UNCERTAINTY

WRITTEN BY
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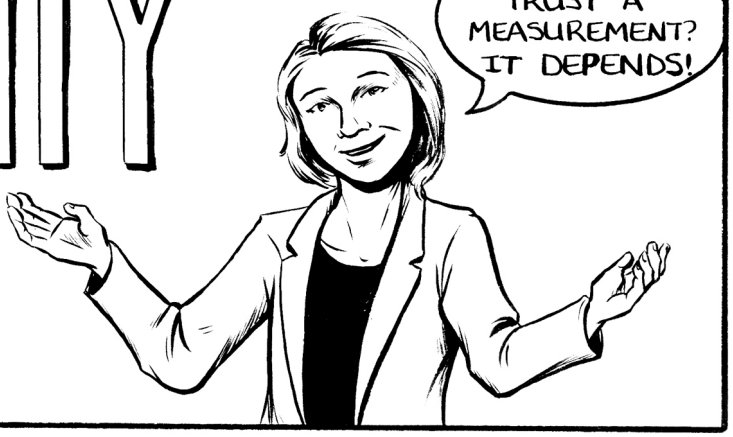

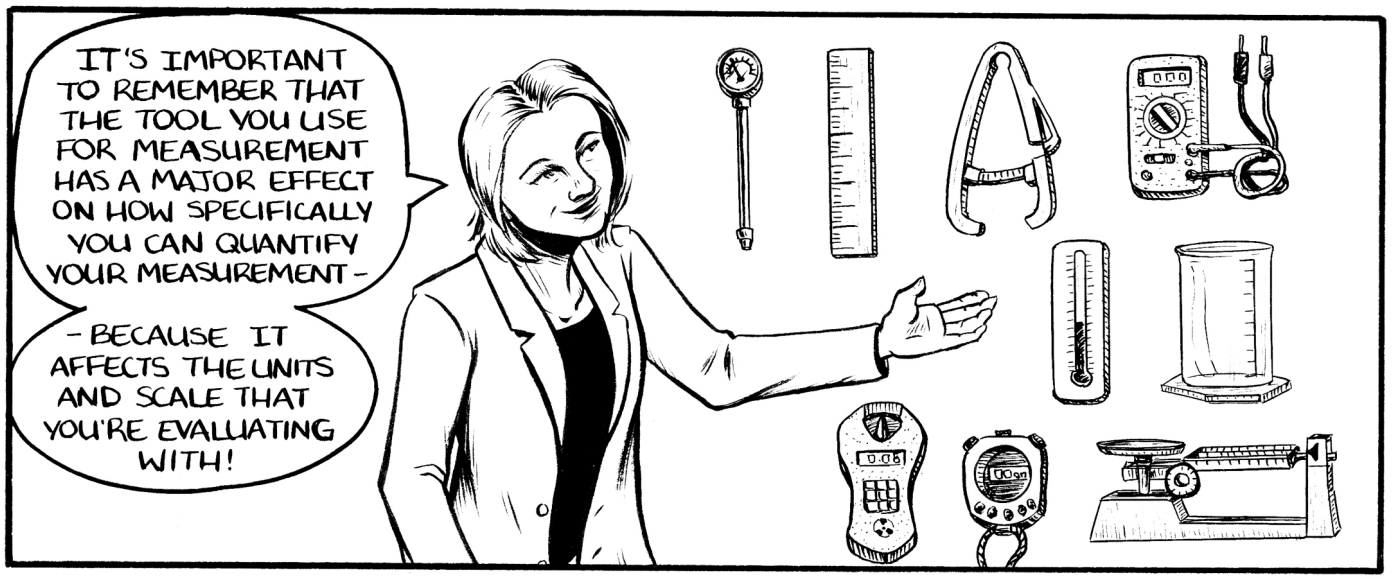

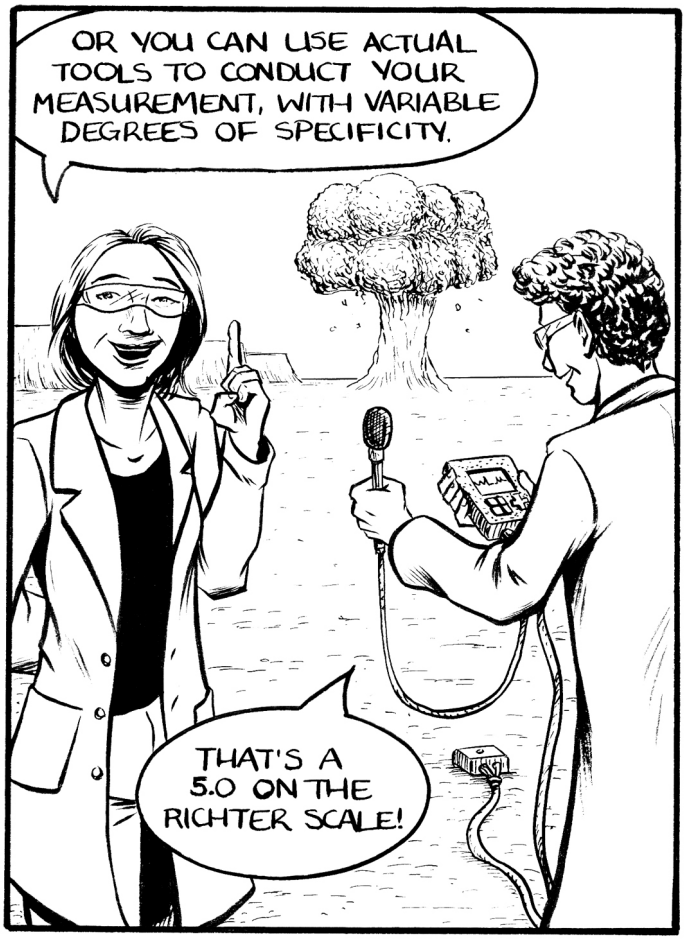

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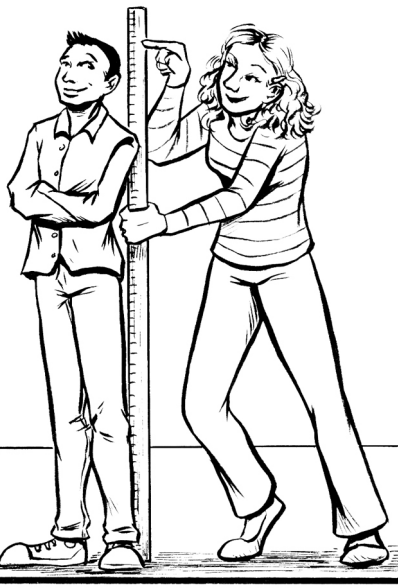
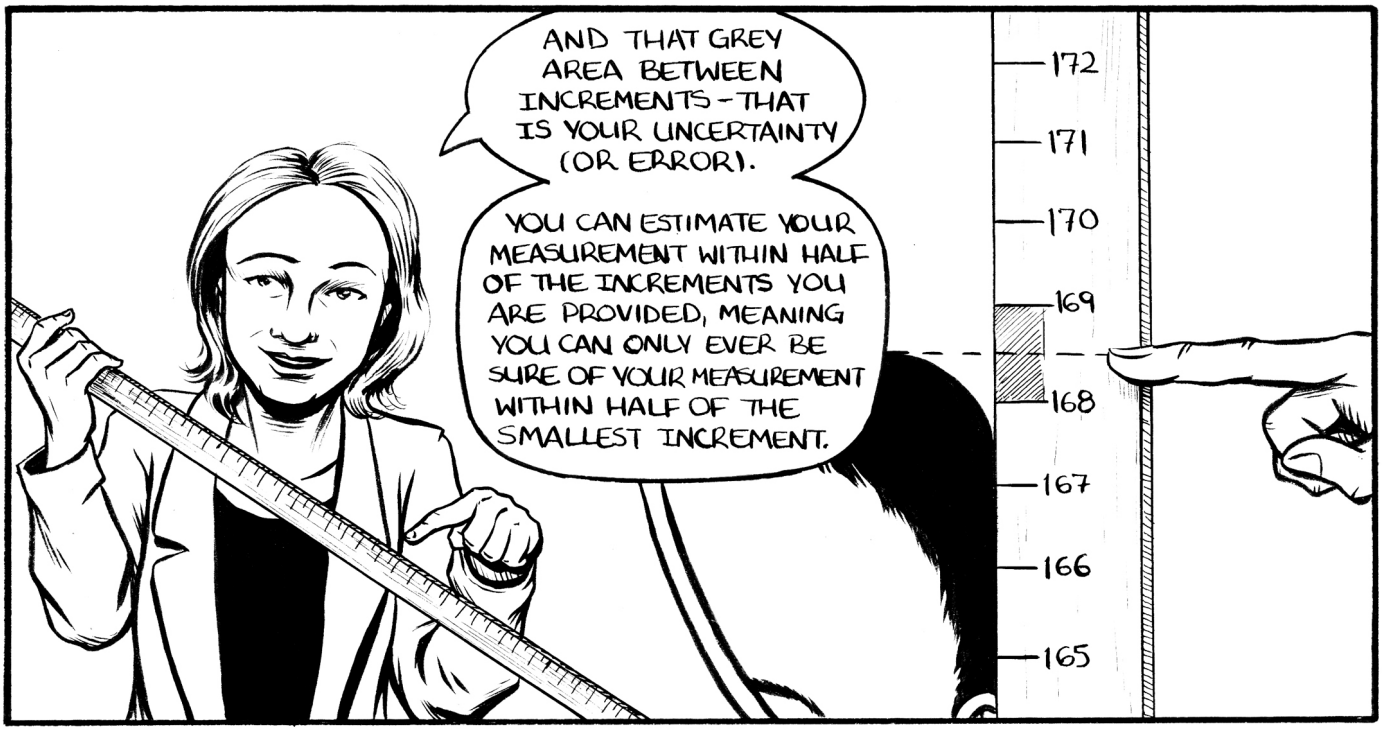
QUANTIFICATION MATTERS, BUT THE TOOL AT HAND IS CRITICAL. IF YOU WERE TO MEASURE SOMEONE'S HEIGHT WITH A METER STICK THAT HAD **NO** INCREMENTS MARKED ON IT, YOU CAN ONLY BE SO SPECIFIC.

BUT THE MORE DETAILED YOUR INCREMENTS ARE, YOU CAN GET VERY SPECIFIC WITH YOUR MEASUREMENT!





THUS EVERY DATA POINT REALLY HAS TWO PARTS:

$$x = x_{best} \pm \delta x$$

THE DATA POINT.

YOUR ESTIMATE OF THE DATA POINT'S VALUE, GIVEN YOUR MEASUREMENT.

THE UNCERTAINTY OF YOUR ESTIMATE.

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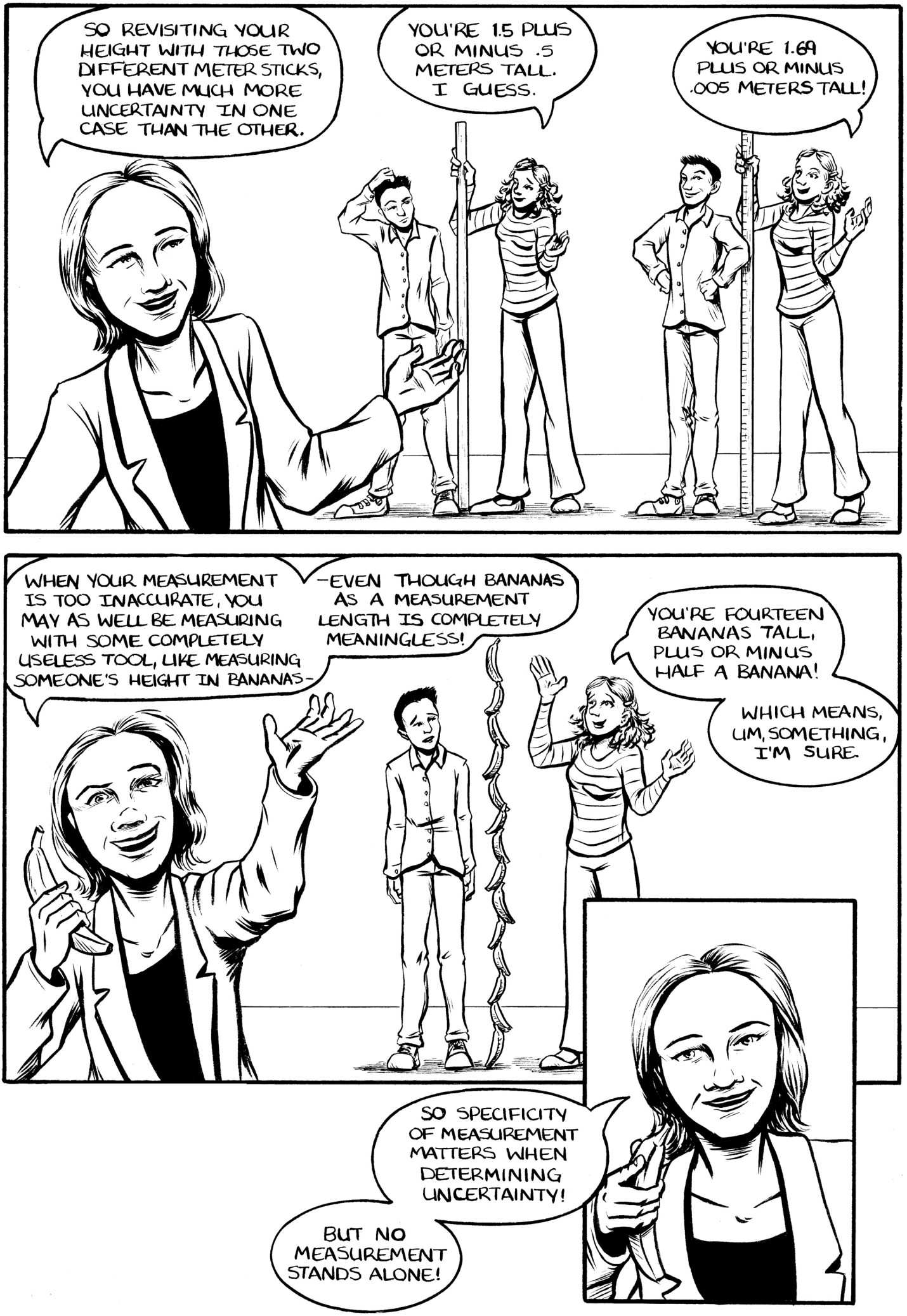

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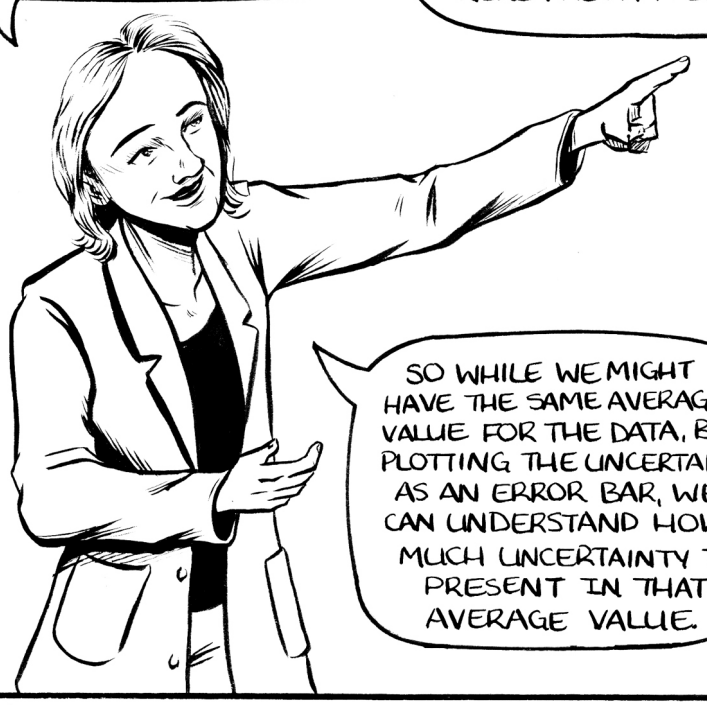
LET'S CONSIDER THAT EXPLOSION AGAIN. REALISTICALLY, YOU HAVE NO GUARANTEE THAT THE EXPLOSION WILL BE EXACTLY THAT LARGE AND DESTRUCTIVE EACH TIME. THAT ONE TIME COULD HAVE BEEN AN IMPRESSIVE FLUKE OR EVEN A RATHER IMPRESSIVE DUD.

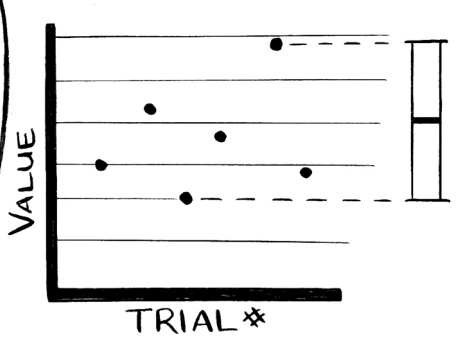
WHOA! DIDN'T EXPECT THAT!

IF YOU REALLY WANTED TO BE SURE THAT YOUR MEASUREMENT ACCURATELY CHARACTERIZED YOUR EXPERIMENT, YOU NEED AT LEAST MINIMUM DATA POINTS TO BE SURE OF THE PRECISION -SO IN THIS CASE, YOU NEED TO SET OFF TWO MORE EXPLOSIONS TO BE SURE THE VALUES ARE ACCURATE!

ONCE WE HAVE AT LEAST THREE DATA POINTS, WE CAN TAKE AN AVERAGE TO DETERMINE THE MEAN VALUE- AND WE CAN CALCULATE THE STANDARD DEVIATION TO DETERMINE THE QUALITY OF OUR MEASUREMENTS.

A LARGE STANDARD DEVIATION MEANS THERE IS A LOT OF UNCERTAINTY INHERENT IN OUR VALUES - WHILE A LOW STANDARD DEVIATION MEANS OUR MEASUREMENTS WERE PRETTY PRECISE!





SO WHILE WE MIGHT HAVE THE SAME AVERAGE VALUE FOR THE DATA, BY PLOTTING THE UNCERTAINTY AS AN ERROR BAR, WE CAN UNDERSTAND HOW MUCH UNCERTAINTY IS PRESENT IN THAT AVERAGE VALUE.

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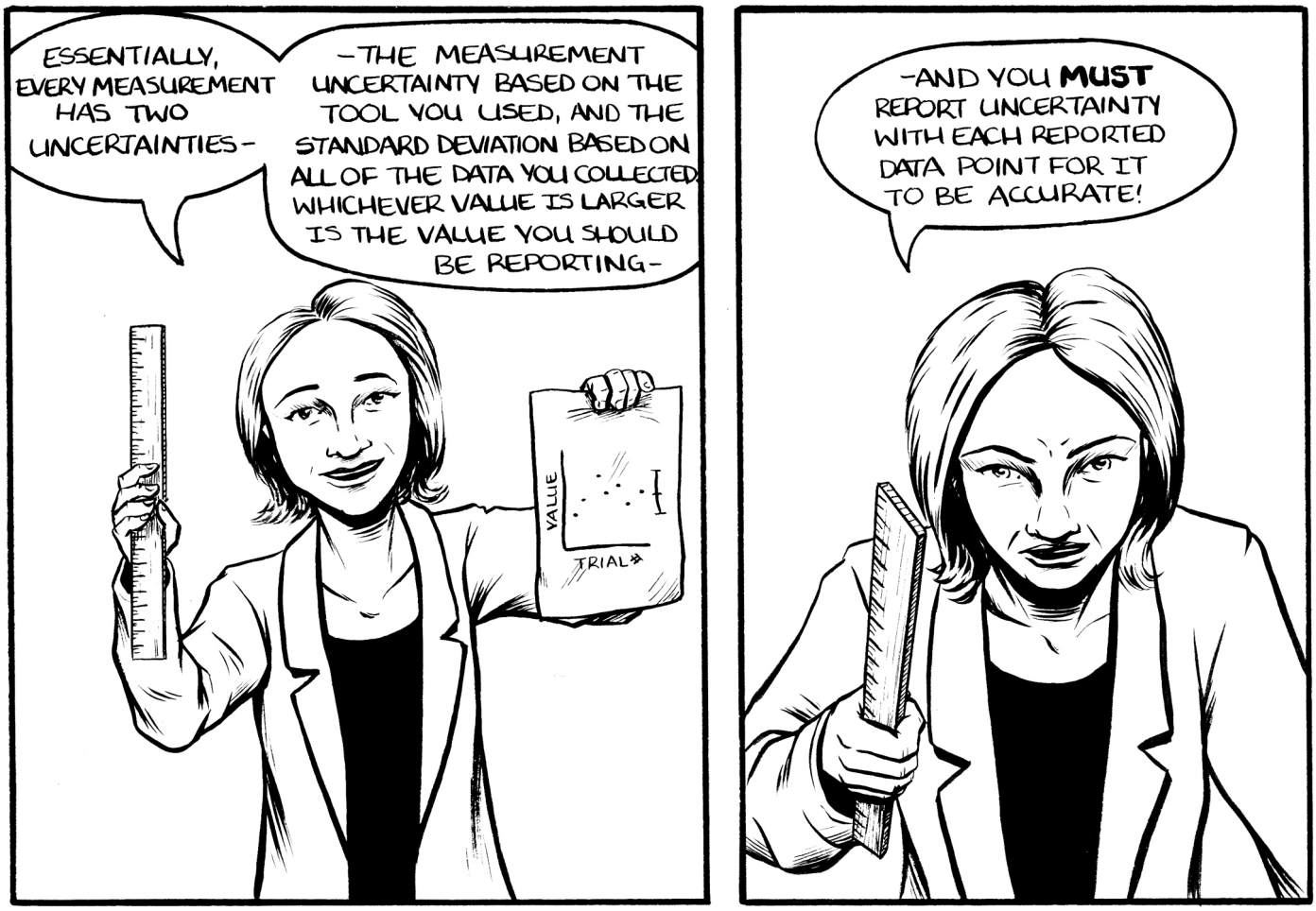

UNCERTAINTY DOESN'T STOP THERE - BECAUSE ONCE YOU START ANALYZING YOUR DATA, YOU ARE LIKELY GOING TO USE RELATIONSHIPS BETWEEN DIFFERENT PROPERTIES TO CALCULATE VALUES OF NEW PROPERTIES. AND BECAUSE EACH VALUE THAT YOU ADD OR MULTIPLY TOGETHER MAY HAVE AN UNCERTAINTY ASSOCIATED WITH IT, YOU WILL NEED TO PROPAGATE THE ERROR!

CALCULATED VALUE → $R = X + Y - Z$ ← MEASURED VALUES

UNCERTAINTY OF VALUE → $\delta R \approx \delta X + \delta Y + \delta Z$ ← UNCERTAINTIES OF VALUES

$$\delta R = \sqrt{(\delta X)^2 + (\delta Y)^2 + (\delta Z)^2}$$

$$R = \frac{X \times Y}{Z}$$

$$\frac{\delta R}{|R|} \approx \frac{\delta X}{|X|} + \frac{\delta Y}{|Y|} + \frac{\delta Z}{|Z|}$$

$$\delta R = |R| \times \sqrt{\left(\frac{\delta X}{X}\right)^2 + \left(\frac{\delta Y}{Y}\right)^2 + \left(\frac{\delta Z}{Z}\right)^2}$$

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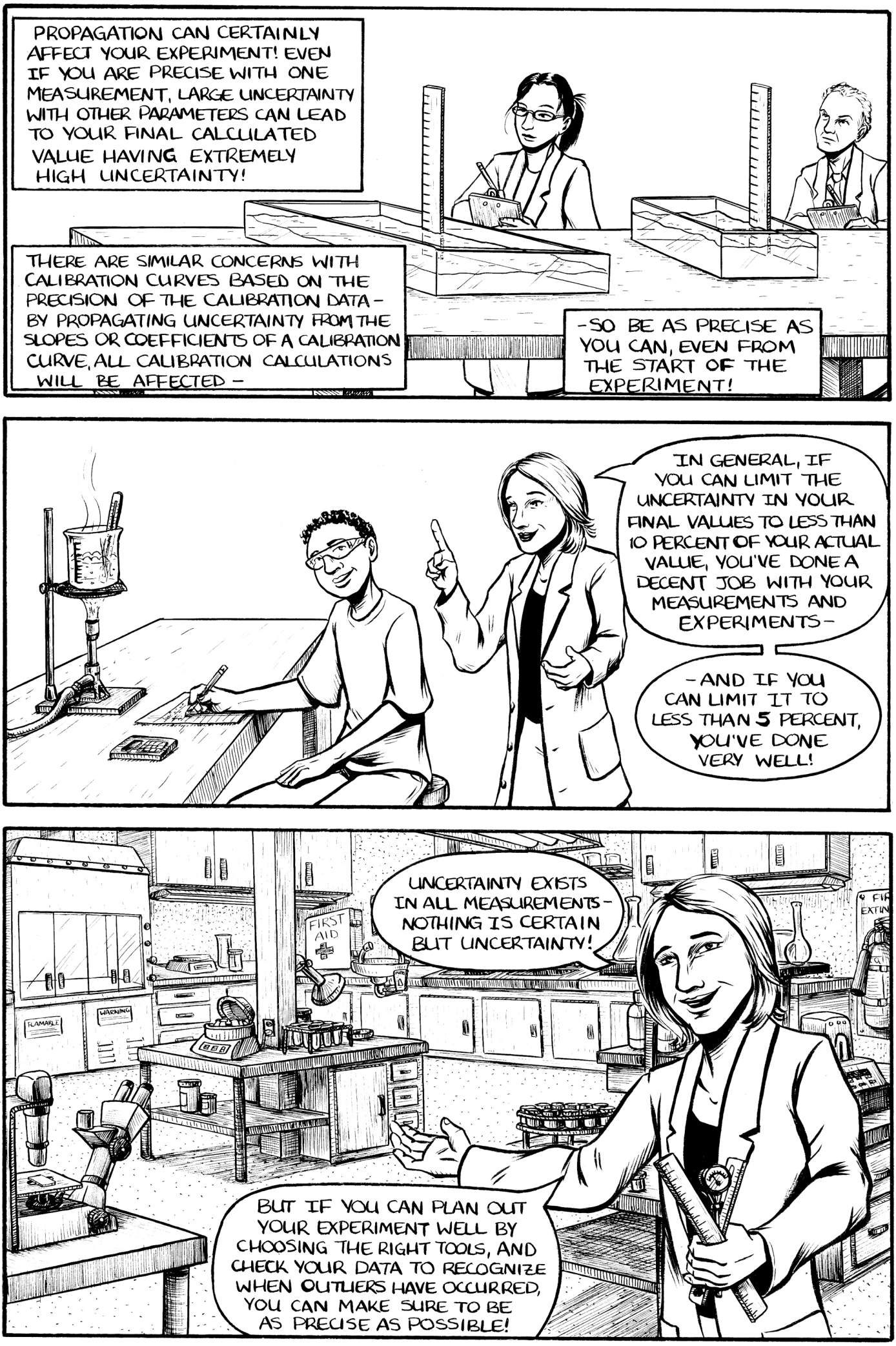

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