

Student: Hi. Prof. I've got a problem. I decided to do a little probability experiment—you know, coin flipping—and check some of the stuff you taught us. But it didn't work.

Professor: Well, I'm glad to hear you're interested. What did you do?

Student: I flipped this coin 1000 times. You remember, you taught us that the probability of getting heads is one-half. I figured that meant that if I flip 1000 times, I ought to get 500 heads. But it didn't work. I got 513. What's wrong?

Professor: Yeah, but you forgot about the margin of error. If you flip a certain number of times, the margin of error is about the square root of the number of flips. For 1000 flips the margin of error is about 30. So you were within the margin of error.

Student: Ah, now I get it! Every time I flip 1000 times, I will always get something between 470 and 530 heads. Every single time! Wow, now that's a fact I can count on!

Professor: No, no! What it means is that you will probably get between 470 and 530.

Student: You mean I could get 200 heads? Or 850 heads? Or even all heads?

Professor: Probably not.

Student: Maybe the problem is that I didn't make enough flips. Should I go home and try it a million times? Will that work better?

Professor: Probably.

Student: Aw, come on, Prof. Tell me something I can trust. You keep telling me what 'probably' means by giving me more 'probablys'. Tell me what probability means without using the word 'probably'.

Professor: Hmmm. Well how about this: it means that I would be surprised if the answer were outside the margin of error.

Student: My god! You mean all the stuff that you taught us about statistical mechanics and quantum mechanics and mathematical probability—all it means is that you'd be personally surprised if it didn't work?

Professor: Well, uh ...

If I were to flip a coin a million times I'd be damn sure that I wasn't going to get all heads. I'm not a betting man, but I'd be so sure that I'd bet my life or my soul on it. I'd even go the whole way and bet a year's salary on it. I'm absolutely certain that the laws of large numbers—probability theory—will work and protect me. All of science is based on it. But I can't prove it and I don't really know why it works. That may be the reason Einstein said, "God does not play dice." It probably is.

by Leonhard Susskind  
from *What We Believe But Cannot Prove*