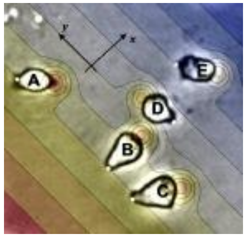
Physics 131- Fundamentals of Physics for Biologists I



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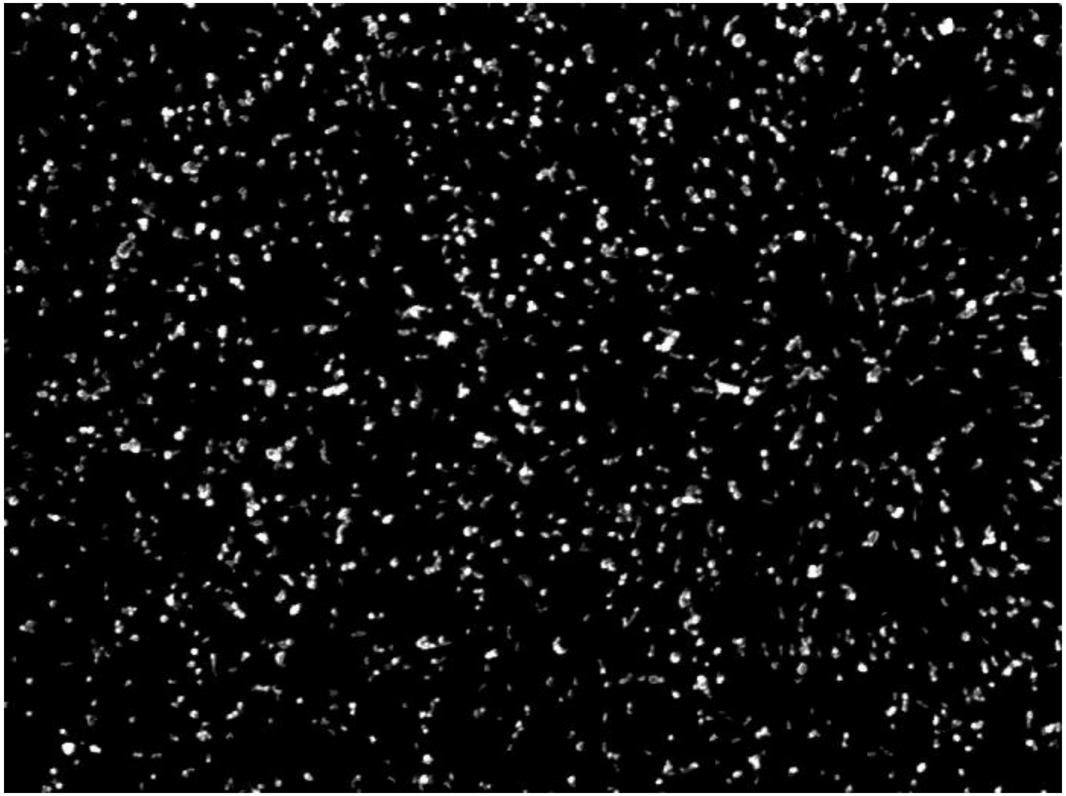
M.A.R.S. - Pump Up The Volume

1. How we learn
2. Math in Natural Sciences
3. Units and Dimensions
4. Estimation
5. Scaling



Collective Motion of Slime Mold cells

An exercise on how your brain processes information

I will show you a slide with a list of color names.

Each word will be printed in a colored ink.

Pair off in groups of twos.

One of each pair will be the reader, the other the checker.

The reader will have 20 seconds to read our loud the COLORS THAT THE WORDS ARE PRINTED IN.

The checker will count the number of words read, and the number correct.

Checkers: How many colors did your partner name?

1. 0-5
2. 6-10
3. 11-15
4. 16-20
5. 21-25

Checkers: How many colors did your partner get right?

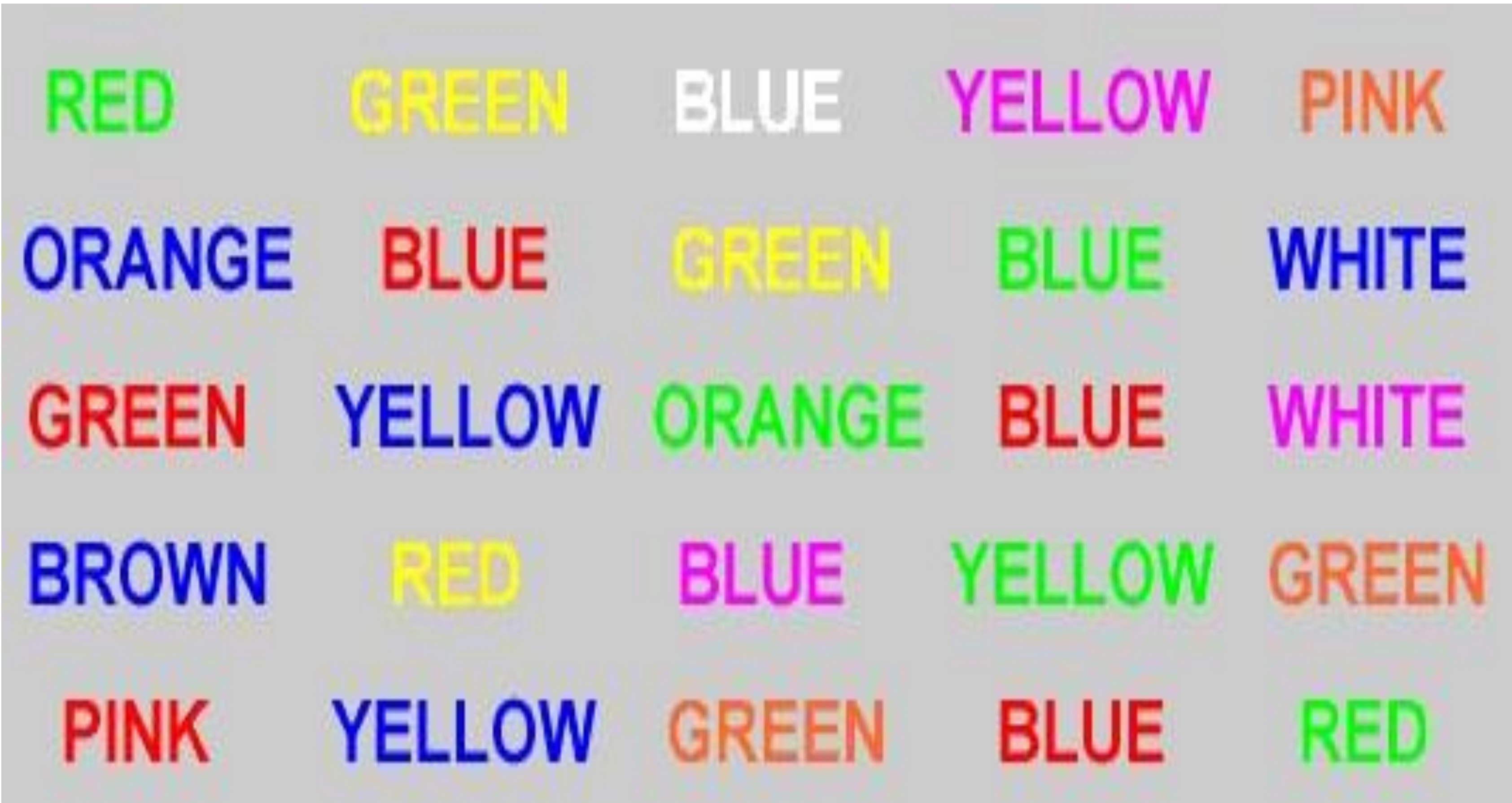
1. 0-5
2. 6-10
3. 11-15
4. 16-20
5. 21-25

Now switch roles!
Lets try again!

Remember:

Say the color ink the word is printed in!

Now do it again – remember: say the color ink the word is printed in!



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What did we learn from this exercise?

- Our brains will connect what we see to things we know.
- You can take advantage of this in learning science!
  - If you have prior knowledge your brain will connect to this prior knowledge when carrying out a task

    -> **foothold principles**
  - Do not rely on the first recollection or intuition that comes to your mind. Active thinking is required!

Topics

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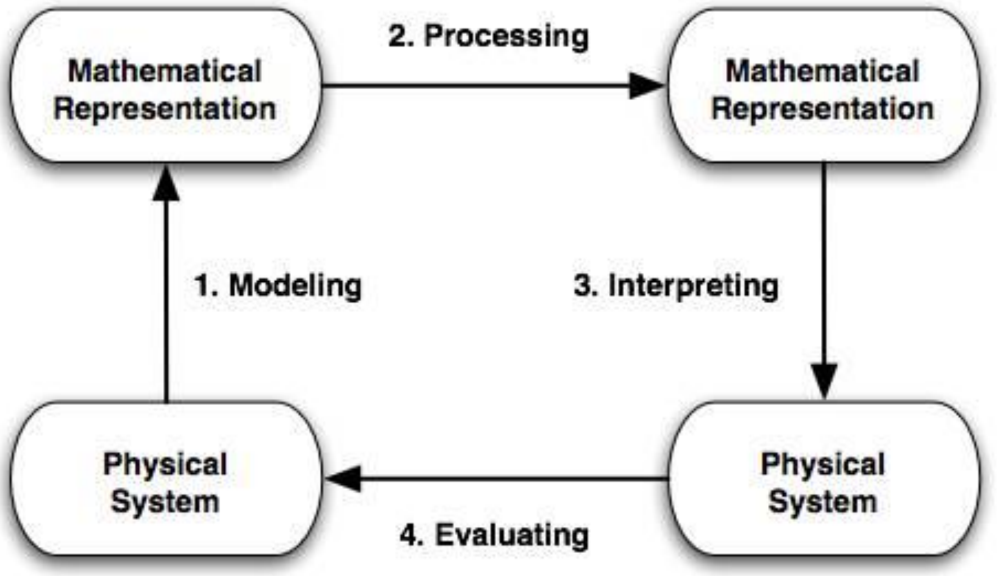
Reading Summaries

too short and cryptic: *The choice of dimension is arbitrary and changes as we learn more.*

Example summary: *This article argues that math in science is more difficult than math in math (normal math). The most important idea they mention is that science math requires an understanding of a real physical system while normal math does not. Science math requires an in depth understanding of what equations and variables represent, while normal math often does not. The authors also make the important point that units in science math run into complications that don't exist in normal math. Since you can't equate all units in science math, it tends to be more difficult than normal math.*

Math as part of Natural Sciences

- We use math to model (1) relationships and properties in physical, chemical or biological systems.
- Mathematical processing (2) allows us to make predictions from the model that we can interpret (3) for the physical system.
- Very non-natural physical systems such as lasers, transistors have been designed via such *“model based extrapolation”.*
- In biology, steps 1 and 3 are still very hard



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Units

- Units specify our measuring unit (e.g. meter, kg, second) we have chosen.
  - Units should be manipulated like algebraic quantities.
  - Units can be changed by multiplying by appropriate forms of "1" e.g. 1 = (1 inch)/(2.54 cm)

Units are important:

A 125 Million $ Mistake

http://en.wikipedia.org/wiki/Mars_Climate_Orbiter

Unit Conversion

Convert the following

A. second to millisecond
B. millimeter to meter
C. Inch to centimeter
D. Kg to minute

1. 10^{-6}
2. 10^{-3}
3. 2.54
4. 100
5. 10^{3}
6. 10^{6}
7. Cannot convert
8. Do not know

Foothold Idea
Dimensional analysis

- Modeling physical systems requires numbers, i.e. measurements
- Measurements have dimensions:

This is what the brackets mean!

[x] = L means "the dimension of x is a Length"

[t] = T means "the dimension of t is a Time"

[m] = M means "the dimension of m is a Mass"

[v] = L/T means "the dimension of velocity is Length/Time

- **Models allow us to think about how the numbers fit together**
- **<u>A first check on any model - Dimensional analysis:</u> Both sides of an equation have to have the same dimension**

Which equation could represent the surface area of a soccerball or radius R?

1. _ $2pR$
2. _ $4pR^2$
3. _ $\frac{4}{3}pR^3$
4. _ pR^2

Note

In this class, multiple choice questions may list

more than one correct answer, or

NO correct answer!

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Interesting Reading Summary and Questions

Confession: *In elementary school, my math teacher loved to have us estimate, but I didn't have a good grip on the concept...so I would calculate the precise correct answer, round up to the nearest 10, and then place that number in the "estimation" box. I hope to make more of an attempt at estimating in this class.*

How can we determine how credible an estimation is? What criteria has to be met?

Would estimations matter to a doctor? I feel like there's no room for estimation in a life-or-death situation.

Estimate the number of cells in your body.

1. 10^0 (one)
2. 10^3 (thousand)
3. 10^6 (Million)
4. 10^8
5. 10^{10}
6. 10^{12} (trillion)
7. 10^{14}

Foothold Ideas:
Estimation – Quantifying experience

- Use 1-digit arithmetic
- **Do** figure out your estimations by starting with something you can plausibly know and
scale up or down
  - **You will learn useful numbers for biology**
  - Document these “foothold” numbers and ideas by using the whiteboard in class, and the paper for HW and exams.
- **Do** actively think about your answer to see if it’s reasonable

Foothold Biology Lengths

Cell Biology scales we need to build an intuition for living systems

Cell Biology Scales	
Size of a typical animal cell	~10-20 microns (10^{-5} m)
Size of a bacterium, chloroplast,or mitochondrion	~1 micron (10^{-6} m)
Size of a medium-sized virus	~0.1 micron (10^{-7} m)
Thickness of a cell membrane	10 nanometer = 0.01 micron (10^{-8} m)
Size of a typical protein	~3-5 nanometer
Length of one DNA basepair	~0.5 nanometer (10^{-9} m)

The number of neurons in your brain?

Work in groups of 3 with Whiteboard

Learning Assistant(s) and TA will join discussions

1. 10^0 (one)
2. 10^3 (thousand)
3. 10^6 (Million)
4. 10^8
5. 10^{10}
6. 10^{12} (trillion)
7. 10^{14}

Would estimations matter to a doctor? I feel like there's no room for estimation in a life-or-death situation.

Discuss in groups of 3: Can you think of a situation where a doctor could or does estimate?

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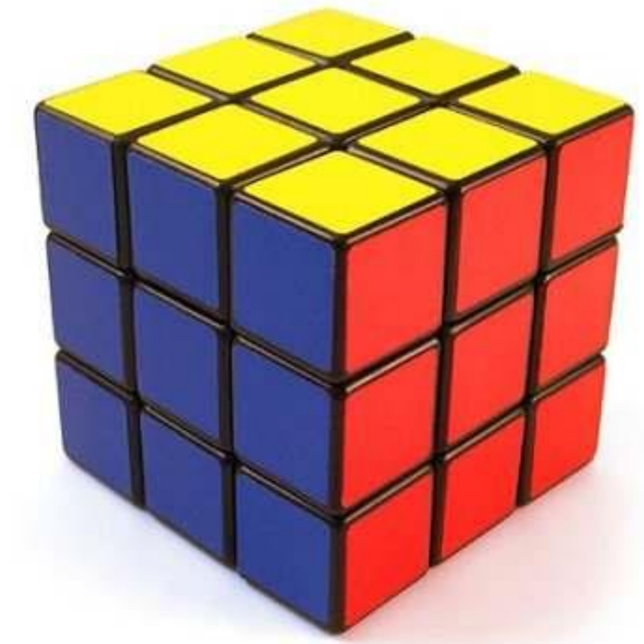
Measurement is basically about counting – but counting *what*?.



N	Perim	Area	Vol
1			
2			
3			

Scaling

Assume that instead of using a unit L, you are using a unit that is different λL

(e.g. if you use cm instead of mm then this factor λ would be 10: 10mm = 1cm).

- How does the number assigned to the
  - Area
  - Volume

  of a cube change?