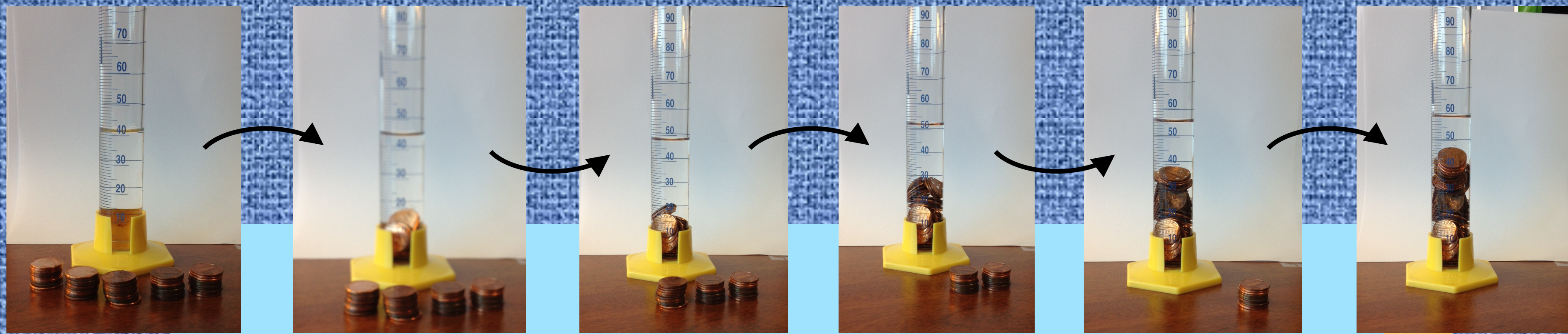
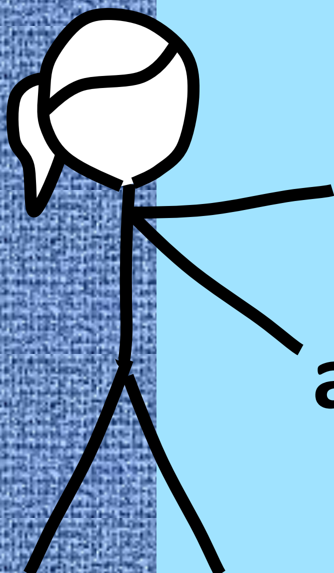
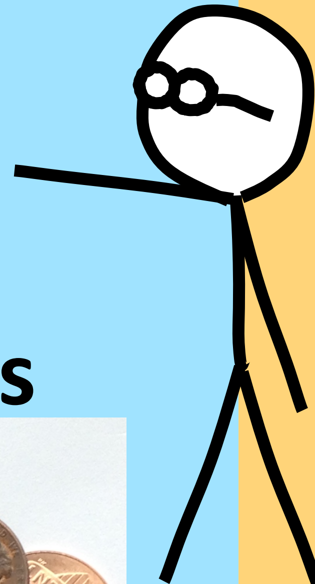
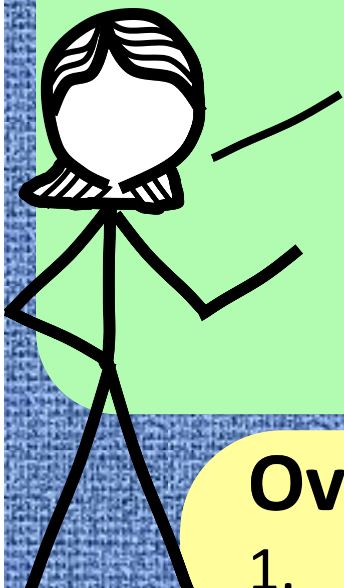


Experiment 1
27 August 2019
Making Measurements and the Density of Pennies





Objectives: Learn to make the best possible laboratory measurements.



Today we will become familiar with some critical lab skills like picking the best glassware for measurements and making good measurements. We will talk about significant figures, and rounding.

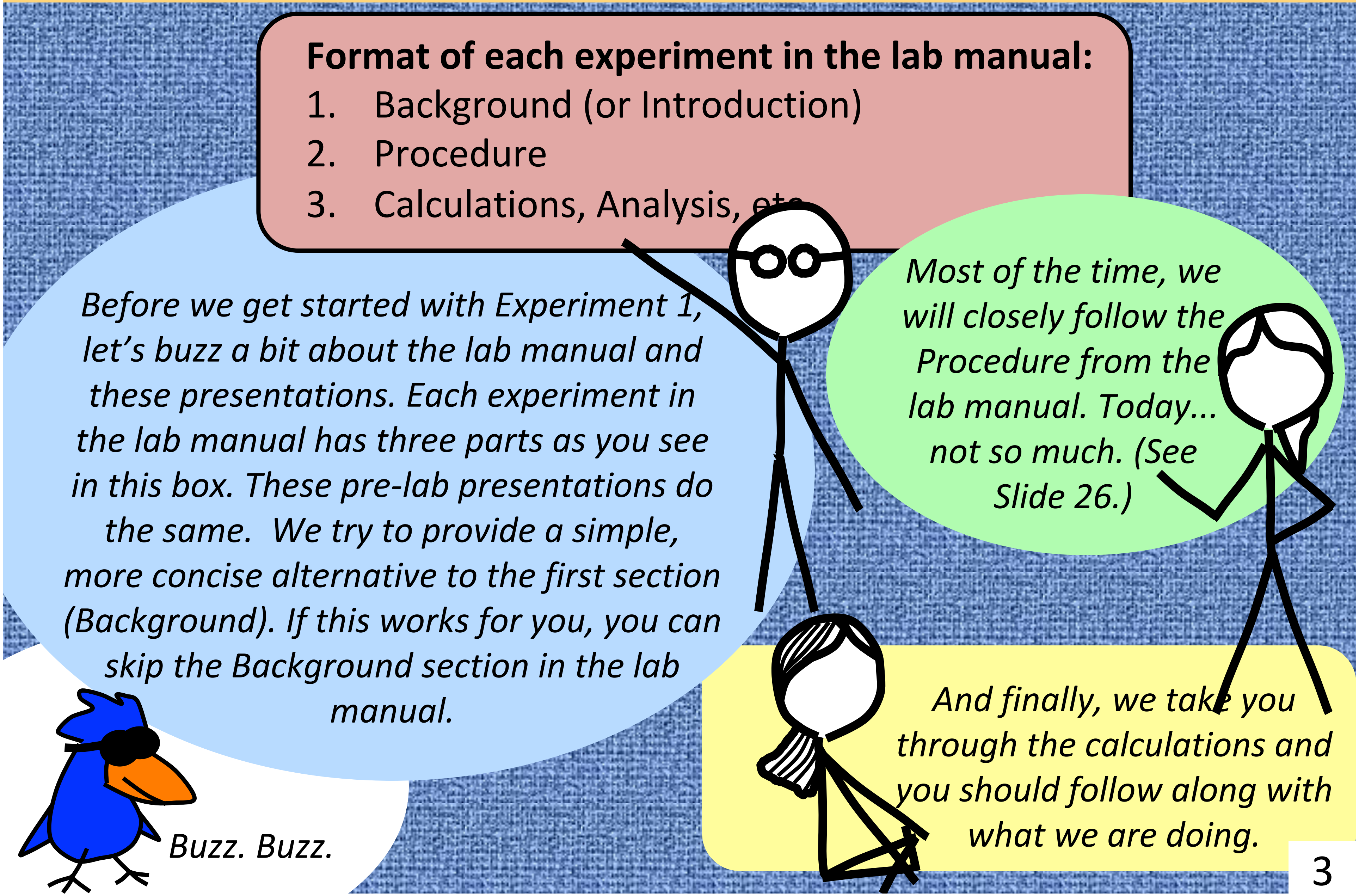
We will collect data and use it to obtain a meaningful result – the density of a metal.

Overview:

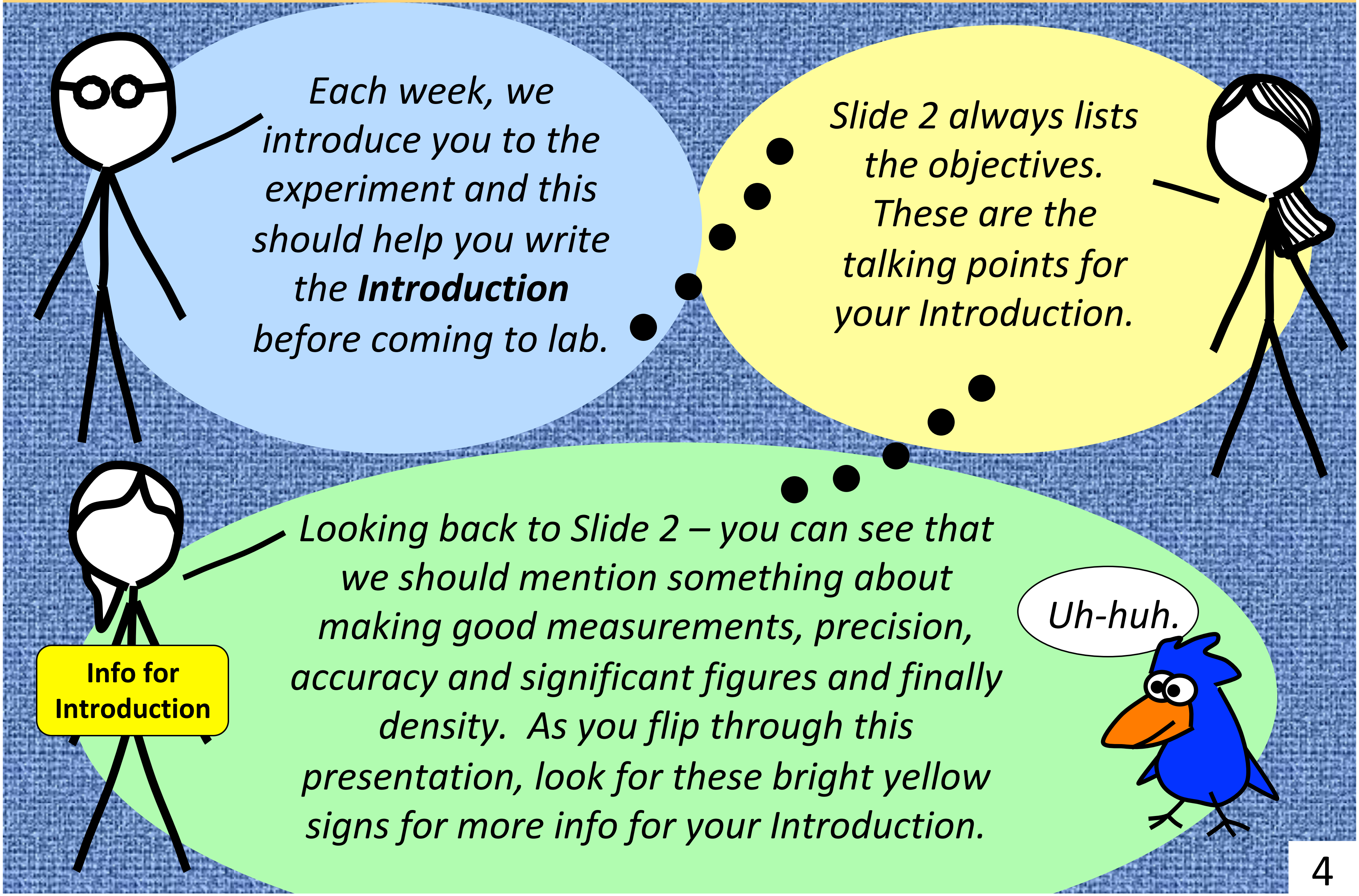
1. How to use these pre-lab presentations.
2. Making good measurements
3. Precision, accuracy, significant figures
4. Procedure for today (summary of what we do today)
5. Density of pennies
6. Your lab report

Info for Introduction

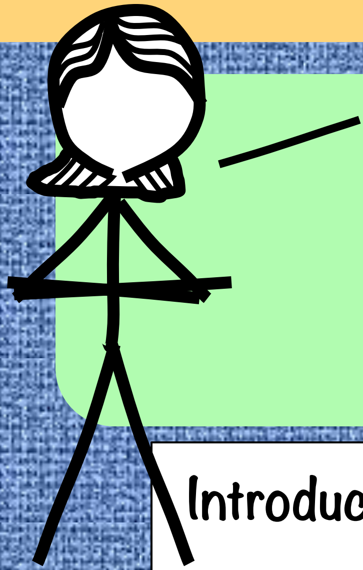
1. How to use these pre-lab presentations.



1. How to use these pre-lab presentations.



1. How to use these pre-lab presentations.

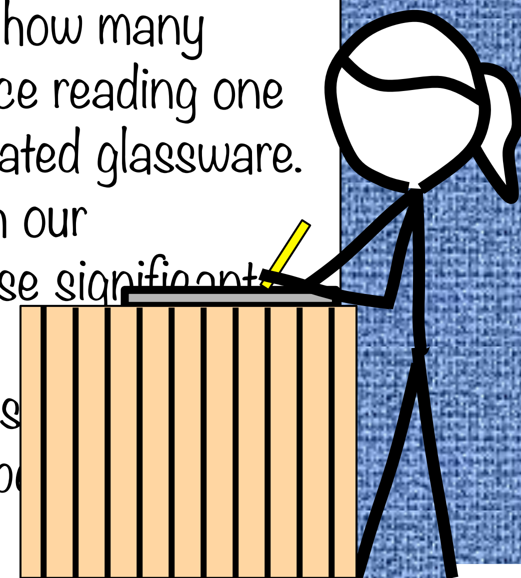


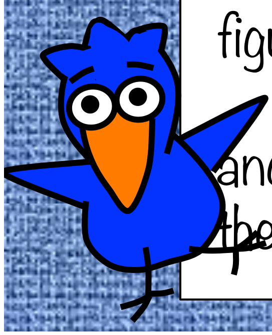
Introductions usually run about a half-page. They should be in your own words and cover all pertinent topics. Here is an Introduction for Experiment 1. Yours could look somewhat similar but in your own words. Notice how all of the "talking points" were addressed, but only as a preview?

Introduction.

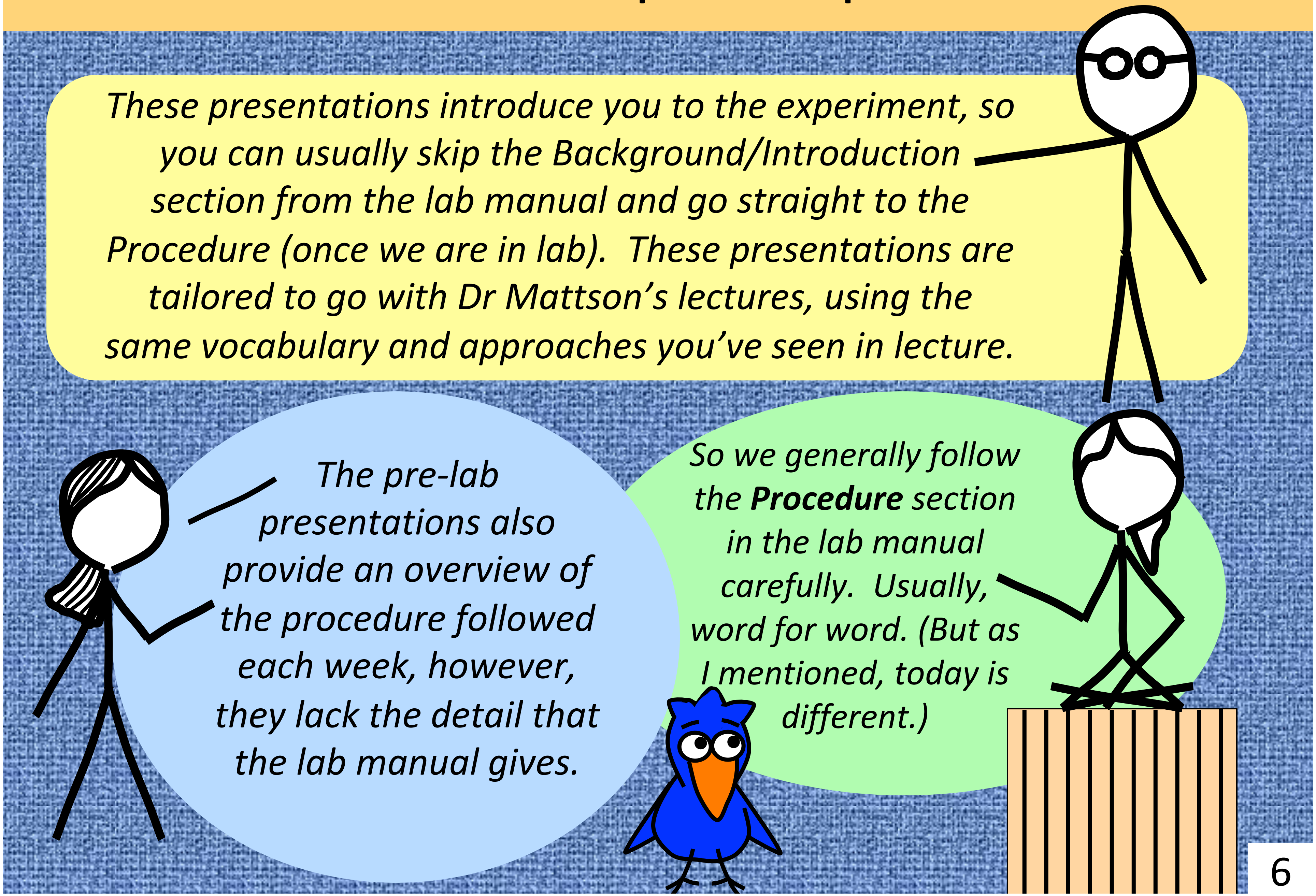
This week in lab we will use various glassware, balances and rulers in order to compare how accurately each one makes measurements. We will practice making good measurements and will learn how many significant figures each measurement gives. We will practice reading one more number in between two lines on a ruler or with graduated glassware. We will encounter examples of precision and accuracy with our measurements. In our calculations, we will review how to use significant figures correctly.

We will determine the density of pennies using a s
and volume measurements that we will plot so that the slop
the density.

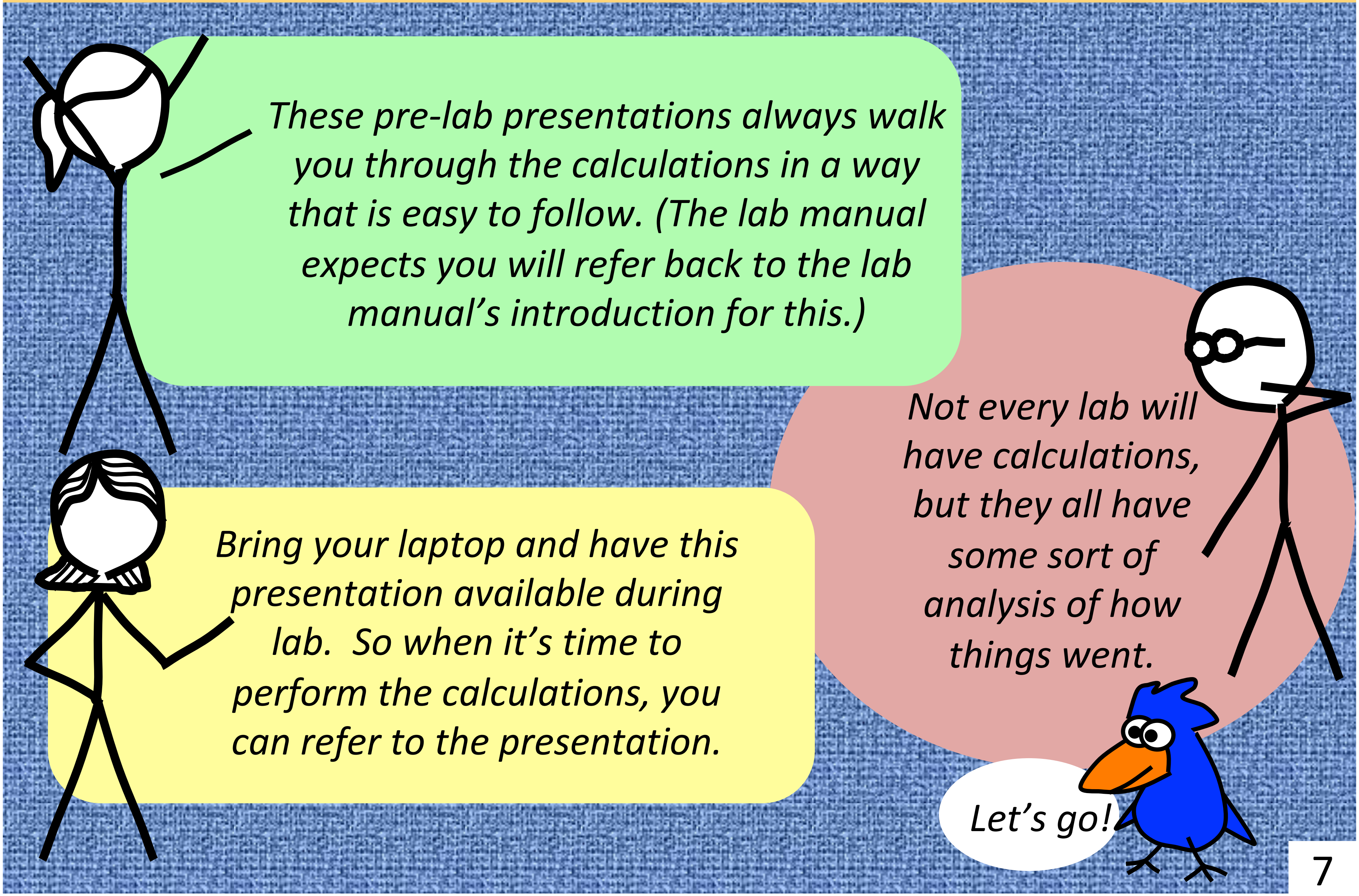




1. How to use these pre-lab presentations.



1. How to use these pre-lab presentations.

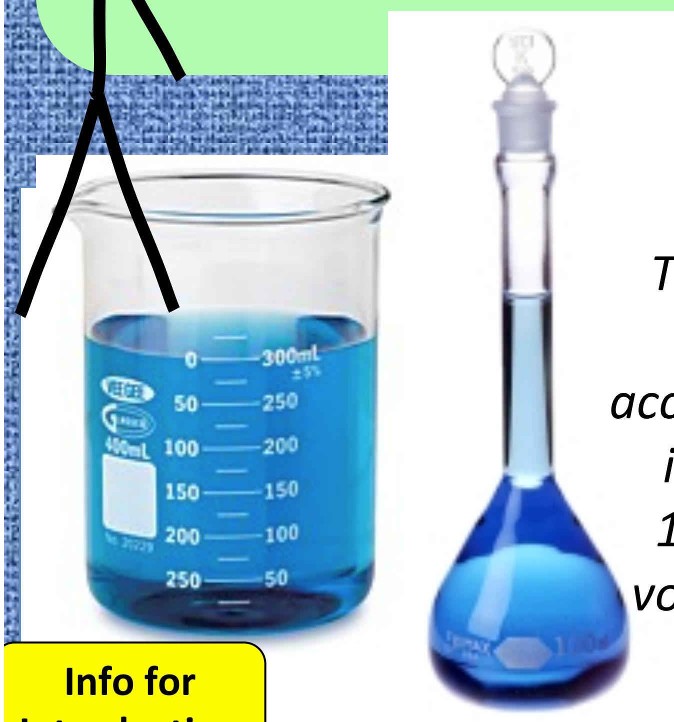


2. Making good measurements.

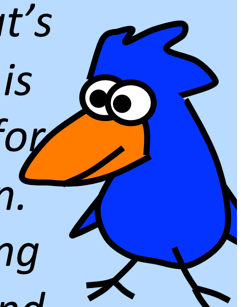
So this week we are making good measurements?

What about great measurements?

Good (great) measurements start with the proper glassware – or equipment such as balances.



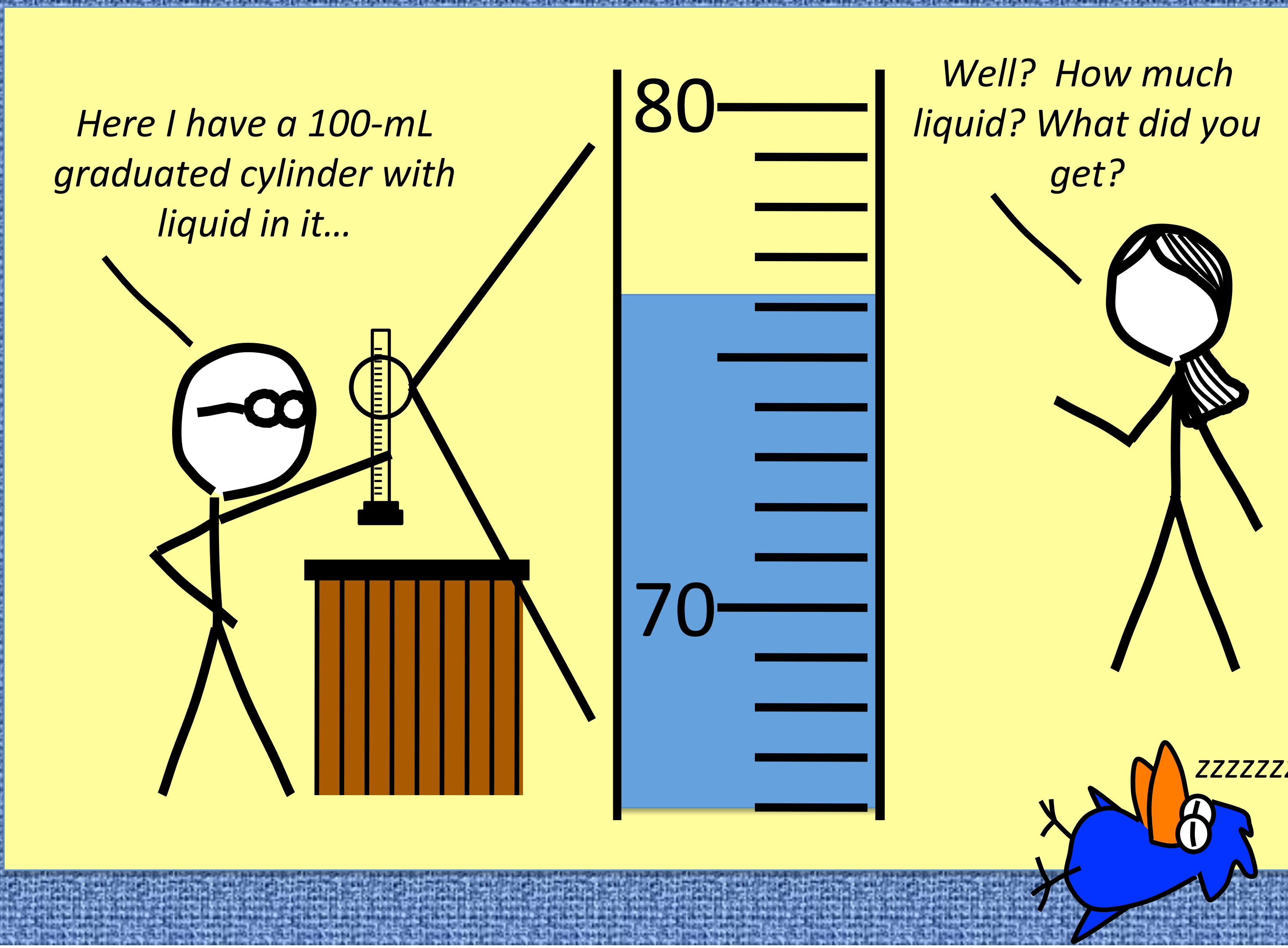
The beaker (that you have your foot in) is not very accurate. The volumetric flask is very accurate – exactly 100.0 mL. Hint: The word volumetric in the name says it's accurate.



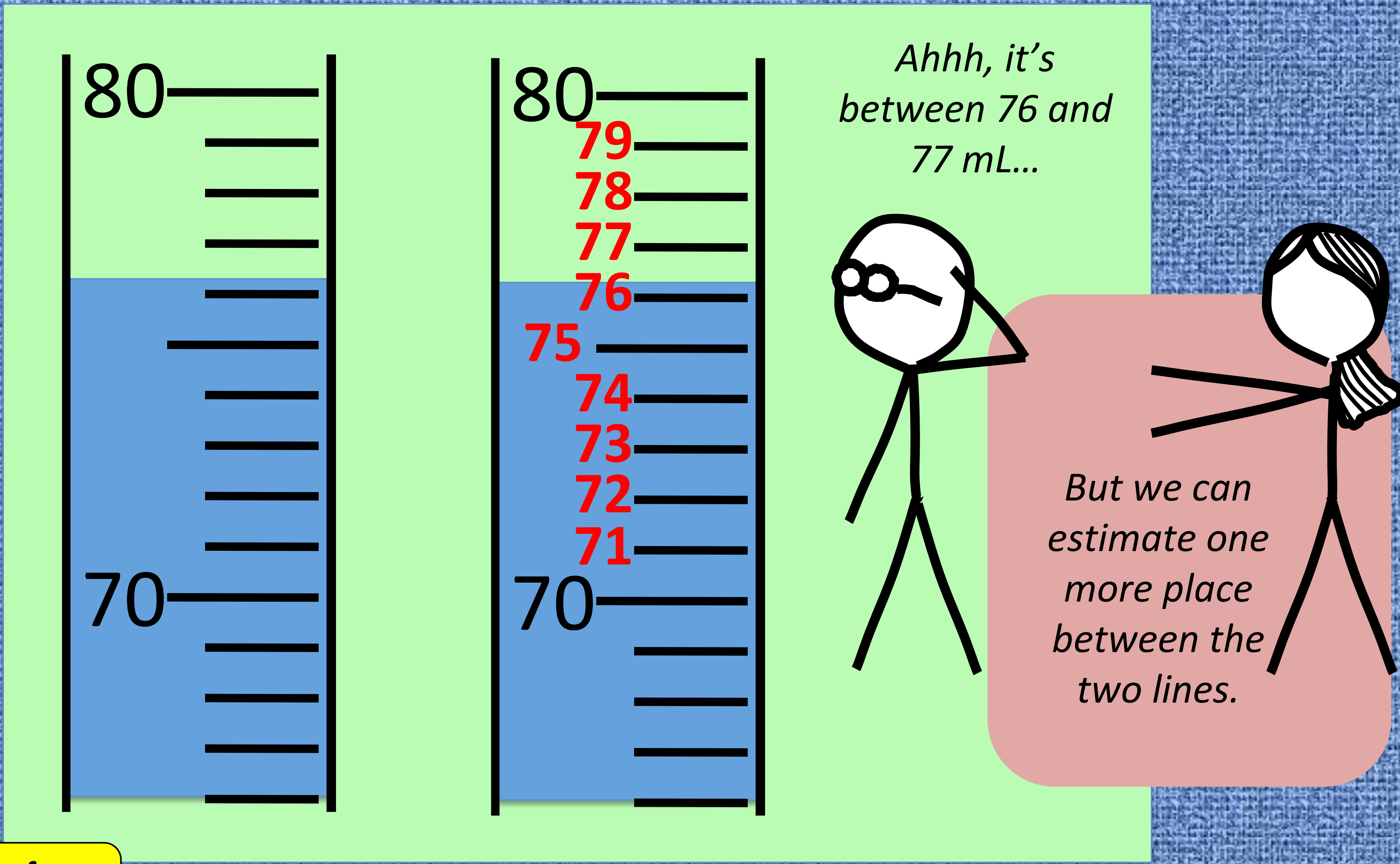
See that yellow sign in the corner? That's a hint that there is info on this slide for your introduction. Perhaps something about accuracy and glassware?

Info for Introduction

2. Making good measurements.

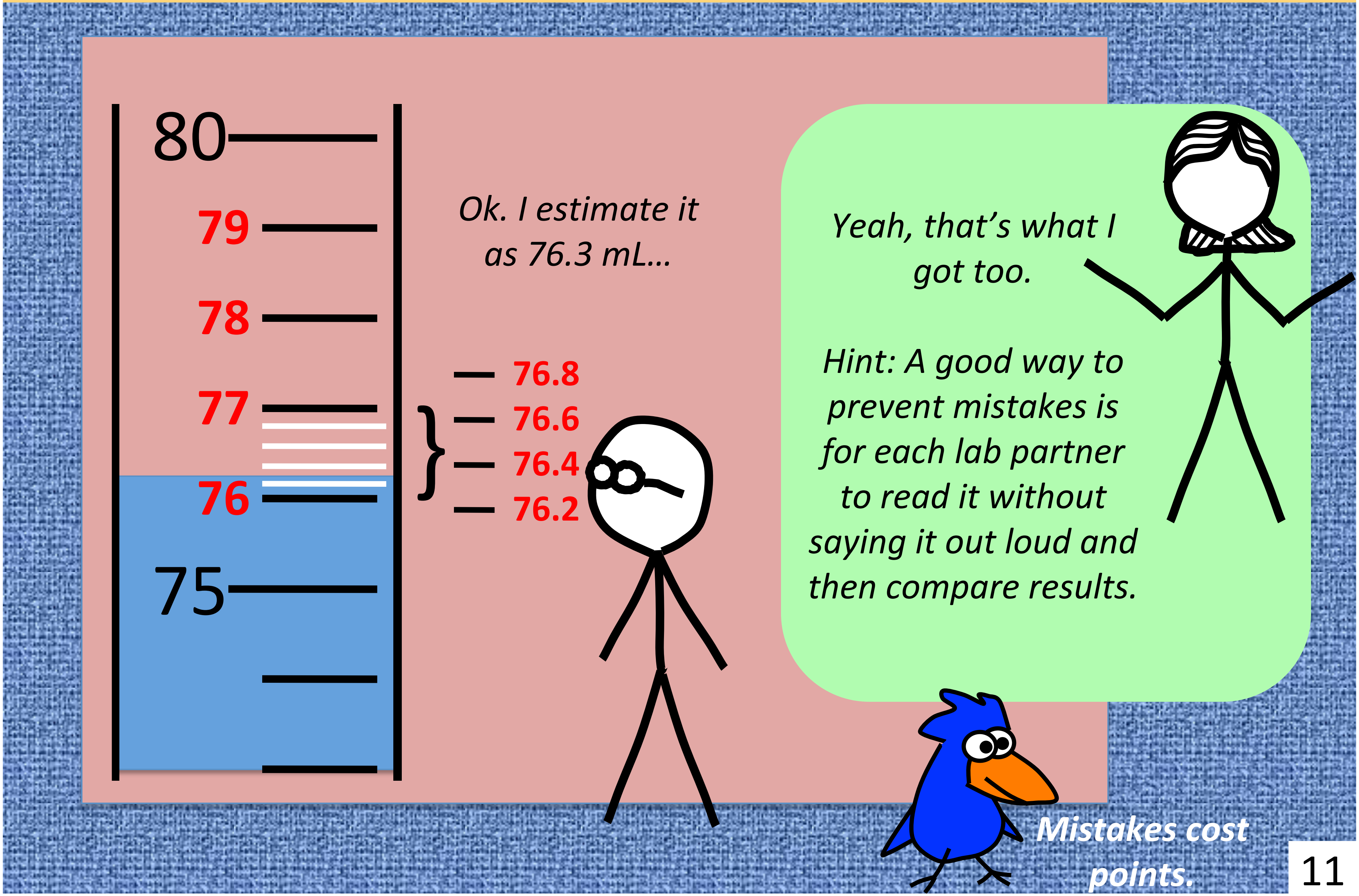


2. Making good measurements.

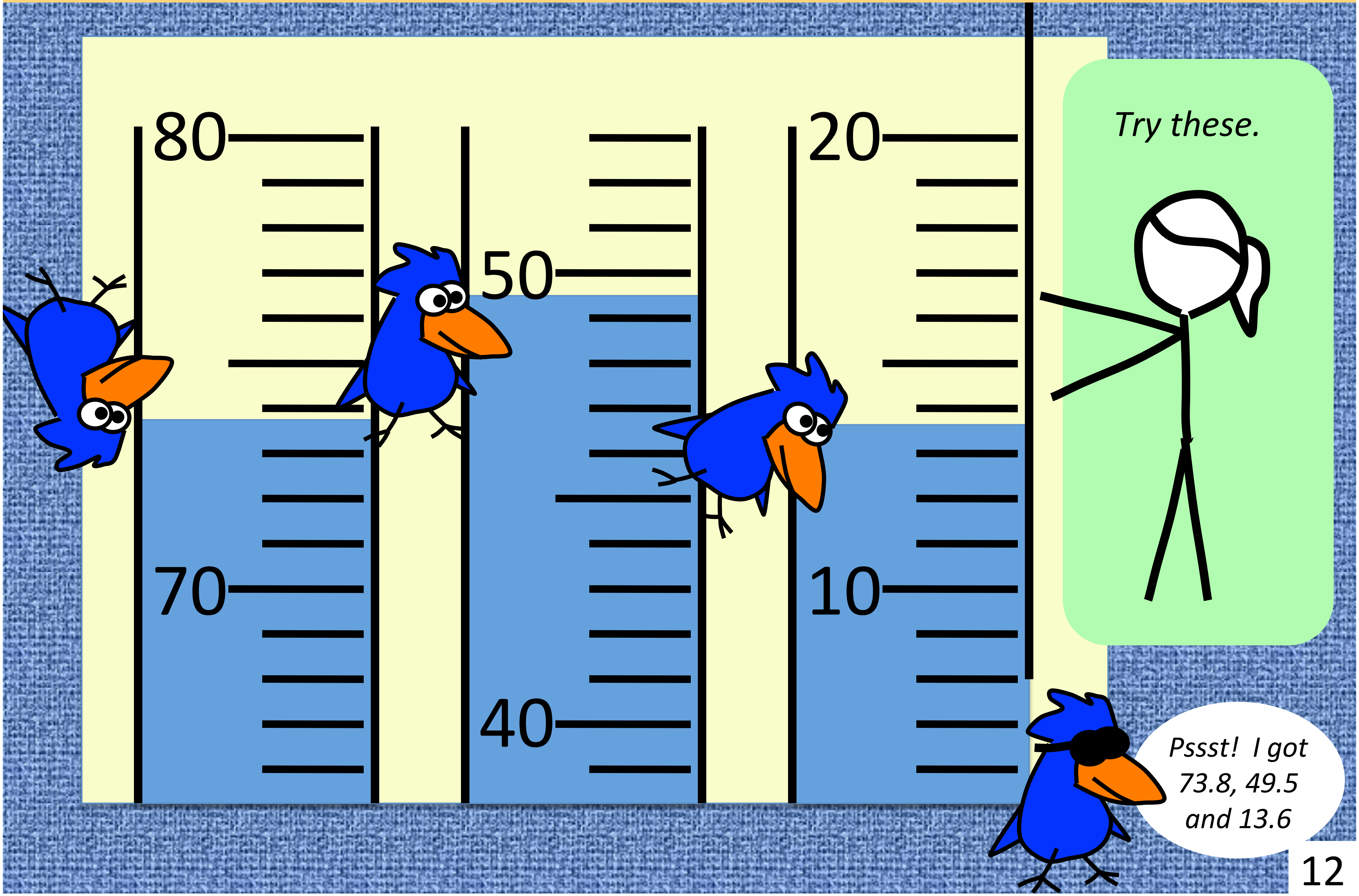


Info for Introduction

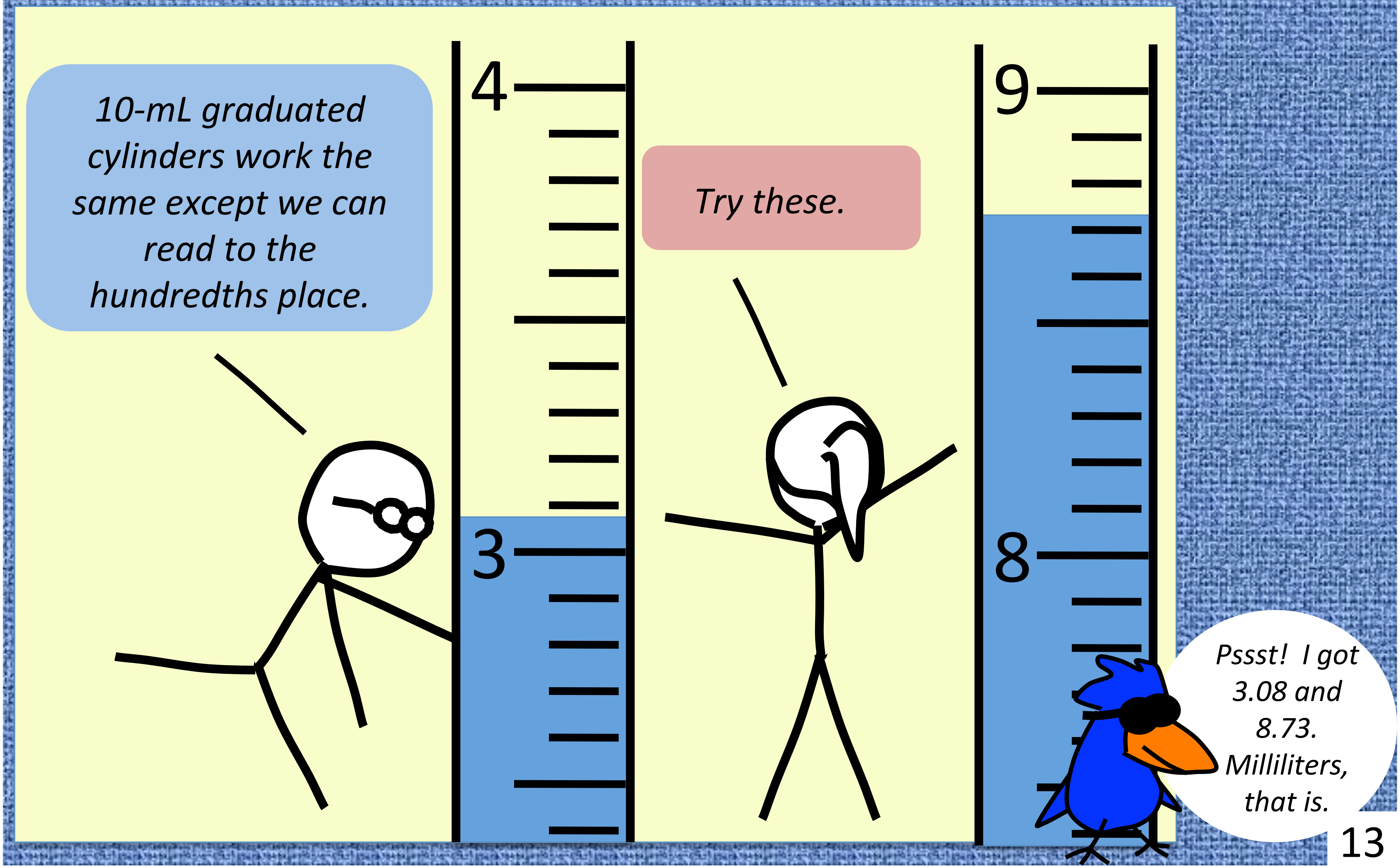
2. Making good measurements.



2. Making good measurements.



2. Making good measurements.



2. Making good measurements.

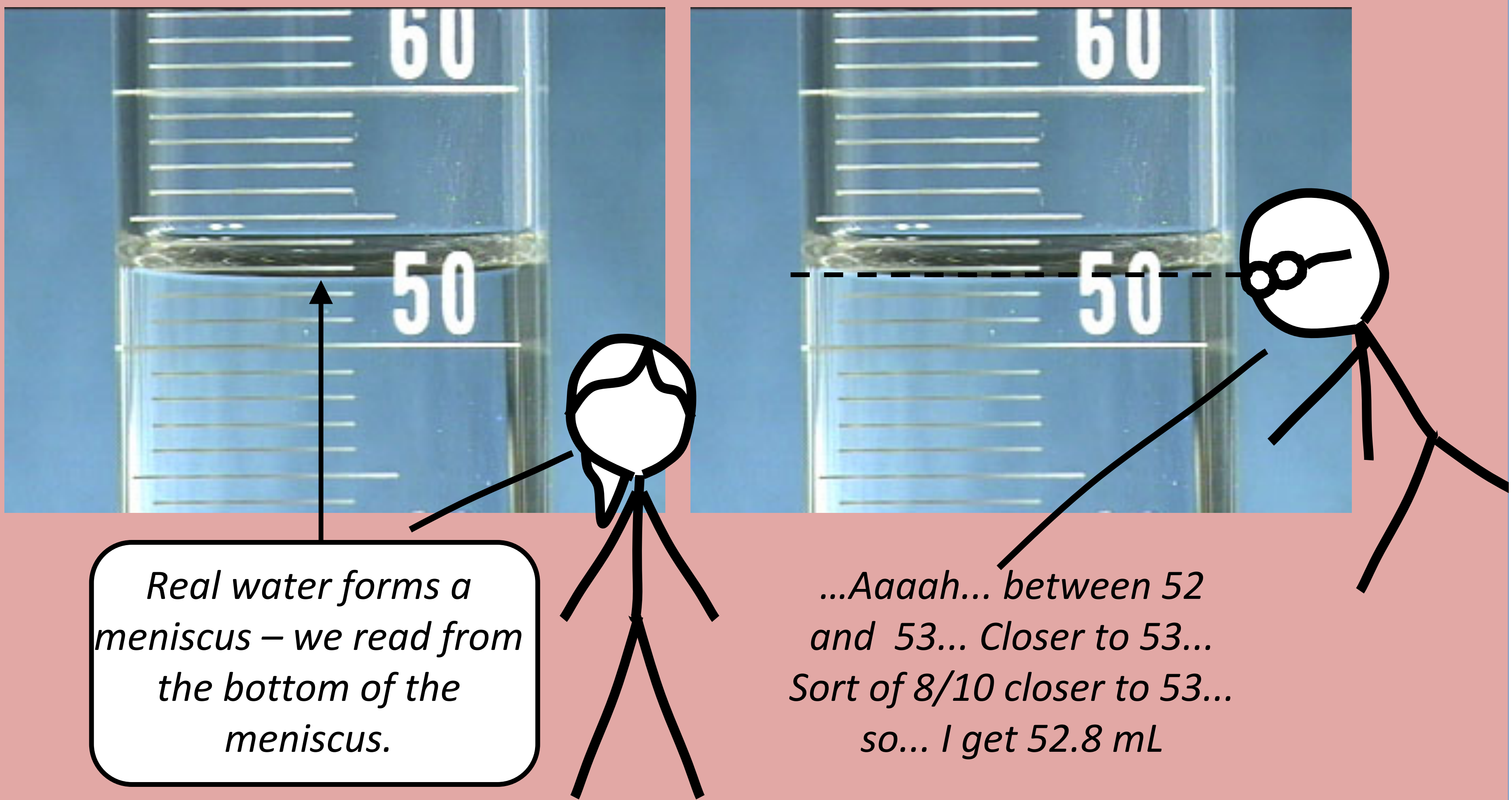
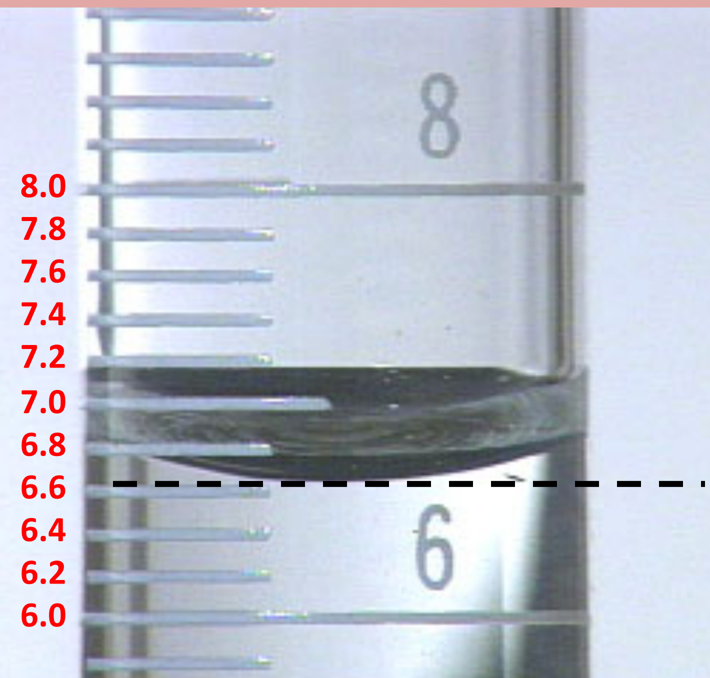


Photo credit: http://www.austincc.edu/biocr/1406/labm/ex2/images/graduated_cylinder.jpg

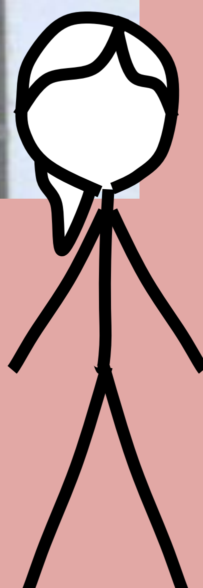
2. Making good measurements.

Try this…

…without help, or…



…with help.



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3. Precision, accuracy and significant figures.

***PRECISION** has two definitions. In our textbook, precision refers to how well a set of independent measurements agree with one another.*

*In lab, **PRECISION** also refers to how many significant figures the measurement gives. So it has two definitions.*

We could measure the mass of a penny multiple times, for example, using various pocket balances that read to the hundredths place.

These data look pretty good. They are all similar so that suggests precision of the first kind.

The mass of a 2017 penny

Trial 1	**2.76 g**
Trial 2	**2.74 g**
Trial 3	**2.73 g**
Trial 4	**2.74 g**

Average 2.743 g

We certainly expect uncertainty in the last decimal place.

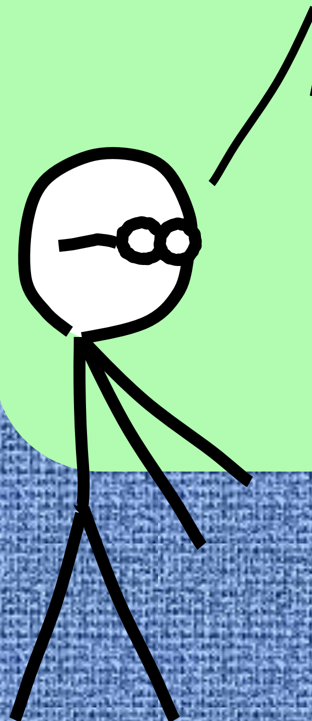
Info for Introduction

3. Precision, accuracy and significant figures.

The mass of a 2017 penny using pocket balances

Trial 1	**2.76 g**
Trial 2	**2.74 g**
Trial 3	**2.73 g**
Trial 4	**2.74 g**

Average 2.743 g



Using analytical balances we get one or two extra places past the decimal point – better precision (of the second kind)

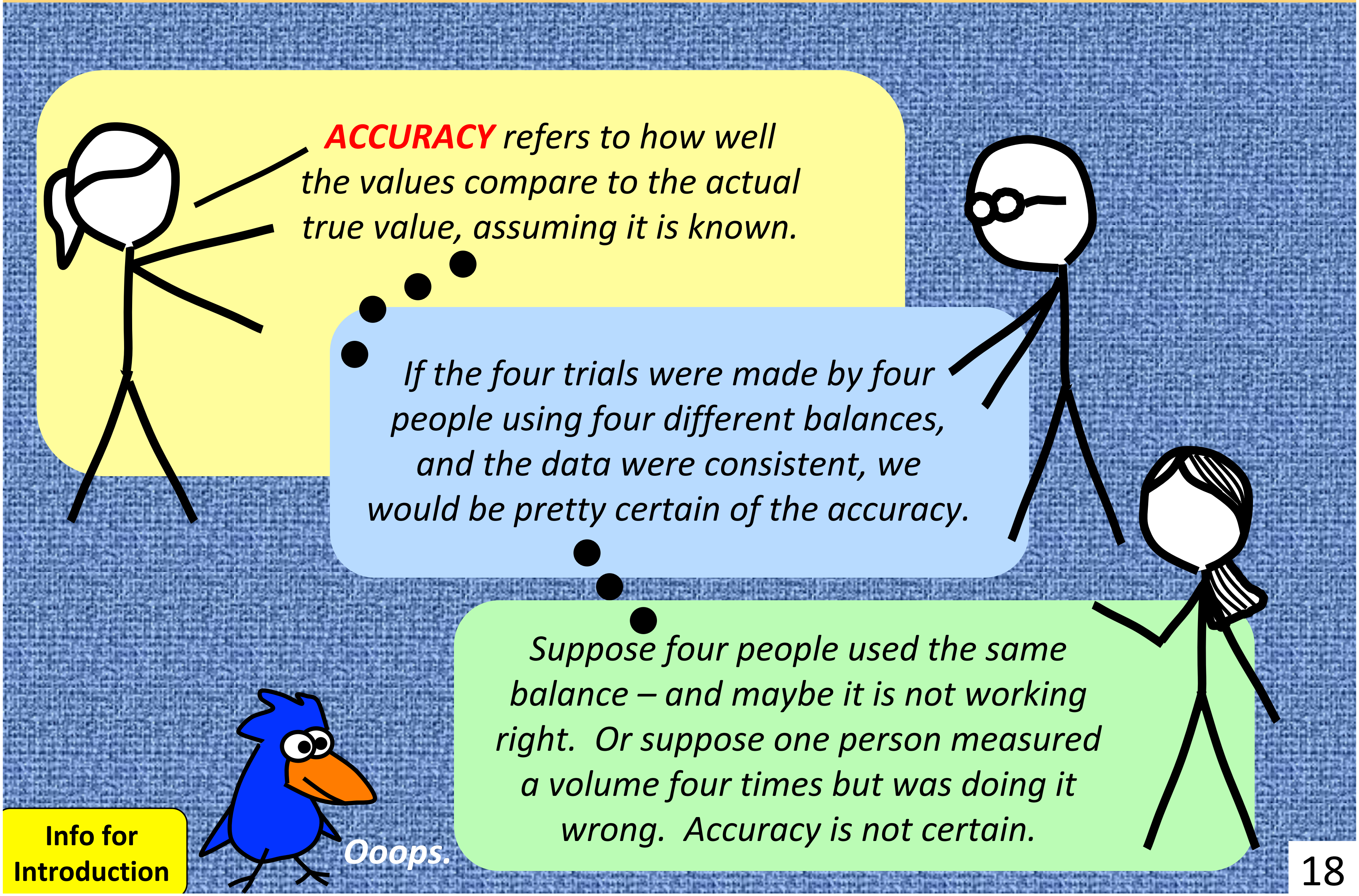
The mass of the same 2017 penny using different analytical balances

Trial 1	**2.763 g**
Trial 2	**2.751 g**
Trial 3	**2.729 g**
Trial 4	**2.744 g**

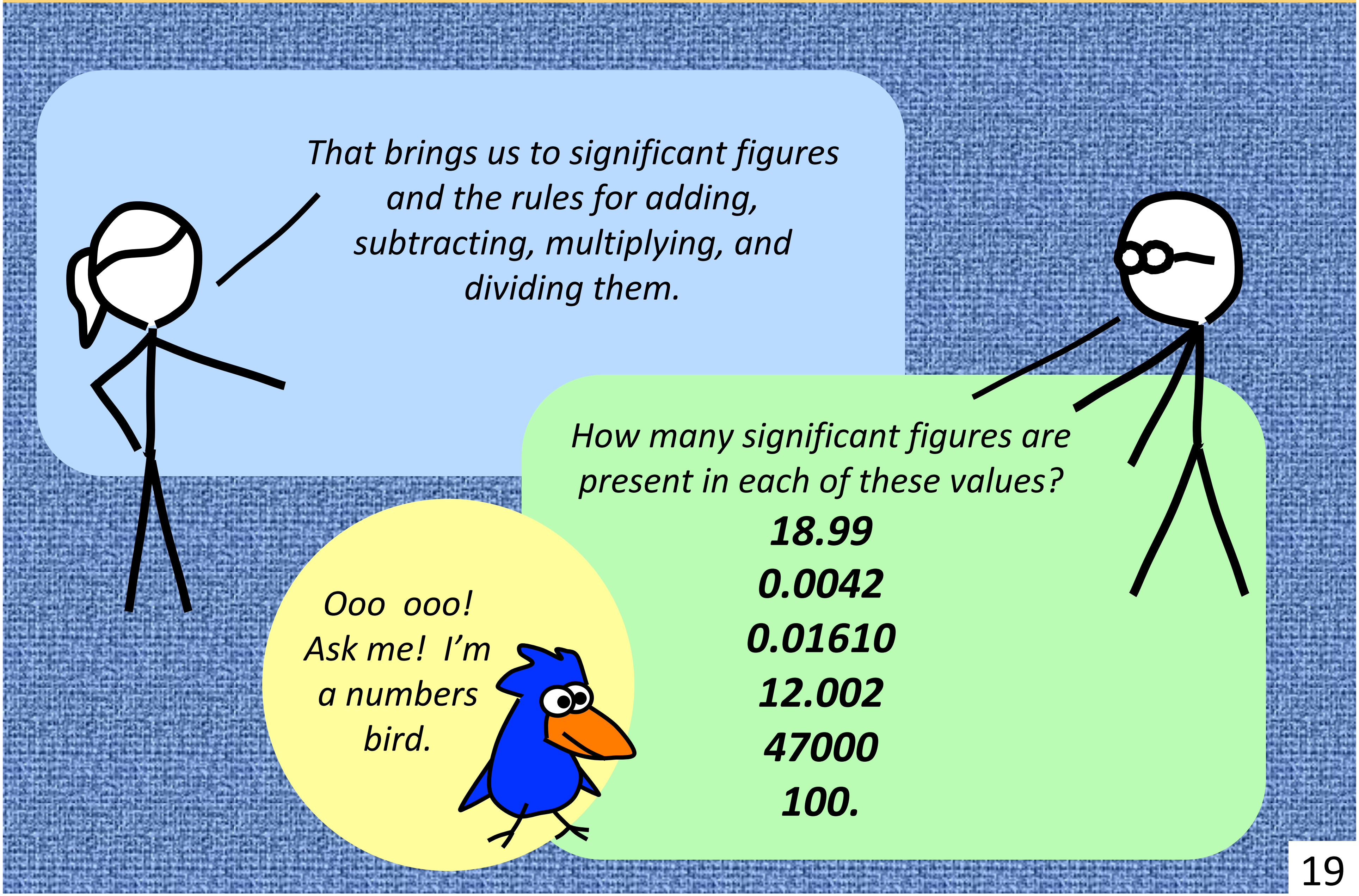
Average 2.7468 g

Info for Introduction

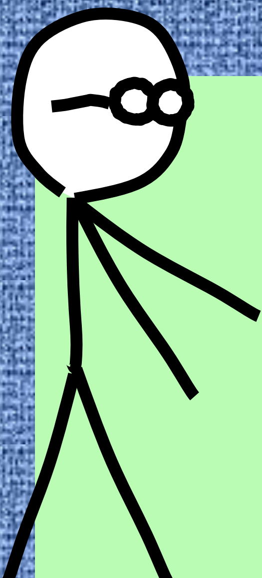
3. Precision, accuracy and significant figures.



3. Precision, accuracy and significant figures.



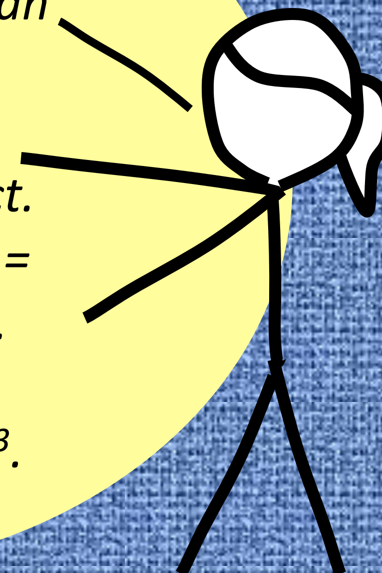
3. Precision, accuracy and significant figures.

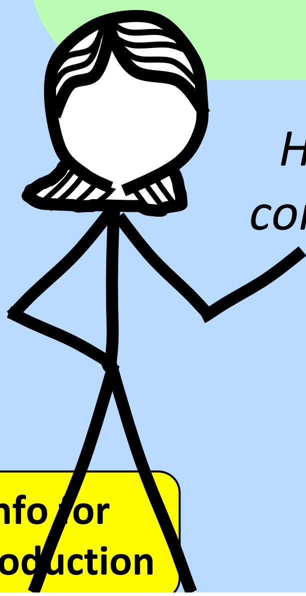


How did you do?

18.99 (FOUR)
0.0042 (TWO)
0.01610 (FOUR)
12.002 (FIVE)
47000 (TWO)
100. (THREE)

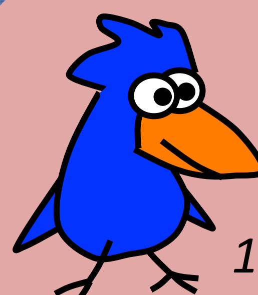
*Moving along, numbers that are **defined** have an infinite number of significant figures because they are exact. For example, 1 dozen = 12, or 1 m = 100 cm. And my personal favorite: 1 mL = 1 cm^3.*





Here are a two examples of conversions that are not exact – both have five sig figs:

1 L = 1.0567 qt
1 pound = 453.59 g

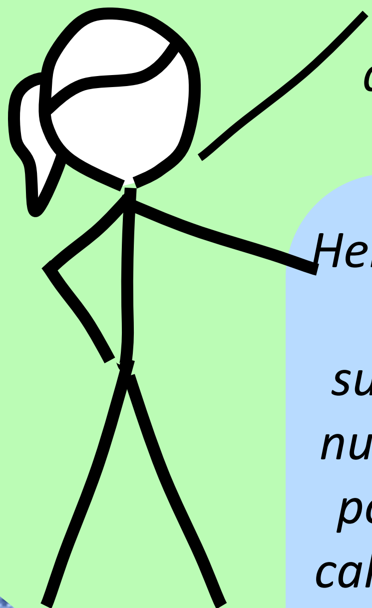


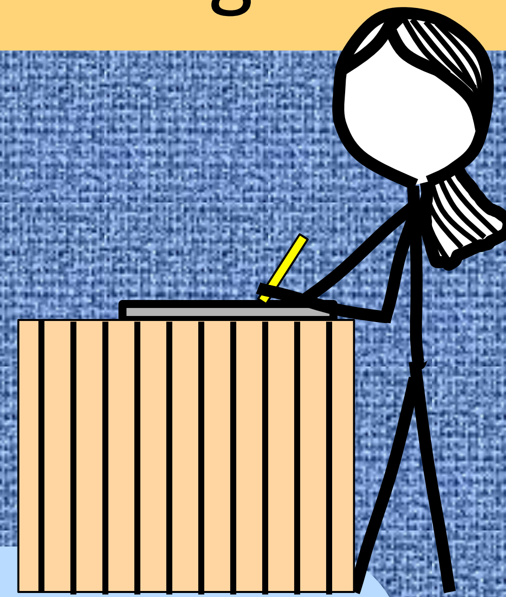
Here are two bizarre exact conversions (by definitions):

1 inch = 2.54 cm exactly
1 cal = 4.184 J exactly

Info for Introduction

3. Precision, accuracy and significant figures.



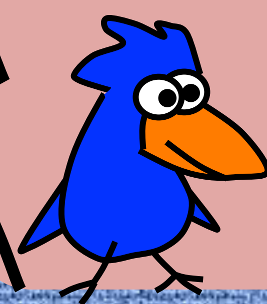


The rule for adding or subtracting numbers is trickier than the rule for multiplying or dividing… We'll start with tricky.

Here's how: Line up the decimal points of the numbers to be added or subtracted. This involves writing the numbers down all lined up by decimal point. Then add them up using your calculator (or your head). Chop off the answer to match the number that has the fewest places past the decimal.

EXAMPLE 1

$$\begin{array}{r} 8.653 \\ +\ 94.03 \\ \hline 102.68 \end{array}$$



See? You can easily get more (or fewer) significant figures than you started with!

Info for Introduction

3. Precision, accuracy and significant figures.

Example 2

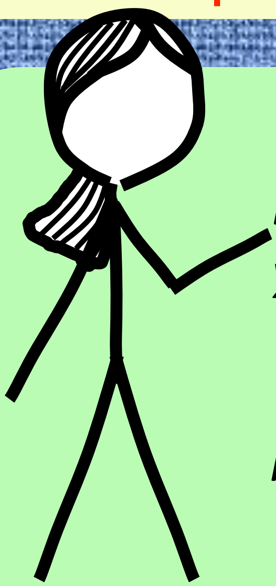
```
  2.1
+ 7.422
-------
  9.522
  9.5
```

Example 3

```
  0.0077
+ 1.04
--------
  1.0477
  1.05
```

Example 4

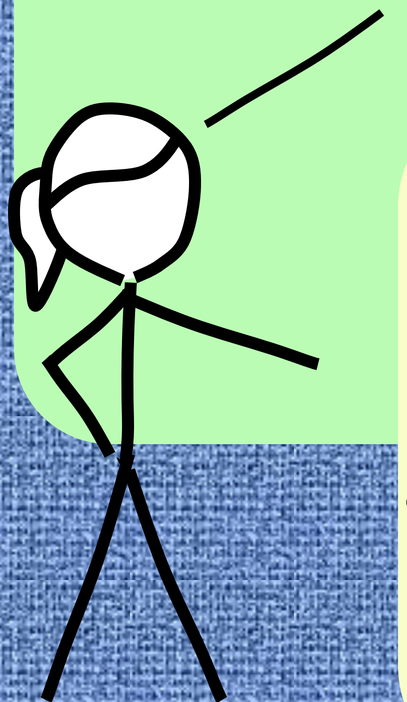
```
  0.0027
+ 1.040
--------
  1.0427
  1.043
```



Here are some more examples. See how we rounded in Examples 3 and 4? Also, listen up! This is important! Keep your full answer in your calculator until the very end – just keep track of how many figures your answer should have. This prevents propagating rounding errors. In Example 2, keep 9.522 for the next calculation, but remember you get only two sig figs from it in the final answer..

3. Precision, accuracy and significant figures.

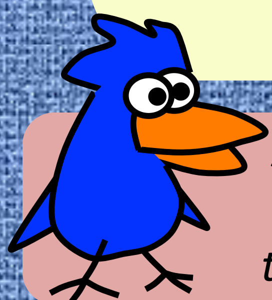
The rule for multiplying and dividing...
Well, we all know that rule...



If one number has five significant figures and the other number has only three, the product or quotient has only three – the same as the least of the participant numbers.

Example 1. A density problem: Suppose 2.6943 g has a volume of 1.37 mL. What is its density?

density = mass/volume = 2.6943 g / 1.37 mL
= 1.966642336 g/mL → 1.97 g/mL

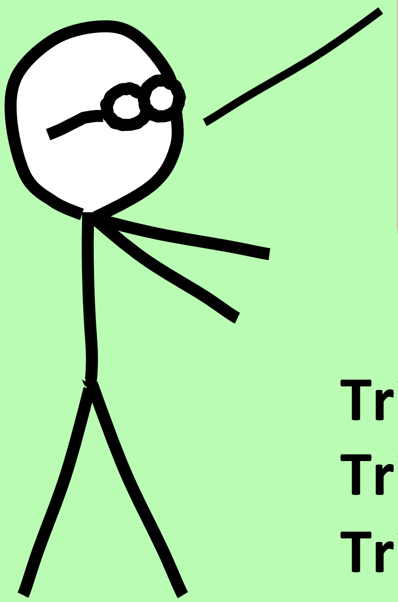


Again, keep the whole number in your calculator until the end of the calculations Just remember there are supposed to be three significant figures.

Info for Introduction

3. Precision, accuracy and significant figures.

Example 2. What is the average mass of the penny from the pocket balance measurements?



Here we use both rules: We add up the four masses using the adding rule and then divide by 4 (an exact number this time) using the dividing rule.

Trial 1	**2.76 g**
Trial 2	**2.74 g**
Trial 3	**2.73 g**
Trial 4	**2.74 g**

Sum = 10.97 g

4 significant figures

DIVIDE BY 4 (EXACT)

The mass of a 2017 penny using pocket balance

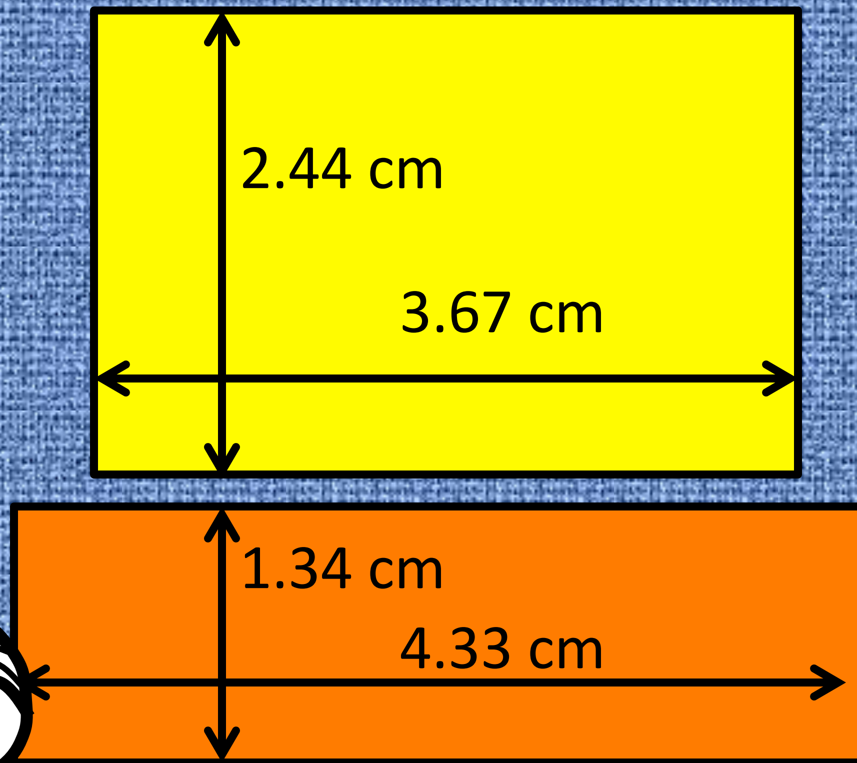
Trial 1	**2.76 g**
Trial 2	**2.74 g**
Trial 3	**2.73 g**
Trial 4	**2.74 g**

Average 2.743 g

Info for calculations

3. Precision, accuracy and significant figures.

Example 3. What is the total area of these two blocks?



$\text{Area}_{\text{yellow}}$ = 2.44 cm x 3.67 cm
= 8.9548 cm^2 (3 sf)

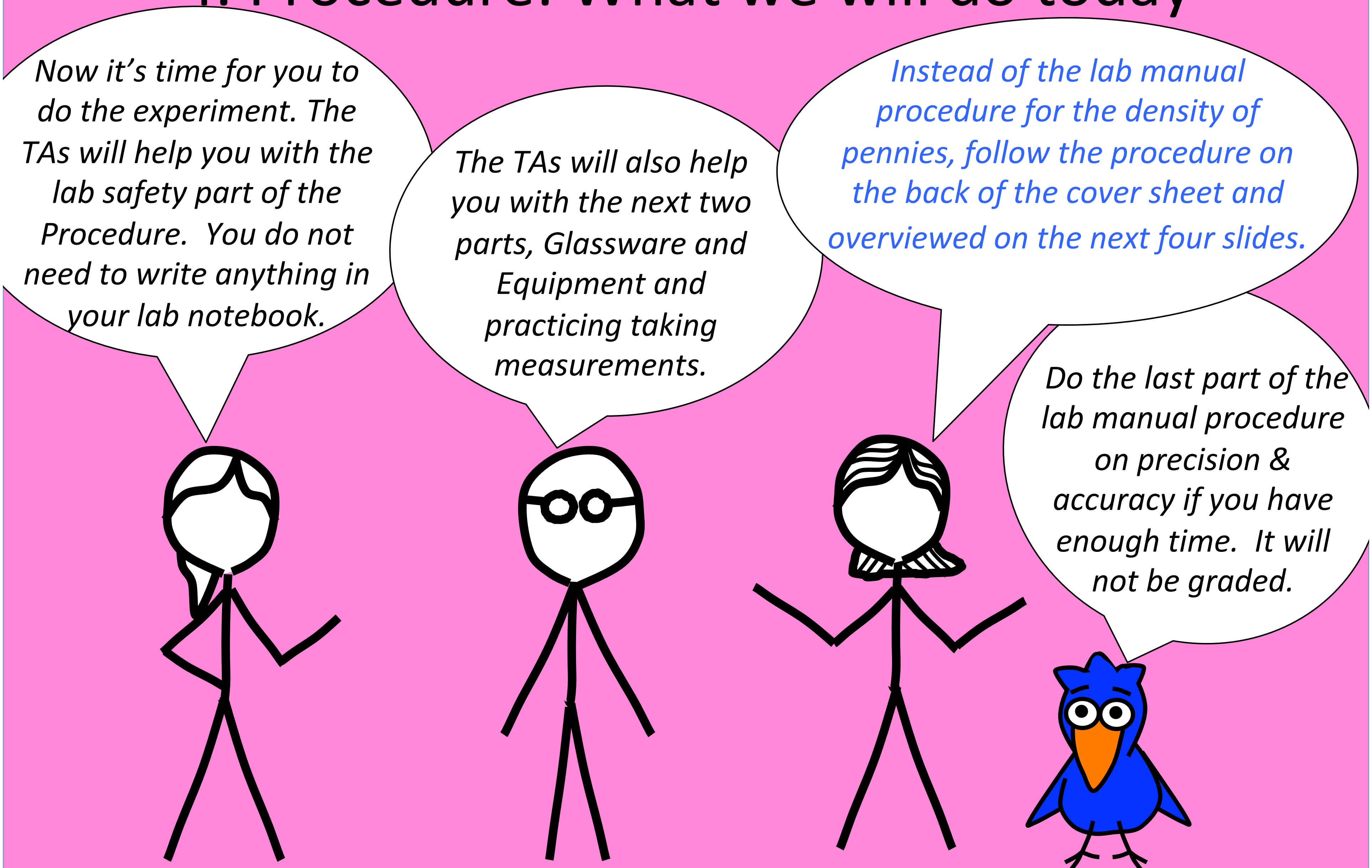
$\text{Area}_{\text{orange}}$ = 1.34 cm x 4.33 cm
= 5.8022 cm^2 (3 sf)

Total area = 8.9548 cm^2
+ 5.8022 cm^2
= 14.7570 cm^2

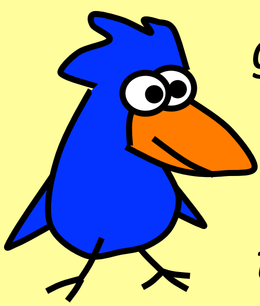
Rounding as we go would yield 14.75 cm^2. Carrying the extra numbers yields 14.76 cm^2 after rounding the final number – probably a better answer.

Info for calculations

4. Procedure: What we will do today



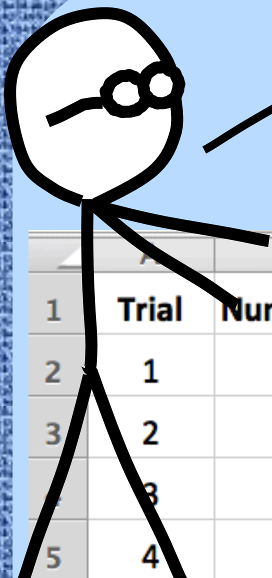
5. Procedure for the density experiment. (Details given on the back of the cover sheet.)



Your experiment will look like this sequence as it goes along. Start with five piles of 10 pennies each and weigh each pile to the nearest 0.01 g. Fill a graduated cylinder with about 40 mL water. Read the volume to the nearest 0.1 mL. Add the first pile of pennies and read the volume again. Record the mass of pennies just added and the new volume. Repeat until all five piles have been added.

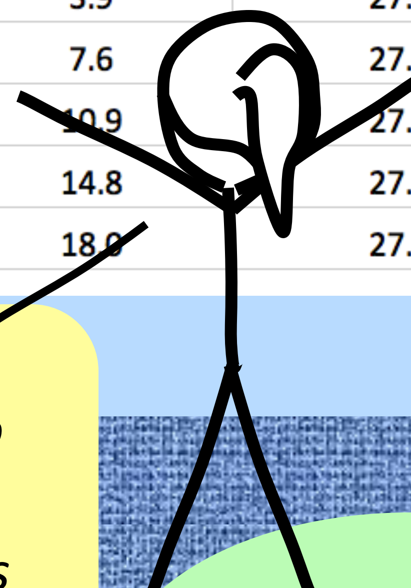
Info for Introduction

5. Procedure for today (our density experiment)



Follow the instructions on the back of your cover sheet to create an Excel spreadsheet with your data.

	A	B	C	D	E	F	G
1	Trial	Number of Coins	Initial Volume	Final Volume	Volume of Coins	Mass of coins added	Total mass coins
2	1	10	40.1	44.0	3.9	27.0	27.02
3	2	20	40.1	47.7	7.6	27.6	54.60
4	3	30	40.1	51.0	10.9	27.0	81.62
5	4	40	40.1	54.9	14.8	27.1	108.74
6	5	50	40.1	58.1	18.0	27.1	135.83
7							

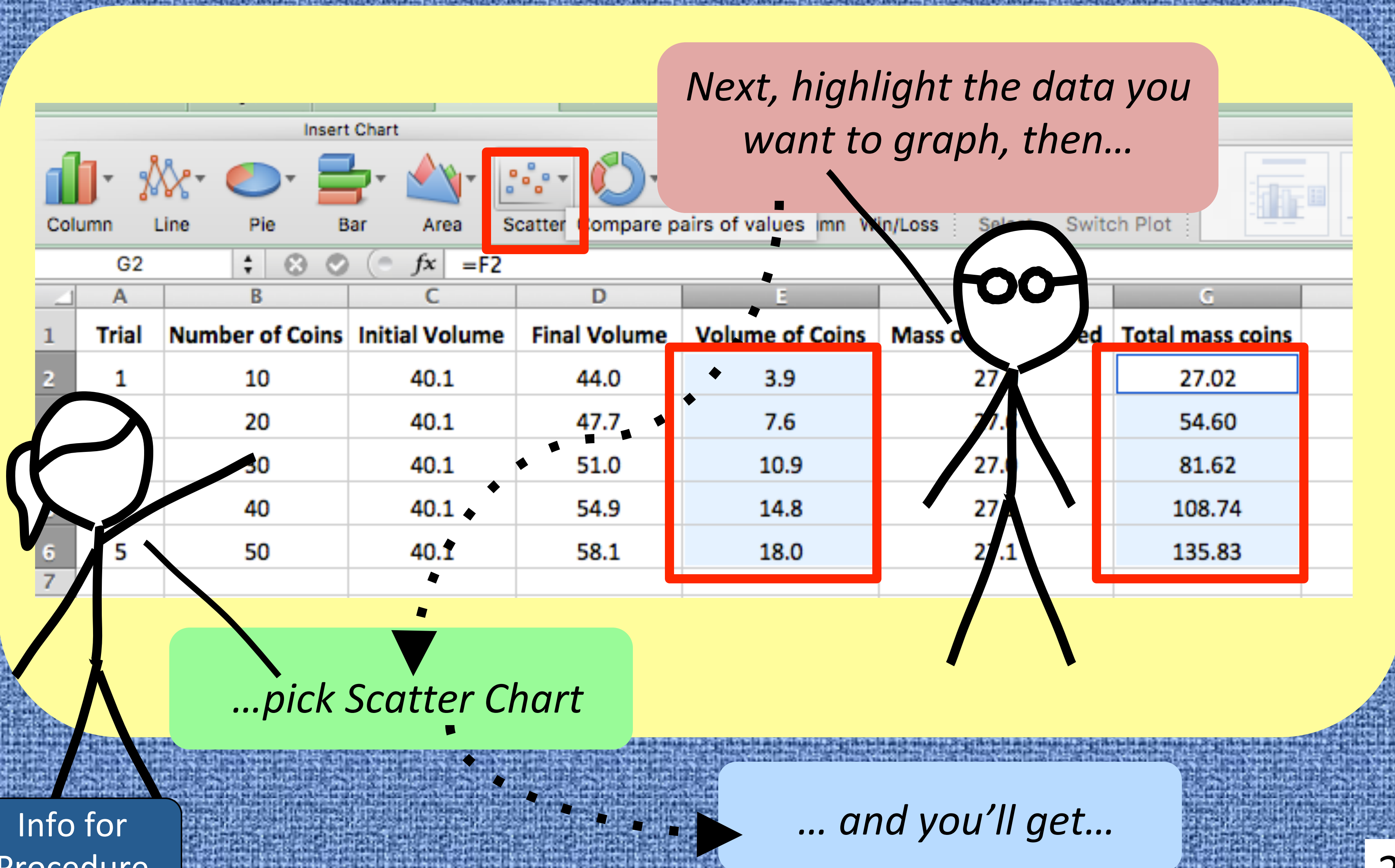


Learn to write formulas, learn to copy and paste formulas and how to format your numbers. Help each other and ask Dr. Mattson or the TAs if you have questions.

You and your lab partner can work together on this, but print a copy for each of you.

Info for Introduction

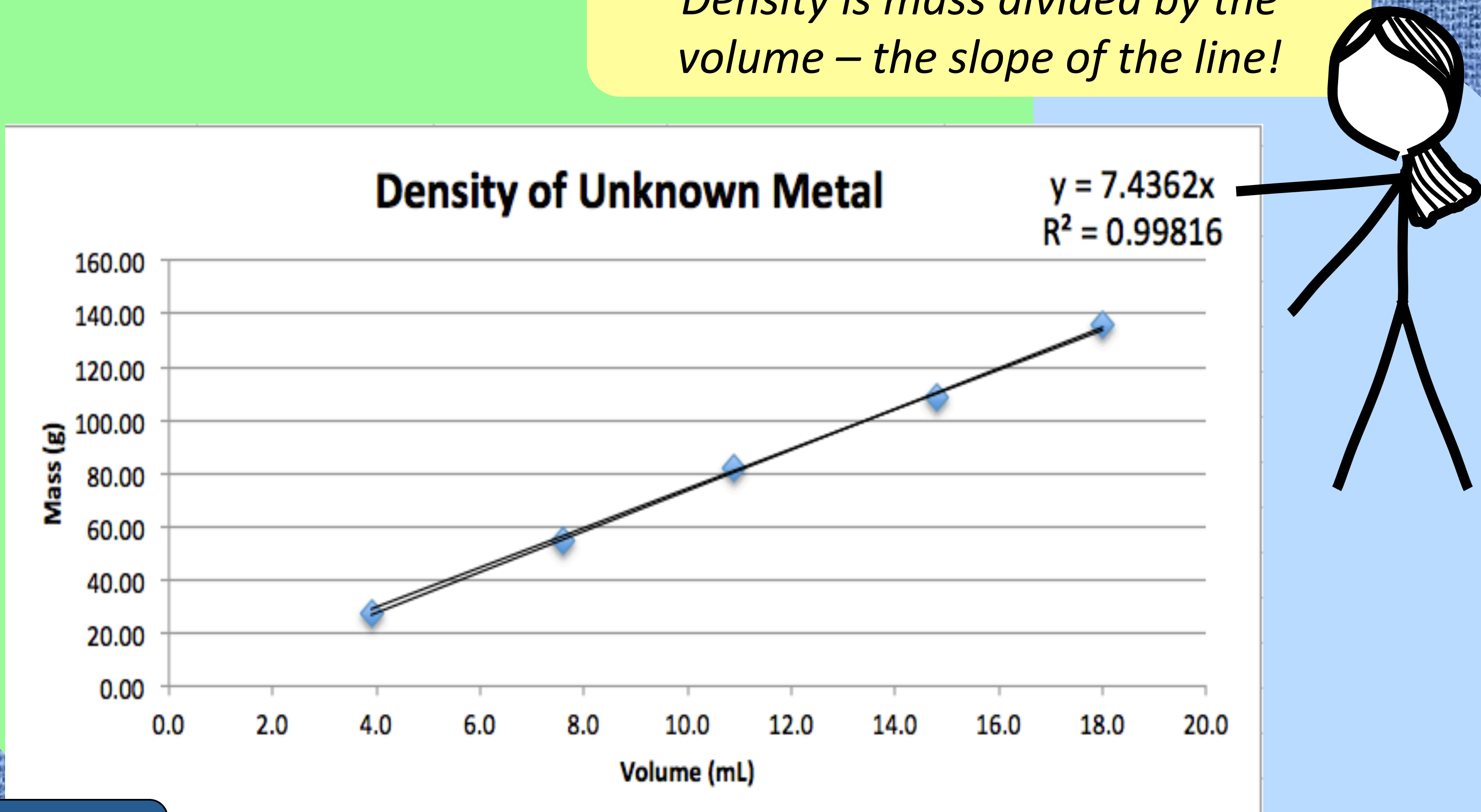
5. Procedure for today (our density experiment)



Info for Procedure

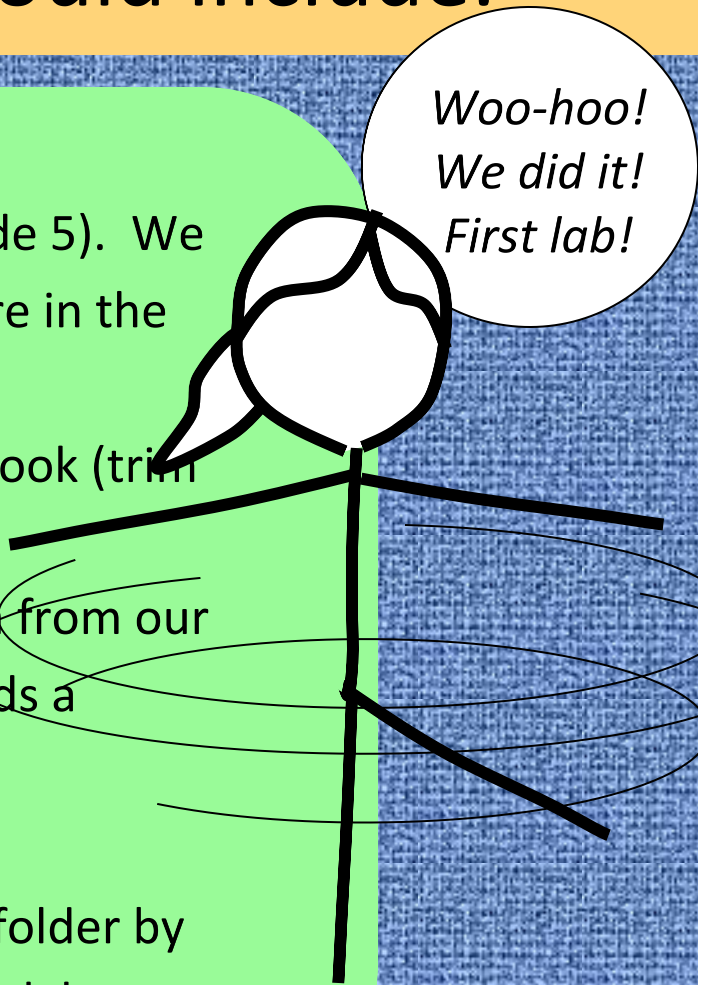
5. Procedure for today (our density experiment)

…this graph!
Density is mass divided by the volume – the slope of the line!



Info for Procedure

6. What your lab report should include.



① First, the cover sheet with TA initials.

② You now know how to write an Introduction (Slide 5). We will discuss conclusions and sources of error more in the pre-lab to Experiment 3.

③ Next, attach the copy pages from your lab notebook (trim off rough edges)

④ Last, the printed Excel x-y scatter graph and data from our density of pennies experiment. Each person needs a graph.

⑤ All of the above stapled together.

⑥ Turned in lab report (each individual) to correct folder by start of class tomorrow. Or… turn it in right after lab today. *Late labs may not be graded – see the syllabus*

Next week: We will need to dress for a mess.

Stick people inspired by xkcd cartoons by Randall Munroe (www.xkcd.com)

Chem Lab with the Stick People and Bird was created and produced by Dr. Bruce Mattson, Creighton Chemistry. Enjoy it and share it if you wish.