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Between Cosmology and System: The Heuristics of a Dissenting Imagination[1]

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INTRODUCTION

The history of the debates between tradition and modernity in India is a story that has been told twice. The first fable centers on the archives of the national movement;[2] the second springs from the debates on science and technology enacted during the grassroots struggles of the last two decades. These debates in India, both in the colonial and post-colonial eras, have been marked by three qualities.

First, the notion of hospitality. The national movement sought to overthrow colonial rule yet was confident enough to invite the British to participate in the debates on modernity. Some of the most fascinating contributions to the understanding of traditional systems came from these dissenting Englishmen. "The other colonialisms," as I call this genre of discourse, saw in India a set of possibilities that the West had either out or rendered recessive. These Englishmen were particularly interested in creating a more humane transition to modern industrialism. One can cite the works of Patrick Geddes, Albert Howard, and Alfred Chatterton in this context (Visvanathan, 2001a).

Second, the Indian national movement also saw the West as a possibility. We fought the West but the West, like the Orient, was not just out there but something within ourselves. It became an experimental site for the free play of the nationalist imagination, which sought to liberate the other Wests that England had suppressed within itself.

Third, while the concerns and experiments in science, technology, medicine, and education were local, there was a feeling that the neighborhood must reflect the interests of the cosmos. Furthermore, the debate did not reify the dualism of tradition and modernity, especially in the domain of knowledge, but sought an encounter that was both confrontational and

dialogic. Tradition and modernity were not only self-critical sites but were also what might be called a complicity of opposites. Unfortunately the pluralist archives of the nationalist movement became partially submerged in the 1950s and 1960s. They appeared more in the form of eclectic quotes used instrumentally to make less fascinating arguments.

These debates were however re-invented during the spate, the epidemic, of experiments in science and technology that arose in the early 1970s, triggered by several phenomena. One must emphasize in particular the famines of Bihar, the Emergency (which was the declaration of a dictatorship by Indira Gandhi), and the abortive Marxist movements that began at Naxalbari. This chapter begins with the backdrop of these events. In the domains of science and technology, what one saw was an encounter between transfer-of-technology models and social movements like those concerned with forestry (Chipko), anti-dam struggles (Narmada, Koel Karo), anti-nuclear protests (Kaiga), and scientific movements like that of the Kerala Shastra Sahitya Parishad (KSSP). Many of these groups spun off their own critiques of science and knowledge, and these I believe can be mapped in terms of their positions *vis-à-vis* the transfer-of-technology model (TOT) (Visvanathan, 2001b).

The TOT model is the genetic code of the Third World nation-states. The nation-state is a modern creation. It represents a social contract between the state and modern Western science to pursue the twin projects of security and development. The battle between traditional knowledges and modern Western science was fought in this political context. Simplistically put, the TOT model is an innovation chain, and it consists of three phases: invention, innovation, and diffusion. The invention stage represents the conceptualization of a scientific idea and its possible translation into a small sample or a product. Innovation is the upscaling, the commercialization of the idea, from pilot plant to market. Diffusion represents the wider extension of the product into society. The three stages of the chain are not monotonic.

The science movements, the experiments in science and technology that arose in the last two decades, can be mapped in terms of the critique of the TOT model. It represents, as it were, a quick semaphore of the politics of knowledge in the last two decades. The movements in science that were inspired by the left "black-boxed" modern Western science as a cosmology. Their dream was to diffuse Western science. India, they felt, would be more democratic as it became more scientific. Science, modern Western science, was to be a liberating Brechtian force that was to be the domain of every citizen. So democracy in science became analytically reduced to two acts: First, diffusion and second, participation. The lingo of the World Bank and left groups like the KSSP, the Delhi Science Forum (DSF), and the Bharatiya Gyan Vigyan Samiti (BGVS) often sounded similar.

Outstanding among this genre of movements was the KSSP and the Hoshiangabad experiment in Madhya Pradesh. The latter was a superbly conceived exercise in pedagogy, of taking science to the villages. The preoccupation was with science books, science kits, weaving the environment into the child's imagination. The KSSP, like the Hoshiangabad experiment, was generally leftist and modernist. It was conceived as a giant tutorial college, a popularized cram course in science, replete with quizzes. It was a populist drama of science with Desmond Bernal, Albert Einstein, and C. V. Raman as heroes. Its greatest achievement was to help save one of the last great tropical tracts of land, the Silent Valley in Kerala, from the impact of development. The KSSP used traditional forms of theater like the *Jatra* for diffusing science, although in this case tradition was more a costume ball within which the modern script of science was enacted. Its attitude to traditional knowledge verged on the illiterate and its theory of science was desperately positivist. The DSF and the BGVS were all lesser clones of this same imagination and worked at the diffusion end of the map. As a result, they often became extension counters of the regime. Their attitude to traditional systems was patronizing or hostile.

The innovation phase was the preoccupation of many Gandhians and scientists working on technologies. This pluralism of experiments, ranging from the Khadi Village Industries Corporation (KVIC) to the Application of Science and Technology to Rural Areas (ASTRA) at the Indian Institute of Science at Bangalore has often been grouped under the Schumacherian idea of intermediate technology. Schumacher himself was a consultant to the Indian Planning Commission. Outstanding among these experiments was Amulya Kumar Reddy's ASTRA at Bangalore. Its contributions to energetics, to biogas plants, and to the conceptualization of biomass are classic. For ASTRA, traditional technology was both rational and ecologically sound but it was a text disrupted by new contexts. This group worked with the basic belief that science was universal but that technology was local and adaptable. *Local* knowledges, *local* materials came into play in this context. Ashok Khosla's Development Alternatives (Delhi), now playing the scripts of sustainable development, is another example of this genre. Within this discourse local knowledge was welcome, but epistemology was noise or taboo.

A more critical focus came from a fascinating group that had christened itself with a terrible name: the Patriotic and People Oriented Science and Technology Group (PPST). Basically a group of scientists and technologists from the Indian Institute of Technology and the universities, it sought its inspiration in the historiography of the maverick nationalist Dharampal (Dharampal, 1971). The group claimed that colonialism destroyed not only the political economy but the epistemological basis of Indian society, namely agriculture. The *PPST Bulletin* chronicled the strengths, the imagination, and the rationality of traditional systems of agriculture, medicine, and water management. It was fascinatingly orientalist in some ways but it also provided a devastating critique of the scientific antics of the Indian nation-state. Its annual conference, part fair (*mela*), part science congress replete with papers, reflects both its statist policy inclinations and a touch of the carnivalesque.

The one set of movements not generally included within this frame is that of the farmers' movement, the anti-dam struggles, and forest movements like the Chipko. Each of these titanic struggles produced their own hermeneutics of science. The work of Vandana Shiva (1988), Claude Alvares (1995), and Sunil Sahasrabuddhey (1991) are outgrowths of this struggle. The writings of Jit Uberoi and Ashis Nandy are more rarefied academic reflections in this genre. Chipko has been hyphenated with a feminist critique of science. The farmers' struggle is addressing the issue of genetic diversity where the question of traditional knowledges is central. To this we must add one organization, a science laboratory that has fought a lonely, exuberant, maverick struggle to create a different dream of science, inspired by the intellectual exuberance of the chemist C. V. Seshadri (Seshadri, 1993).

His laboratory became the site for a beautiful set of experiments, an encounter between tradition and modernity that was playful, elliptical, plural, and utterly unfundamentalist. It was a critique of modern scientific knowledge conducted by a practicing scientist. The Indian adage that good scientists do science, but that bad ones do science policy does not apply to Seshadri. But Seshadri argued that the scientist must be his own anthropologist and philosopher. The work of the Murgappa Chettiar Research Group produces as it were a frame for the debate between traditional and modern knowledge. It begins with three suggestions.

One, the work of the science movements produced its own historiography of science. The grassroots groups in various forms were the dissenting academics of the university and the national laboratories in India. Plotted across the TOT model we get a new critique. Science as a black box is opened up. The work of the movements can be visualized in terms of two oppositions: first, the opposition of internalist and externalist approaches to science, and second the opposition between exoteric and esoteric approaches. Science becomes not only a political economy *à la* Marx but a cosmology.

Two, the challenge arises of how other religions and cosmologies can introduce life-giving hypotheses into science. The classic example is the work of J. C. Bose, the Indian botanist.[3] While the first step opens the black box called invention, the second introduces knowledge as a problem in democratic theory. Questions of cognitive justice and methodologies of assessment all become crucial. How does one relate the question of energy and justice? Seshadri's theory of energetics and biomass becomes central to this debate.

Three, the debate between tradition and modernity is not one of preservation or conservation. In an everyday sense, it emphasizes the importance of invention, of heuristics. We need neither a rigid theory of the modern nor an ossification, an orientalizing, or a museumification of tradition. In Seshadri's laboratory, tradition and modernity meet in the theater called the laboratory. Science becomes an inventive morality play around the dreams of energy in India and neither tradition nor modernity is privileged in this agonal struggle.

This chapter begins with some biographical reflections which could also be considered as reflections on biography. It then moves to a more impersonal phase and describes the conceptualization of energy in India and Seshadri's critique of thermodynamics. The next section deals with the politics of a biomass society and Seshadri's experiments to develop quality markers for projects in science. The final section deals with Seshadri's efforts to link science and democracy. The whole effort is presented as a thought experiment, a site for the heuristics of a debate. One hopes that more such dramas are enacted in the years to come.

BIOGRAPHICAL REFLECTIONS

C. V. Seshadri was a scientist, an engineer trained at Bombay and Carnegie Mellon University. He taught at the Indian Institute of Technology (IIT), Kanpur, where he wrote a standard book on fluid dynamics. He left IIT to establish India's first yeast factory. The last two decades of his life were spent at the Murgappa Chettiar Research Centre at Chennai.

C. V. Seshadri was more than a scientist. He used to growl, "I am not a sociologist of science. I am a scientist and I want my science to do the talking." And talk it did, in many voices. I can still remember the day he drove in late, stood in front of the car glaring at the tire as if it was a new exotic species. He looked like a huge little-boy-lost and said, "Gender was the first diversity and we muffed it." I asked him wickedly, "Did you quarrel with your wife today?" and he said, "Yes," as if "yes" was an affirmation of life in all its complications. For him everything was autobiographical and everything was cosmological. He loved life in its grand patterns and loved life in its little particulars. I remember his student V. Balaji once told me, "for Doc, science was not about policy and populations. Science was about particular persons. He wanted to know what troubled Rajathi and he turned her complaints into scientific problems." For Seshadri, an autobiography could not be an act of bookkeeping, and he hated the chartered accountants of life. He made mistakes and he hurt people. Some of his decisions were

disastrous, particularly the choice of his successor. Yet he could reflect on his mistakes. He was a hundred unfinished hypotheses. He was fascinated by death, was himself quite a hypochondriac, but saw hypochondria as a collection of redeemable hypotheses.

He felt Indians were cosmologists except when it came to modern western science, and he missed this cosmic daydreaming and this thinking with the hands. He wanted science to be a life-giving myth and he read and reread Descartes, Poincaré, and Feynman in order to envision the possibilities of one. He saw the Cartesian meditations as an ethical exercise. His was an anthropological, even a religious sense of science as a mode of thought and a code of conduct. A Confucian science. An ethics of possibility. Not method but ritual and, beyond method, lifestyles. He loved Paul Feyerabend but saw his epistemological anarchism as a truncated critique, a Dadaism that never really challenged method because it failed as a cosmology.

He loved words, their magic, and their etymology. He was obsessed with dictionaries as a form of life and always wanted to write one. An Ambrose Bierce on science, a philosophical dictionary, a "don't use me" dictionary.[4] He had even scribbled the beginnings of one. For him everything was a sign to be read. Landscapes, buildings, and bodies. Even chemistry was an almost semiotic discipline, an alchemy where matter, meaning, sign, symbol, and symptom could combine and yet be read separately. In that sense, the history of science was a part of science and not separate from it, as De Solla Price and other historians had argued.

The socialist leader Ram Manohar Lohia once wrote a fascinating piece on the two models for modern India, Mohandas Gandhi and Visvesveraya. He saw them as ideal citizens and emphasized the competitive complementarity between them. One was the author of *Industrialise or Perish*, the other of *Industrialise and Perish*. Seshadri's ideas pushed this perspective even further. He saw in each the idea of the autobiography as an experiment. Gandhi wrote of his life as an experiment on truth while Visvesveraya wrote everything as if it were a scientific report. The autobiography with the body as vessel and the self as experiment itself becomes a laboratory, a thought experiment. Seshadri wanted to see each life as a set of unfinished hypotheses. It is only when a life is incomplete that it is a part of the whole. Seshadri felt that autobiography as experiment prevents it from being an iconography or a hagiography. Otherwise India becomes a demographic anomaly, a population that makes no mistakes from Shivaji to G. Parthasarathi. Science allows for that confident open-ended humility.

When the self becomes an experiment, the standard dualisms of western science are broken or rethreaded in interesting ways. Bruno Latour once made a fascinating Archimedean statement: "Give me a laboratory and I will change the world." In this sentence, subject and object are still estranged, the observer and observed still distant. The experiment as an existential act is still on the other. To this the Seshadrian reply would have been, "Give me a laboratory and I will change myself." One could respond similarly to the ethics of the Cartesian meditation: "I think therefore I am." It becomes "I think of the other, therefore I am."

The "I" of science is a denatured I. But there is the I of evolution, of cosmology, of genealogy, of civilization, and of citizenship. The reductionism of science and its power begins with the impoverishment of the I, of the self in science. For Seshadri, an autobiography begins an experiment in the construction of the self and the self he wants to unravel is the Brahminic, scientific self. In an everyday sense Seshadri knew his laboratory was called "Iyer and Company." He was deeply aware of his Brahminism and deeply critical of it. He wanted to sustain it, reinvent it, and exorcise it. He realized the deep affinity between Brahminism and science, an affiliation as deep as that between Protestantism and science as immortalized in the essays of Max Weber. In both, there is an effort to look at that devastating combination of repression and creativity that we dub as science.

Seshadri and I used to talk about Brahmin Madras for hours. I didn't interview him. We gossiped, compared notes, talked of intellectual pregnancies and philosophical corns.[5] There was an aloneness in each that the other recognized. I remember a line in Bar-Olman's book on physics where there was an inexplicable statement, about science as a solace, a balm for grief. It had been underlined almost tentatively, almost shyly. We were both preoccupied with genealogies, felt generations of time and multiplicities of time within us. We were Brahmins. There is a crudity to the fact, even an obscenity that we recognized. To be a Brahmin is almost unforgivable in Marudur Gopalamenon Ramachandran's Madras. I remember a colleague of mine, a Lohiaite Socialist, fat, in his forties, raving against Brahmin hegemony. Seshadri listened quietly and then asked "How many generations of public service will exonerate me for being a Brahmin?" An ethical self was confronting a political cut-out. Yet Seshadri knew he was a double anachronism, someone who didn't fit in the ghettoized world of Brahmin Madras. He was fascinated by elite Brahmins, who were the scientific hawks of the nation-state, and who were also perpetual émigrés of the mind, who saw San Francisco and Princeton as an annex, an upmarket extension of Adyar, Madras. He also knew that in a deep and fundamental way that we were the last Victorians.

He knew that any critique of Tamil Brahmin science must begin with the grandfathers. He saw grandfathers as a heuristic, a halfway house between genealogy and autobiography. He used to make me talk about my family and about Bengali scientists. We used to chuckle wickedly about a photograph of the Calcutta School of Science, which included Raman, Ramanathan, Venkatesvaran, Ganesan, Krishnan, Ramdas and, yes, there were a Bannerji and a Ghosh thrown in. Talking about science at that time we classified scientists in terms of two musical metaphors—the piano and the violin. The piano was classically Western. It stands outside Indian culture and yet has a niche in it. Popular culture captures it best. When there is something everyday but Western the piano is all there. Think of all the "happy birthdays to you" and "I love you" in Hindi films—which desperately need a piano. Yet it remains Western. The violin is a hybrid. It is something Carnatic, music absorbed and imbibed creatively.[6] The violin represents the west we had taken and domesticated.

For Seshadri, Westernization was not just the three-piece suit. It was the violin. In the idiom of science, Homi Bhabha was the piano; C. V. Raman was the violin. Yet neither actually produced a grammar for a modern Indian science, and this is what Seshadri sought. There was something distressing, even authoritarian about science. It was a combination of the authoritarian and the authoritative. It was a kind of repressive masculinity. Let me emphasize science in Brahmin India was not a theory of method. It was more of what Richard Rorty once called a collection of virtues. Live life in a certain way and the scientific becomes possible. It was a domestic civics, a grammar, a hygiene, a ritual for living.

Science in Tamil Brahmin India was definitely male. What marked it off was that ghastly invention called home science. Physics was male, home science was female. My aunts practiced home science or social work and worshipped physics. Home science and social work were the *oikos* and *polis* of a woman's life. Home science was to physics as female was to male. The women of that generation were talented, driven, close to science, and deeply voyeuristic about it. Science was like their husbands, contiguous and strangely distant. Science in Tamil Brahmin India produced the bureaucratic ascetic. It was a *service* in that double sense Indians gave the English word. Science, especially physics was a sublimated field, a non-erotic domain. It was not so much truth but certainty, predictability, and correctness that mattered. There was an imperious intolerance about it, an authoritarianism articulated in linear time. In this world, "Be scientific" and "be good" were synonymous statements, but what bothered one were the qualities of goodness and science. Let me cite some of the stories Seshadri and I collected.

The first was about my grandfather. I remember my father had brought me an electric train from Germany. I was about 7 then. I wrote to my grandfather about it, claimed it ran at 500 miles an hour. Pat came the reply: "Your electric train could not possibly run at that speed. Please check and let me know the correct speed." I think my disgust with science began that day with grandfathers who calibrated fantasies.

I secretly dreamt my grandfather and other scientists were clocks, or at least timetables. There was an arid precision to life that bothered me. In fact, science was like table manners, a ritual correctness in life where morality yielded to routine. Clock time was central to their lives. When they went to their office they put on their science, when they came home they put on their caste and their ritual clericalism. Time and honesty were the two spokes of their lives. In fact, the presentation of the watch was as important a ritual into manhood as the sacred thread. The clock was aridly male and it didn't menstruate. The clock was secular and utterly indifferent to all other times. In constructing the civics for the scientist and of his surrogates the clerk and the accountant, we swallowed the variety of times. The Republic of Brahminic Science was constructed on clock time, like the plan, the laboratory, and the calendar. In fact, Seshadri and I believed that the national movement was all about clocks. Remember Gandhi's clock, his punctuality, and Nehru's obsession with plans. I remember a cousin of mine who went to meet S. Chandrasekhar. He rushed in full of expectation to meet his uncle and was stunned to find the latter upset that he had not made an appointment.

What I want to emphasize is the link between this disciplinary body, its time and its honesty, and science as it was constructed by Brahmin-Brahmo India. I remember the psychologist Ashis Nandy's lovely story about the statistician Prasanta Mahalanobis's father.

The father of Indian planning was then only a child. He was travelling with his father to Burdwan. In those days, like today, you could travel on a half-ticket if you were under 12. The train was chugging happily when Mahalanobis senior suddenly pulled the chain and demanded that his son get down immediately. The fellow passengers were flabbergasted and asked the father what the son had done. He replied that Prasanta was 12 a few minutes ago and was travelling under false pretences. Fortunately, common sense came to the rescue. The passengers suggested that the father should pay the other half and the journey proceeded happily.

What fascinated Seshadri and me was the strange stiffness of this generation, a definition of the body and the mind that it projected on to public space. It was a generation that dealt with love out of pipettes and loved the Emergency because the trains ran on time. It is a question we must ask. "Why did so many Tamil Brahmin scientists love the Emergency, the imposition of dictatorship in the 1970s?" We formulated the question in a different way. Science, we felt, was based on the impoverished body, on an impoverishment of time, and an aridness of sexuality. Seshadri felt he wanted to create a science that was muscular, not machismo, a science that thought with its hands, a science that was more sexual and sensual, a science that was sensitive to suffering.

He felt that there was a connection between the autobiography as experiment and the nation-state as one. One remembers the old idea of

Visvesveraya about nation-building, character-building, and dam-building as isomorphic activities, and Seshadri hinted that something had gone wrong with all three. Seshadri felt that the roots and the theater for such an examination lay in science. He also added that the laboratory as theater must reflect the rules of dialogue. He realized that this was less of a set-piece battle that Tagore dreamt of between the city university and the forest university (Visvanathan, 2001a). This was a more fluid movement of ideas across osmotic categories.

To systematize this, one must begin with a genealogy of words. For Seshadri, contemporary constitutions like modern Western science were Judeo-Christian documents. One must not allow for the immaculate innocence of words and instead realize that there is more violence tucked into words like "health," "poverty," and "energy" than in the worst annals of crime. Once you introduce words such as "history," "development," and "progress" into poverty and suffering, you economize and scienticize it on Judeo-Christian time. For Seshadri it was the Judeo-Christian nature of modern texts that was a bit unsettling. Whether it is thermodynamics or the detective novel, one had to realize the Christian nature of the exercise. Consider the classic detective novel. It is a scientific text built on a Judeo-Christian frame. Murder is a violation of order and the detective restores it. The detective in the text plays God. Remember the last chapters. All the characters are assembled around the table with the detective at the head. The whole act is modeled on the Last Supper. Seshadri's work is not an attack on Christianity but a critique of those who fail to explore the tacit knowledges underlying their life worlds. He said that Einstein was fond of saying that scientists imbibed their concepts with mother's milk. One sometimes feels that scientists are more critical of mother's milk than they are of science at the everyday level.

Seshadri also added that dialogicity in Western science was difficult because science was caught between the dualisms of state and Church and science and religion. Here science was a public role and religion a private space. Encounters between religion and science were either conflict-ridden, as in the evolution debates, or weak-kneed and sentimental, as in the writings of John Barrow, Stephen Gould, and Fritjof Capra. One needed to improvise a more agonal space for such dialogues, where one is critical and avoids the fundamental of both extremes. Seshadri did not develop a strict grammar but did develop a set of exercises for such a critique, especially through his examination of the axiomatics of energy.

THE CONCEPTUALIZATION OF ENERGY IN INDIA

Jawaharlal Nehru's often quoted statement, "Dams and laboratories are the temples of new India," was an idiotic combination of Comte and Fabian socialism. These temples of energy, these creations of science were indices of modernity. Reified, dams became the health of the nation. A threat to a dam or nuclear reactor was a threat to the state. When Medha Patkar and the anti-Narmada activists protested, the state prohibited such acts under the Defense of India Rules. A threat to the dam was a threat to the security of India. When journalists and scholars like Praful Bidwai or a Dhirendra Sharma criticized nuclear energy, they were seen as both anti-scientific and anti-national. Today grassroots groups realize that they must begin by breaking this social contract between state-science-economic development. Underlying all three is the metaphor of energy. Jawaharlal Nehru's statement on dams as the temples of modern India is only another variant of Lenin's celebrated and more genocidal dictum, "Soviets + Electrification = Communism." The man who bridged Lenin and Nehru was the Indian physicist Meghnad Saha (Visvanathan, 1985).

Meghnad Saha was one of the legendary scientists of India, a poor boy who became one of the fathers of Indian planning, a scientist whose work on ionospheric research earned him a nomination for the Nobel. Meghnad Saha was born and brought up in the Brahmaputra valley, where floods were a frequent event. Both in 1913 and 1923 Saha participated in flood relief operations. After the 1923 flood, Saha was obsessed with the idea of flood control. His early efforts were published in *Modern Review* and in the festschrift to the great botanist J. C. Bose. By 1938, as President of the National Institute of Sciences, Saha had convened a seminar on river valley civilizations where he echoed the words of the British engineer Francis Spring, that "the establishment of a River Commission for the organized study of the alluvial rivers would be an act worthy of the state." It was the result of Saha's efforts that Voordiun, an expert from the TVA, was invited to India and it was the latter's report that provided the basis for the Indian equivalent of the TVA—the Damodar Valley Corporation.

Saha wanted to move to a more total vision of planning and his encounters with Congressional politicians left him irritated. These agitators had little conception of modern science or economics. In 1936, Meghnad Saha the astrophysicist decided to turn economist. He began by consulting the yearbooks of the League of Nations in order to generate a comparative index of income. He started with the production of various commodities but failed to generate an appropriate index. He then felt that the wealth of a country was proportionate to the energy it consumed. He calculated the per capita output of every country. The energy index of the UK was 2000, of the USA, 2500. Statistics on India were unreliable but Saha estimated that the average energy consumption was 90 units per year. "It was equal to that of Europe in the middle ages." Saha went out in search of a model of a high energy society and found it in Lenin's Russia. He was enchanted by the GOELRO plan and particularly in the relation between Lenin and Krzhizhanovsky. Krzhizhanovsky, a colleague of Lenin from his undergraduate days, was an electrical engineer. He saw in the October Revolution a prelude to the technological revolution. He shared with Lenin a belief in a society based on the efficient use of energy and even coined a term for it, the *Energetika*. By 1921, Lenin had made electrification the second program of the party. Krzhizhanovsky's commission for electrification became Russia's first planning body. Saha went out in search of his Lenin, and found it in Subash Chandra Bose. While Bose was president of the Indian Congress, he established the Indian planning committees. What is interesting about this is the role of energy in linking science to economics.[7]

Energy provides not only a rationale for the state but a grid of discipline. Energy is potentially an organizational metaphor. It is a polyvalent term, at once work, power, potential, vigor, and effect; it is occult, spiritual, and kinetic. What the advocates of planning scientists and economists did was to desemanticize the term, break its varied meanings into one politically correct word, transforming an icon into an index, a multivalent possibility into one univalent quantitative concept. Simultaneously it became a disciplinary term; energy had to be measured, planned, and channeled. What threatened excess or uncontrolled flow was now a controlled grid. Dam, reactor, and laboratory were the pilgrimages of this new geography. Discipline and energy became deeply linked and stratified. So energy became transformed into what the state and the plan considered it to be, and petroleum, nuclear, hydel and electric now constituted the alphabet of the energy of the new state. Expert energy was official energy. Energy generated by the people, the traditional world of dung and fuelwood was not considered immaculate and scientific. Within this view, all forms of energy were seen as standardized and convertible, disembedded from the knowledge systems that they were implicated in.

Mahatma Gandhi realized in a deep and fundamental way the danger of such a preoccupation with energy as an index of material progress. He warned that "the control over the hidden forces of nature enables every American to have 33 slaves. Repeat the process in India and every Indian will be 33 times a slave," and he was right. Energy has been the Trojan horse through which development has completed its bloodless conquest. In the late seventies, when scientists like Hussein Zaheer and Adinath Lahiri requested Indira Gandhi to move away from the petroleum base of industrialization, we find the first recognitions of this impasse. But this was more reactive and desperate than systematically epistemic. To exorcise the modern dreams of energy we must shatter the term and this can only begin if we re-examine the steam engine and the laws of thermodynamics.

SHESHADRI'S CRITIQUE OF THERMODYNAMICS

The steam engine is the basis of the industrial revolution. The role of the steam engine is captured in Marx and Engel's statement that if the windmill gave us feudalism the steam engine gave us industrial society. This statement in *The Communist Manifesto*, even if reductionist, emphasizes the importance of the steam engine. The steam engine is popularly seen as the basis of the mechanical world, of industrialism. Yet it is around steam that the laws of thermodynamics were developed. These were the most polemically contentious laws of physics and even today scientists grumble about some aspects of them. We shall provide two glimpses of the steam engine, first through the brilliant exegesis of Georgesceau-Roegen and then through the lenses of C. V. Seshadri. What we wish to show is that the physics of the steam engine carries along with it its anthropology of modernity.

Imagine an old-fashioned railway steam engine. Heat from the burning coal flows into the boiler and escapes as steam into the atmosphere. As a result of this the engine has moved from point A to point B. Yet, following the laws of conservation, the overall quantity of matter and energy has remained constant. What has occurred is a qualitative change. Coal has been converted to ash. Heat has moved from the hotter to the colder part of the machine. Physics, which has so far dealt with the laws of locomotion, has encountered a qualitative change. The nature of this "conversion" experience is described brilliantly by Nicholas Georgesceau-Roegen (1971). The steam engine startled the world of Newtonian mechanics. Classical mechanics could not deal with unidirectional movement, for mechanical time dealt with qualityless movement and was reversible. The fundamental metaphor was that of a swing of a pendulum and mechanics as a science was indifferent to its directionality. But thermodynamic phenomena conformed to a picture of an hourglass that could not be inverted, that is, they were basically irreversible.

The concept of entropy was coined by Rudolf Clausius while formulating the two laws of thermodynamics. It was used to differentiate between bound and free energy available for work in the system. For example, the coal used to run the engine when burnt turns into ash, becoming bound energy. Entropy is the measure of this bound or unavailable energy in a system. Scientists were in general ambivalent to the notion of entropy. The ambivalence stemmed from several reasons. First, they felt that entropy was a subjective concept, that it introduced the taint of anthropomorphism into physics. Only the human mind can make a distinction between free and bound energy and this distinction pertains to what human beings find *useful*. As Jaynes has remarked, "entropy is an anthropomorphic concept for it is the property not of the system but of the experiments you and I choose to make of it."

Second, the notion of time it introduces becomes problematic for Newtonian mechanics. Entropy introduces the arrow of time, the notion of irreversibility into physics. Weyl has remarked that "in the world of exact laws, time is reversible." For example, the film of a mechanical phenomenon, such as the bouncing of a perfectly elastic ball, can run either way without the observer noticing the difference. But anyone would notice the difference if the film of a plant growing from a germinating seed and in the end dying is run in the reverse. The second law of thermodynamics is the most important example of an evolutionary law.

Third, by emphasizing qualitative change like degradation rather than quality-less locomotion, entropy emphasized *waste*. Work and waste became central parts of any production system. As Georgesceau-Roegen noted, *had* economics recognized the entropic nature of the economic process, it would have realized that bigger and better washing machines, automobiles, and superjets mean bigger and better pollution.For Nicholas Georgesceau-Roegen, economics is still mechanistic and does not realize that thermodynamics itself creates a physics of limits to the world. As a result, the myth of the perpetual machine rather than being a valuable heuristic has become one of the reified pursuits of both economics and science. As late as 1972, the Nobel Laureate Glenn Seaborg could claim that "ultimately we will be able to recycle any waste, to extract, transport and return to nature when necessary materials in an acceptable form, in an acceptable amount and in an acceptable place so that the natural environment will remain natural." By showing that the energy cost of recycling is high, the idea of entropy forecloses the possibility of bootlegging energy through the continuous recycling of coal or uranium. It is this theology of *limits*, popularized through the eschatological notion of "heat death" that has irritated scientists and economists. But it is precisely by doing this that entropy becomes so fundamentally ecological. In fact the liminality of the entropy concept increases because it mediates the world of economics and physics. Entropy deals with the physics of economic value.

In 1983, C. V. Seshadri worked as a fellow at MIT under the auspices of the United Nations University. During that period he wrote his monograph *Development and Thermodynamics*, a theoretical reflection of the work at Murugappa Chettiar Research Center (MCRG). For Seshadri, the theology of limits that physics as thermodynamics provides is forceful but not life-enhancing enough precisely because it is theological. Science is replete with Judeo-Christian concepts and it is precisely as theology that entropy fails.

Let us reread the liturgy of the steam engine. If one reads the records of the steam engine, whether it is Crosbie Smith on energy or Cardwell's life of Joule, one realizes that there is something Christian about the discourse. Push your mind a bit. One wished one had a Roland Barthes to help; Barthes with a touch of Umberto Eco. The ritual of the engine constitutes the equivalent of the Christian mass. The boiler is the vessel, the coal the literal equivalent of sacred bread. The nature of the act and its meaning constitutes one of the great theological problems of Western society. It raises questions about quality, of time, of transubstantiation, of the liturgy of work, and of the notion of death and apocalypse. One often hears the claim that science owes more to the steam engine than the steam engine to science. One must elaborate on the nature of the debt.

First, the steam engine obviously did as much for the nature of work as the Christian monastery. The economic notion of "work" or "duty" becomes central to this physical concept. Pierre Duhem's complaint of the factory mentality of nineteenth-century English physicists is well known. While fair to Britain, it is also equally true for thermodynamics in general. It is this that led the American physicist Percy Bridgman to complain that these laws "had an unblushing economic tinge." The preoccupation with energy, as Crosbie Smith points out, replaces the concept of force with the concept of *work*. Work remained the central measure of energy throughout this period, appearing under various names such as mechanical power (John Smeaton) or simply "effect" (James Watt) or "duty." It was the basic measure of engine achievement and derived from the practical work of early engineers, who required a useful comparison of the relative performances of water, wind, animal, and steam power. The work of Joule, Carnot, Mayer, and Thompson sought to provide a measure of work and efficiency.[8]

But what sort of work? The work that thermodynamics is talking about involves work done at high temperature gradients. Consider the statement of the American Physical Society on energy quality. It states that "from the perspective of the second law, organized coherent motion is most precious, very high and very low temperature energy is next most precious and heat at a temperature near ambient (lukewarm cool) is degraded energy." Apart from the mechanistic bias present, this holds that 1) the higher the temperature, the lesser the entropy production, and the more useful the work produced; 2) ambient temperature processes are degraded energy processes. Such descriptions, says Seshadri, are unfortunate.

Consider the following examples. A monsoon over Africa and Asia carries billions of tons of water across continents, performing countless gigawatts of work, but work as defined by physics deems this a work of low quality since it is done across small gradients at ambient temperatures; also, living creatures work and live at ambient conditions but that energy is seen as degraded. The American Physics Society (APS) sets strange standards of energy quality, strictly related to economics. Thermodynamics sensitizes one to the limits of natural resources but not fully to the fact that nature works. Given its preoccupation with gradients it provides the rationale for the factory and synthetic fertilizer processes rather than traditional farming. In terms of the APS statement, composting is a low-quality activity!

Thermodynamics is anthropomorphic but one often misses the fact that the anthropomorphism is of two kinds. "One by virtue of being *human* and the other by virtue of being *western*. The poorer countries, ignorant of the latter kind of anthropomorphism, apply it to end up with gross misapplication and enhancement of existing disparities." Seshadri was the first to point out it was not just that thermodynamics had an unblushing economic tinge. Applied as a scale of value it increases disparities or warps priorities. Since energy is inseparable from use, it becomes a criterion for prioritizing the use of resources. Consider, for example, a forest. A forest had a multiplicity of uses. Forest wood, for instance, was used as fuel for smelting iron, boiling sugar, and as household fuel. Wood provides the fuel for cooking in many households in India today. Considerations of energy indicate that the forest should be primarily used as a raw material for industry. Forests are marked more and more for the paper and pulp industry. Forest people in fact are deprived of their traditional rights to fuel, and the forest becomes the preserve for the paper pulp industry. So when we apply the modern criteria of efficiency embodied in the Second Law, tribal people lose access to the forest that provides food, fuel, fodder, and medicine, this diversity of uses losing out to the paper industry, which soon converts the forest into a monocultural plantation of fast growing eucalyptuses. Seshadri shows that the logic of thermodynamics sets loose a chain reaction that works against the tribes and peasants of the Third World. So the tribes and peasants are confronted not just with nation-states and the multinationals but also with the logic of modern science, which works against them. Within this view, Chipko and the anti-dam movement are complete only when the laws of energy are rewritten.

There is a final point. The notions of time, of heat death, and of the apocalyptic ending of the world, all rhyme with the Judeo-Christian ideas of eschatology. In fact whether it is thermodynamic laws or the modern detective story, both are constructed out of the scaffolding of Christianity.[9] Thermodynamics coincides with the doomsday view of knowledge that has become such a powerful feature of modernity. It is just such a narrow scaffolding of religious belief that Seshadri objects to. He makes two separate points. First that the scientific method is not neutral. It is a part of the Judeo-Christian consciousness. It is based on cultural roots that are not universal, and consequently "they become very difficult to stream into the consciousness of a practicing engineer who does not share the tradition. Dreaming and creativity require native categories." Otherwise one loses one's sources in the archetypal and the primordial. Second, our civilizational notions of time are different. "We should teach our people that our own lives and deaths are not synonymous with the deluge, that they are a part of much larger enmeshed cycles, helices, spirals of time which give the earth substance and civilization."

For Seshadri, the debate between traditional knowledge and modern science required a reconstruction not only of the categories of science and economics but of the myths at its core. We do not seem to be able to escape the myths of Faust, Prometheus, or the Schumpeterian entrepreneur. Even someone as sensitive as Nicholas Georgesceau-Roegen lapses back to Prometheus. In his *Energy, Matter and Economic Evaluation* he divides history into three Promethean phases, the wood age, the mineral age, and the third uncertain phase where one is waiting for Prometheus III. Nicholas Georgesceau-Roegen is clear that the market will not provide him with this but he is equally committed to the caloric power of the Promethean myth. We are looking for a world that modulates both Prometheus and the price system. In that sense thermodynamics is still an incomplete mythopoesis-cum-science of limits. The inadequacies of such a view become clearer when we conceptualize the idea of biomass economics.

THE POLITICS OF A BIOMASS SOCIETY

For Seshadri, the idea of a biomass society was not anchored on a second-rate science for a second-rate society. He evaded many of the political traps associated with the intermediate technology movement. He repeatedly emphasized that the idea of biomass demanded a new epistemology and a reinvention of citizenship. He also added that the concern with biomass societies is not only a Third World discourse but that it emerged at two levels. There was first the northern discourse that began with the oil crisis and the discussion of the *Limits to Growth* model, as well as with the discussion of the need for soft energy paths in a nuclear world. There was a radicalism to the discourse, a critique of industrialism where, to paraphrase Patrick Geddes, "the economics of the leaf and the economics of metals were in opposition." But sadly the radical edge of such a discourse became co-opted into the technocratic and ecocratic discourse called sustainability.

In the Third World biomass as a discourse arose primarily as a challenge to the surreal science of elites who worshipped electricity. It was a crisis of wood and cooking. But the biomass discourse began as a radical critique of industrialism at two levels. A theory of limits became a praxis of creative possibilities. We realize today that oil, the Green Revolution and modern medicine cannot deliver. Given this—the local, the traditional, and the futuristic—all become sites of innovation.

The radical possibilities of biomass as an epistemology can be easily suppressed. For example, in anthologies of energy, biomass is categorized as a way of life, of societies outside the pale of industrialism. It usually appears in chapter 10 or 12 of a textbook on energy, a sidebar following the preoccupations with nuclear, oil, hydel, or even wind energy. It is seen as residual.

There is simultaneously a split in the construction of the globalization regime. Oil and nuclear are for the industrial what biomass is for the societies of Africa and Asia that may be triaged out of history. Biomass then becomes the discourse of the defeated, the Third World, and the third rate. Consider how the regime of biomass appears in the spy thrillers that Seshadri was so fond of. Into the happy life of Western industrialism appear the oil sheikhs, the OPEC cartels, and the urban guerrilla. Constructed simultaneously with the oil crisis is the wood crisis. The pictures of the woman carrying wood, the guerrilla in the forest, and the oil sheikh become the three archetypal figures of the crisis. Yet we should not succumb to such a reading because it not only predetermines narratives but also creates pre-emptive futures. We have to remember that the Vietnam War represents the victory and resistance of a biomass society over an industrial high-calorie regime. Seshadri repeatedly emphasized that biomass is the conversation of the leaf with its ancient friends coal and oil, establishing similarities and differences in their common genealogy in their relation to the sun.

One must emphasize some dangers here. The first is the sheer economism of discourse and the danger of conventional economic categories and thought. The sun is not a conventional factory. It is not too keen to subject itself to man-made time and organization. Second, biomass should not be reduced to the language of scarcity and crisis. There are shortages, there is poverty, but biomass need not be reduced to a discourse on scarcity. Nicholas Xenos's comments are apt in this context. In his *Scarcity and Modernity* (1989), Xenos observes that the European eighteenth century saw the invention of both the steam engine and of scarcity. Scarcity, as anthropologists have pointed out, is seen as episodic in most societies. It first signified a period of insufficiency or dearth. This remained the principal usage until the late nineteenth century, when neoclassical economics made the scarcity postulate its foundation. The notion of scarcity also opens up a Pandora's Box of technological fixes, where biomass problems need biotechnology and then the entire spectrum of biotechnology gets reduced to genetic engineering. Seshadri explained that biomass is a word for people. It smacks "of the ordinary and the non-mechanical. Compare the tree to a factory, or a cow to a reactor. Like the people it is not amenable to efficiency and control in a factory sense. You can't boss over the science of photosynthesis." The state thus has problems with biomass in a way that it does not have with electricity. Electricity is a disciplinary grid but biomass offers little ground for collectivization to "turn the stinking pastry of the ordinary people into a tasty pie by trainers, educators, the masters." You can't say Soviets + Electrification = Communism in a biomass society. Unless, you are a Pol Pot.

It is around biomass that the resistance to the state can come into being. Biomass reopens the debate in a tremendous way. First, energy forms such as oil, nuclear, or large dams are state-oriented, while biomass speaks the language of civil society. Second, by linking life and death in the idea of the cycle, it brackets the idea of obsolescence, preventing it from being read as a universalizing process. Biomass brackets the idea of progress in its linear form by offering the multiplicity of times that democracy so desperately needs. Biomass also recalls the idea of the commons and particularly the idea of cognitive justice. The two concepts are closely interlinked. The idea of the commons is not just an amalgamation, a mapping of physical and natural resources. It is also the diversity of skills required to understand, access, and dwell within it. Seshadri dubbed it "a commons of the mind." It is in this context that we must emphasize that rights often speak the economistic language of access. Speaking a language of rights in a biomass society only leads to conceptual inflation, to a proliferation of rights, including the rights to food, fuel, and employment without tying or connecting them at a moral or epistemic level. The language of rights, particularly in its individualistic-economistic language, becomes partly alien to a biomass society, creating in fact the tragedy of the commons. One does not seek to abandon it but to translate it into the language of community and cosmos.

In this sense, the politics of a biomass society go beyond the standard discourses of the French revolution, of the *Communist Manifesto*, or the *Rights of Man*. First, it goes beyond the discourses of liberty and equality towards an emphasis on fraternity, not merely between communities but between man and nature. But it should not be seen only as an ecolacy of nature but of technology. It reads liberty, equality, and fraternity as the first triangle of modern politics. But it counterposes to it a second triangle of pollution, waste, and obsolescence, which it reads in terms of a community of multiple times. The notion of the cycle becomes fundamental here. As Balaji observed, "When Seshadri introduced the centrality of food, he knew that food chains exist in cycles. Through food you can see the interrelationship between a wide variety of complex systems. Terrestrial. Aquatic. Cosmic. A variety of cycles interface and Doc wanted to track the process through energy."

It is around the idea of cycles that the discourse on waste, pollution and obsolescence is constructed. Seshadri's idea of *shakthi* was an attempt to develop quality markers for creating a grammar for this discourse. Seshadri, the early Seshadri, talked in aphorisms and epigrams. I remember him grinning and observing that "pollution is someone else's profit," or that "one man's waste is another man's resource." But these were not just pretty little proverbs. Consider the popular idea of recycling. He said, "You can't recycle waste without violating the second law of thermodynamics. The question of recycling has to be looked at in this perspective for all waste is useful in some context." For Seshadri it was more fruitful to recycle ideas instead of things. He provided the example of sheet metal stamping.

> Circular blanks of metal are stamped out of metal sheets leaving behind perforated sheets that the manufacturers characterize as waste. But one man's waste is another man's resource. The perforated sheets are used by many poor people as fencing, structural elements in housing, tracks for paths, etc. What has been recycled is neither material nor energy. *Only the idea*. A waste has been turned into a resource by perceiving it differently. A low-value high-entropy perforated sheet becomes a high-value low-entropy fence, tracks, and such through the recycling of ideas. The process also adds value locally.

"The classic recycling option would be to melt down the perforated sheets and then re-roll them. The material is recycled at tremendous cost. Idea recycling is far less energy intensive than material recycling." Recycling ideas is the forte of the squatter and scavenger. The Indian slum becomes the great laboratory for recycling ideas. "For the wasted people of our states, wastes and nature are the only resources left for them to build on. Only these resources are available outside the commercial mainstream."

The idea of cycles substitutes and goes beyond the alchemical limits of the perpetual machine. In fact, the idea of cycles is disappearing in modern agriculture. As one Japanese scientist noted, "modern agriculture has replaced most of the cycles in nature by products of manufacturing, especially with chemical fertilizers and petroleum products. These are not compatible with the cycles of nature."

Seshadri's still incomplete idea of *shakthi* was developed as a quality marker to understand such processes. V. Balaji observed that "it helped one redesign processes, identify the real wastes in the system like the amount of pure water used in flush toilets in western countries, or the consumption of processed water in chemical industrial processes. Viewed this way the efficiency of the thermal plants may be scaled down by 50 percent."

"The notion of *shakthi* is scale invariant. It can range from the depth of the ocean to the upper atmosphere. It can look at the interaction of two microbes in a bio-gas digester." Balaji added that it is an engineer's understanding of thermodynamics.

> It is like a *Thanedar's* understanding of thermodynamics rather than a commissioner's. It sensitizes you to the real costs of water and nutrients in, say, an agricultural process, as for instance the over-application of water and fertilizers in hybrid seed technology. *Shakthi* would give you a knowledge-intensive rather than an input-intensive approach to agriculture. You

apply that many grams of fertilizer at *that* time on *that* place. A *vaidyar's*.. approach rather than that of agri-business.

But biomass is not merely a discourse on nature and the environment; it is a plea for a new pedagogy of citizenship. Seshadri felt that the state was not going to wither away or that it was something easily compostible. The more interesting challenge for lateral thinking in politics was to reinvent nature, citizenship, and civil society. In this context, he and Joe Thomas would often talk of the *Juliflora* almost as a fable. I remember one of the first times Joe and I were having tea outside the gate of the Murgappa Chettiar Research Group (MCRG). Joe showed me a beautiful garden fence, exquisitely green, trimmed and beautiful. "The prosopis Juliflora,"[10] he announced. No compère could have been prouder and more delighted.

The Juliflora, a mesquite, provides 40 per cent of Madras firewood. The irony is that it is not a creation of state forest policy but an inadvertent introduction that grew in spite of the state. One felt that Seshadri wanted the Julifloras of citizenship.

Once we accept Arthur Koestler's statement that "the greatest superstition of our time is the belief in the ethical neutrality of science," we have to look again at biomass economics. In a vernacular world, technology is not a solution; it is a means to an end. Love is a solution, and if technology is to be an act of love, like cooking or prayer, we have to go beyond the political economy of biomass. This sees only poverty and hunger. We have to look beyond the scientific epistemology of biomass, which sees poverty as hunger, hunger as nutrition, and nutrition as so many kilo-calories. The moral economy of resistance and reciprocity worked out by James Scott needs an epistemic sense that the knowledge system itself may create immiseration. The politics of knowledge must combine all three: ethics, politics, and science. This marriage of Gandhi and self-critical thermodynamics can be illustrated through the calculus of sugar. It is a search for quality markers that can also alter the level of debate. Otherwise you are caught in contradictions. It is no use criticizing the Green Revolution and accepting a petroleum economy. For this you need a different notion of economics. One can examine the need for a different, more holistic quality marker other than price by means of the problem of the sugar-food-alcohol nexus.

UNITING SCIENCE AND DEMOCRACY

The sugar-food-alcohol nexus

Consider the use of a carbohydrate resource such as sugar cane or cassava. Sugar cane in a tropical country is one of the highest-yielding photosynthetic

organisms. India is not only the largest sugar cane producing country but has the largest area under cane cultivation. The decision that one faces is whether cane should be used for the manufacture of white sugar and alcohol or as food. Alcohol always appears profitable as an end product not only because of taxability but as a substitute for imported petroleum. The question is what are the quality markers used in such a decisional calculus. "Assuming once again that purely economic criteria should not be allowed to be the method of choice, how should we grow a proper mix of food and fuel; how do we balance food and fuel calories?" Seshadri calls this search for a comparative standard the search for *shakthi*. He describes it as an attempt to link Gandhi's objection to prohibition to the world of thermodynamics.

The cane industry produces a variety of products from sugar, alcohol, *gur*, bagasse, *khandsari*, etc. In optimizing the welfare of the people we have to decide how much importance to give to each of these products. India has been the traditional home of sugar or *sarkara*. There are two ways to refine cane to make a sweet product. We could make open pan sugar or *khandsari*, or make jaggery or *gur*, which is solidified cane juice. Today these traditional processes are disappearing, giving way to modern sugar factories with their huge evaporators and crushers. In fact, today the sugar industry is one of the largest in the country, second only in scale to cement, steel, and petroleum. In 1977 the percentage of traditional sugar was 56 percent, today it has decreased to 35–40 per cent or less. This change is usually justified in terms of "efficiency," science, progress, or the laws of scale, all of which appear objective and value-neutral, justifying the downgrading of *gur*.

There are generally three ways of downgrading a traditional product. First, you imprint a traditional product as impure, dirty, and unhygienic. Unlike *gur*, sugar carries all the moral semantics of white. It is something produced by a man in a white coat, as clean, cool, and hygienic as Listers antiseptic. *Gur* smacks of dirt and soil, it is "muddy" and in need of refinement. It carries all the ambiguity of a mixed product. Second, you downgrade traditional products through the laws of scale and finally through the laws of science. "In general, energy that is consumed for metabolic purposes is supposed to be of low quality since the temperatures at which humans and animals live is at ambient temperatures. On the other hand, according to the Carnot principle, energy is of high quality, the higher the temperature of its availability." This logic is implicit in the market value of sugar.

> Large scale crushers are seen as more efficient using less steam per kilogram of sugar. It is also attested that white sugar is stored and transported easily. While the last point is to be conceded no one bothers to calculate the respective energy cost of making sugar and *gur* including the capital costs of machines. It is a paradox of modern science that the more reductionist and refined the

practice, the more it justifies its extravagance. Thus a 10,000 tonnes per day crusher is supposed to be more efficient than a 1000 tonnes per day crusher regardless of how much entropy and waste it adds to the surroundings.

What is worse, within such calculations no one examines the nutritional value of these commodities. *Gur* has more naturally occurring iron, calcium, and phosphorus than refined white sugar. Even molasses is richer in vitamins. *Gur* is a natural supplement for the iron deficiency of our populations, especially women and children. In fact the government is planning to spend huge sums to combat anemia. Finally, the negative effects of white sugar should also be considered. Combating dental and diabetic problems is a multibillion dollar industry. Viewed this way the real value of sugar is far less than its calorific value as obtained from a bomb calorimeter.

The tragedy of white sugar is further compounded by the alcohol industry. "Only if you make white sugar, do you make large amounts of molasses, gigantic amounts of which are used for drinking; thanks to official policies. The constitution of India has a moral commitment, yet successive governments have seen alcohol as a profit maker."

Seshadri itemizes the questions of choice as follows:

1) Do we wish to live with the white sugar problem?
2) If the answer is yes, do we want to get the best out of molasses?
3) If the answer is yes, do we want to supplement the food situation?

The question of a quality marker becomes absolutely necessary in this context. Assuming the answer to the first question is affirmative, despite all the negative effects of white sugar, we can still ask for all the uses of molasses, which include feedstock/cattle, fertilizers, substrates for yeast, as well as alcohol; we have to produce an energy accounting that balances "molasses for food" against alcohol, despite it being one of the most energy profligate processes. Alcohol is the choice if economics as profit were the only criteria. Here economics dictates energetics. But once we search for new quality markers, the question can be readdressed. Given a piece of land, given knowledge of the constraints, what is the best mix of food-fuel we can obtain? Consider the following facts:

—1 sq km of cane gives 20,000 children all their vitamins from yeast at 10 gm per day.

—On land used for growing 60×10^6 liters of alcohol, we can produce 21,000 tonnes of paddy.

—India's 50×10^7 palm trees can yield 10×10^6 tonnes of sugar per year, releasing all cane land for other crops.

Viewed in this way, sugar cane can only be grown to make yeast for people's welfare. In this, prohibition is a technological necessity. Yet current technological imperatives lead one to emphasize the wrong value system, where alcohol and profit triumph over well-being.

This question of quality markers, the search for what Seshadri dubs *shakthi*, is a recurrent theme of any effort to liberate energetics from economics. It leads to an examination of another of the great sources of fermentation technology, the *idli*. The *idli*, south India's exquisitely fermented rice cake, is a ubiquitous cereal food. Seshadri reports that a survey in Madras showed that in one street "10,000 *idlis* were sold per linear kilometer everyday." Yet the government is the greatest propagator of white bread. In his paper to the Seventh GIAM Congress, Seshadri compares the nutritive value of *idlis* and white bread, each made respectively from 1 kg of *idli* batter and white wheat flour dough.[11]

	Protein mg/kg	Minerals gm/kg	ß-Carotene ug/kg	Fe mg/kg	Thiamine mg/kg
1 kg *idli* batter 42 *idlis*	83.3	3.05	5.5	13.3	0.07
Bread 1 kg dough 45 slices	67.6	0.35	14.7	15.29	0.7

In reading the table we must remember that all the vitamins in commercial bread are added synthetically while in *idlis* they are synthesized naturally by the microbiota. It is also well known that white bread contains neither fiber nor roughage. The question we must ask is why does the government promote white bread and what are its consequences? White bread displaces *idli* in a deliberate policy of "commerciogenic" malnutrition. It encourages the introduction of food habits that cannot be sustained by local production, such as wheat and wheat products. In addition, large bread factories are energy intensive and cannot provide the employment that the world of the *idli* provides. It is the absence of a new quality marker that creates this litany of malnutrition, whether it is polished rice, white bread, or white sugar. Such a notion of *shakthi* has to be built into conventional economics and energetics.

Murgappa Chettiar Research Group (MCRG) and its FADs

If the first set of instances show how to interrogate modern Western science from an eccentric or marginal perspective, the second set of efforts deals with MCRG efforts to preserve traditional forms of life. One shall focus in this context on the making of fish aggregation devices (FADs) and the refashioning of the catamaran.

India has a 7517 km-long coastline that is farmed by three kinds of boats. It is important to realize that even now large trawlers only contribute one percent of the total marine fish production and that another 33 percent comes from mechanized boats. Roughly 66 percent of India's sea fish come from the 1.8 million traditional fishermen using country crafts.

Over the last decade fish production in India has stagnated at about 1.6 million tonnes a year. There were several reasons for this, including the lack of effective harvesting technology and the inability to diversify fishing techniques. Compounding this was the depredation of fishing pirates from Taiwan, Thailand, and Pakistan, who, using giant trawler nets and modern fishing vessels, are robbing India of valuable fish.

MCRG's constituency was the traditional fishermen. In 1985, MCRG began a project on fish aggregation devices.

> Our fishermen, who do not have motors and things like that, will spend about six hours going into the ocean and about six hours coming back and three to four hours fishing. They spend a long time searching for fish. To save the search time for a fish you make a fish aggregating device. A fish aggregating device is an ancient technology in this country. What they do is to cut a big palm tree, drag it out and anchor it in the middle of the ocean. The fish in the open ocean like the shade and the little shell fish like to hang on to the leaves of the palm tree and lay their eggs. The big fish come in search of the smaller fish and so on. Therefore a fish aggregating device is something in the middle of the ocean that collects fish together.

In nature, the coral reef is the ideal FAD and thus MCRG fashioned an equivalent. Between 1985 and 1986, MCRG built three types of FAD, using different types of attractants—replicas of shore drilling pipes, of coral reefs, and of coconut fronds—and installed them on an experimental basis in the Bay of Bengal. The results were encouraging but these floating rafts were towed away by mechanized boat operators. The scientists of MCRG had long discussions with the fishermen and the group decided to submerge the structure, creating sunken FADs. The idea worked and MCRG was besieged by fishing cooperatives for more of these devices. There was something ecologically efficient about FADs. It was discovered that FADs attracted and concentrated fish from far away waters. In fact, nineteen varieties of fish not generally found within the 5-km zone were attracted to these structures. Given such concentrations it was also possible to engage in line fishing. By harvesting bigger fish with lines, with single and multiple hooks, juvenile fish were spared. This helped in the conservation of fish in the long run. FADs, it was obvious, were increasing the average income of the fishermen.

But a scientific solution has to be seen within the politics of resource

conflicts. FADs became a threat to mechanized boats, which attempted to destroy them or tow them away. One realizes that one begins with a community and sees the community as a solution. MCRG felt the solution was not just the improvement of traditional technology but the revival of the fishing panchayats.[12] A cluster of villages around the FADs would discover not only an improvement in technology but new possibilities of resistance. In this sense, MCRG's work on FADs illustrates one of its basic principles. To the MCRG scientists there are two kinds of innovation, the innovation of the virus and the innovation of the organism. The virus enters the body and replicates itself, thus destroying the body. An organism lives in symbiosis, engaging in reciprocity and conversation. Sustainability for the MCRG requires the symbiosis of laboratory and society. In fact, a laboratory seen as alien to a society becomes a virus. A scientist's relation to a society is that of dwelling. You begin not with poverty but with the poor and the people in a particular community. Poverty is not a state to be eradicated but a site for invention. Seshadri illustrated it with an example from housing.

> When we go to an architect to decide how to build a house in the city, he will throw phrases like metabolic comfort, temperature control, humidity control, comfort index, etc. We don't want any of these considerations for houses to be built for poor people. Why don't we introduce metabolic comfort for the poor people as the first criteria of low-cost housing? It can be done easily by sloping the roof in such a way that solar energy coming into the house is minimized. We are so busy eradicating poverty that we never think of comfort for the poor. It needs a change in framework from thinking of a slum as a threat to the slum as a warm living human organism that can invent its way out of poverty.

One of the most fascinating attempts at working out the interface between traditional forms of life and knowledge and modern science is the laboratory's work on the *Katumaram*. It also involves the elaboration of a style of thinking. Consider a tree. A tree can either be an icon or an index. Iconographically, a tree becomes a cosmology of connections. For instance, the coconut is a little cosmology, a network of connections linking myth, religion, economics, ritual, food, and agriculture. A coconut is a celebration of over a hundred different uses. It is also a micro-climate creating its own minor ecology of plants. Seshadri suggests science must think like the coconut, link cosmology and system, and it is precisely this that the monocultural effects of modernity abandon. Monoculture is not only thinking of one kind of plant or tree. It is reducing it to a single one of its uses. When we reduce the forest to pulp, the answer is eucalyptus. But once we understand the trophicity of even a tree we realize that one man's waste is another woman's life material. It is precisely this kind of iconic thinking that Seshadri suggests. One captures an idea of this in his work on the catamarans, an imagination that links the forest and the sea.

The *Katumaram*, or the catamaran as they call it in English, is a great achievement. Seshadri describes it as a superb hunting steed for what are perhaps the last great hunter-gatherers—our fishermen. Seshadri points out that these fishermen are great "predators" in one context, but that in another, that of land, they are at the lowest trophic level of the market-economic system. The question that faces our country is how long we can support our fishermen with boats, given that the wood they use is now subject to competing demands. Almost all the trees used for the catamaran—the Bombax, the *shorea robusta* (*sal*), the mango—have competing industrial uses. Further, *sal* is used by tribals as food, for oil, and for its leaves. The Bombax is used for making matchsticks and fodder. Mango trees are used for housing, packaging and mangoes. So any competition for the forest is likely to hit the fisherman hardest. Yet the catch of fish from the catamarans supplies most of the animal protein of cities like Vizakapatnam, Madras, Pondichery, Tuticorin, Trivandrum, and Bombay. Yet we face the fact that over 5000 boats have to be replaced annually in Tamil Nadu alone.

Seshadri realized that the industrial uses of forestry are so predominant in even social forestry programs that the small users of forests, the traditional fishermen, may be given little consideration.The solution that Seshadri devised was a polyethylene boat made from biomass products. Polyethylene is a polymer made from alcohol or ethanol. Since ethanol is a product made from cellulose biomass, polyethylene may be looked at in some sense as a renewable resource. Seshadri suggests that only a small portion of the alcohol obtained from molasses can supply all the fishermen with boats. He cites the following figures:

> 22.5 km of Bombax forest supply 5000 *marams*.
> 70 sq km of sugarcane can supply 5000 *vastis*, which can last over 25 years instead of the usual five.

Such rafts can also be used for river hydroponics. The *vastis* developed by the MCRG are an example of how science can keep traditional crafts alive.

I will consider one other attempt at thinking about the forest and mediating between traditional ways and modernity. An experiment still in progress, it deals with MCRG's experiments with paper.

The Energetics of Paper

The MCRG as an institute is full of thought experiments, outrageous hypotheses that become the basis of scientific programs. Scientists like Seshadri often contend that political rhetoric without numeracy is romanticism. They point out that there is repeated talk of the commitment to education but few translate the requirements of that commitment into the question of the number of students, the quality of paper, the acreage of forests or the energetics of paper. Seshadri performs what Hans Jonas calls a heuristics of fear: mental exercises to find out the future of various resources like paper. Heuristics of fear then need technologies of hope where innovative answers are worked out. The paper industry is a protected industry attracting enormous subsidies in terms of power, materials, and forest land. However, by the turn of the century, the consumption of paper per capita is likely to be only 4.5 kg. Yet, even at the current demand of 3 kg per capita per year, India will need 150,000 to 600,000 tonnes per annum if 50 to 200 million people are going to be literate. One faces the possibility that a literate India is a deforested India. Seshadri adds that "even if the present illiterate population cannot be taught using paper, future children will need about 10–15,000,000 tonnes per year at the rate of 1 kg/child/year, assuming an annual birth rate of two percent. The demand for innovative techniques in education and materials are needed." The problem is further compounded by the nature of the paper industry in the Third World. The Indian paper industry has an installed capacity of 25 lakhs of tonnes[13] spread over roughly 250 units. Production of hand paper is about 7000 to 10,000 tonnes a year. An examination of the paper industry reveals that it is wasteful at almost every stage. Discounting the wastage of leaves and twigs, only 20 per cent of a tree crop ends up as paper. For this, enormous forest areas have been taken over.

The energetics of paper in India is even more disheartening. Paper manufactured from wood pulp is even more energy intensive than steel manufactured at 67 MJ/per kg of paper.[14] Roughly "24–25 percent of the total energy is wasted irreversibly, the maximum loss of high quality energy (39.8 percent) occurs in the soda recovery process, followed by another 30 percent in the steam production unit. The annual fuel energy cost of paper manufacture is approximately 21.9 percent of the annual turnover of the industry." Not only is the industry highly energy intensive, it is excessively polluting. "Waste water is regarded as the biggest hazard to the environment from the paper industry. Chemical compounds that contain chlorine have been identified as the major source of pollution. Conventional pulp bleaching which includes chlorination will produce 6000–9000 gm of chlorinated organic material per tonne of bleached pulp prior to effluent treatment."

The MCRG developed a two-pronged strategy that embodied what Seshadri calls its philosophy of holistic invention:

1) The choice of the appropriate technology with its accompanying energetics.
2) Reconceptualizing the tree.

The strategy of energetics begins with the fact that "under Indian conditions wastes or residues become a resource for energy generation and the manufacture of useful products." Rice straw, for instance, is considered waste in Punjab but is deemed valuable in other parts of India. Similarly, distillery effluents, which are valuable carbohydrate resources, are discarded after minimal treatment. All these are what we might call renewable wastes from renewable materials.

Cellulose, which has a worldwide production of 50 billion tons, is one such resource, particularly in countries short of petroleum. Cellulose raw materials or wastes could be the raw material for paper. Cellulose degradation through biotechnology seemed the optimal choice because the process eliminated the requirement of caustic soda and steam for paper and thus effected drastic cuts in the energy budget. "Given that in India over 1.7 million tonnes of cotton lint are required to be disposed of annually, such a process could result in the control of hazardous pollution with the simultaneous production of paper."

The MCRG also felt treating forests as pulp was violence. The diversity of tropical forest soon gives way to the monoculture of pulpwood species. Instead of using trees as raw material, they decided to use tree usufructs to harvest the raw material for pulp. Silk cotton, obtained from the Cuba *pintandra* or S. Malabarica, contains 64–70 per cent cellulose and is used for papermaking. The cotton that is to be degraded to pulp is treated with ash, or with bacteria and solar energy. Less energy is spent and there are no harmful chemicals used.

These silk cotton trees are available generally all over India. Each tree gives 20 kg of cotton annually and is presently used for making mattresses and lifebelts. The plan is to cultivate these trees in wastelands. They need watering for the first two years. The trees start to yield from the second year and the maximum yield is from the sixth to the fiftieth year, although the trees live for a hundred years. Nor is the tree reduced to silk cotton. "Besides cotton, the trunk can be used for matchsticks and boats, and oil can be extracted from the seeds." Finally, since the harvesting is an annual one and is based on a crop rather than on timber, the problem of the depletion of forest cover is avoided. Work on the cellulose degradation process is still continuing. For the MCRG, this approach to paper reflects what American ecologists dub "green chemistry," which generates little waste, is resource conservative, and energy prudent.

Some axioms

The anthropologist in me can go on describing MCRG's efforts in algal technology, wind erosion, windmills, and biogas, but I will stop now by

summing up how the scientists themselves conceptualize this experience. I must begin with a story.

While browsing through Seshadri's library I came across Harold Morowitz's beautiful essay on Willard Gibbs. Morowitz was asked to write an essay on the American bicentennial. Spurred on by the request, Morowitz remarks that the declaration of the thirteen colonies was historical, but that Gibbs's paper, his work on thermodynamics, was the second most historical document. It is this juxtaposition that tantalizes. A declaration of independence and an essay on entropy. It made me think of the sheer fascination of a scientific addendum to the constitution. There is talk of the scientific temper but reading it you would think that the scientific temper is some kind of extract that, once injected, provides immunity against some forms of imagination. This way, the scientific temper is little more than a bit of secular elitist moralizing. An appendix on science would make the constitution more alive, more real, more playful. You could begin to look at concepts like poverty and equity in a new way.

In the beginning was the "word." One must realize that scientific statements like the statements of the constitution are words. Words are not innocent. They have deep-rooted cultural meanings. Most of what we call science is 1) anthropomorphic and 2) Judeo-Christian. It posits the superiority of man in the universe, or at least a special place for him, as in the anthropomorphic principle. "This is by no means universally true and there are many examples of bird, insect, or animal communities excelling us in some attribute or other." It is this anthropic arrogance that led the biologist Lynn Margulis to demand a trade union to represent the role of bacteria.

If the first argues for the superiority of man, the second allows for the mastery and use of nature. Nature is made for man's use. Secularized, it is termed as a resource. The covenant with life is broken. This is important in a civilizational sense, for science must remind the constitution of the ecological matrix in which its society is embedded. Apart from the above, the addendum can include the following axioms.

Axiom I

1) Language is important in a second sense, for languages can be exploitative.
2) The language of science and technology is English. From English, if at all, we translate science and technology and development into our languages.
3) Thus the scientific temper is to be created in this country through this language.
4) But who is to temper the English language? England has the traditions of a small island that had to exploit the outside world for its benefit.

5) The semantics of western science and technology is by and large growth-oriented. This semantics is not helpful for resource conservation, or for resource distribution.

6) The technology, and therefore its semantics, is ultimately related to the market economy and the language of market forces. "How can such a language be used for the aid of a people who are completely outside the market economy? We think there is a need for a less exploitative linguistics."

Axiom II

Science and technology have always been and will always be the pursuit of exploitable knowledge with all the artifacts of such exploitation. All we can do is seek to minimize these effects.

Axiom III

A belief system should not be independent of lifestyle. Lifestyle is coeval with the technology that enables its practice. Violating this belief leads to the trauma of thermodynamics or Gandhian truth inconsistency. Science can no longer settle for observer participancy. It must be linked to questions of lifestyle. If not:

(a) Technology will become a substitute for ideology.

(b) Technology Imperatives may lead you to emphasize the wrong value system.

Axiom IV

1) "Indians should have a lifestyle that is evolved for Indian conditions. This includes resource constraints, disparities in society, overall lack of complex modern systems and the fact that the Third World does not have the fourth, fifth, and sixth worlds to exploit any more."

2) Science links lifestyle to ecolacy (ecological awareness). We must ask the question democratically and scientifically: "What level should we live at? Is it 5000 kilo calories a day or 10,000 kilo calories a day? This number must be arrived at by consensus."

Axiom V

Science must be linked to citizenship. A citizen is a person of knowledge. No science can be deskilling. Knowledge is a commons. Science must address itself to the question of diversity where life forms are disappearing, whether it is one variety of plant a day, or one language a week.

Paradigms must be linked to lifestyles to create ground rules for citizenship. Such ground rules should be seen as thought experiments that reveal the nature of choices, the knowledge base and their link to lifestyles. Such a greening may involve a coercive holism.

Three examples can illustrate this. One can think first of George Fernandes's directive that only mud *khullars* be used in railway stations, instead of paper or plastic cups for serving tea. Or Seshadri's suggestion that all school uniforms be made from *khadi*.

The "coercive holism" of Seshadri is only another variant of Gandhian Swadeshi, where locality provided the basis of lifestyle and self-reliance. You used local goods, local skills, and local raw materials to create a lifestyle that was self-reliant. Seshadri ends his essay with this dictum: "We can develop by developing new languages or remain underdeveloped forever. It is only through the creation of such thought experiments that science can link lifestyle to citizenship."

Axiom VI

Every citizen has to be a craftsman and an inventor. Gandhi was a master citizen and inventor. He was craftsman, cook, weaver, scavenger, lawyer, surveyor, drainage expert, psychologist, a theologian of Christianity, a practicing Hindu, as well as his own Havelock Ellis and Masters and Johnson. Inventiveness demands irony and humor. The industrialist Jamnalal Bajaj once donated a car to Gandhi's *ashram*, which refused to function after a while. It was pulled on occasions by a pair of bullocks. Gandhi called it his own Ox-FORD.

Citizenship as craftsmanship also needs ideas of numeracy and literacy.[15] Development like citizenship involves not only access, but competence and judgment. "Development involves vast transfers of knowledge. Before we undertake this, it is important to transmit the science of knowledge that underpins the knowledge we transfer." Seshadri emphasized that "by concentrating on lived concepts like numeracy, ecolacy, literacy, and democracy we evade the dualism of tradition and modernity."

Loosely, numeracy is the ability to see discrete entities in a connected whole or a continuum. Those lacking in numeracy usually possess two kinds of deficiency. The first is the inability to see discreteness in continuity. The second is to see only discreteness and not to perceive the continuum at all. Both deficiencies can create survival problems in a developing society.

Deficiencies of the first kind:

1) "This would include all tribals who gather fuelwood thinking it is a free good, unaware that energy has a value in the market place and that gradually they are being denied access to the traditional resource of fuelwood.

2) "All people who do not realize the difference between rearing five children and seven.

3) "All roads in South India are used as solar driers. However, roads do not belong to the village any more. They belong to the lorries, buses, and cars of a larger system. The enormous wastage of grain and cereals due to traffic is not accounted for—if it were, then people perhaps would arrange for a better drying system."

One must emphasize that innumeracy is not just a lack of arithmetic skill. It is a tacit knowledge, the awareness of resource limitation, a feel for quantity and its allocation that we need to inculcate in people.

Deficiencies of the second kind:

1) "These include all people who thought the forests of Silent Valley were equal to so many megawatts of hydel power.

2) "All people who do not realize that over 50 per cent of the total energy consumed in the country is consumed in the cooking stove.

3) "All the people who think that because non-commercial energy cannot be accounted for in our theories, it need not be accounted for. This is saying that the discretization of the money market is the only part of the continuum that exists."

4) "All people who consider development as increase in average per capita income." Numeracy is an absolute essential for survival in a developing society. It is also linked to time in a significant way. "Time is an essential constituent of numeracy, in fact time is the prime numeraire." This problem of time, science, and development constitutes one of the fundamental issues of exploitation.

Axiom VII

A constitution by itself does not complete the charter of modernity. To it one would add the other charters, each of which captures time in a particular way—the plan, the calendar, the metric system, the collection of standards, or even the schemes for the transfer of technology each exploits through a particular imposition of time.

Standardized time emasculates a series of vernacular times in a process called economic development. Seshadri observed that the Gregorian calendar is a measure of time. Peasant time is time. Confusing time with its measure is one of the greatest tragedies that have befallen the poor in the tropics. "The tax structure and collection, the education system, and the weekly and yearly holidays are all tied to an artificial system that bears no relation to the cycles of the peasant and those of husbandry. The 'oestrus window' of his cattle, the 'ploughing windows' of his fields, the synchrony of crop harvest and his earnings, have no place in printed calendars: the latter measure concepts of time far removed from nature befitting Roman emperors of bygone days." The East India Company used calendar time as the most potent tool to separate the farmer from his land.

The time of modernity is an attempt to impose Cartesian time on a basically a-Cartesian people. Concepts of time expressed independently of human existence fall into Cartesian categories. Peasant time is lived time, the time of the body, the time of nature's cycles. Modernity imposes a mind–body separation through time. The digital watch becomes an extreme example. Time is no longer a continuum here. It is discretized and attached to a number system.

Consider the negative discrimination that time imposes on the following people. The educational calendar is designed with the children of city office-goers in mind. The monsoon generally comes in June when school starts for the year. The question arises: should the farmer send his able-bodied children to school or should they assist him on the farm? It is not surprising that 8- to 10-year-old children have the highest dropout rates.

It is in the domain of time that the politics of affirmative action also needs to operate. Consider migrant communities. When one is talking of migrant shepherds or fishermen, one sees that not much effort is made to have mobile schools for them. Within a Western colonial heritage, education for the children must be separated from adults. Seshadri suggested that in tribal areas, all members of the family should have access to education simultaneously.

CONCLUSION

All knowledge systems (both traditional and modern) must embody principles of self-destruction.

These rules of impotence are limits, but limits should not be seen as constricting or puritanical. The analogy is to fasting. Fasting is not a calorific word, dieting is. When you fast, you don't lose weight; you live in harmony with your body.

1) Each knowledge system if it is to be democratic must realize it is iatrogenic in some context.

2) Each knowledge system must realize that in moments of dominance it may destroy life-giving alternatives available in the other. Each paradigm must sustain the otherness of other knowledge systems.

3) No knowledge system may "museumify" the other. No knowledge system should be overtly deskilling.

4) Each knowledge system must practice cognitive indifference to itself in some consciously chosen domains.

5) All major technical projects legitimized through dominant knowledge forms must be subject to referendum and recall.

I have presented this chapter as a set of fragments that I believe has the making of a heuristics. The laboratory is a critical site mediating between the policy-making agencies and the community. In this context, I must mention that Seshadri had a theory of the laboratory as an intrinsic part of his theory of knowledge. He felt that the science laboratory in India was a remote entity, an outpost of the western scientific establishment, but that it is unaware of its intellectual genealogies or its political contours. He felt that a laboratory must be as innovative and as embedded as the *gharanas*. In this context he saw the laboratory as a fourfold experiment. He felt it should be a *dharamshala*. This emphasizes the concept of refuge and hospitality to defeated and marginal ideas. The *dharamshala* is contra the museum, the repository of dead and traditional knowledges. The laboratory was to be also conceived as an *ashram*, appealing to an ascetic style of life, a science lean and sinuous in muscle. One adds to the other elements the notion of a *gurukul*, a transmission of the craft, the spirit and tradition of knowledge from generation to generation. And finally the laboratory was to be modelled on the kitchen, domestic, feminine, and open to the household, the farm, and society. It was a combination of four institutional elements setting a different style from official structures of science.

C. V. Seshadri did not complete his axiomatics of a compassionate science. He was deeply influenced by Sam Neillson's Nobel Symposium, "*The place of value in a world of facts*," particularly by Linus Pauling's argument that science must be based on an axiomatics of suffering. Yet it is necessary to emphasize that the text of suffering must remain polyvocal enough so that it is not reduced to innumerate indices of poverty or nutrition as calories. Yet he also emphasized that the constitution of India must guarantee a basic daily metabolic intake for all its citizens.

The Seshadrian experiment remains incomplete. The laboratory stands, but as an unhappy shell. The hypotheses and wishful thinking, the daydreams he conspired to construct with Joe, Jeejibhai, and Balaji are now memories. What we need today is to remember that he emphasized that memory is reinvention. We can turn him into a monument. We have to reinvent him and quarrel with his ideas in new and playful ways. He felt a sense of defeat in his last years, a sense of the embourgeoisement of radicalism, a feeling that NGOs had added to the overall sense of cynicism. He wanted more oddballs, eccentrics, dissenters, and classicists as citizens. I remember his comments during a seminar at the Max Mueller Bhawan in Madras. He was complaining there were not enough cranks in the room. "Have you read Schumacher's comments on the crank?" he asked. Schumacher said a crank is a simple everyday instrument and yet every time it is turned around it produces revolutions.

This chapter then, is a tribute to a classicist scientist, a crank who wanted to reinvent democracy, a crank who saw autobiography, the laboratory, and the constitution as thought experiments, a visionary who felt India could transform the current idiocies of globalization into something life-giving, and a crank who believed that Tamil Brahmin Madras had something radical and creative to contribute.

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Notes

1 This chapter is based on fieldwork done for my forthcoming book on C. V. Seshadri. I wish to thank Jo Thomas and V. Balaji for their insights and conversations. All unreferenced quotations come from conversations with C. V. Seshadri.

2 See Visvanathan, 1985, especially chapters 1–3.

3 See Nandy, 1980.

4 *Editor's note:* North-American author of *The Cynic's Word Book* (1906) later published as *The Devil's Dictionary* (1911).

5 *Editor's note:* Indeed, throughout this chapter several citations occur which result from informal exchanges between the author and Seshadri.

6 *Editor's note:* Carnatic music is the classical music of Southern India. For more information go to http://www.carnatic.com/

7 See Visvanathan, 1985, chapter 3.

8 See Elkana, 1974.

9 See Sahasrabuddhey, 1991.

10 *Editor's note: Prosopis cineraria* (*Bot.*), known in India as khejri, jand, sangri, jand, kandi, sami, or sumri, good for the arborization of desert land.

11 *Editor's note:* The VII Conference of GIAM tooks place in Helsinki on '12–16 de August' 1985.
12 *Editor's note: Panchayats* is the traditional form of communal government in Índia.
13 *Editor's note: Lakh* is a unit in the Indian numbering system. One lakh is equal to a hundred thousand.
14 *Editor's note:* MJ is the acronym for megajoule, a heat unit representing one million joules.
15 See also Hardin, 1985.