

A glimpse into the Technology of 21st Century NANOTECHNOLOGY

I. Introduction

Computers reproduce information at almost no cost. A push is well underway to invent devices that manufacture at almost no cost, by treating atoms like computers treat bits of information. This would allow automatic construction of consumer goods without traditional labour, like a Xerox machine produces unlimited copies without a secretary retyping the original information. Electronics is fuelled by miniaturization. Working smaller has led to the tools capable of manipulating individual atoms like the proteins in a potato manipulate the atoms of soil and water to make copies of itself (Drexler, Merkle paraphrased). The secret to self-replication, biological or synthetic, is prefabricated building blocks. Biology uses atoms. Atoms are as new and squeaky clean as the instant they condensed out of pure energy of the Big Bang, come in 92 flavors (elements), each atom is identical (electronically) to any other atom in a flavor and have the remarkable attribute of sticking to each, other.

The shotgun marriage of chemistry and engineering called “Nanotechnology” is ushering in the era of self-replicating machinery and self-assembling consumer goods made from cheap raw atoms (Drexler, Merkle paraphrased). If we can place atoms on a structure under construction individually, this opens up a realm of super large molecules not found in nature, designed by engineers (adhering to the normal laws of chemistry) Structures, big structures, or microscopic structures and machines could be made of materials with unusual physical properties like carbon in its ultra-

strong form, diamond. Ideally, programmed “nanites”, machines with atomic sized components could take any source of required atoms and energy, make copies of themselves, then “grow” things without traditional manufacturing techniques and without by-products. No waste and no side reactions means this tech would be super green Nanites could be programmed and unleashed to clean up existing industrial pollution (and will within two decades).

II. The father of Nanotechnology



Who thought all this up? Where did this outrage originate? Dr. K. Eric Drexler is the father of Nanotechnology, seeing the pattern of the passable in his studies of biology; computer science, etc. while still a student in the late seventies. He realized what a different world we could have, if we could build with individual atoms like nature. Drexler (and Dr. Chris Peterson) fought one heck of an uphill battle throughout the ‘80s and ‘90s for acceptance of these radical ideas by the scientific community. Now, things have changed.

History will read, Newton, Einstein and Drexler.

III. Nanometre

A nanometre is one billionth of a meter (3 - 4 atoms wide) i.e. $1/1000000000$ of a Meter. Utilizing the well-understood chemical properties of atoms and molecules (how they “stick” together), Nanotechnology proposes the construction of novel molecular devices possessing extraordinary properties. The trick is to manipulate atoms individually and place them exactly where needed to produce the desired structure

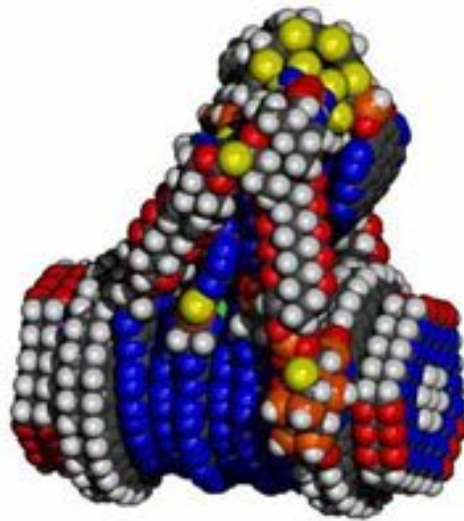
IV. Universal Assembler

Nanotech’s goal is a device called a “Universal Assembler” that takes raw atoms in one side and delivers consumer goods out the other. It could also make a copy of itself you could give to a friend. What happens to the economy if demand for just about everything is foiled by a household appliance... is a good question?

Scientists are on the verge of manipulating atoms and molecules with the same precision as life. Research in molecular biology, chemistry, and scanning probe microscopy (scopes that can see and move atoms) are laying the foundations for a technology of self-replicating molecular machines by developing positional controlled chemical synthesis. By building objects on such a fine scale, we could make extraordinary things from ordinary matter. If the fields of molecular biology (which some call wet nano), chemistry and solid state physics were all to shut down today and make no more advances, chip manufacture in their quest for evermore speed would develop

MNT(Molecular Nanotechnology) single handed. They have the incentive. Nanotechnology is molecular manufacturing or, more simply, building things one atom or molecule at a time with programmed nanoscopic robot arms.. This ability is almost in our grasp.

V. Robotic Arm



This is a molecule and a machine, just like proteins are molecular machines. This molecule is not found in nature, but will physically stick together. One such working molecule could build others that could build anything possible with matter and spark the age of self-replicating machinery, material opulence, super health and extraordinary inventions. According to Dr. K. Drexler “A general-purpose molecular assembler arm must be able to move its “hand” by many atomic diameters position it with fractional- atomic-diameter accuracy, and then execute finely controlled motions to transfer one or a few atoms in a guided chemical reaction.”. Yet, how are we going to build it... when such a molecular machine needs to be built with an atomic precision motion control robot arm? Which comes first... the assembler or the assembled? Chicken and the egg problem...

VI Technical feasibilities

- Self-assembling consumer goods
- Computers billions of times faster
- Extremely novel inventions (impossible today)
- Safe and affordable space travel I
- Medical Nano... virtual end to illness, aging, death
- No more pollution and automatic cleanup of already existing pollution
- Molecular food syntheses... end of famine and starvation
- Access to a superior education for every child on Earth
- Reintroduction of many extinct plants and animals
- Terraforming here and the Solar System

VI. NanoMachine Components of AI Globus & Team, NASA (in progress)

Extraordinarily Small, Strong and Resilient Components...

- Smart Materials
- Super Materials
- Bucky tubes
- Nanogear
- Nanometer

Nanomachines can also be incorporated into various materials to make those materials respond to their environment, or to outside commands. Examples of such materials would be “smart” fabrics that respond to the environment to become warmer or cooler, or walls and furniture that can

move or change shape on command. Nanomachines could also be used as tools both in industry and by consumers. Such tools could cut apart or glue together material far more efficiently than anything large-scale that is used today. Nanomachines could also repair cars, furniture, appliances, or almost anything else quickly and efficiently. Or these objects could be designed with nanomachines to repair themselves should the need arise. Life would be greatly simplified by relieving people of the need to repair objects at home or at work.

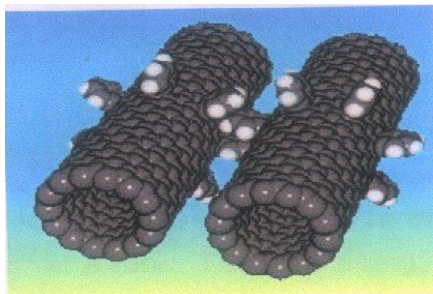
Smart Material: - Cosmetics is one of many multi-billion dollar industries that will benefit from a new class of coating called “Smart Materials”. This smart coating will certainly cross genders because of, some utilitarian properties unrelated to fashion. The proposed class of smart coatings, though extremely thin, contain a grab bag of nano structural composites. Laced with nano-computers, their extraordinary powers offer usages yet to be imagined. Like with all smart materials, conversion of the polish to a flat screen color monitor or video phone is a snap. A fingernail may be a desirable place to locate your personal computer interface. An environmental monitor could be included to warn of high carbon dioxide concentration or radiation. One’s physiological status could be constantly monitored. All of these functions could run on solar power generated in normal lighting conditions.

If you combined microscopic motors, gears, levers, bearing, plate sensors, power and communication cables etc., with powerful microscopic computers, you have the makings of a new class of materials called Smart Materials. Programmable smart materials could shape-shift into just about any desired object. A house made of smart materials would be quite useful and interesting. Imagine a wall changing colour at your command, or commanding the appearance of a window where there was none, drapes of any style listed in the smart materials software or from some source of the Internet. This is all

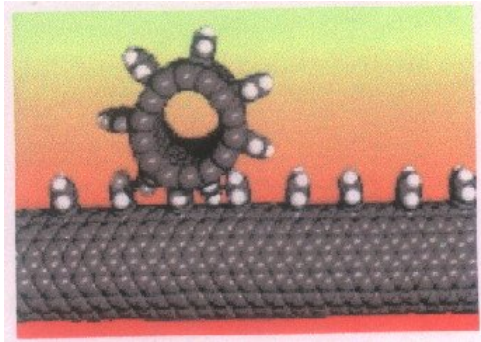
purely mechanical and can be done today, although with much larger parts, resulting in a coarser effect (and at great expense).

Super Materials: - Atomic precision construction could produce metal structures devoid of micro imperfections, dramatically increasing strength. Bearings made to (unheard of) atomic precision (every atom in “round”) would last far longer, run cooler and bear greater loads. Today’s industrial products would benefit greatly, but why bother with first wave industrialization materials when diamondoid super composites available? Nano-constructed materials can be to material utility what scientific notation is to math. In diamond form, carbon is 50- 70 times stronger than steel and less than one fourth the weights. Much of the carbon needed to build with is available now from the billions of pounds of fossil fuel burned into the atmosphere since the industrial revolution. The raw material delivers itself.

Bucky tubes:-Gears made of Buckytubes are great nanomachine components... Buckytubes are carbon graphite sheets rolled into a tube (looks like tubes of chicken wire), and are “like” carbon in its diamond form, but with ALL available bonding strength aligned on one axis These tubes are stronger than diamond fiber, and the strongest fiber possible with matter, so we’re starting out with real racehorse material. Globus and Team designs are chemically stable, very tough and varied in geometry, including gears made from “nested” Buckytubes or tubs inside of tubes. Such a gear would be stiffer and suited for a “long” drive shaft. And talk about performance.

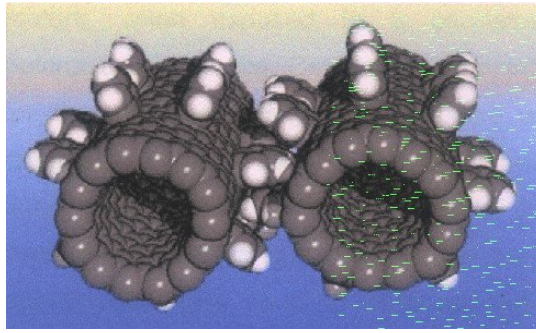


“Results suggest these gears can operate at up to 50-100 gigahertz in a vacuum or inert atmosphere at room temperature. The failure mode involves tooth slip, not bond breaking, so failed gears can be returned to operation by lowering temperature and/or rotation rate.”



Long Buckytubes connected by their ends (a loop) could make motion transition belts (a fan belt) for nanomachines.

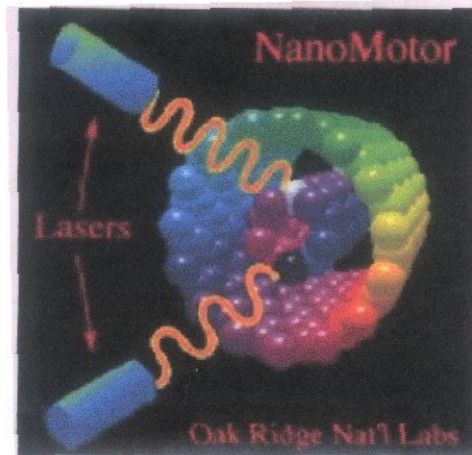
Nanogear: - Synthesizing Nanogear... Drafted for gear teeth is the famous circular (snake biting its tail) Benzene molecule, a hoop of connected carbon atoms ringed by hydrogen atoms attached to each carbon's "unused" dangling bond. Globus' computer simulations show (in a very non-Drexlerian technique) Benzene atoms stick to and bond with Buckytubes if a collision between the two is of proper energy — shoot Benzene "high speed" at a tube. Too little energy and the tough, elastic carbon structure just bounce off each other... too much, and they both shatter.



Building gears this way and obtaining precise results at this resolution is a formidable task, but perhaps not impossible. Another approach involves bending the flexible tube, causing an electronic condition favourable for a bond at the point of greatest lattice distortion (Carbon bonds are stretched apart, holes in the chicken wire get bigger). Mass with these techniques again are not impossible.

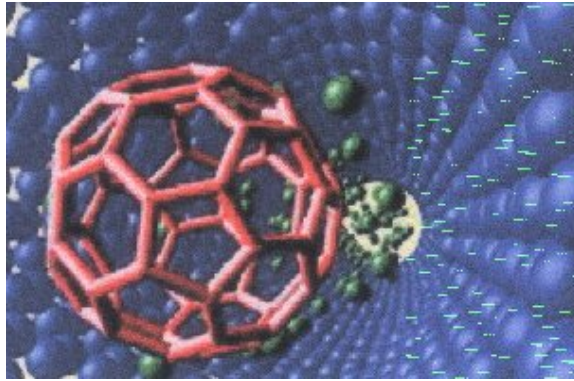
The Drexlerian method, building things the new fashion way, “One Atom at a Time” is a more direct approach where carbon and hydrogen deposition tools have elements delivered and a gear would be built (extruded) like building with Lego Blocks. The atoms and the blocks will build just about any structure, if you stick the right ones together in the right places.

Nanomotors by Oak Ridge National Laboratories :- NanoMotors... and the Oak Ridge Nat'l Lab Boys: “Over the past 15 years, prominent scientists like Noble Laureate Richard Feynman, Eric Drexler and Ralph Merkle have hypothesized about these mechanical machines,” said Don Noid, co-author of a proposal that helped gain seed money for the project last year. “Now, ORNL is modelling nanomachines using fundamental calculations.”



Researchers Don Noid, Robert Tuzund and Bobby Sumpter of Oak Ridge National Laboratories show these versatile burnt sausages can become extraordinarily simple motors, when exposed to an oscillating polarized light source. Certainly a candidate for the smallest motor, tubes act like an antenna and rotate away from the “highest energy state” resonance. Exposure to the oscillating polarized light continuously bumps the tub up into the high energy resonance coupling while the tube continuously “wants to fall down hill” to lower energy.

“The motors consisted of two concentric graphite cylinders (shaft and sleeve) with one positive and one negative electric charge attached to the shaft. Rotational motion of the shaft was induced by applying one or sometimes two oscillating laser fields [MPEG animation (3.7MB)]. The shaft cycled between periods of rotational pendulum-like behaviour and unidirectional rotation (motor-like behaviour). The motor ON and OFF times strongly depended on the motor size, field strength and frequency, and relative location of the attached positive and negative charges.”



Slap a few Benzene teeth on the end and power up some rod logic components on a nanocomputer or animate a conveyer belt. NanoPipes... Buckytubes, the multi-use nano component grow to different diameters and conduct electricity like copper, even better when stuffed with metal atoms. Larger tubes are big enough to pipe full sized C₆₀ Buckyball molecules as in the illustration of the soccer ball shape (red) followed by Helium atoms (green), used as a transport “fluid”. In addition to piping atoms and molecules, for perhaps a nanomachine construction sites, these tubes could be used as ultra small chemical reaction vessels.

“The animations show a variety of features of fluid flow that are not readily apparent from the raw computer data. As the fluid atoms, shown in green, flow through the pipe, they bounce off the pipe wall and cause it to flex. In some simulations, the helium gas carries along a comparatively heavy buckyball molecule, which has a cage-like structure. Because of its tight fit, the buckyball can cause the pipe’ to bulge as it passes through. If the pipe flexes or bulges, parts of the nanomachine attached to it may vibrate. When designing nanomachines, the effects of this vibration must be accounted for.”

VIII. Nanotechnology in different branches of science

Biology: - The field of medicine will use nanotechnology most heavily, and it will draw much more from engineering than from clinical medicine. While engineers so far have manipulated matter only in great blocks of atoms, they will now be asked to build medical delivery devices atom by atom.

- Microminiaturisation will enable minuscule robots to flow through the body's bloodstream delivering lethal medicinal drugs directly to alien germs and diseased cells such as cancer cells.
- Cochlear implants restore a measure of hearing to some deaf people
- Experimental implants for the blind can partially replace the brain's visual processing circuits. In these cases the advanced technology consists of neural networks, a configuration of computer intelligence that mimics the learning ability of brain circuitry.
- Using Buckyball medicine could be delivered to the body orally and the body then eliminates the Buckyballs without any side effects. It is possible to attach the needed drugs on the bucky ball structure as is required for the particular disease. This is much easier and effective than the conventional capsule approach. In capsules, a mixture of drugs is delivered into the body, a major part of which is eliminated by the body. When using mechanisms like bucky balls, it is easy to ensure that they are tailor-made to deal with the specific cell disorder that the disease causes.
- Drugs that make use of buckyballs for the treatment of AIDS could be out by 2006. One of the daunting challenges faced by researchers in fighting the HIV virus has been the inability of drugs to attach themselves to the virus and stop it from reproducing any further. Nanotechnology-powered medical techniques like buckyballs have the ability to fix themselves to the virus, thus preventing further reproduction.
- Tissue damages can be reduced by providing more oxygen in the form of an "artificial red blood cell".

- Yet another exciting though futuristic prospect that Nanotechnology presents is the ability to have minute machines travelling inside our body protecting us from inside. These 'nanodoctors' will be able to find and repair damage at the cellular level. For this to be possible, molecular assemblers-with better capabilities than the current scanning tunnelling microscopes are needed. They have to have the capability to move atoms and molecules faster and more precisely than present day STMs. However, this wouldn't be possible for the next 15-20 years, to say the least.

Computer: - The people working in computer are the best novel audiences. They are intimately familiar with the concept of replicating quanta. The step toward treating atoms like bits of information is no distance at all. They see their own hardware driven by economic frenzy in an exponential dive toward the atomic realm... and beyond. They don't need the chemist or biologist to hit Nanotechnology, the chip manufacturer will develop manipulation at this resolution regardless of any prejudice and a little math shows how very soon. The computational power of the system can be increased drastically, we can pack more computational power into a sugar cube than exists today.

Chemistry: - Chemists are another story. Having so much invested in super clever synthesis of structures using Shake and Bake technology, when presented with the idea of placing an atom on a hot spot of a synthetic molecule the size of a 747... Chemists flinch with an involuntary negative reaction difficult to quench with rational. To increase offense by saying something like, "This shotgun marriage of chemistry and engineering..." is a deliberate push over the edge.

Electronics: - Now in Chip Industry every 18 months or so the size of wires and transistors is cut by 50% while the speed of the chip is doubled. The wires

are already a fraction of a micron small. How long can you keep cutting the size of components in half and expect it to function? As it turns out, not much longer. Soon the wires will become so thin and packed so tight that an effect of Quantum Mechanics will come into play, namely, tunnelling. The electrons tunnel through insulating barriers too thin to keep them contained. If one builds a chip with wires so small' and insulators so thin, electrons start wholesale tunnelling, or shorting out, rendering the device totally useless.

Some chip designers will be forced to switch to an old-fashioned mechanical calculator concept, but with a nouveau twist. If you can build these mechanical parts one atom at a time, they can be thousands, of times smaller and millions of times faster than existing transistors. The competition for faster chips is fierce and the profit at stake immense. It's a freight train running downhill that cannot be stopped. And that train's destination is Nanotechnology.

Economics: - Society is in for a spin as we head for a novel form of economics in an age of self replicating machinery, where the design of an object cost about the same as today yet production cost is nearly zero. All first wave manufacturing will be obsolete. No cobblers, just shoe designers, no autoworkers, just car designers, no feed lots, just chefs. Ask yourself, what will be of value? What is money in a nano age? How will politics and war change when we don't have traditional resources to fight over? Most people think pace of technological change has increased over the last few decades, but it really hasn't. We've just spread things out and made it seem that way. We don't have breakthrough developments anymore. The developments that we've seen over the last three decades pale in comparison to those of the early twentieth century when the telephone, automobiles, airplanes, television and anti-biotics burst onto the scene for the first time. Today's seemingly goal-less change has made many people believe that we are changing for no other

reason than for change sake. As a result, people are getting burnt out on the idea of technological progress. They're paying less attention, and that's when you have the potential for a surprise that no ones prepared for. The goal of developing molecular nanotechnology is something that must be pursued in a "direct" way that gets the publics attention. The NTDC effort seems to be focused on this more appropriate and opportunistic approach.

In a world of information, digital technologies have made copying fast, cheap and perfect, quite independent of cost or complexity of the content. What if the same were to happen in the world of matter? The production cost of a ton of tera byte RAM chips would be about the same as the production cost of steel. Design costs would matter, production costs wouldn't.

IX. Arrival of Nanotechnology

"Arrive", is broadly defined as the arrival of the first "Universal Assemblers" that has the ability to build with single atoms anything one's software defines. A Universal Assembler may look like a microwave oven, connected to raw atomic feed stock, like carbon black, O₂, sulphur powder, etc. Other portable assemblers (for camping) extract atomic feed stock out of the air and soil. The Assembler can make Dock Martins as easily as it can make a supercomputer or a pizza (not any pizza mind you, but atomically exact replicas from your favourite joint in Boston) or, (hold on) a copy of itself.

So when already 8 -15 years seems to be the best guesstimate (Zyvex says 5-10). As more people from all walks of life learn of the Nanotechnology concept and add their talents to the quest, you can be sure that research will accelerate and the time frame will shorten. How long will it take for paradise

(hopefully) to arrive on Earth and in Space after the Universal Assembler is invented?

Some Nanotechnology enthusiasts have become infected with an “easy Nanotechnology” myth. They talk or write about Nanotech as if one day a scientist will dump the contents of two test tubes together to create the first nano-manipulator and that’ll be it from then on we’ll have Nanotechnology.

Now probably most of these people understand that it will take a long, disciplined effort, and it will not be an accidental discovery. Even so, they seem to believe that shortly after getting the first Nanotech manipulator, we’ll get many of the promised Nanotech miracles. As the premise quotation of the novel Terminal Cafe puts it “The first thing we get with Nanotechnology is immortality.”

Probably the first thing we’re likely to get with Nanotech will be cute publicity demos, intended to drum up funding for further research. And those cute demos may not even be visible to the naked eye. Spelling ‘IBM’ in atoms with atomic force micros has probably set the standard. Perhaps the first nano-manipulators will stack up molecules as if they were blocks or force specially prepared molecules to bond together into a chain or rod.

By this, they presumably mean a useful assembler, or even better, a self replicator. OK so let’s jump ahead, over the years of work needed to get to that point. Assume we have an assembler technology that can build an identical assembler, and that can be programmed to build other things.

It’ll take a few years of research to figure out how to safely use Nanotech inside a living human body to achieve any useful results. And maybe it will be a few years beyond that before we get any significant life

extension for most people. How about something more mundane such as building consumer goods from the atoms up?

Let's just replicate a few billion assemblers, and put them to work churning out a Nanotech toaster. It'll have arrays of infrared lasers and optical sensors - so it'll make perfect toast every time. It's bound to be a hot item! I'll just call up the toaster's CAD design helpfully specified down to the atomic level by some over-eager Nanotech enthusiast.

How to tell one assembler to make another, and even how to tell a billion assemblers each do the same thing. But how do I tell a thousand teams of a million assemblers each how to cooperate with each other within their teams and between teams to make a toaster? Maybe if I used a million teams of a thousand assemblers each? No... I'd better get the guys in research to spend a week or two figuring this out for me.

X. Risks Inherent to Nanotechnology

We are on the threshold of material opulence and greatly enhance physical health. However, in a bed of roses, one still must avoid the thorns. Like all technology nano can be used for good or not so good (serious understatement) and could cause considerable panic to the under informed during the transition. As post-nano international relations thinker Tom McCarthy points out, if China's perception of its ancient rival India's advanced software and technology lead might produce Nanotechnology first, this could prompt China to nuke Indian research centres before India could strike with Nanoweapons. Now consider this, unlike nuclear, nano is a desktop industry... and one sufficiently advanced disgruntled hack working in a garage could program a self replicating Nanite to kill all bovine on the planet, or all

people with brown eyes, or indeed, all DNA based life. But wait; check this small example of the wonders possible building things with atomic precision. Building on the atomic scale, mechanical computers with the power of a mainframe could be manufactured so small, that several hundred would fit inside the space of a biological cell.

XI. The Industries likely to disappear because of nanotechnology

Everything -- but software, everything will run on software, and general engineering, as it relates to this new power over matter... and the entertainment industry. Unfortunately, there will still be insurance salesmen and lawyers, although not in my solar orbiting city state. If as Drexler suggest, we can pave streets with self assembling solar cells, I would tend to avoid energy stocks. Mature nanites could mine any material from the earth, landfills or asteroids at very low cost and in great abundance. The mineral business is about to change. Traditional manufacturing will not be able to compete with assembler technology and what happens to all those jobs and the financial markets is a big issue that needs to be addressed now. I intend to start or expand organizations addressing these issues and cover progress in the pages of Nanotechnology Magazine.

We will have a lot of obsolete mental baggage and programming to throw out of our heads... Traditional pursuits of money will need to be re-evaluated when a personal assembler can manufacture a fleet of Porches, that run circles around today's models. As Drexler so intuitively points out, the best thing to do, is to get the whole world's society educated and understanding what will and can happen with this technology. This will help

people make the transition and keep mental and financial meltdowns to a minimum.

XII. New industries Likely to appear because of Nanotechnology

Future generations are laughing as they read these words... Laughing at the utter inadequacy and closed imagination of this writing... So consider this a comically inadequate list. However, if they are laughing, I am satisfied and at Peace, as this means we made it through the transition (although I fear it shall not be the last).

Mega engineering for space habitation and transport in the Solar System will have a serious future. People will be surprised at how fast space develops because right now, a very bright core of nano-space enthusiasts have engineering plans, awaiting the arrival of the molecular assembler. People like Forrest Bishop have wonderful plans for space transport and development, capable of being implemented in surprisingly short time frames. This is artificial life, programmed to “grow” faster than natural systems. I think Mars will be terraformed in less time than it takes to build a nuclear power plant in the later half of the good old, backward 20th century.

An explosion in the arts and service industries are to be expected when no fields need to be ploughed for our daily bread, similar to the explosion when agriculture became mechanized and efficient and the Sons and daughters of farmers migrated to cities. This explosion will be exponentially greater. Leisure time, much more leisure time, more diversions.. What professions should disappear because of nano-technology?

Ditch digger, tugboat captain -- most professions where humans are as “smart brawn”, or as “the best available computer”, including jet fighter pilot, truck driver, surgeon, pyramid builder, steel worker, gold miner... not that there will not be people doing these jobs, just for fun. Charming libation vendors a good future, until the A.I. people make some really scary breakthroughs. I do expect “the best available computer” to be important for novel for quite a while... and we are just on the verge for finding out how frequent and varied novel situations can be.

Think of people who have reading and math impairments and thus -- poorly educated, yet a brilliant self taught mechanics. Molecular machines are just small machines. With the right visualization tools (VR with tactile feedback), those people could become a competent molecular machine designer and trouble shooter. We all have our talents to contribute. Perhaps this may be the greatest opportunity in history to express talents.

XIII. New objects likely to appear because of Nanotechnology

Perhaps the big story -- with mature Nanotechnology, any object can morph into any other imaginable object... truly a concept requiring personal exposure to fully understand the significance and possibilities, but to get a grip on the idea, consider this: The age of digital matter -- multi-purpose, programmable machines change the software, and something completely different happens.

A simple can opener or a complex asphalt paver are both, single purpose machines. Ask them to clean your floor or build a radio tower and they “stare” back blankly. A computer is different, It is a multi purpose

machine -- one machine that can do unlimited tasks by changing software... but only in the world of bits and information.

Fractal Robots are programmable machines that can do unlimited tasks in the physical world, the world of matter. Load the right software and the same “machines” can take out the garbage, paint your car, or construct an office building and later, wash that building’s windows. In large groups, these devices exhibit what may be termed as macro (hold in your hand) sized “nanobots “, possessing AND performing many of the desirable features of mature nanomachines (as described in Drexler’s, Engines of Creation, Unbounding the Future, Nanosystems etc.). This is the beginning of “Digital Matter”.

These Robots look like “Rubic’s Cubes” that can “slide” over each other on command, changing and moving in any overall shape desired for a particular task. These cubes communicate with each other and share power through simple internal induction coils, have batteries, a small computer and various kinds of internal magnetic and electric inductive motors (depending on size) used to move over other cubes. When sufficiently miniaturized (below 0.1mm) and fabricated using photolithography methods, cubes can also be programmed to assemble other cubes of smaller or larger size. This “self assembly” is an important feature that will drop cost dramatically.

The point is -- if you have enough of the cubes of small enough dimension, they can slide over each other, or “morph” into any object with just about any function, one can imagine and program for such behaviour. Cubes of sufficiently miniaturized size could be programmed to behave like the “T-2” Terminator Robot in the Arnold Schwarzenegger movie, or a lawn chair... Just about any animate or inanimate object. Fractal Shape Shifting Robots have been in prototype for the last two years and Drexler rather expect this form of “digital matter” to hit the commercial seen very soon. In the near

future, if you gaze out your window and see something vaguely resembling an amoeba constructing an office building, you'll know what "IT" is.

This is not to say individual purpose objects will not be desirable... Back to cotton -- although Cubes could mimic the exact appearance of a fuzzy down comforter (a blanket), if made out of cubes, it would be heavy and not have the same thermal properties. Although through a heroic engineering effort such a "blanket" could be made to insulate and pipe gasses like a comforter and even "levitate" slightly to mimic the weight and mass, why bother when the real thing can be manufactured atom by atom, on site, at about a meter a second (depending on thermal considerations).

Also, "single purpose" components of larger machines will be built to take advantage of fantastic structural properties of diamondoid - Buckytube composites for such things as thin, super strong aircraft parts. Today, using the theoretical properties of such materials, we can design an efficient, quiet, super safe personal vertical takeoff air car. This vehicle of science fiction is probably Science future.

XIV. Commonly known objects likely to disappear because of Nanotechnology

People living before and through the transition - at first and because of prejudice for things we know and because people have not imagined the variety and super rich realm of new possibilities -- the objects failure to everyday life will be sought by the public and reproduced by assembler technology. People will still want cotton beach towels, although the cotton farmer will no longer be needed when fibres can be manufactured atom by atom from carbon in the air or from limestone. Lots of familiar items will appear "traditional" on the outside, yet posses a multitude of new tricks and functionality made possible with MNT - cars with Utility Fog crash protection

for instance. Of course MNT Smart Materials can look like anything, yet perform “magic”.

Now, the next generation and generations to follow, born into the age of nanotechnology will have a “clean slate” without concrete historical prejudices, will design objects and lifestyles that take advantage of the new wealth of possibilities and I should expect design objects and “environments” that would appear bizarrely alien, extraordinarily novel to even the most advanced nano thinker today. The general concept is familiar in science fiction, only now we have a clear engineering path to make real, the stunning constructs of uninhibited imaginations and those yet to be born.

The wild card to consider and the reason that frankly, it is Ludicrous project past a few decades -- or more than say, one generation or so, is the affect nanotechnology will have on intelligence enhancement efforts. Once these efforts are even mildly successful, the “experimenters” will spend much of their time amplifying intelligence enhancement efforts and the valve controlling what is imaginable and what can be engineered opens at a geometric rate. By definition, what can and will be is unimaginable now, and Drexler is not even addressing the issue of machine intelligence in the equation. The curve approaches vertical.

XV. New professions likely to appear because of Nanotechnology

The ninety-two elements can be combined in a zillion to the zillionth power, forming different molecules of nanometre to gas planet dimensions. Nanotechnology is about being able to put those atoms together any way we want, in an affordable manner. An explosion of new endeavours and professionals of such endeavours. Perhaps when Drexler order that extra grey

matter, his answer will be more imaginative. Ah, the freedom to imagine, then build.

XVI. The Implications of Nanotechnology

- Humanity will be faced with a powerful, accelerated social revolution as a result of nanotechnology.
- In the near future, a team of scientists will succeed in constructing the first nano-sized robot capable of self-replication.
- Within a few short years, and five billion trillion nano-robots later, virtually all present industrial processes will be obsolete as well as our contemporary concept of labor.
- Consumer goods will become plentiful, inexpensive, smart, and durable. Medicine will take a quantum leap forward.
- Space travel and colonization will become safe and affordable.
- For these and other reasons, global life styles will change radically and human behaviour drastically impacted.

XVII. Conclusion

Imagine being able to cure cancer by drinking a medicine stirred into your favorite fruit juice. Imagine a supercomputer no bigger than a human cell. Imagine a four-person, surface-to-orbit spacecraft no larger or more expensive than the family car. These are just a few products expected from Nanotechnology.

The ultimate goal of nanotechnology is to imitate life by producing minuscule self-replicating devices to fight disease, store and process

information, and perform construction tasks. To be effective, nanodevices must be self-replicating because to manufacture them individually would be prohibitively expensive.

As a conclusion, we could say that the prospects of nanotechnology are very bright. It will take some time to really make an impact on the human race. But when it finally comes, Nanotechnology will be an undeniable force, which will change the very course of life.

XVIII. References

- Drexler, K. Eric and Chris Petersen with Gayle Pergamit. Unbounding the Future: The Nanotechnology Revolution. New York: John Wiley and Sons, 1992.
- Drexler, K. Eric. Engines of Creation. New York: Doubleday, 1986. The book that started it all is now online at this website.
- Drexler, K. Eric. Nanosystems: Molecular Machinery, Manufacturing, and Competition. New York: John Wiley and Sons, 1992 (Ed, Note: the definitive technical textbook on nanotechnology.)

- Crandall, B.C. and James Louis, eds. Nanotechnology: research and Perspectives. Papers from the First Foresight Conference on Nanotechnology: Cambridge: MIT Press, 1992.

Science-Fiction

- Kress, Nancy. Beggars in Spain. New York: Avon Books.
- Stephenson, Neal. Diamond Age.
- Varley, John. Steel Beach.

Periodicals

- Journal of Nanotechnology
- American Cryonics Society
- The American Institute of Physics

Nanotechnology Web Pages

- tww.Nanotechnology.com
- www.ponozne.com
- www.nasa.org
- www.Nanotechnology.org

ABSTRACT

Shotgun marriage of Chemistry and engineering is called nanotechnology. Aim of this nanotechnology is to produce self-replicating machinery and self-assembling consumer goods from cheap raw atoms. If we can place atoms on a structure under construction this opens up a realm of super large molecules not found in nature designed by engineers. Ideally programmed nanities, machines with atomic sized components could take any source of atoms and energy, make copies themselves, then grow things

without traditional manufacturing technique and without by products. No waste no side reaction means this technology will be super green.

Contents

1. Introduction
2. The father of Nanotechnology
3. Nanometre
4. Universal Assembler
- .5. Robotic Arm
6. Technical feasibilities
7. NanoMachine Components of At Globus & Team, NASA
8. Nanotechnology in different branches of science
9. Arrival of Nanotechnology
10. Risks Inherent to Nanotechnology
11. The industries likely to disappear because of Nanotechnology
12. New industries likely to appear because of Nanotechnology
13. New objects likely to appear because of Nanotechnology
14. Commonly known objects likely to disappear because of Nanotechnology
15. New professions likely to appear because of Nanotechnology
16. The Implications of self replicating Nanotechnology
17. Conclusion
18. References

ACKNOWLEDGEMENT

I thank God Almighty for the successful completion of my seminar. Sincere feelings of gratitude for Dr.Agnisharman Namboothiri, Head of the Department, Information Technology. I express my heartfelt gratitude to Staff-in-charge, Miss. Sangeetha Jose and Mr. Biju, for their valuable advice and guidance. I would also like to express my gratitude to all other members of the faculty of Information Technology department for their cooperation.

I would like to thank my dear friends, for their kind-hearted cooperation and encouragement.

BREESON FRANCIS