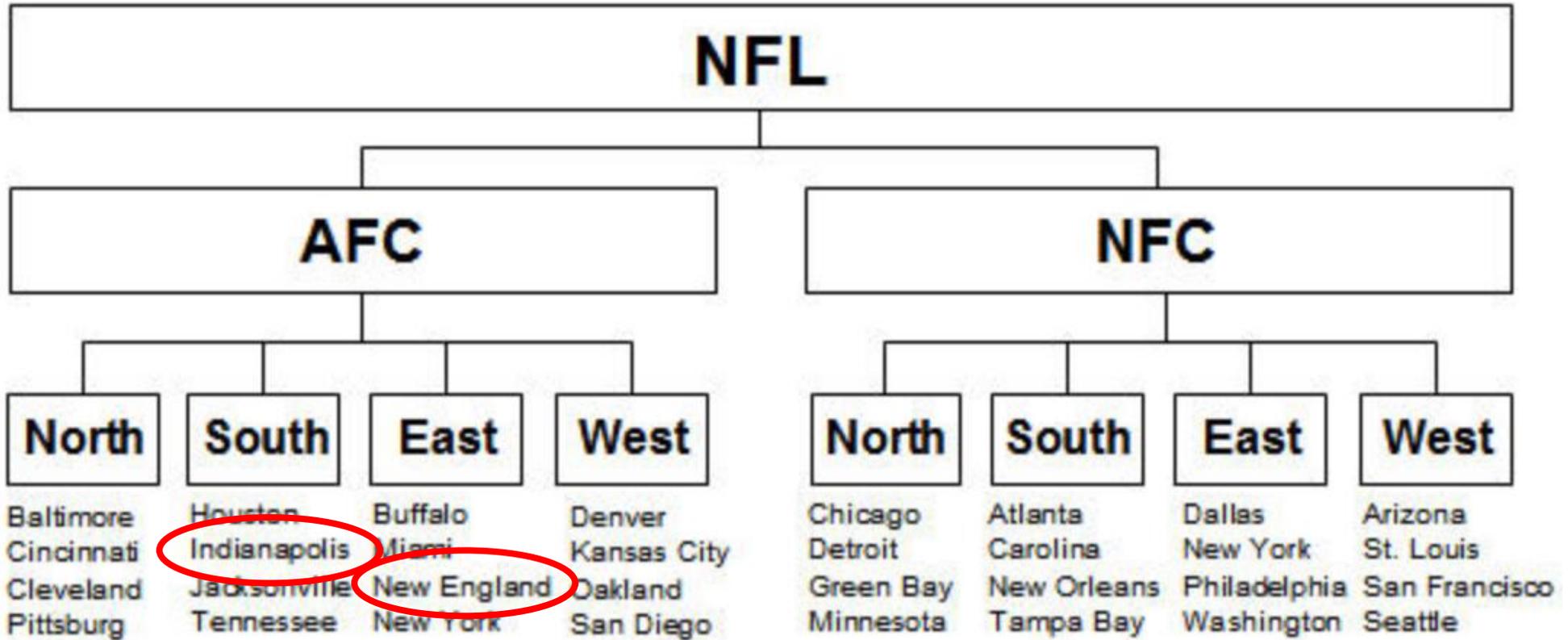
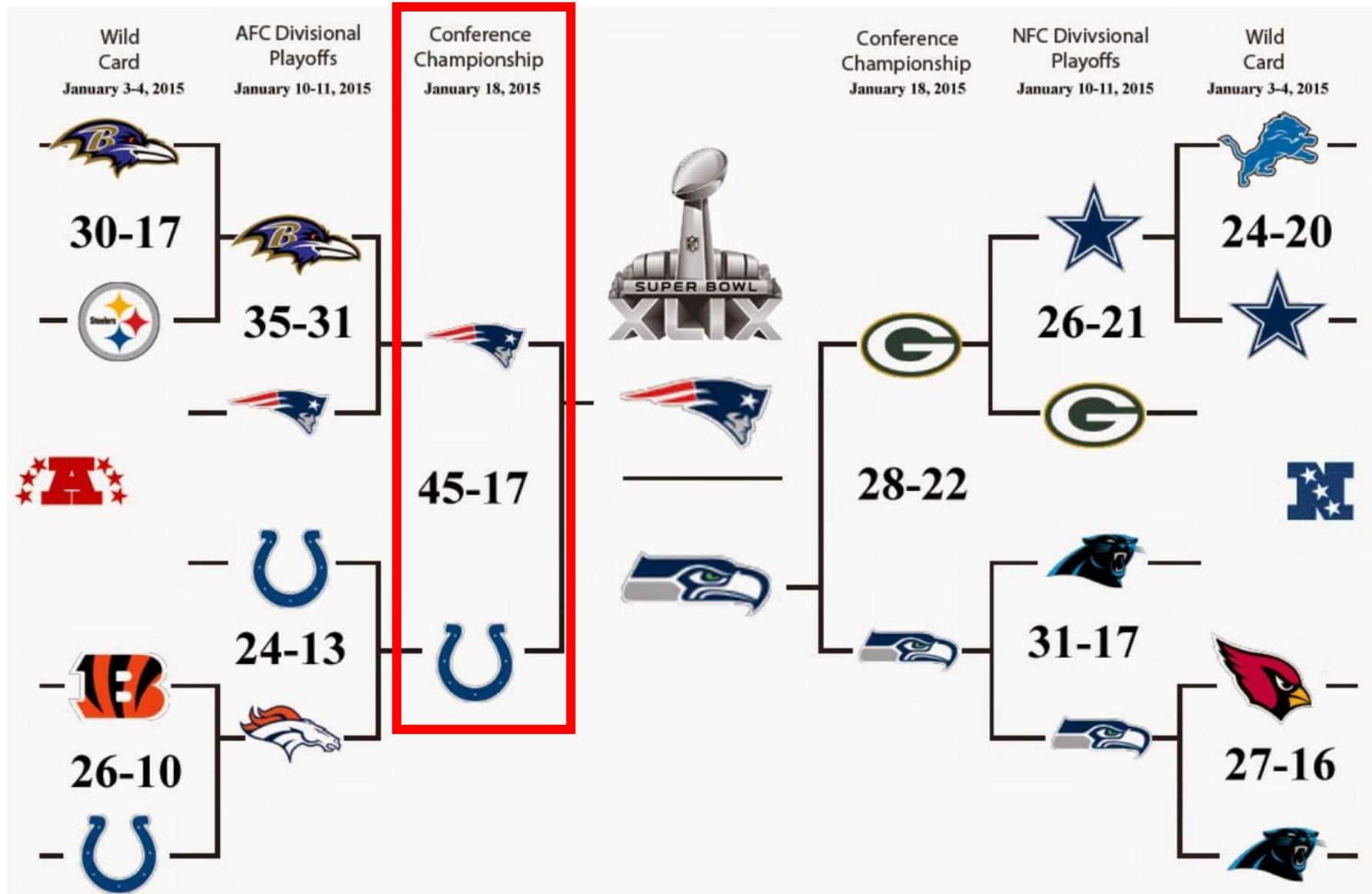


Naughty or Nature—Bringing Chemistry to Deflategate





Bit of Background



So what exactly happened?

January 18th, 2015 the New England Patriots squared off with the Indianapolis Colts for the American Football Conference (AFC) Championship game at Gillette Stadium in Foxborough, MA. During the first half of the game, the Colts raised suspicions about the inflation pressure of the Patriot's footballs. This led the officials to check the pressure of both the Patriot's and the Colt's footballs at half-time. They found that all eleven of the Patriot's balls were under-inflated (less than 12.5 psig) using two different pressure gauges, whereas, the four Colt's balls tested were within the accepted pressure range of 12.5-13.5 (psig) on at least one of the two pressure gauges used. At the time, the referees filled the Patriot's balls to the proper pressure, and the game concluded uneventfully with a convincing win for the New England Patriots, 45-7.

The media immediately began to speculate as to the cause of the underinflated footballs. Detractors suspected deliberate tampering with the balls' pressure, while supporters reasoned it was merely a result of the cold field conditions that day. In an effort to quell these suspicions, the NFL announced that they had hired an independent law firm, Paul, Weiss, Rifkind, Wharton and Garrison (PWRWG), to lead an investigation. PWRWG assembled an investigative team that included Exponent, a USA scientific and engineering consulting firm, and Daniel Marlow, professor of physics at Princeton University. And so the investigation and data collection began.



Vox

OFFICIAL BALL DIMENSIONS

The ball shall be inflated
12½ to 13½ lbs.



11 to 11¼
inches long

21 to 21¼
inches
around

Part 1

With your group members, make a list of **all the information** you would like to have in order to answer the following question:

“Could the under-inflated footballs be the result of the environmental conditions of the day?”

Potential Impact of Physical Factors

The scientific and engineering firm investigating the case, Exponent, ran a series of tests and concluded the following:

The impact of game use on ball pressure- Performed load test of 650 lbs/sec for 1000 cycles and found it did not affect the ball pressure

The impact of repeated insertions of an inflation needle into the football- Based on the information provided by referees, it is most likely that each ball was tested three times. The investigation showed a loss of 0.01psig/needle insertion. Therefore, they concluded that the pressure change was not significant.

The natural leak rate and permeability of properly functioning footballs- The permeability tests found the balls were functioning properly and no significant loss was detected.

The relative humidity of the air in the room(s) in which the footballs were inflated- Tested using humidity chambers and found to have no significant effect on pressures.

Variation of the volume of the footballs- Tested the volume of the footballs using a high resolution laser scan at the various relevant pressures (10.5 to 13.5 psi) and moisture conditions and found that the volume of the ball was constant. In addition, the volume of an NFL football was found to be 4.24 L.

The different treatments used by the Patriots and the Colts to condition the surface of the balls prior to the game, such as the vigorous rubbing described by the Patriots as a step in the process used to break in their footballs.

Tested using an infrared camera and found that rubbing increased the pressure slightly, but it returned to normal after 30 minutes.

The report concluded that no combination of these factors was sufficient to explain the lower than expected pressure of the Patriot's footballs.

Part 2

Assume you have all the information you need to answer the questions you generated. **What would be your next step?** Which questions are relevant to answering the question? How would you analyze the data? What scientific principles are you employing in analyzing the data? What equations would you need? How would you interpret the results?

Chemistry Information That You Should Know

$$PV = nRT \qquad \frac{P_1V_1}{n_1T_1} = \frac{P_2V_2}{n_2T_2}$$

Gauge Pressure vs. Absolute Pressure

Gauge Pressure—The pressure measured using a pressure gauge; it is the difference between atmospheric pressure and the pressure inside the object (the ball). Its units are typically expressed in “psig”—pounds per square inch gauge

Absolute Pressure—The “true” pressure inside the object, calculated as the sum of the atmospheric pressure and the pressure of the gas in the object.

- To use the ideal gas law, you must use **absolute pressure**
- To convert psig to psi, simply add 14.7 psi

Chemistry Information That You Should Know

When using the ideal gas law, the units you choose will affect the gas constant, R.

$$R = .0821 \text{ L} \cdot \text{atm/mol} \cdot \text{K}$$

$$R = 62.32 \text{ L} \cdot \text{mmHg/mol} \cdot \text{K}$$

$$R = 8.31 \text{ L} \cdot \text{kPa/mol} \cdot \text{K}$$

2 Important Conversions

$$^{\circ}\text{F} \rightarrow \text{K} \quad \text{K} = (^{\circ}\text{F} - 32)5/9 + 273.15$$

$$1 \text{ atm} = 14.7 \text{ psi}$$

Part 3—Here is your data

Use the data presented in the Well's Report (given to you by your teacher) to perform any necessary calculations. Then use your knowledge of scientific inquiry, the Kinetic Molecular theory and gas laws to answer the original question.

"Could the under-inflated footballs be the result of the environmental conditions of the day?"

Part 4—Construction of Argument

“Could the under-inflated footballs be the result of the environmental conditions of the day?”

Write an explanation in the Claim, Evidence, and Reasoning (CER) format, that answers the original question. According to the CER model, a scientific explanation consists of:

- A claim that answers the original question (not a yes/no answer)
- Evidence from data, calculations made, and any other known theoretical information that support the claim. This should tell the reader “what you determined” from the data without making interpretations of the evidence (i.e. “we found the average pressure of the footballs used was 12.2 psi”)
- Reasoning that involves an analysis (interpretation) of what the evidence means and explanation of the scientific principle (e.g. ideal gas law or combined gas law) that justifies why the evidence supports the claim.

Part 5—Presentation

Prepare to present and defend your findings to the class. Your presentation should include a brief PowerPoint (or Google Slides) presentation of 3-4 slides with your Claim, Evidence, and Reasoning. Include all data you used in your analysis and the scientific principle(s) used.