Discovery and Learning with Big Data/Machine Learning

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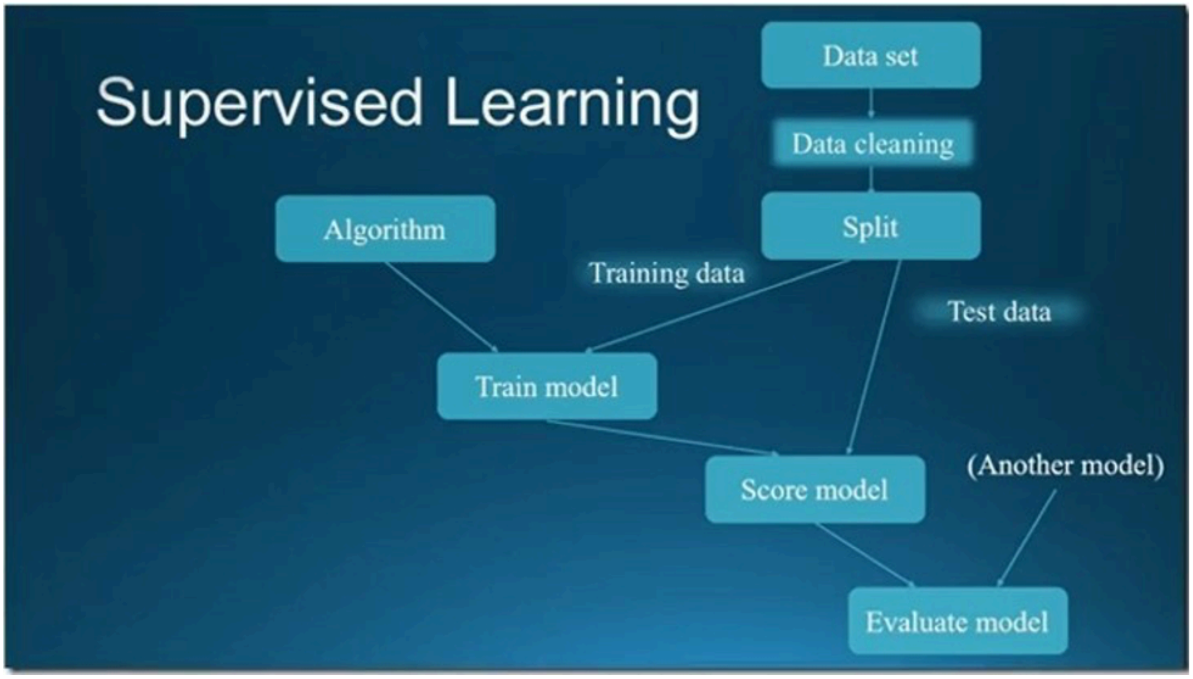
Machine Learning Supervised Logistic Regression

Supervised Learning Workflow



- You can see in this picture that supervised learning startw 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/Indepentdent 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 lastly, evaluate/validate the model. So let's begin.

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
- Date: 1988

Relevant Information: This is perhaps the best-known database to be found in the pattern recognition literature. Fishers 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:

- 1.sepal length in cm
- 2.sepal width in cm
- 3.petal length in cm
- 4.petal width incm
- 5.class:

1. What is happening in the code blocks below? Enter your answer by adding a new code block and use markdown.

In [1]:
```
# Import Python Libraries: NumPy and Pandas
import pandas as pd
import numpy as np
```

In [2]:
```
# Import Libraries & modules for data visualization
from pandas.plotting import scatter_matrix
import matplotlib.pyplot as plt
import seaborn as sns
```

In [3]:
```
# Import scikit-Learn module for the algorithm/modeL: Logistic Regression
from sklearn.linear_model import LogisticRegression
```

In [4]:
```
# Import scikit-Learn module to split the dataset into train/ test sub-datasets
from sklearn.model_selection import train_test_split
```

In [5]:
```
# 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 [6]:
```
# Import scikit-Learn module classification report to later use for information about
#try to classify / lable each record
from sklearn.metrics import classification_report
```

The previous six (6) code blocks imports entire python libraries for data analysis, machine learning, and data visualization.

2. What is happening in the code block below question 3? Enter your answer by adding a new code block and use markdown.

In code block three (3), we are importing 'iris.csv' file, and assigning it to a DataFrame.

3. What would happen to the code if you enter '..iris.csv' instead of 'iris.csv'? You should create a new code block and make the change to the code and then run the code. This will create an error code. Create a new code block and enter the error code in that 2nd created code block using markdown. Don't forget to delete the code block were you entered '..iris.csv', the incorrect code.

In [8]:
```
# Specify location of the dataset
filename = 'iris.csv'
# Load the data into a Pandas DataFrame
df = pd.read_csv(filename)
```

In [10]:
```
file_name = '..iris.csv'
iris_df = pd.read_csv(file_name)
```

```
---------------------------------------------------------------------------
FileNotFoundError                         Traceback (most recent call last)
Cell In[10], line 2
      1 file_name = '..iris.csv'
----> 2 iris_df = pd.read_csv(file_name)

File ~\anaconda3\Lib\site-packages\pandas\io\parsers\readers.py:912, in read_csv(file
path_or_buffer, sep, delimiter, header, names, index_col, usecols, dtype, engine, con
verters, true_values, false_values, skipinitialspace, skiprows, skipfooter, nrows, na
_values, keep_default_na, na_filter, verbose, skip_blank_lines, parse_dates, infer_da
tetime_format, keep_date_col, date_parser, date_format, dayfirst, cache_dates, iterat
or, chunksize, compression, thousands, decimal, lineterminator, quotechar, quoting, d
oublequote, escapechar, comment, encoding, encoding_errors, dialect, on_bad_lines, de
lim_whitespace, low_memory, memory_map, float_precision, storage_options, dtype_backe
nd)
    899 kwds_defaults = _refine_defaults_read(
    900     dialect,
    901     delimiter,
   (...)
    908     dtype_backend=dtype_backend,
    909 )
    910 kwds.update(kwds_defaults)
--> 912 return _read(filepath_or_buffer, kwds)

File ~\anaconda3\Lib\site-packages\pandas\io\parsers\readers.py:577, in _read(filepat
h_or_buffer, kwds)
    574 _validate_names(kwds.get("names", None))
    576 # Create the parser.
--> 577 parser = TextFileReader(filepath_or_buffer, **kwds)
    579 if chunksize or iterator:
    580     return parser

File ~\anaconda3\Lib\site-packages\pandas\io\parsers\readers.py:1407, in TextFileRead
er.__init__(self, f, engine, **kwds)
   1404     self.options["has_index_names"] = kwds["has_index_names"]
   1406 self.handles: IOHandles | None = None
-> 1407 self._engine = self._make_engine(f, self.engine)

File ~\anaconda3\Lib\site-packages\pandas\io\parsers\readers.py:1661, in TextFileRead
er._make_engine(self, f, engine)
   1659     if "b" not in mode:
   1660         mode += "b"
-> 1661 self.handles = get_handle(
   1662     f,
   1663     mode,
   1664     encoding=self.options.get("encoding", None),
   1665     compression=self.options.get("compression", None),
   1666     memory_map=self.options.get("memory_map", False),
   1667     is_text=is_text,
   1668     errors=self.options.get("encoding_errors", "strict"),
   1669     storage_options=self.options.get("storage_options", None),
   1670 )
   1671 assert self.handles is not None
   1672 f = self.handles.handle

File ~\anaconda3\Lib\site-packages\pandas\io\common.py:859, in get_handle(path_or_bu
f, mode, encoding, compression, memory_map, is_text, errors, storage_options)
    854 elif isinstance(handle, str):
    855     # Check whether the filename is to be opened in binary mode.
    856     # Binary mode does not support 'encoding' and 'newline'.
    857     if ioargs.encoding and "b" not in ioargs.mode:
    858         # Encoding
--> 859         handle = open(
    860             handle,
    861             ioargs.mode,
    862             encoding=ioargs.encoding,
    863             errors=errors,
    864             newline="",
    865         )
    866     else:
    867         # Binary mode
    868         handle = open(handle, ioargs.mode)

FileNotFoundError: [Errno 2] No such file or directory: '..iris.csv'
```

The error above is a result of '..iris.csv' directory path referencing a directory rather a single file.

4. What does the df.head function do? Enter your answer by adding a new code block and use markdown.

The df.head() function will display the first five (5) records of the given DataFrame.

In [11]:
```
df.head()
```

Out[11]:

	Id	SepalLengthCm	SepalWidthCm	PetalLengthCm	PetalWidthCm	Species
0	1	5.1	3.5	1.4	0.2	Iris-setosa
1	2	4.9	3.0	1.4	0.2	Iris-setosa
2	3	4.7	3.2	1.3	0.2	Iris-setosa
3	4	4.6	3.1	1.5	0.2	Iris-setosa
4	5	5.0	3.6	1.4	0.2	Iris-setosa

In [12]:
```
df.tail()
```

Out[12]:

	Id	SepalLengthCm	SepalWidthCm	PetalLengthCm	PetalWidthCm	Species
145	146	6.7	3.0	5.2	2.3	Iris-virginica
146	147	6.3	2.5	5.0	1.9	Iris-virginica
147	148	6.5	3.0	5.2	2.0	Iris-virginica
148	149	6.2	3.4	5.4	2.3	Iris-virginica
149	150	5.9	3.0	5.1	1.8	Iris-virginica

5. What is different between the output of the df.head() in your linear regression homework and this

logistic regression homework? Enter your answer by adding a new code block and use markdown.

df.head() within linear regression reflects the relationship between the independent and dependent variables, while logistic regression df.head() will reflect the relationship between the independent variable and the target variable.

Preprocess the Dataset

6. What is happening in the code block below? Enter your answer by adding a new code block and use markdown.

In [13]:

```
# mark zero values as missing or NaN
df[[ 'SepalLengthCm' , 'SepalWidthCm' , 'PetalLengthCm' ,'PetalWidthCm' ]] \
= df[['SepalLengthCm' , 'SepalWidthCm' ,'PetalLengthCm' , 'PetalWidthCm' ]].replace(0,
# 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
```

In the code block above, we are (1) replacing all the zeroed values with null a null indicator (NaN), then we are printing the sum all of the null values within in the each column index.

Performing the Exploratory Data Analysis (EDA)

7. What is happening when df.shape is being called and how many rows and columns are in the dataset? Enter your answer by adding a new code block and use markdown.

In [14]:

```
print("Shape of the dataset(rows, columns):",df.shape)
```

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

When df.shape() is called, it shows the dimensions of a Dataframe - it shows the rows by columns of a DataFrame. For this dataset in particular, it has 150 rows and 6 columns.

8. What is happening when df.dtypes is being called. Enter your answer by adding a new code block and

use markdown.

When df.dtypes is being called, it show the data types of each column index.

In [16]:

```
#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
dtype: object
```

9. What is happening when df.describe is being called? Enter your answer by adding a new code block and use markdown.

In [17]:

```
df.describe()
```

Out[17]:

	Id	SepalLengthCm	SepalWidthCm	PetalLengthCm	PetalWidthCm
count	150.000000	150.000000	150.000000	150.000000	150.000000
mean	75.500000	5.843333	3.054000	3.758667	1.198667
std	43.445368	0.828066	0.433594	1.764420	0.763161
min	1.000000	4.300000	2.000000	1.000000	0.100000
25%	38.250000	5.100000	2.800000	1.600000	0.300000
50%	75.500000	5.800000	3.000000	4.350000	1.300000
75%	112.750000	6.400000	3.300000	5.100000	1.800000
max	150.000000	7.900000	4.400000	6.900000	2.500000

When df.describe() is called, it provides brief statistics of a given dataset.

10. What is the mean of SepalWidthCM? Enter your answer by adding a new code block and use markdown.

SepalWidthCm is the column index or name for the sepal width (in centimeters) of a each iris flower.

11. What is the mean of PetalWidthCM? Enter your answer by adding a new code block and use markdown.

PepalWidthCm is the column index or name for the petal width (in centimeters) of a each iris flower.

12. What is the count of PetalLengthCM? Enter your answer by adding a new code block and use markdown.

PetalLegnthCm is the column index or name for the petal length (in centimeters) of a each iris flower.

In [19]:

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

```
               Id  SepalLengthCm  SepalWidthCm  PetalLengthCm  PetalWidthCm
count  150.000000     150.000000    150.000000     150.000000    150.000000
mean    75.500000       5.843333      3.054000       3.758667      1.198667
std     43.445368       0.828066      0.433594       1.764420      0.763161
min      1.000000       4.300000      2.000000       1.000000      0.100000
25%     38.250000       5.100000      2.800000       1.600000      0.300000
50%     75.500000       5.800000      3.000000       4.350000      1.300000
75%    112.750000       6.400000      3.300000       5.100000      1.800000
max    150.000000       7.900000      4.400000       6.900000      2.500000
```

13. What does the df.groupby.size() function do? Enter your answer by adding a new code block and use markdown.

In [20]:

```
print(df.groupby('Species').size())
```

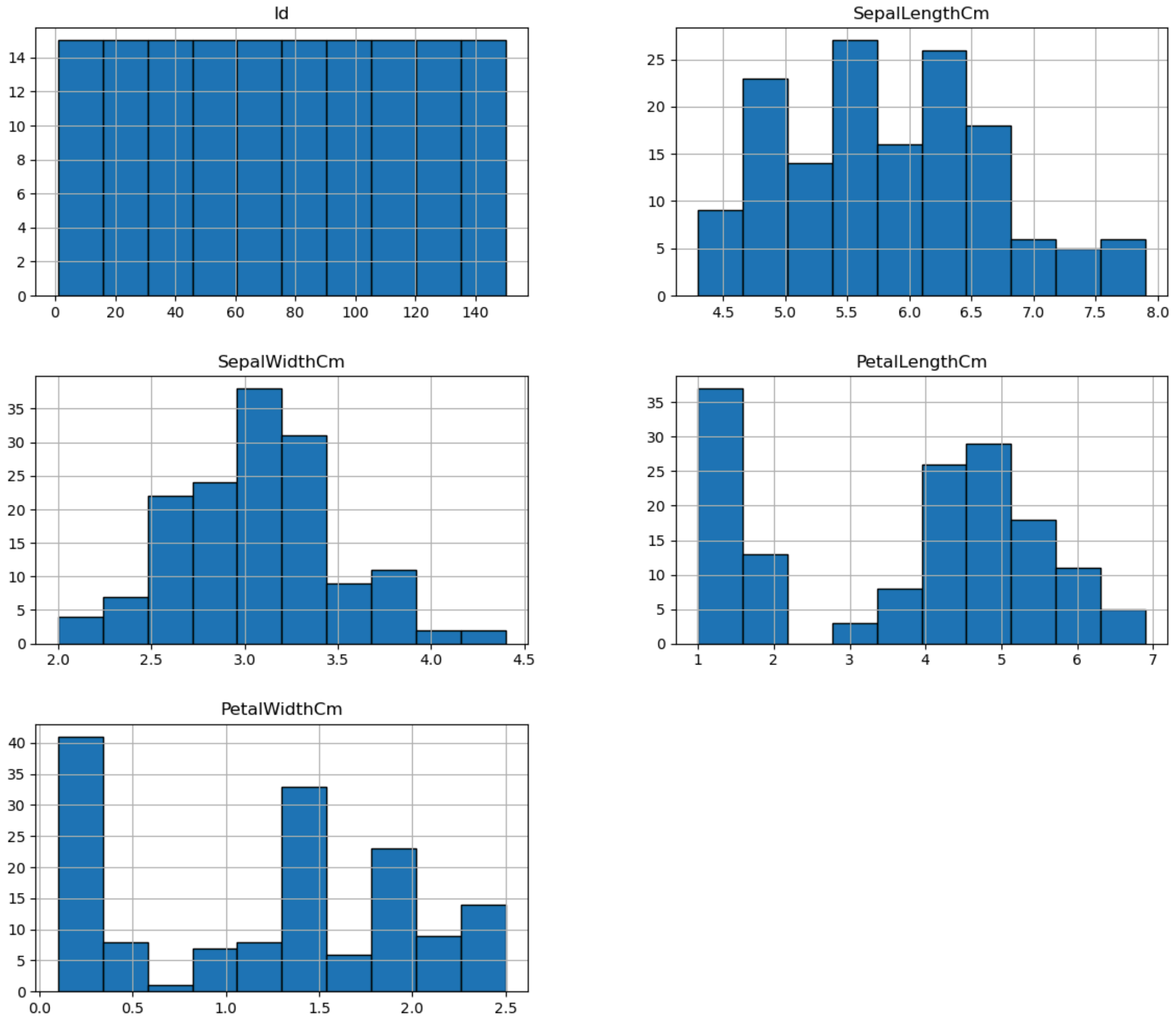
```
Species
Iris-setosa        50
Iris-versicolor    50
Iris-virginica     50
dtype: int64
```

When the df.groupby.size() function is called, it will two things: (1) it will group the dataset by a specified category, (2) it will return the cumulative sum of each category.

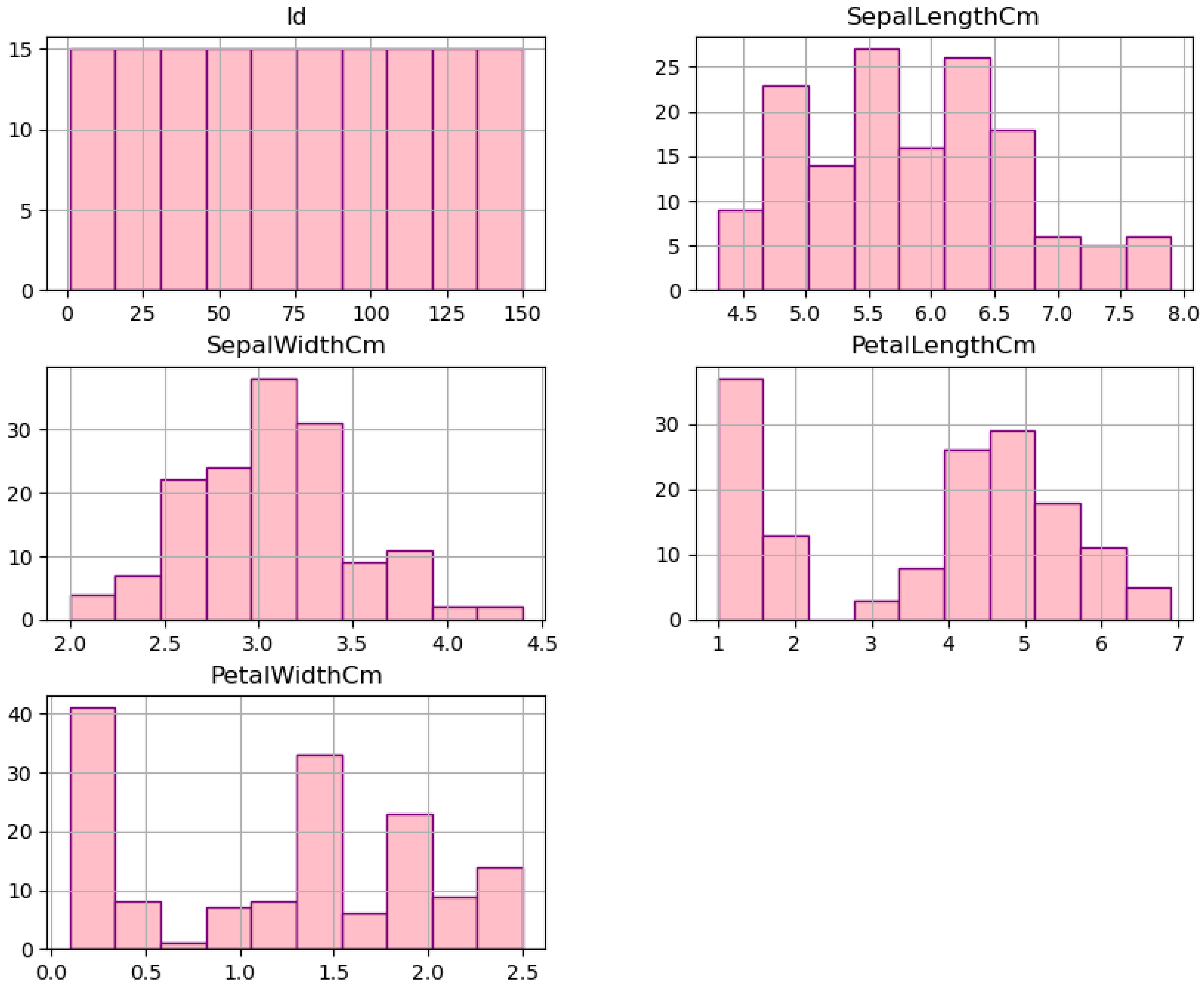
Creating a Histogram

In [21]:

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

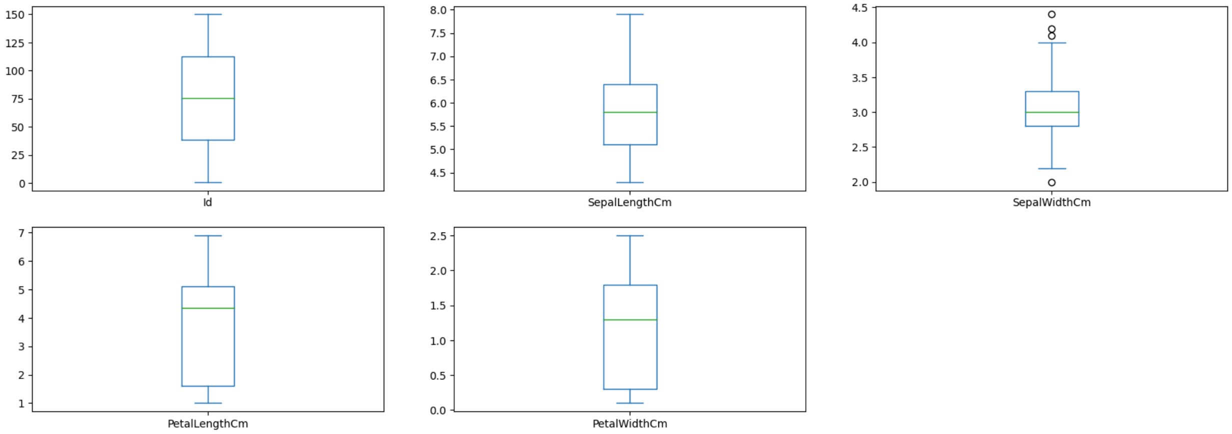


In [23]:
```
# Plot histogram for each variable. I encourage you to work with the histogram. Rememb
df.hist(color = "pink", edgecolor= 'purple',figsize=(10,8))
plt.show()
```

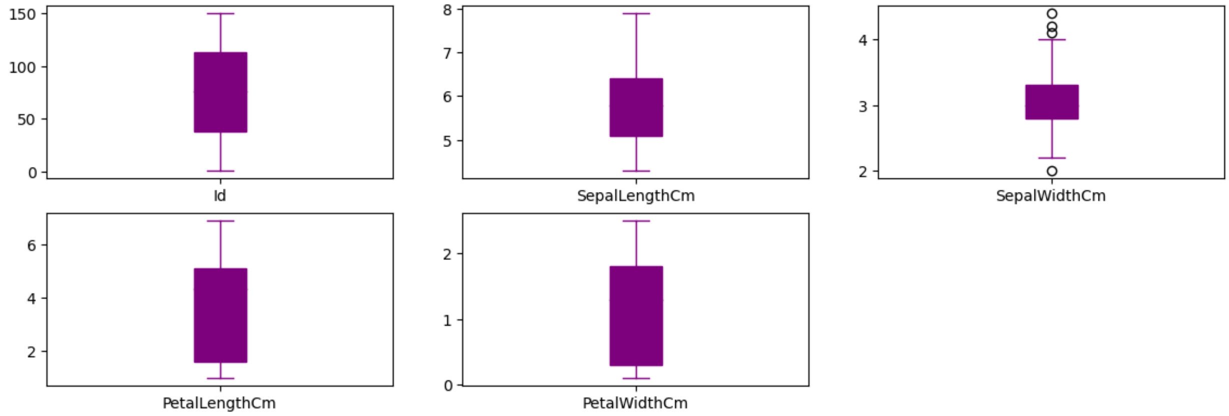


Creating a Box Plot

In [24]:
```
# Boxplots
df.plot(kind="box", subplots=True, layout=(5,3), sharex=False, figsize=(20,18))
plt.show()
```



In [26]:
```
# Boxplots
df.plot(kind="box", subplots=True, layout=(5,3), sharex=False, figsize=(14,12), color
plt.show()
```



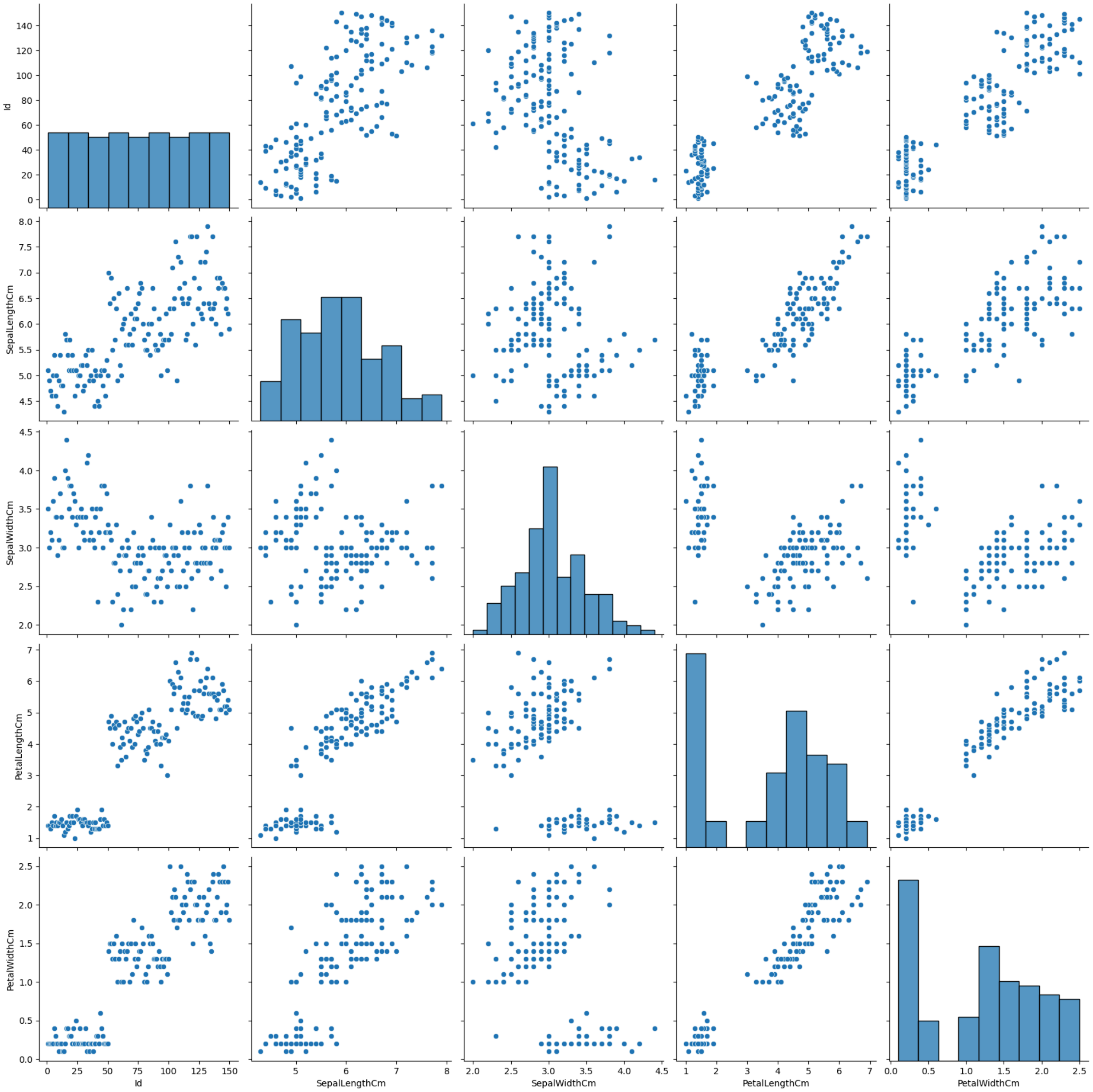
Create a Pair Plot

14. What does a pair plot illustrate? Enter your answer by adding a new code block and use markdown.

In [27]:

```
# Please click on the aobe URL to learn more about Pair Plots
sns.pairplot(df, height=3.5);
plt.show()
```

```
C:\Users\deaun\anaconda3\Lib\site-packages\seaborn\axisgrid.py:118: UserWarning: The
figure layout has changed to tight
  self._figure.tight_layout(*args, **kwargs)
```

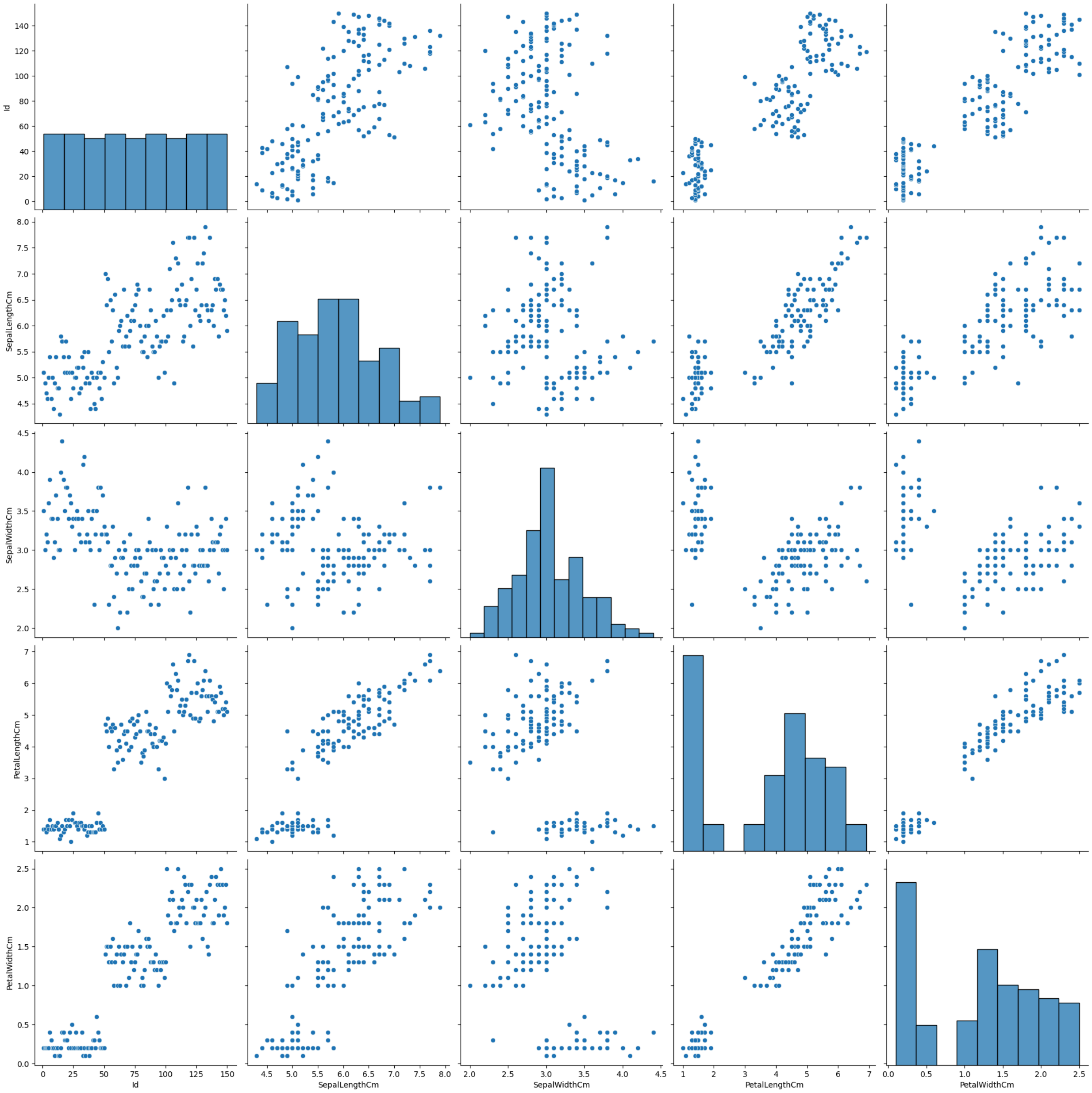


Pair plot shows the relationship between variable.

15. Create a new sns.pairplot using a height of 4.0. Enter your answer by adding a new code block and use code.

In [31]:
```
sns.pairplot(df, height=4);
plt.show()
```

```
C:\Users\deaun\anaconda3\Lib\site-packages\seaborn\axisgrid.py:118: UserWarning: The
figure layout has changed to tight
  self._figure.tight_layout(*args, **kwargs)
```

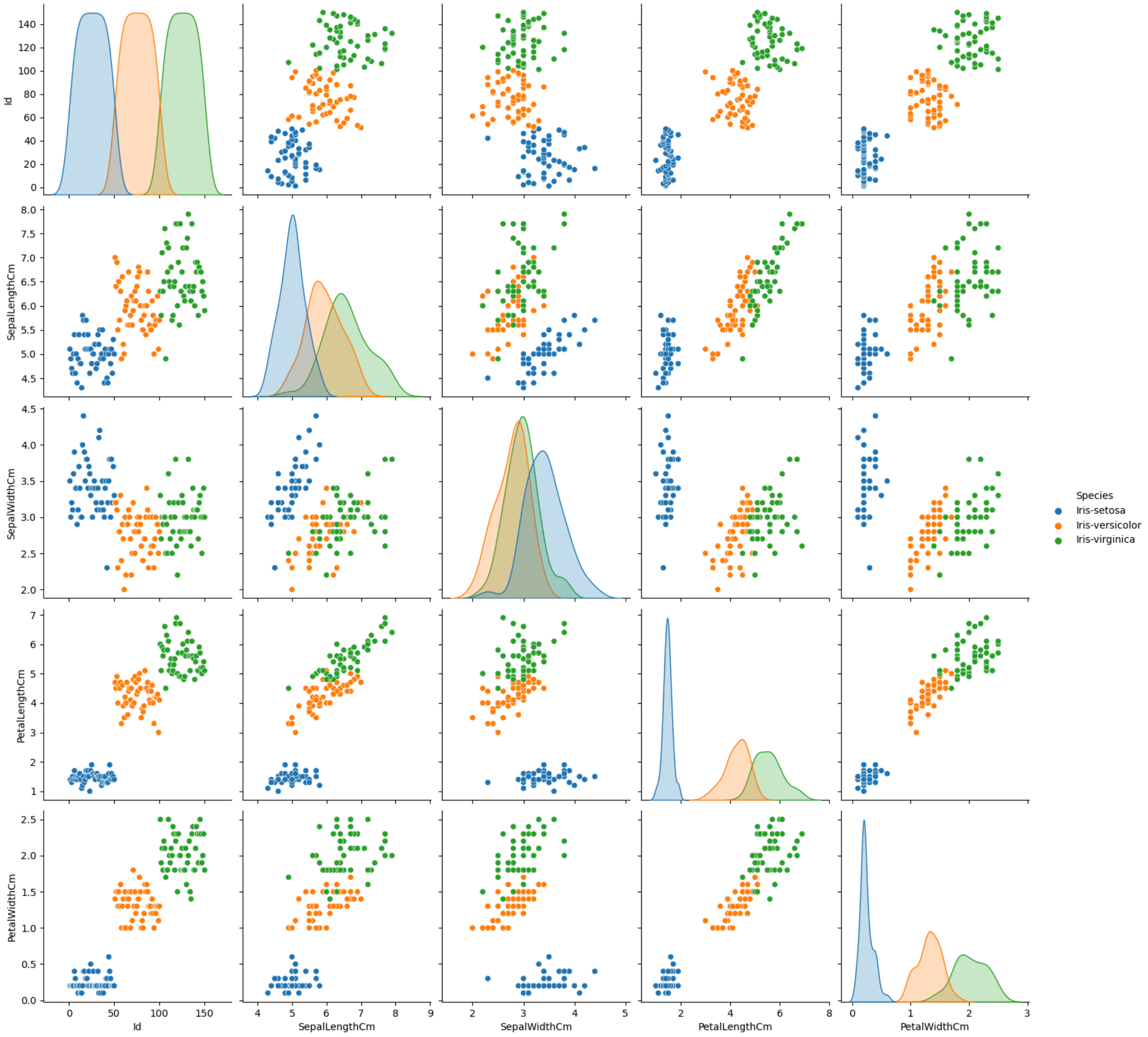


Creating a Pair Plot with Color

In [32]:

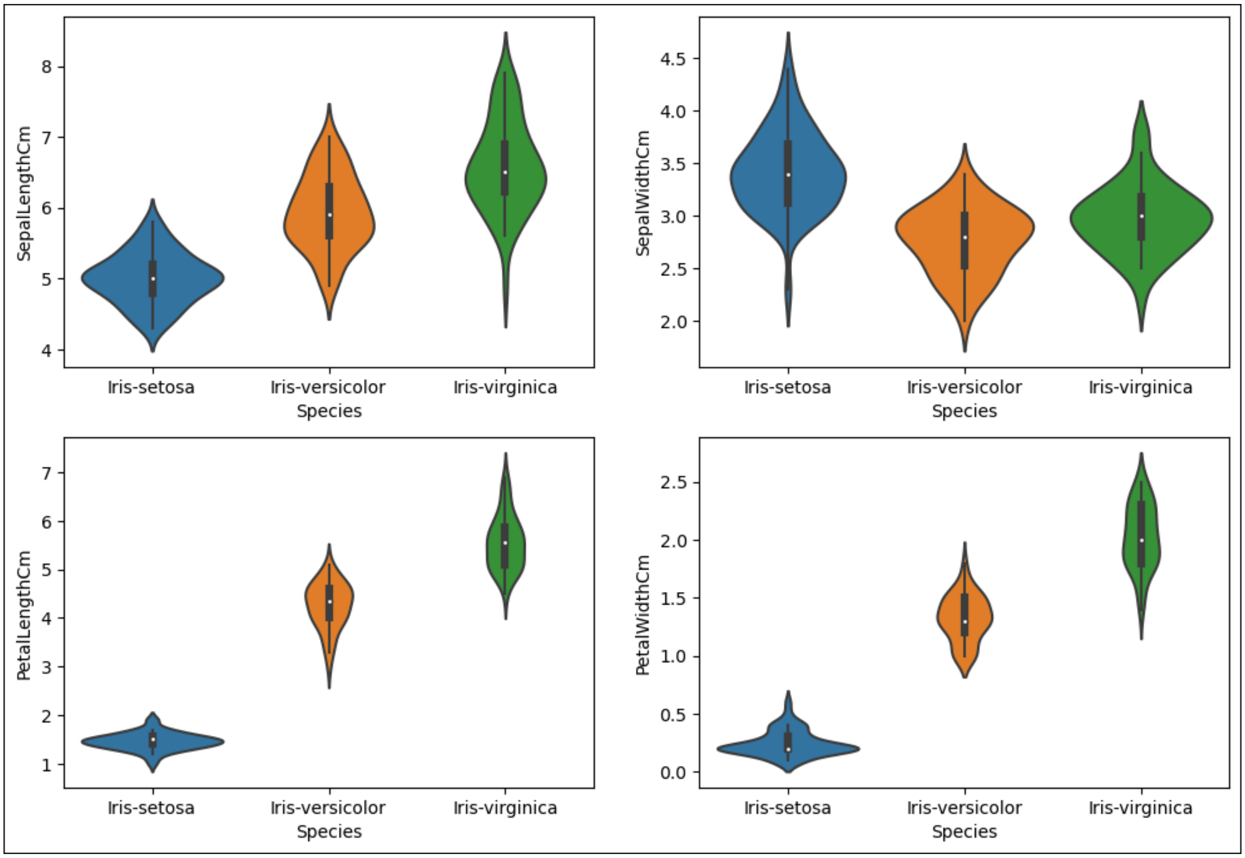
```
# Let's try that again using color.  Notice: assigning a hue variable adds a semantic
sns.pairplot(df, hue='Species', height=3, aspect= 1);
```

```
C:\Users\deaun\anaconda3\Lib\site-packages\seaborn\axisgrid.py:118: UserWarning: The
figure layout has changed to tight
  self._figure.tight_layout(*args, **kwargs)
```



Creating a Violin Plot

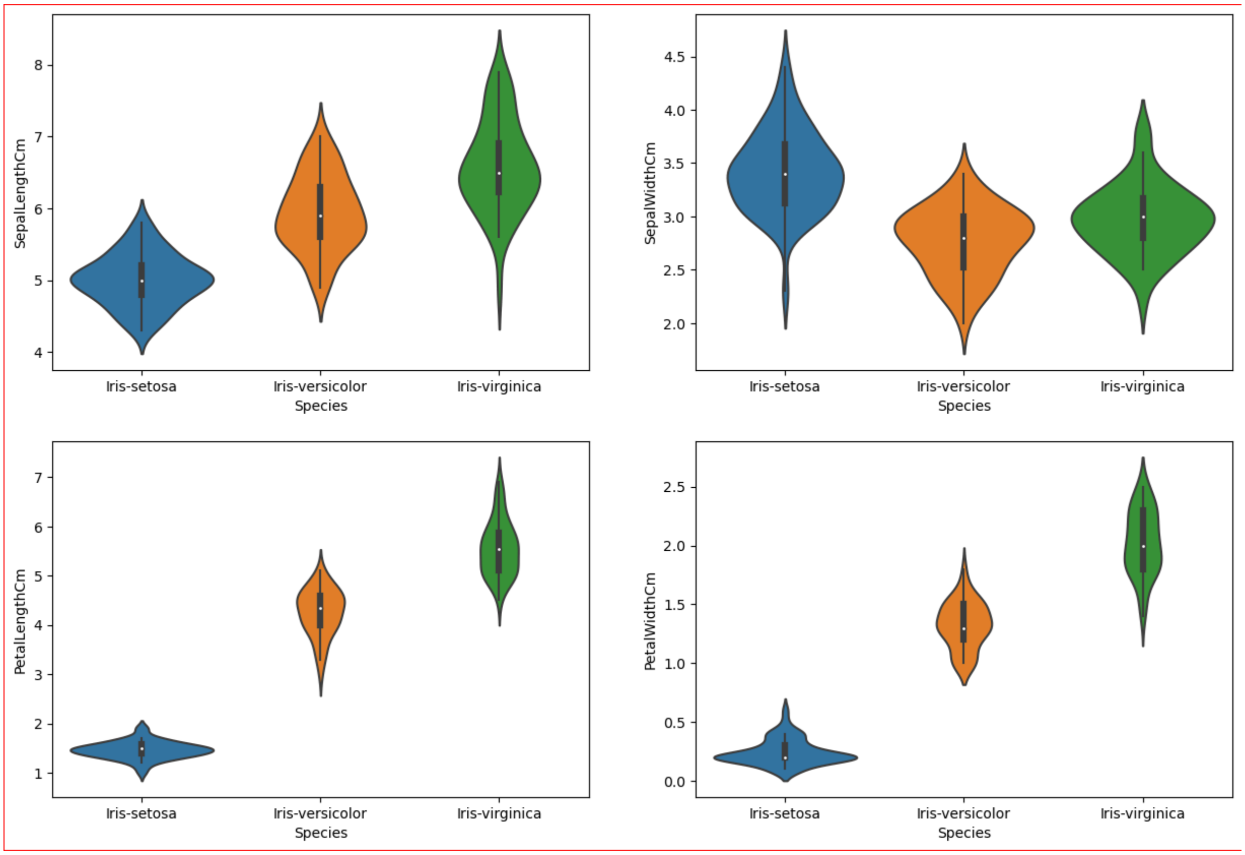
```
In [33]: #  Please click on the URL above to learn more about Violin Plots
plt.figure(edgecolor="black", linewidth= 1.2,figsize=(12,8));
plt.subplot(2,2,1)
sns.violinplot(x='Species', y = 'SepalLengthCm', data=df)
plt.subplot(2,2,2)
sns.violinplot(x='Species', y = 'SepalWidthCm', data=df)
plt.subplot(2,2,3)
sns.violinplot(x='Species', y = 'PetalLengthCm', data=df)
plt.subplot(2,2,4)
sns.violinplot(x='Species', y = 'PetalWidthCm', data=df);
```



16. Using above code that created a Violin Plot, add a new code block and change the edgecolor to 'red' and the figsize to 15, 10.) Don't forget to hit run.

In [34]:

```python
plt.figure(edgecolor="red", linewidth= 1.2,figsize=(15,10));
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);
```



Separate the Dataset into Input & Output NumPy Arrays

In [59]:

```
# 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]
```

17. What would you set the X = array to if you only wanted to use the first 100 rows? Enter your answer by adding a new code block and copy and paste the above code but change the code to reflect your answer. However, be sure to comment out all lines so only the original code block is used in the analysis.

In [60]:

```
# 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[:100,1:5] #inclues first 100 rows, columns from 1-5
```

```
# for Y(input) [:, 5] --> all the rows, column 5
# this is the value we are trying to predict
#Y = array[:,5]
```

Spilt into Input/Output Array into Training/Testing Datasets

In [61]:

```
# 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
#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_state=seed)
```

18. What seed are you using in the above code? Enter your answer by adding a new code block and use markdown.

We are using seven (7) as the seed value.

19. Why do we enter a seed value? Enter your answer by adding a new code block and use markdown.

We enter a seed value to show reproducibility - a seed value allow us to use the same value(s) when training and testing each experiment.

20. How do you know there is a 67/33 split? Enter your answer by adding a new code block and use markdown.

I know there there is a 67/33 split due to 'test_size' variable having the value of '0.33,' indicating that 33% would be for the testing the dataset, while the remaining 67% would be left for training the dataset.

Build and Train the Model

21. What is the model being used below? Enter your answer by adding a new code block and use markdown.

In [62]:

```
#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)
#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
```

Logistic Regression

Score the Accuracy of the Model

In [63]:

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

```
Accuracy: 92.000%
```

Classify/Prediction

> ### We have now trained the model. Let’s use the trained model to predict the type of flower we have with the listed values for each variable.

22. How would you enter comments to the model.predict to illustrate the variables and values that you used in your prediction? Enter your answer by adding a new code block and use markdown.

Predict Iris Class based on long petal length - PetalLengthCm > 2.0

In [64]:

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

Out[64]:

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

23. (Same as above, but with the second prediction. How would you enter comments to the model.predict to illustrate the variables and values that you used in your prediction? Enter your answer by adding a new code block and use markdown.

Predict Iris Class base on short petal length - PetalLengthCm < 2.0

In [68]:

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

Out[68]:

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

24. Make a new prediction by copying and pasting the code above into a new code block. Include comments to descibe your variable and their values. (EX. # PetalWidthCm = 7, etc.) Enter your answer by adding a new code block and use code. Don't forget to run the code.

In [70]:

```
#Predict Iris Class based on short sepal length - SepalWidthCm < 2.0
model.predict([[5, 1.5, 1.4, 1.5]])
```

Out[70]:

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

In [76]:

```
#PetalWidthCm = 6
model.predict([[5, 3.6, 1.4, 6]])
```

Out[76]:

```
array(['Iris-virginica'], dtype=object)
```

Evaluate the Model using the 10-fold Cross-Validation Technique.

In [77]:

```
# evaluate the algorythm# specify the number of time of repeated splitting, in this ca
n_splits=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 dataset into folds
# In k-fold cross-validation, the original sample is randomly partitioned into k
#subsamples. Of the k subsamples, a single subsample is retained as the validatio
#testing the model, and the remaining k 1 subsamples are used as training data. T
#process is then repeated k times, with each of the k subsamples used exactly onc
# the validation data. The k results can then be averaged to produce a single est
# advantage of this method over repeated random sub-sampling is that all observat
# both training and validation, and each observation is used for validation exact
kfold=KFold(n_splits, random_state=seed, shuffle=True)
# for logistic regression, we can use the accuracy level to evaluate the model /
scoring="accuracy"
#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
#result: the average of all the results obtained from the K-fold cross validation
print("Accuracy: %.3f (%.3f)"% (results.mean(), results.std()))
```

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

25. What other splits are recommended for n_splits? Enter your answer by adding a new code block and use markdown.

For k-fold in particular, other than 10-fold splits, 5-fold splits are recommended. It is best to use a small k-fold, to ensure balance between resampling subsets and lessening biases. Other splits in general, it is recommended to use Stratified Shuffle Splits and Time Series Splits; each has their own advantages and disadvantags.

26. Please leave any comments or questions you may have by adding a new code block and using markdown.