Research

Although there are already a lot of products in existence which use nanotechnology, there are more on the way. However, they are continuing to research new ways in which Nanotechnology can be used to benefit us.

This research covers many different areas including military and medical.

Military Research

Many militaries are looking at research into Nanotechnology. This is because it is being used in the development of weapons, as well as soldiers of the future - including their armour and what they are equipped with.

Future Force Warrior

Wars are evolutionary, with each new conflict bringing more powerful and advanced weaponry. Weapons that yield success on the modern battlefield today can quickly become outdated and ineffective in just a few years. The reality of the battlefield necessitates continuous change in the pursuit to stay a step ahead of the enemy.

To better equip its soldiers, the U.S. Army is developing an advanced infantry uniform that will provide superhuman strength and greater ballistic protection than any uniform to date. Also, using wide-area networking and onboard computers, soldiers will be more aware of the action around them and of their own bodies.

Today's technology will create the Future Force Warrior, which turns a soldier into an "F-16 on legs."

Suiting Up For Battle

With the development of a bionic uniform for its soldiers, the U.S. Army is planning for a change in the logistics of war. Integrated physiological monitoring, enhanced communication and augmented physical strength will give the soldiers of the future the tools they need to overwhelm their opponents simply by putting on a hi-tech suit.

There are two phases to the Future Force Warrior program. The first phase involves the deployment of a uniform in 2010 that will meet the Army's short-term needs, although pieces of the uniform may be deployed earlier. According to Future Force Warrior Equipment Specialist Jean-Louis "Dutch" DeGay, *"The Department of the Army has built what's called design spirals, so roughly every two years, if a piece of technology has matured, we try to get it in the field, rather than waiting until 2010 to field the entire system."* In 2020, the U.S. Army will roll out a suit that integrates nanotechnology, exoskeletons and liquid body armour, all of which exist only in concept now.

Here are the basic components of the final version of the suit:

- **Helmet** - The helmet houses a GPS receiver, radio and the wide- and local-area network connections.
- **Warrior Physiological Status Monitoring System** - This layer of the suit is the closest to the body and contains sensors that monitor physiological indicators, such as heart rate, blood pressure and hydration. The suit relays the information to medics and field commanders.
- **Liquid Body Armour** - This liquid body armour is made from magnetorheological fluid, a fluid that remains in a liquid state until the application of a magnetic field. When an electrical pulse is applied, the armour transitions from a soft state to a rigid state in thousandths of a second.
- **Exoskeleton** - The exoskeleton is made of lightweight, composite devices that attach to the legs and augment the soldier's strength.

Together, these subsystems combine to create a uniform that informs, protects and enhances the abilities of its wearer. Now let's take of each of these components separately.

Battlefield Awareness

The value of enemy reconnaissance depends on how quickly that information can be relayed to the soldier on the battlefield. The soldiers of the future will have more information immediately available to them than ever before.

The U.S. Army currently employs a system called Blue Force Tracker (BFT). The system enables a commander to get a real-time picture of the battlefield from his or her personal computer. The commander can then track individual unit movement and provide this information to friendly units. The U.S. Marines have used BFT, although they initially opted for a more portable and rugged system called the Enhanced Position Location Reporting System, or "ePLRS." Both ePLRS and BFT share the same goal: real-time tracking of friendly forces. The downside to both systems, however, is that they are bulky, somewhat dated and require computers with operators who could otherwise be carrying a weapon.

Back view of a Future Force Warrior suit

The Future Force Warrior setup is a significant improvement on these current systems. A computer embedded in the suit and located at the base of the soldier's back will be connected to a local and wide-area network, allowing for data transfer.

DeGay explains it this way:

"Essentially, it's what we call the "borg" effect, to borrow a theme from Star Trek. Everything in the battle space is a sensor, whether that's a vehicle, rotor wing, fixed wing, aviation vehicle, ground vehicle, individual soldier or unmanned robotic platform. That becomes a sensor that I can track for data. I can send data to it or take data, video or audio from it."

Soldiers will utilize a voice-activated, drop-down screen in the helmet to access information without having to put down their weapons. Embedded in a pair of transparent glasses, the display will appear to the soldier as a 17-inch screen. This screen can display maps and real-time video provided by a forward-positioned scout team, satellite or aircraft. According to DeGay, "We are working to have the graphic user interface inside the computer systems to either replicate computer graphic user interfaces or even Playstation 2/Xbox graphic user interfaces," because most of today's soldiers are already familiar with how those systems work.

Future Force Warrior helmet

Not only will Future Force Warriors know more about their fellow soldiers, but they also will know more about their own physiological condition. The physiological subsystem of the uniform lies against the soldier's skin and includes sensors that monitor soldier's core body temperature, skin temperature, heart rate, body position (standing or sitting) and hydration levels. These statistics are monitored by the soldier and by medics and commanding officers who might be miles away. Knowing the condition of a platoon of soldiers allows commanders to make better strategic decisions. The Future Force Warrior helmet also includes a GPS receiver, providing commanders with exact positioning data on their troops.

Another vital component of battle is communication between soldiers. The Future Force Warrior will use sensors that measure vibrations of the cranial cavity, eliminating the need for an external microphone. This bone-conduction technology allows soldiers to communicate with one another, and it also controls the menus visible through the drop-down eyepiece. The helmet has 360-degree situational awareness and voice amplification.

"What this will allow you to do is to know where that sniper round or mortar round came from, but at the same time it will cancel out noise at a certain decibel so as to not cause damage to the soldier's ears," said Robert Atkinson, liaison sergeant, operational forces interface group, Natick Soldier Centre.

The situation-awareness technology also allows soldiers to:

- detect other soldiers in front of them up to a couple of kilometres away
- focus in on a particular sound and amplify it

Powering the entire suit is a 2- to 20-watt microturbine generator fuelled by a liquid hydrocarbon. A plug-in cartridge containing 10 ounces of fuel

can power the soldier's uniform for up to six days. Battery patches embedded in the helmet provide three hours of back-up power.

Liquid Body Armour

With advances in ballistics, armies must develop better body armour. One type of modern body armour, first developed in the 1960s, is made out of advanced woven fibres that can be sewn into vests and other soft clothing. More commonly known as Dupont Kevlar, this is one of the many body armour solutions currently employed by U.S. Forces. Another type of armour, SAPI plates, or "small arms protective insert" plates, are hardened ceramic composite plates inserted into a soldier's fragmentation protective vest in both the forward and back torso pockets.

Now, scientists are working on a new breed of armour made from magnetorheological (MR) fluids -- *liquid* body armour.

The Future Force Warrior is protected by liquid body armour built into his or her uniform.

One type of MR fluid consists of small iron particles suspended in silicon oil. The oil prevents the particles from rusting. The fluid transforms from liquid to solid in just milliseconds when a magnetic field or electrical current is applied to it. The current causes the iron particles to lock into a uniform polarity and stack on top of each other, creating an impenetrable shield. How hard the substance becomes depends on the strength of the magnetic field or electrical current. Once the charge or magnetic field is removed, the particles unlock, and the substance goes back to a fluid state.

MR fluid will fill small pockets in the Future Force Warrior uniform fabric. The uniforms will be wired to allow an electrical current to pass through the fabric. The electrical current will be controlled by the onboard computer system and will automatically charge the MR fluid when there is a ballistic threat present.

MIT scientists who are developing the liquid body armour say that it will take five to 10 years to make the substance fully bullet resistant.

Exoskeleton

Superhuman strength has always been confined to science fiction, but advances in human-performance augmentation systems could give soldiers the ability to lift hundreds of pounds using the effort they would usually use to lift a fraction of that weight.

In the shoulder of the Future Force Warrior uniform is a fabric filled with nanomachines that mimic the action of human muscles, flexing open and shut when stimulated by an electrical pulse. These nanomachines will create lift the way muscles do and augment overall lifting ability by 25 to 35 percent.

"Think of yourself on steroids, holding as much weight as you want for as long as you want," said Atkinson *. "It will also allow a 90 pound male or female to carry a 250 pound male or female off of the battlefield and it wouldn't feel like they were carrying 250 pounds worth of person."*

The exoskeleton attached to the lower body of the soldier will provide even more strength. The overall exoskeleton will provide up to 300 percent greater lifting and load-carrying capability.

"The Exoskeleton, which is in conjunction with DARPA, will give the soldier more stability," Atkinson said. *"It makes the soldier become a weapons platform."*

With this added strength, weapons can be mounted directly to the uniform system. In the concept uniform (at right), the exoskeleton is the protruding composite material you see below the knee.

The exoskeleton will merge structure, power, control, actuation and biomechanics. Here's a look at some of the challenges that DARPA has outlined:

- Structural materials - The exoskeleton will have to be made out of composite materials that are strong, lightweight and flexible.
- Power source - The exoskeleton must have enough power to run for at least 24 hours before refuelling.
- Control - Controls for the machine must be seamless. Users must be able to function normally while wearing the device.
- Actuation - The machine must be able to move smoothly so it's not too awkward for the wearer. Actuators must be quiet and efficient.
- Biomechanics - Exoskeletons must be able to shift from side to side and front to back, just as a person would move in battle. Developers will have to design the frame with human-like joints.

As warfare changes, armies are looking for any advantage they can get against potential enemies. The new Future Force Warrior suit will take human performance to unprecedented levels. Imagine a platoon of soldiers wearing suits that turn an ordinary person into a real, live superhero.

Medical Research

To advance medical technology, we need to understand the body. By developing nanotechnology devices which can explore and analyse the body, we are able to achieve a detailed knowledge, allowing the technology to advance.

Nanotechnology devices could monitor levels within the body, their location and the time and store that on an internal memory. This could then be gathered by filtering them out of the blood and a picture developed on what's affecting the body, where and at what times. These findings could also be reinforced by taking small tissue samples with the devices.

What Could Medicine Achieve?

A lot of diseases and illnesses are caused by damage at the cell level. For these to be worked on it requires small fine tools, making the surgical tools currently used appear to large and unsuitable for the task and possibly cause more damage than good.

Using nanotechnology, small machines could be created which are smaller than human cells, allowing for intervention at a cell level.

What could they be used for?

There are many tasks the nanobots could be used for including:

- Removing obstructions in the circulatory system
- Killing Cancer cells
- Artificially fulfilling a task within the cell, such as that of a mitochondria
- Examining tissue in high detail

These machines could also be designed to be self replicating, achieving low manufacturing costs. Although many people fear that this could make nanotechnology dangerous it will take many years to reach that stage and eventually will become unavoidable.

The Size of Devices

The size of the machines is obviously required to be very small, with the volume of each element being less than 100 cubic nanometres. Meaning overall, the device should be less than 100 nanometres long on each side of a cube. This device would hold the equivalent of a small computer today.

Within this volume, a 'robotic' arm would be included at less than 100 nanometres long and binding sites and 10 nanometres long or less.

In comparison a red blood cell is over 80 times larger than this.

Applications

Killing Cancer Cells

A device could be designed with the ability to identify and kill cancer cells. To achieve this, the device would have to have some binding sites to attach itself to cells to test them, a computer on board with information to compare the findings to see if the cell is cancerous and some poison which could be released on the cell in order to kill it.

The device would be able to go around the body in the circulatory system and using the binding sites check the different molecules surrounding it until a cancerous cell was detected.

By using acoustic signals the device would be able to send and receive instructions as well as determine where it is in the body, in a similar way to GPS in a car.

Providing Oxygen - Artificial Red Blood Cells

Using items such as bucky balls oxygen could be delivered to parts in the body where it is required, creating an artificial blood cell. This would help prevent tissue damage as it could detect when oxygen levels fell below a certain point and release the oxygen.

To completely become an artificial red blood cell, the device would also have to absorb oxygen when levels were higher than the threshold.

Artificial Mitochondria

The mitochondria within cells often fail after tissue injury cause by loss of blood flow, therefore increasing oxygen would not restore the tissue. However designing a device to be artificial mitochondria could help restore the functions of the cell, even if the original mitochondria are no longer active, thus restoring the metabolite levels in the body.

Taking Snapshots of the System

The devices could take tissue samples which they could then analyse at a molecular level. These samples could also be frozen to halt chemical process and allow the tissue samples to be analysed at a later date.

If these devices are able to self replicate, a lot of these devices could be going around the body, raking and analysing samples and eventually building up a picture of the whole body.

How long until it happens?

An exact time can't be put on this, however looking at the development of technology in the previous 50 years; it could be feasible to see it within 20 years. The medical applications of this technology would only need slightly longer than this to develop.

The exact timescale largely depends on public demand. If the public is very negative on the advancements, then these developments will slow down, if they happen at all, however, if the public like the idea and money into research is increased, it could happen sooner.

It is quite possible, to our advantage, that the technology could be developed and begin helping within our lifetimes, and it is clear to see some ideas slowly coming through.

Places of Research

There are many places of nanotechnology research around the world. Here are just some of them:

UK
London
Swansea

America
Northwestern University
Albany - New York
Northeastern University

Canada
NASA Ames Research Center

Europe
Copenhagen

Japan
Hokaido University

Worldwide
IBM

With Thanks To:
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