

“I often say that when you can measure what you are speaking about, and express it in numbers, you know something about it. But when you cannot express it in numbers, your knowledge is of a meagre and unsatisfactory kind; it may be the beginning of knowledge, but you have scarcely in your thoughts, advanced to the stage of science, whatever the matter may be.”

—Lord Kelvin (*William Thomson*)

¶ 1. Enrico Fermi (1901–1954) was an Italian-American physicist, particularly remembered for his work on the development of the first nuclear reactor, and for his contributions to the development of quantum theory, nuclear and particle physics, and statistical mechanics. Awarded the Nobel Prize in Physics in 1938 for his work on induced radioactivity, Fermi is widely regarded as one of the leading scientists of the 20th century, highly accomplished in both theory and experiment.

He was also known for his well developed knack for intuitive measurements. For example, he was an observer at the Trinity test in 1945, the first test of the atomic bomb. Scientists were trying to calibrate instruments to measure the yield of the blast of the nuclear explosion during the test. Fermi tore his notepad into confetti size bits and let it be carried away by the blast wave. By measuring the spread of his confetti, he was able to estimate that the yield of the blast was about 10 kilotons of TNT. The actual yield was 18 kilotons.

In his lectures at the University of Chicago, he would often pose his students seemingly impossible to answer questions. These are called Fermi questions; we will examine some of them below.

¶ 2. How many hairs do you have on the top of your head?

- (a) Less than 100,000
- (b) Between 100,000 and 200,000
- (c) Between 200,000 and 500,000
- (d) More than 1/2 million

¶ 3. How many M&M's fit in a half gallon carton of milk? In a bottle of wine ( $\frac{3}{4}$  liters)?

- (a) Less than 1,000
- (b) Between 1,000 and 2,000
- (c) Between 2,000 and 5,000
- (d) More than 5,000

¶ 4. How many piano tuners are there in the City of Los Angeles?

- (a) Less than 10
- (b) Between 10 and 100
- (c) More than 1000
- (d) Have no idea!!

- ¶ 5. How many water balloons does it take to fill your school classroom? How many tennis balls?
- ¶ 6. How long is the celluloid film for the movie “Avatar”? How many frames were needed for the whole movie?
- ¶ 7. How many ears of corn were needed to provide for all popcorn eaten by all the moviegoers that went to see “Avatar” since its release?
- ¶ 8. Right now, how many gallons of gas are carried by all the gas tanks of the cars in the US?
- ¶ 9. (a) Estimate the total amount of time that HS students in the US in the US spent during this past semester studying for exams in college.
- (b) Estimate the total amount of time that these HS students spent on the phone (texting, talking, or any other phone activity) this past semester.

## **Literature**

[1] Lawrence Weinstein and John Adam, *Guesstimation*, Princeton University Press, 2008.