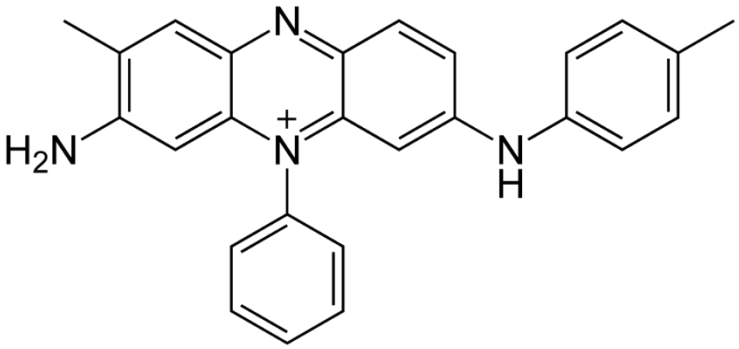
FD&C Dye Content of Popular Children's Beverages

- What is an FD&C dye?
- Why quantify them?
- How to quantify
- Results

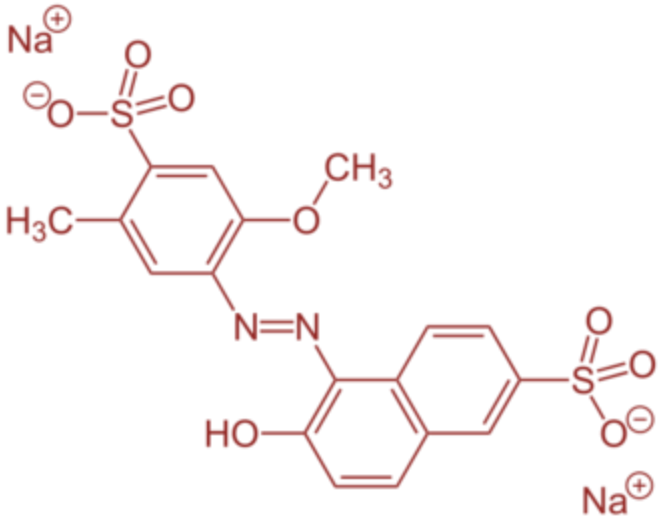
A Brief History of Food Coloring

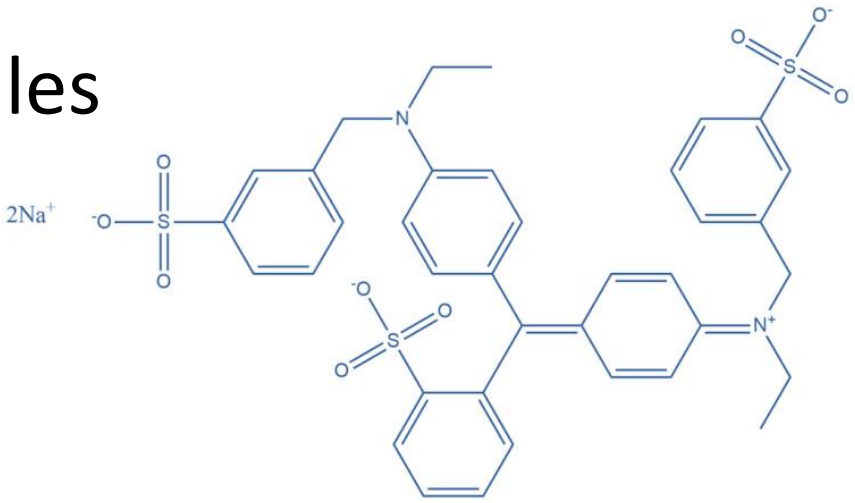
- First century – smoke and aloe in wine
- $PbCrO_4$ in milk
- PbO_2 in bread
- $CuSO_4$ in tea

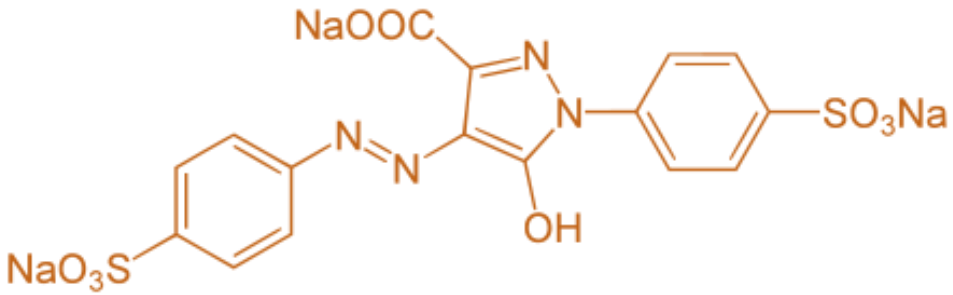


What is an FD&C Dye?

- Originally derived from coal tar
- Large, conjugated molecules

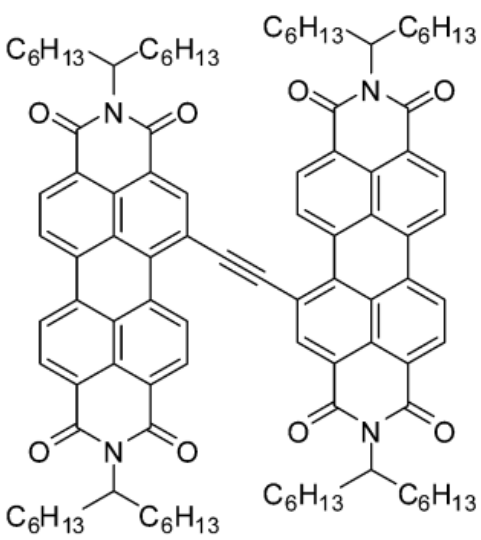




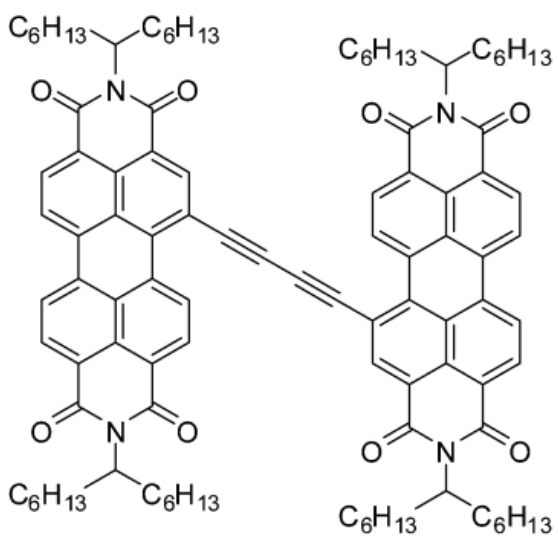


Conjugated Systems

More conjugation = longer wavelength absorbed



PEP



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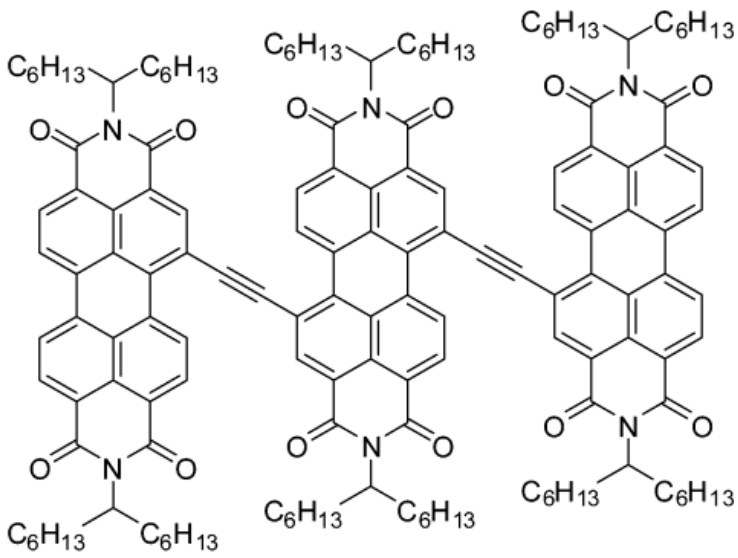

PEPEP

Cho, J., Yoo, H., Lee, J., Yan, Q., Zhao, D., Kim, D. *J. Phys. Chem. Lett.*, **2014.** 5(*21*), 3895-3901

Physical properties of Red 40, Blue 1, and Yellow 5.

FD&C Dye	Molecular Weight ($g \cdot mol^{-1}$)	λ_{max} (nm)	Molar absorptivity ($L \cdot mol^{-1} \cdot cm^{-1}$)
Red 40	496.42	505	25023
Blue 1	791.84	630	105431
Yellow 5	534.30	429	21208

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Are they safe?

- "Generally recognized as safe" by the FDA
- Allergic reactions
- Attention deficit
- Cancer?

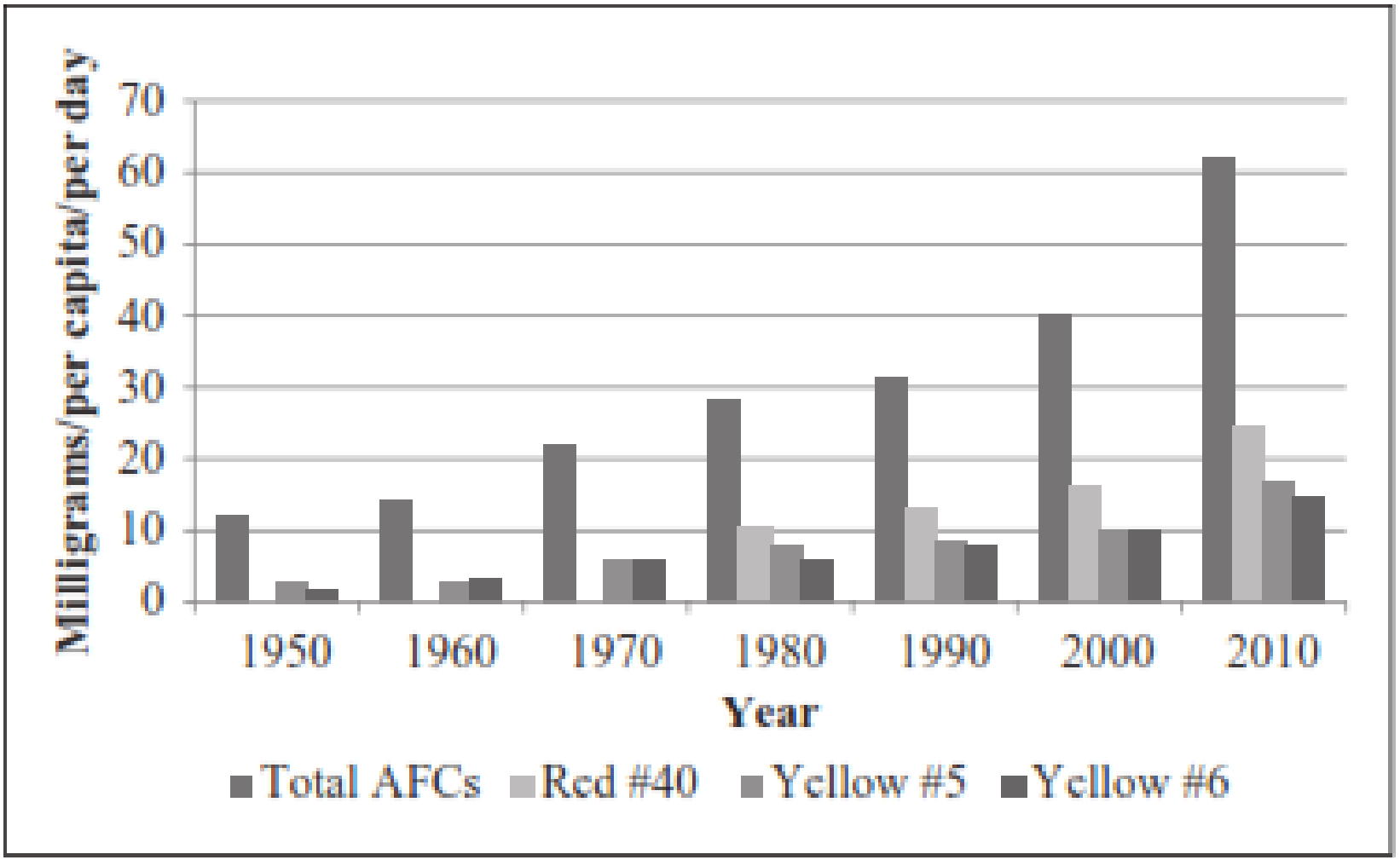
Aungst, J. *Background Document for the Food Advisory Committee*. **2011.**

How much do Americans consume?

Table 2. Amounts of Artificial Food Colors Consumed in the United States by Children in 1977, Consumers Only[a,b].

FD&C Color	Age (Years)	No. of Children	Intake (mg) by Age and Percentiles				
			Mean	50%	90%	95%	99%
Red #40							
	2-5	903	26.0	22.0	50.0	84.0	95.0
	6-12	1776	35.0	27.0	56.0	68.0	90.0
	13-17	1133	33.0	28.0	62.0	75.0	100
Yellow #5							
	2-5	903	13.0	11.0	23.0	28.0	37.0
	6-12	1776	15.0	13.0	25.0	29.0	37.0
	13-17	1133	15.0	13.0	27.0	31.0	41.0
Yellow #6							
	2-5	903	12.0	11.0	21.0	23.0	34.0
	6-12	1776	14.0	13.0	24.0	29.0	41.0
	13-17	1133	14.0	12.0	25.0	30.0	38.0
Blue #1							
	2-5	903	3.9	2.9	8.1	9.7	15.0
	6-12	1776	4.5	3.8	8.7	11.0	15.0
	13-17	1133	4.6	3.9	9.1	12.0	16.0

Batada, A., & Jacobson, M. F. *Clinical Pediatrics*. **2016,** *55*(12), 1113-1119.



Batada, A., & Jacobson, M. F. *Clinical Pediatrics*. **2016,** *55*(12), 1113-1119.

- What is an FD&C dye?
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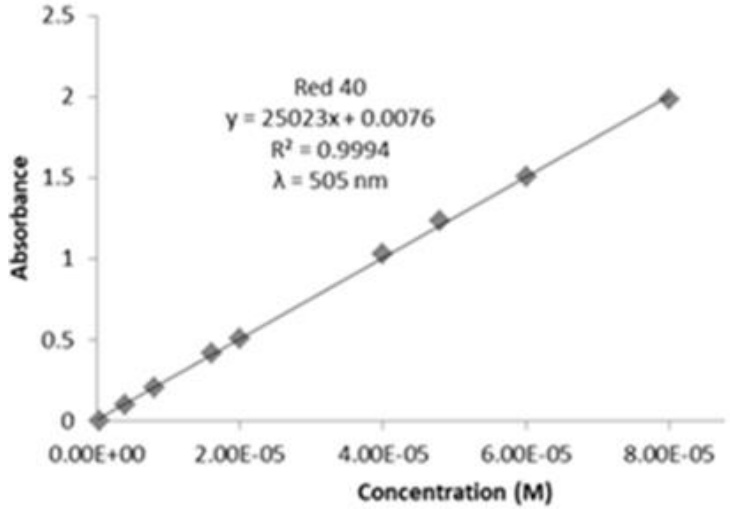
Experimental

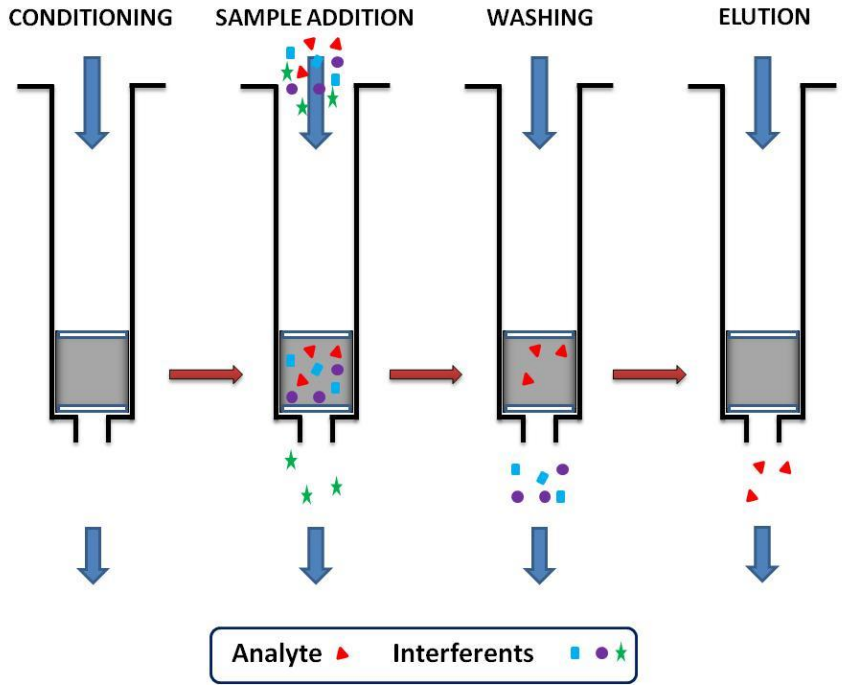
- Calibration curve and Beer's Law

$$A = \varepsilon bc$$



Experimental

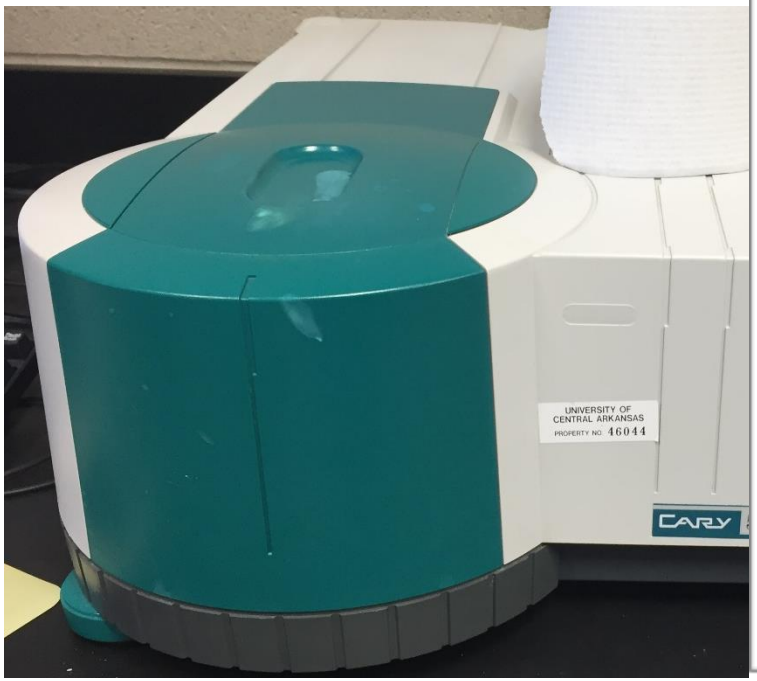
- Need to make sure nothing other than the dye absorbs at λ_{max}

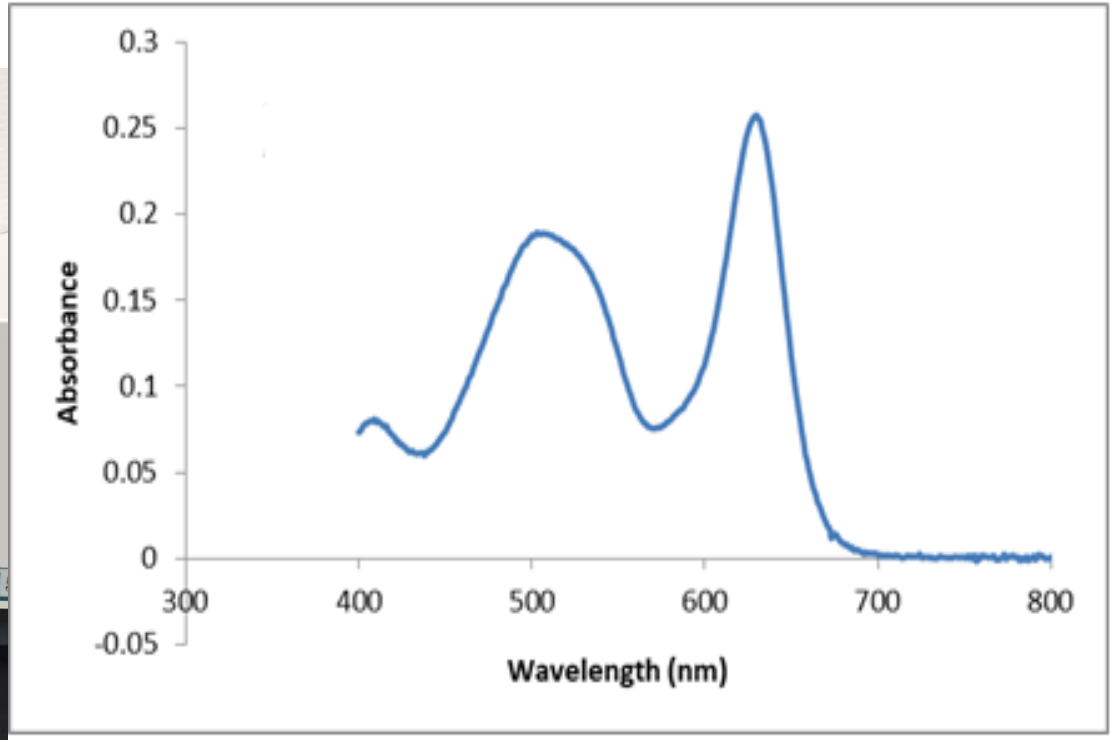


Alkarawi, D. *Western Kentucky University.* **2016.**

Experimental

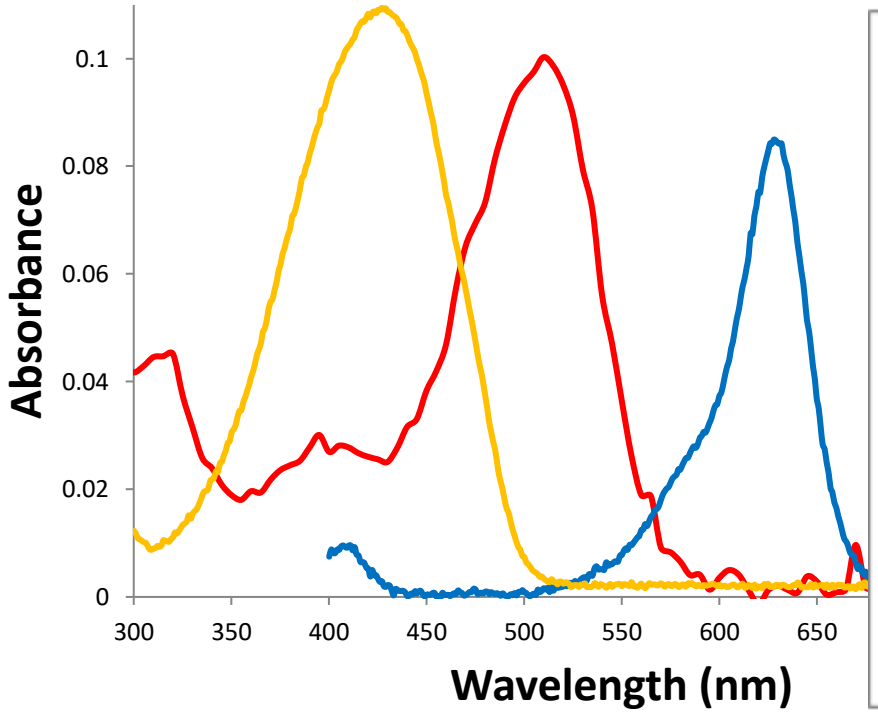
- UV-Visible Spectrophotometer

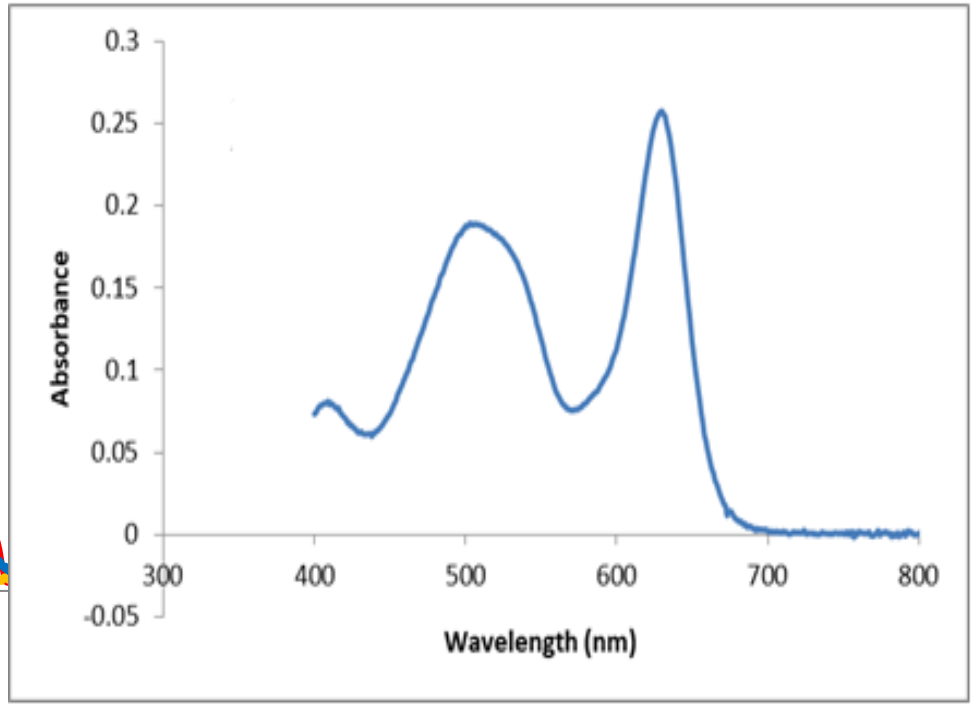




Analysis

- Absorbances are additive





Analysis

- *Two equations two unknowns*

$$A_{B1} = A_{630} - 0.0462A_{R40}$$
$$A_{R40} = A_{505} - 0.00670A_{B1}$$

	630 nm	505 nm	429 nm
Blue 1	1.00	0.00670	0.0219
Red 40	0.0462	1.00	0.291
Yellow 5	0.00604	0.00	1.00

Calculations

Kool-Aid Bursts Cherry

$$0.3198 = \left(25023\ \frac{L}{mol \cdot cm}\right) \cdot (1.00\ cm) \cdot c$$

c = 1.28 X 10^{-5} M Red 40 after dilution

$M_1V_1=M_2V_2$

M_1 = 3.19553 X 10^{-4} M Red 40

$$100\ mL \cdot \left(3.195523 \times 10^{-4}\ \frac{mol}{1000\ mL}\right) \cdot \left(\frac{496.42\ g}{mol}\right) \cdot \left(\frac{1000\ mg}{1\ g}\right)$$

- The mass of Red 40 in 100 mL of Kool-Aid Bursts Cherry is 16 mg.

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Sample	Blue 1 (mg)	Red 40 (mg)	Yellow 5 (mg)
Kool Aid Jammers Grape	0.044	0.11	-
Gatorade G2 Grape	0.67	1.2	-
Gatorade G2 Fruit Punch	-	15	-
Gatorade Tropical Cooler	0.92	-	25
Gatorade Icy Charge	0.71	-	-
Powerade Twisted Blackberry	0.14	45	-
Powerade Fruit Punch	-	48	-
Powerade Lemon Lime	-	-	69
Powerade Mountain Berry Blast	3.0	-	-
Kool Aid Bursts Fruit Punch	-	15	-
Kool Aid Bursts Grape	1.3	3.2	-
Kool Aid Bursts Cherry	-	32	-
Kool Aid Grape Powder	1.2	3.3	-
Kool Aid Tropical Punch Powder	-	16	-
Hawaiian Punch Fruit Juicy Red	-	22	-
Mountain Dew	-	-	6.1
Pedialyte Grape	0.22	0.73	-
Pedialyte Strawberry	0.012	2.1	-
Nyquil Children's Cold & Cough Cherry	-	7.0	-

This information should be provided!

- Recommended limits of each dye (per day/kg)
  - 7 mg of Red 40
  - 6 mg of Blue 1
  - 7.5 mg of Yellow 5

Nutrition Facts

Serving Size 1 cup (228g)
Servings Per Container 2

Amount Per Serving

Calories 250 Calories from Fat 110

	% Daily Value*
Total Fat 12g	18%
Saturated Fat 3g	15%
Trans Fat 3g	
Cholesterol 30mg	10%
Sodium 470mg	20%
Total Carbohydrate 31g	10%
Dietary Fiber 0g	0%
Sugars 5g	
Protein 5g	
Vitamin A	4%
Vitamin C	2%
Calcium	20%
Iron	4%

* Percent Daily Values are based on a 2,000 calorie diet. Your Daily Values may be higher or lower depending on your calorie needs.

	Calories	2,000	2,500
Total Fat	Less than	65g	80g
Sat Fat	Less than	20g	25g
Cholesterol	Less than	300mg	300mg
Sodium	Less than	2,400mg	2,400mg
Total Carbohydrate		300g	375g
Dietary Fiber		25g	30g

Conclusion

- Should we ban artificial food dyes?

children from the general population without particular behavioral problems may exhibit a unique intolerance to AFC resulting in typically small to moderate behavioral changes which may not necessarily be characteristic of the ADHD syndrome.

- Are there alternatives?