Special Topic: Future technologies

Prognoses of the future technical development

Nobody really can say in which direction our science goes. There are so many different subjects that can revolutionise the whole world.

Here are some examples of these future technologies:

Gene engineering:

The scientists think that they will have completely decoded the DNA (Desoxy Ribo Nuclein Acid) of humans in 50 years. After that we will be able to create a human with all the attitudes we want to give him. (more intelligent or good looking, for example). Today we are able to clone an organism and force bacteria to produce medicine. It sounds simply you just put the gene (building plan) for the enzyme (medicine) into the DNA of a bacterium and you let this bacterium multiply itself. After a certain time you have millions of bacterias which produce the medicine you want.

Fusion energy:

This technology can change society completely. We would have unlimited energy for the whole world. The sun is the best example. It has been burning for billions of years just with the help of fusion energy.

With further researches perhaps it will be possible to replicate any atomic element, connection, molecule and material we want.

Robots:

Today many people could not imagine working without their computer. This computer technology is the base of Robots, Computers that can walk and talk. Today we are far away from this technology but there are programmes that can talk with you or machines that can walk.

Space Ships:

If you had asked a person 200 years ago if mankind would fly to the moon someday, he/she would have laughed at you. Today it is possible to fly to the moon so perhaps in the next 200 years we will fly beyond our solar system to other planets. In contrary to the other technologies I have mentioned before the scientists haven't started to research the theories for flying faster than the light. With our technical status it is not possible to check the theories the scientists have in mind.

The internet and virtual reality

This result of our modern computerized society is certainly a future technology. The net grows and people are communicating with each other all over the world. The internet connected with virtual reality is the next step. Perhaps in the future business meetings 5 men and women will sit in front of their computers with I (Intelligent) -Glasses on 5 different places over the world but their eyes will see each other on a big table where they discuss problems.

Nanotechnology a combination of VR technology, computers and gene engineering and Bio Cybernetics a combination of Computer technology gene engineering and nanotechnology.
I will explain these future technology further down. It is impossible to summarize them because these technologies are too complicated and there are so many possibilities, which result out of these technologies that a summary could not be satisfy.

Explanation and the future of gene technology

Today we are able to influence and add information to the DNA Code. When the scientists will have decoded the whole DNA of an organism, it will perhaps be possible to configure or create this creature as we want it to be.

But what is DNA?

We can see the genes which consists of DNA in three ways:

1) Genes as structural units: DNA, the chemical basis of genes, can be modified, cleaved and legated etc. In this sense it is about as interesting as sugar, lipids and other constituents of the cell, - putting it bluntly, relatively boring, or at least, no more interesting than chemical substances in general. However, what is exciting is the fact that it can be reintroduced into living organisms. DNA, as such, has nothing to do with life. It is dead. It is as \`inert\` as salt. It does not create life, but it can be integrated into life processes. Results like those I have described demand further investigation and research. Identification of the 2,500 genes required for eye formation, their functions and interactions is a tremendous challenge for generations of molecular biologists. Identification and elaboration of the chromosomal organisation of the 80 - 100,000 genes of the human genome, their functions, regulation in time and space will keep researchers busy for decades. And all the work, all the experimentation, is set to follow the very same scheme: manipulation and engineering, - for we live in the age of \`invasive biology\`. At this point these reflections could easily deviate into ethical and moral concerns, but I trust these will be considered later. Suffice it to say here, this first level of reality could be called the \`technical instrumentalisation\` of life.

2) Genes as informational units: Genes are carriers of information. From a given sequence of genes,

the primary structure of proteins, its amino acid sequence, can be deduced. The flow of information from DNA to RNA to protein can be unequivocally predicted, but is by no means sufficient to draw any conclusion on function. Indeed, any undergraduate could derive the protein primary sequence from a given stretch of DNA, but the genome projects show beyond any doubt that the function of a protein cannot simply be read from its amino acid composition. We are thus left with the problem that either the molecular approach to life does not grasp the entirety of living beings or that there exists occult information in the gene besides that of the genetic code. We either embark on DNA mysticism or acknowledge the limitation of purely genetic explanations of life.

3) Genes as functional units: Let us presume that we have identified a gene and elucidated the function of its product. We have already seen in the example of the eye formation that the function alone is not sufficient to explain its `meaning` or `significance` for the organism itself. More importantly, most of us are familiar with the poorly understood situation in animal model systems, where human disease conditions are simulated. Often enough, transgenic animals with the correct genetic changes can be generated, but the expected traits are lacking. One of the most important examples is the retinoblastoma gene. It is essential for cell cycle regulation in man and in its mutated form results in the formation of eye tumours. Mice with the very same genetic change develop a number of abnormalities, but retinoblastomas have not been detected in a single animal. If the gene had first been discovered in mouse it would not have been called the retinoblastoma gene. The genetic condition is necessary, but is obviously not sufficient for the formation of the organismic, phenotypic characteristics.

But there are far more possibilities to use gene engineering:

The book “Jurrasic Park” shows one example how we can use gene engineering in it’s on one hand fascinating and on the other hand dangerous way.

Summary:

Scientists develop a means of bringing dinosaurs to life using DNA taken from dino` blood, which has been preserved inside insects encased in amber. Whilst Hammond is showing off his dinosaur `theme park` to a selected audience [a lawyer (Gerrano), mathematician (Malcolm), dino` expert (Grant), palaeobotanist (Sattler) and his grandchildren (Tim & Lex)],

What the company has built there, we gradually discover, is a theme park inhabited by living dinosaurs cloned from fossils. As the project`s presiding madman, John Hammond, explains: the obstacles to making a profit on genetically engineered pharmaceuticals have proved insurmountable. "Now, think how different it is when you`re making entertainment. Nobody needs entertainment. That`s not a matter for government intervention. If I charge $5,000 a day for my park, who is going to stop me?"

You fool, says Hammond`s resident Cassandra, Ian Malcolm, who is described as "one of the most famous of the new generation of mathematicians who were openly interested in `how the real world works.` " One can`t clone hundreds of prehistoric dinosaurs, put them in an environment, and expect to control the results. Chaos theory tells us that a big complicated system like that defies understanding. "There is a problem with that island," Malcolm warns. "It is an accident waiting to happen."

And this accident happened when Nedry (computer expert) disables the security system so that he can make his escape with some stolen embryos. This enables all the dinosaurs to escape their enclosures.

Robots:

I want to explain the future of robots by 2 examples. "Data" from "Star Trek" and Asimov's "I'Robot":

Data has 100,000 terabytes of memory (equiv to 100,000,000 one-GB hard drives). When on trial, he stated that he had a storage capacity of 800 quadrillion bits (100 quadrillion bytes). Data processes 60 trillion computations per second. If you`d like to compare Data`s 100,000 terabytes of storage capacity to something real-world, someone mentioned a chart that set the maximum storage capacity of the human brain to approximately 3 teraBITS, which would mean that Data`s brain could contain everything from over 260,000 human brains.

The television program Star Trek: The Next Generation included an android character, Data, who we are specifically told (in the episode "Datalore") was created in an attempt to bring "Asimov`s dream of a positronic robot" to life. Unfortunately, the producers of the show locked onto the "positronic" aspect as if that were the key quality to Asimov`s robots. Asimov`s view was exactly the opposite -- his robots are "positronic" because positrons had just been discovered when he started writing robot stories and the word had a nice science-fictiony ring to it. The use of positrons was just an engineering detail and relatively unimportant to him.

Asimov`s key insight was that, inasmuch as we engineer our tools to be safe to use, we would do the same with robots once we start making them -- and that the main safeguards for an intelligent being are its ethics. We would, therefore, build ethics into our robots to keep them going off on uncontrollable killing sprees.

In some sense, the specific Three (Four) Laws are themselves an engineering detail, the robotic equivalent of the Ten Commandments -- it is a specific ethical system but not the only one possible. In Asimov`s universe, they are the basis for robotic ethics and so absolutely fundamental to robotic design that it is virtually impossible to build a robot without them.

Asimov tended not to let other people use his specific Laws of Robotics, but his essential insight -- that robots will have in-built ethical systems -- is freely used.

In particular, Data is an "Asimovian" robot because he does have an in-built ethical system. He does not have the Three Laws, however (witness the episode "Measure of Man" in which he refuses to follow a direct order from a superior officer [Second Law] without invoking either danger to a specific human [First Law] or the higher needs of all of humanity [Zeroth Law]). Moreover, his ethical programming is not fundamental to his design (his prototype, Lore, lacks it altogether, and Data`s ethical program is turned off for much of "Descent, part II").

What are the Laws of Robotics, anyway?
The Three Laws of Robotics are:

1. A robot may not injure a human being, or, through inaction, allow a human being to come to harm.
2. A robot must obey the orders given it by human beings except where such orders would conflict with the First Law.
3. A robot must protect its own existence as long as such protection does not conflict with the First or Second Law.
(From Handbook of Robotics, 56th Edition, 2058 A.D., as quoted in I, Robot.)
In Robots and Empire (ch. 63), the "Zeroth Law" is extrapolated, and the other Three Laws modified accordingly: 0. A robot may not injure humanity or, through inaction, allow humanity to come to harm. Unlike the Three Laws, however, the Zeroth Law is not a fundamental part of positronic robotic engineering, is not part of all positronic robots, and, in fact, requires a very sophisticated robot to even accept it.

Asimov claimed that the Three Laws were originated by John W. Campbell in a conversation they had on December 23, 1940. Campbell in turn maintained that he picked them out of Asimov`s stories and discussions, and that his role was merely to state them explicitly.

The Three Laws did not appear in Asimov`s first two robot stories, "Robbie" and "Reason", but the First Law was stated in Asimov`s third robot story "Liar!", which also featured the first appearance of robopsychologist Susan Calvin. (When "Robbie" and "Reason" were included in I, Robot, they were updated to mention the existence of the first law and first two laws, respectively). Yet there was a hint of the three laws in "Robbie", in which Robbie`s owner states that "He can`t help being faithful, loving, and kind. He`s a machine - made so." The first story to explicitly state the Three Laws was "Runaround", which appeared in the March 1942 is sue of Astounding Science Fiction.

Space Ships:

Impulse Drive, Warp Drive and Dilithium Crystals

The impulse drive is powered by nuclear fusion. The problem here is that fusion turns only one percent of the available mass into energy. you can work out how much fuel would be required to do the following simple manoeuvre: start from rest, go to half the speed of light and then stop. It turns out that you need about 7000 times the mass of the ship in fuel just to do that.

The galaxy is about 100,000 light years across. If you`re travelling at mere light speed it would take years just to get to the nearest star. So if you want to do any significant travel in the galaxy in a reasonable amount of time - say an episode - you have to travel much faster than the speed of light [which impulse drive cannot provide]. Enter the warp drive.

The warp drive is powered with matter and antimatter. Every elementary particle has an associated antiparticle with the same mass but opposite properties, like charge. And when the two come together, they annihilate to produce pure radiation. This is probably the best kind of rocket propulsion because all of the mass is turned into energy.

The rate at which matter and antimatter interact in the warp drive are apparently regulated by dilithium crystals. That doesn`t really make sense, because when matter and antimatter interact, its either all or nothing. You can`t regulate the rate.

Another problem is that they annihilate on a scale which is thousands, if not millions of times smaller than the scale of atoms in a crystal. So its hard to imagine how any crystalline structure is going to channel matter and antimatter

Warp Drive and Negative Energy

The warp drive is impossible, the way the writers describe it. As everyone knows, Einstein says you can`t go faster than the speed of light. But there is a way that warp drive could work. Although Einstein caused the problem, he also came to the rescue by inventing general relativity.

In principle general relativity allows you to go faster than the speed of light compared to distant objects, but locally be standing still. As we sit here we`re not moving relative to our local surroundings. But relative to a galaxy at the other end of the visible universe, we are moving away at the speed of light. And that galaxy is also standing still relative to its surroundings. What's happening is the space between the two galaxies is actually expanding. So if you wanted to have a warp drive in principle, you could let space do the work for you. Let`s say you wanted to go to the nearest star. You`d have to fire up your chemical rockets, and go up about 200 miles from the Earth`s surface. Now you`re about four light years away from the nearest star. Then what you have to do is arrange for the space between you and the star to catastrophically collapse, and the space between you and the Earth to expand. Then suddenly you`re 200 miles from the star and four light years away from Earth. Your clocks haven`t changed, and no physical object has been moving.

What`s wonderful about general relativity is it allows you to create designer space-times. You could take any kind of universe with any geometry and write that down mathematically. A few years ago a physicist named Miguel Alcubierre found a solution of Einstein`s equations that would have all the properties of warp drive, but didn`t violate general relativity.

The question is - can you create the configuration of matter and energy that is required? Mathematically you can, but how about physically? Gravity always pulls, so to make space expand, you have to add a repulsion term. It turns out that you need something called negative energy. On small scales negative energy configurations do exist. But can you create negative energy in a controlled way on a macroscopic scale? We don`t know.

I think that interstellar travel will be impractical for a very long time because of the huge energy requirements. If we ever interact with extraterrestrial life, I think the last way we will do it is by sending spacecraft. Broadcasting our existence with radio messages would certainly be much cheaper.

What is Fusion?

Fusion is simply combining the nuclei of light elements to form a heavier element. This nuclear reaction results in the release of large amounts of energy - typically a million times more energy than can be obtained by combining atoms chemically (such as burning coal).

In a fusion reaction, the total mass of the resultant nuclei is slightly less than the total mass of the original particles. This difference is converted to energy as described by Einstein's famous equation, $E=mc^2$.

First-generation fusion reactors will use deuterium and tritium, isotopes of hydrogen, for fuel. Deuterium occurs naturally in nature - about one part in 6000 is found in ordinary water. Tritium can be produced from lithium. Advanced fusion reactors will burn pure deuterium (or maybe even hydrogen), of which there is essentially a limitless supply.

This deuterium-tritium fusion reaction results in an energy gain of about 450:1.+14.1 Me V +3.5 Me V deuterium tritium neutron alpha.

Explanation of virtual reality:

Although VR is still in its infancy, potentially the technology represents a new medium for human communication, education and entertainment. VR arcades are already a reality: playtime costs $1.00 per minute. Virtual cadavers help future doctors explore the human body.

A VR system can be based on a personal computer. The computer controls several different sensory display devices to immerse you in a 3-dimensional virtual environment. The most common sensory displays are head-mounted displays for 3D visual and headphones for 3D audio. Since these displays need to be updated with new sensory information more than 20 times per second it often helps to have additional processing power in the form of add-on 3D graphics cards and 3D sound cards.

A VR system needs to be able to track the position and orientation of your head in order to calculate the appropriate perspectives to display. Any other body parts, such as your hands, feet, or prehensile tails, that will play an active part in the virtual environment must also be tracked. The device that does this is called (surprisingly enough) a tracking device.

Input devices make up the final category of VR hardware. In order to interact with the virtual environment you may wish to use a joystick (sometimes called a wand in VR systems), an instrumented glove, a keyboard, voice recognition, or other types of input. These devices allow you to travel through the virtual environment, manipulate objects, and perhaps even build on to the virtual world. Tracking devices are sometimes used together with input devices to add a spatial (3 dimensional) component to their operation.

In order to build virtual environments you often need auxiliary software for creating the objects that go into the virtual environment and setting their characteristics. Three-dimensional modelling software allows you to construct the geometry of the objects and specify some of their visual properties. Two-dimensional graphics software lets you manipulate textures to be applied to the objects which can often greatly enhance their visual detail. Digital sound editing software lets you mix and edit the sounds that objects make. All these software packages have other commercial uses in addition to building VR, and so there is a great variety to choose from.

The simulation software is what brings all the components together. It accepts data from the trackers and input devices, applies this information to the objects you have built, and updates the sensory displays. You use the simulation software to program how the objects behave and set the rules that the virtual world follows.

Although they have improved dramatically in the last few years, VR simulations are not yet photorealistic, and a complete VR system is still quite expensive. VPL`s cost upwards of $300,000; the VR system GE built for the military cost $16 million. VR hardwear includes 3-D audio-visual head-mounted displays (based on Ivan Sutherland`s 1965 design of the "ultimate display"), and realtime tracking devices like "datagloves" and "cybersuits." These are linked by umbilical cables to some very sophisticated software and some powerful computer hardware. Together, they immerse the user in cyber spaces and places s/he then has the sense of participating in.

Current Applications

Practical applications of virtual reality are under active development by a variety of agencies and disciplines. The range of applications illustrates the enormous potential for this technology to address highly varied problems and needs.

Medicine: Virtual reality is used in planning radiation treatments for cancer patients at The University of North Carolina (Stewart, 1991). Using computerized scans of a patient`s anatomy viewed through virtual reality, physicians can move proposed beams around by hand and position them so that they converge most effectively on a tumor. By combining ultrasound scanners with head-mounted display units, Robinett (1991) believes that physicians will soon be able to "see directly inside of living tissue" (p. 18). With half-silvered mirrors, the display allows the wearer to see through to the real world, with images from ultrasound data optically superimposed onto the patient. Using this "x-ray vision", an obstetrician could "see the woman, feel the fetus kick beneath her hands, and see the ultrasound image of the fetus appearing to hang in space inside her belly"(p. 18).

Chemistry: At the University of North Carolina, chemists use virtual reality to "see" protein structures in three dimensions, and holding a special joystick, find ways to design new drugs that will "dock" perfectly with enzyme molecules (Brooks, 1988; Stewart, 1992).

Architecture: Architects can now "walk through" building designs before any actual construction takes place, with the aid of a treadmill and data sensors. The use can judge design features from any perspective they choose (Southwest Educational Development Laboratory, 1990).

Interior Design: Customers in Japan may design custom kitchens and use virtual reality to see the result. Wearing goggles and a glove, they can walk through their design and actually touch "virtual appliances" (Peterson, 1992).

Military: For some time, there have been investigations among military agencies concerning use of virtual reality in personnel training, and in the design of new weapon systems. The technology is being applied to the design of tank simulators, flight simulators, and to aircraft design and repair (Lowenstein & Barbee, 1990).

Space Exploration: NASA has designed a virtual reality system which creates the illusion of flying over a Martian landscape accurately created from photographs of the planet`s surface (Peterson, 1992). The Visualization for Planetary Exploration Project (also designed by NASA) employs virtual reality to allow users to explore the solar system (Ditlea, 1989). Current efforts are focusing on the use of virtual reality to prepare astronauts to live and work on orbiting space stations (Fritz, 1991) and to undertake construction and repair in a space environment (Southwest Educational Development Laboratory, 1990).

Robotics: One of the most practical and immediate applications for virtual reality is robotics. The use of simple, small hand movements in a DataGlove can control complex robotics equipment.

Nanotechnology and gene engineering:

A new science has been born which may solve this problem, as well as many other problems previously regarded as unsolvable. That science is called molecular nanotechnology, defined as "thorough, inexpensive control of the structure of matter based on molecule-by-molecule control of products and by products; the products and processes of molecular manufacturing." (Drexler, 1991, p. 19) Nano means one-billionth, as in one-billionth of a second (nanosecond) or one-billionth of a meter (nanometer). In the world of molecular manufacturing, we will think in terms of nanomachines and nanomotors, and in the world of its products we will speak of nanocomputers and nanomedicine. The challenge of research in nanotechnology will not be how to make things smaller, the top-down method, but how to make molecules and collections of molecules larger, a bottom-up approach.

Human beings have always tried to control the environment (i.e., matter) around them, but until recently have only been able to do so in a crude and visible fashion. It is a bit staggering to think of being able to control and manipulate matter at the molecular level, but in fact scientists have doing just that for a number of years. Chemists have been able to build larger molecules, and biotechnologists have been able to manipulate genes and proteins (hence genetic engineering and protein engineering). Molecular modeling through the use of computers is already firmly established, and more recently the techniques of virtual reality have enabled researchers to don gloves and goggles and actually walk around the image of a molecule and to maneuver two molecules together (molecular docking). (Rheingold, p. 14-15)

Nanomachines that are used for molecular manufacturing can already be found in nature, most prominently RNA and DNA, as well as enzymes which contribute to cell repair and reproduction and to the fabrication of proteins. And we already have man-made molecular machines such as artificial antibiotics which are "programmed" to seek out specific disease organisms and destroy them. The next step will be accomplished when scientists can manipulate the same molecules in different ways by changing inputs or stored instructions. Custom-built molecules which can process information and fabricate or manipulate other molecules can be used to assemble other molecular machines and could replicate themselves, just as in nature. Primitive nanoassemblers could build better assemblers, which could build even better assemblers, which could build a wide variety of products and accomplish a wide variety of tasks, which could alter the way that we live! The idea of molecular entities both reproducing themselves and also behaving as building blocks not only has models in nature but also in computer science. Many of us by now have had some experience with computer viruses which are usually premised on some form of self-replication. Researchers already write computer programs that have only the purpose of writing other, more advanced computer programs. Using tools to build better tools is an ancient tradition.

Nanocomputers might not be products of silicon and solder molecules: naturally occurring molecules can be induced to change state back and forth, acting as a switch, through pulsing laser light or minor electrical charges. Trillions of such molecules, whether natural or synthetic, could form a nanocomputer that would produce unimaginably vast storage and processing capabilities.

Possible use of nano technology:

The environment: Drexler suggests that molecular manufacturing will leave no waste and therefore no pollution. Molecules can be devised which will clean up the toxic wastes and other ground and water pollution produced in the 20th century. Other molecules will be able to consume the excess carbon dioxide in the atmosphere and solve the problem of the greenhouse effect and holes in the ozone layer. Products made through nanotechnological means could be disassembled and therefore recycled. Molecular manufacturing will need to consume little to no natural resources and will use very little energy. Forest land and plains which have been cleared for lumber or for farming and grazing could be quickly restored.

Medicine: Nanorobots could be injected into the bloodstream and consume fatty cells or plaque in the walls of the blood vessels. They could also repair cell damage caused by cancer or AIDS. They could rebuild severed limbs and organs. Nanomedicine could reverse the effects of aging; we would not be able to live forever, but we could live a very long time (though, as Drexler points out, after several decades of bad TV we may long for the peace of the grave). Nanomouthwashes could eliminate gum disease and tooth decay. Nanomachines could act as security guards and attack any foreign entity in the body. And all could be programmed to leave the body through normal elimination when their work is complete.

Manufacturing: Almost any product we now use and many that we have never thought of could be made through molecular manufacturing. Materials would be stronger, more durable, very inexpensive, and could even be "smart" enough to self-repair tears or fraying. Factories with smokestacks would be a thing of the past. Housing, food, clothing, appliances, all would be cheap, abundant, and flawless.

Transportation: Lightweight and fast spacecraft could be made inexpensively, and space travel could be available to anyone. Molecular tunneling machines could rapidly and at low cost create thousands of miles of tunnels underground, paving the way for a national or international subway system with trains which could operate at aircraft or spacecraft speed. Automobiles, for those who still wanted one, would be very cheap, very light, and very safe. They would burn clean, inexpensive fuels very efficiently at high mileage. They could be loaded with all the luxury options anyone could ever want and still be easily affordable.

Computers and information technology: A desktop computer composed of trillions of nanocomputers would possess more power and speed than all of the world`s computers of today put together. Nanocomputers could make possible three-dimensional images so realistic that they could be photographed. The virtual reality technologies of today and the near future would seem primitive compared to those made possible by nanocomputing. Research being done now into ubiquitous computing could lead, through nanocomputers, to a scenario much like we see in the TV series Star Trek and Star Trek: The Next Generation in which one needs only to speak and the computer will respond to requests for information, for changes in temperature and lighting, for food, and so on. Advanced computing problems posed by artificial intelligence and hypertext systems would be easily solvable and in turn would contribute greatly to the easy use of nanocomputers. Cables resembling string could be run anywhere and would enable one to hook into a worldwide data network. Small devices the size of a pocket calculator could readily contain the information and knowledge of every volume in the Library of Congress.

Bio Cybernetics:
Pacemakers and other subcutaneous implanted microprocessors have become common medical technologies, as have prosthetics and reconstructive surgery. If we could implant a cellular neural-net chip in the human brain, our consciousness could, theoretically, jack in and out of virtual realities, transmit and receive thoughts mind-to-mind, no "virtual reality" mediation necessary.

Genetic Engineering is a fact of life today. The goal of the Human Genome Project--slated for completion early in the new millennium--is to map the entire human genetic code. When successfully completed, our knowledge of genetics will increase dramatically and relatively suddenly. We will know exactly what gene and combinations of genes produce which physiological, neurological, and psychological characteristics. Our genetic engineering skills and abilities should increase commensurately. Indeed, genetic engineering may become a branch of another exotechnology.

Nanotechnology would enable genetic engineers to manipulate single atoms to create structures (like molecules or genes) that can in turn be used to create even larger structures (like materials or beings). A Virtual Reality version of such genetic nano-engineering is inherent in Doyne Farmer`s and Chris Langton`s field: Artificial Life.

You can think of a computer in two ways: You can think of a computer as something that runs a program and calculates a number, or you can think of a computer as a kind of logical universe, a digital universe that you can make behave in many different ways. We believe we can put into computers sufficiently complex universes able to support processes that with respect to that universe, would have to be considered alive ... the goal is to abstract what it is to be alive from the material. (Brockman, p.5)