Zeros…all those zeros! What do they mean?

The largest denomination banknote ever circulated was the 1946 Hungarian 100 quintillion Pengo note… (100,000,000,000,000,000,000, or 10E20), worth 20 US cents. A Hungarian billion-Pengo is really American trillion-Pengo, but hey, as long as we're talking really huge numbers, who cares?

But I digress.

Some years back I went on a first date. After dinner, we were parked, looking at the stars, my arm around her shoulder. I made some terribly nerdy remark (now best forgotten) about how many stars there were and the conversation gradually disclosed the astounding fact that she thought scientists with computers and technicians in white lab coats and clipboards devoted themselves solely to the arduous task of counting as high as they possibly could. Just counting!

"Have they been able to count to a billion yet?" she asked me—her blonde hair shining in the moonlight. Flummoxed…I knew I would regret any possible relationship this led to, and sent her home.

But she is hardly alone. The CFO of a company I worked for was befuddled when I mentioned that the national debt was then a shocking three trillion dollars.

"Trillion?" he queried, "You mean billion…?" the MBA-CFO-Executive said. His incapacity still bothers me…I wonder where he works now?

Billion, trillion, zillion, million, hell what's in a name? I read and hear cognitive-consonant-confusion of those terms on the news and in the media on a daily basis. No one corrects them. The TV guide said that a 60 Minutes segment would examine California's massive $40 million debt. I would have watched the show to see how this

was possible, since $40 million comes to about $1.10 per Californian—nearly a balanced budget. Amazing if true, but of course they meant billions not millions.

Often, I've wondered if I'd heard the person right. The words rhyme after all—and the really significant amounts differ by only a single phonic. It would be a vast improvement if the words for increasingly large sums of money would be increasingly longer and more difficult. Then it would be clear if you meant for example, mere hectos (100's), kilobucks (1000's), megamuchos (1,000,000's), gigagianticostlies (1,000,000,000's), and terasuperduperultrabuckaroonies (1,000,000,000,000's). Beyond this amount, people would have to pass some sort of proficiency test before being licensed to speak or write the words, or better yet, only scientific notation would rule; after all, it is only a particularly British madness to expect everything to have a name.

It is hard to think about big numbers—and it is fascinating that most people seem to have no clear understanding of the meaning of large sums. If they did, reasonable persons would strike, riot in the streets and take sniper positions when an executive gets a couple billion dollars. Why? Well, the town I live in, Southbridge, Massachusetts, and all its 17,214 citizens, has a combined net worth of maybe a couple billion dollars.

There are kajillions of ways to calculate this, but the point I am trying to make is that big money has only the faintest connection to reality, or at least is totally incomprehensible to most people—even the people who are getting the *really Big Bucks*.

The only way of understanding a really big pile of dollars is "Opportunity Cost"; that is, what you could buy with the money. What could one do with a billion dollars? A billion dollars is more than all the Alaskan gold mined in 2010—more than a cubic stack of gold bars 1.13 METERS on a side. Just *five percent* of that billion dollars ($50 million) would get you: A lifetime lease on a Gulfstream G450 at your beck and call—Plus a home, condo or apartment in ten major exotic destinations, with a (leased) luxury fleet of cars at each—Plus a coterie of servants to follow you around—Plus memberships in every exclusive club you wanted—Plus all you could possibly eat, wear, play with and see for a lifetime. And Hell, throw in a leased ultra-luxury yacht. Then you could sail around sipping expensive booze imagining ways to spend your remaining *$950-million dollars*.

When the Wall Street bailout sailed through the Congress I was mortified that almost nobody took notice of what really had been done. That $800 billion is the approximate amount it would take to build every single structure (and its infrastructure) in the entire state of Massachusetts—Every private home, public building, road, bridge, courthouse, street, waterline, electrical line, sewer, power generating plant, gas station, highway, overpass, playground, airport, dam, farmhouse, cell tower, prison, library, school, museum, dock, hotel, firehouse, store, sidewalk, tunnel, waste treatment facility, railroad, light pole, traffic signal, police station, restaurant, warehouse, lumber yard, grocery store, hair salon, bar, manufacturing plant, parking lot….all of it. And you could throw in the most expensive public works project in the history of the US…the Big Dig, which costs as much as 2.25 brand new Panama Canals.

The Panama Canal— the largest construction project in history at the time— cost

$375 million in 1913 dollars. The CPI from that time to today has grown 21.2×, making the cost in 2008 dollars about 7.95 billion dollars. So $800 billion today would buy, from scratch, 100 new Panama Canals.

Spent another way, $800 billion would pave the entire state of Massachusetts, all 27,340 km² in concrete, 30 cm thick (including really hefty steel-bar reinforcement). Some think this would be a better use of the money.

Here's another, perhaps more practical purchase–

The approximate cost of constructing a twin track 10,000 km maglev train system including 300 kph trains, tunnels, bridges and stations, between most major US cities is about $800 billion. Average construction cost would be only about $50 million per kilometer. About 1200 maglev cars would be needed. The rolling stock would cost only $20 billion.

Actually, like most big mass transit systems, it would not be able to pay its own way, but at least you'd see where your money went…and how fast.

Some more Really Big Numbers:

How Big is the Universe?…No Really….

One could start a Cosmology class (or even a Cosmetology class, I suppose) with the interesting question—How many grains of sand are on all the beaches on Earth? (credited to Sir James Hopwood Jeans "The mysterious universe" 1937.)

The calculation goes something like this:

If a cubic millimeter contains 10 grains of sand, then a cubic meter contains 1000 × 1000 × 1000 × 10 grains of sand. (Or 10E10 grains of sand per cubic meter).

Now, our "average beach" (watch me wave my hands around…) is 100 meters wide and 30 meters deep and 1,000,000 kilometers long, when you wrap it around all the land, every island, and inlet bordering any body of water anywhere. So that is 100 × 30 × 1,000,000 × 1000 cubic meters (Or 3×10E12).

Multiplying the cubic meters of sand by the number of grains in a cubic meter yields 10E10 × 3×10E12= 3 × 10E22 grains of sand on all the beaches on Earth.

Now it turns out that current best estimate is that there are approximately 1.5 × 10E11 galaxies 2×10E11 stars per galaxy= 1.5×10E2 × 2×10E2 × 10E9=3×10E22 stars in the universe.

Don't look surprised…the point of this is *not* that these numbers are the same, in fact we have done some juggling of numbers to make this come out right. Nobody knows what an "average beach" is, for example. And the number of stars-per-galaxy and the number of galaxies in the universe is always open to revision upon better measurements. But the numbers are believed correct to within a factor of 2 or 3.

So what? Well, this is a perfectly good answer to Fermi's Paradox, which proposes that aliens should be here *if there were any in our galaxy*, since on average they

would be millions of years more advanced than Earthlings, they should easily have populated the entire galaxy. So as Fermi is reported to have asked, "So then, where are they?"

Well, I'll tell you where they are: Many use the familiar Drake Equation—to try to arrive at a reasonable estimate of how many intelligent civilizations there are in our galaxy. But here's my perfectly reasonable backwards calculation: Let's assume there are 15,000,000,000 (fifteen billion) intelligent extraterrestrial civilizations—in the observable universe. Let's define "intelligent" as someone capable of sending us any kind of a signal. Then only one-in-ten large galaxies have one, and ever detecting one is probably hopeless, or stated another way; and given these numbers, there is a 10:1 probability that we are alone in our galaxy.

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