Hey Honey, I Shrunk The Kids

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During my senior year of high school this poor farm boy had two life jolting experiences. The first occurred October 4, 1957. All of the high school students at Utica High School were called into the gymnasium for a general assembly. A single table, a chair, and an unusual looking radio on the table occupied the stage. The chair was occupied by my old chemistry and physics teacher, Mr. John P. Miles. As the students quietned, the volume of the radio was increased and a steady silence was interrupted with a beep.....beep..... beep. Mr. Miles later explained to the audience that the Soviet Union had just launched into outer space the world's first artificial satellite, Sputnik I.

The second was my first experience of travel out of the Commonwealth, except for an occasional trip across the river from Owensboro to Evansville, IN to the stockyards. These trips were to out-of-state schools that had offered me a basketball scholarship.

I was both awed and stimulated by these experiences. The awe came from my first awareness of this universe. My stimulation grew from my realization that I had a lot to learn.

The year following the completion of my undergraduate work at Georgetown College I received another of those life-jolting experiences. I was serving as a science teacher in the Eminence, Kentucky independent schools. Wanting to initiate interest in the sciences, I organized a school wide science fair. I approached an acquaintance that managed the local Bell Telephone office for a prize for the winner of fair. He told me in a few days that he had something. It turned out that the prize was an all expense paid trip

for the winner and his teacher for a week at Bell Labs in Murray Hill, New Jersey. I was like a kid in a candy store. My student was equally excited. High on the list of research projects that we observed was the first operational laser in the world. They demonstrated its far ranging potential for communications, medicine and defense. We viewed the first prototype of a now common transistorized integrated circuit. Needless to say, at that time of my education and career, I had no awareness of either of those innovations.

Once again I was reminded how little I knew about the world around me.

When I got out of college and had a steady income, I became involved in a hobby that I had long aspired to pursue, amateur radio. My first radio station, which I still have as an item of memorabilia, was a Knight Kit R100A receiver and a T100A transmitter which occupied the entire surface of my restored office desk. Between my education and my hobby, I became well versed in electricity and electronics, regularly building transmitters, receivers, amplifiers and power supplies. At one point I even built a microwave oven. I tell you of these experiences to make a point. I became aware of the rapid pace of technology development and the shrinking dimensions of its elements. That early transmitter that I built contained a simple triode amplifier tube. (I demonstrate to you its size). Shortly thereafter, that voluminous tube was replaced with a transistor that was $1/100^{th}$ its size and 10 times its power. However, that reduction in size didn't last long for the power transistor was replaced with an even smaller one. And now, we can boast the inclusion of the complete electronic components of a radio receiver in a single integrated circuit.

In a parallel universe consider the shrinkage of computer technology and the related hardware. While in graduate school at the University of Kentucky I was required

to schedule time on the University's only student accessible computer. A Univac, that occupied an entire floor of the School of Engineering. Subsequently, after moving to Hopkinsville and assuming a science teaching job at Hopkinsville High School a student's father, who managed the computer department for Thomas Industries, gave me an opportunity to experience a much more powerful machine that occupied a single large room. After joining the staff of the Pennyroyal Center and outgrowing the capacity of our board chairman's computer, the IBM System 3 at Mr. Frank Yost's Hopkinsville Milling Company. The System 3 was not much larger that a good sized office desk and possessed a processing ability 5 times that of the TI computer and a 100 times that of UK's . Not only did the physical size of computer technology shrink, but the cost to consumers did also. When I retired from the Pennyroyal Center, they made me a present of two of the purchases I made while there, the Center's first electronic calculator and the first personal computer. The first calculator was really a whiz. It would add, subtract, multiply and divide and possessed a memory that would allow you to do chain computations without re-entering one of the numbers. Physically it was 6 inches thick, 16 inches long and sixteen inches wide. It's cost…..$650.00 and the supply house told us we were getting a real bargain. That was 1970.. I'm holding in my hand a miniaturized model that a local vendor was giving away in 1980. It will do all the same functions plus extract a square root. That original PC was a real whiz too. It contained a special integrated circuit that would process data at a blazing speed, store 8,000 bytes of information in its memory and could read and write stored data in an instant to a magnetic disk…no more punched cards or paper tape. The nominal price for that miracle of technology was only $6,000. Just before I retired I signed the contract for the

purchase of a new computer that would operate the entire Center, link all its facilities, handle of the voice communications of the integrated telephone system, had the magnetic storage capacity to contain the entire medical record of every individual that ever received any kind of service from the center, the electronic accounting records for the history of the Center and everything added in the foreseeable future. All of that capacity would fit in box no larger that your typical Labor Day picnic cooler. And the price of that hardware was less than half the cost of that original PC.

While we were all witnessing the shrinking size of office technology similar strides were being made in business, industry, medicine and aerospace. Most of the innovations being made in all these arenas was being driven by studies in the latter, aerospace. We've all been impressed with the dramatic improvements in textiles, pharmacology, medical diagnostic and treatment procedures,

In a relatively quiet manner, with all this technology growth, there burst on the scene a whole new realm in the world of discovery. Labeled by those most informed as the "new industrial revolution", these efforts promise to effect the worlds population in a fashion far more dramatic than that of the industrial revolution. I am speaking of the ultimate in miniaturization, technology development in the dimensions of 1/1,000,000,000,000 (one billionth) of a meter, or a nanometer. The new efforts have been called by the creators, NANOSCIENCE or NANOTECHNOLOGY.

Just what is nanotechnology? The name is a catch-all phrase for materials and devices that operate at the nanoscale. Likely during your past science instruction regarding measurements of length, you became well familiar with kilometers, meters, centimeters and millimeters. Possibly a measurement in the "micro" or "pico" ranges. In

that system of measurement, "nano" is the prefix that symbolizes a billionth and therefore a nanometer is one-billionth of a meter. Reference to nano materials, nanoelectronics, nanochemistry, nano devices and nano powders simply mean the material or activity can be measured in nanometers. Allow me to put this dimension in perspective for you. For comparison, a human hair is about 100,000 nanometers. A human red blood cell is over 2,000 nanometers long, virtually outside the nano scale range.

Nanotechnology had its beginnings in the late 50's when Nobel Laureate physicist Richard Feynman gave a lecture entitled, "There's Plenty of Room at the Bottom, in which he proposed that the properties of materials and devices at the nanometer range would present future opportunities. The term reached greater public awareness in 1986 when K. Eric Drexler, PhD., published, "Engines of Creation: The Coming Era of Nanotechnology".

So how will nanotechnology work?

When Henry Ford built a manufacturing plant for Ford automobiles in the early 1900's the plant occupied 2,000 acres along the Rouge River in Michigan. The factory included the equipment for every phase of the car including the blast furnaces to produce the steel, a steel rolling mill, a glass plant and more than 90 miles of railroad rail. Designed for mass production, it was lauded as the industrial miracle of the era.

Such manufacturing facilities will be a historical spectacle for those who in this 21st century see nanotechnology come to fruition. Over the next decades, machines will dramatically shrink in size....becoming so small that it would take thousands of them to fit in the period at the end of this sentence. In these future decades these machines will

be used to manufacture products at the molecular level, piecing them together one atom or molecule at a time creating baseballs, telephones or automobiles. You name it.

The visions include nanogears no more than a nanometer wide that could be used to construct a matter compiler through which raw materials would be arranged an atom at a time, producing a macro scale structure.

As early as 1990 IBM scientists, with the assistance of an atomic force microscopy instrument positioned 35 xenon atoms on the surface of a nickel crystal spelling out IBM, the worlds smallest logo.

A first step in this nano-leap is the construction of group of nanomachines called assemblers. It would take such a machine thousands of years to construct anything of visible size, however, trillions of assemblers will reduce the time required to a reasonable period. To solve this problem replicators will need to be constructed. Their task will be the production of the assemblers.

Since the beginning of the 21st century, millions of public resources and untold fortunes of private funds are flowing toward the effort. Major universities across the country are offering advanced degrees in the nanosciences, building an effort to build the intellectual infrastructure required to accomplish the feats.

Dreamers in the medical field have not ignored these opportunities. In the nano world, patients will drink a fluid containing nanorobots that are programmed to attach and reconstruct the molecular structure of a cancer cell or a virus making them harmless. Nanorobots could be programmed to perform delicate surgeries. Such nano surgeons could work at a level a thousand times more precise than the sharpest scalpel.

Nanoscience has the potential for a positive effect on the environment. These nanoscale devices would dramatically reduce the dependence of traditional fuels. Contaminants could be removed from water supplies, toxic wastes could be recycled to use products. Cutting trees, mining for coal or drilling for oil could well become passé.

So, are these technology frontiersmen correct??

An observed phenomena in the nano world of atom sized particles is the change of the element's historical properties. Despite some views that nanotechnology is a far-fetched idea with no near-term applications, nanotechnology has already established a beachhead in several industries. Early it was predicted that the early progress would be in the production of fibers, both metallic an non-metallic. This is a reality. The majority of nanotech products commercially used today are based on nano-sized particles.

Developers of fabrics for your friendly Eddie Bauer store have created stain resistant Nano Care™. Small whisker-like particles are used to coat the surface fibers, creating a stain repelling surface. Health care companies have discovered that a coating of nanocrystals of silver on bandage fabrics renders the antimicrobial.

The most dramatic progress comes in the area of carbon fibers. The aerospace industry continues to amaze us with outcomes. You are likely familiar with the carbon fiber design of shuttle surfaces and more notably the stealth aircraft. Recently, while attempting to improve the difficult and multiple step process for producing carbon fibers, researchs created a unique structure of carbon atoms at the nano dimension. Called carbon tubes, the tubular thread prove to be hundreds of time stronger than present day fibers.

Progress is also being made in the area of metallurgy. For example, aluminum, known for its light weight and oxidation(or rusting) resistance, has been a popular material for thousands of household and commercial products. Its brittleness to angular forces, however, has limited its use in many applications. With a single atom thick veneer of nanosized aluminum oxide particles, aluminum takes on a whole new realm of properties making it tougher and stronger than the steel used to make bearings.

Another example, comes from your life of paint up-fix up around the house, where you became aware that the principal pigment in white and pastel paints is zinc oxide. A study of this chemical reveals a crystalline structure that possesses a unique property, it scatters 100% of the visible light spectrum, hence a white appearance. On the nanoscale ZnO, however, ZnO oxide particles' small size makes them invisible to the naked eye but they retain their reflective properties. Therefore, these optically transparent particles have been used to create sunscreen products. The particles' invisibility result in a lotion that is clear.

The exposed surfaces of many new refrigerators, air conditioners, and laundry machines act as antibacterial and antifungal agents because they have been painted with nano-produced pigments.

Nanoscale layering of materials have resulted in a four-fold increase in the performance of permanent magnets.

The new chemical properties of some nanocrystals show promise as photocatalysts to speed up the breakdown of toxic waste. In the same field, porous inorganic hosts with self-assembled monolayers are being used to trap and remove heavy metals from solvent sources.

While there have been no nanomachines of the styles described earlier, their has been great progress. Dr. Drexler, who was mentioned earlier, has, with a couple of other collaborators, become one of the world's foremost authorities. He has created computer aided design (CAD) software to simulate the creation and operation of nanomachines. Among his creations are numerous gear drives, a planetary gear, a speed reducing and increasing gear box. The corporation with which he is affiliated has announced that they will demonstrate their first actual assembler nanomachine at an October 2005 symposium in San Francisco. Called the Nano-Engineer I, they claim that their nano machine is capable of reproducing itself until halted externally.

Nano science has not evolved without its detractors. Among the most of them are the social scientists who express concern over the ethics and social implications of the science. A recent publication numbering over 280 pages went into the detail of their concerns. In this writer's opinion their main concern lies in their fear that their profession is not being included in the academic arena pursuing nanotechniques. Their report made strong recommendations that every nanotechnology team must include, for the sake of ethics and sensitivity to societal impact, well trained social scientists.

It's a good thing these folks weren't visibly present when Ford was developing that first assembly line, else we'd all still be walking.

Thank you!