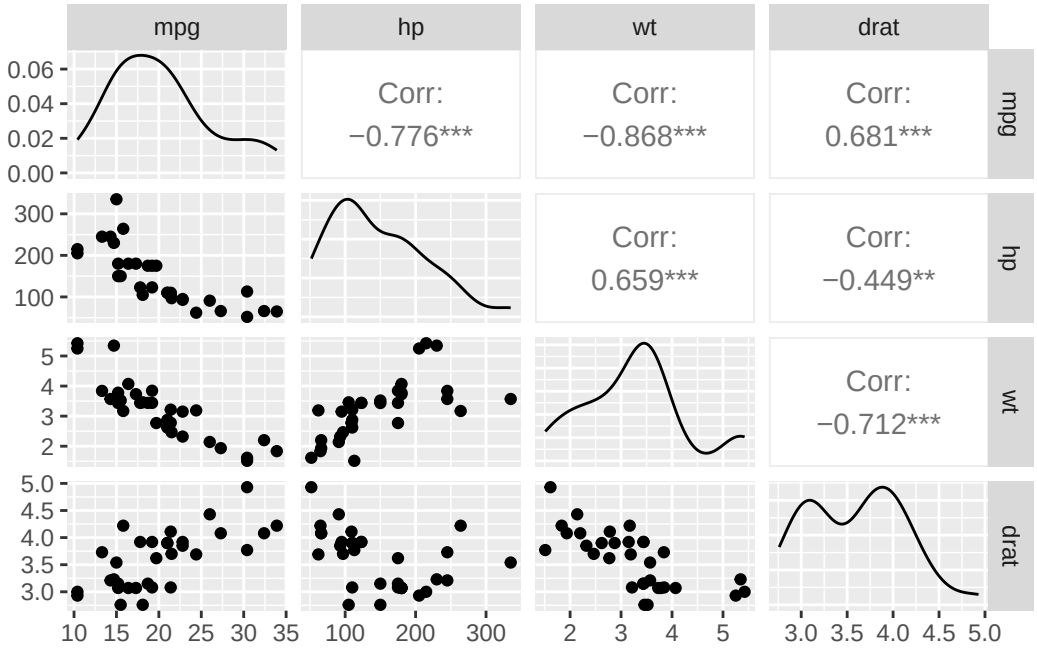
Homework & Friday Quiz

The `mtcars` dataset is a classic and widely used dataset in R that contains specifications and performance data for 32 different car models from the 1974 Motor Trend magazine. Each row represents a unique vehicle, and each column records a specific attribute related to engine performance, design, or efficiency. Some key variables include `mpg` (miles per gallon), `hp` (gross horsepower), `wt` (weight in 1000 lbs), `drat` (rear axle ratio), and `qsec` (quarter-mile time). Additionally, the dataset includes categorical variables encoded as numeric values, such as `cyl` (number of cylinders), `am` (transmission type), and `gear` (number of forward gears).

This dataset is frequently used in regression modeling and statistical learning due to its compact size, real-world relevance, and mixture of quantitative and categorical variables. Analysts often model fuel efficiency (`mpg`) as a function of other variables to understand how engine power, vehicle weight, or gear ratios impact gas mileage. With its balance of complexity and interpretability, `mtcars` serves as a great playground for developing skills in exploratory data analysis, model selection, variable interpretation, and diagnostics in both teaching and applied settings.

Exploratory Visualization

```
mtcars %>%
  select(mpg, hp, wt, drat) %>%
  ggpairs()
```



Model 1: `mpg ~ hp`

```r
model1 <- lm(mpg ~ hp, data = mtcars)
summary(model1)
```

```
Call:
lm(formula = mpg ~ hp, data = mtcars)

Residuals:
    Min      1Q  Median      3Q     Max
-5.7121 -2.1122 -0.8854  1.5819  8.2360

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept) 30.09886    1.63392  18.421  < 2e-16 ***
hp          -0.06823    0.01012  -6.742 1.79e-07 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 3.863 on 30 degrees of freedom
Multiple R-squared:  0.6024,    Adjusted R-squared:  0.5892
F-statistic: 45.46 on 1 and 30 DF,  p-value: 1.788e-07
```

```
               type    RSS  RSE  R2 Adj_R2    AIC    BIC
1 Model 1: mpg ~ hp 447.67 3.86 0.6   0.59 181.24 185.64
```

Model 2: `mpg ~ hp + wt`

```r
model2 <- lm(mpg ~ hp + wt, data = mtcars)
summary(model2)
```

```
Call:
lm(formula = mpg ~ hp + wt, data = mtcars)

Residuals:
   Min     1Q Median     3Q    Max
-3.941 -1.600 -0.182  1.050  5.854

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept) 37.22727    1.59879  23.285  < 2e-16 ***
hp          -0.03177    0.00903  -3.519  0.00145 **
wt          -3.87783    0.63273  -6.129 1.12e-06 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 2.593 on 29 degrees of freedom
Multiple R-squared:  0.8268,    Adjusted R-squared:  0.8148
F-statistic: 69.21 on 2 and 29 DF,  p-value: 9.109e-12
```

```
                   type    RSS  RSE   R2 Adj_R2    AIC    BIC
1 Model 2: mpg ~ hp + wt 195.05 2.59 0.83   0.81 156.65 162.52
```

```r
# Partial F-test: Does adding wt help?
anova(model1, model2)
```

```
Analysis of Variance Table

Model 1: mpg ~ hp
Model 2: mpg ~ hp + wt
  Res.Df    RSS Df Sum of Sq      F   Pr(>F)
1     30 447.67
2     29 195.05  1    252.63 37.561 1.12e-06 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Model 3: `mpg ~ hp + wt + drat`

```r
model3 <- lm(mpg ~ hp + wt + drat, data = mtcars)
summary(model3)
```

```
Call:
lm(formula = mpg ~ hp + wt + drat, data = mtcars)

Residuals:
    Min      1Q  Median      3Q     Max
-3.3598 -1.8374 -0.5099  0.9681  5.7078

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept) 29.394934   6.156303   4.775 5.13e-05 ***
hp          -0.032230   0.008925  -3.611 0.001178 **
wt          -3.227954   0.796398  -4.053 0.000364 ***
drat         1.615049   1.226983   1.316 0.198755
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 2.561 on 28 degrees of freedom
Multiple R-squared:  0.8369,    Adjusted R-squared:  0.8194
F-statistic: 47.88 on 3 and 28 DF,  p-value: 3.768e-11
```

```
                          type    RSS  RSE   R2 Adj_R2    AIC    BIC
1 Model 3: mpg ~ hp + wt + drat 183.68 2.56 0.84   0.82 156.73 164.06
```

```r
# Partial F-test: Does adding drat help?
anova(model2, model3)
```

```
Analysis of Variance Table

Model 1: mpg ~ hp + wt
Model 2: mpg ~ hp + wt + drat
  Res.Df    RSS Df Sum of Sq      F Pr(>F)
1     29 195.05
2     28 183.68  1    11.366 1.7326 0.1988
```

Model Comparison Summary

```
bind_rows(model1_metrics, model2_metrics, model3_metrics)
```

```
                          type    RSS  RSE   R2 Adj_R2    AIC    BIC
1            Model 1: mpg ~ hp 447.67 3.86 0.60   0.59 181.24 185.64
2        Model 2: mpg ~ hp + wt 195.05 2.59 0.83   0.81 156.65 162.52
3 Model 3: mpg ~ hp + wt + drat 183.68 2.56 0.84   0.82 156.73 164.06
```