DOWNLOAD PDF NANOTECHNOLOGY APPLICATIONS IN BIOTECHNOLOGY

Chapter 1 : BIOINFORMATICS AND NANOTECHNOLOGY APPLICATIONS IN BIOLOGICAL SYSTEMS -

Research in the use of nanotechnology for regenerative medicine spans several application areas, including bone and neural tissue engineering. For instance, novel materials can be engineered to mimic the crystal mineral structure of human bone or used as a restorative resin for dental applications.

Bionanotechnology attempts to exploit these differences to create new biomedical research tools, diagnostic tests, and drug-delivery systems. The promise is great. So is the hype. How close are we? Recent advances in bionanotechnology, a biomedical branch of this burgeoning field, suggest the technology indeed exists. Moreover, magic may be just what the pharma and biotech industries need now. Most drugs on the market have tremendous value and are priced right, according to many industry leaders. But, some cancer drugs and other biologic therapies developed by biotechs and their pharma partners are relatively costly and may add, on average, only a few months to the lives of patients using them. These and other drugs may be more effective if prescribed at earlier stages of disease or may have fewer side effects if delivered in lower effective doses. Enter nanotechnology, which holds promise for reducing overall medical costs, improving outcomes, and adding value to drug therapy â€” mostly by increasing the efficiency of drug discovery, disease detection, and drug delivery. What is nanotechnology â€" that is, aside from a buzzword flying around the investment community these days? Biologists at UCSB are working with materials scientists to develop bionanotubes â€" tiny drug-delivery devices. Uri Raviv, PhD, a postdoctoral researcher, says that in the future, the tubes could deliver a drug or gene to a targeted location in the body. Widely disparate definitions can be found in dictionaries, organizational glossaries, and published documents Use of the term in science fiction, credible and fantastic, along with the sometimes questionable adoption of the word by research facilities and companies seeking funding or investment, contribute to this semantic dilution. Bionanotechnology, then, typically applies this to atoms, molecules, and molecular fragments â€" together, the most elemental level of biology. Whatever definition applies, think small. Objects in the nanoworld have dimensions that are between 1 and nanometers, which is at least 1, times smaller than objects in the micro-world. One micrometer or micron , which is 1 millionth of a meter, equals 1, nanometers. To appreciate how small the nanoworld is, consider the scale of a few materials: The width of a human hair is about 80 to microns; red blood cells are approximately 2. Researchers envision using nanochannels â€" tiny tunnels â€" to analyze DNA. At the nano level, physical, chemical, and biological properties of materials differ in fundamental and valuable ways than we are used to. Yet this technology still is not sensitive enough for researchers like Han Cao, PhD, a molecular biologist interested in embryonic stem cell research. Cao is the founder and chief scientific officer at BioNanomatrix, a maker of nanodevices and systems for cancer diagnostics, complex disease therapeutics, and personalized medicine. To do one experiment using the most sensitive technology available, it takes two months to accumulate enough sample because the cell is so rare. And if I drop the tube? Two months down the drain! Where there is a need to analyze a small sample size, especially down to the level of a single cell or a molecule, an opportunity exists for using nanotechnology. Cao, for example, wants a technology that he could use to discern a few pre-cancerous cells out of a heterogeneous cell population that is commonly found in biopsy samples. Nanotechnology could help with early detection of some cancers, which depends on the detection of very small quantities of protein markers in the blood or on cell surfaces. This is the case with ovarian cancer, for which Inhibin A, a hormone, is possibly a marker. Current technology is not sensitive enough to detect this protein until the disease has progressed to an advanced stage, by which time the 5-year survival rate is less than 30 percent. An example of a nanotechnology early-warning assay system is the biobarcode technology that is being developed by Nanosphere, a nanotechnology-based life sciences company in Northbrook, Ill. The technology employs a gold nanoparticle probe with antibodies to the target protein attached to its polymer surface. It also carries a large number of unique, covalently attached oligonucleotides and complementary oligonucleotides. When the probe attaches to the target protein, the complementary oligonucleotides, which are the biobarcodes that serve as markers for the target protein, can be washed away. Because the nanoparticle probe carries many oligonucleotides per bound protein, there is substantial amplification, relative to protein. Nanotechnology could help with early detection of some cancers, which depends on the detection of extremely small quantities of protein markers in the blood or on cell surfaces. The challenge in applying this technology is to identify potential markers for a variety of diseases such as cancer, neurodegenerative diseases, infectious diseases, and cardiac and pulmonary diseases. Lab on a chip. The so-called lab-on-a-chip technology currently being used in drug research and diagnostics is another example of a practical application of nanotechnology in medicine. The chip â€”no bigger than a thumbnail â€” contains more than 15, different oligonucleotide probes that can detect genetic variations in the cytochrome genes and enable highly accurate prediction of a patient phenotype poor, intermediate, extensive, or ultrarapid metabolizer. Test results will allow physicians to consider unique genetic information from patients before prescribing medications. The lowest effective dose then can be prescribed, thus reducing potentially harmful side effects that may show up at higher doses. Researchers envision other forms of lab-on-a-chip technology. Cao, for example, anticipates using nanochannels to analyze DNA. Nanochannels resemble the long, narrow shape of DNA molecules. Cao and his colleagues at BioNanomatrix have been able to fabricate nanochannel arrays comprising hundreds of thousands of enclosed nanochannels with dimensions of 10 nm on a mm wafer. The use of fluorescent dyes to tag cells and cellular components goes back about years. Dyes, however, are not as precise as biomedical researchers would like and, can be illuminated only for very short periods. Quantum dots â€” nanometer-sized semiconductor crystals that act like light emitting diodes â€” promise to revolutionize bioimaging. Quantum dots are used to light up specific biological events brightly and to allow rapid, parallel, and ultrasensitive detection of biomolecular interactions. A variety of targeting molecules, including monoclonal antibodies, can be attached to the polymer coating of quantum dots allowing them to attach to specific biomarkers. Scientists at Genentech, for example, working in collaboration with Quantum Dot Corp. Because of their small size, quantum dots can function as cell- and even molecule-specific markers that will not interfere with the normal workings of a cell. The availability of quantum dots of different colors provides a powerful tool for following the actions of multiple cells and molecules simultaneously. Nanotechnologies such as lab-on-a-chip and quantum dots are already well on the way to revolutionizing the drug-discovery process. Yet, the real promise of nanotechnology lies in its ability to target and facilitate drug delivery. An open-ended tube is shown in the center and a closed-end tube with a lipid cap is shown on the left. A top view of the nanotubes and a magnified region are shown on the right. An implantable, silicon-based nanochannel drug delivery system, for example, may provide a way of delivering toxic drugs like interferon-alpha for the dosing of individual metastatic melanoma lesions without exposing the entire body to the powerful drug. Researchers at Ohio State University recently constructed and tested a device composed of labyrinthine nanochannels etched in a crystalline silicon substrate. Wyeth, Merck, and Abbott all have developed FDA-approved nanoparticulate drugs using NanoCrystal technology developed by Elan Drug Delivery, a neuroscience-based biotechnology company located in Ireland. Previously available only as an oral solution in bottles or sachets, the new nanoreformulated sirolimus tablet was approved by the U. Food and Drug Administration in So-called smart bionanotubes are lipid-protein tubes with an inner space, for these experiments, measuring about 16 nm in diameter. The whole capsule is about 40 nanometers in diameter. Raviv explains that the chemotherapy drug paclitaxel Taxol binds to microtubules and, therefore, could become one of the first drugs to be delivered by smart bionanotubes â€” in a manner specific to cancer cells â€” thereby reducing the side effects of chemotherapy treatments. New materials and new formulations will increase dosing efficacy, increase targeting ability, and eventually make the drug and biotech industry more profitable in the long term, though much research and development still has to be done to get it there.

Chapter 2 : Nanobiotechnology - Definition and Applications

Nano-biotechnology is an emerging field of nanotechnology with biochemical and biological applications or activities. It integrates biotechnology on the nano-scale. In order to engineer new devices (biosensors), existing elements of nature has been studied in nano-biotechnology.

English Pocket K No. Nanotechnology refers to controlling, building, and restructuring materials and devices on the scale of atoms and molecules. To get the sense of the nano scales, the width of the human hair is 80, nm and the smallest things visible with the naked human eye are 10, nm across. At nano scales, the basic rules of chemistry and physics are not applicable. They made DNA crystals by producing synthetic DNA sequences that can self-assemble into a series of three-dimensional triangle-like patterns. When multiple helices are attached through single-stranded sticky ends, there would be a lattice-like structure that extends in six different directions, forming a three-dimensional crystal as illustrated in Figure 1. This technique could be applied in improving important crops by organizing and linking carbohydrates, lipids, proteins and nucleic acids to these crystals. Nanocapsules can enable effective penetration of herbicides through cuticles and tissues, allowing slow and constant release of the active substances. MSNs are chemically coated and serve as containers for the genes delivered into the plants. The coating triggers the plant to take the particles through the cell walls, where the genes are inserted and activated in a precise and controlled manner, without any toxic side or after effects. This technique has been applied to introduce DNA successfully to tobacco and corn plants. Stereographic image of the surrounding of a triangle; b. Stereographic image of the rhombohebral cavity white lines formed by the triangles. When cotton is processed into fabric or garment, some of the cellulose or the fibers are discarded as waste or used for low-value products such as cotton balls, yarns and cotton batting. With the use of newly-developed solvents and a technique called electrospinning, scientists produce nanometer-diameter fibers that can be used as a fertilizer or pesticide absorbent. These high-performance absorbents allow targeted application at desired time and location. Cellulosic feedstocks are now regarded as a viable option for biofuels production and nanotechnology can also enhance the performance of enzymes used in the conversion of cellulose into ethanol. Scientists are working on nano-engineered enzymes that will allow simple and cost-effective conversion of cellulose from waste plant parts into ethanol. When rice husk is burned into thermal energy or biofuel, a large amount of high-quality nanosilica is produced which can be further utilized in making other materials such as glass and concrete. Since there is a continuous source of rice husk, mass production of nanosilica through nanotechnology can alleviate the growing rice husk disposal concern. Through the use of nanomaterials and global positioning systems with satellite imaging of fields, farm managers could remotely detect crop pests or evidence of stress such as drought. Once pest or drought is detected, there would be automatic adjustment of pesticide applications or irrigation levels. Nanosensors dispersed in the field can also detect the presence of plant viruses and the level of soil nutrients. Nanoencapsulated slow release fertilizers have also become a trend to save fertilizer consumption and to minimize environmental pollution. Scientists at Cornell University used the concept of grocery barcodes for cheap, efficient, rapid and easy decoding and detection of diseases. They produced microscopic probes or nanobarcodes that could tag multiple pathogens in a farm which can easily be detected using any fluorescent-based equipment. This on-going project generally aims to develop a portable on-site detector which can be used by non-trained individuals. The project, in cooperation with the U. Department of Agriculture is expected to be completed towards the end of Scientists at Purdue University developed a nanosensor that reacts with auxin. This interaction generates an electrical signal which can be a basis for measuring auxin concentration at a particular point. The nanosensor oscillates, taking auxin concentration readings at various points of the root. A system of formulas then verifies if auxin is absorbed or released by the surrounding cells. This is a breakthrough in auxin research because it helps scientists understand how plant roots adapt to their environment, especially to marginal soils. Just like biotechnology, issues of safety on health, biodiversity, and environment along with appropriate regulation are raised on nanotechnology. However, nanotechnology products such as anti-bacterial dressings, stain-resistant fabrics, and suntan lotions have long been commercially available. House Committee on Science in He emphasized that the impact of nanotechnology on health, wealth, and lives of the people will be at least equal to the combined influences of microelectronics, medical imaging, computer-aided engineering and man-made polymers developed in the 20th century. Pest Management Science Journal. Industrial and Engineering Chemistry Research. Information Systems for Biotechnology.

Chapter 3 : Nano-biotechnology: A Branch of Nanotechnology

Scientists at Genentech, for example, working in collaboration with Quantum Dot Corp., a leader in quantum dot biotechnology applications and products, succeeded in labeling the breast cancer marker HER2 with semiconductor quantum dots.

The term "nano-technology" was first used by Norio Taniguchi in , though it was not widely known. Eric Drexler used the term "nanotechnology" in his book Engines of Creation: The Coming Era of Nanotechnology , which proposed the idea of a nanoscale "assembler" which would be able to build a copy of itself and of other items of arbitrary complexity with atomic control. Also in , Drexler co-founded The Foresight Institute with which he is no longer affiliated to help increase public awareness and understanding of nanotechnology concepts and implications. Since the popularity spike in the s, most of nanotechnology has involved investigation of several approaches to making mechanical devices out of a small number of atoms. First, the invention of the scanning tunneling microscope in which provided unprecedented visualization of individual atoms and bonds, and was successfully used to manipulate individual atoms in Buckminsterfullerene C60, also known as the buckyball , is a representative member of the carbon structures known as fullerenes. Members of the fullerene family are a major subject of research falling under the nanotechnology umbrella. In the early s, the field garnered increased scientific, political, and commercial attention that led to both controversy and progress. These products are limited to bulk applications of nanomaterials and do not involve atomic control of matter. Some examples include the Silver Nano platform for using silver nanoparticles as an antibacterial agent, nanoparticle -based transparent sunscreens, carbon fiber strengthening using silica nanoparticles, and carbon nanotubes for stain-resistant textiles. By the mids new and serious scientific attention began to flourish. Projects emerged to produce nanotechnology roadmaps [19] [20] which center on atomically precise manipulation of matter and discuss existing and projected capabilities, goals, and applications. Fundamental concepts Nanotechnology is the engineering of functional systems at the molecular scale. This covers both current work and concepts that are more advanced. In its original sense, nanotechnology refers to the projected ability to construct items from the bottom up, using techniques and tools being developed today to make complete, high performance products. By comparison, typical carbon-carbon bond lengths , or the spacing between these atoms in a molecule , are in the range 0. By convention, nanotechnology is taken as the scale range 1 to nm following the definition used by the National Nanotechnology Initiative in the US. The lower limit is set by the size of atoms hydrogen has the smallest atoms, which are approximately a quarter of a nm kinetic diameter since nanotechnology must build its devices from atoms and molecules. The upper limit is more or less arbitrary but is around the size below which phenomena not observed in larger structures start to become apparent and can be made use of in the nano device. In the "bottom-up" approach, materials and devices are built from molecular components which assemble themselves chemically by principles of molecular recognition. The positions of the individual atoms composing the surface are visible. Nanomaterials Several phenomena become pronounced as the size of the system decreases. These include statistical mechanical effects, as well as quantum mechanical effects, for example the " quantum size effect" where the electronic properties of solids are altered with great reductions in particle size. This effect does not come into play by going from macro to micro dimensions. However, quantum effects can become significant when the nanometer size range is reached, typically at distances of nanometers or less, the so-called quantum realm. Additionally, a number of physical mechanical, electrical, optical, etc. One example is the increase in surface area to volume ratio altering mechanical, thermal and catalytic properties of materials. Diffusion and reactions at nanoscale, nanostructures materials and nanodevices with fast ion transport are generally referred to nanoionics. Mechanical properties of nanosystems are of interest in the nanomechanics research. The catalytic activity of nanomaterials also opens potential risks in their interaction with biomaterials. Materials reduced to the nanoscale can show different properties compared to what they exhibit on a macroscale, enabling unique applications. For instance, opaque substances can become transparent copper ; stable materials can turn combustible aluminium ; insoluble materials may become soluble gold. A material such as gold, which is chemically inert at normal scales, can serve as a potent chemical catalyst at nanoscales. Much of the fascination with nanotechnology stems from these quantum and surface phenomena that matter exhibits at the nanoscale. Molecular self-assembly Modern synthetic chemistry has reached the point where it is possible to prepare small molecules to almost any structure. These methods are used today to manufacture a wide variety of useful chemicals such as pharmaceuticals or commercial polymers. This ability raises the question of extending this kind of control to the next-larger level, seeking methods to assemble these single molecules into supramolecular assemblies consisting of many molecules arranged in a well defined manner. The concept of molecular recognition is especially important: The Watsonâ€”Crick basepairing rules are a direct result of this, as is the specificity of an enzyme being targeted to a single substrate , or the specific folding of the protein itself. Thus, two or more components can be designed to be complementary and mutually attractive so that they make a more complex and useful whole. Such bottom-up approaches should be capable of producing devices in parallel and be much cheaper than top-down methods, but could potentially be overwhelmed as the size and complexity of the desired assembly increases. Most useful structures require complex and thermodynamically unlikely arrangements of atoms. Nevertheless, there are many examples of self-assembly based on molecular recognition in biology , most notably Watsonâ€”Crick basepairing and enzyme-substrate interactions. The challenge for nanotechnology is whether these principles can be used to engineer new constructs in addition to natural ones. Molecular nanotechnology Molecular nanotechnology, sometimes called molecular manufacturing, describes engineered nanosystems nanoscale machines operating on the molecular scale. Molecular nanotechnology is especially associated with the molecular assembler , a machine that can produce a desired structure or device atom-by-atom using the principles of mechanosynthesis. Manufacturing in the context of productive nanosystems is not related to, and should be clearly distinguished from, the conventional technologies used to manufacture nanomaterials such as carbon nanotubes and nanoparticles. When the term "nanotechnology" was independently coined and popularized by Eric Drexler who at the time was unaware of an earlier usage by Norio Taniguchi it referred to a future manufacturing technology based on molecular machine systems. The premise was that molecular scale biological analogies of traditional machine components demonstrated molecular machines were possible: It is hoped that developments in nanotechnology will make possible their construction by some other means, perhaps using biomimetic principles. However, Drexler and other researchers [27] have proposed that advanced nanotechnology, although perhaps initially implemented by biomimetic means, ultimately could be based on mechanical engineering principles, namely, a manufacturing technology based on the mechanical functionality of these components such as gears, bearings, motors, and structural members that would enable programmable, positional assembly to atomic specification. In general it is very difficult to assemble devices on the atomic scale, as one has to position atoms on other atoms of comparable size and stickiness. Another view, put forth by Carlo Montemagno, [29] is that future nanosystems will be hybrids of silicon technology and biological molecular machines. Richard Smalley argued that mechanosynthesis are impossible due to the difficulties in mechanically manipulating individual molecules. Leaders in research on non-biological molecular machines are Dr. An experiment indicating that positional molecular assembly is possible was performed by Ho and Lee at Cornell University in They used a scanning tunneling microscope to move an individual carbon monoxide molecule CO to an individual iron atom Fe sitting on a flat silver crystal, and chemically bound the CO to the Fe by applying a voltage. Current research Graphical representation of a rotaxane , useful as a molecular switch. This DNA tetrahedron [33] is an artificially designed nanostructure of the type made in the field of DNA nanotechnology. Each edge of the tetrahedron is a 20 base pair DNA double helix , and each vertex is a three-arm junction. Rotating view of C60, one kind of fullerene. This device transfers energy from nano-thin layers of quantum wells to nanocrystals above them, causing the nanocrystals to emit visible light. Nanomaterials with fast ion transport are related also to nanoionics and nanoelectronics.

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Nanoscale materials can also be used for bulk applications; most present commercial applications of nanotechnology are of this flavor. Progress has been made in using these materials for medical applications; see Nanomedicine. Nanoscale materials such as nanopillars are sometimes used in solar cells which combats the cost of traditional silicon solar cells. Development of applications incorporating semiconductor nanoparticles to be used in the next generation of products, such as display technology, lighting, solar cells and biological imaging; see quantum dots. Recent application of nanomaterials include a range of biomedical applications, such as tissue engineering , drug delivery , and biosensors. DNA nanotechnology utilizes the specificity of Watsonâ€"Crick basepairing to construct well-defined structures out of DNA and other nucleic acids. Approaches from the field of "classical" chemical synthesis Inorganic and organic synthesis also aim at designing molecules with well-defined shape e. More generally, molecular self-assembly seeks to use concepts of supramolecular chemistry, and molecular recognition in particular, to cause single-molecule components to automatically arrange themselves into some useful conformation. Atomic force microscope tips can be used as a nanoscale "write head" to deposit a chemical upon a surface in a desired pattern in a process called dip pen nanolithography. This technique fits into the larger subfield of nanolithography. Molecular Beam Epitaxy allows for bottom up assemblies of materials, most notably semiconductor materials commonly used in chip and computing applications, stacks, gating, and nanowire lasers. Top-down approaches These seek to create smaller devices by using larger ones to direct their assembly. Giant magnetoresistance -based hard drives already on the market fit this description, [41] as do atomic layer deposition ALD techniques. Focused ion beams can directly remove material, or even deposit material when suitable precursor gasses are applied at the same time. Atomic force microscope tips can be used as a nanoscale "write head" to deposit a resist, which is then followed by an etching process to remove material in a top-down method. Functional approaches These seek to develop components of a desired functionality without regard to how they might be assembled. Magnetic assembly for the synthesis of anisotropic superparamagnetic materials such as recently presented magnetic nano chains. These could then be used as single-molecule components in a nanoelectronic device. Synthetic chemical methods can also be used to create synthetic molecular motors , such as in a so-called nanocar. Biomimetic approaches Bionics or biomimicry seeks to apply biological methods and systems found in nature, to the study and design of engineering systems and modern technology. Biomineralization is one example of the systems studied. Bionanotechnology is the use of biomolecules for applications in nanotechnology, including use of viruses and lipid assemblies. Speculative These subfields seek to anticipate what inventions nanotechnology might yield, or attempt to propose an agenda along which inquiry might progress. These often take a big-picture view of nanotechnology, with more emphasis on its societal implications than the details of how such inventions could actually be created. Molecular nanotechnology is a proposed approach which involves manipulating single molecules in finely controlled, deterministic ways. This is more theoretical than the other subfields, and many of its proposed techniques are beyond current capabilities. Nanorobotics centers on self-sufficient machines of some functionality operating at the nanoscale. There are hopes for applying nanorobots in medicine, [46] [47] [48] but it may not be easy to do such a thing because of several drawbacks of such devices. Because of the discrete i. Due to the popularity and media exposure of the term nanotechnology, the words picotechnology and femtotechnology have been coined in analogy to it, although these are only used rarely and informally. The dimensionality play a major role in determining the characteristic of nanomaterials including physical , chemical and biological characteristics. With the decrease in dimensionality, an increase in surface-to-volume ratio is observed. This indicate that smaller dimensional nanomaterials have higher surface area compared to 3D nanomaterials. Recently, two dimensional 2D nanomaterials are extensively investigated for electronic , biomedical , drug delivery and biosensor applications. Tools and techniques Typical AFM setup.

Chapter 4 : Nanotechnology: Whatâ€™s in it for Biotech?

The ability to systematically modify the properties of nanostructures by controlling their structure and their surface properties at a nanoscale level makes them extremely attractive candidates for use in biological contexts, from fundamental scientific studies to commercially viable technologies.

Terminology[edit] The terms are often used interchangeably. When a distinction is intended, though, it is based on whether the focus is on applying biological ideas or on studying biology with nanotechnology. Bionanotechnology generally refers to the study of how the goals of nanotechnology can be guided by studying how biological "machines" work and adapting these biological motifs into improving existing nanotechnologies or creating new ones. For example, DNA nanotechnology or cellular engineering would be classified as bionanotechnology because they involve working with biomolecules on the nanoscale. Conversely, many new medical technologies involving nanoparticles as delivery systems or as sensors would be examples of nanobiotechnology since they involve using nanotechnology to advance the goals of biology. The definitions enumerated above will be utilized whenever a distinction between nanobio and bionano is made in this article. However, given the overlapping usage of the terms in modern parlance, individual technologies may need to be evaluated to determine which term is more fitting. As such, they are best discussed in parallel. Concepts[edit] Most of the scientific concepts in bionanotechnology are derived from other fields. Biochemical principles that are used to understand the material properties of biological systems are central in bionanotechnology because those same principles are to be used to create new technologies. Material properties and applications studied in bionanoscience include mechanical properties e. DNA computing and agriculture target delivery of pesticides, hormones and fertilizers. Nano-biotechnology takes most of its fundamentals from nanotechnology. Most of the devices designed for nano-biotechnological use are directly based on other existing nanotechnologies. Nano-biotechnology is often used to describe the overlapping multidisciplinary activities associated with biosensors, particularly where photonics , chemistry, biology, biophysics, nano-medicine, and engineering converge. Measurement in biology using wave guide techniques, such as dual polarization interferometry , are another example. Applications[edit] Applications of bionanotechnology are extremely widespread. Insofar as the distinction holds, nanobiotechnology is much more commonplace in that it simply provides more tools for the study of biology. Bionanotechnology, on the other hand, promises to recreate biological mechanisms and pathways in a form that is useful in other ways. Nanomedicine[edit] Nanomedicine is a field of medical science whose applications are increasing more and more thanks to nanorobots and biological machines , which constitute a very useful tool to develop this area of knowledge. In the past years, researchers have done many improvements in the different devices and systems required to develop nanorobots. This supposes a new way of treating and dealing with diseases such as cancer; thanks to nanorobots, side effects of chemotherapy have been controlled, reduced and even eliminated, so some years from now, cancer patients will be offered an alternative to treat this disease instead of chemotherapy, which causes secondary effects such as hair loss, fatigue or nausea killing not only cancerous cells but also the healthy ones. At a clinical level, cancer treatment with nanomedicine will consist of the supply of nanorobots to the patient through an injection that will search for cancerous cells while leaving untouched the healthy ones. Patients that will be treated through nanomedicine will not notice the presence of these nanomachines inside them; the only thing that is going to be noticeable is the progressive improvement of their health. Three American patients have received whole cultured bladders with the help of doctors who use nanobiology techniques in their practice. Also, it has been demonstrated in animal studies that a uterus can be grown outside the body and then placed in the body in order to produce a baby. Stem cell treatments have been used to fix diseases that are found in the human heart and are in clinical trials in the United States. There is also funding for research into allowing people to have new limbs without having to resort to prosthesis. Artificial proteins might also become available to manufacture without the need for harsh chemicals and expensive machines. It has even been surmised that by the year , computers may be made out of biochemicals and organic salts. Researchers are seeking to design polymers whose fluorescence is quenched when they encounter specific molecules. Different polymers would detect different metabolites. The polymer-coated spheres could become part of new biological assays, and the technology might someday lead to particles which could be introduced into the human body to track down metabolites associated with tumors and other health problems. Another example, from a different perspective, would be evaluation and therapy at the nanoscopic level, i. While nanobiology is in its infancy, there are a lot of promising methods that will rely on nanobiology in the future. Biological systems are inherently nano in scale; nanoscience must merge with biology in order to deliver biomacromolecules and molecular machines that are similar to nature. Controlling and mimicking the devices and processes that are constructed from molecules is a tremendous challenge to face the converging disciplines of nanotechnology. Natural evolution has optimized the "natural" form of nanobiology over millions of years. In the 21st century, humans have developed the technology to artificially tap into nanobiology. This process is best described as "organic merging with synthetic. Gunther Gross at the University of North Texas. Self-assembling nanotubes have the ability to be used as a structural system. They would be composed together with rhodopsins ; which would facilitate the optical computing process and help with the storage of biological materials. DNA as the software for all living things can be used as a structural proteomic system - a logical component for molecular computing. Ned Seeman - a researcher at New York University - along with other researchers are currently researching concepts that are similar to each other. Another important area of research involves taking advantage of membrane properties to generate synthetic membranes. Proteins that self-assemble to generate functional materials could be used as a novel approach for the large-scale production of programmable nanomaterials. One example is the development of amyloids found in bacterial biofilms as engineered nanomaterials that can be programmed genetically to have different properties. Given the myriad uses that biological systems have for proteins, though, research into understanding protein folding is of high importance and could prove fruitful for bionanotechnology in the future. Lipid nanotechnology is another major area of research in bionanotechnology, where physico-chemical properties of lipids such as their antifouling and self-assembly is exploited to build nanodevices with applications in medicine and engineering. Basically, nanomaterials are distinguished depending on the origin: Among these, engineered nanoparticles have received wide attention in all fields of science, including medical, materials and agriculture technology with significant socio-economical growth. In the agriculture industry, engineered nanoparticles have been serving as nano carriers, containing herbicides, chemicals, or genes, which target particular plant parts to release their content. Likewise, other literature describes that nano-encapsulated slow release of fertilizers has also become a trend to save fertilizer consumption and to minimize environmental pollution through precision farming. These are only a few examples from numerous research works which might open up exciting opportunities for nanobiotechnology application in agriculture. Also, application of this kind of engineered nanoparticles to plants should be considered the level of amicability before it is employed in agriculture practices. Based on a thorough literature survey, it was understood that there is only limited authentic information available to explain the biological consequence of engineered nanoparticles on treated plants. Certain reports underline the phytotoxicity of various origin of engineered nanoparticles to the plant caused by the subject of concentrations and sizes. At the same time, however, an equal number of studies were reported with a positive outcome of nanoparticles, which facilitate growth promoting nature to treat plant. Similarly, AgNPs-treated common bean and corn has increased shoot and root length, leaf surface area, chlorophyll, carbohydrate and protein contents reported earlier.

Chapter 5 : Applications of biotechnology : Agriculture, Food Processing, Biotech Industry

[4] Growing interest in the future medical applications of nanotechnology is leading to the emergence of a new field called "Nanomedicine", where it is defined as the science and technology of.

Biotechnology as a route to nanotechnology By Ralph C. This web version differs in some respects from the published version and is available at http: The ability to hold and position parts gives us remarkable flexibility in the manufacturing process, whether we are making furniture or synthesizing complex molecular structures. Applying this powerful concept at the molecular scale will require the development of new tools and pose new challenges in many fields, yet the rewards will be enormous. Introduction Nanotechnology is creating a growing sense of excitement because we see an opportunity of unprecedented magnitude looming on the horizon: This will have a pervasive impact on how we manufacture almost everything -- what is manufacturing but a way to arrange atoms? If we can arrange atoms with greater precision, at lower cost, and with greater flexibility then almost all the familiar products in our world will be revolutionized. To name just three: Underlying the excitement is a very simple fact: Very roughly, if we can pack atoms into a cubic nanometer, and each atom can be any of the approximately elements, then there are something like different ways we can arrange the atoms in just a single cubic nanometer. A cubic micron expands this to , while an object the size of you or me makes even this number seem vanishingly small. The goal that now seems possible: In Feynman said: It is not an attempt to violate any laws; it is something, in principle, that can be done; but in practice, it has not been done because we are too big. Entirely new classes of incredibly strong, extremely light and environmentally benign materials could be created" and went on to discuss inexpensive superconductors and medical applications. NSF is backing up this rhetoric with grants. NASA has a computational molecular nanotechnology research group examining the ways in which this technology can be used to advance the exploration and human habitation of space. IBM is doing pathbreaking research to revolutionize computing. Storing one bit in a few atoms no longer seems outlandish, and molecular switches will someday replace the bulky devices made today using optical lithography. As we move beyond the vision and start asking how we are going to do this and how long it will take, opinions begin to diverge. These remarkable instruments have already demonstrated an ability to move atoms and molecules on a surface in a controlled way often spelling out names of interest to the researchers or their sponsors , but have so far been confined to two dimensions. Stacking molecules one on top of another is the next obvious goal, which will no doubt be accomplished in the next few years. Could these versatile instruments go on to make molecular machines? Or perhaps the design and modification of proteins and their self assembly will provide the key to progress? Living systems already use many molecular machines, such as molecular motors. Could we adapt them to our own uses, perhaps using them to power tiny pumps or open and close tiny valves? There are many novel uses of existing biopolymers that could provide us with new tools. DNA, for example, is known primarily for its ability to encode information. The great diversity of proposals, ideas, and experimental capabilities makes it very difficult to predict exactly how we will proceed towards the more general goals of nanotechnology. Yet there are a few principles that seem both powerful enough and clear enough that they can provide some sort of framework for orienting ourselves. The first principle we consider is that of positional assembly. Positional assembly There are two main ways to assemble parts. In self assembly, the parts move randomly under the influence of thermal noise and explore the space of possible mutual orientations. If some particular arrangement is more stable, then it will be preferred. Given sufficient time, this preferred arrangement will be adopted. For example, two complementary strands of DNA in solution will eventually find each other and stick together in a double-helical configuration. In positional assembly, some restoring force keeps the part positioned at or near a particular location, and two parts are assembled when they are deliberately moved into close proximity and linked together. While common at the scale of humans we commonly hold, position and assemble parts with our hands this ability is still quite novel at the molecular scale. Thermal noise still plays a significant role, as "holding" a molecular part does not provide absolute certainty about its position but instead imposes a bias on the range of positions it can adopt. Using a linear approximation, an object might be subjected to a restoring force F which is proportional to its distance from the desired location, i. The fundamental equation relating positional uncertainty, temperature and stiffness is4: This is accurate enough to permit alignment of molecular parts to within a fraction of an atomic diameter. It is important to remember, however, that the actual error could be many times s. Errors of a few times s are common, but errors of 20 times s would be extremely unlikely. The distinction between self assembly and positional assembly is not binary, but moves continuously along a scale depending on the positional uncertainty which is a function of the restoring force and the temperature. When the positional uncertainty s is large, we are near the self assembly end of the spectrum. When s is small, we are at the positional assembly end of the spectrum. While the SPM provides programmable positional control you can adjust x, y and z to essentially any values , a simple form of positional assembly can also be seen in enzymes which bind two substrate molecules. The two bound molecules are positioned with respect to each other, thus facilitating their assembly. A limited form of positional assembly is also used in the ribosome, which can position the end of a growing protein adjacent to the next amino acid to be incorporated into that protein5. This combination of positional assembly and self assembly can also be seen at the macroscopic scale. The vibratory bowl feeder6 is commonly used in manufacturing to position parts with sizes on the order of a centimeter. The bowl is shaken by a motor, causing parts in the bowl to bounce onto and along a spiral track leading out of the bowl. By careful design of the track, parts in the right orientation continue to move along it, out of the bowl and into further assembly steps. Parts in the wrong orientation are bounced back into the bowl, where they can try again to move up the spiral path leading out of the bowl. While the power of self assembly has been amply demonstrated by the wide range of complex molecular structures it has made including a remarkable range of biological structures , we have barely begun to explore the power of positional assembly at the molecular scale. Despite this, it seems clear that this new capability will play a major role in our future ability to synthesize molecular structures. While its application at the molecular scale will differ in many details, it will provide a new and remarkably powerful tool for extending the range of structures that we can make. Biotechnology and programmable positional control Schematic illustration of a Stewart platform. The lower blue triangle forms the base, while the upper green triangle froms the platform. The position and orientation of the platform with respect to the base can be controlled in six degrees of freedom X, Y, Z, rool, pitch, and yaw by adjusting the lengths of the six gray struts. If we really want positional assembly to make products in the volume that ribosomes make proteins, we must have small, fast positional devices7. Yet it seems unlikely that biotechnology will directly give us a molecular robotic arm. Which brings us to the Stewart platform8,9, This device, basically an octahedron six of whose struts can be lengthened or shortened under programmatic control see illustration , provides six degree of freedom positional control for the "platform," the green triangle at the top of the octahedron with respect to its base the blue triangle at the bottom of the octahedron. The ability to make an octahedron does not seem beyond the capabilities of biotechnology in the broad sense of the term , particularly when the ability to self assemble a truncated octahedron has already been demonstrated by Seeman2. All we need are twelve stiff struts, some way to make their ends stick together, and some way to lengthen or shorten six of those struts. As the latter seems the harder problem, we discuss one possible approach to solving it. Consider a single strut: One way would be to use two struts that overlap, and then make them slide past each other in a controlled fashion. If we want to combine these two struts into one long strut, then we have to join them together. Suppose we use "joiners" that have two ends: Then, as illustrated above, the two struts would be held together by this a-x joiner to form a single longer strut. First, we add a c-y joiner. They will at first be strained, but as we add more and more c-y joiners they will start to balance out the a-x joiners. If we now wash the a-x joiners out of solution the simplest arrangement would be to anchor the octahedron in place by a tether, and flow a solution with an appropriate concentration of joiners past them , then the c-y joiners will dominate the linkage between the two struts leading to the results in the final illustration, below. If we repeat the whole process again, this time washing in a b-z joiner and washing out the c-y joiner, we can again move the two struts over by one monomer. Finally, if we wash in an a-x joiner and wash out the b-z joiner, we are back where we started. By running the cycle in reverse, we can reverse the motion. In essence, we have a three-phase linear motor. The essential point here is not that this particular approach is the right one or even necessarily a good one, but that biotechnology and self assembly can be used to make positional devices. This is just one possible way: Building blocks If we are to use positional assembly, we must have something to assemble. In biotechnology and self assembly, the most common building blocks are monomers that are built into polymers. Each monomer has two linkage groups which let it become part of a chain. Proteins and RNA form complex three dimensional structures because the monomers from which they are made have strong preferences in how they bind to each other. By appropriately arranging the linear sequence of monomeric units, it is possible to indirectly control the three dimensional structure of the resulting polymer. While the demonstrated capabilities of this approach are remarkable, if we could hold and position building blocks in three dimensions we should be able to assemble complex three dimensional structures much more directly from building blocks. To this end, we require building blocks that have more than two linking groups as two linking groups would give us polymers, which provide only indirect control over three dimensional structure. Three points define a plain, and so three groups are frequently found in two-dimensional structures. In graphite, for example, each carbon atom is joined to three neighbors. Four points define a three-space, so four linking groups in tetrahedral symmetry are well suited to the formation of three dimensional structures, much as the carbon atoms in diamond are each bonded to four neighbors. In the near term, building blocks that are relatively large many atoms and which can be readily manipulated in solution are more likely to be experimentally accessible. While synthetic methodologies and reactions for arranging carbon atoms in desired patterns have been proposed4,11,12,13, these approaches require very controlled conditions, extremely good absolute positioning capbabilities, and very clean ultra-high vacuum environments. While these conditions should be achievable in the future, at present they present formidable experimental challenges. Molecular building blocks made from many atoms can be designed that are easier to manipulate, easier to link, less susceptible to contaminants, and more easily positioned. We need to start with large, easy to use building blocks. If we are to build large, stiff structures then the building blocks themselves should be stiff. Drexler has proposed the use of artificially designed proteins in which simultaneous use of many stabilization techniques produces a protein that is much more stable than naturally occuring proteins

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In other words, nanobiotechnology is essentially miniaturized biotechnology, whereas bionanotechnology is a specific application of nanotechnology. For example, DNA nanotechnology or cellular engineering would be classified as bionanotechnology because they involve working with biomolecules on the nanoscale.

The key scientific and engineering pursuit in nanotechnology proposed here is worded in the following questions: What biological macromolecular components lend themselves well to engineering application? How can the functionality of the macromolecular components be harnessed and coordinated to provide the desired work function? The answer to the first question lies in the development of a novel bioinformatics framework to allow the searching of biological knowledge to look for nanoscale, biomolecular components that may be used as components in a system with coordinated complexity. The answer to the second question is directly related to the development of nanotechnology. To create a broad portfolio of applications, leadership in both nanotechnology and bioinformatics is crucial. Project Methods Effective nanobiological systems engineering requires inputs from the following three core disciplines: The study of the structure, function and interaction of biological components within their own native context. The development of tools and methods to classify biological information to serve as an information base for engineering design. The tools and techniques collected from the physical sciences, such as microfabrication, synthetic chemistry and materials science that allow the organization of biological macromolecules to coordinate their function and synthesize devices and systems with a higher order of built functionality. Apart from Systems Biology, Bioinformatics and Nanotechnology are inherently engineering disciplines. Bioinformatics has evolved from information theory and computer software engineering, while nanotechnology is a wide collection of techniques and design philosophies from various engineering disciplines. The research themes mentioned above leverage existing procedures and protocols found in conventional biotechnology, information systems and synthetic chemistry. A bioconjugation laboratory will be established that will provide the necessary synthesis and characterization capabilities necessary for constructing these devices and systems. Bioconjugation research will commence immediately and will be applied in the development of sensors and sensing systems for biological and non-biological analytes. Bioinformatics for nanodevice design is a very new concept, and two papers delineating this theme have already been published Lee et al. The work on transcriptional control has been only described in conferences on computer sciences. A concept paper will first be written to highlight its application in biotechnology. This work is a long-term endeavor and will progress over the next few years. Research was conducted on environmental impacts of nanotechnology as well as on synthetic biology. Two PhD students have graduated and both have been placed in reputable postdoctoral positions. One MS student has graduated and has been placed at a large agricultural biotechnology company. Three additional MS students are in the process of completing their research. Two courses have been developed during this period pertaining to nanotechnology and analytical methods in biological engineering. Several products have been developed in the course of this project. These include, a plasmid database for engineered gene circuits, as well as several videos for informing stakeholders on the progress and benefits of the research. These materials have also been used for dissemination. Target audience includes various agricultural producers and agricultural biotechnology researchers an companies. Not relevant to this project. Impacts Change in knowledge: We have developed a formal understanding of a small class of positive feedback-based engineered gene circuits and their behavior over long periods of time. This information will be useful in developing the next generation of biotechnology and has been used now by the students of this program in their own scientific careers Change in actions: We believe our research on the environmental impact of nanotechnology will be crucial in developing policies pertaining to the widespread use of nanotechnology Publications Nistala, G. A modular positive feedback-based gene amplifier. Journal of Biological Engineering. A positive feedback-based gene circuit to increase the production of a membrane protein. DIMER - a framework to study environmental toxicity of nanoparticles. Metabolic burden in synthetic gene circuits. Conducting and analyzing experiments on the use of synthetic gene circuits as biological sensors, mentoring four graduate students, teaching a course on biological nanotechnology. Both projects began in October Participated in one conference Annual meeting of the Institute for Biological Engineers and a multistate meeting NC and presented research results there. Course materials, a plasmid database for public consumption at http: One student graduated with an M. Two publications on the subject outlining our design methodology for the biological sensors. One book chapter on bioconjugation techniques accepted in a book on biosensors. Students on the project: Student , Karan Bansal M. Student, graduated, now employed , Rekha Balachandran M. Student , and Sun Min Kim M. Robert Gennis Biochemistry, U. Illinois , and Prof. Chris Rao Chemical Engineering, U. San Fransisco , Prof. Christina Smolke Stanford , Prof. Jim Haseloff Cambridge, UK. Industrial groups engaged in agricultural, industrial and pharmaceutical biotechnology. Impacts Change in Knowledge: Two publications have been accepted by the Journal of Biological Engineering on the subject of bacterial sensors. One review article has been published in Trends in Biotechnology and was on their list of highly downloaded articles. The next wave in biotechnology Trends in Biotechnology. Work was done on two different goals outlined in the hatch proposal. Under nanotechnology applications, we have discovered some important phenomena pertaining to the aggregation of a corn protein, zein. We have determined, e. A paper describing these findings is under preparation. A presentation including these findings was made at a professional conference by the student working on the project. The student in is in the process of completing her doctoral dissertation on the subject. Under bioinformatics applications, we are engineering a strain of cyanobacteria capable of producing ethanol directly from sunlight. We have determined the specific genes in the pathway that need to be introduced in the cyanobacteria. Currently, we are trying to insert the pathway in cyanobacteria to test the pathway. We have not published any results yet. Also under this goal, we have demonstrated a novel genetic circuit that can be used to amplify the production of a membrane protein. Membrane proteins are an object of intense scientific and pharmaceutical investigation, and sufficient quantities of protein need to be produced for crystallization and analysis. Our technology can cut down the time to produce membrane proteins to a third. We have tested this system for a well-characterized protein called bd oxidase. A journal article is in process and will be submitted soon. The student working on this project has produced a thesis and will be graduating soon. Goutam Nistala, PhD candidate. Karan Bansal, Graduated with M. Munima Haque, Passed her doctoral defense, currently completing her dissertation. Chih-Ting Kuo, currently working on the cyanobacteria project. Christopher Griffin and Ms. Awnye Taylor Worked as summer research apprentices on the cyanobacteria project. Impacts Under the nanotechnology project, a student, Ms. Munima Haque, has defended her doctoral dissertation describing her findings related to the aggregation behavior of zein investigated at the colloidal and nano-scale level. The methodology developed in her dissertation may be applicable to studying the aggregation behavior of biomacromolecules such as proteins. Chiefly, we have developed a rational methodology to characterize the aggregation, temperature dependance and microrheological characteristics of highly polydisperse protein solutions. Such techniques may have wider application, e. The application of bioinformatics and molecular biology techniques to develop novel genetic circuits is quickly becoming an important engineering discipline called synthetic biology. It is expected that synthetic biology is the intellectual framework which will lead to the biotechnology of tomorrow. Encyclopedia of Agricultural, Food and Environmental Engineering. Commissioned by Taylor and Francis Group. Experiments have been conducted to observe the nanostructure and the dynamics of zein protein aggregation. A new theoretical model has been developed to understand the process from a thermodynamic perspective. Initial experiments have been conducted to demonstrate applications in biosensing and increasing productivity of biotechnological systems. Results from experiments have been presented at the annual meetings of the Institute of Biological Engineering and the American Society for Agricultural and Biological Engineers. Serving as a mentor for a student group participating in an international contest on genetically engineered systems. Engineering data has been gathered to create a foundation for the rational design of a zein separation process from the corn-ethanol production system. Results have been presented at professional society meetings and technical conferences in the form of presentations and posters. Michael Olmos - High school student, summer research program.

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Chapter 7 : Nanobiotechnology - Wikipedia

Biotechnology and nanotechnology are two of the 21 st century's most promising technologies. Nanotechnology (sometimes referred to as nanotech) is defined as the design, development and application of materials & devices whose least functional make up is on a nanometer scale [1, 2].

Nanotechnology Images Nanobiotechnology Nanobiotechnology is the application of nanotechnologies in biological fields. Chemists, physicists and biologists each view nanotechnology as a branch of their own subject, and collaborations in which they each contribute equally are common. One result is the hybrid field of nanobiotechnology that uses biological starting materials, biological design principles or has biological or medical applications. While biotechnology deals with metabolic and other physiological processes of biological subjects including microorganisms, in combination with nanotechnology, nanobiotechnology can play a vital role in developing and implementing many useful tools in the study of life. Although the integration of nanomaterials with biology has led to the development of diagnostic devices, contrast agents, analytical tools, therapy, and drug-delivery vehicles, bionanotechnology research is still in its infancy. Our Nanowerk Spotlight section on bionanotechnology contains hundreds of research articles on this topic. Here is a brief overview: Applications of nanobiotechnology in medicine Nanotechnology in medicine is a wide area that encompasses disease diagnosis, target-specific drug delivery, and molecular imaging. In particular thanks to nanoelectronics will the medical sector undergo deep changes by exploiting the traditional strengths of the semiconductor industry â€" miniaturization and integration. While conventional electronics have already found many applications in biomedicine â€" medical monitoring of vital signals, biophysical studies of excitable tissues, implantable electrodes for brain stimulation, pacemakers, and limb stimulation â€" the use of nanomaterials and nanoscale applications will bring a further push towards implanted electronics in the human body. In previous Nanowerk Spotlights we have already covered numerous research advances in this area: The development of a nanobioelectronic system that triggers enzyme activity and, in a similar vein, the electrically triggered drug release from smart nanomembranes ; an artificial retina for color vision; nanomaterial-based breathalyzers as diagnostic tools; nanogenerators to power self-sustained biosystems and implants ; future bio-nanotechnology might even use computer chips inside living cells. A lot of nanotechnology work is going on in the area of brain research. For instance the use of a carbon nanotube rope to electrically stimulate neural stem cells ; nanotechnology to repair the brain and other advances in fabricating nanomaterial-neural interfaces for signal generation. TSEM micrograph of a cultured rat hippocampal neuron grown on a layer of purified carbon nanotubes. Laura Ballerini, University of Trieste Sensors and diagnostics Molecular sensing and molecular electronics is a diverse area that can include molecular conformational changes, changes in charge distribution, changes in optical absorbance and emission, or changes in electrical conductivity along or across simple or complex-shaped molecules, all in response to a target input. Each of these approaches can be integrated into a transduction system that provides a measurable and desired change in response to a specific or range of inputs. The ability to integrate such transduction mechanisms with biomolecules or to use biomolecules as the source of such materials provides, to varying extent, biocompatibility with other systems. Plasmonic nanobiosensors , could ultimately become a key asset in personalized medicine by helping to diagnose diseases at an early stage. In other work, nanobiosensor that were originally designed to detect herbicides can help diagnose multiple sclerosis and a new type of smartphone-based nanobiosensor has shown promise for early detection of tuberculosis. Silver and fullerene coated cellulose-acetate sensors are flexible and could be used to detect tuberculosis in early stages. The inset shows a smartphone-based detection scheme for use in point-of-care settings. Quantum dots and noble metal nanoclusters are very active and exciting areas in the field of bionanotechnology, with new progress constantly being made in adapting these technologies in the creation of new biosensors and bioelectronic devices. Integrating DNA and other nucleic acids with nanoparticles Functionally integrating DNA and other nucleic acids with nanoparticles in all their different physicochemical forms has produced a rich variety of composite nanomaterials which, in many cases, display unique or augmented properties due to the synergistic activity of both components. For instance, researchers have fabricated a DNA impedance biosensor for the early detection of cancer or the rapid detection of the flu virus. These capabilities, in turn, are attracting greater attention from various research communities in search of new nanoscale tools for diverse applications that include bio sensing, labeling, targeted imaging, cellular delivery, diagnostics, therapeutics, theranostics, bioelectronics, and biocomputing to name just a few amongst many others. The role of nanobiotechnology in the food sector The development of nanotechnology in food and agriculture has led to nanobiotechnology applications in that include pesticide delivery systems through bioactive nanoencapsulation; biosensors to detect and quantify pathogens; organic compounds; other chemicals and food composition alteration; high-performance sensors electronic tongue and nose ; and edible thin films to preserve fruit.

Chapter 8 : Nanotechnology - Wikipedia

1 Department of Biosystems Engineering and Soil Science, Center for Environmental Biotechnology, Institute for a Secure and Sustainable Environment, The University of Tennessee, Knoxville, TN , U.S.A. 2 Department of Civil and Environmental Engineering, Center for Environmental Biotechnology.

A Branch of Nanotechnology By: Nanobiotechnology is an emerging field of nanotechnology with biochemical and biological applications or activities. It integrates biotechnology on the nano-scale. In order to engineer new devices biosensors , existing elements of nature has been studied in nano-biotechnology Nano-biotechnology is an emerging field of nanotechnology with biochemical and biological applications or activities. In order to engineer new devices biosensors , existing elements of nature has been studied in nano-biotechnology. Biotechnology is a branch of molecular biology having applications of technological revolution related to biology and life sciences. Studies have shown that bio-nanotechnology and nano-biotechnology has been interchanged, although these two terms are distinguished and a distinction has been drawn between the two. Bio-nanotechnology usually refers to intersect between biotechnology and nanotechnology while nano-biotechnology refers to goals of biotechnology with the use of nanotechnology. Bio-nanotechnology often includes the use of biomolecules any organic molecule produced by a living organism as a motivation for Nano-technological devices. Multidisciplinary activities that are associated with biosensors an analytical device for the detection of an analyte that combines a biological component with a physicochemical detector component - predominantly where chemistry, biology, biophysics uses the methods of physical science to study biological systems , nano-medicine medical application of nanotechnology , photonics including the emission, generation, modulation, transmission, switching, signal processing, amplification, detection and sensing of light and engineering congregate are often described by means of nano-technology. Other examples for the measurement in biology are waveguide techniques two-wire transmission line used in conventional circuits is inefficient for transferring electromagnetic energy at microwave frequencies such as dual polarization interferometry. Another important example of nano-biotechnology involves the research of nano-spheres a spherical particle whose diameter is measured in nanometers glazed with fluorescent polymers. To target a specific molecule researchers are trying hard to design polymers whose fluorescent is extinguished. Different metabolites would be detected by different polymers. To overcome human health problems or problems that are associated with tumors these fluorescent coated polymers would be introduced into human body which might someday lead to new biological assesses. As we know that nano-biotechnology field is new to medical, end user, and commercial bodies. In the expansion of vehicles which can be used for the treatment of cancer, diagnosis of various diseases and application of nano-biosensors, the unification of antibodies and nanoparticles with high affinity and specificity via receptor-ligand mode is of an overriding significance. The artificial nanomaterial like Nano-liposomes and Nanoparticles and biological objects like an antibody forms bio-complex that is carried by the establishment of covalent bonds. These covalent bonds are based on the specificity of chemical and structural properties biocompatibility, water solubility and biodegradability. By having all this knowledge one can easily understand the disease and the treatment for that disease and can go through all other applications. This knowledge is of great importance in the establishment of nanoscale devices. Moreover, to gain a detailed knowledge about the energetically favorable binding modes Molecular Dynamics Simulation can be used. Recently the studies have been showed by Noon et al. For example, the mouse immune system has a specific antibody that can easily recognize C60 fullerenes with the binding affinity of about 25mM. I have also worked with molecular markers in M.

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In addition to utilizing different materials, the applications for which biotechnology and nanotechnology are utilized also distinguish the two fields. Biotechnology is primarily applied to life science fields such as agriculture, health science, and pharmacology.

That is where the field of nanotechnology is currently headed. Nanotechnology will have an almost endless string of applications in biotechnology, biology, and biomedicine. One day, the concept of creating an implantable nanosensor to watch for the signature molecules of cancer will no longer be dismissed as the wishful thinking of wide-eyed dreamers. Nanotechnology has created a growing sense of excitement due to the ability to create and utilize materials, devices, and systems through the control of matter on the nanometer scale 1 to 50 nm. This bottom-up approach requires less material and causes less pollution. Nanotechnology has had several commercial applications in advanced laser technology, hard coatings, photography, pharmaceuticals, printing, chemical-mechanical polishing, and cosmetics. Soon, there will be lighter cars using nanoparticle-reinforced polymers, orally applicable insulin, artificial joints made from nanoparticulate materials, and low-calorie foods with nanoparticulate taste enhancers. The advancement of biotechnology has been facilitated by the availability of enabling technologies such as laser tweezers, optical traps, and nano-pokers as well as the atomic force, scanning electron, and scanning tunneling microscopes. These tools enable the biotechnologist to have better understanding, characterization, and control of living cells. Bioinspired nanodevices and materials are currently formed by self-assembly, molecular imprinting, or other patterning techniques. Nanoreactors prepared from reversed micelles are capable of producing well defined, nano-sized crystallites or manipulating individual protein molecules. Half of useful drugs are hydrophobic, and reducing the size of the drug particles to the nanoscale can significantly enhance the administration of such drugs. Highly porous nanomaterials are ideal candidates for controlled drug delivery. Successful gene therapy is dependent upon the development of safe and efficient gene vectors. Nonviral vectors, nanoparticles, complexes between lipids, or polymers with DNA have been proposed as alternatives to viruses used to incorporate specific genes into target cells. Significant advances in nanotechnology will soon perfect the preparation of such DNA nanoparticles. Nanobiosensors have several immediate applications in generic research to monitor the inherent nanoscale components of living cells. They are also envisioned for the detection of chemical and biological threats such as pollutants, microbial contamination, viruses, communicable and genetic diseases, and cancer. DNA array technology itself might play an important role in enabling nanofabrication. Rapid and sensitive drug screening, one of the limiting factors in combinatorial chemistry for drug discovery and development, is another important application of nanobiosensors. Chip-sized biodevices could revolutionize the detection and management of illness. For example, a nanosensor can be combined with a nanoscale drug delivery system to dispense optimum amounts of drugs to maximize their efficacy. Nano-total analysis systems nano-TAS: These nanosystems are also known as "nanolabs-on-chips," which are distinguished from simple sensors because they conduct a complete analysis: They consist of three important elements: With the ability to make chemical and biological information faster and cheaper, nanolabs-on-chips in array may profoundly change the current practice in clinical diagnostics, genome sequencing, environmental monitoring, food safety, and other areas of the public interest. Nanoscale bioprocesses for bioremediation: Novel properties of nanocrystals such as TiO2 that show promise as photocatalysts can be used in combination with microorganisms to break down toxic pollutants to clean up a variety of waste streams. Nanoscale scavengers are able to capture heavy metals in contaminated sites. There are, however, several problems associated with the commercialization of nanotechnology. One well-known citation is the superior performance of transistors made from carbon nanotubes. Unfortunately, it is almost impossible to mass-produce such transistors for making computer chips. Similarly, formidable challenges still remain in the synthesis and processing of drug-carrier nanoparticles at the commercial scale. Another critical issue is the integration of nanostructures or nanodevices with the larger, human-scale systems or platforms around them so that they can be used as components of electronic devices, sensors, etc. Nanostructures are often unstable due to their small constituent sizes and high chemical activity. Therefore, a real challenge is to increase the thermal, chemical, and structural stability of these materials and the devices made therefrom. Last but not least, the biggest problem nanotechnology could encounter towards commercialization is the costs of manufacturing. With myriad nanomaterials or nanostructures in hand, there is no question that more and more nano-objects with novel or enhanced properties will be developed. However, technical feasibility and commercial viability are two different things. One of the key factors is the identification of promising areas for future research and commercial development. The complexity of nanosystems begs for strong, interdisciplinary research programs to aid this process. Several potential applications of the technology are still in an embryonic phase, and the government must play an important role to sustain the research effort required for establishing the scientific and technological infrastructure. It is of utmost importance to educate a new breed of researchers who can work and think across several disciplines. The challenge for nanotechnology will be to foster more interdisciplinary collaborations and get more young people interested in science and engineering. Therefore, it is essential to create a series of interdisciplinary centers of excellence and research chairs at Canadian universities to conduct research and train graduate students. Such centers will serve as a vehicle to foster on-campus interaction through interdisciplinary research involving multiple departments. These centers should carry out long-term nanoscience and engineering research leading to fundamental discoveries of novel applications, processes, phenomena, and enabling tools. Numerous workshops and symposia with specific objectives must be organized to spur and encourage the government, private foundations, and industries to support research and education in nanotechnology. Of course, both federal and provincial funding agencies are expected to play an important role in fostering the research and development in this important area. They must have a "national nanotechnology initiative" to support basic research and an "implementation plan" to assess their strategic investment in nanotechnology. He received a Ph. He has seven patents and over research papers.