brockman on the edge

DINNER AT TAPAS There is no progress in evolution. The fact of evolutionary change through time does not represent progress as we know it. Progress is not inevitable. Much of evolution is downwards (in terms of morphological complexity), rather than upwards. We are not marching towards some greater thing.

I am sitting in Tapas, a restaurant in Porter Square, Cambridge, talking to Stephen Jay Gould about zoology, paleontology, evolutionary history, and baseball. Steve is working on measuring progress in baseball and evolution. In his musings on the assessment of excellence he speaks about eohippus, Kentucky Derby winners, human history, 18th century castrati, Ted Williams, and Mozart. "I want to propose to you," he says, "that the reason (and this is paradoxical) for the decline and disappearance of .400 hitting in baseball is because baseball has gotten better."

I had accepted Steve's invitation to attend a Boston Red Sox night game at Fenway Park. Then it rained. So we sit at Tapas swapping Red Sox stories. Why talk about punctuated equilibrium or The Burgess Shale with the world's foremost evolutionist when you can commiserate about Boston's 1986 World Series loss to the New York Mets, and that unforgettable moment when the ground ball dribbled through the legs of Red Sox first baseman Bill Buckner into right field?

I like Tapas, and I like talking about serious ideas in public spaces, especially in a place like Cambridge, where the weight of the institutions of learning sometimes seems to be inversely proportional to the velocity of intellectual play. As I graze on cazuela de chorizo and papas a la arequitena, Steve talks to me about his current work:

"The actual history of life is awfully damn curious in the light of our usual expectation that there is some predictable drive towards a generally increasing complexity in time. If that were so, life certainly took its time about it, namely five-sixths of the history of life is the story of single-celled creatures only.

"I would like to propose to you that the modal complexity of life has never changed—it never will—that right from the beginning of life's history it has been what it is. And that our view of complexity is shaped by our warped decision to focus on only one small aspect of life's history. And that the small bit of the history of life that we can legitimately see as involved in progress arises for an odd structural reason, and has nothing to do with any predictable drive towards it.

"When we get to human history we seem to suffer from a reverse myth, namely this incurable notion of the past golden age, and questions and thoughts of degeneration ever since. We always hear talk about golden ages, particularly in fields that give rise to a lot of nostalgia, like movies and sports. I would like to propose to you, although I am certainly no pollyanna, that a priori, with perhaps a few exceptions, the myths of golden ages can't really have any content to them. For one thing, it's a simple question of demographics. If you just think of how many more people there are now, of how many people there are with opportunities, it really is improbable that excellence has been declining in any absolute or relative sense.

"The mythology of baseball is an important theme in our culture. The disappearance of .400 hitting is thought to betoken a loss of heroes—there were giants on the earth in those days—and nobody does it anymore. Up until 1930, .400 hitting was quite common. It was done by nine different players until the last person, Ted Williams, hit .406 in 1941. Prima facia it would appear that the great heroics of batting have disappeared. Something that used to be done that clearly betokens excellence, such as getting four hits in every ten times at bat, simply is not being done anymore. An enormous body of literature is dedicated to this perceived problem; and it makes the cardinal mistake of assuming that .400 hitting is a thing, that it is an essence, that is itself an incarnation of excellence that existed at one time, and exists no more. It has been removed from us. But .400 hitting is not a thing at all. .400 hitting is the right tail of the distribution of batting averages in some years. It's not a thing. It's part of a system of variation—the frequency distribution of batting averages through time.

"The arts have an unquestioned ethic of innovation: you cannot be considered to possess greatness unless you're innovative with respect to past styles. Yet is it conceiv-

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INSIDE

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able that there might be a limited realm of accessible styles, and that as long as this ethic is maintained where it is absolutely necessary to be innovative in order to be seen as creative, there could be a special tragedy in certain of the arts in that you could perhaps use up all the accessible styles. The styles would be accessible to large numbers of reasonably intellectual technical amateurs, and so you might end up in the tragic situation of only speaking to a very small group of specially trained coteries. And I have often wondered, although it's sacreligious, why it is that we can't ever allow the attempt to create to be interpreted as genuine innovation, and not merely as a part of the service industry. It's tragic that we don't have five more Mozart operas.

"Between 1700 and 1800 in Europe, in Germanic-speaking countries, there lived a Bach, a Handel, a Mozart, a Haydn, a Schubert, a Beethoven—a tiny little coterie of people from whom musical greatness was drawn. It's inconceivable, given the demographics, that there aren't more people of that potential degree of talent. Some people say they're writing rock music, they're writing jazz, and maybe that is the answer. Or, maybe all the accessible styles have been used up, and the talented people are forced to write (music) in highly academic styles largely inaccessible to those outside the priesthood of a few professional composers. Why would it be wrong if there was someone who could write Mozart—why couldn't we commission her to write those five Mozart operas and actually put them on and actually cherish them?"

BIG C & LITTLE C I take Howard Gardner very seriously. As a matter of fact I always do whatever he says. "A good progressive school is a gift to your son," he advised me five years ago when Max was about to enter first grade at the Bank Street School. "The challenge is also to empower your child to act upon his environment. Just make sure," he went on, "that he masters an art or musical form and a sport as a balance to the process-oriented academic education he will receive." Five years have passed and I often think of Howard while I listen to piano practice, or freeze my ass off winter weekends at various outdoor ice hockey rinks around Western Connecticut watching Max play right wing for the Washington "Squirt" team. But it's surely been worth it and Howard, who is professor of education at Harvard, director of Harvard's Project Zero, and a MacArthur Fellow, remains my education and creativity guru.

Howard recently stopped by and talked about his new work on creativity in the modern era.

"Anyone who decides to talk about creativity has at least three points—if not three strikes—against him:

1) Creativity is a huge and amorphous subject. Noam Chomsky calls it a mystery, rather than a problem, with the clear implication that scholars should not waste their time studying mysteries.

2) Nearly all of the work in the psychology of creativity is worth little; the track record of researchers gives little encouragement to current workers.

3) Most individuals think of themselves as being creative, and so almost any generalization is immediately arrayed against the personal experience of the audience. There is none of the respectful distance which is routinely accorded to physicists or economists who are discussing their research.

"I want to introduce one useful distinction. The distinction contrasts 'little C' creativity, the sort which all of us evince in our daily life, with 'big C' creativity, the kind of breakthrough which occurs only very occasionally.

"A preliminary definition, which has emerged as a result of collaborative work with David Feldman and Mihaly Csikszentmihalyi, is: a creative individual is one who regularly solves problems, fashions products, and/or poses new questions in a domain in a way which is initially considered novel but which is ultimately accepted in at least one cultural setting.

"Nearly everyone who defines creativity notes that creative behaviors are initially novel or original but that ultimately they become accepted. If they are not initially novel, no one would consider them creative. And if they are not ultimately accepted, then they may be bizarre or anomalous but not creative.

"However, my definition takes a further, more controversial turn. According

to this definition no person or work or process can be considered creative unless it is so deemed by relevant social institutions. Following Csikszentmihalyi I term this social dimension 'the field.' The social institutions or field will vary enormously from one domain to another. Thus in the case of a domain like physics, the relevant field can be as small as a dozen knowledgeable peers; in painting, a melange of critics, gallery owners, dealers, and the art-loving public constitute the field; while in newspaper or magazine publication, the field can consist of thousands or even millions of purchasers.

"Researchers have been asking the wrong question. Instead of asking 'What is creativity?' or 'Who is creative?' Csikszentmihalyi has suggested that one tackle the question 'Where is creativity?' Csikszentmihalyi proposed that creativity lies not at a single locus but rather in the dynamic interaction among three nodes: the individual person or talent, the formal structure of knowledge in a domain, and the institutional gatekeeping mechanism, or field.

"The scheme can be concretized by the following example. Say that there are one thousand budding painters at work in New York City, each with his or her peculiar strengths and styles. All of these individuals attempt some mastery of the domain of painting, as it now exists; and all of them address their work, sooner or later, to the field—the set of gallery owners, art school departments, newspaper critics, dealers, and the like. Of these individuals, a few will be selected as worthy of special attention by the field; and at least today, their novelty will be a significant factor in their selection. Of these individuals, at most one or two will paint in a manner which becomes so esteemed that their efforts will ultimately have some effect on the domain itself—on the structure of knowledge which must be mastered by the next generation of painters. We can see here that creativity lies not in the head of the artist (or in his hand), not in the domain of practices, nor in the set of judges; rather the phenomenon of creativity can only—or at least best—be understood by taking into account the interaction among these three nodes.

"Painting, however, may seem an idiosyncratic domain, perhaps one where the field assumes undue importance. What of a contrasting domain, such as mathematics? I submit that the processes at work here are essentially the same. Substitute for our thousand artists an equal number of mathematicians, say topologists. Each of these students must master the domain as best he can, and those who want to move on must address their proofs and their discoveries to the field—this time a set of professors, journal editors, prize givers. Only a few of the young topologists will stand out in terms of professorships and publications; and of these even fewer will actually affect the domain in which they work sufficiently, so that the next generation of youthful topologists will encounter an altered domain.

"The field is as important in mathematics as in the visual arts. It differs chiefly in that it is somewhat smaller and far more consensual in its judgments. By an amusing coincidence, the mathematics community awards every four years a medal to the most gifted mathematician under the age of 40: this medal is called the Field Medal! Where mathematics differs most from painting on the contemporary scene is that the choice of Field Medal winners is rarely controversial, and nearly all the winners are considered later to have been important. In contrast, the winner of a given year's biennàle in painting has often been forgotten a decade later."

FILTERS AND BLINDERS "When we filter our information, will we be blinding ourselves to the kind of 'irrelevant details' that can lead to new insights? When we screen our communications, will we be shutting down possibilities for building new communities?" I am sitting at the soda fountain in the General Store on The Green of Washington, Connecticut talking to Howard Rheingold, author, editor and ruminator on subjects as diverse as language, virtual reality, technology, and communication.

Today, Howard is unusually energized. Maybe it's his new job as editor of "Whole Earth Review." Perhaps he's stopped listening to the "Grateful Dead." Perhaps he's stopped smoking. He's alive. Sparkling. For months, we've been

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debating my comments in *EDGE #1* about electronically linked networks, the WELL (The Whole Earth Electronic Link) in particular. I can buy into the line that the WELL is important, but problems remain: a user interface beneath contempt, stilted and mannered conversational etiquette, a lack of filters which means that people you can't bear to hear from are electronically in your face. No unlisted phone numbers here. No answering machines to hide behind. No office staff to screen calls and mail.

Cars pull up to the Green as we gaze out the window drinking in the theatrically New England scene. Flinty-looking locals pull up in Fords and Chevrolets next to Ralph Lauren-clad weekenders in Range Rovers and Mercedes. Howard sips his drink and comes back at me with "Rheingoldian" rhetoric:

"John, although you eschew the WELL for its awful user-interface, and hate the fact that your electronic mailbox tends to fill up with messages that you would rather not see, I have found that the WELL serves as both an information funnel that brings all kinds of knowledge to my desktop, and as an intelligent filter that helps me sort my way through all the information that comes my way. Although visions of 'information agents' of the future predict that AI-endowed personal information secretaries—smart software that will combine the functions of librarian, answering machine, and directory services—will serve as informational buffers for us in the coming decades, we are still far from knowing whether such technologies will be feasible. At the same time, those of us who receive information in the mail, over the telephone, via fax and modem and BBS, find ourselves inundated. We need to shield ourselves from all the information we don't want without crippling our ability to find our way to the information we need. On the WELL, we found that a new kind of technology-assisted social contract is making it possible to do what technology alone is not yet able to do.

"If, in my wanderings through information space, I come across items that don't interest me but which I know one of my group of online friends would appreciate, I send the appropriate friend a pointer to the key information. This social contract requires me to give something and enables me to receive something. I have to keep my friends in mind and send them pointers instead of throwing my informational discards into the virtual scrap-heap. It doesn't take a lot of energy to do that, since I have to sift that information anyway in order to find the knowledge I seek. And with twenty or a hundred other people keeping an eye out for my interests while they explore sectors of the information space that I normally wouldn't frequent, I find that the help I receive far outweighs the energy I expend helping others.

"The WELL serves me as a communications filter as well as an information filter. You can pick up a telephone and call anybody in the world. But you have to know who you want to call. You can't ask directory services to connect you with someone who has taught their six year old daughter how to play chess, or knows

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in tel lec tual graffiti

"In the real world all markets are local and all relationships are personal."

—Edward T. Hall

"The problem with architecture as art, and as a public monitor of the psyche, is its dependence for expression on the rather ponderous elements of construction technology. This handicap is all the more reason to engage the ever-changing and unpredictable ingredients of nature. Their inclusion in an architectural context is the ideal critical device to question and contradict the methodical processes of building. Landscape is also primal and universal. It strips away redundancies and constantly reveals new information. It is rich in associations. It is dialectical, evolutionary, and indeterminate. It is, finally, an iconographic force that can advance the language of architecture and, at the same time, confirm the inalienable right of people to try to salvage the earth before it is too late."

—James Wines

where to stay in Kyoto, or remembers the title of that book about the guy who changed his skin color. But a computer mediated community can help you find those people. I have been able to build my own communities of interest to augment the more haphazard communities of geography and occupation.

"I see that the next communications revolution will bring enormous information and communications resources to individuals, and along with those resources, the capabilities to build new communities. At the same time, I see that the increased access to information and communications is necessitating new kinds of filters to protect us from overload and intrusion, and I fear that one of the side effects of these filters is that new means of sifting and sorting information and communications will force us to wall ourselves off from one another in new ways. In other words, filters can be blinders.

"The WELL and the Internet and linked networks will grow to involve tens of millions of users worldwide; backbone sites and some local loops will upgrade to fiberoptic channels and gigabit transmission rates that will enable multimedia conferencing, video email, and other high-density information exchanges.

"Cellular and satellite-based schemes will lead to further proliferation of handheld, totally mobile communication devices with significant onboard computing capacity; smartcards and other high-density information storage devices will enable individuals to personalize their communication units to include information about reaching specific people, about which people one wants and does not want to be able to reach oneself, and about the location of information and information services.

"Telephone companies are beginning to offer services such as voicemail, caller identification, call blocking and tracing, selective call forwarding, priority ringing.

"Another kind of information filtering capability, rather than a communication filtering capability, was the 'newspaper of tomorrow' prototype developed at MIT's Media Lab. 'Newspeek,' as it is known, presumes that the newspaper reader of tomorrow will have direct access to all the raw news feeds, and will have an intelligent filter that will search for news that each individual has specified as an item of personal interest. Thus, my newspaper might have headlines about technology breakthroughs in Japan, and my neighbor's headline might be related to increases in energy prices.

"Two major trends seem to be working in rather opposite directions: more and more people worldwide will gain access to vast pools of possible partners in communities of interest; second, the increasing threats to privacy and the increasingly technological ability to screen communications make it possible for people to construct 'communities of exclusion' that specify, via smartcards or similar devices, who will be prevented from gaining access to them via communications. We will be filtering information and screening communications.

"Even those who have the most privileged access to advanced communications might find that our own devices will work against our best interests in subtle ways. If we all have unlisted numbers, who will we be filtering out of our lives? If we all filter our news, what items will we be missing that we don't know now that we will want to know tomorrow?

"In order to create a filter, you need to know what is relevant. And that can be a problem. A few years ago, my attention was attracted to a scientific report by a neurophysiologist who was conducting research for the Air Force. Using a sophisticated electrophysiological probe known as 'evoked potentials,' this researcher was able to determine which details in their perceptible environment pilots in flight simulators were paying attention to. When he used this probe to try to determine the attentional differences between expert and novice fliers, the researcher discovered something that struck a chord with me: 'Experts,' he concluded, 'pay more attention to irrelevant details.' Humans are far better than machines at pattern recognition, at making connections between details on the periphery of perception, obscure facts on the outer boundaries of orthodoxy."

If we all have unlisted numbers, who will we be filtering out of our lives? If we all filter our news, what items will we be missing that we don't know now that we will want to know tomorrow?

BOVINE IMPERIALISM Whenever I hit the American Southwest I call on my friend "Deep Desert" to be my guru and guide, and to tell me what's wrong with my New England background and New York thinking. Deep, a gifted biologist and naturalist, disappeared into the sands more than a decade ago. I don't know why, it's a long way from Brooklyn and Harvard. I find myself heading down to Tucson at least once a year just to hang out with him.

Very little money is made on cattle out of this part of the country because you can only put about eight cattle per section, six hundred forty acres. . . . It would actually be cheaper to do away with the animal damage control unit and get rid of the cattle, than it is to raise these cattle.

We are driving through Patagonia on the way to Nogales, Mexico. Deep is on my case to talk to Tony Burgess about "bovine imperialism." Last year, he introduced me to Tony at the annual West Texas barb-b-que. Tony sings bawdy ballads. He has a great red beard and suspenders. According to Deep, he is probably the best naturalist of the Sonoran Desert and of all the fog deserts of the world, such as the Baja Desert, and the Namibian Desert.

Deep walks me across the border into Mexico. He lightens up immediately as we wander through the streets of this poor, crowded border town. Deep likes it here. He's a third-world kind of guy. I guess it's no accident that most of his work in water resources takes him to the poorer nations of Africa and South America.

We find our way to Elvira's, the place to eat if you ever find yourself in Nogales, where we sit and talk, downing tequilas and eating burritos. "Am I really going to have to listen to a spiel on 'bovine imperialism?'" I think to myself. The local Mexicans are incredibly friendly. Some of them come over to the table to talk. It's all very relaxed. I am mellowing. Every town, every highway, every landscape, skyscape, even every restaurant provides a different mirror for the mind. That's why, for me, it's important to go away, or not go away. So here I am in Nogales, astonished to find myself listening with fascination as Deep talks about the history of the cattle cult in the human species.

"The cattle cult began about 5000 B.C. on the plains of northern India with the first domestication of the wild ox. People used to have ox heads in these temples and they would worship the ox and only keep the cows because they could be easily domesticated. They were always trying to domesticate the wild bulls which they never could quite do. The cult spread across India through the Middle East and into Africa. At that point the major predator of cattle in Northern India was the bear. The high grasslands where the cattle were driven in the dry season were full of bears that would prey on calves. So those people who still lived in the mountains and were basically cave people, or used caves for shelter that were also shared by bears, became the bear cult. And those people who became pastoralists and could finally go out on the grasslands and survive without shooting animals, became the bull cult or the cattle cult. That theme in a very general way has gone through five thousand years of history and ends up with Tony Burgess.

"Coming to the United States there was a revival of the bull and bear story. It was grizzlies versus the criollo, the Mexican wild cattle that came up from Mexico that the Apaches started hunting before white men even showed up. White men came along, told the Apaches that they couldn't hunt these beasts, and this led to the beginning of the Apache Wars. It also meant that the settling of the West meant killing off the grizzlies because they were calf predators. That still goes on. This year fifteen bears were shot but now you have the environmentalists supporting the bears and the cattle growers supporting the bulls. Tony talks about how the cow cult has dominated the southwest, and what he calls 'bovine imperialism.'

"Very little money is made on cattle out of this part of the country because you can only put about eight cattle per section, six hundred forty acres. Ninety-five percent of all the cattle grown in the United States is grown east of the Mississippi on pasture. The west only has three to five percent of all the cattle, and yet this has the incredible power. They spend more money on predator control than most ranchers make off their cattle. It would actually be cheaper to do away with the animal damage control unit and get rid of the cattle, than it is to raise these cattle."

The next day, back in Tucson, Deep and I hook up with Tony. We drive

through a freaky desert snow storm (and I had packed a bathing suit!) talking about cattle cults. I am far, far away from New York. Tony looks and talks like a cowboy. But I don't know too many cowboys who can parlay ideas on bovine imperialism into a discourse on current thinking in complexity and evolutionary theory. I listen to him, driving very slowly past the icicle-encrusted cacti, trying not to crash on the icy roads.

"When I was in school we were programmed with the notion that any system, if undisturbed, would come to a climax in equilibrium with the climate. This was called the 'climatically driven climax' and there was complicated terminology to explain the whys and wherefores of any deviations. But what we began to discover was something quite different. We started looking at old photographs and then matching them up and we started seeing changes on one scale. Then we looked at vegetation plots that had been monitored for seventy years and saw changes on another scale. And then we started looking at old pack rat midden deposits to look for changes on millennial scales and, of course, what we saw were massive changes on a continuing basis. Then we started looking at seedlings and realized that it is only in an exceptional year that you get the biological and climatic conditions set for the recruitment of a seedling of any one of these perennials, and they all slightly differ in the conditions required. So actually what we had was a system that not only exploited variance but *required* variance to make it work. Therefore, given the fact that it was a variance-driven system, it was unreasonable to expect that it would ever achieve this so-called equilibrial state. In fact, the richness of the system derived from the fact that it never came to equilibrium and, if it did, it would collapse.

"Looking at ecology on a millennial scale we are seeing massive changes sweeping back and forth across the landscape, and the real crux is always to find a safe-site in time and space for a species to keep from going extinct. And that of course brings us forward in time to the fact that there is global climate change. Climate change is the norm. Global warming is no big problem. If you look at the end of the Eocene there are alligators north of the Arctic circle, with deciduous forests on Ellesmen Island, which was well into the Arctic Circle even at that point. However, it is the rapidity of change that's crucial; how to cope with change that's more rapid than the biosphere can normally adjust to. This is where I think we need to take a more active role of management.

"What is needed is a mix of management strategies. I have seen both extremes, having worked in the Texas desert, which is almost all in private hands, as well as in Arizona, where there are large areas of public acreages. And I think the best future for any ecosystem is lots of different units of management, so that no one big mistake can be made. For example, it was federal policy from 1920 to 1950 that the wolf was a bad thing, and they succeeded: the wolf is now extinct in the southwest through the efforts of the federal government. But Italy has viable wolf populations. Spain has viable wolf populations. Why? Because there was local management and if wolves became extinct in one area, they always had some other area they could recolonize from. This is again the lesson we are seeing. You've got to look at ecology on a landscape scale of patches out of sync. The

at the reality club

The Reality Club road tour continues through the United States with recent meetings in Oracle, Arizona, and Nambai, New Mexico.

John Allen, Director of Research and Development at Space Biospheres Ventures, hosted a meeting at the Biosphere 2 where Reality Club members Allen, Roy Walford, Peter Warshall, and Tony Burgess discussed developments at Biosphere 2 with a group of the SBV scientists and several of the "biospherians" who will enter the biosphere for the two-year experiment. Part of the day included a tour through the nearly finished structure.

Cultural anthropologist Edward T. Hall spoke at a meeting in Nambai, New Mexico. Ned's topic: "The Hidden Order in Acquired Culture: The Ultimate Reality." Michael Nesmith hosted the evening at his Gihon Foundation. We met at Gihon's art gallery, which contains an interesting collection of painting and sculpture by women artists such as Frankenthaler, Nevelson, and Grandma Moses. Twenty people showed up, including Rudolph Wurlitzer, Doyne Farmer, Philip Glass, Stuart Kauffman, Mildy Hall, Eric Trinkaus, and Chellis Glendinning.

Because of travel advisories, Reality Club meetings scheduled for Tokyo and Kyoto in February were postponed. The Milan, Munich, and Paris meetings are still on for mid-April.

saguaros are going extinct in one part of this valley due to a combination of management strategy and some climatic problems. However, on the other side of the valley it is exactly out of phase. These saguaros have no problems. This is a young, vigorous population. So the real key to keeping the richness of the system is to make sure that it is never under one unified management. Ever. And I'm beginning to wonder if this isn't true for cultures also.

"Perhaps the reason we get this recession into tribalism is because as people get integrated into this global tech culture most of them become no better than consumers, mindless consumers and highly manipulated consumers at that, and so they want roots. They want local meaning and they want to have an effect, and for this reason the obvious backlash is the extreme nationalism and provincialism which we are seeing now. There ought to be a way to integrate this somehow so that nobody gets too far out of line and goes into what you would call a destructive mimetic syndrome like the Zulu outbreak of the 19th century where they started destroying everything. And the same thing applies to ecosystems.

Bovine imperialism is the idea that the desert must be made to support its fair share on the way to increasing humanity, and the idea that the only good we can get from semi-arid and arid lands is bovines—meat.

"A case in point would be the release of some of the South African grasses. This is the result of one of the myths of what I call 'bovine imperialism.' Bovine imperialism is the idea that the desert must be made to support its fair share on the way to increasing humanity, and the idea that the only good we can get from semi-arid and arid lands is bovines—meat. And the reason that agenda is still on some official government dossiers is because they have no concept of an intrinsic value in native (or shall we say unaltered or less altered) vegetation. So the question then becomes, now that we have the ability to do global management—the ability, for example, to transform the Sonoran desert into an Africanized Savannah—do we really want to make all ecosystems engines of commodity production, or is there in fact an intrinsic value in intangibles such as lifestyle, pretty saguaros, stuff like that?

"When Anglo settlers first came here there was a lot more grass than there is now, in some parts of the southwest anyway—thus the myth of 'grass belly high to a horse.' Then of course they loaded every cow they could find onto the range. Everybody was getting rich quick on the open range. They stripped it. The drought of the 1880's hit. Then the top soil that had supported that grass cover was stripped (this has happened in semi-arid lands the world over). Then, with the change in the soil structure, you get a change in the run-off pattern, a change in the whole dynamics of water through the system, and it flips into a brush mode, which is useless for growing cattle or any kind of bovines. But because you've got this myth of 'paradise lost,' which is certainly true if you are trying to grow cattle in an area that has gone from grass to brush in thirty years, the mission then becomes: we must restore the grass. Soil conservation tried to do it but the native grasses did not come back, because the conditions that allowed them to persist couldn't be achieved again without another Ice Age. Eventually, they discovered African grasses that worked, so the agenda is now to introduce the African grasses and convert this 'useless brush' back to grassland and fulfill the destiny of regrassing the Sonoran desert.

"It is succeeding, especially in Mexico. So you flip the ecosystem into a different mode but at a tremendous sacrifice in diversity, because you are getting maybe four or five African grasses as opposed to thirty or forty native kinds of shrubs and subshrubs. Yes, you produce more cattle, but is it really a desirable thing, to draw the system more into a mainstream commodity culture? "

"WHERE (OR WHAT) IS TODAY'S FRONTIER?" A creature of habit, I am back at Tapas in Cambridge having dinner with Mary Catherine Bateson, Sidney Coleman, Stephen Jay Gould, and Danny Hillis, an ecletically genial mix of anthropology, cosmology, zoology, and computer science, with a dash of radical epistemology (me). It's a casual meal, but Danny, looking earnest, has an agenda. "I'm looking for today's frontier," he says to me, leaning over the small platters of delicious tapas.

Danny Hillis, 34 years old, is a computer scientist and artificial intelligence researcher. He never carries a briefcase, or even papers. He sits at the table wearing his signature plain white t-shirt, not exactly the traditional outfit for a multi-millionaire mogul. Danny founded Thinking Machines Corporation (sales last year of $60 million) which sells the "Connection Machine," the first commercially produced computer using massive parallelism architecture (thousands of small processors working together in parallel—as opposed to the Cray supercomputer, which has one processor that processes everything very quickly). He's recently received a DARPA grant to begin work on a computer capable of reaching a trillion floating point operations per second—the "teraflop machine." It will be one thousand times faster than today's fastest supercomputer. The teraflop machine will be developed by the latter half of this decade. This race will, I believe, define the economic and scientific environment of the 90s and beyond.

Unlike many computer scientists, Danny's intellectual horizons exceed the binary discourse of bits and bytes. The part of dinner I enjoy the most is a back and forth between Danny and Steve Gould about computer science and evolutionary theory, i.e. applying massive parallelism to problems in punctuated equilibrium.

"You have the best mailing list," Danny says to me a few weeks later on the phone. He's ready to move ahead with the "frontier project," and asks for labels for the Reality Club mailing list. A week later I receive a postcard in the mail with the following query: "Where (or what) is today's frontier?" Here are some of the legible responses:

• John Allen: "The synthesis and synergy of biospherics, space, virtual reality, dreams, and drama."

• Ralph Abraham: "Today's frontier—the spirit—lies between the body and the soul."

• Isaac Asimov: "In cis-Lunar space and on the Moon, at this moment."

• Richard Baker: "INSIDE"

• Peter Berg: "Today's political and cultural frontier is the relationship between our identity as a species and the rest of the planetary biosphere. Our political ideas need to become based on Homo Sapiens considerations and interdependence with natural systems before anything close to ecological harmony can occur. Cultural expressions of our species identity is necessary before people can understand the importance of this prospect or the need to create new political forms."

• Morris Berman: "Finally having the courage to get beyond the whole notion of frontiers."

• Stewart Brand: "Nano. Adaptive complex systems. Ecology/economics—both theory and practice. Partially hierarchical global government."

• John Brockman: "Technology as culture."

• Ellen Burstyn: "World Unity. 1 World—1 People. Earthians living in peace."

• Joel E. Cohen: "Today's frontier (I think) is putting together how ocean, air and land interact with each other and with living nature, i.e. the whole earth is the frontier."

• Wim Coleman: "The narratizing of ideas. Many of today's best thoughts are too big and paradoxical to be conveyed by exposition. More philosophers and scientists should become storytellers—and vice versa. But like all frontiers, this one is risky. The storyteller always relinquishes authority to the listener. As Calvino put it, 'It is not the voice that commands the story: it is the ear.'"

• George Cowan: "Difficult to answer in a phrase, but surely related to the information explosion; to the shrinking and erosion of frontiers due to the immediacy of events that were far removed only a decade ago; and to the related adaptivity required of human institutions and human behavior if we are going to achieve desirable and sustainable human society before we create an irretrievable disaster."

• Peter Coyote: "The frontier is a line drawn in the mind."

• Thom de Zengotita: "Today's frontier lies between the categories 'grammar' and 'morality.'"

• Dan Dennett: "Outer space has been stormed and (largely) understood. Today's frontier is inner space: the mind of the conscious observer. The space in the brain is becoming much better mapped and understood—thanks to MRI and PET and the other new technologies for high-resolution non-invasive data-gathering—but that space is only indirectly related to the inner space I am talking about, which is the logical space of mental representation supported by the brain's machinery. The confusion about the relations between these spaces is almost universal, but it is now beginning to dissolve. I expect the breakthroughs in this area to reconceptualize the observer of quantum mechanics, and to provide testable models of how human consciousness is realized in the operations of the brain."

• Annie Dillard: "What is today's frontier? Feeding and housing the world's people, starting with our own."

• Hugh Downs: "Today's most important frontier is in the control of weapons of destruction. I believe we're seeing the dawn of an era when the world's nations will act in concert to pull the teeth of mad dog leaders and get serious about nipping in the bud nuclear, bacterial and chemical weaponry. Disarmament is no longer a bilateral issue between superpowers. Survival, I should think, must take precedence over other urgent concerns and perhaps we're seeing the first feeble step in recent UN actions."

• Eric Drexler: "1. Matter processing: in particular, steps toward molecular nanotechnology and thus thorough and inexpensive control of the structure of matter. 2. Information processing: in particular, massively parallel computational hardware and software exploiting evolutionary and market principles."

• Esther Dyson: "The frontier is finding structure in data."

• George Dyson: "The nature of consciousness itself, specifically, if or when does the great, unfathomably complex electron/neural network we are now part of become conscious on some level that may or may not be understandable to us?"

• Mike Fine: "Today's frontier is wherever the struggle to free and nurture each individual on the face of the earth is waged."

• Richard Foreman: "Therapeutically assisting people (through art, science, education) in two great tasks. First, learning to see both their inner and outer worlds as constructs of absolute contingency and flux. Second, learning to function with confidence and lucidity within a world so re-constituted."

• Betty Friedan: "—a new politics of social responsibility and individual freedom;
—a vision of power of the restructuring of life for women, men and children beyond the polarized male model;
—a paradigm of personhood transcending mind-body, male-female, and age polarities."

• Howard Gardner: "We're doing fine in science, technology, saving thousands of lives, or wasting millions. The real frontiers haven't changed for millennia: enough food to the needy, the need for selfless leaders, civility, kindness to children, eradication of racism. What's changed is the distance between what we're doing and what we could do."

• Michael Harner: "Shamanism, especially shamanic journeying into nonordinary reality. But, then, I'm prejudiced."

• Ihab Hassan: "Today's frontier? Not thinking in terms of frontiers, not knowing where the frontiers are, everywhere, nowhere, like Giordano Bruno's God."

• Nick Herbert: "Today's intellectual frontier is between the speakable and the unspeakable—pick your field: matter, mind, spirit, for instance. In matter, it is the line between the observed and the unobserved; in mind, the line between conscious and unconscious; in spirit, the line between willing and surrender . . ."

• Jamie James: "The new frontier is the old frontier: survival."

• Mitch Kapor: (Sent paper by John Perry Barlow and himself, entitled "Across the Electronic Frontier") "Over the last 50 years, the people of the developed world have begun to cross into a landscape unlike any that humanity has experienced before. It is a region without physical shape or form. It exists, like a standing wave, in the vast web of our electronic communication systems. It consists of electron states, microwaves, magnetic fields, light pulses and thought itself."

• Kevin Kelly: "1. The nature of control.
2. Whose culture is this, anyway?
3. Are the laws of the universe eternal, like God, or mutable, like species?
4. Is evolution based on contingencies?
5. The clone revolution—how do we treat copies of things, from DNA to floppy disks to ideas to styles of singing to twins?"

• Art Kleiner: "The most constant frontier is always the next five minutes. But for me, personally, I think there is a frontier in maturity. It has to do with accepting a certain amount of personal responsibility for people and events. That may simply be a life passage, but I see it echoed in institutions, maybe in machine design, maybe in countries—without conscious awareness. There's something that isn't 'work' and isn't 'play' that people are doing instead of 'work' and 'play.' When sincere, it's a frontier."

• Richard Kostelanetz: "As a sometime historian, I sense that today's 'frontier' lies in places we cannot foresee in advance and probably do not recognize as such now, which is to say that those of us who study frontiers might be prepared for surprise."

• Paul Krassner: "— Food, clothing and shelter.
—Transforming insane priorities.
—Survival of the planet. Demilitarization.
—Saving the young. Then education.
—Limiting the population. Eliminating censorship.
—Revolutionizing energy sources.
—Legalization of drugs. Free health insurance.
—Exploration of natural healing medicines.
—Exposing secret governments."

• Chris Langton: "One frontier is certainly studying the natural dynamics of distributed systems, especially emergent properties. I think that what we learn from the study of such systems will shed much new light on life, intelligence, and the universe."

• Robert Langs: "There must be many frontiers. I believe that I am working at one of them, with a mathematician, Anthony Badalamenti. Our frontier can be called a science of the (emotional) mind; a science of human communication or the physics of the mind. We are quantifying dimensions of emotional dialogues—in and outside psychotherapy—and applying mathematical models from physics: motion, energy, entropy, thermodynamics, electricity, etc. And we're seeking laws and constraints. It is truly unmapped territory. I'll by interested in the answers we get. (I am a psychoanalyst.)"

• Steven Levy: "Two frontiers, related (I believe). 1. Understanding the laws of complexity, in order to understand phenomena such as life. 2. Breaking through the negative behavior of fellow humans so that we can begin to work in concert to deal with Earth's problems."

• Josh Mailman: "Figuring out how the resources of the world can be equitably used to serve justice and sustainability through an awakening of vision and commitment at the highest levels of global society."

• Rollo May: "The frontier today is man-woman kind. I do not mean their relationships (that is established, whether practical or not). I mean rather the nature of what it means to be human, the worth and value of life."

• Michael Nesmith: "Now—not the present time but the 'now'—beyond time (it's always 'now')—beyond space (we're always 'here'). Now is the frontier."

• Jay Ogilvy: "People are the last frontier. We hairless monkeys house more mysteries than any other part of the universe. We lack a Freud or Jung of societies and institutions. And it's not so clear that Freud and Jung got that far with individuals."

• Pat Perrin: "It seems to me the frontier is right there where it always was—just beyond what can be seen, said, or quite conceptualized. We're always groping over that edge—or those edges—in every field of thought and endeavor. Culturally and individually, we tend to privilege some frontiers and ignore others."

• Richard Rabkin: "For me the frontier lies between the mechanical paradigms of the 'modern' scientific period and information-oriented post-modern science."

• Paul Ryan: "The notion of 'frontiers' is a dangerous illusion now. The critical terrain is intransitive relationships."

• Dorion Sagan: "Today's frontier is the eighth rank, where pawns are reborn as queens."

• Roger Schank: "Software (especially for kids to learn from)."

• Carolee Schneemann: "The critical frontier is the psychic and erotic penetration of systems of masculist abstraction—self-righteous, competitive, identified with unexamined traditions of power and dominance."

• Gene Schwartz: "I see two frontiers: 1. a new religion, based on what we have learned since Newton. 2. Implantation of the computer into the human nervous system; i.e. the creation of the hyper-cortex."

• John Searle: "Today's frontier is consciousness."

• Rupert Sheldrake: "Our relationship to living nature and matter."

• Gerd Stern: "Frontiernalogies: —Pushing the line between human life/death up the age scale. Cum maintenance via youthification.
—Since real time is non expandable on the level of, try to fit more than (one day = x hours) x of those hours into one day. A frontierology of options (personal choices) expanding time by automating tasking needs."

• Cliff Stoll: "Today's frontier is under the asphalt: learning and exploring the underside of civilization."

• William Irwin Thompson: " 1. The appropriation and literalization of the subtle body—'chi' in Chinese, 'prana mayakosa' in Sanscrit—through Virtual Reality, full body suits and unconscious environments of electronic noise, and the resultant disintegration of 'biological autonomy' chez Varela. 2. The crossing of bacteriology and architecture—chez John Todd—and immunology and A.I."

• Joe Traub: "What do the noncomputability and intractability results of theoretical computer science really imply for what is knowable in science?"

• Sherry Turkle: "The cell (unlocking its final mysteries will allow us to cure cancer, AIDS . . .) The environment (finding the ways to make peace with it will allow us to continue to live here)."

• Francisco Varela: "The mind-mind problem: What's the relation (bridge, nexus) between a mind-event as process (we are getting closer and closer to a good answer) and a mind event as experience (elusive, essential remainder)."

Danny calls. He's pleased with the responses.

"Ok," I say, "your turn."

"I finally realized," he replies, "that the frontier had been sitting in my office all along—on the other side of the computer screen. That's basically where the cowboys are today. First, fortunes are being made and lost; second, it's where new law is being made, and third, new territories are up for grabs for anyone with the courage and imagination to take them. I didn't think this way when the project started."

edge interview
"the inflationary universe"
a conversation with alan guth

I'm so in love with the universe that anything less than everything means nothing to me. That's why Alan Guth is one of my favorite people. He really is out there on the edge of the cosmos. Alan, an astrophysicist at MIT, is hotter than the Big Bang. He had a big week recently. First, a front-page profile in The Wall Street Journal, *followed the next day by a front-page* New York Times *article featuring his work along with that of other colleagues. I interviewed him over lunch at Turner Fisheries in Boston's Westin Hotel in Copley Square. We talked about amazing ideas such as "wormholes" as I ate a dozen oysters and bag after bag of oyster crackers.*
—JB

BROCKMAN: Alan, let's cut the small talk and get down to three things: your inflationary universe model, how you propose to create a universe in your backyard, and your ideas on wormholes and time travel.

GUTH: One of the most amazing features of the inflationary universe model is that it allows the universe to evolve from something that is initially incredibly small. Something on the order of twenty pounds of matter is all it seems to take to start off a universe. This is very different from the standard cosmological model. Before inflation the models that existed required you to assume that all the matter that exists now was already there at the beginning, and the model just described how the universe expanded and how the matter cooled and evolved. With the new idea that it really is possible, given the laws of physics as we know them, for the universe to evolve from something incredibly small, it becomes very tempting to ask whether, in principle, it is possible to create a universe in the laboratory—or in your backyard—by manmade processes.

BROCKMAN: How do you even begin to ask questions of this nature?

GUTH: The first question you want to look at is what would happen if you had a small patch of inflationary universe in the midst of our universe, never mind how it might have gotten there. Let's just pretend that it exists and ask how it evolves. It turns out that if this patch is big enough it will grow to become a new universe, and it will grow to become arbitrarily large, but it does this in a very strange way. It does not—and this is very important for environmental purposes—it does not displace our universe. Instead what happens is that this patch actually bulges outward from our universe, creating new space as it grows. From our universe it always appears very small and actually looks more or less like an ordinary black hole from the outside. But on the inside this universe is expanding and can become arbitrarily large, certainly large enough to encompass a universe like the one we see. And in a very short length of time—a small fraction of a second—it completely pinches off from our universe and becomes a totally isolated new closed universe.

BROCKMAN: Is this a mathematical model? Or is this an event?

GUTH: Well, of course, we haven't done it yet.

BROCKMAN: Can you give me a brief explanation of inflationary theory?

GUTH: Inflationary cosmology is a new twist on the Big Bang theory. It does not in any way do away with the Big Bang theory. It's completely consistent with everything that's been talked about in terms of the Big Bang model. What it does is change our conception of the history of the first small fraction of a second of the Big Bang.

BROCKMAN: So what's new about inflationary theory?

With the new idea that it really is possible, given the laws of physics as we know them, for the universe to evolve from something incredibly small, it becomes very tempting to ask whether, in principle, it is possible to create a universe in the laboratory—or in your backyard—by manmade processes.

GUTH: There are two key features that are different in inflationary cosmology from the standard Big Bang. One key feature is that the inflationary model is actually a mechanism by which matter can be created as the universe grows, while in the standard Big Bang model it was always necessary to assume that all the matter was there at the beginning. There was no way to describe how it might be created.

By the way, this is all consistent but gives a very different picture of the notion of conservation of energy. Energy is still conserved. This is all in the context of really standard classical general relativity, in which conservation of energy is built into the fundamental features of the theory; but what happens is that gravity plays a major role in the energy balance.

It turns out that the energy of the gravitational field is actually negative; so what happens during inflation is that as the universe gets bigger and bigger and there's more and more matter being created, the total energy of the matter goes upwards by an enormous amount. But meanwhile the energy in gravity becomes negative and cancels this energy in matter, so the total energy of the system remains whatever it was when it started, something very small. It could, in fact, even have zero total energy, and that is consistent with the way the universe looks. There does not appear to be any net energy to the universe in spite of its enormous size. So that's one crucial difference between inflation and the previous model.

The other important difference is that in the standard cosmological model it was always necessary to incorporate many features that we see in the universe into a very careful choice of the initial conditions, but most of the important features of our universe never came out naturally from the Big Bang model. Take for example the large scale uniformity of the universe. When we look at great distances it appears that the universe is remarkably uniform. The best evidence for this comes not from looking at stars but from the furthest thing that we can actually see—the cosmic background radiation, a kind of an afterglow of the Big Bang itself. People have now made very accurate measurements of the cosmic background radiation and found that it has the same energy density in all directions in the sky to accuracies of a few parts in a hundred thousand, which is the best that anyone has been able to measure so far.

BROCKMAN: What does this say about the early universe?

GUTH: It says something very clear about the early universe. When we look at this cosmological background radiation we are actually seeing a snapshot of what the universe looked like a few hundred thousand years after the Big Bang, and it is telling us that it was incredibly uniform. In the context of the standard Big Bang model, that was always an incredible mystery. One of the reasons why it was such a mystery is that the early universe was so large compared to its age that there was not nearly enough time for light to travel across it during the time period involved. When the radiation was released one hundred thousand years after the Big Bang the matter that was releasing from one direction was separated from the corresponding matter on the other side by a distance which was about a hundred times larger than the total distance that light could have travelled up until that time. Since we believe that nothing can travel faster that light, it means that that point over there had no way of even knowing what was going on at this point over here; but somehow they managed to be at the same temperature at the same time to this extraordinary precision of a few parts to a hundred thousand. So that's the mystery.

BROCKMAN: How does the inflationary model deal with this mystery?

GUTH: The inflationary model differs from the standard model by allowing for a short period in the very early universe during which the universe expanded far, far faster than in the standard cosmology. The total extra expansion is at least a factor of a trillion trillion to make the model have the properties that one wants. It couldn't be much larger than that.

BROCKMAN: William Empson wrote that all physics is one tautology and that things become true because the tools you use to describe them feed back into themselves.

GUTH: Many people think that way but I don't. I tend to take a rather hard-nosed,

concrete point of view as to the philosophy behind the universe. I think the universe really does exist as a physical object and that physicists and other scientists are making a lot of progress in trying to understand the rules by which the universe works. I also think it's important in science, and in life, to recognize that there are always going to be some questions that you are not going to be able to answer at any given time. You continue to try to answer them, but you aren't shocked if you find that you are not capable of answering them.

BROCKMAN: Can we move on to your other work on wormholes and creating a universe in your backyard?

GUTH: The first question we look at is the evolution of inflating a region of the universe in the midst of ours, and that can be solved very cleanly and unambiguously. It's a consequence of general relativity. What's added here is an idea from particle physics about a certain kind of matter called a false vacuum which is what drives the inflation.

The next question, which turns out to be a much harder question, is what does it take to produce this small region of inflation to start everything going?

This false vacuum material is far too high in energy density to be producible in any practical sense. I'm talking about something that, just by its sheer energy, would have a mass density which is about ten to the sixty times more dense than an atomic nucleus, so it's absolutely out of sight. There is no technology that exists or is foreseeable that would allow us to do this sort of thing in any foreseeable time period. But nonetheless one can talk about the physics of this as a matter of principle, and I find it a very interesting question.

So I am going to imagine that somebody can make such material and can gain access to those energy densities. But then there's still another problem. As you start to collect this material, by its own gravitational force it tends to collapse into a black hole, unless you can start it expanding at a great enough speed. We found that in order for it to expand fast enough to grow to become a universe, it has to start from what in technical terms is called an initial singularity, also called a white hole, which is the opposite of a black hole.

The Big Bang origin of the universe is in itself an example of such a white hole, but outside of that certainly nobody knows how to make a white hole in the laboratory, and nobody has ever seen a white hole. So from the point of view of asking the question, can one in principle do this in the laboratory, the answer from the point of view of classical general relativity is no.

But classical general relativity is not the end of physics. We are all thoroughly convinced in physics that the universe is a quantum universe, a universe that is not governed by deterministic classical laws. We have found that quantum theory is absolutely essential to understanding atoms and molecules, subatomic particles. And one firmly believes that quantum theory is essential to understanding the true nature of gravity. Unfortunately, we do not yet have a successful quantum theory of gravity. There are very complicated technical problems that one gets into in trying to build a quantum theory of gravity. And that's what we need here, because in this problem gravity is clearly essential, and if we are going to describe it from a quantum point of view we need a quantum theory of gravity.

BROCKMAN: Any new developments here?

GUTH: There are, of course, approximate notions even though we don't have a real detailed quantum theory. Two colleagues, Edward Farhi and Jemal Guben, and I looked at the quantum problem applying the approximate ideas that people have about quantum gravity, and what we discovered were two things. First, we discovered that the naive ideas about how quantum gravity should work in fact didn't quite work. The other thing we found was that if the calculation we did is correct—if the rules of quantum gravity really do work out the way we now think they do instead of the way we previously thought they did—then such an event is possible, and one can in principle create a universe this way. It turns out that how probable it is depends crucially on the energy scales involved in this material—this false vacuum that makes up the new inflationary universe. If it's at the typical scale that corresponds to grand unified theories, it turns out that the rate is still enormously low. However, there are

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energy scales that are even higher than grand unified theories, and if the energy scale involved a scale of energy of about a thousand or ten thousand times larger than the scale of grand unified theories, then this could become a highly probable event.

BROCKMAN: How will you show experimental results for these theories?

GUTH: This is clearly well beyond the range of experiment, and the only hope for finding out in our lifetimes whether this is right or not is the hope of building a more detailed theory of matter of extremely high energies and quantum gravity. Those two ideas go together: as the energy of matter becomes enormously high, gravitational interaction becomes important. People working on that sort of thing—right now the most promising idea that people are pursuing is what is called string theory—and if string theory succeeds the way some hope it will, perhaps it will provide the testing ground for the ideas we are exploring now, which are much more naive.

BROCKMAN: Maybe that's happening in another universe. By the way, Alan, have you been doing a lot of time traveling lately?

GUTH: No, not any time travel.

BROCKMAN: There has been a lot of talk about your wormhole theory as a time machine.

GUTH: Right. The same kind of wormholes that I talk about in the context of creating a universe, which essentially creates a wormhole and disappears through it, are also talked about with regard to the question of whether or not time travel is possible. It's in a slightly different context. In order for time travel to work, what one needs is more than what I get out of my theory or what one knows to exist. The laws of physics as we know them readily give rise to very small wormholes that exist for very short times and which allow, for example, this process that I'm talking about of a universe forming and escaping from ours.

In order for time travel to work one needs more than that. One needs to have a stable wormhole, one that can be built large and exist for a long time so you could walk through it. It can only travel as long as it can exist. It doesn't allow you to travel into the future. You can build it now and carry an end of it with you and sometime later in the future you can come back to where you built the initial end. So it requires that you have a wormhole that exists for as long a period of time as you will eventually time travel.

BROCKMAN: How long might a wormhole live?

GUTH: Ten to the minus forty seconds. So to get long-lived wormholes is a stretch of our understanding of physics, although it's not known to be impossible. The articles that have been written about it have probed the question of whether or not the laws of physics might be consistent with wormholes living so long. Nobody has found anything within the laws of physics that allows us to create wormholes that live so long, but at the same time no one has given any kind of categorical proof that it's impossible.

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