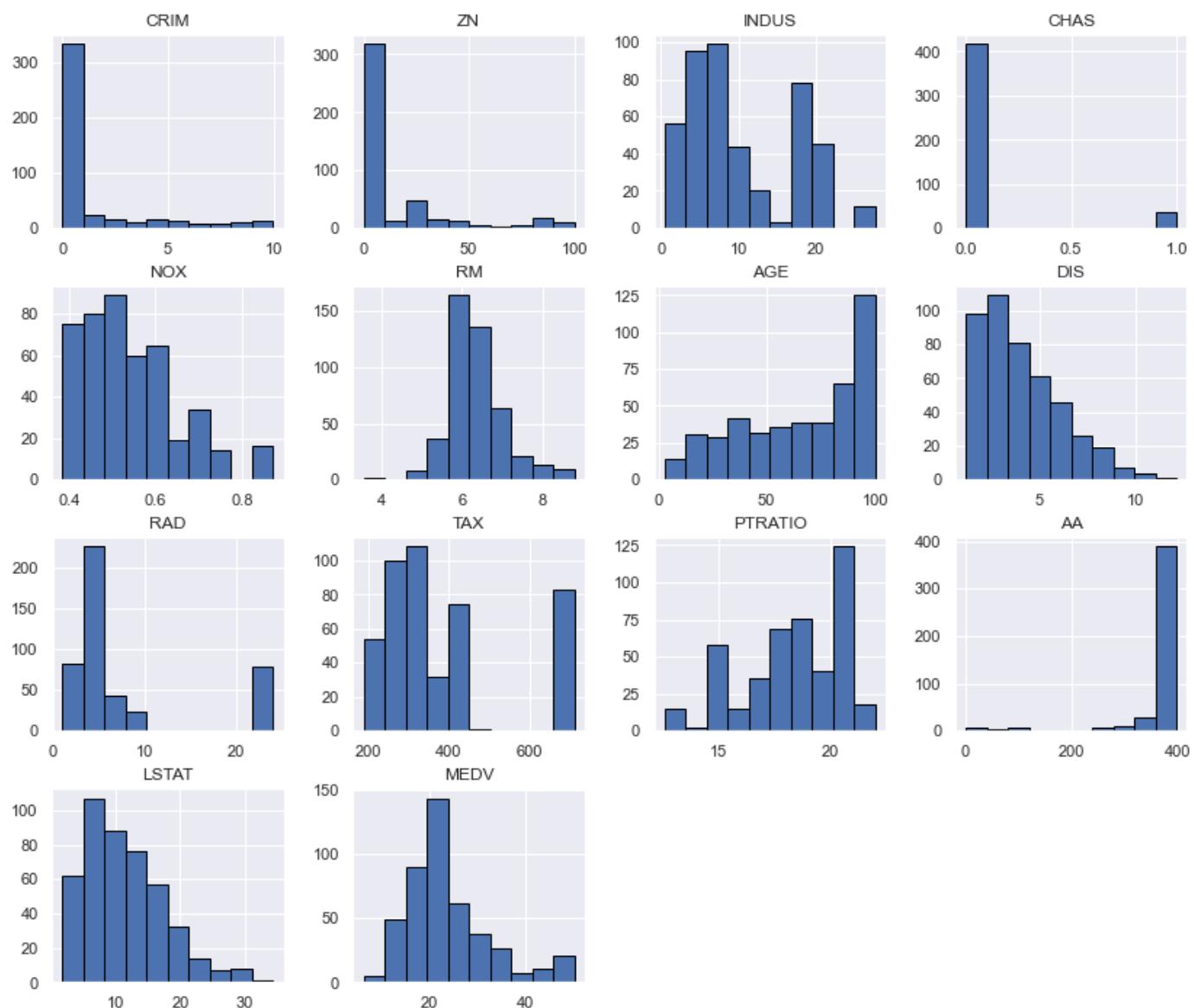
	LSTAT	MEDV
count	452.000000	452.000000
mean	11.441881	23.750442
std	6.156437	8.808602
min	1.730000	6.300000
25%	6.587500	18.500000
50%	10.250000	21.950000
75%	15.105000	26.600000
max	34.410000	50.000000

## STEP 5A: Create Histograms

- Create histograms for each variable from the dataframe df with a figure size of 14 x 12
- Plot the histograms

In [12]:

```
# Plot histogram for each variable. I encourage you to work with the histogram. Remember
df.hist(edgecolor= 'black', figsize=(14,12))
plt.show()
```



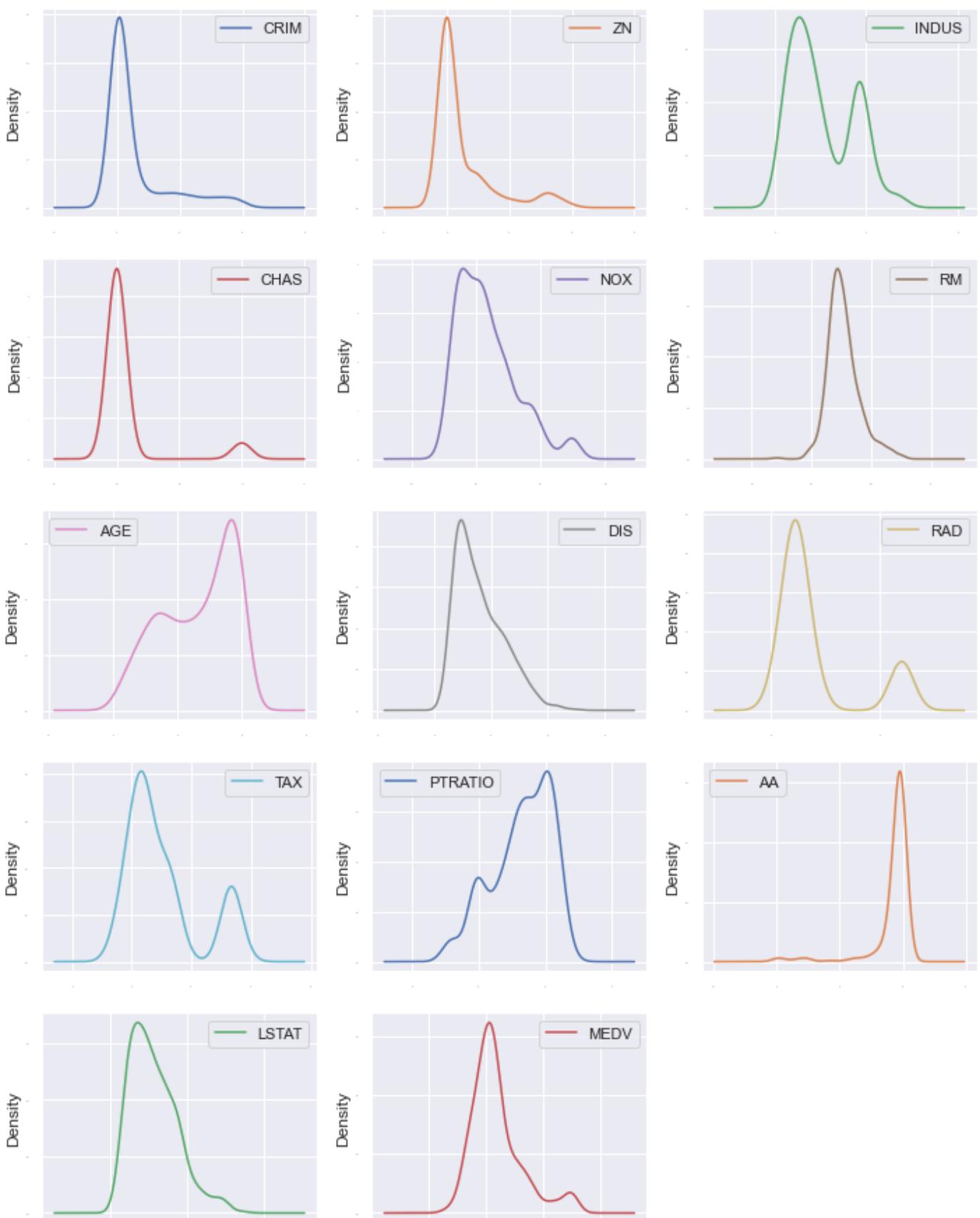
## STEP 5B: Create Density Plots

- Create density plots from the dataframe df that 14 numeric variables, at least 14 plots, layout (5,3): 5 rows, each row with 3 plots

- Plot the density plots

In [13]:

```
# Density plots
# Notes: 14 numeric variables, at least 14 plots, layout (5,3): 5 rows, each row with 3
df.plot(kind='density', subplots=True, layout=(5,3), sharex=False, legend=True, fontsize=10)
plt.show()
```

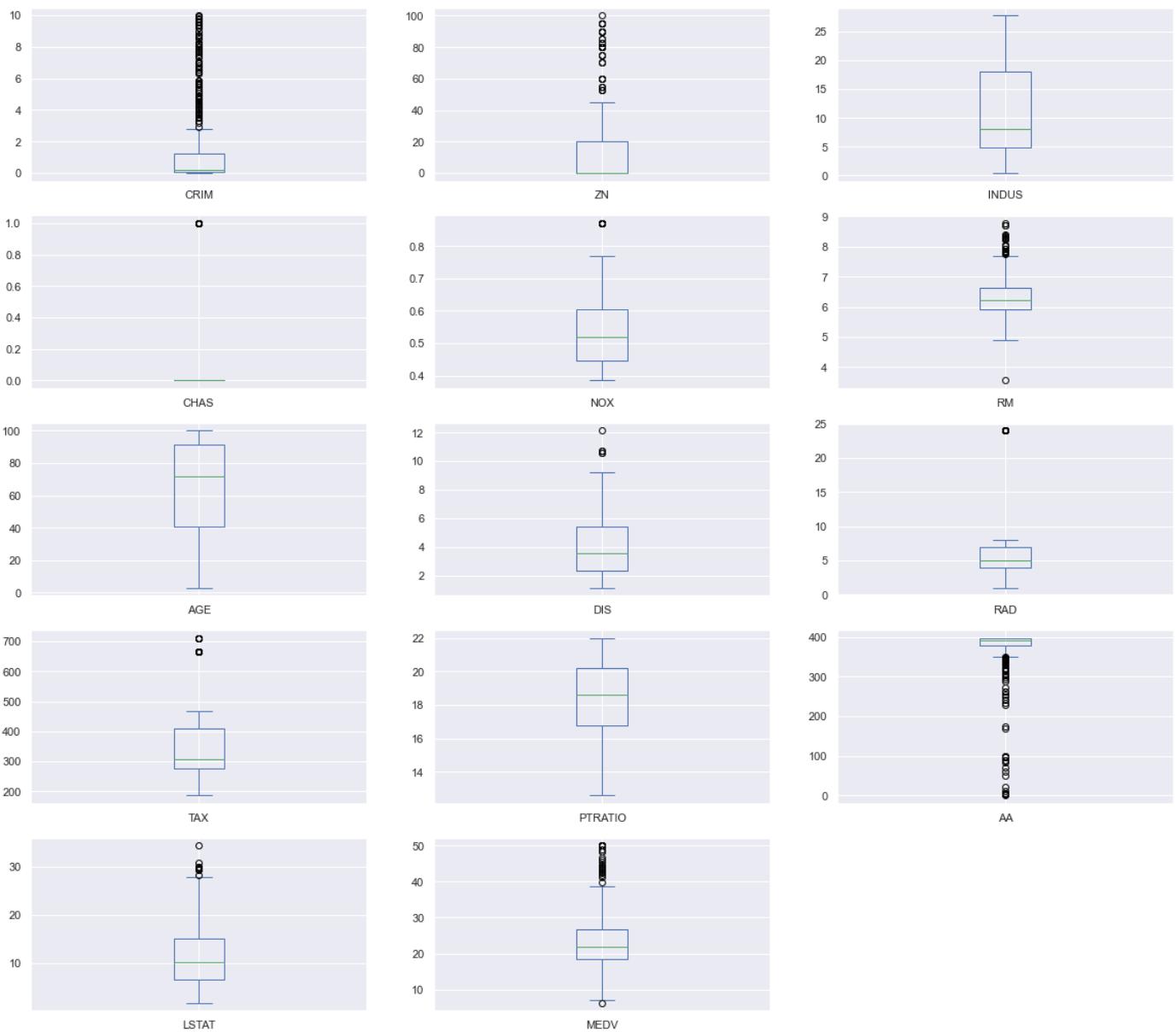


## STEP 5C: Create Boxplots

- Create a boxplots from the dataframe df with a layout (5,3) and figure size (20,18). Ensure subplots is True and sharex is False.
- Plot the boxplots

In [14]:

```
# Boxplots
df.plot(kind="box", subplots=True, layout=(5, 3), sharex=False, figsize=(20, 18))
plt.show()
```

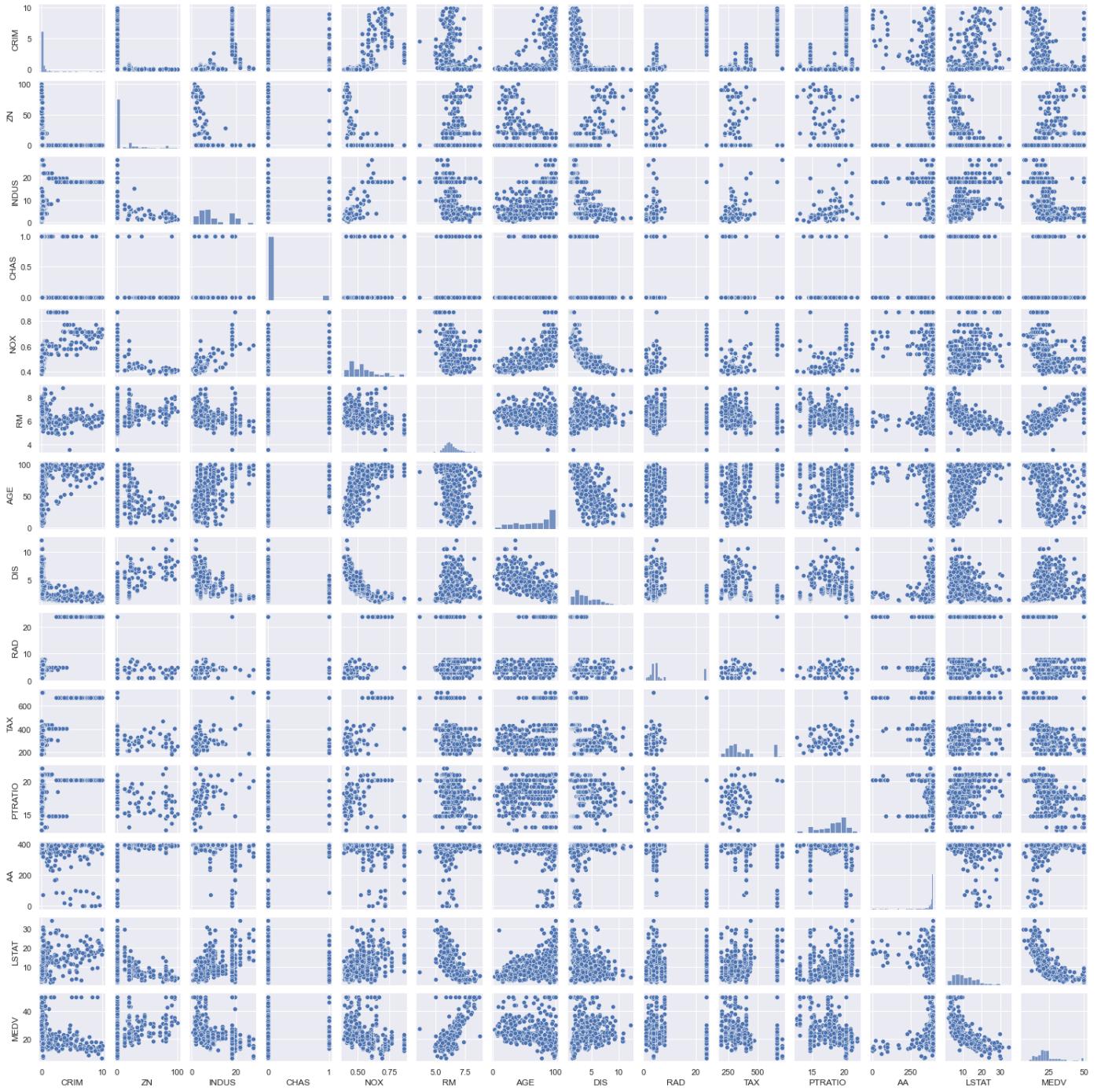


## STEP 5D: Pair Plots - Correlation Analysis and Feature Selection

- Create pair plots of the dataframe with a height of 1.5
- Plot the pair plots
- Use the format function to decrease the number of decimal places to three
- Obtain the correlation of the dataframe

In [15]:

```
#Obtain pair plots of the data. I know this is a lot of information, but I wanted you to
sns.pairplot(df, height=1.5);
plt.show()
```



```
In [16]: # We will decrease the number of decimal places with the format function.
pd.options.display.float_format = '{:.3f}'.format
```

```
In [17]: # Here we will get the correlations, with only 3 decimals.
df.corr()
```

Out[17]:	CRIM	ZN	INDUS	CHAS	NOX	RM	AGE	DIS	RAD	TAX	PTRATIO	AA	LSTAT	MEDV
<b>CRIM</b>	1.000	-0.281	0.574	0.050	0.637	-0.142	0.448	-0.462	0.898	0.826	0.319	-0.413	0.425	-1
<b>ZN</b>	-0.281	1.000	-0.514	-0.060	-0.501	0.307	-0.556	0.656	-0.267	-0.269	-0.364	0.150	-0.411	-1
<b>INDUS</b>	0.574	-0.514	1.000	0.103	0.739	-0.365	0.606	-0.669	0.513	0.673	0.317	-0.317	0.565	-1
<b>CHAS</b>	0.050	-0.060	0.103	1.000	0.134	0.077	0.123	-0.141	0.057	0.017	-0.100	0.013	-0.009	-1
<b>NOX</b>	0.637	-0.501	0.739	0.134	1.000	-0.265	0.707	-0.746	0.542	0.615	0.103	-0.358	0.537	-1
<b>RM</b>	-0.142	0.307	-0.365	0.077	-0.265	1.000	-0.188	0.139	-0.096	-0.215	-0.334	0.108	-0.607	-1
<b>AGE</b>	0.448	-0.556	0.606	0.123	0.707	-0.188	1.000	-0.720	0.359	0.427	0.193	-0.224	0.573	-1

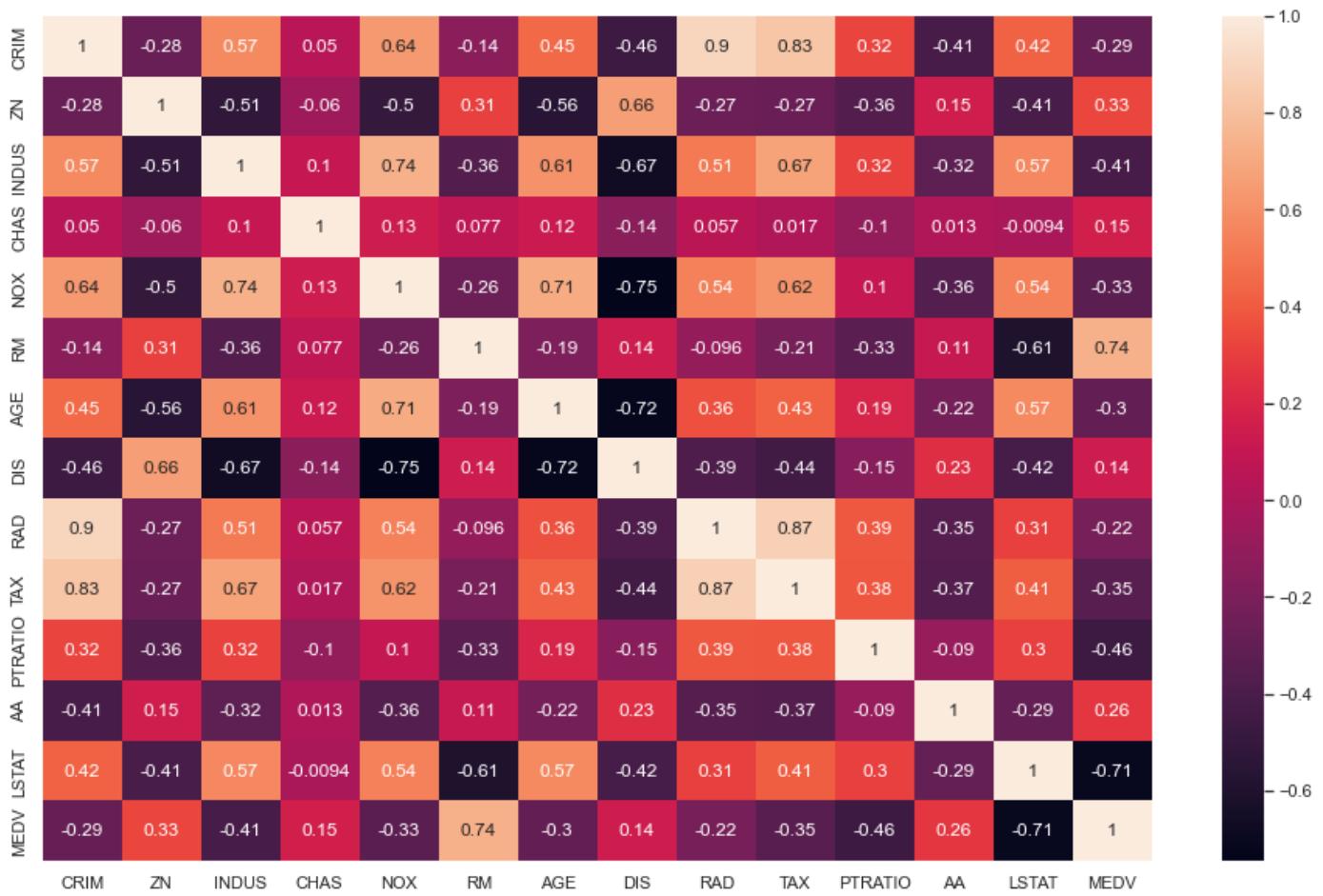
<b>DIS</b>	-0.462	0.656	-0.669	-0.141	-0.746	0.139	-0.720	1.000	-0.388	-0.444	-0.152	0.234	-0.424	1
<b>RAD</b>	0.898	-0.267	0.513	0.057	0.542	-0.096	0.359	-0.388	1.000	0.873	0.387	-0.353	0.310	-1
<b>TAX</b>	0.826	-0.269	0.673	0.017	0.615	-0.215	0.427	-0.444	0.873	1.000	0.385	-0.367	0.411	-1
<b>PTRATIO</b>	0.319	-0.364	0.317	-0.100	0.103	-0.334	0.193	-0.152	0.387	0.385	1.000	-0.090	0.303	-1
<b>AA</b>	-0.413	0.150	-0.317	0.013	-0.358	0.108	-0.224	0.234	-0.353	-0.367	-0.090	1.000	-0.291	1
<b>LSTAT</b>	0.425	-0.411	0.565	-0.009	0.537	-0.607	0.573	-0.424	0.310	0.411	0.303	-0.291	1.000	-1
<b>MEDV</b>	-0.286	0.332	-0.412	0.154	-0.333	0.740	-0.300	0.139	-0.218	-0.346	-0.461	0.265	-0.706	1

## STEP 5E: Creating Heatmaps

- Create a heatmap of the dataframe with a figure size of 16x10, use the dataframe correlation and ensure annot is True
- Plot the heatmap
- For help type sns.heatmap?
- Create another dataframe df2 with less variables
- Obtain the correlation of the dataframe df2
- Plot pair plot for df2 with a height of 5.5
- Create a heatmap of the dataframe df2 with a figure size of 20x12, use the dataframe correlation and ensure annot is True
- Change the color to blue and increase the font size 20

In [18]:

```
# We could simply look at the correlations, but a heatmap is a great way to present to t
plt.figure(figsize =(16,10))
sns.heatmap(df.corr(), annot=True)
plt.show()
```



```
In [19]: # If you get stuck on what can be done with the heatmap, you can use the following code
sns.heatmap
```

```
Out[19]: <function seaborn.matrix.heatmap(data, *, vmin=None, vmax=None, cmap=None, center=None, robust=False, annot=None, fmt='.2g', annot_kws=None, linewidths=0, linecolor='white', cbar=True, cbar_kws=None, cbar_ax=None, square=False, xticklabels='auto', yticklabels='auto', mask=None, ax=None, **kwargs)>
```

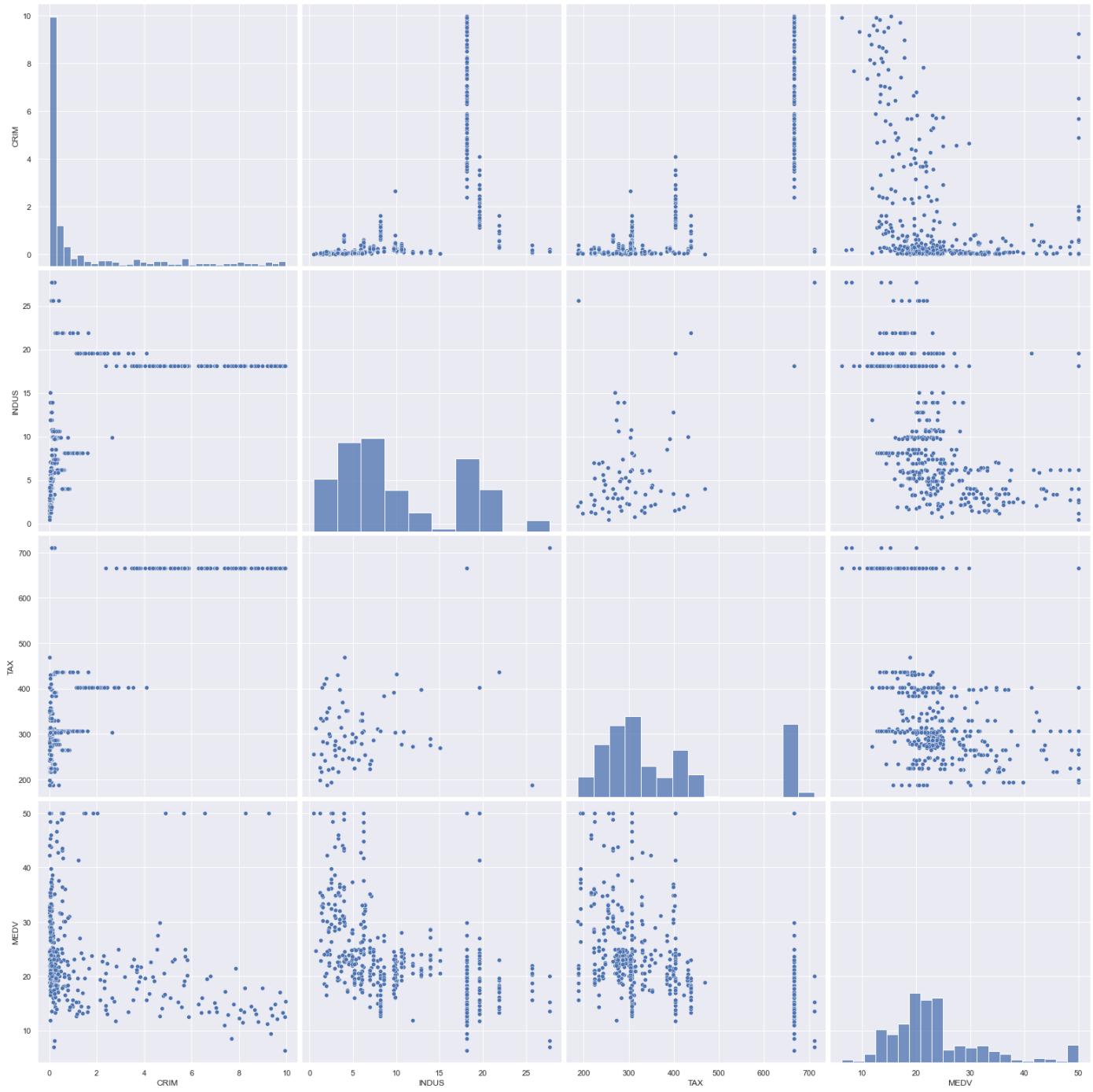
```
In [20]: # Now, let's say we want to decrease the number of variables in our heatmap.
# We would use the following code.
# Remember how to make a subset. Try using different variables.
df2 = df[['CRIM', 'INDUS', 'TAX', 'MEDV']]
```

```
In [21]: # Here we will look at the correlations for only the variables in df2.
df2.corr()
```

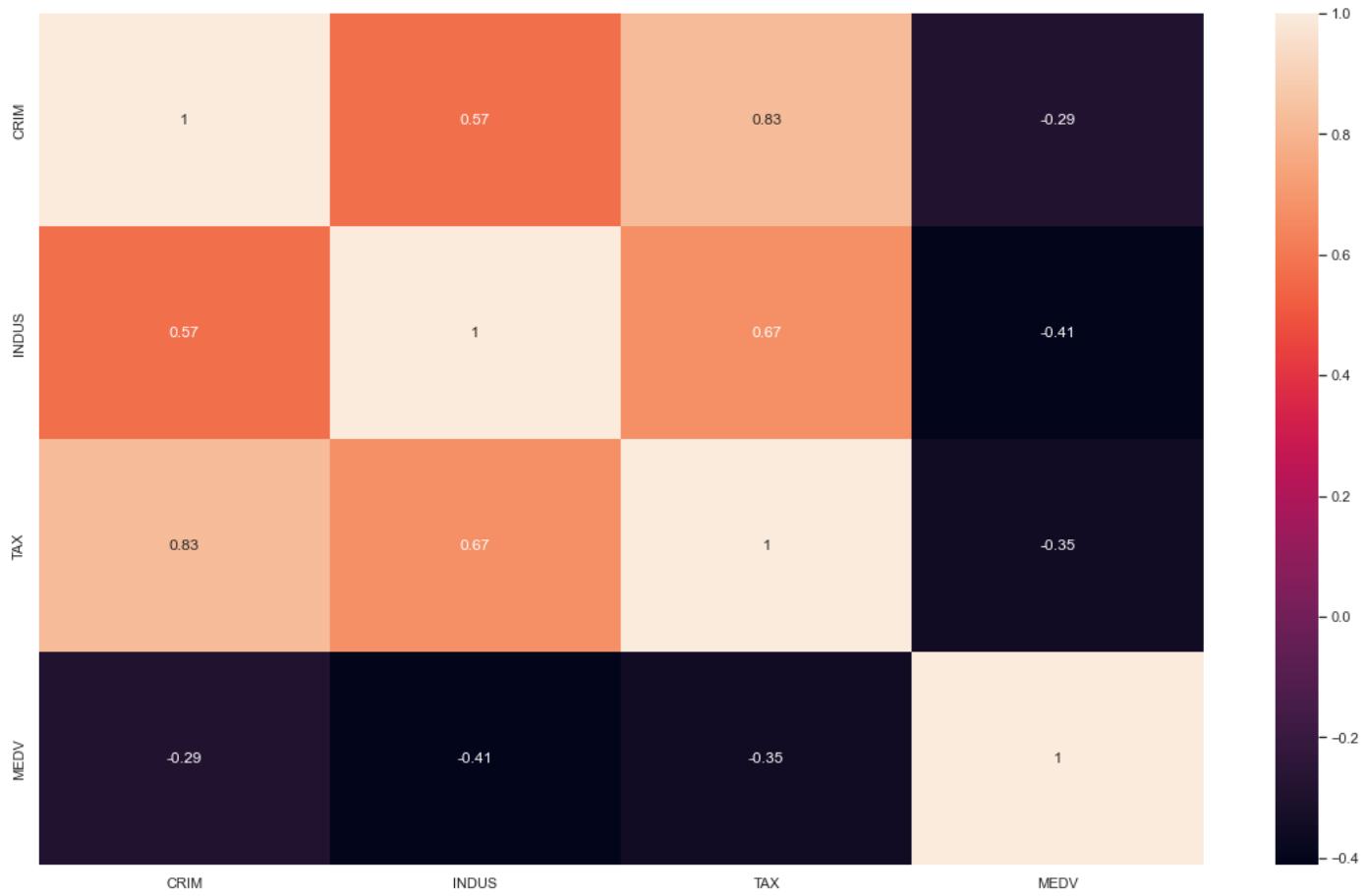
```
Out[21]:
```

	CRIM	INDUS	TAX	MEDV
<b>CRIM</b>	1.000	0.574	0.826	-0.286
<b>INDUS</b>	0.574	1.000	0.673	-0.412
<b>TAX</b>	0.826	0.673	1.000	-0.346
<b>MEDV</b>	-0.286	-0.412	-0.346	1.000

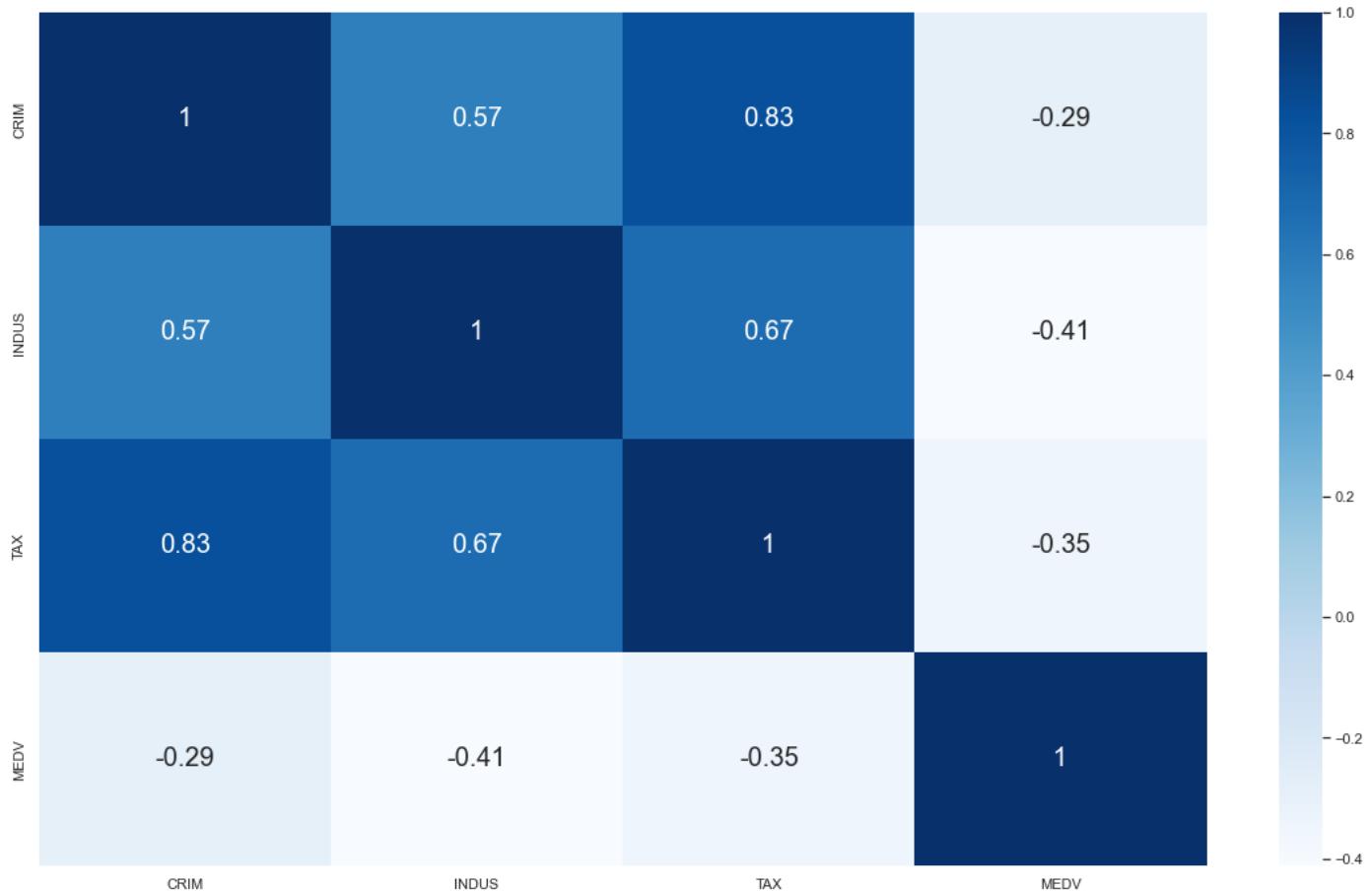
```
In [22]: # Let's try the pairplot with only the variables in df2
sns.pairplot(df2, height=5.5);
plt.show()
```



```
In [23]: # Now, we will make a heatmap with only the variables in the df2 subset.
plt.figure(figsize = (20,12))
sns.heatmap(df2.corr(), annot=True)
plt.show()
```



```
In [24]: #If you want to change the color and font to make the labels easier to read, use this code
plt.figure(figsize=(20,12))
sns.heatmap(df2.corr(), cmap="Blues", annot=True, annot_kws={"fontsize":20})
plt.show()
```



# WORKFLOW: DATA SPLIT

## STEP 6: Separate the Dataset into Input & Output NumPy Arrays

- Store the dataframe d2 values into a NumPy array
- Separate the array into input and output components by slicing

```
In [25]: # Store the dataframe values into a NumPy array
array = df2.values
# Separate the array into input and output components by slicing
# For X (input) [:,3] --> All the rows and columns from 0 up to 3
X = array[:, 0:3]
# For Y (output) [:3] --> All the rows in the last column (MEDV)
Y = array[:, 3]
```

## STEP 7: Split into Input/Output Array into Training/Testing Datasets

- Split the dataset into training at 67% and test at 33% with the seed = 7

```
In [26]: # Split the dataset --> training sub-dataset: 67%, and test sub-dataset:33%
test_size = 0.33
# Selection of records to include in which sub-dataset must be done randomly - use the f
seed = 7
# Split the dataset (both input & output) into training/testing datasets
X_train, X_test, Y_train, Y_test = train_test_split(X, Y, test_size=0.2, random_state=seed)
```

# WORKFLOW: TRAIN MODEL

## STEP 8: Build and Train the Model

- Assign LinearRegression to the model
- Train the model
- Print the intercept and coefficients
- Print the list of the coefficients with their correspondent variable name

```
In [27]: # Build the model
model = LinearRegression()
# Train the model using the training sub-dataset
model.fit(X_train, Y_train)
# Print intercept and coefficients
print ("Intercept:", model.intercept_)
print ("Coefficients:", model.coef_)
```

```
Intercept: 31.393427670412983
Coefficients: [ 0.09859287 -0.42388844 -0.00931847]
```

```
In [28]: # Print out the list of the coefficients with their correspondent variable name
# Pair the feature names with the coefficients
names_2 = ["CRIM", "INDUS", "TAX"]
coeffs_zip = zip(names_2, model.coef_)
# Convert iterator into a set
coeffs = set(coeffs_zip)
```

```
# Print (coeffs)
for coef in coeffs:
    print (coef, "\n")

('CRIM', 0.09859287239144014)

('TAX', -0.009318474474503551)

('INDUS', -0.4238884417716139)
```

```
In [29]: LinearRegression(copy_X=True, fit_intercept=True, n_jobs=1)
```

```
Out[29]: LinearRegression(n_jobs=1)
```

## WORKFLOW: SCORE MODEL

### STEP 9: Calculate R-Squared

- Calculate the R-Squared
- Print the score

\*\* Note: The higher the R-squared, the better (0 – 100%). Depending on the model, the best models score above 83%. The R-squared value tells us how well the independent variables predict the dependent variable, which is very low. Think about how you could increase the R-squared. What variables would you use?

```
In [30]: R_squared = model.score(X_test, Y_test)
print("R-squared: ", R_squared)
```

```
R-squared: 0.15473313373590336
```

### Step 10: Prediction

- Execute model prediction
- We have now trained the model. Let's use the trained model to predict the "Median value of owner-occupied homes in 1000 dollars" (MEDV).
- We are using the following predictors:
- CRIM: per capita crime rate by town: 12
- INDUS: proportion of non-retail business acres per town: 10
- TAX: full-value property-tax rate per \$10,000: 450

\*\* Note: The model predicts that the median value of owner-occupied homes in 1000 dollars in the above suburb should be around \$24,144.

```
In [31]: model.predict([[12, 10, 450]])
```

```
Out[31]: array([24.14434421])
```

## WORKFLOW: EVALUATE MODELS

### Step 11: Train & Score Model 2 Using K-Fold Cross Validation

# Data Split

- Specify the k-size to 10
- Fix the random seed to 7
- Split the entire data set
- Obtain the Mean squared error
- Train the model and run K-fold cross-validation
- Print results

In [32]:

```
#Add Your Code Here# Evaluate the algorithm
# Specify the K-size
num_folds = 10
# Fix the random seed
# must use the same seed value so that the same subsets can be obtained
# for each time the process is repeated
seed = 7
# Split the whole data set into folds
kfold= KFold(n_splits=num_folds, random_state=seed, shuffle=True)
# For Linear regression, we can use MSE (mean squared error) value
# to evaluate the model/algorithm
scoring = 'neg_mean_squared_error'
```

In [33]:

```
# Train the model and run K-fold cross-validation to validate/evaluate the model
results = cross_val_score(model, X, Y, cv=kfold, scoring=scoring)
# Print out the evaluation results
# Result: the average of all the results obtained from the k-fold crossvalidation
print("Average of all results from the K-fold Cross-Validation, using negative mean squa
```

Average of all results from the K-fold Cross-Validation, using negative mean squared error: -64.35862748210982

Note: After we train, we evaluate. We are using K-fold to determine if the model is acceptable. We pass the whole set since the system will divide it for us. We see a -64 avg of all errors (mean of square errors). This value would traditionally be positive, but scikit reports this value as a negative value. If the square root had been evaluated, the value would have been around 8.

## Step 12: Score Using Explained Variance

Let's use a different scoring parameter. Here we use the Explained Variance. The best possible score is 1.0; lower values are worse.

- Specify the k-size to 10
- Set the seed to 7
- Split the entire data set
- Obtain the explained variance score
- Train the model and run K-fold cross-validation
- Print results

In [34]:

```
# Evaluate the algorithm
# Specify the K-size
num_folds = 10
# Fix the random seed must use the same seed value so that the same subsets can be obtained
# for each time the process is repeated
seed = 7
# Split the whole data set into folds
kfold= KFold(n_splits=num_folds, random_state=seed, shuffle=True)
```

```
# For Linear regression, we can use explained variance value to evaluate the model/algor
scoring = 'explained_variance'
```

In [35]:

```
# Train the model and run K-fold cross-validation to validate/evaluate the model
results = cross_val_score(model, X, Y, cv=kfold, scoring=scoring)
# Print out the evaluation results
# Result: the average of all the results obtained from the k-fold crossvalidation
print("Average of all results from the K-fold Cross Validation, using explained variance
```

```
Average of all results from the K-fold Cross Validation, using explained variance: 0.190
23822025958687
```

To learn more about Scikit Learning scoring [[https://scikitlearn.org/stable/modules/model\\_evaluation.html](https://scikitlearn.org/stable/modules/model_evaluation.html) (Links to an external site.)]

## Part 2: Logistic Regression

### Machine Learning Supervised Logistic Regression

- Let's begin Part 2 using logistic regression using the same Supervised Learning Workflow used in part 1.

#### STEP 1: Import Libraries

- import pandas and numpy libraries
- import scatter\_matrix from pandas.plotting
- import matplotlib
- import seaborn
- import LogisticRegression from sklearn.linear\_model
- import train\_test\_split, KFold, and cross\_val\_score from sklearn.model\_selection
- import classification\_report from sklearn.metrics

In [36]:

```
# Import Python Libraries: NumPy and Pandas
import pandas as pd
import numpy as np
```

In [37]:

```
#Add Your Code Here# Import Libraries & modules for data visualization
from pandas.plotting import scatter_matrix
import matplotlib.pyplot as plt
import seaborn as sns
```

In [38]:

```
# Import scikit-Learn module for the algorithm/model: Logistic Regression
from sklearn.linear_model import LogisticRegression
```

In [39]:

```
# Import scikit-Learn module to split the dataset into train/ test subdatasets
from sklearn.model_selection import train_test_split
```

In [40]:

```
# Import scikit-Learn module for K-fold cross-validation - algorithm/model evaluation &
from sklearn.model_selection import KFold
from sklearn.model_selection import cross_val_score
```

In [41]:

```
# Import scikit-Learn module classification report to later use for information about ho
```

```
from sklearn.metrics import classification_report
```

## WORKFLOW: DATA SET

### STEP 2: Read data description and Load the Data

- Read the description of the dataset listed below
- Dataset is provided in the module and assignment. It is called iris.csv.
- Load the data into Pandas dataframe called df
- View the first five rows of the dataframe

### Description Iris Dataset

Data Set: iris.csv

Title: Iris Plants Database Updated Sept 21 by C. Blake -Added discrepancy information Sources:

- Creator: RA\_Fisher
- Donor: Michael Marshall (MARSHALL%PLU@io.arc.nasa.gov)
- Date: 1988

Relevant Information: This is perhaps the best-known database to be found in the pattern recognition literature. Fisher's paper is a classic in the field and is referenced frequently to this day. (See Duda & Hart, for example)

The data set contains 3 classes of 50 instances each, where each class refers to a type of iris plant.

Predicted attribute: class of Iris plant

Number of Instances: 150 (50 in each of three classes)

Number of predictors: 4 numeric

Predictive attributes and the class attribute information:

- sepal length in cm
- sepal width in cm
- petal length in cm
- petal width in cm

class:



Iris Versicolor



Iris Setosa



Iris Virginica

```
In [42]: # Specify the location of the dataset  
filename = 'iris.csv'  
# Load the data into a Pandas DataFrame  
df = pd.read_csv(filename)
```

```
In [43]: # Look at the data frame  
df.head()
```

```
Out[43]:
```

	<b>Id</b>	<b>SepalLengthCm</b>	<b>SepalWidthCm</b>	<b>PetalLengthCm</b>	<b>PetalWidthCm</b>	<b>Species</b>
<b>0</b>	1	5.100	3.500	1.400	0.200	Iris-setosa
<b>1</b>	2	4.900	3.000	1.400	0.200	Iris-setosa
<b>2</b>	3	4.700	3.200	1.300	0.200	Iris-setosa
<b>3</b>	4	4.600	3.100	1.500	0.200	Iris-setosa
<b>4</b>	5	5.000	3.600	1.400	0.200	Iris-setosa

## WORKFLOW: Clean and Preprocess the Dataset

### STEP 3: Clean the data

- Find and Mark Missing Values
- If there are no missing data points, then proceed to Step 4.

```
In [44]: # mark zero values as missing or NaN  
df[['SepalLengthCm', 'SepalWidthCm', 'PetalLengthCm', 'PetalWidthCm']] \\\n= df[['SepalLengthCm', 'SepalWidthCm', 'PetalLengthCm', 'PetalWidthCm']].replace(0,np.nan)  
# count the number of NaN values in each column  
print (df.isnull().sum())
```

```
Id          0  
SepalLengthCm 0  
SepalWidthCm 0  
PetalLengthCm 0  
PetalWidthCm 0  
Species      0  
dtype: int64
```

### STEP 4: Performing the Exploratory Data Analysis (EDA)

- Print a count of the number of rows (observations) and columns (variables)
- Print the data types of all variables
- Print a summary statistics of the data
- Print the number of records in each class

In [45]: `# Get the number of records/rows and the number of variables/columns  
print("Shape of the dataset(rows, columns):", df.shape)`

```
Shape of the dataset(rows, columns): (150, 6)
```

In [46]: `#get the data types of all the variables / attributes in the data set  
print(df.dtypes)`

Id	int64
SepalLengthCm	float64
SepalWidthCm	float64
PetalLengthCm	float64
PetalWidthCm	float64
Species	object
<b>dtype:</b>	<b>object</b>

In [47]: `#return the summary statistics of the numeric variables/attributes in the data set  
print(df.describe())`

	<b>Id</b>	<b>SepalLengthCm</b>	<b>SepalWidthCm</b>	<b>PetalLengthCm</b>	<b>PetalWidthCm</b>
<b>count</b>	150.000	150.000	150.000	150.000	150.000
<b>mean</b>	75.500	5.843	3.054	3.759	1.199
<b>std</b>	43.445	0.828	0.434	1.764	0.763
<b>min</b>	1.000	4.300	2.000	1.000	0.100
<b>25%</b>	38.250	5.100	2.800	1.600	0.300
<b>50%</b>	75.500	5.800	3.000	4.350	1.300
<b>75%</b>	112.750	6.400	3.300	5.100	1.800
<b>max</b>	150.000	7.900	4.400	6.900	2.500

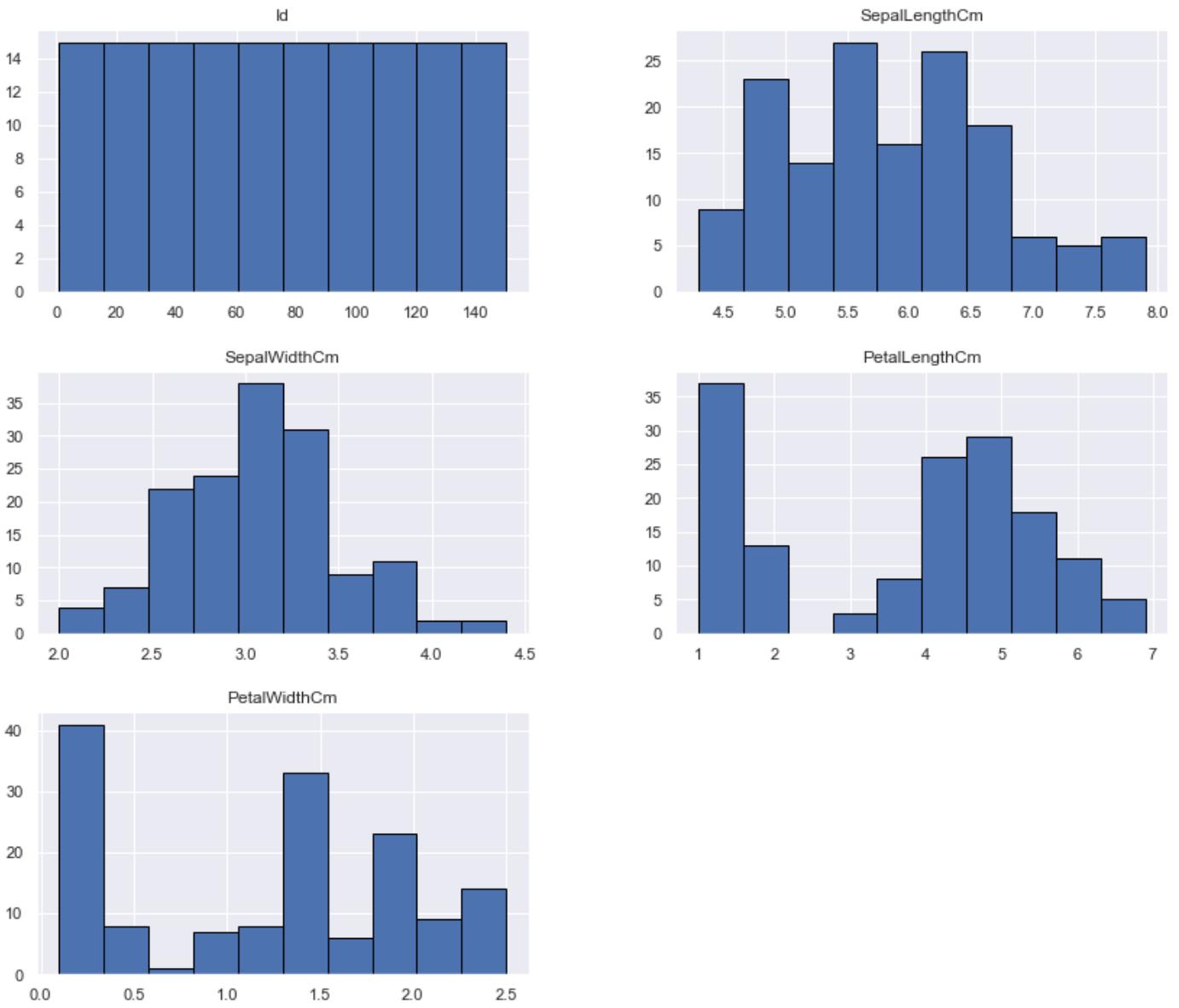
In [48]: `#class distribution i.e. how many records are in each class  
print(df.groupby('Species').size())`

<b>Species</b>	
Iris-setosa	50
Iris-versicolor	50
Iris-virginica	50
<b>dtype:</b>	<b>int64</b>

## STEP 4A: Create Histograms

- Create histograms from the dataframe df that is black with a figure size of 14 x 12
- Plot the histograms

In [49]: `# Plot histogram for each variable.  
df.hist(edgecolor= 'black', figsize=(14,12))  
plt.show()`

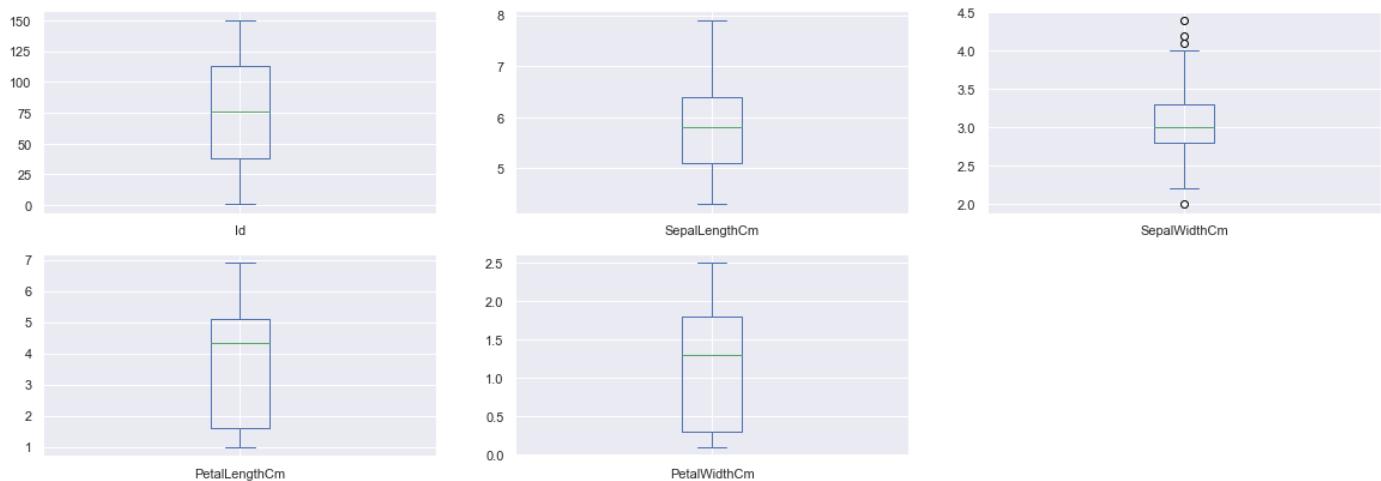


## Step 4B: Creating Boxplots

- Create boxplots from the dataframe df with a layout (5,3) and figure size (20,18). Ensure subplots is True and sharex is False.
- Plot the boxplots

In [50]:

```
# Boxplots
df.plot(kind="box", subplots=True, layout=(5, 3), sharex=False,
figsize=(20, 18))
plt.show()
```



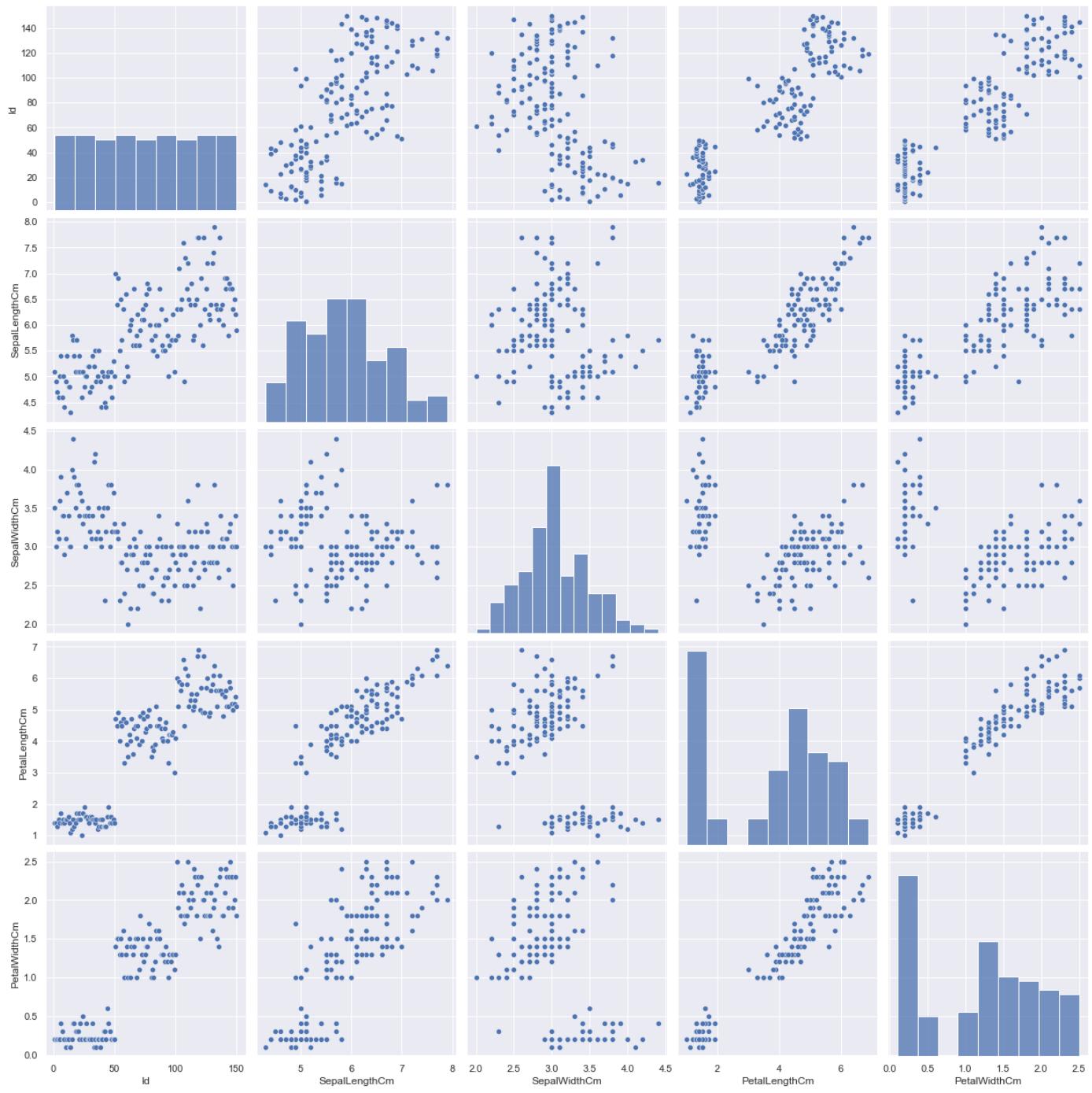
## Step 4C: Create Pair Plots

- Create pair plots of the dataframe with a height of 3.5
- Plot the pair plots
- Add color

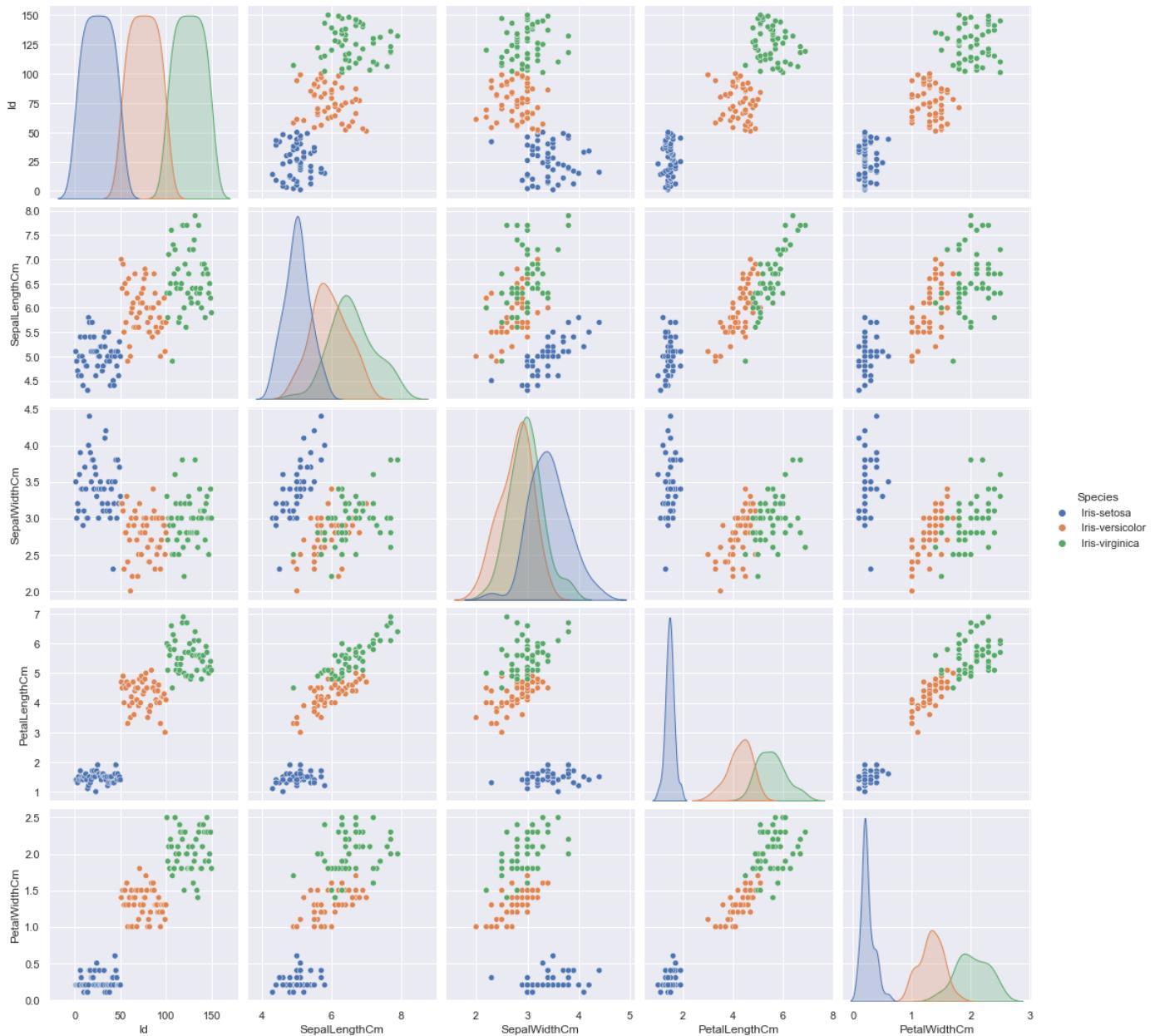
Note: Please click on the above URL to learn more about Pair Plots

<https://seaborn.pydata.org/generated/seaborn.pairplot.html>

```
In [51]: # Create pair plots
sns.pairplot(df, height=3.5);
plt.show()
```



```
In [52]: # Let's try that again using color. Notice: assigning a hue variable adds a semantic map
sns.pairplot(df, hue='Species', height=3, aspect= 1);
```



## Step 4D: Creating Violin Plots

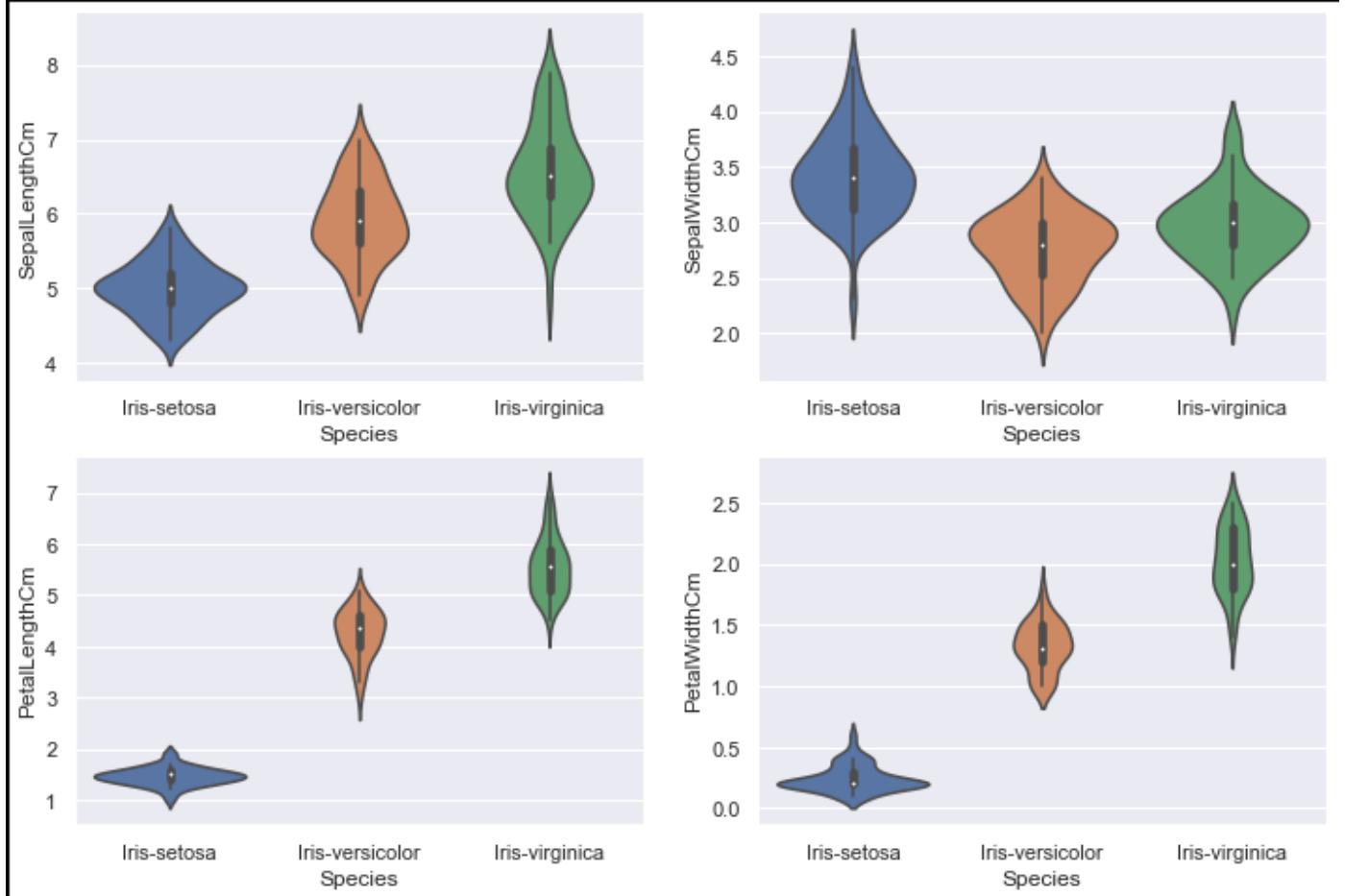
- Create violin plots
- Plot the violin plots
- Add color

Note: Please click on the above URL to learn more about Violin Plots

<https://seaborn.pydata.org/generated/seaborn.violinplot.html>

In [53]:

```
# Violin Plot
plt.figure(edgecolor="black", linewidth= 1.2, figsize=(12,8));
plt.subplot(2,2,1)
sns.violinplot(x='Species', y = 'SepalLengthCm', data=df)
plt.subplot(2,2,2)
sns.violinplot(x='Species', y = 'SepalWidthCm', data=df)
plt.subplot(2,2,3)
sns.violinplot(x='Species', y = 'PetalLengthCm', data=df)
plt.subplot(2,2,4)
sns.violinplot(x='Species', y = 'PetalWidthCm', data=df);
```



## WORKFLOW: DATA SPLIT

### STEP 5: Separate the Dataset into Input & Output NumPy Arrays

- Store the dataframe values into a NumPy array
- Separate the array into input and output components by slicing

```
In [54]: # store dataframe values into a numpy array
array = df.values
# separate array into input and output by slicing
# for X(input) [ :, 1:5 ] --> all the rows, columns from 1 - 5
# these are the independent variables or predictors
X = array[ :, 1:5 ]
# for Y(input) [ :, 5 ] --> all the rows, column 5
# this is the value we are trying to predict
Y = array[ :, 5 ]
```

### STEP 6: Split into Input/Output Array into Training/Testing Datasets

- Split the dataset into training at 67% and test at 33% with the seed = 7

```
In [55]: # split the dataset --> training sub-dataset: 67%; test sub-dataset: 33%
test_size = 0.33
#selection of records to include in each data sub-dataset must be done randomly
seed = 7
```

```
In [56]: #split the dataset (input and output) into training / test datasets  
X_train, X_test, Y_train, Y_test = train_test_split(X, Y,test_size=test_size,random_stat
```

## WORKFLOW: TRAIN MODEL

### STEP 7: Build and Train the Model

- Assign LogisticRegression to the model
- Train the model
- Print the classification report

```
In [57]: #build the model  
model = LogisticRegression(random_state=seed, max_iter=1000)  
# train the model using the training sub-dataset  
model.fit(X_train, Y_train)
```

```
Out[57]: LogisticRegression(max_iter=1000, random_state=7)
```

```
In [58]: #print the classification report  
predicted = model.predict(X_test)  
report = classification_report(Y_test, predicted)  
print("Classification Report: ", "\n", "\n", report)
```

Classification Report:

	precision	recall	f1-score	support
Iris-setosa	1.00	1.00	1.00	14
Iris-versicolor	0.89	0.89	0.89	18
Iris-virginica	0.89	0.89	0.89	18
accuracy			0.92	50
macro avg	0.93	0.93	0.93	50
weighted avg	0.92	0.92	0.92	50

## WORKFLOW: SCORE MODEL 1

### STEP 8: Score the Accuracy of the Model

- Calculate accuracy score
- Print the score

```
In [59]: #score the accuracy level  
result = model.score(X_test, Y_test)  
#print out the results  
print(("Accuracy: %.3f%%") % (result*100.0))
```

```
Accuracy: 92.000%
```

## Step 9: Prediction

- Execute model prediction

Note: We have now trained the model and using that trained model to predict the type of flower we have with the listed values for each variable.

```
In [60]: model.predict([[5.3, 3.0, 4.5, 1.5]])
```

```
Out[60]: array(['Iris-versicolor'], dtype=object)
```

```
In [61]: model.predict([5, 3.6, 1.4, 1.5])
```

```
Out[61]: array(['Iris-setosa'], dtype=object)
```

## WORKFLOW: EVALUATE MODELS

### Step 10: Train & Score Model 2 Using K-Fold Cross Validation Data Split

- Specify the k-size to 10
- Fix the random seed to 7
- Split the entire data set
- Obtain the accuracy level
- Train the model and run K-fold cross-validation
- Print results

```
In [62]: # Evaluate the algorithm and specify the number of times of repeated splitting, in this
n_splits=10
#Fix the random seed. You must use the same seed value so that the same subsets can be o
seed=7
kfold=KFold(n_splits, random_state=seed, shuffle=True)
# for logistic regression, we can use the accuracy level to evaluate the model
scoring="accuracy"
```

```
In [63]: #train the model and run K-fold cross-validation to validate / evaluate the model
results=cross_val_score (model, X, Y, cv=kfold, scoring=scoring)
# print the evaluation results. The result is the average of all the results obtained fr
print("Accuracy: %.3f (%.3f) "% (results.mean(), results.std()))
```

```
Accuracy: 0.967 (0.054)
```

**GREAT JOB! YOU ARE DONE.**