Dialogue

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A journal of Calvin College art and commentary published monthly by the Calvin College Communications Board. Address correspondence to Dialogue, Calvin College, Grand Rapids, Michigan 49506. Copyright 1978 by the Calvin College Communications Board. Dialogue is printed on 100% recycled paper.

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Cover
"Mantessa," by Margaret Dykhuis
Several Calvin students spent the fall semester in Chicago on the "Chicago Metropolitan Semester." This program brings students together from six different Christian colleges and finds job internship placements for each student in his or her chosen field. The students live and work in the city itself, gaining practical experience in their disciplines, living in an urban setting, and getting an intense education in metropolitan life. The following are reflections on the Chicago program and on urban life in general by two of the students who participated.

Jim DeBoe

My internship was in a state-run community mental health center which offers counseling services to the community, as well as serving as a contact point for out-patients from the state mental hospitals. The range of people and problems coming into the center runs from problem children, family conflicts, and depressed housewives to chronic mental problems such as neurosis, high anxiety levels, and schizophrenia. The community was lower-middle to lower-lower class in inner-city Chicago, complete with welfare, pimping, and drugs. Enter one very nice, very white, and very middle-class boy-psychologist.

Exit one very confused student. The problems that I encountered constantly for the three months were so numerous and so deep-seated within the individuals that it was staggering. An entirely new and different world from safe, sane, secure Calvin and middle America hit me with a culture shock that resulted in a cycle of emotions from hopelessness and depression to frustration and anger to resigned cynicism. I am still amazed that people live in such hopeless situations; I still wonder where their strength comes from in the midst of such constant life-pain. Hatred and anger wrack family structures and result in broken marriages, distorted children, and siblings who are strangers to each other. God does not seem to live there or even to exist.

It is hard to say where the pain originates—in technocracy and the "big city" or in the day Eden’s gates closed. My guess is the latter; technology just gives fallen man a new context to be fallen in. Nonetheless, the main lesson Chicago and the mental health center offered me is that the pain in life is very real, it is strong and prevalent, and it lacks a cure. Carl Jung once said something to the effect that man cannot hope to escape suffering, he can only hope to escape blind suffering. (The Bible has a few comments on the subject as well.) I got an early taste of the end of the dream called Calvin College where the fourth year fades into the world, where people do not think in terms of God, let alone John Calvin.

This type of experience tends to crinkle one's faith around the edges a bit. Sometimes it even rips and tears. But on the whole, faith grows stronger and God seems a bit closer. Maybe that is one use God makes of pain. Anyway, there is a crying need for God and his comfort in this huge and hurting world. The needs are desperate in Chicago as well as in downtown Grand Rapids. It is a tremendously unChristian world; needs are waiting to be filled.

Jane Bosma

It’s early evening in Uptown. Inside a severe community college building a group of musicians gather for the square dance. Three guys from violin-making school tune up their fiddle, banjo, and mandolin. More old-timey musicians join them. At first glance, it seems they belong in a country grange hall. They don’t seem to think so. They like the city. Fred, the leader, tells curious folk at the door that a barn dance is going to be held here tonight. The Latinos, Blacks, Koreans, and East Indian on-lookers laugh, stay awhile to watch, and later join in once the dance gets going. The regular crowd gathers: a retired couple, a young divorcee, several single career men and women, a strict orthodox Jew, and a sixty-year old woman with a bad case of TB (travelling blood, she calls it) come together with others to dance Appalachian style. A Cherokee Indian taking a city break from the rodeo circuit joins them. The mixture of social classes, ethnic groups and religious backgrounds astounds me. I listen, learn, and let go a little.

The city is people. God’s image bearers. The staff of the Chicago Metropolitan Center (CMC) told us that from day one, destroying my first naive conception of the city. I expected it to be an inhuman monster of iron, noise, and smells that confined and subdued people against their will. Only a few talks on the bus, an introduction to the Loop, square dances in Uptown, and nights on the town were enough to convince me—the city is people; people who create, produce, destroy, expect, and need. How do I respond?

With that question in the back of my mind and at the base of the CMC study program, the semester became one of accel-
erated self-discovery. I wasn’t reading about moral and urban issues in the comfort of the Calvin Library. I was seeing the effects of them every day. The value system I had acquired in a somewhat disinterested manner during my three years at Calvin had to function for me or be discarded. The plethora of lifestyles I encountered daily demanded immediate response. How do I accept the large, visible gay population in Chicago? Is my religious conviction only a finishing touch on a well-rounded life of my making, or is it central to a life no longer my own? How do I love the powerful technocrats who unmercifully hoard federal money meant for the poor for their upper- and middle-class causes? The diverse questions carved my foundation stone until I knew more clearly than ever before what I believed and where I was coming from. At that point I was appreciative of Calvin and the concept of liberal arts education. My college education, as that which intends to prepare me for adult life, would not have been complete, if it had not been juxtaposed with the reality of city life.

A second important lesson I learned was that there was more to me than I thought. That is, I could rise to the challenge of self-directed learning in Chicago on fuel from inner reserves of spiritual and intellectual energy I didn’t know I had. This would be true for almost any Calvin student who would try out the program, I am certain. I am not saying I tackled the challenges in my own strength. Rather, I quit measuring myself against the competitive standard of the serious Calvin student, saw myself in relation to the average city dweller (if there is such a person), and discovered I had some basic equipment from my upbringing and education that would enable me to function effectively in the city. I had denied or buried some gifts within myself under the cover of humility. The challenges of the city make me affirm those gifts, acknowledge the giver, and use them. My confidence in my ability grew alongside my continuing recognition of my dependency on God. Simultaneously, the measure of hope and joy in me increased.

Hope and joy were two qualities I didn’t expect out of a city semester. I thought my ideals would be crushed, and I’d leave depressed and cynical for the most part. That shows how small I had let God become in my perception. I was pleasantly surprised and am still uncertain about the basis of the undying hope I have toward the city. But the people I met weren’t isolated, pathetic products of technology: they were, on the whole, friendly, creative people, hungry for more good relationships with others. I met them on buses, on the “ell”, in Uptown, at work, and on the street. Some of the people, even a few urban Appalachians, declared that Chicago is home and it’s hard for them to stay away.

I probably will find that it’s hard for me to stay away, due to the third lesson. I need the city and the city needs me. I need the city in several ways. The city offers the best in art, entertainment, and service to name a few important features. Its function as a center of communication, for example, enriched my job as a community organizer and small agency administrator. Clearinghouses of all kinds, people to match every interest, resource libraries on every subject are all available in one central area. I thrive on the challenges that come via visual art and drama, abundantly varied in Chicago’s museums and theatres. And, of course, the music selection in the city on a given weekend is phenomenal. The city requires a bright faith for a Christian, for a dull one dies there. I need that challenge, too. Finally, I need people and Chicago’s full of them.

Probably hundreds of people are hurt more than helped by the city—the entity they’ve indirectly designed. I refer to the people living lonely, empty, and desperate lives; the ones who struggle for the necessities of life and the ones who’ve got all they’ve ever wanted, except love and purpose. I’ve had to conclude that to these people I have something to give. The lasting hope, combined with the actual skills and the solid (solidifying) “world and life view,” is a gift I must give a few people in the city. I began, feebly, at the square dance in Uptown, middle evening.
Much of what anti-technologists claim to be the fruits of technology is truly undesirable. Theorists such as Ellul, Heidegger, and Roszak have blamed technology for the mechanized lives, the estrangement from nature, and the ugliness of our cities and streets. Surely these phenomena are beginning to wreak havoc on our existence here on this earth, but what is this thing called technology? Is it really a Frankenstein's monster, created by human beings, and now out of control?

Most anti-technologists hold that technology is the result, the application of technique, to every facet of life. This thoroughgoing application of technique, then, has resulted in the unbearable complexity and meaninglessness that is characteristic of twentieth-century life. Is it not true, however, that we employ technique when we hoe our gardens, play our musical instruments, and prepare our meals? Surely no anti-technologists would hold that these activities are in some sense harmful. Moreover, activities involving technique have always pervaded every area of human life. Technique itself, then, is not the culprit. Rather, there must be some other aspect of technology which renders it unbearable.

Anti-technologists also hold that it is the relentless application of the norm of efficiency that makes technology evil. Yet, on close scrutiny, this efficiency is also rather harmless. It is no more than a measure of the ratio of input to output. According to the anti-technologist, technology is characterized by a relentless drive to maximize output while minimizing input. This is not, however, necessarily wrong. If, in measuring efficiency, the factors considered in measuring input and output are sufficiently comprehensive, efficiency might well be considered very desirable. For instance, if, in building a factory, pollution, human psychological well-being, community health, and the quality of labor are considered in determining output, efficiency should also be considered.

What is wrong with technology cannot, then, be traced back merely to a deification of efficiency, although the problem does somehow involve efficiency. The evil of technology results when we limit the factors considered in determining efficiency. For instance, corporations often limit considerations of efficiency to economic and material factors, eschew-
ing psychological, social, and aesthetic elements. Thus, what is really a matter of corporate greed has been charged to the name of technology.

Other harmful technological systems are set up not for economic reasons, but rather to consolidate power and to monitor the actions of people. Many of our Western bureaucracies fit into this category. Here again, one cannot appeal to efficiency as the qualifying factor in this technocratic system. Rather, there is a conscious limitation of the considerations taken in determining efficiency.

All harmful technocratic systems turn out to be inefficient, rather than tremendously efficient. The evil in technocratic systems must be the result of something else, something much deeper. We have seen that such evil can result from the overriding desire for power or material goods. These are not, however, ultimate desires. When a person wants material goods or power, why does he want them? Surely not for their own sakes; there must be a more profound motive lying beneath the surface.

This motive is, it seems to me, the desire for a very corrupt, yet tremendously pervasive kind of human freedom. Those who desire this freedom hold that it is man's prerogative to conquer all that there is. In its most radical form, this idea of human freedom implies that man is the creator of his own world. Moreover, man considers himself to be autonomous; he may do with world what he wishes. It is this notion, I think, which is most fundamentally associated with the evil in twentieth-century technocracy.

This concept of human freedom, present in Western thought for centuries, began to predominate during the Enlightenment. Particularly among German philosophers this idea assumed a central and pivotal position. According to Kant, for instance, man is not satisfied with only a inner freedom; he must try to impress his purposes on nature as well. Hegel, a philosopher of the generation after Kant, expanded this notion. In reaction to the romantic idea that the world around man was somehow intrinsically one with him, he stressed the ultimate importance of man's transformation of nature. His thought runs something like this: man in his drive towards absolute freedom must envelope all that there is with his reason. This rational activity includes not only logical thought, but also labor and art—man's practical activities. Humanity through these rational activities gradually makes the true structure of reality—that of reason—evident. In the end, presumably, everything will be put in a rational framework—all will bear the stamp of human activity. Only when this is the case shall man have gained true freedom.

This same concept of freedom is evident in much of modern existentialism and modern psychology. All things outside of the individual are presumed to reside within that individual's consciousness. The world exists, then, for the individual's self-realization, or self-fulfillment. He is free to do whatever he wishes with the world: undertake projects, shape it, mold it—all to the service of his self in its freedom.

If man rejects this idea of freedom, if he resists the desire to have the world at his fingertips, then his notion of what constitutes acceptable technical activity will change. No longer will he then think of efficiency only in terms of power over the world and control over material objects. Rather, he will take every factor, human and non-human, into consideration.

What then should be the Christian's attitude towards technology? First of all, God created the world good—and man was made to exist in the world. We should not, then, want to conquer all that we find around us. Rather, we should attempt to preserve and enjoy it. In our technical activity, too, these should remain principles.

When technical systems come into consideration, we should attempt to preserve a close relationship of man to the world, of man to nature. Automatic and mechanized systems should be subjected to very close scrutiny, for they in particular tend to destroy the unity of man with creation. Often, at the expense of a closeness to nature, men desire to have a certain segment of reality under their push-button control. Lastly, our technology should be truly efficient. In building factories or power plants, we should consider every factor involved, not only, for instance, the economics of the situation. For God intended us to live our lives in wholeness and fullness in service to Him. This, rather than the barren, austere freedom that the secular world preaches, is our true end, our true freedom.
Easter

This poem first appeared in Dialogue in May 1974. Randy VanderMey is currently attending the University of Iowa's Writers' Workshop.

Nation after nation came
One by one, up the path,
Past the mailbox
And the picket fence, past the petunias,
Past the sign "Beware of Dog,"
Past the bulldog sleeping
With a smile on his face.
Each one came in turn
And stood on the welcome mat
And pounded in a nail, one at a time.
One through the foot, one through
The hand. A big shot from New York
Came and smacked one
Through the kidney. The kids came up
With sticky hands and took
Their licks. Bam. "Junior's got
Good hands, Marge, don't you think?"
Marge was busy pounding.
She bent the nail.
The policeman came up.

"Just one, lady. Get along."
He went away, up and down the long line
That stretched for centuries.
"Don't push. You there, come with me."
Etcetera.
Until only the sweeper was left.
Until what had been
A spread-eagled body
Lying whiter than a wedding invitation
Looked more like some kind of
Crazy iron armadillo
There were so many nails.

Dark came and the winds came trampling
Out of the east
Like bulls. The moon looked
The other way. But then it grew,
Like an idea, huge and red,
Wavy with heat.
Everything panicked. Trees shrieked
And withered in the moon's heat.
Birds rose like helium balloons.
Telephone poles popped like corks.
The night was brighter than
A hamburg stand.
The night was hotter than
A hamburg stand.

At last there came a popping sound
And nails were popping off
The crazy iron armadillo
Like buttons. All the nails.
Fizzing high into the air
Until the spread-eagled body
Once again lay white,
Rising like bread,
And the world and all the nations
Fell away.

Randy Vander Mey
Fullfillment

Chuck Dykstra
More Notes from the FBI

(After watching *King* part one on TV; Lincoln's birthday, 1978)

"Martin Luther King is the greatest liar in the United States."

J. Edgar Hoover

Walking home Sunday night late, remembering ten years ago April 4, in the evening a CBS NEWS SPECIAL REPORT.

I ran upstairs to dad, sick in bed. "Dad, hey Dad! He's dead." Laughing scared, "That great black man, I can't remember his name. He's dead." Dad got out of bed. "You know his name. In Memphis, Dad, he's dead." Dad said his name as he put on his robe, then we went downstairs to watch TV.

Walking into my sixth grade class at Oakdale Christian School, day after King's death, everyone's sad except one, he said, "I'm glad. They should have killed him sooner. My dad says it's good that he's dead. He was always causing trouble." Our teacher heard him and looked mad. When he called King a nigger, the old lady cried, and I wanted to hit him, arguing with him, that was impossible. I never spoke to him much again. The next year at school he was gone. Moved out to the country, someone said, and his dad had a junkyard.

Walking downtown Sunday afternoon, a memorial march of mostly whites, it was a hot day for April. We sweated, walking South Division in shirt sleeves.

A red convertible cruised by—men in sport shirts drinking beer. A man sat on the back of the seat—a blond crewcut shouting, "Nigger lovers!" Laughing half drunk, "Nigger lovers!" To the front of the march and coming back, "Hey nigger lovers!" His voice breaking, "You goddamn nigger lovers!"

Walking to the car in Philadelphia, Alabama, after a memorial service for three white social workers: Martin Luther King and friends. While the FBI stands on the side taking notes always taking notes of seven black men escorted out of town by a crowd: good ol' boys close in, with a few punches and pushes. They have been made foolish. They have been made blind. They can only harass through the fingers of God's hands around Martin Luther King and friends.

Speeding in a police wagon late at night, headlights short in the Georgia mist, King in sweats in the cage. Up front a German Shepherd barks, teeth lunging up to the wire. King against the side by the back window, "Hey! This isn't the way to..." Out the back window carlights speed up close—the dog barking. "In those days they could take a black man
out to some deserted country road.
Back then they might make him jump off a bridge
or just leave him in the gravel for the morning."

Walking home Sunday night fast,
from mom and dad's house—
color TV and California Almonds.
My shadow is deep blue
from mercury lights and snow.
Dog on a snow bank barks.
Headlights behind turn close.
The shadow stretches out giant.
I stiffen ready to jump into the snow,
looking quickly at traces of light behind trees
and black forms only bushes between houses.

Walking in the railroad yard of tire tracks,
corner of Alexander and Kalamazoo,
two black kids, one with a brown paper bag,
head home from the store just closed.
They are looking up at the sky; one points.
I come up from behind.
I ask, "What you looking at?"
One says, "Stars."
I say, "See any shooting stars."
One says, "Yeah, a couple."
I say, "Got to get yourself out west,
out in the country, pull off the side of the road
where it's black, lay back on the hood,
and just look at 'em. Then you hear something
rustling in the bushes, coming closer and closer
so you get out a flashlight but don't see nothing,
and you jump back in your car and run."

Bob Boomsma
On the shore of the Pacific Ocean, at Diablo Canyon in California, the largest nuclear power generating station west of the Mississippi sits dormant. The Pacific Gas & Electric Company spent years—and close to a billion dollars—to erect the twin reactors that power the plant, and after the last brick was in place, somebody discovered that the plant was resting only three miles away from a major geological fault line. Experts have estimated that the fault could produce an earthquake with five times the intensity of the one that rocked California’s San Fernando Valley in 1971. No one can say for sure that the huge reactors would remain standing through such a quake, and no one likes to think what might happen inside them in such an event; but neither do Pacific Gas & Electric or its many customers like to think of an outright billion-dollar loss or widespread electrical shortages. Together, the utility and its subscribers, along with the federal government, have yet to decide how much they are willing to gamble to keep their lights on in the face of a spreading energy crisis.

All competent analysts of the world’s energy supplies agree that we are facing an imminent, unprecedented, critical shortage of energy. Before the end of this century it is likely that our ability to produce energy will fall short of our accelerating demand to the extent that it will necessitate a permanent significant alteration of the standards of living of all industrialized nations. Few reputable experts consider it likely that the energy crisis can be averted; instead, our country is engaged in a campaign to decrease the intensity of the inevitable crunch. Resources with which to wage the campaign, unfortunately, are painfully—and in some cases embarrassingly—in short supply.

The energy history of the United States attests to inordinate waste and callous neglect. Oncoming critical shortages of natural gas were made part of the public record already in the fifties. Worldwide oil reserves are notoriously low, and it is unlikely that many significant oil fields remain to be found or economically exploited. “Exotic” energy sources such as solar, geo-thermal, and wind power do not hold much promise for large-scale development in the rest of this century. All realistic hope appears to lie in swift development of our coal and nuclear reserves.

The use of large quantities of coal—especially the low-grade, high-sulfur coal in greatest supply—would entail the ravaged land brought about by strip mining, and a likely gross increase in dangerous air pollution. Development of nuclear energy, on the other hand, poses perhaps the most formidable technological and environmental risks that we have ever taken.

No one involved with nuclear technology denies its risks. Radioactive poisons are extremely toxic, extremely long-lived, and virtually impossible to contain once released into the environment. Predictions by independent researchers of initial fatalities resulting from a nuclear power plant accident range as high as 133,000.¹ A report commissioned by the Atomic Energy Commission (AEC) in 1957 estimated possible property damage from a single accident as high as seven billion dollars—ten percent of the government’s receipts at that time;² an update of this report seven years later suggested seventeen billion dollars as a more reasonable estimate.³ A single major plant accident could render an area the size of Pennsylvania a lethal zone for five hundred years.⁴ In addition to this immense immediate damage, an imponderable number of cancer, leukemia, and genetic-damage cases would continue to show up years after a release of a plant’s radioactivity.

Nuclear reactor accidents account for a relatively small proportion of the potential danger involved in the whole nuclear fuel cycle, however. The nuclear fuel cycle entails “uranium mining, uranium conversion, uranium enrichment, fuel fabrication, radioactive scrap recovery, fissioning uranium in reactors, waste reprocessing, waste storage, and many transportation links.”⁵ Dangers of varying degrees are implicit in each of these steps, and many grave threats to public health and safety have already been documented in the relatively short history of the expansion of the nuclear industry.

It is clear that the debate over nuclear power, then, is not over the presence of risk—because the risk is undeniably there; rather, the debate is concerned with the extent to which technology can reduce that risk, and with the amount of risk we are willing to accept unconditionally in return for badly needed energy.

A tentative evaluation of the risk we face can perhaps best be effected through a consideration of two critical stages of the nuclear fuel cycle—nuclear fissioning in reactors and radioactive waste handling—with a review of the technology which has been developed, and some of the problems which have already been experienced.
In most respects a nuclear power plant is not so very different from a conventional fossil fuel-burning plant. Both are essentially nothing more than sophisticated steam generators. In conventional plants coal, oil, or natural gas is burned (a chemical reaction) to produce heat which is used to boil water and generate steam; in a nuclear plant uranium, or a similar atomic fuel, is fissioned (a nuclear reaction) to produce the heat. The steam produced by either process is used to drive the same kind of huge turbines which generate the plants' saleable electricity. Thus, the only significant difference between nuclear and fossil fuel plants lies in the method of steam generation. The tricky physics of an atomic furnace creates the dangers which belong uniquely to the nuclear plant.

There are a number of different basic nuclear reactor designs and nuclear fuels which can be used to produce power, but all reactors operate on essentially the same principles. The typical reactor is fueled with enriched uranium. Pellets of uranium dioxide are packed into twelve-foot-long metal tubes called fuel rods. These rods are arranged in bundles of from fifty to two hundred rods each. It takes about 40,000 fuel rods—around one hundred tons of enriched uranium—to completely fuel a reactor. The fuel bundles—which constitute the reactor core—are packed tightly together in a huge metal bottle called a reactor vessel which has special fittings to allow manipulation of fuel elements and to pump essential coolant water through the core. The reactor vessel and its machinery are housed in a large containment building—the windowless dome that is the trademark of nuclear plants—which is designed to withstand an internal force equivalent to the explosion of five hundred pounds of TNT.

The uranium in the reactor core undergoes fission: uranium atoms absorb subatomic particles called neutrons and then split, releasing energy, radiation, and an assortment of radioactive elements called fission products. Fissioned uranium atoms also release more neutrons which go on to split other atoms, thus sustaining a chain reaction. An uncontrolled chain reaction can result in an atomic explosion. A controlled chain reaction in a nuclear reactor produces vast amounts of heat which can be used to generate steam and electricity.

No commercial nuclear reactor currently operating in the United States can accidentally produce an atomic explosion. The fuel in its core is not sufficiently enriched to be bomb-grade material. Only a special type of reactor called the Liquid Metal-cooled Fast Breeder Reactor (LMFBR) has the ability to accidentally produce a nuclear blast. The United States does not now have any commercially owned LMFBR's, and President Carter halted construction last year on the prototype Clinch River Breeder Reactor at Oak Ridge, Tennessee. The one commercial LMFBR which did operate in the United States—in Monroe County, Michigan—was permanently shut down in 1972 after a dismal safety and financial history made operation impractical. Britain, France, Japan, and the Soviet Union, however, all have operating LMFBR's and active breeder programs.

That the United States' light-water fission reactors cannot produce atomic explosions is not by any means a guarantee of their safety, however. In fact, it is possible for the accidental release of a conventional reactor's fission products to produce a greater public health risk than would the explosion of an atomic bomb:

The radioactive fuel load of a reactor is larger than a bomb and more atoms are ultimately split in the reactor than in even a large nuclear blast. Whereas the blast lasts for only a fraction of a second, fissioning in the reactor occurs constantly during reactor operation. The result is a radioactive inventory larger than that created by a large atomic bomb. Moreover, when a bomb explodes, its fission products are blown up into the atmosphere, whereas when a reactor releases fission products as a result of a meltdown (accident), it doesn't have the same explosive force, so fission products are released horizontally at lower elevations where they can do more damage.

The danger potential of a reactor increases during its period of operation as the lethal fission products accumu-
late in the reactor core. After sustained fissioning, the core can build up one thousand times the long-lived radioactivity than was produced by the Hiroshima bomb.\textsuperscript{10}

**Accident Risk**

The nuclear reactor is a fantastically complex device; it is designed to operate under conditions of extreme heat and pressure. Maintaining adequate safety demands near-perfect human operators and machinery. Thus far the nuclear community has produced a safety record met by few other comparably technological industries. But there have been malfunctions and accidents. In 1975 the U.S. Nuclear Regulatory Commission logged over 1200 reportable "abnormal occurrences" at licensed commercial facilities.\textsuperscript{11} Although most of these occurrences did not seriously compromise the safety of the plants involved, there have been a number of considerably more serious incidents.

A large number of things can go wrong with any machine of the size and complexity of a large nuclear power plant. In a reactor the most serious accidents entail damage to the core, because problems in the core can swiftly compound themselves and lead to unstoppable disasters.

There are four basic categories of serious accidents involving the reactor core: the power excursion accident (PEA), the power-cooling mismatch accident (PCMA), the loss-of-coolant accident (LOCA), and the spontaneous reactor vessel rupture accident.\textsuperscript{12} Each type of accident involves a meltdown of the reactor core, a potential rupture of both the reactor vessel and the containment building, and a subsequent release of the reactor's deadly fission products into the atmosphere. Limited PEA's, PCMA's, and LOCA's have already occurred in reactors around the world. In some cases sizable quantities of fission products were released; but as yet there have been no accidents approaching the worst possible damage limits.

Of the four types of accident the LOCA is the least serious—\textsuperscript{13}—but is the most likely to occur, and the subject of the most research and discussion. Conventional reactors are kept "cool" by water under enormous pressure—1,000 pounds per square inch in a boiling water reactor (BWR), and 2,250 psi in a pressurized water reactor (PWR).\textsuperscript{14} But even with constant circulation of water through the reactor core normal operating temperatures there reach 4,300°F. If there is a loss of coolant in the core which is not quickly compensated for, the situation can very promptly become critical and initiate a core meltdown.

If there is any serious interruption of the flow of normal cooling water, the reactor is designed to automatically shut down ("scram") the uranium fission process by inserting control rods into the core. The control rods absorb the neutrons which would otherwise sustain the chain reaction. The core continues to produce heat even after it is scrammed, however. The generation of decay heat from fission products such as radioactive strontium and iodine continues, unaffected by the control rods.

Without the flow of coolant waters, decay heat alone will cause the core temperatures to rise 400°F every ten seconds. In less than a minute the fuel rods and surrounding metal would melt and fall into the bottom of the reactor vessel like molten wax. In something less than an hour the incandescent glob of molten fuel, metal, and fission products would burn its way through the reactor vessel bottom and drop onto the floor of the containment building. Having reached the point where no man-made material could any longer contain it, the fiery mass would vaporize the concrete floor of the containment building and continue to sink into the earth.\textsuperscript{15}

With tongue in cheek the nuclear industry refers to the process of the core meltdown as the China syndrome since that is the direction in which the molten fuel heads.\textsuperscript{16} The liquid mass would eventually cool enough to resolidify, but not before it had escaped the plant's containment and entered the outside environment. Before leaving the containment building the fuel would likely cause steam and chemical explosions sufficient to rupture the building\textsuperscript{17} and thereby release the radioactive gases under terrific pressure inside to the air outside. Winds could quickly spread the invisible menace.

Since it would be extremely costly and difficult—if not outright impossible—to construct a containment building that would be unbreachable in the event of a runaway core meltdown, plant designers have instead sought to reduce the likelihood of such an accident. The mainstay of their defense rests with the automatic scram system essential to safe shutdown of the reactor. In one case the scram switches of a BWR were found to be defective because of faulty manufacture—coatings on the switches became sticky with age. During a periodic test all of the switches for both the regular and back-up scram systems were found to be stuck shut.\textsuperscript{21}

Easily as troublesome as mechanical failure, however, is the unavoidably fallible human element. One notable case in which human bungling very nearly produced an atomic disaster was the incident at the Tennessee Valley Authority's Browns Ferry nuclear reactors near Decatur, Alabama.

The Browns Ferry nuclear power station consists of three reactors, two of which were operating early in 1975, and a third which was under construction. The two large BWRs were at full power on the morning of March 22, 1975, producing 2,200 megawatts of electricity and serving some two million customers. Shortly after noon a fire broke out on the floor beneath the control room from which the two reactors were operated. Polyurethane foam insulation surrounding electrical cables was accidentally ignited by two technicians who were
checking the area for air leaks. The fire quickly spread along cable trays that led into the facility's cable-spreading room—a central complex directly beneath the control room which housed all of the more than two thousand cables that ran all of the plant's primary and back-up systems.

Fourteen minutes passed after the fire started before the plant's fire alarm was sounded. Operators in the control room were unaware of the nature of the fire, however, and hesitated to shut the reactors down—not without reason: a single large reactor will cost a utility something on the order of ten thousand dollars for every hour that it is not producing power—nearly a quarter of a million dollars per day—and will create an annoying complication in the larger power grid as other power stations struggle to compensate for the loss and meet consumer load demands.

Six minutes after the fire alarm sounded, the reactor operators got their first hint that the safety of the reactors was in question: the plant's ECCS automatically kicked on. Warning lights in the control panels. The cable-spreading room was now well involved in the fire, and as insulation burned off the cables the electrical equipment was shorting out. The operating crew can monitor and control the reactor only from the remote machinery in the control room, as the fire knocked out their equipment, they were thrown further into the dark concerning what was happening in the reactors. No one really knew what action should be taken—or did they know for certain what machinery was left to do the job.

Only when, at 12:51, the main coolant pumps burned out did the operators finally decide to scram the reactors. Decay heat was already pushing up the core temperature. At 12:55 the ECCS electrical supply gave out and those pumps stopped. Plant personnel feverishly worked to jury-rig some machinery to get water to the overheating core. They used some small pumps which had not yet been deactivated by the fire but which were never meant to carry heavy loads.

After seven hours the crew managed to put out the fire, and the reactors were brought under control—but not before the Unit One reactor had lost 152 of the 200 inches of water normally covering the core. Operating procedures had been violated, 1,600 cables had burned, seven of twelve safety systems had failed, and the plant had come within four feet of a core meltdown.

The Browns Ferry fiasco caused considerable embarrassment for the nuclear industry. The investigation of the U.S. Nuclear Regulatory Commission (NRC) pinpointed eleven specific deficiencies in the plant's preparation for, and reaction to, the fire. Among them: construction personnel using open candle flames had received no training in fire fighting, and many were not even familiar with the plant's emergency procedures; plant management apparently made no effort to obtain expert advice on fighting the fire; emergency breathing apparatus had not been maintained had been installed in the area where the fire started than the plant's approved design specified.23

In addition, the NRC report states that "dangers involved in using flammable [polyurethane]...were evidently not recognized by plant management, even though several smaller fires had occurred during similar testing activities at the plant."24

We have no guarantees that the Browns Ferry plant accident was an isolated or unique incident. We have no guarantees that other commercial reactors have not violated their plant design specifications, that they do not employ incompetent or insufficiently trained personnel, that their safety equipment is adequate or even operational. We have no guarantees that at any nuclear plant a mistake in operation could remove effective control over the plant itself becomes a huge pile of radioactive garbage with no satisfactory place to store it is perhaps the most serious failing of the nuclear industry.

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24Ibid., p. 62.
25Ibid., p. 149.
27Ibid., p. 81.
28Natural occurring uranium consists principally of two isotopes: forms U-235 and U-238. U-235 comprises about 99.3% of natural samples, U-238 about 7%. Only uranium that has at least a 3% concentration of U-235 can serve as nuclear fuel, thus, natural uranium must undergo an enrichment process to increase the proportion of U-235 in the fuel.
29Berger, p. 39.
30Ibid., p. 42.
31Berger, p. 45.
32Ibid., pp. 44-45.
35Ibid., p. 22.
36The BWR and the PWR are the two principal nuclear plant designs in use in the U.S.
37Berger, p. 43.
39It has been estimated that the interaction of only percent of the fuel in the core, if molten, with its coolant water would produce steam explosions sufficient to completely rupture the containment building (see Webb, p. 22).
40Berger, p. 56.
41Ibid., p. 55.
42Webb, pp. 200-01.
43Ibid., p. 193.
44There are a number of reports, both technical and popular, on the Browns Ferry incident. I have based this account principally on Peter Gwynne's article in Newsweek (October 20, 1975, pp. 113-14).
47See Tom Wicker, "Dismantling of Nuclear Plants Poses a Crisis," Grand Rapids Press, October 2, 1977, p. 5B. It is noted that it currently costs more to dismantle nuclear plants than to build them—$100 million and up.
For the U.S. Atomic Energy Commission... and the nuclear industry there is never a problem. They leak radioactivity everywhere... and then comes the standard announcement: But the amounts are too small to be of any consequence to public health. That is sheer nonsense, and a fraud upon the public.

—Dr. John Gofman

The United States, along with the rest of the world, was fresh to the horrors of the atomic bomb when, in 1946, the Congress passed the Atomic Energy Act creating the Atomic Energy Commission. One of the priorities of the AEC was to be the diligent promotion and development of nuclear energy—a peacetime application of nuclear science to offset its dreaded wartime connotations. In 1954 President Eisenhower's “Atoms for Peace” program gave further impetus to the already strong federal push for commercial nuclear power. Nuclear science was still very young to be supporting a full-fledged technology, much less commercially owned applied technology, but only a vigorous promotion of the peaceful atom could hope to balance the bomb scare of the fifties. By December of 1957 the AEC, working with the Duquesne Light Company and the Westinghouse Corporation, managed to get a small reactor—the Shippingport Atomic Power Station—on line producing electricity for the Pittsburgh area, and the era of commercial nuclear power was off to its expensive, and perhaps premature, beginning...

The extreme haste with which nuclear power was developed aggravated the difficulties of on-the-job problem solving common to young technologies. One of the more significant problems that was avoided in those early days remains to plague the nuclear industry today: the handling of nuclear waste. As yet there are no satisfactory plans for dealing permanently with the steadily growing backlog of radioactive garbage being produced by the Defense Department and commercial facilities. Being stored against the day a permanent solution is found are hundreds of thousands of spent fuel rods from reactors, millions of gallons of radioactive liquid waste, and hundreds of millions of tons of uranium mill "tailings" from mining operations.

Nuclear waste is dangerous because it is radioactive; radioactive materials can cause cancer, leukemia, genetic defects, fetal damage, and death in humans exposed to them. In the early years of atomic research health physicists believed that humans could safely receive small amounts of radiation—that beneath some established threshold of tolerance, exposure to radiation would produce no damaging health effects. This threshold theory has since been abandoned; it is now the general opinion of the medical community that humans increase their chances of cancer, leukemia, and birth defects in proportion to their received doses of radiation right down to zero dose.

Everyone receives a small amount of radiation constantly—from naturally radioactive materials in the environment, from the sun, and from residual fallout from the extensive nuclear weapons testing of the early sixties. Additional radiation exposure caused by improperly maintained nuclear waste entering the biosphere could seriously increase health risks already present to some degree.

There are all manner of different types of nuclear waste, ranging from contaminated wash rags to spent fuel rods from reactors. The waste is graded by the amount and longevity of its radioactivity, as low-level, high-level, or transuranic waste (see box). Low-level wastes are routinely buried in shallow trenches in containers made of anything from cardboard to cement. High-level waste is extremely radioactive and enormously lethal—and will remain so for countless generations. Strontium-90, for instance, a fission product often found in high-level waste, remains dangerous for 740 years; it would require 500 billion to one trillion gallons of water to dilute the strontium-90 in one gallon of high-level waste to a safe level.

Transuranic waste consists of man-made radioactive elements (such as plutonium) which are known as alpha emitters: they produce primarily alpha radiation, a type which has only a limited ability to penetrate substances—a sheet of paper can stop it. When alpha emitters come into direct contact with living tissue, however, even minute amounts can pose a serious health risk. Less than a billionth of an ounce of plutonium, for instance, can cause fatal...
WASTE GRADE | TYPE OF MATERIAL | MODE OF DISPOSAL
---|---|---
LOW-LEVEL WASTE | Contaminated construction materials, tools, clothing obsolete machinery | Burial in shallow trenches, sea dumping in metal drums
 | Gaseous effluent from reactors | Release to atmosphere
HIGH-LEVEL WASTE | Spent fuel rods from reactors | Storage in holding pools at reactor sites
 | Leftover liquid caustic waste from fuel reprocessing | Storage in underground tanks
TRANSURANIC WASTE | Man-made elements contaminating high and low-level waste | Disposal with high and low-level waste

Lung cancer if it is inhaled. Thousands of pounds of transuranic waste are routinely buried along with low-level waste in metal drums or other impermanent containers. Plutonium remains lethally toxic for a quarter of a million years.

The nuclear waste problem begins where the nuclear industry begins: with uranium mining operations. The mining process produces vast amounts of sandy scrap material, known as mill tailings, from the crushed uranium ore. Better than 100 million tons of tailings have accumulated in New Mexico, Colorado, Utah, and South Dakota. The mildly radioactive tailings are, for the most part, simply dumped in huge exposed piles; winds blow the tailings around, and the airborne dust endangers all who inhale it. By the late fifties it was discovered that liquid effluent from milling operations was sufficiently radioactive to kill river fauna living in the New Mexico irrigation system into which the waste was dumped. The people of Grand Junction, Colorado, built their town out of concrete made with mill tailings. In 1970 the federal government finally got around to trying to remedy the situation. Sixteen schools were demolished and rebuilt; private residences have taken longer to replace, but most public structures are not scheduled for replacement at all.

The mill tailings problem continues to grow: if predicted industry growth rates occur, the United States will accumulate twenty billion tons of tailings by the year 2000—enough to cover the entire state of Rhode Island to a depth of seven inches. Covering mill tailings piles with two feet of dirt is the best—the only—measure that has been proposed for dealing with the waste. It is not at all clear that this is a satisfactory solution.

The difficulties encountered with tailings and other low-level waste, though significant, are dwarfed by the problems that the nuclear industry is experiencing with high-level waste, however. The genesis of most high-level waste can be traced to the reactor core, where immense quantities of long-lived radioactivity are produced. As mentioned earlier, the typical reactor has 40,000 fuel rods, one-third of which must be replaced every year. The amount of radioactivity in spent fuel rods is such that it would require all of the water in Lake Michigan to dilute the material in a single rod to safe levels. By 1976 commercial nuclear power plants had amassed more than 600,000 spent fuel rods—which are still lying in pools at the various reactor sites. No safe means for disposing of fuel rods has yet been proposed, and many plants are running out of room in which to store them. Consumers Power’s Palisades Nuclear Power Plant near South Haven, Michigan, petitioned for, and received, permission from the NRC to store spent rods closer together in the holding pools, thus buying a little more time. When the plant finally does run out of room, however, it will likely have to shut down.

When public utilities made their enormous investments in nuclear power in the late sixties and early seventies, they did so believing that a commercial fuel reprocessing industry would be growing with them. Reprocessing plants extract unused fuel from the spent fuel rods and return it for use to the plants. Only three commercial reprocessing plants were ever built in this country, however, and of these, two plants never opened. The one that did open—the Nuclear Fuel Services’ West
Valley plant near Buffalo, New York—operated for seven years with a dismal pollution and safety record until it was shut down for renovation in 1972. It never reopened.

Getty Oil, the parent company of which Nuclear Fuel Services is a subsidiary, has unsuccessfully been trying to find a buyer for the West Valley plant. The plant has 600,000 gallons of high-level liquid waste stored in underground tanks which have a life expectancy of less than forty years. Getty Oil and the state and federal agencies that collaborated in opening the plant have that amount of time to determine just who is responsible for the plant and its deadly waste. As yet, no one really knows. Nor does anyone know how the waste can safely be gotten out of the tanks, or what to do with it should that task be accomplished.

The U.S. government has been engaged in fuel reprocessing from the beginning of its nuclear program, and it has not solved the problems either. The Defense Department has produced better than 76 million gallons of high-level liquid waste which it is storing at three locations around the country. By far the most of this waste—55 million gallons—is stored at the government’s Hanford Reservation near Richland, Washington.

The Hanford Waste Disposal Site

The Hanford Reservation is a large nuclear-industrial park bordering on the Columbia River. It was one of the original AEC plutonium production sites, but now it serves principally as an atomic dump. By 1973 the facility had 237 acres of land committed to burial of solid low-level waste, more than 177 acres of man-made radioactive “swamps” (exposed open-air pools of liquid waste laced with plutonium), and 152 underground tanks filled with fiercely radioactive high-level liquid waste. It is at Hanford that the largest accidental spill of nuclear waste ever recorded took place: 115,000 gallons of high-level liquid waste leaked from a corroded underground tank for a period of two months in 1973 before the leak was noticed. Since this first huge leak at least nineteen other leaks have been reported.

The liquid waste in Hanford’s underground tanks is an unimaginably toxic witch’s brew: not only is it radioactive—so extremely so that it boils from the decay heat it generates—but it is also extremely corrosive. Before it enters the tanks, the liquid is highly acid; it is treated in the tanks with caustic chemicals in an attempt to neutralize the solution—with little apparent success. The tanks dissolve anyway.

The U.S. Energy Research and Development Administration has a contract with the Atlantic-Richfield Company which operates the Hanford facility. An NBC news correspondent taped the following interview with an ARCO spokesman at Hanford:

REPORTER: It’s been reported that you really substantially increased your problem of dealing with large volumes of liquid waste by using a neutralizing process. Are you still using that process?

SPOKESMAN: Yes, we still use that process.

REPORTER: If you know it created a problem, why don’t you change the system?

SPOKESMAN: This is the system that we were born with in 1944. All of our facilities are designed to handle caustic waste. To change at this point, in view of the fact that we have 152 tanks in place, would be a horrendous problem.

REPORTER: Is it fair to say that you are proceeding, and intend to remain in operation, with a 1940’s system that is really obsolete?

SPOKESMAN [after some hesitation]: I don’t have an answer to that.

[The plant manager answered the question]: If we were starting over again we would take the new technology, but we don’t have that privilege of starting over again.

REPORTER: If it’s determined that you would certainly not undertake this method today, wouldn’t it be better just to close the whole thing down?

SPOKESMAN: No, the process should not be shut down at this time. We should complete the mission. That makes good economic sense...

It is a chilling thought, but only a realistic one, that the economics of nuclear waste disposal may create a greater concern for those handling it than does the public’s safety. There is considerable evidence—as at Hanford—that this is already taking place on an ominous scale. At Hanford, as elsewhere, the waste cannot seriously be considered to be under control. Dangerous leaks are taking place on the shores of the Columbia River—already the most radioactive river in the world—which empties into the Pacific Ocean. Even relatively small leaks of Hanford’s high-level waste inventory would contain amounts of radioactivity that could not be diluted to safe levels by all the water on the face of the earth. If any significant amount of waste should reach the Pacific, the results on the
global environment would be incalculably catastrophic.

This, then, is the current state of the art with regard to nuclear waste: we are steadily accumulating ever-greater stockpiles of radioactive garbage with not one demonstrably safe means of storing it for the thousands of centuries that it will remain dangerous. No present technology can construct the container that will last for a million years; the tanks at Hanford did not even last the forty years they were supposed to.

The government has long had an active program of looking for some kind of permanent repository for high-level waste. One plan being considered is the burial of waste in salt deposits deep in the earth, but all of the proposed sites for such a project have already been rejected after detailed investigations consistently turned up undesirable features. Even optimists consider a working repository to be decades away at the earliest; whether we can contain the burgeoning backlog of waste until the day the postulated repository would become available is anybody's guess. The record of the industry to date would not seem due cause to be particularly hopeful.

The oncoming energy crisis will doubtless make increasing dependence on nuclear power a tempting option. If there is to be anything approaching a cool-headed debate of the real virtues and dangers of atomic power plants and the wastes they produce, it must take place now—while the lights are still on—or we may thoughtlessly produce a monstrous radioactive legacy that will leave subsequent generations with no choices at all.

"Nuclear Power: Pro and Con," American Broadcasting Corporation broadcast, June 7, 1977. Dr. Gofman served for twenty-seven years as a health physics specialist for the AEC, and is now one of the most outspoken critics of the health risks being produced by the nuclear industry.


ibid., p. 75.

ibid., p. 82.


Berger, p. 83.

"Danger: Radioactive Waste."

ibid.

ibid.


ibid.

ibid.

"Danger: Radioactive Waste."
The North Forty

At forty below and the wind blowing,
It’s a long haul to the outhouse.
Your cigarette will not keep you warm,
Nor will Miss August, nailed
To the back of the door, hanging
Under the half-moon, impaled
On a shithouse spike, smiling
At someone else—waiting.
There’s a rim of hoarfrost waiting
(You know there is)
Even as you pull up your
Boots, and pick up your
Lantern and head out
The back door.
At forty years old his belly growing,
He’s thinking of trouble with his longjohns
(The crap-flap rather small
and buttons tighter than before)
A rotten country where the danger lies
In freezing to the toilet seat,
With no one by to help.
And in the summer with the flies
And heat and wretched stench
Backyard full of shallow holes from
Former movings (always less dirt left
From what you first removed).
And water water everywhere
But not a drop to flush.
At forty feet out and forty owing,
He slips falls settles
In the snow.
This place is a desert; of ice yes,
Rocks, hills, and frozen trees maybe,
The odd person here and there,
White eskimos even,
And though he’s driven iron teeth through trees,
And ripped up hidden earth
Around, over, into rocks,
Extracting sustenance,
Yet with every winter he risks his flesh,
He bares his flesh and dreams,
He dreams of flush toilets.

Al Aasman

Christmas

The ornamented tree
perched like a king on a throne
takes in half of
the high-ceilinged living room,
but it is humble and warm—
grateful for the many people
gathered around
The pirojki and pumpkin pie
went down well.
Papa, high on wine, tickles his children
and speaks of his circus days
when he did tricks
like a squirrel.
Billy's older sister plays carols,
even his brothers join the singing.
They will be leaving
for midnight mass in about an hour.
Outside the snow sleeps
on the window ledge.
Most of the evening
Billy and Lisa,
holding hands on the couch,
talk about buying a station wagon
and going to the ocean.

Chris Campbell
Death in the Chapel

Gray stone rests upon her chest;  
breath of peace does not descend.  
It cannot wind  
through ermine lined  
with silk.

Hands together, yet unclasped,  
for sapphire hugging gold  
sets upon the fingers each,  
with roots that reach  
into her dried up soul.

A length away, a life beyond,  
a lover of the sparrow stands,  
preaching vows of poverty  
of humility  
to God.

Now left alone with all the world  
that groans the rich man’s sigh,  
she weeps to hear the Master’s voice  
and mourns her choice  
to die.
The Problems and Promise of Biofeedback

Put your right hand over your heart. Can you feel it beat? Now, try to increase your heart rate. Can you feel it beat faster?

You have just participated in a very crude biofeedback demonstration. Your hand, acting as the receptor, has passed to your brain information about the functioning of one of your internal organs. Any type of information which one receives concerning the functioning of his internal organs is biofeedback. Further, you have attempted to use this information as a guide to the control of an internal process—your heart rate. So, you have engaged in a small experiment to determine the role of feedback in voluntary control of the heart rate.

Obviously biofeedback is a much more complicated and diverse area of study than what has just been described. However, all of the basic principles involved in voluntary control of internal processes through biofeedback were mentioned above. First, information about a bodily activity is received and recorded; second, the information is transmitted to the brain; and finally, this information is acted upon. We attempt to effect changes in our physical states with our minds, to alter our bodily functions with a conscious act of will. Some might call this mind control.

Perhaps you are now raising some objections. Maybe your heart rate didn’t change much, if at all, during our little experiment. Why didn’t it change? To answer this question we must first become familiar with some of the physiological theory underlying biofeedback techniques.

To begin with, all of our bodily responses are controlled by either our skeletal nervous system (SNS) or our autonomic nervous system (ANS). The SNS is generally thought to control all voluntary behavior—that behavior which is within the realm of conscious control. In contrast, the ANS responses are thought to be involuntary—i.e., not under the control of the conscious mind. ANS responses include the activity of the body’s internal organs and glands.

It would seem that we have found a reason for the heart rate’s failure to increase: the heart beat is an autonomic function. This is the same explanation that most physiologists before 1960 would have given. The reason they would have cited would likely have been their belief that ANS responses were only that—responses. They would have said that the ANS received stimulation from the central nervous system (brain and spinal cord), but sent none back; in other words, there was no feedback. On the other hand, skeletal responses, though being efferent (i.e., receiving central nervous system stimulation), were also afferent: the skeletal system sent information back to the central nervous system (CNS). One might say that the CNS receives feedback from the skeletal system. An hypothesis becomes readily apparent: for any response to be voluntarily controlled, there must be feedback—biofeedback—to the central nervous system.

By now we have established two facts: (1) we can voluntarily control skeletal responses, and (2) we can establish this control because skeletal responses have afferent feedback channels. But can you produce just half the stimulus required to make your right leg move? Obviously you cannot. The reason is simple: you have no sense of what half the necessary stimulus would be. But isn’t moving your right leg a matter under the control of the SNS? Doesn't this mean that you should have voluntary control? It would seem that a limitation must be placed upon one of our assumptions. In order for control to be effected there must be a relatively large amount of neural response—large enough to be recognized by the conscious self.

It would appear, then, that the most essential aspect of biofeedback training is communication of the nervous-system feedback to the conscious mind. Obviously the body has limitations in this communications area. The limitations are drawn at the perceptual thresholds of our basic senses—sight, hearing, and pressure—i.e., at the point of the smallest changes in sensory stimulation that the body can perceive. What can we do to transcend these limitations, to increase the body’s ability to receive feedback from its different members?

In biofeedback, mechanical equipment is used to detect and amplify bodily signals. Let’s go back to the idea of stimulating nerve tissue in your leg. As your senses presently function it is impossible to gauge amounts of stimulus less than the amount required to move the leg. But, suppose that we attach a very sensitive receptor to your leg above the muscles we want you to stimulate this control because skeletal responses have afferent feedback channels. But can you produce just half the stimulus required to make your right leg move? Obviously you cannot. The reason is simple: you have no sense of what half the necessary stimulus would be. But isn’t moving your right leg a matter under the control of the SNS? Doesn’t this mean that you should have voluntary control? It would seem that a limitation must be placed upon one of our assumptions. In order for control to be affected there must be a relatively large amount of neural response—large enough to be recognized by the conscious self.

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Michael Vredevoogd is a senior majoring in psychology. He has been working with Calvin’s biofeedback equipment for more than a year.

Michael Vredevoogd
attached to a voltmeter whose reading would vary in accordance with the nerve stimulus. This receptor would be at the leg. You would find that you could control the variations in nerve stimulus with very little practice.

If such an experiment doesn’t seem particularly impressive, consider a practical application of the method: let us suppose that you are a child who has just recovered from polio. Your muscles are exceedingly weak; in fact, although you try to move them, you cannot feel any response from the muscles. As a result of this lack of feedback, physical therapy moves very slowly. Now, let us tie in an extension of the senses through mechanical biofeedback techniques.

We will record the voltage given off by each of your leg muscles so that even though you cannot feel the response, you know that something is happening. Exercising your leg muscles can now be guided by feedback registered on the dial of a voltmeter, rather than by inadequate bodily senses. Mechanical biofeedback technology enables you to strengthen and control your muscular responses much more quickly and efficiently than under normal circumstances.

That is all that clinical biofeedback amounts to. Quite simply, it is an extension of the senses through mechanical means.

Now, let’s go back a bit and reconsider autonomic responses. It was mentioned that before 1960 most physiologists believed that autonomic responses could not be consciously controlled, and suggested as probable cause the lack of afferent feedback pathways to the central nervous system. Recent research has questioned both of these assumptions. It has been discovered that ANS responses can be controlled through the use of biofeedback techniques. The old distinctions between the SNS and the ANS related to voluntary control of responses are beginning to fade. It would appear that, given biofeedback training, an individual may find himself able to control any bodily response.

At present there are many responses being examined. One response in which biofeedback researchers are especially interested is the EEG activity of the central nervous system. EEG, short for electroencephalogram, refers to the electrical activity of the brain which results from neural discharges. Simply, each nerve in your brain gives off an electrical charge every time it is stimulated. These electrical charges are classified according to frequency, which is to say the number of impulses (cycles) which are given off in one second. There are four basic EEG frequencies: delta, 1–3 cycles per second (Hz); theta, 4–7 Hz; alpha, 8–12 Hz; and beta, 13–40 Hz.

Researchers have found that EEG training has resulted in some very interesting and exciting phenomena. For instance, it has been found that training epileptics to increase alpha production resulted in drastic decreases in seizure activity; in fact, seizures were decreased by a factor of ten. Other researchers have related EEG variations to creativity.

There are many other questions which remain to be answered. We know that there are EEG changes which occur during sleep. Do these have an effect upon what we dream? What about memory? Are there specific EEG patterns which predominate in individuals with exceptional recall? Can this recall ability be altered with biofeedback training? The questions and implications involved in biofeedback studies of EEG alone are tremendous. But EEG is only one aspect of biofeedback technology.

Scientists are also researching the effects of EMG (electromyogram) training. EMG is the amount of electrical discharge given off every time a muscle contracts. The greater the degree of contraction, the greater the proportion of electrical activity produced. Researchers believe that EMG training may be the key to training hypertensive individuals to relax. Aside from hypertension, there are many other possible applications of EMG research—e.g., reduction of anxiety through relaxation training, treatments reducing severe headaches and migraines, and perhaps treatment for insomnia.

Many other possible applications for biofeedback technology exist. Indeed, the only limitation to the science may be the imagination of those involved in research. Present research is looking into such areas as controlling cardiovascular functions such as heart rate and blood pressure, achieving temperature control, checking the effects of EEG training on mental imagery, and alpha stimulus as a means to block or repress chronic pain.

However, when I introduced the various aspects of research, I said that an individual may be able to control his responses. I said may because biofeedback is still a very new field, and although it would appear that the possibilities are limitless, there is still much to be learned and explained. For example, why are some people able to control responses while others are not? Obviously there are many different physical and emotional variables which could explain individual differences in ability to benefit from biofeedback training. These factors, and how they relate to the individual, make biofeedback research a challenging and interesting area of research. Until these factors are investigated, however, we cannot speak of biofeedback as anything more than an area of great promise, and very little practical use.

Suggested Reading:

*New Mind, New Body,* by Barbara Brown

*Beyond Biofeedback,* by Elmer Green

Both books are perceptive considerations of the current state of biofeedback science, and are written especially for the layman.