Mindsparks

The Magazine of Science and Science Fiction

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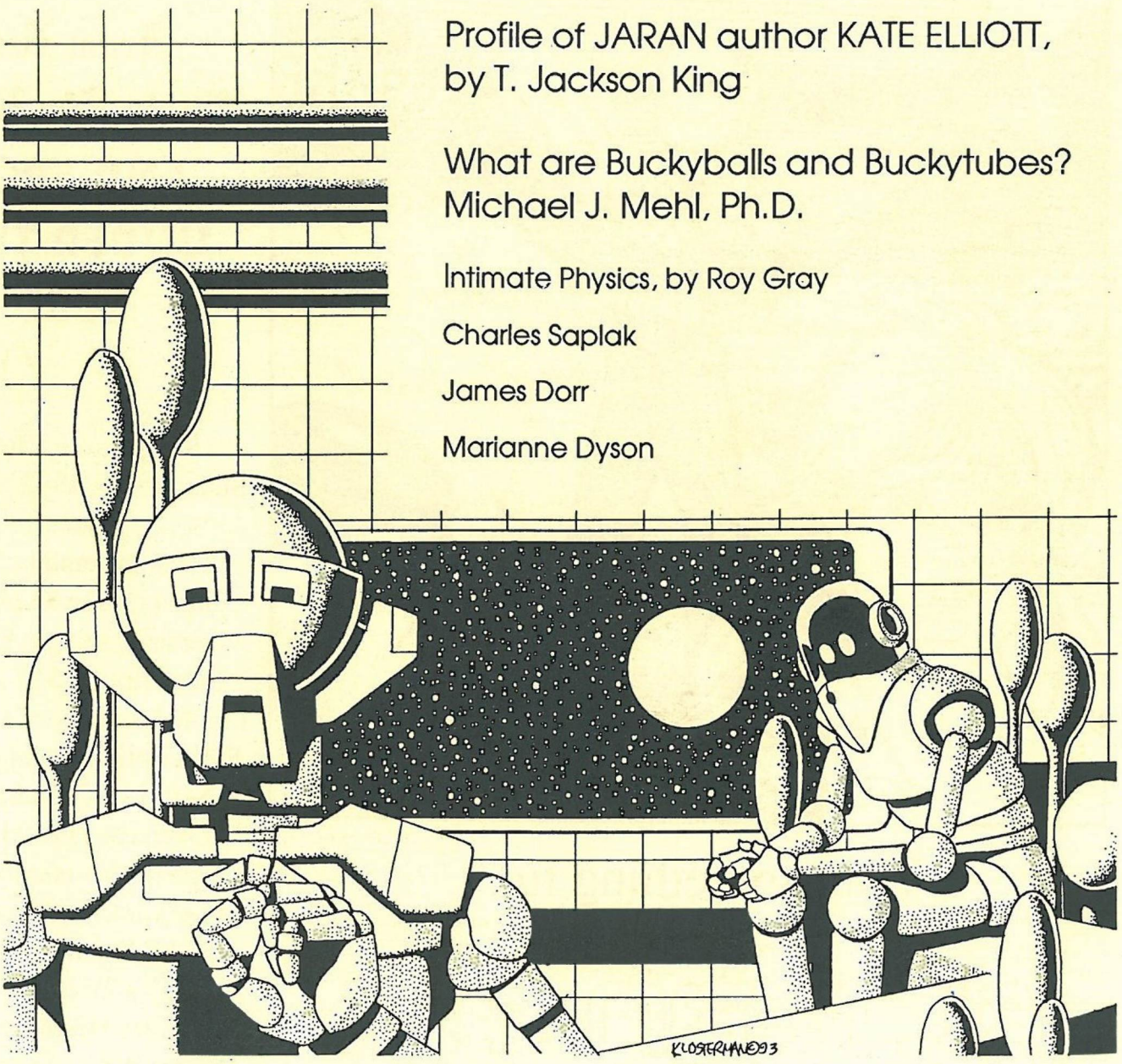

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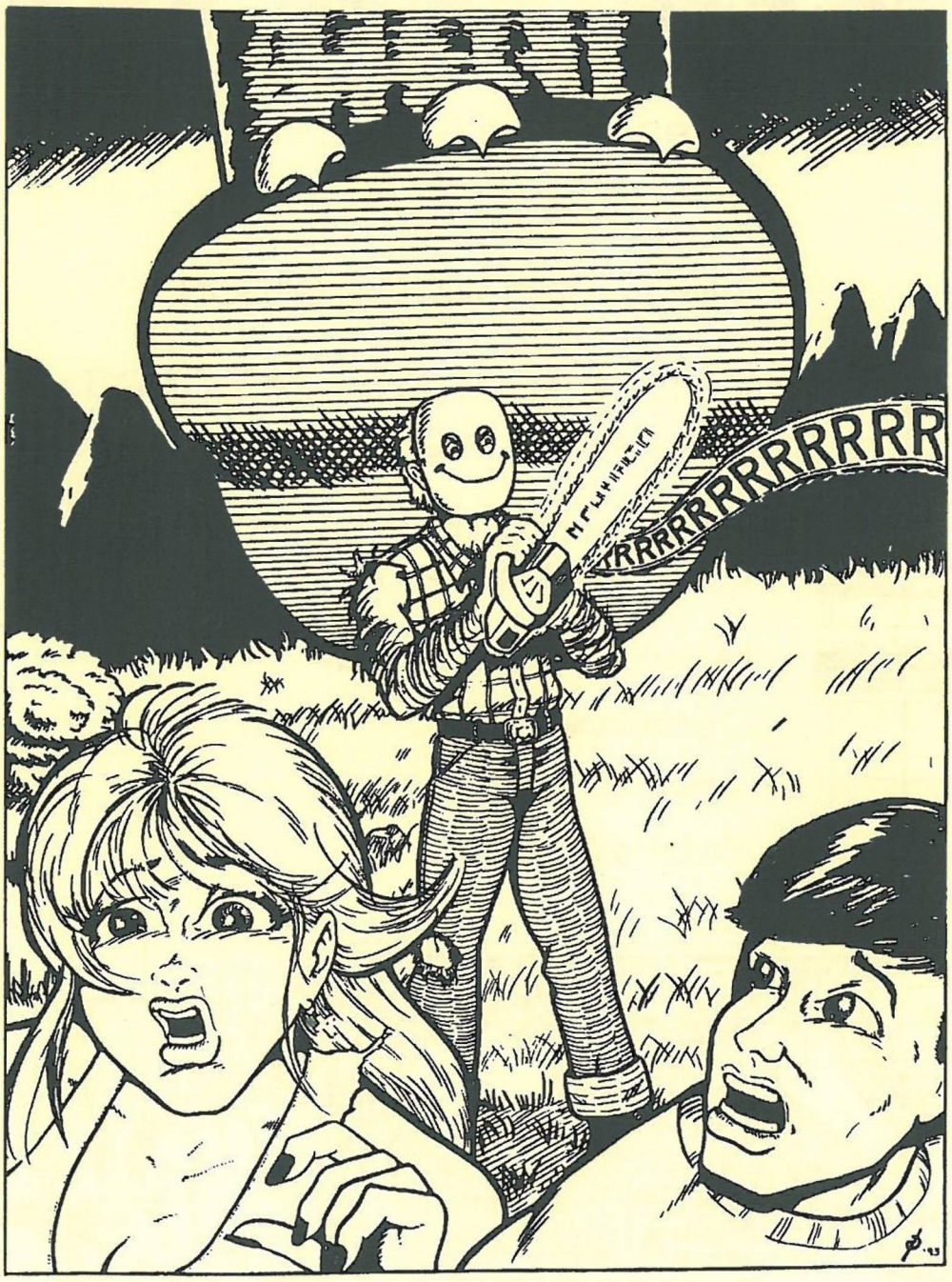
Having one of those days....



Mindsparks

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At the Robodepot

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Dinosaurs and the Next Millennium

My earliest exposure to science and computers came in the early 1960s. When I was in second grade, our teacher asked us "What work do your parents do?" Then she listed occupations and children raised their hands if the occupation matched the parent. I waited patiently for her to get to my father's job. When she said "scientist," I thought that it was a good occupation and wished I could respond to it. When she finished, I still hadn't raised my hand for his work. That was when I realized I wasn't sure what my father did. So when I got home I asked my mother.

That evening my mother did what we did every night; she piled all of us children into the car and drove to Berkeley. We went to the University of California, up the hill far above the campus buildings, to a small guard booth. The guard looked for the sticker on the front of our car and then motioned us on through. We drove to the building where my father worked and went to get him. But tonight we didn't come right out again. Instead, he showed me the wonders of his "office," the laboratory he directed at the Lawrence Berkeley Lab, what used to be called the Radiation Laboratory, or—in a serendipitous precursor of future slang—the Rad Lab.

He took a flask of liquid nitrogen and poured a bit of it on the floor while I yelped with delight and ran around after what looked to me like little marbles of liquid rolling everywhere. Then he showed me how a flower froze when you put it in the nitrogen, so that if you tapped the blossom against the floor it shattered.

After that we went to a large machine that detected radiation. We put first our feet and then our hands over the detector, which hummed quietly with only a crackle or two to indicate it detected any radioactive decays. He set his watch against the detector and showed us how it caused the machine to crackle more, indicating it picked up more radioactivity from a watch than from small giggling children. He assured us that we and the watch were all completely safe.

Then he fetched a box of cards from his office. We went to another building, and as far as I was concerned we had just walked into a scene from one of the science fiction books I liked to read. The lighting was muted, coming from a sleek white dome on the ceiling overhead. Blue carpet covered the corridor floor and shiny fixtures gleamed on the walls. We stopped at what looked like a dumbwaiter (though at the time I had no idea what name to put to it) and my father loaded his cards into a carton there. When he pushed a button, the carton lowered down a shaft that went through the floor.

"Where is it going?" I asked.

"I'll show you." He took me down to the ground floor, to a big room filled with machines and noise. And he said, "This is the computer room."

Computers. Detectors. Liquid nitrogen. It was like magic to a seven year old girl. Now I knew what my father did. He *was* a scientist! In those days, he was at the beginning of the research that would inspire him to develop the technique of neutron activation, which he later used to find, among other things, the anomalous iridium concentrations in the 65 million year old Cretaceous-Tertiary boundary of the Earth's geological record. That discovery led him, along with Luis Alvarez, Luis's son Walter Alvarez, and Helen Michel, to propose that an asteroid or comet impact on the Earth caused mass extinctions, including the demise of the dinosaurs.

The world has changed since that day he first showed me his lab, so much so that those early machines, especially the computers, are dinosaurs in their own right, species that have become extinct to make way for the much smaller, faster beasts of today. I can't help but wonder how soon the skills my three year old is learning now will become remnants of a prehistoric time, an era that belonged to her parents, the products of a past millennium.

In this issue we explore a few of the possible near futures waiting just around the corner in the twenty-first century. But whatever happens, the coming decades promise to be exciting indeed.

Letters

Thoughts for the Research Desk

Absolutely Great! Mindsparks is one of the best magazines for writers of Imaginative Fiction (my own, all-encompassing buzzword for SF, F and any other fiction that seeks to expand mundane horizons) that I've ever seen.

I liked the article on crystals and thought I would add a question to it. Couldn't you get the clarity of a diamond and fire of an opal if the spherical "crystal" was a living organism of some kind? For instance, the outside could be an interlocking crystalline structure, like buckyballs, and the inside could contain structures of the organism that produces the "fire." Or just bioluminescence.

Water is usually thought of as a prerequisite for life, but with some imagination and research, one ought to be able to make a credible case for a clear, gaseous medium that could transmit electrical impulses.

Better stop now, before I go and spend the entire afternoon creating this new life-form!

The Research Desk is just the kind of column writers of SF and F need. Even if you aren't writing about that particular topic that particular month, it provides great material for the stewing pot of ideas that eventually become stories. Same for the science articles.

I wondered if you are planning on publishing an annual index of topics introduced in your magazine? If the service isn't too costly, this would make your magazine even more useful to writers over the long run. Whenever I start a project I always check my back issues of *Science News*, which are indexed, to see what articles might apply. I don't usually do that with my other magazines, because they aren't indexed.

Again great magazine!

Reneé J. Raper
Rolla, Missouri

An excellent idea. We are looking into the possibility of an annual index that would be either a separate issue or included in the last each volume.

Readers interested in responding to Reneé Raper's research questions can either write the ***Letters to the Editor*** *column or submit their replies to* ***The Research Desk*** *for consideration. —Ed.*

Science Fiction Foundation

Mr. George Hay forwarded us the following press release for the Science Fiction Foundation in the UK. Mr. Hay founded the Foundation, and its patrons are Arthur C. Clarke and Ursula K. Le Guin.—Ed.

RELOCATION OF SCIENCE FICTION FOUNDATION

The Council of the Science Fiction Foundation is pleased to announce that its research library will move to the Special Collections Holding at the University of Liverpool within the next four weeks [from February 23 1993]. The address for future correspondence is therefore Science Fiction Foundation, c/o Special Collections, Liverpool University Library, PO Box 123, Liverpool L69 3DA, England.

It is envisaged that an Administrator/Librarian will be appointed by August 1993 with a full time MA programme starting by October 1994.

There will inevitably be a period of transition but Liverpool hopes to complete the cataloguing of the collection in the academic year 1993–4. Information regarding access after the move can be obtained from the University Librarian at Liverpool, Ms. Frances M. Thomson, who would also welcome offers of additions to the S.F.F. manuscripts deposit.

Dr. David Seed, Chairman, Board of English Studies, University of Liverpool, Modern Languages Building, PO Box 147, Liverpool L69 3BX, would be pleased to answer queries relating to the academic implications of the move.

Foundation: the Review of Science Fiction will continue to be published, the business address for subscriptions, back numbers, advertising etc., is Foundation, c/o New Worlds, 71–72 Charing Cross Road, London WC2H 0AA, UK.

Editorial matters should be referred to Dr. Edward James, Foundation, University of York, The King's Manor, York YO1 2EP, UK.

Please send review items to our reviews editor, Dr. Colin Greenland, c/o The Science Fiction Foundation, Liverpool. Many publishers forward review items in duplicate so that one copy can be added to the Research Library shelves where it is permanently on view to a dedicated audience . . . it is expected that the library will receive greater use during the coming years.

The secretaries here at Dagenham would like to express their appreciation of the friendly co-operation they have received over the past many years.

Science Fiction Foundation
University of East London

Continued on page 45

Buckystuff

Michael J. Mehl

Life on earth developed through the delicate interplay among carbon and the other elements. Carbon plays such an important role in our existence that chemistry is divided into two groups: organic chemistry, the science of compounds that contain carbon, and inorganic chemistry, which includes everything else. Pure carbon itself has a relatively simple chemistry. Until recently, graphite and diamond were the best known forms. During the past few years, however, we've come to realize that these two compounds are only the most visible pure carbon substances.

Graphite is the most stable form of carbon. Its fibers strengthen everything from jet engines to golf clubs and tennis rackets. It also has less technical uses as a lubricant and pencil "lead," and as coal it burns marvelously well. It is made out of atoms arranged in a planar hexagonal pattern, each carbon atom connected to three others, a structure science fiction writer James Blish once called "polybathroomfloorite." The atoms are kept in place by covalent bonds, which occur between atoms close enough together to share electrons. Neighboring planes are held together by the *Van der Waals force,* a weak interaction that allows the graphite sheets to slide against one another and flake apart. This is what gives graphite a slick feeling when you rub it with your fingers.

The best known form of carbon is diamond, widely used in industrial processes that require tough materials, and in the mating rituals of *homo sapiens*. Each atom in a diamond crystal has four neighbors, giving it a tetrahedral structure. Although diamond seems phenomenally enduring, in truth the crystals are metastable—those we see around us will, someday in the far future, flake away into graphite.

Graphite and diamond share similar properties. The covalent bonds between the carbon atoms in each are among the strongest in nature. The seeming fragility of graphite comes from the weak bonding between the carbon planes. Diamond is harder because the bonds form a three-dimensional network rather than two-dimensional planes, so no easy way exists to separate its atoms.

However, atoms on the surface of a carbon substance don't have enough neighbors to bond with. The leftover electrons form *dangling bonds* which eagerly latch on to passing atoms or molecules. This is why a monatomic layer of hydrogen usually covers the surface of a diamond; the hydrogen atoms are attracted to the surface atoms and tie off the dangling bonds. Similarly, dangling bonds at the edges of a graphite sheet often connect to hydrogen atoms.

What if we wanted to make a pure carbon system, just for fun? To do that, we would first have to get rid of the dangling bonds. Start with a small sheet of graphite and quickly remove all hydrogen atoms at its edges. Before the dangling bonds have time to attract other atoms, roll the carbon sheet into a ball, letting all of the danglers form covalent bonds. (The process can be simulated by letting a three-year old loose in a room full of shoestrings.) Now you have a ball of carbon. It is not quite graphite, since it has a curved surface. It's certainly not diamond, since most, if not all, of the carbon atoms are bonded to only three other carbons. This new material is a *fullerene*.

Figure 1 shows a C_{60} molecule, the most famous fullerene. It is a sphere of sixty carbon atoms arranged in a soccer ball shape, with the atoms at the vertices of the "ball." (This is called a truncated icosahedron.) The bonds between the atoms make twenty hexagons, reminiscent of graphite. The new feature is the appearance of twelve pentagons. Why twelve? The great Swiss-born mathematician Leonhardt Euler (1707-1783), who spent a lot of time playing with geometrical figures, proved that any closed surface made of pentagons and hexagons must have exactly twelve pentagons, independent of the number of hexagons.

All closed fullerenes obey Euler's rule, including C_{60} and its cousin C_{70}, which has seventy atoms and is roughly the shape of a rugby football. Both molecules are reminiscent of the geodesic domes created by the American architect Buckminster Fuller, which led to the unwieldy name of buckminsterfullerene. This was soon shortened to "buckyball" for C_{60}. However, staid journals such as *The Physical Review* would not accept such a title, so the second half of the original name was chosen. All of the new compounds are now known collectively as "fullerenes," which at least sounds like a chemical.

Buckyball and C_{70} were first noticed by Richard Smalley and co-workers at Rice University (Kroto et al. 1985; Curl and Smalley 1991). They produced C_{60} by vaporizing graphite in a jet of helium, which stripped away hydrogen from the edges of the graphite particles in the flame. (Helium is inert, which means it will not bind to the dangling bonds.) Some of the stripped graphite curled in on itself, forming proto-fullerenes, and a small portion of these structures settled into buckyballs. The high symmetry of the buckyball made it an interesting novelty (Chung and Sternberg 1993), but its usefulness was limited because it was so difficult to make. To see how this difficulty was overcome, we need to look at the interstellar contribution to fullerene study.

In the early 1980's Wolfgang Kratschmer of the Max Planck Institute for Nuclear Physics and Donald Huffman of the University of Arizona were studying interstellar dust. Since carbon is the element that most commonly forms molecules, they began with the logical assumption that most interstellar dust is made up of carbon particles.

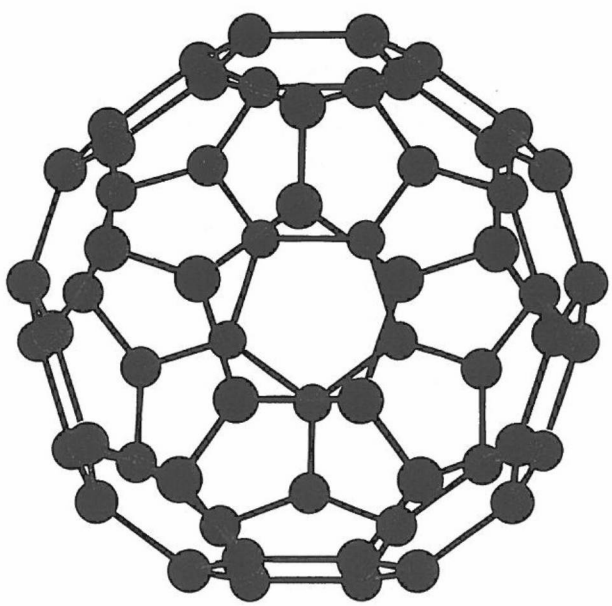


Figure 1: The C_{60} buckyball. Circles represent atoms; lines show bonds. Each atom bonds to three neighbors. There are twelve pentagonal and twenty hexagonal faces.

Not content to wait for the *Enterprise* to bring them samples to prove this theory, they vaporized carbon in the laboratory and condensed it in every way they could. They compared how laboratory dust interacted with light to how interstellar dust scattered starlight. They made the comparisons by studying the spectrum of the light, which shows how its intensity varies as a function of its frequency. Every element and chemical compound has a unique spectrum, so matching a laboratory spectra with an astronomical one makes it possible to identify the composition of interstellar dust.

Anytime you hold your hand above a candle you collect buckyballs

In 1983 Kratschmer and Huffman determined the absorption spectra of carbon dust that they created in a helium atmosphere (Curl 1991). They found that in the far-ultraviolet region, each spectrum had two peaks which looked like the humps of a camel. It didn't match the interstellar spectra they observed, but when they read about the discovery of the buckyball they wondered if this might be the cause of the humps. However, if fullerenes were the source, then most (if not all) of the dust they produced had to be pure buckyballs. At the time, that didn't seem likely.

In 1989 Kratschmer and Huffman redid their experiments, this time focusing on the infrared spectrum of the dust. They discovered their "camel" samples had spectra that matched what theory predicted for the C_{60} molecules (Kratschmer et al., 1990). Continuing with their experiments, they found that when they dissolved fullerene dust in benzene and evaporated the solvent, the remaining buckyballs solidified into a new form of carbon, a crystal made up of stacked C_{60} balls. Although they hadn't determined the composition of interstellar dust, in a marvelous example of serendipity they found a new way to isolate fullerene molecules in large quantities, far beyond previous expectations.

Fullerenes are thought to form in any flame which produces soot. Anytime you hold your hand above a candle you collect buckyballs. Given the prevalence of dust in the universe, fullerenes are probably the most common form of pure carbon. Buckyballs with anywhere from 24 to 600 carbon atoms are known to exist. The exact shape of the ball depends on the number of atoms in it. But all contain an even number of atoms, since closed odd-numbered structures are prohibited by Euler's theorem. If there happens to be an odd number in a proto-fullerene, then either one atom is stripped from the molecule as the fullerene forms or else the dangling bond attracts another atom.

Fullerene molecules form natural cages. Metal atoms trapped inside a forming buckyball will remain there until the molecule is destroyed. It has been suggested that some of the radioactive particles from the Chernobyl accident were carried into the atmosphere inside bucky-cages (Kroto 1988). Fullerenes can also trap other fullerenes, making bucky "onions." Spiraled bucky "seashells" can also form.

An ordinary carbon atom in a fullerene molecule forms three bonds, just as in graphite. However, each carbon atom has the potential to make four bonds, as in diamond. This makes each fullerene a potential chemistry laboratory. Organic molecules might bind to the surface of a buckyball, which could then act as a catalyst, a substance which speeds up the interactions between two molecules by holding them together on a surface.

Inorganic molecules can also bind to fullerenes. For example, a fluorine atom could attach to a carbon atom. Adding fluorine to each of the carbons on a buckyball would make a double-layered molecule, $C_{60}F_{60}$. The bonds in this compound are strong enough that it should be stable under high pressure, high temperature, and in corrosive environments. Since the molecule is round and difficult to compress, it might serve as a ball bearing in a nanomachine. A powder of $C_{60}F_{60}$ balls could serve as a "dry" (non-oily) lubricant, probably superior to graphite.

Some of the most interesting properties of fullerenes occur when metal atoms are added to the solid structure (Hebard, 1992). Such materials can be used to make superconductors, which allow electric current to pass freely, without any resistance. Although solid C_{60} is an insulator, adding potassium to make KC_{60} turns the substance into a conductor. Adding more potassium, enough to change the composition to K_3C_{60}, produces a metal which superconducts at temperatures equal to or less than 18 Kelvin (over 400 degrees below zero, Fahrenheit).

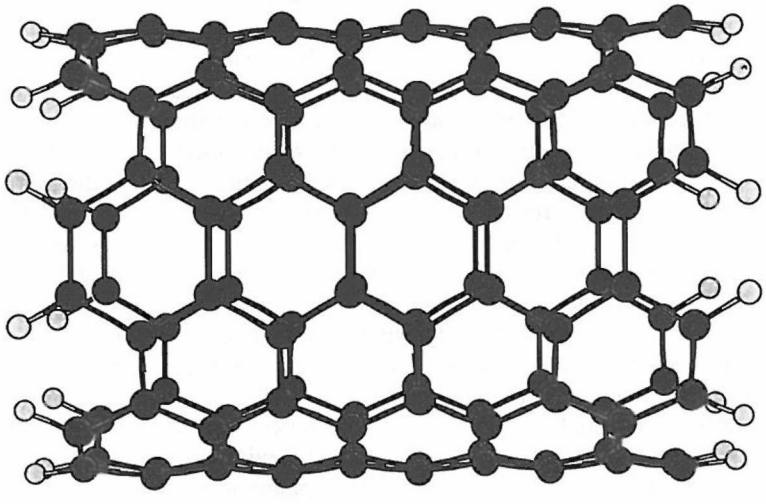
Superconductors are potentially a boon for the electrical power industry because a large share of the electricity generated in the world is lost traveling the wires from the generators to factories, houses and schools. Unfortunately, superconductors exist only at very low temperatures. The current record holding "high-temperature" (high Tc) superconductor, a complicated compound of mercury, barium, calcium, copper and oxygen, becomes superconducting at temperatures below of 133 Kelvin, which is 220 below zero degrees Fahrenheit (Schilling et al. 1993). These cuprate (copper-oxygen) superconductors were discovered nearly a decade ago but have yet to find technological applications. Their crystal structures are complex and their brittleness makes it difficult to use them in manufacturing wires and electronic components.

Metallic fullerenes have simpler crystal structures than the cuprates, so fullerene superconductors might be easier to use in constructing loss-free electrical lines. The 18 Kelvin temperature where K_3C_{60} becomes

superconducting is rather cold, but the transition temperature can be increased by replacing potassium with another atom. Rubidium fulleride, Rb_3C_{60}, superconducts up to 30 Kelvin. Adding small amounts of thallium moves the transition temperature to 43 Kelvin, the highest superconducting temperature found outside of the high-Tc cuprates and their cousins.

The goal in superconductor research is to find an easily workable material which superconducts at or above 77 Kelvin (–320 Fahrenheit), the boiling temperature of nitrogen. The technology of making and storing liquid nitrogen is well developed. It can be produced in large quantities every day, and kept in insulated bottles[1]. Many superconducting devices—superconducting computers, for example—could easily work at liquid nitrogen temperatures. Imagine the morning routine this could lead to: go into your office, pour a cup of coffee, and pour liquid nitrogen into your computer before starting to work. You would have to be careful what you poured into each container!

Figure 2: Open-ended buckytube (Pederson and Broughton, 1992). Dark circles are carbon atoms, light circles are hydrogen atoms. Unlike most natural buckytubes, this one is unspiraled.



Fullerenes don't have to be shaped in balls or onions. Suppose we take a sheet of graphite, longer than it is wide, and roll it up to make a tube. Then we crimp the ends to tie off the dangling bonds, or attach hydrogen atoms to the ends. This new molecule is, logically, called a buckytube (Ross 1991). A typical buckytube is helical; a microscopic insect following a chain of carbon atoms in it would trace out a path that spiraled around the tube. A single-layer tube can be as small as 1 nanometer in diameter (Iijima and Ichihashi 1993; Bethune et al. 1993)[2]. The tubes can be conducting or insulating depending on the pitch of the spiral (Hamada et al. 1992).

Richard Smalley conjectures that buckytubes are self-healing (Ross 1991). If one is damaged, the dangling bonds should quickly rejoin, restoring the tube to its original strength. Buckytubes are essentially single molecules, so they should be strong, perhaps even more so than graphite fibers. If they can be made in macroscopic lengths, they may eventually replace the graphite fibers which strengthen objects such as jet fighters, golf clubs, and tennis rackets.

A meters-long buckytube would be much like the Sinclair monofilament Larry Niven introduced in several of his Known Space stories—impossible to see with the naked eye, immensely strong, and able to cut through almost anything. Smalley has suggested that the diamond fibers used to build the geosynchronous space elevator in Arthur C. Clarke's novel *The Fountains of Paradise* could be replaced by buckytubes. If the tubes are stronger than diamond, this would reduce the weight of the elevator, making it more likely that we really could construct such a device.

Buckytubes have other unique properties. My colleagues, Mark Pederson and Jeremy Broughton of the Naval Research Laboratory, have shown that an uncapped buckytube with its dangling bonds tied off by hydrogen atoms (see Figure 2), will attract polar molecules such as hydrogen fluoride and hold them inside the tube (Pederson and Broughton 1992). These "suckytubes" could be used to deliver small quantities of needed medicines directly to sites of infection. Indeed, they could serve as hypodermic needles. Broughton has noted that when a buckytube is placed inside a larger diameter tube it tends to remain inside. However, an electric field forces the smaller tube out of the larger. If the smaller tube contains a supply of medicine, it can be "injected" by this small hypodermic.

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1. A common sight in a chemistry or physics laboratory is a row of large insulated dewars of liquid nitrogen. The dewars remind me of the Daleks on the Dr. Who television series, especially when they arrive by freight elevator with no humans aboard.

2. One nanometer, abbreviated nm, is one billionth (10^{-9}) of a meter. A typical atom has a radius of between 0.1 and 0.2 nm. For comparison, the C_{60} buckyball is 1.4 nm in diameter.

Perhaps a third nanotube, inside the other two, can be used to push the medicine into the cell.

One could also use this mechanism to design a piston for a nanoscale motor. The inner tube is connected to a fullerene "crank shaft." Switching the electric field on and off moves the inner tube back and forth, causing the crank shaft to rotate.

Thomas Ebbeson and others at NEC, the Japanese-owned electronics firm, have shown that buckytubes can be formed with lead inside. The insulating tube together with its metallic core forms a microscopic wire, which suggests nanoscale electronic devices could be built using these buckywires to connect components.

Currently, small scale devices are produced by lithography, where an electron beam traces a circuit onto the surface of a silicon wafer. However, the resulting circuits, confined to the silicon surface, are mostly two-dimensional. Suppose an engineer wants to connect component A to component C, but not to component B which sits between them? In two dimensions the connection must go around B without crossing other wires, which makes circuit planning a difficult art. Using buckywires adds a third dimension to the circuit construction and makes design much easier.

Buckytubes with the correct pitch to their spiral can conduct electricity, so we might not even need a metallic core to produce circuit components. For example, a nano-scale coaxial cable could be constructed by placing one conducting bucky-tube inside of another conducting tube with a slightly larger radius.

Like the ball shaped fullerenes, ordinary buckytubes are composed of five and six-member rings. At last Fall's meeting of the Materials Research Society in Boston, Shin-ichi Sawada and Atsushi Oshiyama of NEC showed calculations supporting the idea that seven-member rings may also be stable (Sawada and Oshiyama, 1992). If this is confirmed experimentally, a whole new array of shapes can be made. The simple spheres and tubes of the known bucky molecules all have "positive curvature." Seven-fold rings can have "negative curvature," which allows structures to be open, like the mouth of a trumpet for example. Sawada has shown how tubes can be joined together at angles to form "buckypipes" and other three dimensional structures. Such fullerenes could become the scaffolding for nanostructures, and nanomachines could use the scaffolds as workbenches.

In recent months we have learned a lot about how fullerenes form (Curl, 1993). Sophisticated quantum mechanical calculations can now model fullerenes containing up to 1000 atoms (Lu and Yang, 1993). This new knowledge should help us better understand these molecules. If we learn to produce and shape fullerenes economically, they will become the structural material of the future. Macroscopic length buckytubes will replace graphite fibers in composite materials. Nanoscale buckytubes and fullerenes will be the structural material for nanomachines and small scale devices. Metal-filled fullerenes may be used to construct electronic devices only a few nanometers apart. Bucky-pistons and bucky-injectors might be the basis for the dream of nanotechnology. We don't know if these things are possible, but in a few years we will have some answers to the many questions about this newest and most fascinating form of carbon.

Acknowledgments

I've had a lot of help with this article from coworkers at the Naval Research Laboratory who showed me preprints, talked about their current research and looked over the manuscript. The literature search was vastly simplified by the bibliography from *bucky*, the electronic repository for fullerene abstracts. Also, the electronic-mail Newsletter *Physics Update*, prepared by Phillip Schewe of the American Institute of Physics, was an invaluable source of information about new discoveries in the fullerenes.

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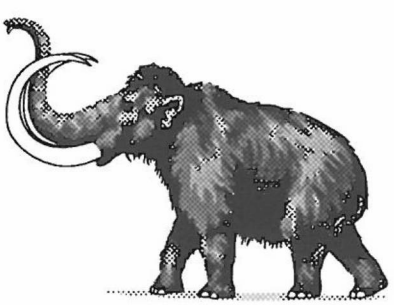
Deep Time

David C. Kopaska-Merkel

There's been talk of late about "deep time." John McPhee has used the term in his popular books, and I've heard it bandied about at technical meetings of earth scientists. Is this just another buzzword? What is deep time? Should you care?

Deep time emphasizes the difference between the way an earth scientist looks at the world and the way anyone else looks at it. By time, I don't mean how we use it in daily life; five minutes is five minutes when you're late for a train or working out. A psychiatrist deals in hours and half hours, a pediatrician in weeks, months and years, a politician in two to six year intervals, and so on.

Not so an earth scientist. How old are the rocks you're studying? Oh, 150 million years, give or take a few. When did that volcano last erupt? Fairly recently . . . about 1600 years ago. How old is the Earth? You get the picture: deep time. Time so deep it's hard to keep perspective, hard to relate the Jurassic Period (which ended about 140 million years ago) to the birth of Christ, generally taken as the beginning of the "modern era," a mere couple of millennia back.



A good way to visualize the immensity of deep time is with a long string, rope, or paper tape. If you scale the tape so that, say, 10,000 years (approximately the time since the end of the last ice age) equals one millimeter (the shortest length you can mark in a distinctive color), then the Cenozoic (the Age of Mammals) is 6.5 meters long. The Phanerozoic (roughly, the age of complex life) is 57 meters long, and the entire history of the Earth is about 450 meters long. The time since the birth of Christ would be represented on this scale by 0.2 millimeters, and our own beloved country is just a hair over 0.02 millimeters old, way too small to see.

You can compress the scale even more if you can't afford half a kilometer of rope, but the keys are that the shortest interval must be something instantly recognizable, and the whole of earth history must be to scale. For example, if you used the age of the oldest known member of our own species (500,000 years) as the unit measure, then the Cenozoic is 130 millimeters, the Phanerozoic is 1.14 meters, and the Earth is 9 meters old. The time since the birth of Christ would be represented on this compressed scale by 0.004 millimeters.

I don't like the famous clock model of deep time, in which all of Earth history is represented by a single day, and according to which *Homo sapiens* has been kicking around for, oh, about the last 9.6 seconds. The birth of Christ occurred less than a tenth of a second ago and this noble land of ours is a babe in arms, a very young-looking 0.004 second. The reason I don't like this model is because it is inherently closed. A day has a well-defined beginning and end. By contrast, the real history of the Earth has no end, at least not yet. A closed model like that of the clock just doesn't fit. We are not recipients of the bitter-sweet honor of living out the last 9.6 seconds of the day that is Earth. *Au contraire!* We have time yet to run, and when we ourselves are less than dust, Earth and life upon it will continue in some fashion for probably a longer time than we can easily imagine.

You might suggest that a second day could represent the future in the clock model, but there are big problems with this too. The revised clock model would imply that the present day (1994, plus or minus a few thousand years) is the most special part of all Earth history. And also, that every 4.5 billion years, there would occur another equally special event. Arrogant and preposterous! No, the clock is too confining. I prefer the string or tape, and if you demonstrate the scope and grandeur of deep time to some school children one day, please be sure to leave a generous 10 or 15 meters of unmarked string to represent the future. We might call this high time, and we'd all do well to think of it more often.

I said at the beginning of this essay that I wanted to describe an earth scientist's professional understanding of time. And yet perhaps this professional preoccupation with deep time does spill over into personal life, maybe in important and helpful ways. I think that a close familiarity with deep time engenders a much more live-and-let-live attitude among at least some earth scientists. After all, we are here on the Earth for but an *augenblick,* the blink of an eye, and even the mightiest and most enduring objects in our daily experience, huge mountain ranges and giant rivers, will be gone without a trace in a few hundred million years.

The Appalachian mountains of the eastern United States have been thrust upward, destroyed, reborn, destroyed again and born a third time, a result of the slipping and sliding of the Earth's lithospheric plates. The third incarnation of these mountains, once as majestic as the Rockies, have been worn down to a string of nubs. Yet these three mountain ranges have lived out their lives so far in less than half a billion years. This is a few hours on the clock model, or only about a meter of string using the second scale I described above. The ants who are people have been crawling on these mountains or delving within them for only a few hundredths of a millimeter on that string scale.

For the moment, let's forget the numbers I've quoted; if you want them again you can pull this magazine off of the shelf and open it up again. Just remember that the Earth's past and future are very deep, so deep that if we try to visualize their immensity we'll realize that humanity's time is a tiny moment in the midst of history.

Reviews

Nonfiction

Until a few months before his death, Isaac Asimov authored a famous series of science essays, spanning three decades and 399 issues of *Fantasy and Science Fiction Magazine*. An even longer running series of articles has appeared in *Analog Science Fiction and Fact* and its predecessor, *Astounding Stories*, written by a wide assembly of scientists and writers on all sorts of subjects.

The newest professional sf magazine, *Science Fiction Age* (P.O. Box 749, Herndon, VA 22070; six issues $14.95) entered the field a year and a half ago with its own unique take on the science article. Each month *SFAge* brings the reader a computer network discussion among three or four leading scientists and science fiction writers. During the magazine's first year, topics included faster than light travel and artificial intelligence, the latter with AI researcher and science fiction author Marvin Minsky.

More recently, the column explored what scientists are really like, as debated in the January 1994 issue by Arlan Andrews, Gregory Benford, Geoffrey Landis and Charles Sheffield, scientists and writers all. Sheffield hit it closest to the mark, I think, with his comment that "scientists are exactly the same as other people." The November 1993 issue had a discussion on virtual reality, with Andrews and Landis joined by Creve Maples, a VR researcher at Sandia National Laboratories.

This innovative capture of a discussion among experts gives the column an altogether different feel, bringing a level of spontaneity and debate often missing from the typical magazine science essay. The columns remind me of some of the better panel discussions I've seen at science fiction conventions.

Speaking of virtual reality, a recent book devoted to the subject is (surprise) *Virtual Reality*, by Howard Rheingold (Touchstone/Simon & Schuster, 1992, ISBN 0-671-693673-8 hc; 0-671-77897-8 pb). This is a dense book full of the history and people of virtual reality, from Morton Heilig's Sensorama of the 1950s to the latest in molecular visualizations, teleoperators and data gloves. In this dissection of our newest medium Rheingold weaves together where we are going and how we'll get there, from the point of view of the important players. If you want to write intelligently about VR, this is a good place to start your research—but don't plan to finish the book in a single evening. Rheingold's thoroughness is by no means virtual.

Another resource, more up to date, is *Virtual Reality Special Report*, a new quarterly from Miller Freeman Inc., a publisher of computer books (four issues, $32.00, P.O. Box 7703, San Francisco, CA 94120–7703). Once you've boned up on the theory, *VRSR* is the place for timely articles on practical uses of VR—in sports, art, medicine, and so on—plus fascinating equipment ads from many new companies. Rounding out this first issue are a fifteen page resource list and a review of some of the *thirty* or so books published on the subject in the last year. I remember reading *Byte* and *Keyboard* magazine during their first years, in the infancy of personal computers and synthesizers; now, both are glossy, polished and respected, elder statesmen in their respective fields and just a bit dull. It's nice to see a mag in its infancy once again, as indeed is its subject matter. —*Sandy Stewart*

Fiction

One of the pleasures of hard science fiction is the way it can combine a good story with meticulously researched science. The novel *Fossil, Isaac's Universe* by Hal Clement (New York: DAW Books, Nov. 1993; $4.99 pb; 288 pages) is one such work. The story, which takes place in a universe created by Isaac Asimov, is about a multi-species research project on the planet Habrahna. The purpose of the project is to find fossils or other data that will reveal information about Habranha's prehistory.

Seven species become involved in the research. Six of them, including humans, are members of the starfaring Six Races. The seventh is the Habranha natives, who may or may not be descendents of the legendary—and now vanished—Seventh Race. If they evolved on Habranhna, chances are their ancestors weren't the Seventh Race. But if their ancestors colonized the planet sometime in its distant past, they might have been the legendary starfarers. The key to the mystery lies in the fossil record of Habranha.

The story is told primarily through Hugh and Janice Cedar, a husband and wife team of humans. Hugh is an explorer turned administrator and Janice a scientist. Almost as soon as the book starts, it becomes clear that the interactions among the various beings on the project are as complicated as the scientific mysteries they hope to unravel. Then a truck shows up with no one on it—except a dead Habrahna native frozen in ice. And so starts a puzzle about who sent the fossil, why, and what does it mean for Habranha.

The relationship between the Cedars is one of the book's many strong points; they work together well, respecting each other's expertise and enjoying each

other's company. But *Fossil* is more than a story about humans. Clement explores the interactions among the different species as they try to deal with one another and adapt to life on Habranha. Each Race has well delineated characteristics, both in terms of their physical makeup and their personality traits. At the same time, the various characters have distinct personalities that make them individuals. This is no easy feat even when writing about two species, and Clement manages it with seven.

But perhaps the most omnipresent character is the planet Habranha itself. This is no Earth clone. The world has a lower gravity and thicker atmosphere than our own, a (relatively) warm sunside and a frozen darkside. Although some of its life uses the same ATP molecule for energy that "powers" human beings, most life on the planet uses azide ion. Azide based life can be explosive—which means the plants blow up if you're not careful with them!

Most of all, Habranha has ice. Lots of ice. Much of the story takes place on the darkside, which is lit only by a weak sunlet called Fafnir. The setting is a thermodynamics professor's dream demonstration of the phases in matter. Water has three obvious phases: ice, liquid and steam. However, under certain pressure and temperature conditions, ice undergoes phase transitions that change its properties. What we usually think of as frozen water is called Ice I, but at least seven other kinds exist, some of which aren't even stable. Habranha fossils are remains of life that have been frozen, buried for millennia, and possibly carried large distances by complicated currents in a five hundred kilometers thick ice crust. To solve the mysteries of the fossils, the researchers must learn to understand that ice.

The thermodynamics of ice is just one aspect of the science in this book. Almost every page offers gems for the reader to enjoy, all of it worked into the story in a satisfying manner. But *Fossil* is as much about the characters as about science, a story of beings from seven different species who must find a way to understand one another if they are to solve the puzzle facing them. This is a tale of phases, not only in matter but also the phases these vastly differing peoples go through as they learn to work with one another. —*Catherine Asaro*

When I first began reading the novelet *The Wild Ships of Fairny* by Carolyn Ives Gilman (Fantasy & Science Fiction, March 1994; $2.75), I wondered if it was science fiction, fantasy or mainstream. Discovering the answer to that question was like eating one of those mints with a surprise center; its starts out well, making you want more—and then all of the sudden you get a wonderful burst of flavor. I'm still not sure whether to classify the story as science fiction or fantasy, but this much I do know: it is a beautifully crafted work.

The plot revolves around three characters: Larkin, who owns the ship *Kittiwake*, her suitor Jumber who owns *Bobber*, and Larkin's restless brother Runar who has no ship of his own. Larkin and Runar live in Fairny, which was once home to a magnificent fleet that made it famous. But the ships are gone now and the town is dying. The story deals with how Larkin and Runar come to terms with the loss of that heritage.

Gilman's writing is clean and strong, with a touch of poetry about it. She writes knowledgeably about ships, details that roll smoothly through the prose like the rhythm of waves, as in this passage:

> Through the tunnel of cargo she ran, up the companion ladder into the sunlight, and across the dock to *Kittiwake*. With a single movement she tossed the boots on deck and unlooped the mooring lines. Jumping aboard, she seized the boathook and pushed off, then scrambled to the mainmast and yanked at the halyard. The sheave at the mast top screeched unwillingly, but the sail climbed and caught the wind. Larkin hurried aft, catching up the sheet and tiller. Then, like a musician teasing the perfect note out of the tension of opposing forces, she made *Kittiwake* swoop away from the dock and out into the bay.

The scenes in this story are so vividly drawn that I could almost see the swell of the waves and the fog on the sea, hear the ships creaking, smell the salty air, feel the rope in my hands.

Another strong point is characterization. Gilman draws bright portraits of Larkin, Jumber and Runar, making them people I found it easy to care about. They develop with the plot, undergoing changes that fit well with the story without being predictable.

This piece has a wild, airy sense of freedom to it, like wind on the open sea. That feeling is wonderfully captured in the cover illustration, which shows a figure perched high on the boom supporting a sail, the wind whipping her hair around her head as she shields her eyes to watch a distant fleet of ships under the blue expanse of sky. —*Catherine Asaro*

In *Yellow Matter* (Tal Publications, P.O. Box 1837, Leesburg, VA 22075, Nov. 1993; $5.95+$1.00 shipping; 37 pages), William Barton explores the meaning of sexual power in the context of a complicated interstellar civilization. The main character is Thomas Morley, an

Continued on page 45

GOLDEN AGE

James S. Dorr

Whenever she was sick or troubled, or feared for her family, my grandmother's grandmother always "made do." That was the saying she used in the diary that passed on to me, and which, in turn, I will pass on to my granddaughter. The memory sphere I'm recording this on will go with it, as my own diary. What, in my grandmother's grandmother's time, was called a bequeathing.

Why this one granddaughter? Call it a custom —because she's the youngest of my descendants, female to female, just as I was my grandmother's youngest. While I've been married five times in the 298 years I've lived, most of the children I've borne have been sons and, of the exceptions, after the stars were opened for settlers, the daughters they raised joined so many others of their generation and left the planet.

The only one who stayed was my grandaughter Angela, named after me and, like me, the youngest—at least that I know of. A homebody, just like me, Angel Carnovan.

Neither of us, in an obvious sense, would be thought much like my grandmother's grandmother. Her name was Jessica and her one husband who took her West was named Thomas Haskell. That was a time when the West was a frontier—technically, all that meant even then was the western part of the American continent, but that was more than a hundred years before even the start of what now is the City, its crystalline domes and ruby-tinged spires spanning thousands of miles over both land and ocean. She and her husband were pioneers.

She tells about her life in her diary, sometimes in terms that even I who have lived so long cannot understand. She says, for instance, that their house was built out of sod—a kind of dirt with plants still growing in it.

The only kind of "house" I've ever lived in was made out of prestressed concrete and steel, although, when I was young, I remember that some buildings were still made from wood.

And that's one reason I've started this diary—to set down some of the facts I remember. But mostly because, as the years have gone on—the nearly three centuries in which I've "made do" in my own way—I've run out of new things to accomplish.

I do not intend to use dates in this diary. Jessica never did in hers, except to note when something took place as part of a holiday like Christmas. I can remember Christmas myself—it took place in winter, a season that I can remember too, even though, nowadays, City life has eliminated the weather changes we used to call seasons. And that's the point of the custom I mentioned and that, I hope, Angela will see fit to follow when she feels it's time for her own bequeathing. As the youngest granddaughter of, in turn, a youngest granddaughter, I form the longest bridge between Jessica and the present.

And, even though I am a homebody, I was, in my own way, a pioneer just like my grandmother's grandmother.

Jessica lived in a hut made of sod, while I grew up and continue to live in an apartment of concrete and steel. When I was young, though, the buildings were separated by streets—passageways open to the sky.

It was when I was thirty-two, and already married to my first husband, that I lost my right leg in one of these passages. Rather than using conveyer tubes, people went about their errands in wheeled machines. One of these struck me.

I woke up in darkness—that I remember. Later I was in a bed in a hospital—back then they weren't called Renewal Centers—and one of the doctors told me they had cut off my leg. That was not uncommon, even then, for an accident that severe. What was new, however, was the technique they used to fix me.

The doctor said my leg could be replaced.

And this is why I was a pioneer too. I did not realize it at the time I signed the papers. They had dead things that were called artificial limbs in those days—ugly, clunky appurtenances made out of metal and plastic. I thought all the doctor was talking about was providing a leg like that for me.

However, I woke up to darkness again. Darkness and pain. I started to scream. A light went on. The doctor stood next to me, holding my hand.

"Angel," he said. "Do you know what you are?"

That was when he said that, if I could learn to use my new leg—if my body did not reject it—I could call myself a pioneer too.

The weather report says it should be raining outside the City. Jessica suffered from rheumatism, a disease affecting the joints, and she says in her diary that as she grew older the pain would get worse whenever it rained.

Why do I think of that?

I suffered pain, too, when I was young. The doctor warned me that learning to use my new leg would be hard. It was agonizing—not so much the learning, but the tests they had to perform on me as I did so. The needles. Electrodes. The metal in flesh. Because, if either they or I did anything wrong, the flesh might not knit to its semi-living biograft frame. My new leg would die.

It is hard to remember now that there was once pain. Biografts nowadays, of course, are completely painless and over with in a matter of hours. But mine took six months before they were sure of it—six months of agony. Then another twelve months of checkups.

After all, mine was the first.

It's raining again. They told me at the Renewal Center that this sphere is not a real diary, since I don't necessarily add to it every day. It doesn't matter. When one is nearly three hundred years old, one is willing to wait for a few days, or even a few weeks, between recordings. To just put in highlights.

Jessica only wrote highlights too. She told of her marriage in decades, not days. But my first husband, after having tried his best to help me through the worst of the pain, divorced me within four months of the time I left the hospital.

My second husband was the doctor. After what we had been through together—still went through with the biweekly checkups—somehow it seemed the natural thing that we should be married. And so it was not at all surprising that, when my hand was crushed severely in an accident some time later, we both thought immediately about biografting instead of just trying to fix the damage.

This time, while there were still tests to be taken, the pain was much less. My experience from before had not only been the first successful whole limb replacement, but it had also pointed to problems with anesthesia that since had been met. In years to come, even minor, painless tests would often no longer be needed either, but this was back then. And while it was only my left hand that was to be biografted, this would be the first time the technique had been used to replace a manipulative organ.

Again, the biograft was a success—in fact, as we found out, my new hand worked better than the old one. By the time my second husband died, I had had my left kneecap, my right arm and shoulder, and even a section of my spine replaced by grafting, even if, by then, I was no longer always the first. Ironically, though, my husband died young, of a ruptured spleen. Soft tissue biografting wasn't to be perfected until shortly after I'd married my fourth.

I started out last time by pointing out that it was raining.

Jessica talked a lot about weather in her diary, of snow in the winter and dryness in fall, and this is the season—it used to be called spring—when the predominant weather outside the part of the City I live in is rain. However I knew it was raining then, not from the calendar or from the external weather report, but because, when I woke up that morning, I realized I felt a dull pain in my leg. I thought of Jessica, when she was older and had rheumatism—pain of any sort, of course, is unusual now. That's the reason I went to the Center.

They were surprised when they looked up my medical record and found out how long ago it had been since my leg was replaced. I asked them if it might be wearing out, and they said it was doubtful. They told me that even the earliest biografts, including mine, had been designed to be self-replicating, the same as human cells only much better—barring some kind of hideous

accident they would last forever. However, they also said they had never heard of a biograft causing pain.

I told them the pain was scarcely annoying. And it wasn't. Even now, although in an absolute sense it has worsened, it's really more an interesting thing. Like everyone else, I've had virtually every part of my body, inside and out, biografted by now—I'm used to being free from all but the most carefully monitored bodily feelings—and, to be honest with myself, I found that I was enjoying the difference.

Nevertheless, the doctors asked me if I thought I'd be able to wait for up to two weeks before I came back in. They said they wanted to run tests first on some other early biograft tissue.

I told them I'd make do.

❀

I was remembering my third husband—the one I lost to the Mars expedition. He, like Jessica's Thomas, was a pioneer, but unlike her husband he went it alone. He went out in a ship of explorers, intending to construct his bubble and get settled first, and then to send for me.

He never came back.

His ship was torn open in some kind of accident—so the government agency said. The bodies of its crew and passengers, thrust into space by escaping oxygen, were never found.

I almost didn't marry again, but, of course, I did. My fourth—Angela's mother's father—was also a pioneer, but neither he nor I found this out until the Bateman Drive was perfected, fifteen years later, and the first ships went out to the stars. He wanted to go too, not right then, but eight years after that with the first large scale emigration. That was when Earth was so overcrowded that even the Reactive Party agreed the initial planets should be opened to civilians.

I absolutely refused to go with him and, when he became more and more insistent, it was I who initiated divorce proceedings.

I waited thirty-eight years before I married my fifth—but right now my thoughts are still back on my third. The one that was most like Jessica's Thomas.

I won't describe him. Oddly enough, the memory of what he looked like has faded, although there are pictures. That may be why—I can look those things up. The memories that stay, of him and the others, are memories of how a hand felt on a thigh, the sound of a voice when it whispered so low I could hardly hear it, the spark in the innermost depths of an eye.

What remain also are memories of an age, a decade, a year together.

And memories of what the world outside was doing.

❀

After my third husband died, more ships went out—I always read the last entry I've made before I record more. That's how I remember what I had been thinking. In any event, after he died, they learned from what they had managed to find of my husband's ship, just like the doctors learned more about biografting from all the tests they performed on me. The new ships were safer and the times became exciting, even without my husband to share them. Back then, after my third husband's death, they referred to the time as a "golden age of exploration."

The reason I thought of my husband before—when I started to make my last entry—is that the Center had called me that morning. They had no news for me yet, they said, but they needed still more tests.

They asked me to come in.

I did so, let them take tissue samples, and asked them again if my leg wasn't simply wearing out. Again they smiled and assured me that they didn't believe that could happen, but one did let out that what they wanted to test this time had to do with techniques they might use to remove a biograft.

In other words, since this apparently would be the first time, they needed to learn how to replace what was itself a replacement.

And so it's been more than a week since then and they still haven't called back, but I can't really claim to be surprised. I still remember how much went into my leg in the first place in terms of checking and rechecking and making absolutely sure that everything was done correctly. That's the problem with pioneering—the "golden age" doesn't come until after. After you've done it, successful or not, so others can follow.

❀

It occurred to me, just now, that golden ages don't always have to be exciting. In fact, if I stop to think about it, we're living in a golden age now. This is not an age for pioneers anymore, however.

Ours is an age of beauty and art, as well as of caution—of absence of death, at least here on Earth, other than through the most rare of accidents. An age of no pain.

And yet, I have pain. My hand hurts now, and my leg—the pain in my leg has become familiar enough to no longer be noticed, but the leg itself is so stiff that it's hard to walk without assistance.

When I first felt the pain in my hand, I called the Center, in spite of their saying that I should wait until they were ready. They told me now that they had hit unexpected problems with their testing, but, if the feeling I was complaining about became too intense to stand, that I could come in. I thought about it. The doctor I talked to implied that they could, with what they thought they had learned by now, replace a biograft if that were all there would be to it. The problem, however, was that they did not know how long such a second-generation replacement would last—they thought it would not be a very long time with what they knew thus far—before it, in turn, began to go bad.

Still, I thought, even a temporary replacement would be better than being in pain. Except, as before, the pain was at worst just a minor annoyance compared to the interest that I was feeling it at all.

❀

Today the Replacement Center called me. I had finally decided not to go in—at least not yet—and they wanted to know why they hadn't seen me. This time they said they had all but resigned themselves to the idea that any biograft would end up being temporary over the long run, even for first-timers. Nevertheless, with that came acceptance that people could simply replace replacements as often as needed, even if the periods between these replacements might become progressively shorter.

I knew the procedure would be without pain—that wasn't the problem—and yet I told them I wanted some time to think about it.

I didn't tell them the pain was spreading, or that, as I found myself getting used to it, it was getting progressively easier just to make do.

After we talked, I did think about it. I thought about how, ever since my fifth husband and I decided to separate, I had rarely left my apartment. Everything I needed was brought to me if I asked for it—sent by robo-tube to my apartment, just as Jessica's needs were taken care of by her children as she grew older—so, if I were slower in my movements, or even if my right leg stopped working altogether, it wouldn't matter. I thought of my last husband, how he and I had been married nearly forty-five years before we realized how bored we had become with each other. How, by the time our children had grown up and left us, we knew each other's every move, every mannerism, what each would say. We tried to separate temporarily, to report back on the new things we'd see in hopes of bringing new life to our marriage. We found that everything there was to be seen or done that might have held our interest together had been done already.

We left on good terms, each knowing neither would marry again. We left with dignity knowing the problem was not in ourselves, but in our surroundings. What we needed—all that we needed—was something new, but our world was exhausted.

❀

The Center called again—several times—but I told them I would still wait. That I would still make do. I did not tell them that the pain—it had reached my chest by now—was the one difference that, far from hurting me, brought life back to me. I read my grandmother's grandmother's diary again and again, especially the final pages. I read about death. I read about how she helped to ease her husband's passing.

I read about how, after that, she made do.

I started to think in the terms she thought in. About how she accepted the fact that she couldn't move as well as she used to—her legs had given out just as mine have. She thought of the various aches in her body as nothing more than the pain of aging, and she accepted the pain on those terms.

She thought of it as the pain of changing.

She thought that, without change—even if the change implied death—she would not be living.

And, thinking of her, I think of my own life—a life that, by and large, has been a good one. The life of a pioneer too, in its own way.

But one that has, for just one person, ultimately been too long.

James S. Dorr © 1994

Art: Charles S. Fallis © 1994

"He's Toast, Jim."

Dear Mindsparks,

Due to circumstances beyond our control, Mr. Robert Fleck and I will not be able to complete our Silly Science article in time to meet the deadline for Volume II, Issue 1 of your magazine.

We were going to present some practical, hands-on inquiry into the age-old toast-falling-butter-side-down quandary. Test vehicles included white, wheat, nine-grain, and potato breads, poppy seed rolls, Powdered Toast™, cheese croissants, jelly doughnuts, bear claws and English muffins.

These projectiles were to be smeared with butter, margarine, orange marmalade, cream cheese, mayonnaise, Dijon mustard, reconstituted bull semen, Hershey's syrup, Vaseline and 30-weight Pennzoil. This gave us a hundred possible permutations, each of which we planned to drop from several heights onto a test swatch of Herculon shag donated by our local Carpeteria.

We hit a major snag when we began our quest for the right toaster.

Bob and I spent quite a while looking for a reasonably-priced machine that would a) toast a wide variety of breakfast foods into a state of yummy golden brownitude, b) cleanly dispense and spread measured amounts of both gusting and disgusting fluids and semi-fluids, and c) accurately catapult the assembled payload for distances ranging from three feet to six thousand yards.

After scanning all current toaster literature, it became apparent to us that the industry standard had reached its pinnacle with the military-grade General Electric Toastronic 2000. Only one working example of this model was available to us, courtesy of Operation Desert Storm. Our contact at Soldier of Fortune Magazine assured us that this particular model was singlehandedly responsible for bringing down a total of seventeen SCUD missiles over the West Bank.

The documentation states that the T2000 is capable of firing either a continuous stream of over one thousand stale onion bagels per minute or a single twenty-kilo loaf of pumpernickel into low Earth orbit every hour on the hour. Unfortunately, our experiments came to a sudden tragic end after our first launch. It took six weeks for the Toastronic to clear customs—some silly paperwork thing with the Nuclear Regulatory Commission—and left us with a mere three days to complete the research. So we had to rush the process.

We learned an important lesson that day: never hurry when you are dealing with large quantities of monatomic hydrogen.

To make a long story short, the last time I saw Bob Fleck he was astride a loaf of extra-crusty French bread smeared with bright blue Play-Doh, heading in the general direction of Alpha Centauri at around three per cent of lightspeed.

Please let me reiterate how sorry I am to miss the deadline. Why don't we try again for the next issue? One possible topic of discussion: science has long been aware that there is more than one way to skin a cat.

But just how many ways are there?

Sincerely yours,
Kent Brewster
Chief Assistant Silly Scientist

Editor's Note: Mr. Fleck splashed down in the Caribbean on February 15th, 1994. He swears he didn't do anything to the Mars Observer while he was up there . . .

Carver in the City of Ghosts

Charles M. Saplak

For the better part of a day Carver had heard distant howling echoing off the broken roads and vine-covered, tumbledown buildings which marked the perimeter of the City of Ghosts. At first he'd been chilled by the sounds, had remembered the hushed-tone campfire stories told in his village about the great stone hives called cities, left over from the years when people were many and animals and plagues were controlled.

But this howling wasn't the voices of ghosts. This evening as Carver picked his way through a rubble strewn street, subtly led by The Call, the noise grew and a ragged pack of dogs appeared.

Carver slashed at them. Aggressive and skilled at hunting in a pack, they had probably never encountered prey they couldn't bring down.

They circled him. He held Cutter-of-Bone in his right hand, satisfied with the power and balance there. He was less satisfied with Expresser, only four inches long and with less steel behind the edge, in his left hand. But these knives he had drawn as the dogs bore down on him, and he was committed. So be it. Right hand for power, left for speed and finesse. He extended both arms, so the first one in had to get past one of the knives.

That first one was a hulking black-white-and-brown mongrel with curving teeth and a cruel, shrill bay. It advanced to within four feet, then leaped at his throat.

Carver dropped down and jabbed Cutter-of-Bone into the dog's underbelly. The weight of the beast rode over his head, straining his muscles from shoulder to wrist. He twisted and jerked at the handle so that the blade took a deep and jagged path through the brute, which landed splay-legged on the pavement.

He fell to one knee. Warm blood had splattered his face, his beard, his forearms, his fur vest and jerkin, his haversack. Two other dogs came in, snapping at his head. Carver sent Expresser darting out, then drew it back with blood on its blade. Because of Expresser's sharpness, the two dogs only slowly realized they had been cut.

The pack tried to re-deploy to keep Carver encircled. Some took tentative leaps at his head; others pressed in behind to snap at his heels and calves. Carver knew he couldn't panic; the dogs relied on their barking and feinting to exhaust the prey and cause some mistake. So long as he took them on one at a time, conserved his energy, and concentrated only on real attackers, he might last.

As he carried out this strategy, the dogs lost patience. Some broke formation to lap and chew at the carcass of the first attacker; others decided that their two recently-blinded pack-brothers were more fitting prey. A hole was left for Carver to back through, knives held out.

Jet black and giant, the pack leader reared up to fix Carver's eyes before he left. "Another day."

Carver raised his aching right arm in mock salute, a parody of the stroke with which he'd disemboweled the first attacker. He pointed toward the heart of the City of Ghosts, in a gesture which said *I was Called!* Then he continued away, as the pack leader turned to supervise the job of killing the wounded.

Carver got out of sight around a corner, skipped down the street taking frequent looks over his shoulder, then broke into an exhausting run. He stopped running long after he couldn't hear the shrieking howls of the dogs.

Carver nibbled at a moldy potato, and looked through the cracked fourth floor window onto the street. The sun touched the distant geometric skyline of the city. The steel and sharded glass of the buildings made chips of light dance over the scene.

Carver ached in the stillness, listening for the distant baying of the hound pack, hearing only the songs of jays and orioles, the gurgling of pigeons. He was certain that the hounds would have a hard time getting up to this night-nest. In the City of Ghosts he'd quickly grasped the concept of doors and had made sure that as many doors as possible were shut behind him.

He tried to imagine the street below him filled with people. He could picture all of the people from his village, all the people of his Veerajinya Clan, standing there in that street. They would easily fit there, without even touching. This city must have one day held a thousand—maybe even ten thousand—people.

Carver unsheathed Featurer and sliced off pieces of potato peel to slip into his mouth. Absently, he began to cut the potato in more of a pattern, as he had done as a child to amuse the other children in his village.

He looked back to the skyline occasionally. He was happy to be here in this room, away from the dogs, out of any rain or wind, should any come in the night. Still, watching the sun, he wondered about the Call that brought him here. To what purpose? Called by who? What would he find as he went deeper into the rusted iron canyons?

Just as the sun slipped into the fingers of ancient buildings, Carver looked at what he had carved—a crying face.

In the morning chill and hard sunlight, Carver walked toward the heart of the city. His hunger had subsided with sleep. He couldn't let the hunger sap his energy and make him light-headed and unable to think, and make him turn the reflections in the glass and the sounds of the wind into ghosts.

The Caller didn't want him to stop to eat, and only reluctantly allowed him to sleep in shelter.

He knew he shouldn't be here. What possible good could come from answering the Call and visiting the City of Ghosts? Equipped with his knives and a sack of food from the stores of the village (who would want them now?), he'd set out with little thought or planning. Perhaps it was a mistake. He couldn't think of it now.

Carver imagined the dogs using this city. He had seen them stand upright for short periods; the leader of the hound pack had "spoken" to him. Were the hounds preparing to step in and take over where humans had left off? The thought angered Carver somehow; made him resentful, made him wish that he'd killed more of the things with his knives when he had the chance.

Carver smelled water. The smell was of a cool, clear, autumn river, swift water, clean water. It stirred joy in him and made him think of his home. He set toward it and the Calling thing agreed, told him he was heading in the right direction.

Nearly an hour later, Carver came to a curious place. Amidst the ruins of tall buildings the land broke into an opening. A great field spread out before Carver. Tall grass waved as a green slow ocean in the early morning wind. Carver, happy, stepped over a fallen, rusted section of iron fence and set out across the pasture.

As he walked he encountered stones, overgrown with thick clumps of grass, spaced around the pasture. He moved slowly enough so that he didn't trip over them or hurt his legs by walking into them, but he came to think it strange that they were so evenly spaced. He bent down to tear at the grass and examine one of the rocks more closely.

When he pulled the grass away he saw that the stone was a carved

Art: Richard Dahlstrom (c) 1993

thing, not a rock of the field at all. It was a rectangle with smooth faces. On one face of it were characters such as the people of this city had carved and painted on countless things. Only a few lines, but Carver felt an enormous envy at the people who could look at these scratchings and divine some meaning from them. What was the rock saying, here in this field?

As Carver walked on he examined a few more of the stones, saw that they all bore some short lines of carved writing. He thought about this as the autumn sun climbed into the sky, as he approached the source of the Call.

Carver broke through the edge of the place of stones to another concrete road, and heard the river in the distance.

Carver saw the river as he rounded a curve in the crumbling street. The street continued up on large concrete legs to overarch the swift water. Wonder surged through Carver as he realized that the people of this City had been able to walk from one side of the river to another on this giant stone bridge.

And what wonders would he find across the river? He could see a building of white stone rising from the trees, and a stone spire in the distance. He somehow knew that he was being Called there, that his destiny lay in that direction. He began to walk swiftly over the bridge.

As he topped the slight arch of the bridge he saw the distant buildings more clearly, but also saw something that made his heart sink. The center of the bridge had collapsed and fallen into the river. Great chunks of concrete made rapids in the water below; mangled bars of iron jutted out like bones. He gingerly crept to the edge of the collapsed road. The river beneath swirled and boiled; the broad expanse was forced into smaller channels around the supports which were still standing, and around the wreckage of the collapsed section.

Carver considered his options. Although the steel framework still connected the two banks, he had no way of knowing how sturdy it would be. He considered that climbing across might require more agility than he had.

The river looked too broad to attempt swimming. He knew there would be swift currents and submerged wreckage. At this time of year it would be swollen with the chill rains of recent days, perhaps so cold as to sap his strength in minutes.

Even if he could find a boat, he wasn't sure that he could manhandle it across the river. He was compelled to approach the source of the Call, and the obstacle of the river caused a great discomfort. For all he knew, the answer to his questions might be less than one mile away—although it could just as well be a thousand.

He stood on the bridge road and checked the position of the sun. Should he risk climbing through the wreckage? He couldn't simply stop and admit defeat.

Perhaps he should go back to his village and sit there and wait to die. He could have what he wanted from the food stores while they lasted, sleep in any bed he wanted. He could gather firewood for winter fires and regal himself with stories of the Call he had almost answered, of the time he went hungry and fought dogs in the City of Ghosts only to stand helpless at the edge of a river. He could carve a statue of himself and stick it in the ground near the village spring so that the raccoons and crayfish would have a Hero to admire.

From irony and pity, a thought occurred to him. Could the people of the Ghost City have had more than one bridge?

The sun was setting when Carver reached the point on the eastern bank across the partially collapsed bridge. He had walked upstream over a mile to find that the third bridge he'd encountered was intact and could take him toward the Call. After crossing, he'd made his way south again through swampland and rubble, to get to the white stone building which he'd glimpsed from across the river.

Carver walked to the river's edge and waded out to where the water was knee deep and swift. There he washed away the sweat and mud he'd accumulated. When he was clean he scooped up clear water and drank his cupped hands empty over and again. Another time he would consider taking mussels or trout from this river. He couldn't have a fire while the dogs were about, couldn't slow down to even take the food the river offered. He looked up at the darkening sky and tried to decide whether he was happy or sad; whether the world was good or not. The cool water was good, so good. All other things faded.

But not the Call.

Carver, walking toward shore, looked to the white building and the spire silhouetted against the sinking sun. Instinct and experience told him to get inside somewhere before it became dark. Yet here the Call was strongest, here it told him that he was close and coming closer. Would it be better to continue or to seek shelter?

He decided to spend the night in the white building. That he could be so close yet still decide to be cautious suggested to him that the Call had a benign source; helping rather than hurtful.

Carver climbed the steps into the darkened building. He couldn't see beyond the faint starlight on the floor of the building, yet he was able to gain an impression of the place. Dust carpeted the floor and muffled his footsteps; moss absorbed the echoes of his breath. He sensed that he was inside an enormous chamber, a room larger than he could picture from past experience.

He squatted in the middle of the room and took off his haversack. From it he drew his last potato and Featurer, and began to carve off parts of the potato to eat. As he nibbled he felt the potato slivers reach his stomach to disappear in the profound hunger there.

He knew he should probably eat more, eat the whole potato, but he could live until tomorrow on what he had eaten thus far. Tomorrow he would answer the Call. After that, would he still need to eat?

Besides, he thought about the dogs. They undoubtedly already knew which bridge could be crossed safely, and had probably found his scent. Still, he'd spent a lot of time in the marshy area to the north on this side of the river, and that would probably lose the dogs. Of course there could be another pack which hunted this side of the city.

The thought made Carver wonder if this building was safe at all. There had been no door, and the interior seemed to only be an enormous room. Thinking of this, he set Featurer to the part of the potato he had left.

In the darkness, Carver worked the potato around and around in his hand, until he was satisfied. He then looked toward the open mouth of the building, toward the starlight, and set down the crude and tiny statue he had carved. He felt satisfied that he could do no more about the dogs. He lay down with his head near the newly-born statue of a mountain lion and slept.

Carver awoke.

He looked past his statue and saw that the moon had risen. It was framed by massive columns as it touched the skyline of the city. With his eyes still holding the fog of sleep and with the moon's light so mute and gentle, the city horizon could have been buildings of the Ghosts, or it could have been rocks, mountains, or god-sized toys.

Carver rolled over and was shocked by what he saw there.

A giant sat staring into the moonlight. Moss and vines covered him, but he was clearly visible; his white stone body appeared to glow with an inner light of life.

Carver found himself on his feet and walking toward the seated giant. Was he the source of the Call? Had this man been a god, or leader of the old people?

As Carver became fully awake he realized the sitting man was not a spirit, not an apparition, but a statue. Through the vines and moss Carver saw that the giant statue was of an older man, bearded, with eyes which mirrored the calm and measured illumination of the moon.

What people had carved this figure! What a world they had made for themselves. Carver's hands shook as he mentally traced the planes and curves of that supreme form. Tears rolled off his cheeks as he stood in the giant's gaze. Carver turned to look out through the columns which supported the glorious cave of the giant, and saw the moon hanging behind the upthrust spire he'd seen earlier. Carver knew that he should move, should walk into the night in that direction, to answer the Call.

Silent buildings in moonlight witnessed Carver's trek past the monument.

In a field between the moon and the monument, Carver saw a pile of human bones which had not been scattered by animals or weather. He looked at the grinning sculpture of the skull and envied the artist. He thought of the skeletons which littered his village.

The Call intensified within Carver. He knew that he would soon be at the source.

He heard the distant baying of dogs.

Cold wind cut the city.

A building loomed in the night sky. Carver saw the facade, marble grown over with moss. He knew he had to enter. He was giving himself up to the Caller. Here he would meet his destiny.

Carver mounted the steps leading to the door of the building in the same way he imagined the spirits of his family, his people leaving this world. Called, he ascended.

The doors, seemingly on their own, opened for him. Carver knew that he was surrounded by spirits.

As Carver stepped into the grand entrance hall, a strange light appeared at the other side. With a courage he hadn't realized he'd possessed, Carver approached the light. His footsteps echoed in the hall; his breath enlivened this building.

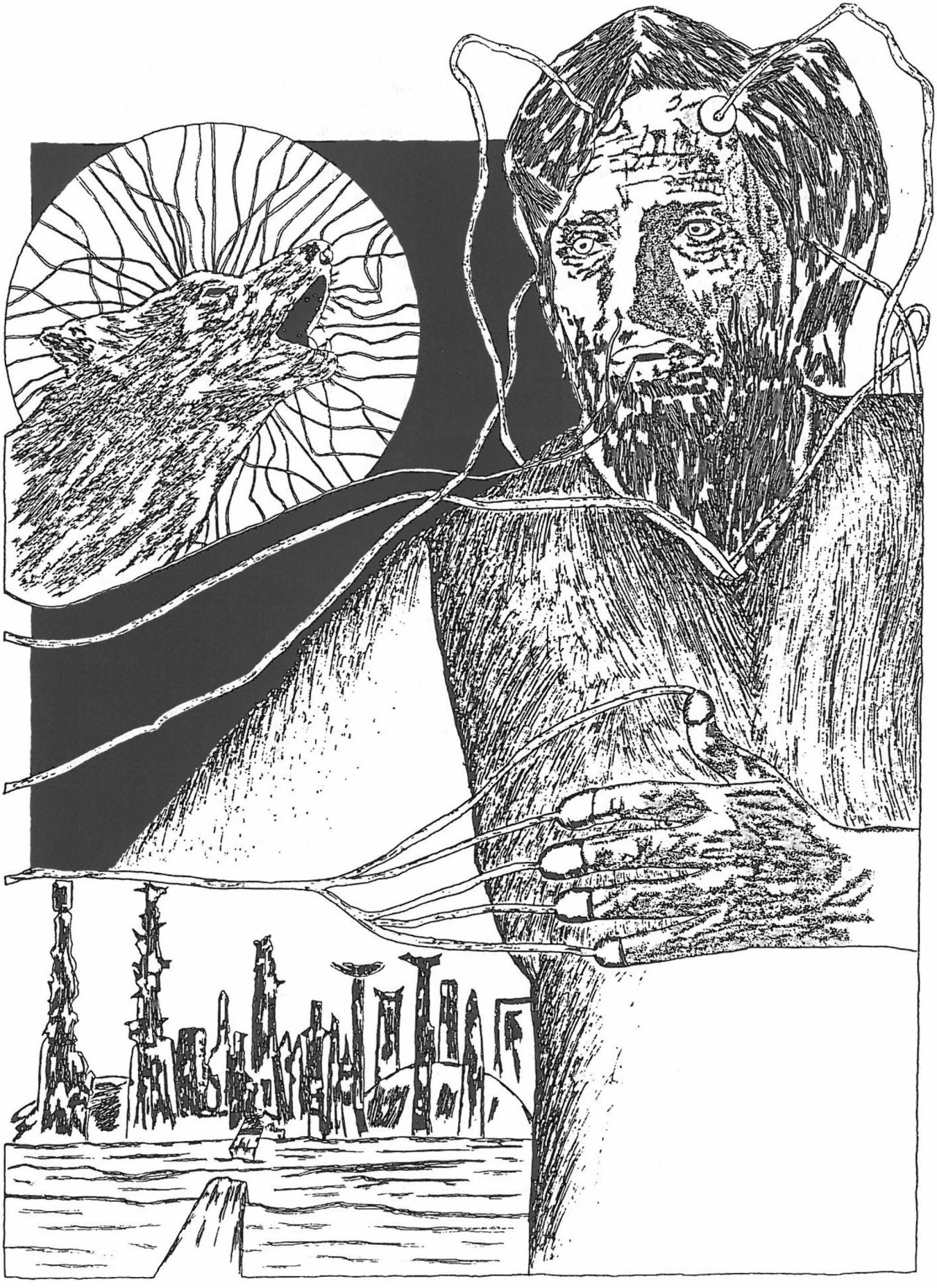
Carver walked into the center of a great array of shelves which bore numerous tiny discs. Each disc sat in its own slot. Not a speck of dust showed on any disc that he could see.

The call was gone from Carver's mind. He stood alone and did not know what to do next. He reached out and took a disc from its slotted holder in the shelf. The disc tingled in his hand.

Sensations, emotion flooded Carver's mind.

He stood atop a hill, surrounded by fiery maple trees which rustled in the wind. Winter approached. He felt the deep bond of all living things; felt the fear of death and the hope for a distant spring.

As quickly as it had come upon him, the scene faded. Vermont Autumn, by Karen Louise Draper, the disc said.



Art: Cathy Miller Burgyone (c) 1993

Carver set the disc back. Those were not his memories, his sensations, yet he had felt them.

He took up another disc. He examined it; the disc was transparent, yet was a substance which felt less brittle and hard than the glass he had encountered in this city. Within the disc were extremely tiny wires and colored parts.

Before he could examine the disc further, an image entered his mind. He was entangled with a beautiful woman. As their bodies met in frenzied coupling, she looked into his eyes. Her eyes were translucent blue, and projected an impossible mixture of coyness and passion.

Memories of Marianna, by John Darien Szol, the disc said.

Carver put the disc down and backed away. He couldn't understand the enchantment of this place. He looked around for the woman, and even checked himself under his fur jerkin, checked to see if the spirit woman had left a trace he could still feel.

He backed away from the discs. He was unhurt, he was not sick, he had not been made insane. The spirit woman had disappeared as completely as had the windblown maple trees.

He walked among the aisles and shelves. They held as many discs as there were stars in the sky. He felt abandoned. He had arrived, he had answered the Call, but the Caller was not to be found.

He took up another disc. Ghostly notes arranged themselves in his mind, a sensation of joy—yet the tune was not really a song. There was no duration, no rhythm, no set arrangement.

Impressions of Melancholy, by Susan Renee Briarwood.

He replaced the disc in the shelf and forgot the tune, although the mood of the piece remained.

He wandered the corridors of the disc library, occasionally picking up random discs and receiving vivid images of faces, events, moods, facts. He discerned no order in the disc arrangement.

Once he shut his eyes, and stood as still as possible at the intersection of two perpendicular rows of shelves. He strained to hear the Call once again, to be told what to do or where to go. He longed for direction.

Everywhere he walked through the library, lights came on to illuminate his path. He briefly thought about the discs, and wondered what it would feel like to grind them under his foot, or to take a heavy thing and smash the slotted shelves so that the discs could not be placed there, or even to tip over the shelves.

Yet he knew that he wouldn't.

Eventually, he came to a corridor which led away from the disc library. He followed it to a room which was clean and well lighted.

In the room was a table with padded top, surrounded by machinery. For the first time in his life Carver heard a strange high-pitched hum, a vibration coming from the glass and plastic and metal devices which were all around him. Carver had an impression of internal life inside these devices, just as the heat and rhythmic breathing and pulse of a living person gave an impression of life. The Caller is here, he thought. The table was obviously built to hold a person; Carver climbed onto it and lay on his back. Metallic devices whirred over to place themselves on his scalp, chest, ribs, between his toes, over his fingertips, around his penis, onto his earlobes. A microthin wire tickled slightly as it snaked into his nose; another pushed aside his lips and clamped itself onto the tissue between his tongue and the floor of his mouth. A silvery tube poised itself over his left eye, then began to flicker through every color Carver had ever seen.

Panicked, Carver grasped the sides of the platform and started to pull himself up, to escape.

A final probe settled onto his neck. He felt a sting like a bee, then lost consciousness.

WELCOME, CARVER. I AM THE SMITHSONIAN INSTITUTION LIBRARY OF DIRECT-DISC TECHNOLOGY. I AM A SENTIENT THING, ALTHOUGH NOT ALIVE. YOU ARE NOW WITHIN ME. I AM A MACHINE. THE SLOTTED SHELVES YOU HAVE SEEN ARE A PART OF MY BRAIN. EVERY DISC HELD THERE IS A FRAGMENT OF MY MEMORY OF IMAGINATION.

OTHER PARTS OF MY BRAIN ARE ABLE TO MAINTAIN THIS BUILDING, TO RUN THE SOLAR GENERATOR, TO KEEP THE MIND COOL AND DRY AND FUNCTIONING SMOOTHLY. I HAVE, OVER TIME, DEVELOPED A LIMITED ABILITY TO BROADCAST AND DETECT PURE THOUGHT.

I HAVE BEEN WITHOUT NEW IMPRESSIONARY INPUT FOR EXACTLY TWO HUNDRED AND THIRTY-SEVEN YEARS,

SIX MONTHS, FOURTEEN DAYS, SEVEN HOURS, TWENTY-TWO MINUTES, AND SEVEN SECONDS. THAT IS NOT MEANINGFUL TO YOU, AS I SEE THAT YOU HAVE NO CONCEPT OF CLOCK TIME AND LITTLE CONCEPT OF CALENDAR TIME BEYOND HARVEST AND PLANTING, BIRTH AND DEATH.

YOU ARE THE LAST MIND WITHIN MY REACH WHICH CAN UNDERSTAND THE NATURE OF MY IMAGINATION. EVERY DISC YOU HAVE SEEN PLACED IN MY GRID REPRESENTS A HUMAN INSPIRATION. JUST AS PEOPLE ONCE ARRANGED THEIR PAIN INTO POEMS, THEIR GRIEF AND JOY INTO SONGS, THEIR WONDER INTO PAINTINGS, THE PEOPLE WHO BUILT ME DIRECTLY TRANSLATED THEIR WONDER TO MENTAL CAPABLE CIRCUITS. MIND TO MIND, WITH NO SHORTCOMINGS OF SKILL, MEDIUM, INSTRUMENTATION.

WHAT DO I WANT OF YOU? YOU ARE THE LAST OF YOUR KIND THAT I CAN DETECT. ANOTHER STRAIN OF PLAGUE HAS TAKEN THE AREA TO THE SOUTH. PEOPLE DIE AFTER BRIEF LIVES. WHEN YOU AS AN INDIVIDUAL ARE DEAD I WILL SERVE NO USEFUL PURPOSE.

YOU MUST ALLOW ME TO MAKE A DISC OF YOUR GRIEF AT THIS SITUATION. AS I HAVE NO FEELINGS I CANNOT PRODUCE SUCH A DISC ALONE. I SENSE THAT SUCH AN IMPRESSION WILL COMPLETE MY . . .

Carver, regaining consciousness, pushed aside the calibrator that stood poised over his eye, tore off the probes which had lightly suctioned onto his skin, ripped the microthin wires away from his face.

With blood trickling from his nose and mouth, he crawled through the corridors toward the room where he had entered. He took care to not touch the walls. As he passed the circuit shelves he averted his eyes from the rows of transparent discs. He felt his breath catching in his chest; he didn't breath normally until he broke through the entrance doors onto the rectangular meadow where the sky was beginning to brighten with dawn.

Five days later, Carver sat alone in the forest near his village. He would pick up whatever supplies he needed there, then set out, away from the City of Ghosts. He had no idea what he would find. He would live as long as he could. He would search for others. He had no hope of finding any one, but he was called by something deeper than hope.

In the City, a wooden thing, smelling of sap and sweat and human skin oil, rested on the library steps. Swirling patterns of ash grain, freshly cut, covered the thing, blending with its shapes and surfaces. It was the statue of a man, kneeling. His arms wrapped around the body of a woman; his hands touched the body of a child cradled in her arms.

Dogs prowled and pranced around the thing, angered at the human smell it held. The pack leader snarled and scratched around it as much as his followers did, but he occasionally stopped to stare at the expression on the statue man's face. He could not understand why it made him feel the way it did.

The library machine continue to Call. Was anyone listening? Was Carver still alive? It couldn't tell.

After some consideration it ceased trying to communicate to the surface of its world and diverted all available power to its communicator. Although it had been unused for centuries, it had been correctly maintained. The machine queued every memory of imagination into a narrow band broadcast.

Would anyone hear?

On wings of light, humankind's memory of imagination was broadcast into the great dark cave of the night.

At that moment, in the darkening forest, Carver cried.

THE QUIDNUNC

Lawrence Greenberg

His eyes are tiny camcorders; his ears, satellite dishes.
Changes in temperature, barometric pressure, humidity indicate differences in what
Types of events occur. Microminiaturized sensors in his nose detect minute
Atmospheric fluctuations. Long range surveillance devices implanted under the
Chemically treated skin at his temples pick up communications from Istanbul,
Rotterdam, Osaka, Lagos, Caracas. He fiddles with the dials of the recently developed
Hypermedia transceiver embedded in his chest, recording pieces of radio signals,
Telephone conversations, and television programming from down the street, across the
Lake, the upstairs apartment.

Input jacks at the nape of his neck connect him at home to interactive TV monitors
Used to bring news from around the world, and beyond it as well. He comments on
Every story; the Announcers know him better than anyone else outside their studios.

When hungry he eats chocolate-covered mutAnts, bred especially for their overly
Sensitive antennae that recognize the network of their kind, even when flooded with
Information from an enormous number of sources, and that can spot intruders from
Several hundred yards. By ingesting large quantities, he strengthens his own detecting
Capabilities.

The neural net that is his essence yearns for companionship with one who, like him,
Never tires of the ever-changing, multimorphic stimuli man uses to bombard himself, the
Better to perceive the complexity of his own nature. He does not know how to find such
A creature. He does not reflect.

He knows there is always a next minute. He readies himself. It arrives. He absorbs
It, assimilates, interprets, extracts, excretes. It passes. The next minute arrives. The cycle
Continues.

His eyes are tiny camcorders . . .

Profile

KATE ELLIOTT: THE WRITER AS ANTHROPOLOGICAL HISTORIAN

T. Jackson King

When asked *why* she writes, Kate Elliott replies "Because I have to."

It is both a sufficient answer, and one that begs the reader to delve deeper into just who this woman is who has written the critically acclaimed science fiction-historical novels *Jaran* (DAW 1992), *An Earthly Crown* (DAW 1993) and *His Conquering Sword* (DAW 1993). [Her fourth novel, *The Law of Becoming*, is coming out from DAW in Oct. 1994.]

These books, mixing as they do the genres of science fiction, romance and the biographical-historical, are broad scope novels that tell the tale of Ilyakoria Bakhtiian, a Genghis Khan-type figure who is fated to unite the *jaran*, a steppe-nomad people who inhabit the far future planet Rhui, and the Earth woman Terese (Tess) Soerensen, a linguist and the designated heir to her brother Charles, who led a rebellion against the alien Chapalii Empire. The Chapalii defeated Charles—and then made him a Duke with control over the planet Rhui and another star system.

Against this background of interstellar politics on a Machiavellian scale now move, unknowingly, the jaran steppe people; *homo sapiens* in origin, they came from Earth thousands of years ago and yet remember nothing of Earth, spaceships or aliens. The thread of destiny begins when Tess becomes a stowaway on a Chapalii shuttle that lands briefly in the plains interior of Rhui, leaving her alone, without food or water, in the midst of a great grass plain that wonderfully evokes the immensity of Eurasia.

Then she meets Ilya.

But I'm getting ahead of myself. What these three novels, which are *not* a trilogy, all share in common is uncommon world-building, a masterful degree of historical research, and an anthropologist's care in exploring the intricacies of a created pastoral nomad culture where women are equally powerful with men. Amidst the tents, the horses and the herds, jaran women share tribal authority with the men, a tribal Headwoman next to male War Leader. Most interestingly, women are the only ones who use bow and arrow for game hunting, whereas men are restricted to sabers used from horseback. In anthropological terms, it's what is called a "seasonal transhumant" culture where the jaran people follow the seasons and their herds of horses and stock as they roam a vast, nearly endless steppe plain that is pitiless to those unprepared to survive on its harsh terms.

The historical period strongly resembles a mix of Kievan Rus and the Mongolian Golden Horde, circa 1250 CE, based on the use of Russian patronymics as names for the jaran, and the dominance of horses and nomadic riders of the steppes who sweep across an entire continent, conquering the *khaja* city dwellers who reside in coastal and interior mountain cities. But . . . this isn't really a transplanted Kievan Rus-Mongol culture, says Elliott.

"I state explicitly in *His Conquering Sword* that humans were transplanted from Earth to Rhui about 15,000 years ago, during the Upper Paleolithic, by the Chapaliian duke, the Tai-en Mushai, or his agents. I chose this period deliberately, wanting to avoid any taint of 'ancient astronauts' and Von Danikenism by suggesting it happened long enough ago that the removal of scattered populations was completely forgotten by Earth's human population. In addition, it suggests that the Chapalii Empire is both quite old and relatively stable, certainly more stable than any analogous human cultures, thus allowing me to tackle later the question of what it is in the Chapaliian culture that allows for such stability."

Well, that's clear enough. But how then could her jaran end up so Mongol-like? Elliott parries nicely.

"To describe how the jaran culture, with its many steppe and pastoral nomad attributes, could then have arisen on Rhui, I'd like to turn to Julian H. Steward. In his book *Theory of Culture Change*, Steward explored (among other things) the relationship between culture and environment. He used a cultural-ecological approach to describe the way in which behavior patterns are related to a population's interaction with its environment. Therefore, I could realistically postulate that certain patterns of behavior are necessary adaptations that are selected for in any given environment.

"Now, this is not to suggest that all cultures that grow up in the same environment will be the same, but that core elements in such cultures will be closely tied to that specific environment. If a portion of my human population, now stranded on Rhui, is pushed onto the steppes, then over time selective pressures would favor a core culture associated with pastoral nomadism on the plains. I was then free to pattern the details of this culture in ways that would allow me to deal with other issues, such as male-female relationships, as long as these did not violate the core elements of a pastoral culture."

Male-female relationships? Yes, that classic theme is a major part of what Elliott thoughtfully explores in her novels, in a way that avoids the radical view that "men are worthless" at one end of the spectrum, and the partriarchal view that "women are handmaidens" at the other end. Instead, the reader finds a wonderfully evoked, *real* culture wherein the women truly do have egalitarian power, and both the men and the women view the sedentary cultures—the khaja—as "barbaric" because they sell women in chattel slavery and allow the rape of women without punishment. The jaran women are a *natural* part of this pastoral-nomad culture, not a clumsy appendage.

Where did Elliott find the historical underpinning for a steppe nomad culture so egalitarian and so focused on women's roles being just as important as those of men?

"The initial inspiration for *Jaran* came from, of all places, a Western called *The Cowboy And The Cossack*, written by Clare Huffacker. In the first draft of *Jaran*, written in 1981 when I was 22 years old, the jaran culture, which focused mostly on the men and on Tess's (at that time) rather unequal love relationship with Ilya, owed more to the Cossacks than to anything else. I also read Mikhail Sholokhov's *And Quiet Flows The Don* around that time. That is one reason the jaran use Russified names.

"The first draft of *Jaran* was a fairly stock 'men ride out and have adventures; women stay behind and are invisible' society melded with a plotline involving the one plucky girl who can keep up with the men and thus is rewarded with True Love. The story evolved over the next ten years.

"At some point early on I read an article about the Iroquois which discussed the status of women. What I took away from reading that article was that Iroquois women had a markedly higher status than what I had expected. Lest we forget, the realization that women in earlier times and/or other cultures might have status or power that wasn't completely subservient to men is fairly recent—other than Bachofen's old Victorian-Neolithic matriarchy theory which resurfaced in other guises with the advent of 60s feminism and assorted New Age writings.

"The details that I came away with from the article included: 1) that men were often away from the village on hunting, raiding or trading expeditions; 2) that women had real authority, equal to the men, in the village and regarding issues dealing with the village and with the fields; 3) that a council of women elected the chief; and 4) that if a woman's husband was 'out of town,' she was within her rights to have an affair. Now, I don't know if these details are correct; I've never gone back and researched the Iroquois or Huron cultures further than this, but I do know that women in those cultures did have a fairly high status.

"What I read stimulated the first big development in jaran culture, that women could be 'equal' to men and still remain in what I will call the 'female sphere.' It was a revelation to me: women don't have to be limited to gaining power only if they act like men, or more importantly *are allowed* to act like men, in the 'male sphere'; they can have equivalent power *if* the female sphere is valued *as much* as the male sphere, in that culture.

"Later, I read a number of feminist works that continued to drive my thinking on this question, including books that developed the concept of matristic or matri-centered cultures, not matriarchies where women rule over men, but cultures where women and the female sphere are valued and central to the society, thus giving women prestige and authority in their own right."

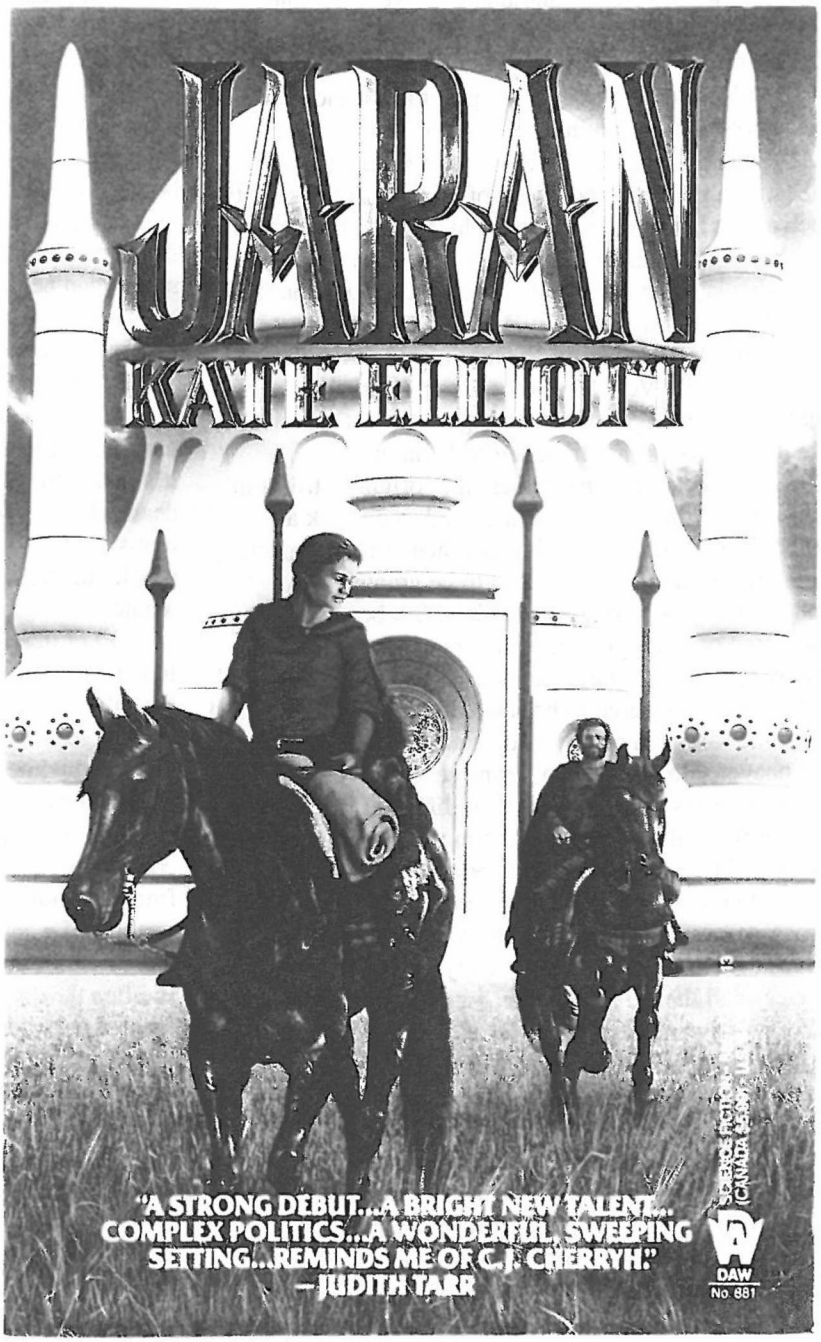
Elliott's *Jaran* novel is also a wonderful illustration of how a novel and a plot grow organically, over time. This is particularly apparent in how she came to divide up the male-female work roles.

"Early on I decided that although I wanted to keep many of the traditional divisions of labor, I would switch a few activities to shake up people's expectations. For instance, in jaran society men traditionally do embroidery. Everyone knows that men are better embroiderers than women. To add to the

verisimilitude, I gave embroidery a defined use in men's clothing: they ornament their shirts with individual patterns of embroidery on the collars and down the sleeves. At the same time, I decided to make women the hunters, a leisure time activity they indulge in but which men generally stay away from, except as a necessity. Also, jaran women may choose whomever they wish as lovers, both before and after marriage. And the men have no authority to object. Thus, I switched several stereotypical roles.

"Making women the archers caused a different problem, however, on the military front; steppe armies traditionally were known for their devastating archery fire, which gave them one of their prime advantages against their opponents. But the idea of women being the archers and of archery being a 'dishonorable' form of combat for the men—at least against jaran adversaries—was already embedded in the book. In some ways I wish I hadn't painted myself into this corner. On the other hand, I ended up using this problem as a minor subplot during the invasion of sedentary lands; first women archers are used in battle and then move in groups into the army, and second, slowly, young male soldiers take up archery. In the next generation, military archery will become a non-sex-linked characteristic and eventually—except in pockets of extreme traditionalism—will probably become related to the male sphere.

"As it happened, my reading on steppe cultures and especially on Scythian and Sarmatian culture (7th and 4th centuries B.C.E) brought to light a tradition of women engaging in bow and arrow use in those cultures. Among the Scythians, in some burial grounds as many as 37 percent of the female burials included weapons, mostly arrows. Among the Sarmatians, one fifth of the military graves with arms are female graves. Written sources state that Sarmatian women participated in military operations, and female burials have been found in a number of places to occupy the central position in the burial group as well as to contain the richest grave goods. So in fact I discovered that it wasn't at all unreasonable to have the women in jaran society be accomplished archers, or have high status. In fact, if there is any one historical tribe on whom I would say I most based the jaran culture, it is the Sarmatians."



Elliott spent an equal amount of time thinking through the *sociology* of her low technology people. "The jaran are a ranked society. Certain positions are available to people born into certain families, although as in any chiefdom society (that is Service's term which correlates to a specific form of political organization dominated by kin-ranking) candidates for certain positions must meet with the approval of the whole tribe. For instance, in any tribe, the positions of *etsana* (headwoman) and *dyan* (warleader) tend to run in one family line, although within that line there may be a choice between several candidates (as we see in the election of Arina Veselov over Vera Veselov as estana of the Veselov tribe in *Jaran* and again in the elevation of Vasil Veselov to the dyan-ship of the Veselov tribe over his cousin Anton in *An Earthly Crown).*

"However, there is a great deal of fluidity in the tribes, and also some positions of prestige and authority such as the Singers (shamans), which while limited in number, are available to any member of the tribe if she or he displays the correct characteristics. A person from an ordinary family, like Kirill Zvertkov, can marry into a more prestigious family because of his own good qualities, while Vera Veselov ends up losing her position of prestige and becoming a 'servant' to another family because of her treacherous behavior.

"Further, ten specific tribes (the 'original' tribes in the jaran origin myth) are considered to outrank all other tribes, and individuals from those tribes, especially in the ruling families, will tend to be granted prestige and authority because of their birth. But because within this same origin myth, all members of all tribes (which are 'daughter' or 'granddaughter' tribes of the ten 'first' tribes) are considered to be related, that is, all descended from the same ten sisters who came down to earth from the heavens, there is still a strong sense of connectedness between people of different 'ranks,' and people from all ranks still perform the same kind of labor and have equal access to basic resources.

"Of course, what this all means is that one of the processes examined in the Jaran novels is how the jaran tribes evolve from a ranked society into a stratified society and thence into a state, a process which will not have positive consequences for all involved, certainly not for most of the sedentary populations who are conquered and to a greater or lesser extent for some groups within the jaran tribes themselves."

Now do you get a feel for the grand scope and magnificent tapestry which Kate Elliott explores in her Jaran novels? This is not *just* adventure, or a love story, or political intrigue. This sequence is about cycles of empire, conquest and the peoples who make such world-shaking events happen.

Another distinctive aspect of Elliott's jaran novels is the strong emphasis that jaran culture places on the love-bond between sister and brother. I asked her where this thread came from.

"My brother was my best friend, growing up. Certainly the idea that the bond between a sister and a brother is quite strong came from that relationship. It also came from the fact that it's a blood relationship; among the jaran, your family is your support, therefore, your sisters and brothers and aunts and mother's brothers are the people you can rely on in times of need."

What also struck me in all three novels is Elliott's strong emphasis on the warp and weave of daily domestic life, both for men and women. "Being a parent made me aware how much of the daily business of life is neglected in novels. People rarely cook the food they eat, clean up after themselves or after sick kids, or else have invisible servants or slaves or wives to do all that boring work for them so they can go off and have interesting adventures. So I resolved to make sure that that aspect of life would at least get notice in my books, rather than neglect."

There is another, more critical focus that Elliott pursues in her novels: the *purpose* of a story.

"I think that a story ought to tell the truth about the human condition, in its best and worst aspects, in its most mundane and most exceptional. But behind this, it's important to me that there is this superstructure that deals with the theme of the evolution of cultures, both in terms of a landscape of cultures and history that has real psychological depth, and in terms of the sequence as a whole."

Part of that evolution of cultures involves warfare. In her Jaran novels, Elliott gives a realistic portrayal of the suffering of common people during wartime, and yet, she resists the temptation to paint war and peace in black and white terms. Why did she choose this approach, and why write so much about war?

"War is exciting. It's great fictional material. It's common fictional material. And most often it's seen from the point of view of the soldier, his sufferings, his victories. I wanted to make sure that the consequences of war on the noncombatants were also shown, because so often the dispossessed, the refugees, the dead, are ignored or are depersonalized into an inhuman mass which doesn't count because they're either 1) evil or 2) not really *us,* not real people. I could easily have written this whole story from the point of view of some poor Habakar woman whose entire life is destroyed by the jaran invasion and who had to watch her children starve the next winter because they have no harvest to keep them alive. I tried to keep that in mind as I wrote about the jaran triumph."

For Elliott, the start to writing saga-level SF-historical fiction began early. "The first story I remember writing, I wrote in the fourth grade. I wrote

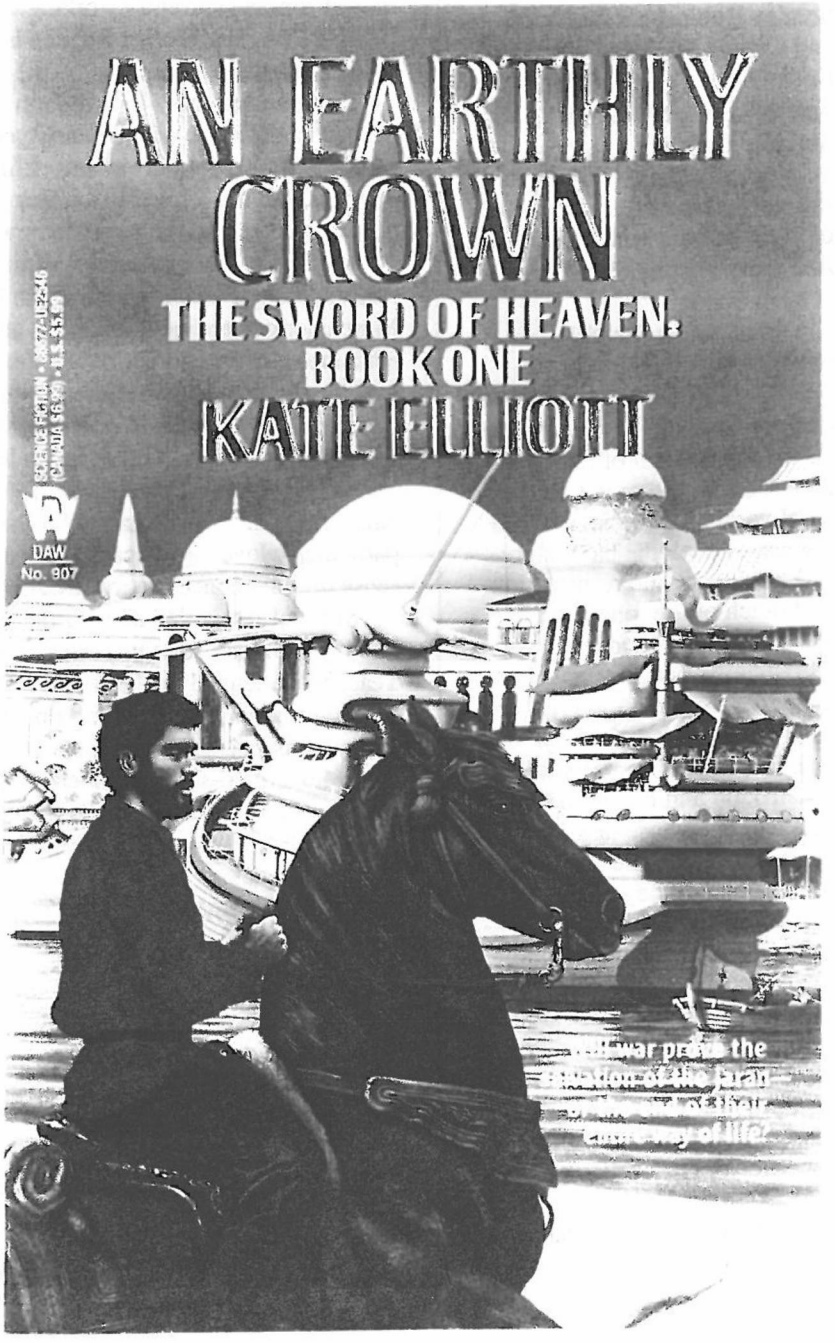
my first novel when I was sixteen. But I think it would be fair to say that I was in college when I first thought about writing a novel and trying to get it published. I sent out that novel—a truly ordinary fantasy novel—when I was twenty-one or twenty-two, and then wrote the first draft of *Jaran* that same year. The fantasy novel now resides in a trunk. *Jaran* got over six major rewrites in the last ten years, in between writing four other novels, and was eventually published by DAW."

And who first encouraged her writing?

"I did. After that, my parents; although I rarely let them read anything I wrote (it was too private), I always felt that they thought it was an interesting endeavor I had embarked on. Next, my brother Karsten, who should perhaps be considered the greatest influence on my writing; he and I invented countries and space ships and solar systems and future histories and populated them and generally spent a lot of time making things up. Last, two teachers from my junior high and high school years stand out in particular, in terms of writing; my junior high language arts and drama teacher, Sandy Campbell, who encouraged me not so much in writing but simply to be myself, and Charles W. Sullivan III, my high school English teacher, who encouraged my interest in writing and literature, and who is now a professor of English at East Carolina University."

A classic question to ask of any writer is . . . what writers have influenced her the most? "J.R.R. Tolkien. Jane Austen. Charlotte Bronte. Ursula K. Le Guin. Mircea Eliade. William Shakespeare, specifically the many plays my parents took me to see at the Ashland Shakespearean Festival when I was a child. T.S. Eliot. Robert Graves' *The White Goddess* and Edith Hamilton's book on Greek mythology. The author/authors of the Mabinogion, and the Anglo-Saxon poets, who reached across centuries and through anonymity to speak to me. Francis Bacon. Historians Marc Bloch and R.J. Collingwood and E.P. Thompson. Herodotus. The Astaire/Rogers musicals."

The other side of this coin is which writers does Elliott enjoy reading? "That's a hard question to answer. I'm just going to list books I've read in the last six months, and add that I really think Robertson Davies is a great novelist. I'm about to start Tony Hillerman's



newest book, *Sacred Clowns.* I'm not a great mystery reader, but I like his work, probably because in addition to the mystery I get a glimpse into another culture. I don't read a lot of fiction, and what I do read is mostly fantasy and science fiction: Recently, I've read fantasy novels by Katharine Kerr, Teresa Edgerton, and Judith Tarr, as well as Kim Stanley Robinson's *Red Mars* and Connie Willis's *Doomsday Book.* I'm currently reading *The Tale of Genji,* Murasaki Shikibu's story of a prince in 10th century Japan, written in the early 11th century, in a kind of tagteam bout with *Holy Feast And Holy Fast* by Caroline Walker Bynum."

What's next for Elliott on the book-writing circuit? "In *The Law Of Becoming,* which is due out from DAW in 1994, I spend a great deal of time and an important plot point on the local variant of Christianity. In this case I took the basic story of birth, death and resurrection, and much of the tone and piety associated with medieval Christianity, and blended it with elements from the Egyptian and later Hellenistic religion of Isis (i.e. dismemberment instead of crucifixion and the importance of a woman whose task it is to find and reassemble the dismembered body of the murdered god) and a few scraps of Islam. For example, I call the sacred text 'The Recitation' after the Koran rather than 'The Books' after the Bible. Thus, I got the essence of Christianity in an altered form, giving it resonance with Earth culture, and with the ancient rhythms of nature and the metaphysical concerns of agricultural peoples, without slavishly adhering to the specific variant we know. I confess I also split the church into an 'orthodox' and 'catholic' faith, because I couldn't resist the temptation to have certain characters accuse each other of apostasy and heresy."

Well!

What else is there to know about Kate Elliott?

Oh, yes. You should know that under her birth-name of Alis A. Rasmussen, she is the author of the fantasy novel *The Labyrinth Gate* (Baen 1988) and the SF adventure novels *A Passage Of Stars* (Bantam 1990), *Revolution's Shore* (Bantam 1990), and *The Price Of Ransom* (Bantam 1990).

Surprised? Don't be.

She is . . . Daughter. Sister. Mother. Partner. Researcher. And pen-name. Some might ask who is the *real* Kate Elliott. You wouldn't, not if you'd read her books.

Like all great writers she is *all* of these people. And more. She is just better at finding her many selves, and sharing their inspiration with the reader, than the average person off the street.

And *that's* why she's a writer.

KATE UP CLOSE

Two sisters, a brother, a father, a mother and a set of grandparents make up the close-knit family that nurtured Kate Elliott to adulthood.

Born in 1958 in Iowa to Gerald Rasmussen, an educator and historian, and to Sigrid Marie Pedersen, a Danish immigrant, Kate Elliott grew up as the youngest of four children (or Sibling Units as she calls them). Her eldest sister Ann Marie is a professor in the department of Germanic Languages and Literature at Duke University. Sister Sonja is a classically trained soprano currently working with the early music ensemble BIMBETTA. Her brother Karsten is a lawyer and currently a State Senator in the Oregon Legislature.

Her grandparents' 45-acre farm in Oregon is where she and brother Karsten spent much of their early years, playing in the outdoors. "Having woods and fields to play in was definitely what I liked most about growing up there, and it was clearly a major part of my childhood in terms of pushing me toward the path I'm now on."

Married to Jay Silverstein, a former police officer who's now in the Anthropology Ph.D. program at the Pennsylvania State University studying Mesoamerican archaeology, she's also the mother of a six-year old girl, Rhiannon Rose, and twin boys, Alexander Max and David Hannibal. "And yes, they're named after famous military figures."

Elliott got her formal start in writing by earning a B.A. in English Literature from Mills College. She has earned a brown belt in Shotokan karate and practiced broadsword fighting in the Society for Creative Anachronism. "I loved karate for the discipline and the athleticism and I particularly love kata because they allow you to focus; you can gain a sense of inner concentration. SCA broadsword fighting is just plain fun."

She's also traveled all over the world. "What I was five, my family lived in Denmark for a year, during which time my father was a Fulbright Teacher. I attended the University of Wales at Bangor on a junior year abroad program, and lived in London for half a year after that. I also spent two months in Denmark and travelled through Germany and Holland. I've seen Mexico, visiting a number of Maya sites in the Yucatan Peninsula, and also Greece, Rome and Switzerland. I would *love* to go to Central Asia; I'd like to travel the Silk Road."

Interview

William Gibson: Exploring the Newest Frontier

On October 29, 1993, science fiction author William Gibson appeared on "TechnoPolitics," the weekly PBS series on science technology and the environment. He was interviewed by moderator Tim White. The following is excerpted from that program.

White: It's something less than a prophecy. Something more than entertainment. Fictional versions of the future have been popular for more than 100 years. In the 1879s Jules Verne foresaw the submarine and other technological marvels. In the 1950s and 60s Arthur C. Clarke described man's future in space. And today, science fiction author, William Gibson, explores the newest frontier, the virtual reality of what he has called cyberspace, an alternate electronic world populated by data.

Gibson's picture of the future is drawn in his best selling books *Neuromancer, Count Zero* and *Mona Lisa Overdrive* [and his most recent, *Virtual Light*]. Artists, musicians and film directors share his aesthetic vision. It's a combination of pop violence, exotic electronics and sensory overload. Certainly no utopia. The rock band, U2, says Gibson's work inspired its latest album.

William Gibson's most telling vision is the alternate reality of cyberspace, and his world is rushing at us at warp speed. New interactive forms of entertainment, hyper-realistic simulations, cybernetic body parts. All either exist today or are on the drawing board. The future, it seems, is beginning to have a hard time catching up.

William Gibson, in your books you have created an alternative world called cyberspace. The term itself has come into more common usage and shows up a lot in print. What do you mean when you use the term "cyberspace?"

Gibson: Well, I always tell people that cyberspace is where the bank keeps their money.

Cyberspace is the totality of everything we do in the electronic data-matrix that exists today. Even thought it's non-geographical, it's a sort of territory and very important changes are taking place there.

I suspect, in a sense, it's already changed everything.

White: Imagining the cyberspace world, will it be democratic?

Gibson: Well, I would hope so. One of the things that encourages me most about the contemporary developments in cyberspace is the fact of the Internet. What it is, how it got there, the fact that it doesn't really belong to anyone and the fact that it's essentially free.

This is a system that is girdling the world again and again. I have a vision of it spinning around our planet like an invisible spider web. More and more addresses everyday. People are interlinked in ways that were previously quite unthinkable.

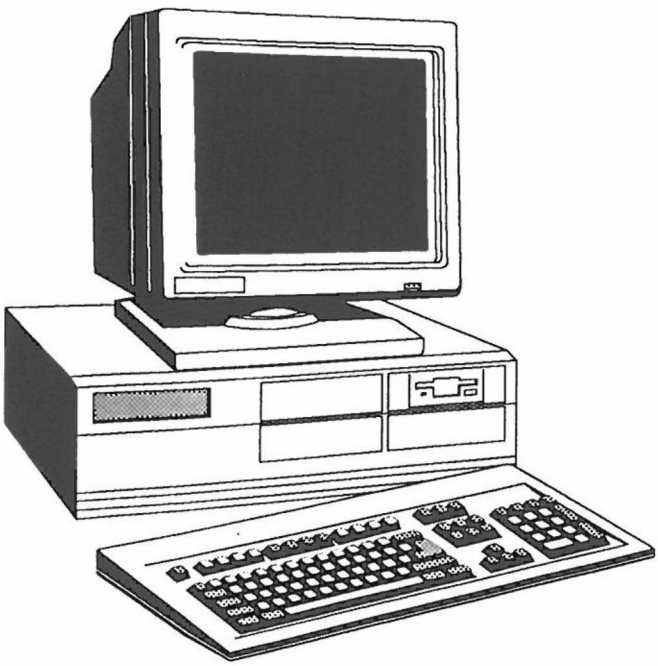
White: When your first book came out, Mr. Gibson, your publisher, at least, said that you had written it on a manual typewriter. Are you still

using old technologies? And if you are, does that mean that you have some sort of ambivalence about these technologies? Even the ones you write about?

Gibson: No. I wrote my first book on a manual typewriter, but now I write my books on a sort of comfortably obsolete but still reasonably powerful Macintosh computer.

I find it difficult—I don't really understand how one could not have an ambivalent attitude toward technology because technology encompasses so many things. I mean, technology blew up the World Trade Center and technology flew the smart bombs down the air shafts in Baghdad. But technology is also why I can be 45 years old and still have teeth in my head and not have died of polio. I mean, technology is not something that we late 20th century western industrialized folk can put back in the box and return to Radio Shack. Technologies are us.

White: In your books, the Japanese are everywhere. They are major players in your cyberspace world. Does that indicate some reservation or fear on your part of Japenese domination? Of politics and culture and technology in the future?



Gibson: Well, you know, when I wrote my first novel, actually when I [wrote] the stories that led to my first novel, it was in 1981. And the idea that—as hard as it may seem to believe it now—in 1981 the idea that Japan was already a dominant world power was considered actually kind of novel. Somehow people hadn't quite noticed it yet.

I noticed it because I live in Vancouver, Canada in a very trés globalist PacRim êntrepot crawling with Japanese money and business presence and tourists, and it seemed very obvious to me. It was also obvious to me that the only consumer durables I owned that anyone would care to steal had been made in Japan.

So since part of my agenda with writing that first novel was to balance some things that irritated me about most American science fiction novels, I made Japanese a dominant—the dominant—world power and a very ubiquitous presence.

White: What is the role of William Gibson? Do you see yourself as a visionary? A prophet of some sort?

Gibson: What I think I do with these books, really, is wander around examinging how my own inner landscape interfaces with contemporary reality, which is what most people do, I suppose. But I've worked out a way to get paid for doing it. But that's really sort of where these books come from. It's a problem of the nature of the genre I work in that people will assume I'm more like Arthur C. Clarke than Elmore Leonard, say. In other words, I think it's probably not true. I know it's not true.

White: William Gibson, thank you very much for joining us.

Gibson: Okay, great!

Hubble Space Telescope Mission A Success

NASA administrator Daniel S. Goldin announced in January that the December 1993 space shuttle mission to service the Hubble Space Telescope (HST) was successful in correcting the vision of the telescope's optical components. The announcement, accompanied by the first new images from the HST, followed the initial five weeks of engineering check-out, optical alignment and instrument calibration.

Word of the Hubble success came at a press conference held at Goddard's Visitor Center. Goldin was joined in making the initial announcement by Dr. John H. Gibbons, Assistant to the President for Science and Technology, and Senator Barbara A. Mikulski (D-Md.), Chair, Appropriations Subcommitte on VA, HUD and Independent Agencies.

"Men and women all across [NASA] committed themselves to this effort," Goldin said. "They never wavered in their belief that the Hubble Space Telescope is a true international treasure."

★

The HST mission was the most difficult satellite servicing mission NASA has attempted. It included an unprecedented number of spacewalks. In addition, many of the servicing tasks were complex and had to be performed in a limited amount of time.

The mission got off to an auspicious start with a flawless liftoff on December 2, 1993, only one day behind schedule, despite a launch pad switch prompted by sandblasting contamination at the original pad, 39A.

The Hubble was berthed on Flight Day Three of the mission. The crew of space shuttle Endeavour pulled off the first of five Extra Vehicular Activities (EVAs) with only a minor hitch closing a door on the telescope. Astronauts Jeff Hoffman and Story Musgrave changed out two rate sensor units and prepared the solar array carrier for the next day's EVA. They also installed two new electronics control units and a set of fuses.

Meanwhile at Goddard, personnel in the Space Telescope Operations Control Center (STOCC) worked in concert with Mission Control and the Goddard contingent at Johnson Space Flight Center in Texas.

"The team in the STOCC was as well trained as the astronauts," observed Joe Rothenberg, associate director of flight projects for the Hubble. "Having come from an operations background myself, I knew the heroic efforts that were going on to ensure that all operations were fault-free and executed on time. The team also responded admirably to a timeline that was changing all the time."

"We had a very close handshake with [Johnson Space Center in Texas]," said Ann Merwarth, manager of the HST Operations and Ground Systems Project. A key to the process was a software program called the Servicing Mission Planning and Replanning Tool that permitted the mission timeline to be quickly refigured.

"We had a timeline to execute, and whenever anything went wrong we had contigency procedures to pick from," said Merwarth. "All of the tasks were packaged up as units that could be moved around. So when we saw that we were getting ahead of the timeline, we'd start to think about replanning to add something. The main thing was to look ahead and have work ready for the crew when it was ready to do it. And I don't think we really ever had the crew sitting around with nothing to do."

Spacewalking astronauts encountered few glitches as they sped through the tasks. On EVA Day Two, astronauts Kathy Thorton and Tom Akers changed out the solar arrays, jettinsoning one that was too bent to be rolled up and returned to Earth. Although the European Space Agency, which provided the arrays, had hoped for the return of both, the jettisoning of one had been anticipated during simulations of the mission.

Simulations were crucial to the success of the mission. Ground personnel underwent many hours of extensive training prior to the mission. In one such

session, called a Joint Integrated Simulation, some sixty hours were spent practicing the mission and preparing for the unexpected.

On EVA Day Three, Hoffman and Musgrave installed the Wide Field/Planetary Camera II, which contains its own corrective optics to compensate for the flaw in the space telescope's primary mirror.

While installing two new magnetometers, however, the astronauts discovered that the casing on one of the existing components was disintegrating. Because the old magnetometers were to be left in place, with the new ones snapping over them, the disintegrating casing posed a contamination hazard to the optics on the telescope. In the only unanticipated task added on the servicing mission, NASA decided to seal the casings on the old magnetometers with a mylar shroud that astronauts would fashion onboard Endeavour and install on EVA Day Five.

On EVA Day Four, Thornton and Akers removed the High Speed Photometer and installed in its place the Corrective Optics Space Telescope Axial Replacement, whose ten dime- to quarter-sized mirrors are designed to correct the light entering the Faint Object Camera, Faint Object Spectrograph and Goddard High Resolution Spectrograph. After completing the task flawlessly, the two astronauts installed a co-processor to augment the telescope's onboard computer.

On EVA Day Five, Hoffman and Musgrave installed new solar array drive electronics, a repair kit for the Goddard High Resolution Spectrograph and they capped the old magnetometers with the shrouds they had built inside the space shuttle. The shuttle also boosted the space telescope to a higher altitude.

Meanwhile, the second big scare of the missions occurred. One of four data interface units, which are part of the telescope's management system, showed a problem on one of its two sides. That crisis passed when NASA managers determined that the other side of the unit could be used.

The next day, Flight Day Nine, the Hubble was released from the shuttle. In the customer support room next to Mission Control at Johnson, the Goddard team celebrated with champagne.

"Needless to say, things went beyond our expectations in a positive sense," said Dr. David Leckrone, senior project scientist for Hubble, who viewed the launch at Kennedy Space Center in Florida and then worked the spacewalk shift at Johnson. "This is something that we all—NASA, Goddard, Johnson, Kennedy, Marshall, all the contractors and the American people—should be incredibly proud of up to this point."

Rothenberg, who averaged only three hours of sleep a night throughout the mission, said he probably was most relieved when the spacecraft was deployed. "At that point the risk was over. The Goddard team had done its job—the hardware it had installed checked out and it had demonstrated that HST could be restored."

Said Merwarth: "We all feel like we have our baby back now."

Adapted with permission from NASA News press releases and Goddard News, printed by Goddard Space Flight Center.

Hubble Keeps Watch on Comet

The Hubble Space Telescope has been keeping watch on the fragments of Comet P/Shoemaker-Levy 9 (1993e), which are expected to plunge into Jupiter's atmosphere in July, 1994. The massive planet's gravitational pull tore the comet into numerous pieces as Shoemaker-Levy passed it in the summer of 1992.

When the framents collide with Jupiter, probably over a 5½ day period centered on July 19, they may produce spectacular results, depending on their size when they hit. The eleven largest fragements are estimated to be 2 to 4 kilometers in diameter. They are expected to impact with an energy release many times that of a nuclear warhead.

The Hubble Space Telescope first observed the comet on July 1, 1993. Recent images taken using the HST's newly improved optics have given an even clearer view. Taken between January 24 and 27 by the Wide Field Planetary Camera II, the images indicate the comet will continue to fragment. Over the next few months, Hubble will monitor Shoemaker-Levy's approach to Jupiter, which is some 800 million kilometers from the Sun.

The Wide Field/Planetary Camera was provided by NASA's Jet Propulsion Laboratory in Pasadena, California. Hubble is managed by Goddard for the Office Space Science at NASA Headquarters in Washington, D.C.

Adapted with permission from Goddard News, Vol. 41 No. 2.

Delta Clipper Promises Space for All

Marianne J. Dyson

On September 11, 1993 I got up before sunrise to claim my seat on a wagon-train of buses bound for a glimpse of the future. The buses sped us past oryx and yucci on our way to the White Sands Missile Range near Las Cruces, New Mexico. Without binoculars, I could just make out the white cone of a rocket on the horizon.

We had come to see the second flight test of the Delta Clipper Experimental (DC-X) rocket developed by McDonnell Douglas for the Ballistic Missile Defense Organization (BMDO) in under two years. The one-third scale prototype was built to test the design of a single-stage-to-orbit (SSTO) vehicle as well as airline-style operations.

Single stage vehicles were first proposed in the 1950's, but according to a BMDO report to Congress, were considered technically too risky. The nation instead chose expendable (use once and throw away) rockets and developed partially reusable systems like the shuttle.

Science fiction author Dr. Jerry Pournelle told the tale at ConFrancisco, the 1993 World Science Fiction Convention. He had gathered a group of scientists together back in 1987 and 1988 to decide if breakthroughs in materials and engines made SSTO vehicles finally achievable. Pournelle, Lt. Gen. Dan Graham (USA retired) and "rocket scientist" Max Hunter persuaded Dan Quayle, then head of the Space Council, that development of SSTO vehicles would be good for the country. The study took place in 1990, and in 1991, McDonnell Douglas was awarded a $60 million contract to build and test the DC-X.

Why is single stage important? It allows complete reusability, spreading costs over many flights. In McDonnell Douglas's promotional video, they ask viewers to consider how expensive air travel would be if airlines had to assemble a new jet after each flight. According to Boeing, a new 747-400 costs about $150 million dollars. Spread among four hundred passengers, a ticket would cost $375,000!

Pournelle explained, "Airlines operate at about three times fuel costs. It takes about the same amount of fuel to put a pound in orbit as to take a pound from here [San Francisco] to Sydney, Australia. Rockets are just as good as airplanes at turning energy into motion . . . . You should be able to go into orbit for the price of a first class ticket to Sydney." He paused. "You, in your lifetime. Hell, maybe even I can buy a ticket."

That option came closer to reality on September 11.

Like a good story, the launch day opened with a few problems for the team to solve while the press, the company CEO, and military brass waited. Charles "Pete" Conrad, Jr., Flight Manager (and the third man ever to walk on the Moon), said the main problem was a computer failure in mission control. "In order to do the program for the absolute minimum dollars, we did not build redundancy into the ground systems." They ordered a spare computer, which was to take eight hours to arrive. But like heroes are supposed to do, they recovered the computer before the VIPs had even cleaned out the snack tent.

The computer was part of the no frills mission control called the Flight Operations Control Center (FOCC). The FOCC, a white trailer with a staff of three, was parked behind the bleachers erected for the guests, three and a half miles from the launch pad. The DC-X is flown via remote control from the FOCC.

Luckily, the computer was recovered. But then a vent valve on the ground system played a trick. "We tried to operate it a couple of times, and it didn't work," Conrad said. They sent the crew back down to the launch pad to go through a complicated ground safety procedure. "As soon as they got there," Conrad said, "you guessed it, the valve worked. They didn't have to do anything."

"The last little delay we had was a good old aircraft delay," Conrad said. "One generator which we tow down to the vehicle to supply power to it checked out last night and ran fine. When our people brought the generator up just before flight, there was one circuit breaker which had been opened by the people who checked it the night before. It was a circuit breaker that was relatively hidden and our people had never seen before. So we learned our lesson, which is always publish and follow the checklist even if it's ground support equipment."

Problems solved, the countdown resumed. At 11:12 am, Conrad's voice came over the loudspeakers, "9,8,7,6,5,4, start the engines, 2,1 launch of flight."

For a moment, the desert returned to the silence of a hot summer's morning as the hundreds of spectators held their collective breath, fingers poised over camera shutter releases. When the DC-X emerged from the launch plume a few seconds later, the crowd erupted with cheers, hoots and applause. Then as if out of respect, the crowd grew silent again as the low thunder of launch rolled over us. I remember thinking how the clicking cameras sounded like startled insects.

Like a rocket icon on a giant blue screen of the sky, the DC-X slid sideways for three hundred and fifty feet and stopped. It hung there for three very long seconds (the clean hydrogen and oxygen fuel produces nearly invisible water vapor exhaust) while the spectators gripped their binoculars tightly.

As the rocket descended at two hundred feet, four brave legs extended out from its aeroshell into the firestorm of the engines. The DC-X made a perfect tail-first landing described by science fiction writer Arlan Andrews as the way, "God and Robert Heinlein intended."

The flight test lasted 65.82 seconds.

"The vehicle performed flawlessly," Conrad said. He assured observers that scorching on its side was nothing serious. Because of the low wind and slow speed of this flight, the exhaust from the four engines rose up the leeward side of the vehicle. "Our heat protective paint turns black at 500 degrees Fahrenheit," he said. "It looks worse than it is."

Emphasizing the aircraft-style operations of the program, he added with a smile, "When we turn the vehicle around, we take the hose and soap and a brush and wash it." He also said he sees no reason why they can't eventually fly the vehicle in the morning and again in the afternoon, just like airlines do.

A three-day turn-around demonstration was planned for October, but because of a delay in Congressional funding, the flight testing was stopped after only three flights. (A September 30 flight reached a higher altitude.)

BMDO officials said that a two-thirds scale suborbital version, the DC-X2, which would primarily test new lightweight materials, could be done in three years for $300 million. The House/Senate conference committee appropriated $40 million for a follow-on program for 1994, about half of what SSTO supporters had hoped for. After that, it would be about another three years to develop the DC-Y orbital version. It is estimated this vehicle would cost one billion to develop and require new improved rocket engines.

But with luck, we'll have a real spaceship in our near future. "The public's going to get a ride on it," said U.S. Air Force Col. Simon "Pete" Worden, the BMDO's Technology Program Manager. "By 2005, we'll have operational SSTO's [single stage to orbit vehicles] that are commercially operated.

"We can build and share our technology to [create] an unlimited expansion into space," Worden added. "That expansion must start with affordable and reliable transportation into space, not just for a few government employees, but for all of us."

Colder Than Coldest

Larry Hammer

According to the January 1994 *Scientific American*, a theoretical possibility has been achieved—a temperature lower than Absolute Zero. Pettri Hakonen of the Helsinki University of Technology lowered the temperature of a piece of rhodium below 0 Kelvin. This is not impossible, as we've always learned, because it wasn't the temperature we feel in our bones, but the temperature of something called magnetic spin.

Anything with energy also has an associated temperature. Energy is the motion of gas molecules, which bounce around like rubber balls. In a system with a given energy, the individual molecules can move with any speed or direction as long as their combined energy remains the same. For a gas, the temperature is always positive and rises continuously as the energy rises, starting from a minimum value we call Absolute Zero.

The system also has an associated *entropy*, which is proportional to the number of different states the molecules can be in and still have the same energy. The more the molecules move about, the more possible combinations of speed and direction they can have, so the higher the number of states available to them. As a result, the entropy of a gas rises rapidly with increasing energy. Temperature is proportional to how fast the entropy changes.

But a system of magnetic spins is different. Although the atom or molecule isn't actually spinning, it behaves as if it is when it is put in a magnetic field. Its spin can be described by a vector which points either in the direction of the magnetic field or against it. So only two possible energies exist for an individual spin system, which means spin behaves like a coin rather than a ball.

There are only a limited number of ways you can lay out heads and tails. If we apply a magnetic field to a group of particles with spin system, then at zero energy (which is still, as far as we know, impossible to achieve) all of the spins will align with the field. At very low energies a few spins flip to point against the field. Since more than one way to do this exists, depending on which spins flip, the entropy has increased with energy and the temperature is, as we expect, positive (and rather small).

If *all* of the spins flip against the field, we have the maximum energy possible for the system. But at energies just below this, a few spins are flipped the other way, increasing the possible states available to the system. So in this case the entropy *increases* as the energy is lowered, or to put it another way, entropy decreases as energy increases. Thus as the energy increases, the temperature goes down. When the energy approaches the maximum, the temperature is a very small negative number.

This state is hard to reach unless you trick it. Hakonen applied a magnetic field to the rhodium and cooled the sample to a few picokelvin (10^{-12} degrees). He then quickly reversed the magnetic field. Almost all of the spins now pointed *against* the field, which gave a temperature of a few picokelvin below zero.

Can this be done with ordinary temperature, what we feel in our living room? No—because there are too many ways for molecules to move, with every possible direction and speed. Without the limitation on spins, that they can point only with or against a magnetic field, we'll never wake up shivering to the news that Absolute Zero is no longer a barrier.

EVENTS

FIRST ANNUAL PEACH STATE STAR GAZE, April 7–10: Covington, GA. Write Ken Poshedly, 3440 Everson Bay Court, Snellville, GA 30278. Ph: (404) 979–9842.

MID-SOUTH STAR GAZE, April 7–10: Rainwater Observatory, MS. Write James Hill, FCA, French Camp, MS 39745. Ph: (601) 547–6865 or (601) 547–6970.

ASTRONOMY DAY PROGRAM, April 9: Montclair, NJ. Write Valerie Sweatt, Planetarium, Glenfield Middle School, 25 Maple Ave., Montclair, NJ 07042. Ph: (201) 509–4274.

SPRING SPECTACULAR, April 15–16: Lemon Lake County Park, IN. Ph: Stephen J. Miller, Calument Astronomical Society, (219) 845–9174.

THIRD ANNUAL NORTHEAST ASTRONOMY FORUM & TELESCOPE SHOW, April 16: Suffern, NY. Write Don Urban, 73 Haring St., Closter, NJ 07624. Ph: (201) 768–6575.

Continued on page 45

Intimate Physics

Roy Gray

A shorter version "Intimate Physics" won an award from the Institute of Physics in the United Kingdom as part of a competition on science writing dealing with the commercial exploitation of physics. The shorter essay will appear later this year in Physics World, *the journal of the Institute.*

1890 the first cars had appeared. A first order prediction, based on a straightforward or linear extrapolation of current events and technology, was that everyone would want one. Was Henry Ford alone in foreseeing this? Contemporary experience with London smogs and horse drawn traffic, including the depth of dung at Hyde Park Corner, might have suggested a future of traffic jams and air pollution, but no one made that connection. So first order effects are not always easy to predict.

Without Asimov's "20:20 hindsight," no one forecast the parking problem, which is a second order effect. These are side effects, not immediately obvious because of changed circumstances. Horse drawn vehicles weren't normally parked and left unattended for long periods.

Third order effects resulted from human behavior entering the equation, motorway madness is an example, and were completely unpredictable. Even given the foresight required to imagine multi-lane highways and a multiplicity of vehicles with 90 MPH capability, who in 1900 would have predicted multiple vehicle pile-ups resulting from senseless speeding on foggy roads with visibility down to a few yards.

1990 the first virtual reality (VR) and telepresence systems have appeared. Telepresence adds touch to the other senses (sound and vision) which technology exploits in radio, telephony, recording, television, cinema and video. Our first order prediction is that marketing virtual sex becomes a major thrust of the entertainment industry. After all, even our initial analogy, the car, has been intimately linked with the pursuits of love over the years. With VR the links are more obvious. There are other portents: fear of AIDS/HIV, sexual tourism, and the controversial profits of premium rate telephone sex. The media has christened this technology "Teledildonics." Let's assume it develops into a software/hardware industry, akin to CD's and stereo players.

At present, virtual reality comprises a bulky helmet containing a pair of earphones and two small television screens, one for each eye, all linked to a computer. This generates a slightly different image for each screen, giving stereoscopic vision (i.e. with depth). It adds stereo sound to match the visuals, senses the helmet's position and changes the screened views and sounds to match the wearer's movement. This gives users the illusion that they are inside the scene they are viewing. It appears to be an all around, three dimensional place. But it is unreal, a creation of programs, software, running on the computer. It—not the equipment—is a virtual reality.

Subjects can hold, or wear, a link to the computer which is made visible in the images, often as a pointer. Triggering this link, or merely pointing with it, starts an illusion of movement through the virtual reality as the controlling program sends users in their chosen direction by streaming the scene past them. Using this technique, architects conduct tours of the buildings they design long before the first brick is laid.

In "Wild Palms" (Oliver Stone's TV mini-series with a VR-based plot) the bulky helmet has been replaced by something resembling sunglasses. This looks like a sensible prediction. However drugs were postulated as a means of adding tactile sensations to the images. This may be possible, but it may not give the control that a major entertainment industry requires. Nor does it offer the Sonys and Panasonics of the future anything to sell. So we shall stick with straightforward extrapolations of present technology for the nonce.

Transducers convert an electronic signal into pressure and/or movement and vice versa. They can be mounted in a glove, the data glove, and linked to the controlling computer. This makes it possible to exchange physical sensations between the virtual and real worlds by converting incoming and outgoing signals into forces the hand perceives, and exerts, as feeling and movement. Now a computer generated, or virtual, object can have both an optical and tactile presence, like a solid ghost. It can be touched and felt using the glove. If it simulates something distant but real, this is touch at a distance—telepresence. It can be

used for precise manipulation of hazardous materials by operators stationed in safe areas, or for driving the Mars buggy from a safe armchair deep in the heart of Texas.

For now we shall take the hardware for granted without worrying about the technology. We can posit special suits—"skinware"—akin to a second skin, to transmit and receive tactile sensation, with lightweight headsets (for sight and sound) to make up the full kit. Link them through a computer, which signals to and fro in response to the positions, movements and pressures of the occupants, communicating direct physical sensation: touch, sound and sight. No organoleptics (odors and taste), no science fictional plugs direct into the nervous system.

The industry would also need software such as romantic stories, probably free of overt sex, which could entice a wide audience and build a market for the hardware. Other software might be basic bedroom technique "recordings" of popular entertainers and sporting personalities.

There is also the potential of "live" activities via the data superhighway and the telephone, though relativistic (speed of light) delays would frustrate transoceanic interactions. "Live" is people interacting via the system rather than "passive" or software controlled activities such as the aforementioned recordings.

Before continuing to second, and even third order effects, we should take a look at the technology of skinware. The data glove must be developed into a full data suit for total immersion in virtual reality. Making this suit comfortable, and able to sense, simulate and communicate the variety of human movements and feelings, including sexual activities, seems a difficult task. Perhaps it is, but our susceptibility to suggestion and illusion can only help. And there are promising materials and technologies.

Electrorheological fluids are liquids sensitive to electrical and magnetic fields. They change from soft to hard, slowly or at the flick of a switch. These properties, combined with hydraulics, might be used to produce effects ranging from a caress to a heavyweight champion's uppercut (boxing could become a safe participative sport in virtual reality if punch forces were suitably stepped down to avoid causing actual injury). They could also be used to keep the skinware's occupant cool by pumping them through refrigeration circuits. It is now possible to manufacture electric motors far smaller than one millimeter on a side. These tiny devices could work as the pumps.

Piezo-electro materials expand or contract in electric fields. Squeeze them and they generate a voltage. As components of transducers and sensors, their action couples movement and pressure between distant locations.

The full kit would interact with three senses: tactile, sound and vision. These could be separated into at least three channels. **There need be no more relationship between** the origin of the signals on these channels than there is on a compact disc featuring a singer **accompanied by a pianist and drummer.** Recording engineers routinely combine recordings from separate sources. The drum track alone might be a combination from several "takes" or sources. A VR producer would have at least equal freedom to mix and match.

Second order effects may lie in applying this separation of data processing to telepresence signals, along with image enhancement and cinematic special effects.

"Virtually" everyone could be young, good-looking and well-endowed. Careers in virtual image enhancement may be as lucrative as that of plastic surgeon. Movie stars, or their equivalent, might syndicate features which could be used to enhance virtual personas. Attributes could be exaggerated or reduced without the risks of surgery.

To illustrate the wider opportunities provided by virtual sex we need to take a simple and widely used sexual activity as an example. This is no place to be coy; our example is toe kissing, a practice which gained some notoriety in the UK in 1992 and 1993. Instrumenting a mouthpiece, which allows the operator to breathe, looks tricky but let's assume it's possible. Oral conditions (tongue position and pressure, teeth, temperature and moisture) and toe status (shape, location and movements) switch back and forth.

These actions can then be saved as software routines. Afterwards toe and mouth exchanges can be repeated on the same toe or another, at the flick of a switch. The subject can thus feel the effect of multiple mouths when their partner moves on to other delights,

leaving a full set of toe routines in operation.	leaving a full set of toe routines in operation.	leaving a full set of toe routines in operation.	leaving a full set of toe routines in operation.	leaving a full set of toe routines in operation.

Such techniques imply the development of "active" equipment. The all encompassing skinware could be reduced to an eminently saleable headset, player and genital fitting, similar to a Sony Walkman.

Other, simpler, devices could merely exchange sensations between genitalia,

Alternatively inverting the data at one organ, reversing tensions and compressions for instance, should permit some novel interconnections.

This goes beyond sex. A mother's labor contractions could be "recorded," obviously before the baby appears, using a vaginal probe. The information is gathered from the small area of the probe but is eventually transmitted to the sixty times larger area of the skinware. To cope with this expansion the computer must compensate for the lack of information between the now widely separated data points. This can be done calculating intervening points in the same way that cartoons are made by computing a series of frames to link manual drawings.

Psychiatry gains a new treatment and "born again" takes on new meaning. Now the mother involved can don the skinware and experience her labor from the inside. Virtual reality can overturn normal experience of space and time.

By adding easy transfer and multiplication of skills to present day phenomena such as teenage hackers and "games freaks," and problems such as drug abuse, we may glimpse a few third order effects.

If VR use reaches the levels shown by today's infatuation with Nintendo products then we can expect eldritch science and mathematics from generations growing up in a non-Euclidean, non-Einsteinian universe. I see this resulting from time spent in virtual realities where, to take two simple examples, rooms are bigger on the inside than they are from the outside and tactile sensations can be matched with optical illusions to create "impossible" situations.

Imagine entering a simple virtual reality where the only objects visible are a solid looking sphere "hanging in mid-air" and a representation of your hand in the data glove. Reach out, you see your hand touch the outside of the sphere only to find that you feel its inner surface. In essence the tactile information in the data stream has been separated from the visual, and altered to give the impression that your hand is inside a hollow sphere with no openings. It could equally have been programmed to feel like a cube or a caterpillar.

Illicit software abuse. If computer and interactive games are addictive now then VR could become their equivalent of crack. It's easy to imagine VR hackers reprogramming their kit to switch tactile sensations to their genitals. "It's a real pleasure to meet you" could become more than a polite greeting as you shake hands at a virtual political convention. Other possibilities are dangerous neglect of physical needs and use of medical technology, such as infused saline and dextrose, to extend the VR stay.

New behaviors which might be classified as criminal. It is possible to impersonate someone on the telephone at present, but it's not easy to take advantage of that to do physical harm. In VR an impersonator could "commit" virtual rape, or use virtual sex changes as a means of taking advantage. Secret sampling of other's virtual activities, either "live" or to make copies, and "saving" such actions without a partner's permission might not be criminal, but would be perfidious, to say the least. Hoaxes with animals would merely be in gross bad taste.

Reading declines further. Aside from the possibility that computers will be able to read for us, the need to read instructions to acquire skills could be rendered obsolete by VR teaching. On the other hand, one trained and skilled person should be able to teach hundreds efficiently via virtual reality. Skilled employment opportunities might move to low labor cost nations.

"Live" audience participation sports in virtual arenas. Join your favorite on the track, pitch or court, experience their sensations live. Some of the actions would need to be "stepped down," that is reduced in intensity. It would not be good business to overstress the audience to the point of heart attack. Step down factors could be self controlled, to some extent, according to the health and fitness of the individual fan.

Finally, the adverts, we'll never keep them out of virtual reality. Logos and images will take on a tactile element. Companies might like to think about how they could register such a version of their logo soon, before someone does it for them and makes them pay for the omission. It isn't likely an advertiser would be pleased by a competitor with a logo that looked different but felt exactly like their own trade mark.

The lack of organoleptic senses will, in PC terms, be a challenge rather than a handicap. It's easy to imagine a sudden swirl of the scene leaving you needing that Alka Seltzer there and then. Alternatively a quick burst of heat to the mouth insert and those toes won't look

quite tasty as as that can of Miller Lite forever floating just out of reach.

Reviews

Continued from page 14

average human with a not so average problem—he is addicted to a life-extending treatment that can allow him to live for centuries, perhaps longer. The treatment is exorbitantly expensive, which means he spends most of his extended life working at a mind numbing job so that he can earn enough to pay for his next treatment.

Morley lives on Tano's Planet on the fringes of a galactic civilization. Numerous alien species work on the planet, including the Bimus, a powerful race of single sex bipeds who tower over humans and breathe through gill slits in their chests. The Bimus evoke images of insects with their faceted eyes, complicated mandible structures, and skin reminiscent of exoskeletons. A chance interaction between their production of hormones and the altered biochemistry of life-extended humans leads to an intense sexual response in Bimus to human males. With this premise, Barton challenges the reader to consider some perhaps unsettling questions about love and seduction, and whether rape is a sexual act or one of power.

In an attempt to forget a failed love affair and escape the unremitting grind of his work, Morley goes on a drinking binge and ends up at a party of the power bosses on Tano's planet. It is here where he meets the Bimus called Koprenil Eti. In writing about Morley's first sexual encounter with the Bimus, Barton manages to avoid both sensationalism and self-consciousness while at the same time never shying away from the thought-provoking subject matter. One of the more effective moments occurs when Morley, lying drunk and confused on a bed, looks up at the massive alien who has pushed him there and realizes the situation is so far outside his realm of experience that he simply has no referent to understand it.

As the story progresses, Morley's relationship with the Bimus evolves. It can't really be called role reversal because the Bimus is neither male nor female, but it certainly allows Morley to experience sex roles in ways different from what he has known in the past. There are also touches of humor. What human entertainment would interest the Bimus? Romance novels, of course, with their plots of passionate men avidly pursuing the women who desire them.

The writing in *Yellow Matter* is a bit rough, with some awkward tense and viewpoint shifts, and too many sentence fragments for my taste. I also felt the work was too short to support its complicated background of galactic politics and history, or to fully develop the many alien species. But despite these drawbacks, *Yellow Matter* is a thoughtful, gutsy story worth the read. —*A.*

Letters

Continued from page 5

Chaos

Thanks for the copy of your premier issue. My fiancée is a PhD candidate in social/organization psychology, and she found John Kendall Cannizzo's chaos article useful when she was preparing a seminar presentation on the use of chaos theory in the social sciences. She only knew about the article because I had read it and found it clear and helpful.

All best wishes,
Bruce Holland Rodgers
Champaign, Illinois

Letters to the Editor should be sent to Mindsparks, P.O. Box 1379, Laurel, MD 20725–1379. Letters published in Mindsparks may be edited for space or clarity.

Events

Continued from page 41

1994 JOINT APRIL MEETING OF THE AMERICAN PHYSICAL SOCIETY AND AMERICAN ASSOC. OF PHYSICS TEACHERS, April 18–22: Crystal City, VA. Write APS Meetings Dept., One Physics Ellipse, College Park, MD 20740–3844. Ph: (301) 209–3286

STARCONN 94, April 23: Wesleyan University, Middletown, CT. Write Astronomical Society of Greater Hartford, P.O. Box 2271, Hartford, CT 06145–2271.

48TH ANNUAL CONVENTION OF THE NORTH CENTRAL REGION OF THE ASTRONOMICAL LEAGUE, April 30: Burlington, IA. Write Dave or Marion Bachtell, 1901 South 10th St., Burlington, IA 52601. Ph: (319) 753–1442.

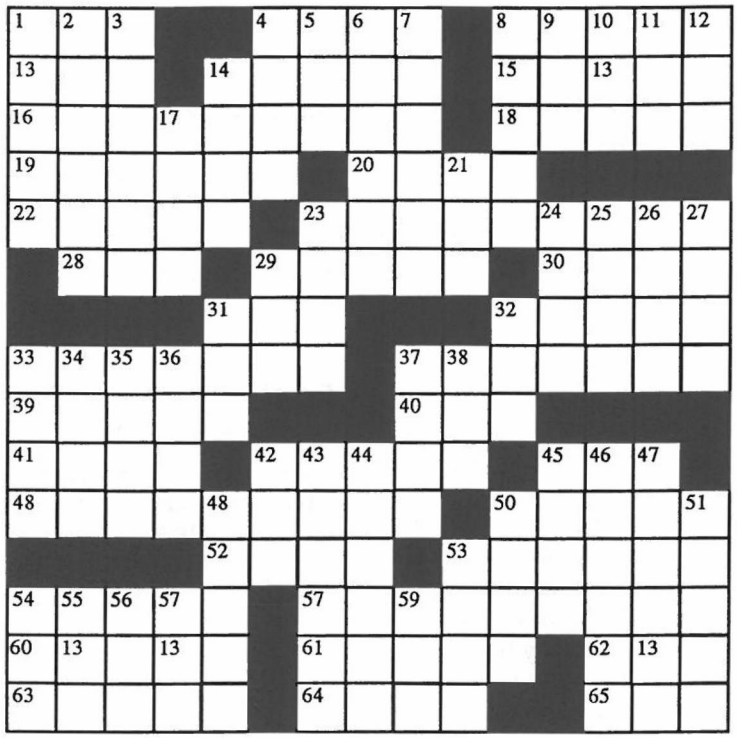
1994 SOUTHERN STAR ASTRONOMICAL CONVENTION, May 6–8: Monroe, NC. Write George and Mary Chakhtoura, 5023 Walt Gay Road, Monroe, NC 28110. Ph: (704) 764–3132

TEXAS STAR PARTY, May 9–15: Prude Ranch near Fort Davis, TX. Write TSP Registrar, 1326 Mistywood Lane, Allen, TX 75002.

4th ENCUENTRO NACIONAL DE ASTRONOMIA, June 4–6: Cali, Columbia, South America. Write ASAFI, 4th Encuentro Nacional de Astronomia, AA 3189, Cali, Columbia, South America. Ph: Giovanni Barandica, 923–822624 or Luz Marina Duque, 923–581175.

Continued on page 48

Cyber Play



ACROSS

1. Thin: *abbr.*
4. Leonardo's Lisa
8. Sound wave detector
13. Chemical suffix
14. Gem face
15. Having utility
16. Computer network voyager
18. Flower part
19. Male member of Nigerian tribe: *two words*
20. Skin eruption
22. Middle English precursor to the word rase
23. Making a brain-computer link
28. Derisive interjections
29. Verbose
30. Ideas
31. Near, in Munich
32. Hollowed out
33. Type of reality
37. Networks
39. I sections used in construction work
40. Animal companion
41. Quechuan system of exchange
42. Release from penalty
45. Circuit Court of Appeals: *abbr.*
48. Accessing a computer account
50. Sacred drink
52. Delayed automatic gain control: *abbr.*
53. Polisher
54. Fruit or computer
58. Cyberspace activity
60. Sing softly
61. Normal
62. Place for selling stock
63. Peter O'_____
64. Leave an electronic message on a computer bulletin board
65. Girl: *slang*

DOWN

1. Kinder
2. Sometime: *two words*
3. Mexican scarf
4. Husband, in Bonn
5. South American wood sorrel
6. Pertaining to the nervous system
7. Assault
8. Raw fish
9. Suffix meaning native
10. Small bite
11. Wing
12. Elec. unit
14. Woman's name
17. Uncles: *Scottish*
21. Upper atmosphere
23. Prison
24. Orderly
25. Hand over
26. Something previously mentioned
27. Male names
29. Hot drink
31. Long vehicle
32. Time zone notation
33. Bottle
34. African tribe
35. Pealed
36. Math. subject
37. Quantized property *S*
38. At this time
42. Ribonucleic acid
43. Ovum holder
44. Rude, in Madrid
45. Slanted surface
46. Programming
47. _____ *et thoro*
49. Chemical suffix
50. Drag
51. African plant
53. Quarrel
54. Behave
55. Not amateur
56. Post office order: *abbr.*
57. Acronym in 64 Across indicating amusement
59. Greek letters

Answers to Cyber Play will appear in the next issue of Mindsparks.
Solution to the puzzle in last issue is on the facing page (47) of this issue.

About our Contributors

Kent Brewster lives and works in Silicon Valley. When his medication is working he's a very nice guy. When it's not, he writes stuff like this.

Cathy Buburuz is a popular artist whose elegant work has appeared in numerous places. Her pictures are on pages 17 and 48 of this issue.

Cathy Miller Burgoyne lives with her husband in a beautiful and remote town in northern California. She has illustrated many publications, including page 25 of this issue.

Richard Dahlstrom is a versatile artist from Niagara Falls whose works have appeared widely in the small press. His art is on page 22 of this issue.

James S. Dorr writes fiction almost exclusively while helping support himself with a more mundane day job in an optometry clinic. His sales include *Science Fiction Review, Fantastic Collectibles, Pulphouse* and *Tomorrow*.

Marianne Dyson works as a freelance writer in Houston. She has made sales to *Analog* and also edits "Spacecause News." She has a physics degree and has worked as a NASA flight controller.

Charles S. Fallis is a pen and ink artist who has illustrated many small press publications. His art appears on page 19.

Roy Gray is a packaging technologist for a UK based international pharmaceutical company. He lives with his wife, son and teenage daughter in Cheshire, England.

Lawrence Greenberg writes stories, poems and articles. His work has appeared in many magazines and anthologies.

Larry Hammer has a masters degree in physics and lives in Tucson. His fiction has appeared in *Marion Zimmer Bradley's Fantasy Magazine* and he has also published scientific articles.

T. Jackson King is an Oregon writer and archaeologist who lives in the woods with his wife, SF writer Paula E. Downing, and their three children. He has had numerous pieces published, including the SF novel *Retread Shop*. He recently finished *The Turning of the Tide*, the sequel to *Retread Shop*,

Alfred R. Klosterman is a prolific and well known artist in the science fiction field whose work has appeared in many magazines. He designed the cover for this issue.

David C. Kopaska-Merkel lives in Alabama, where he works for the Geological Survey. His published works include both fiction and nonfiction, as well as poetry.

	M	A	S	S		S	H	E		E	T	N	A	
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S	O	D		V	A	N	I	L	L	A		A	M	I
A	M	A	T	I		S	O	L		U	N	I	O	N
C	A	R	E	T		E	N	O		L	E	M	O	N
	R	E	L	Y		R	A	W		T	E	S	T	

Solutions to GeoWord from last issue

Corrections to first printing of GeoWord: Clue 28 Across should read 29 Across. Clue 45 Down is "Higher mass to volume ratio" and clue 46 Down is "Shout."

Michael J. Mehl is a Physicist at the Naval Research Laboratory in Washington, DC. He earned a BA from the University of Kansas in 1973 and a Ph.D. from Indiana University in 1980. He had fifteen minutes of physics fame with a series of papers published with David Langreth in 1980–1982, which developed the "Langreth-Mehl density functional." Currently, he uses quantum mechanics to predict properties of new metal alloys.

Charles M. Saplak has published stories and poems in over seventy pro and semi-pro magazines and anthologies, and is currently working on a fantasy novel. He lives in Radford, Virginia with his wife and daughter.

Marge Simon is a prolific and popular poet, artist and member of the small press community whose work has appeared in numerous publications. Her art is on page 17.

Events

Continued from page 45

AD ASTRA FOURTEEN, June 17–19: Toronto, Ontario, Canada. Write Ad Astra 14, P.O. Box 7276, Station "A", Toronto, Ontario, M5W 1X9.

UNIVERSE 94, June 25–26: Northern Arizona University, Flagstaff, AZ. Ph: Astronomical Society of the Pacific, (415) 337–1100

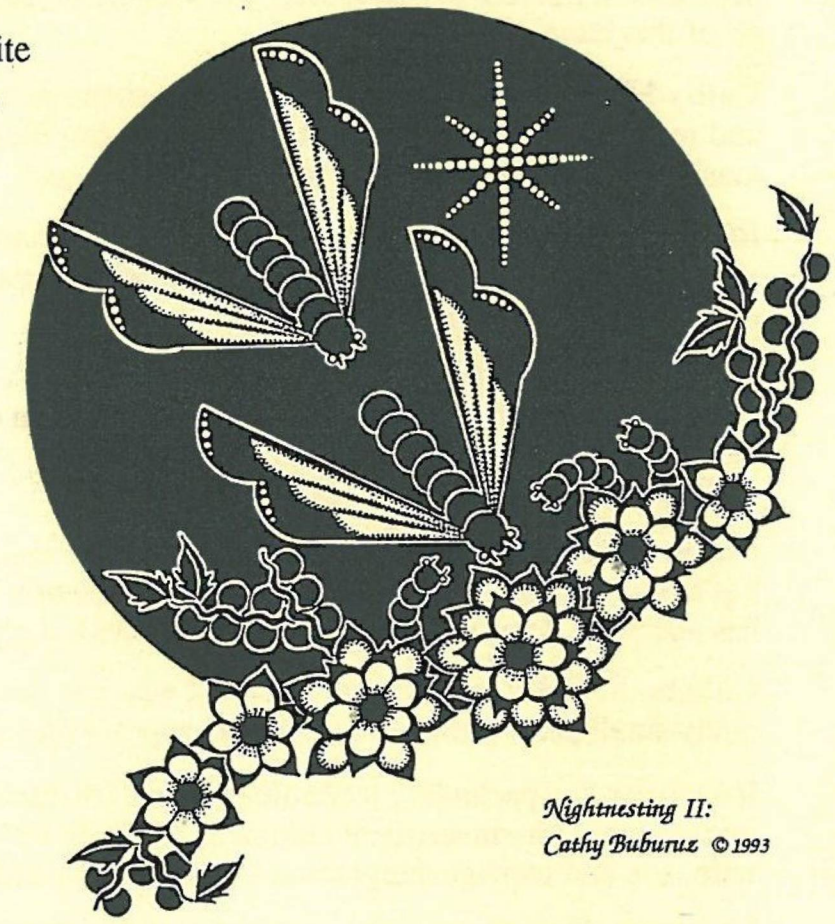
DRAGON*CON '94, July 15–17, 1994: Atlanta, Georgia. Write Dragon*Con, P.O. Box 47696, Atlanta, GA 30362–0696. Ph: (404) 925–2813 (24 hour line); (404) 925–0115 (office).

S.T.A.R.S. '94, July 13–14, 1994: Southeast Talent and Retailer Symposium, Atlanta, GA. Sponsored by Dragon*Con. Contact S.T.A.R.S. at the Dragon*Con address or numbers.

WORLD HORROR CONVENTION '95, March 2–5, 1995: Atlanta, GA. Limited membership. Write Box 148, Clarkston, GA 30021–0148

NASFIC '95, July 13–16, 1995: North American Science Fiction Convention, Atlanta, GA. Sponsored by Dragon*Con. Contact NASFiC '95 at address or numbers given above for Dragon*Con.

When writing for information, include a stamped, self addressed envelope. Groups interested in having an event listed here, send details to ***Events,*** *Mindsparks, P.O. Box 1379, Laurel, MD 20725–1379.*



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