

WANNA BET?

LONG BETS

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Seventeen of the world's most wired minds stake their names – and their cash – on the future.

Pronouncements about the future come easy. Even when made with an air of authority, they're usually just cheap talk, rarely revisited. Only the tiny fraction that have proven correct tend to be remembered, when their authors want to take credit.

But what if there were some cash at stake?

The Long Bets Foundation, a new project masterminded by Well founder Stewart Brand and Wired editor at large Kevin Kelly, hopes to raise the quality of our collective foresight by incorporating money and accountability into the process of debate. The idea is simple. If someone makes a grandiose claim, any skeptic can challenge it – "Would you bet on that?" – and the Long Bets Foundation will keep tabs on the wager, whether it takes five years or five decades to come to pass. If proven right, a predictor can relish the victory; if wrong, the challenger gets the glory.

By preserving the terms of the wager in public view, Long Bets promises to be more than a service for confident prognosticators. Over time, it hopes to foster better understanding of how predictions in aggregate work out in reality – what kinds of truths are easiest (or hardest) to forecast, and what kinds of people are right (or wrong) most reliably.

Following are the first-ever "long bets." According to the Long Bets Foundation, all stakes are treated as charitable donations, tax deductible when the bet is made.

Bettors designate nonprofits to receive the proceeds. Meanwhile, the foundation holds the funds in an investment account for the life of the bet, with half of the growth covering administrative costs. A competition designed to thrive in the public eye, Long Bets uses time as a teacher.

Transportation

Publishing

Artificial Intelligence

Astronomy

Software

News

Sports

Open Bets

"Wanna Bet?" writing and reporting contributed by Martha Baer, Chris Baker, Alix Berger, Ted Greenwald, and Jenn Kahn.

Look for more Long Bets – and reports on their outcomes – in subsequent issues of Wired.

Seven years ago in the pages of Wired, I made a \$1,000 bet with self-described neo-Luddite Kirkpatrick Sale. I was irked by his assertions of the coming collapse of civilization-as-we-know-it, and I challenged him to bet on his prediction that by 2020 we will suffer the convergence of three disasters: a global currency collapse, significant warfare between rich and poor, and environmental problems that render whole continents unlivable. The bet forced both of us to refine strongly held beliefs, and because our predictions were now public, our reputations were on the line. On the judgment date of our bet, my ideology or his will gain credence.

This is what public wagers can do: sharpen logic, filter out the halfhearted. Sometimes they can even alter collective views and shape society.

In 1980, biologist and ardent environmentalist Paul Ehrlich was so certain that natural resources would become scarce and expensive that he publicly bet iconoclast Julian Simon that the price of five mineral commodities (copper, chromium, nickel,

tin, and tungsten) would rise in 10 years. In fact, by 1990 prices had plummeted by almost half, and Simon won the bet easily. Simon was a prolific skeptic of environmentalism, yet nothing that he ever wrote had as much impact on the course of culture as his wager with Ehrlich. That single, relatively small bet transformed the environmental movement by casting doubt on the notion of resource scarcity.

In the world of science, making a bet is a customary form of accountability. The earliest scientific wager on record was between the astronomers Johannes Kepler and Christian Longomontanus in 1600. Kepler bet his arch rival that he could derive the formula for the solar orbit of Mars in eight days. He lost. Although his slow calculations were correct and spawned modern astronomy and physics, they took him five years.

Since then, betting on future discoveries has been rampant among scientists and technologists. Robin Hanson, an assistant professor at George Mason University, has set up a prototype market where bettors back scientific ideas as a way to inform and guide research funding. He imagines these as "idea futures," much like corn futures "except that you bet on the settlement of a scientific controversy instead of the price of corn." But whereas Hanson's market involves no actual exchange of money, many bets involve real stakes. Maurice Goldhaber, a particle physicist, bet a colleague \$500 that his brother Gerson, also a particle physicist, would never find the antiproton he was looking for, because it did not exist. Maurice lost. And so did Nobel laureate Edwin McMillan, who made the same bet against particle physicist Emilio Segre. (The antiproton was discovered in 1955.) The historian Allan Franklin counted at least three wagers on whether left-right symmetry (parity) is maintained in subatomic reactions. In 1957, researchers determined it wasn't, and one of the

notables who lost this contest (at 50-1 odds) was the legendary physicist Richard Feynman.

Cosmologist Stephen Hawking has made a number of high-profile wagers on future discoveries. In 1975, he bet Kip Thorne a subscription to Penthouse (the loser would get it mailed to his home) that a celestial mystery named Cygnus X-1 would turn out to be a black hole. It didn't. In 1991, he again lost to Kip Thorne, betting \$140 and a T-shirt "embroidered with a suitable concessionary message" that a naked singularity could not exist. (A singularity is assumed to be the cosmic weirdness at the heart of a black hole; a naked singularity would be the weirdness of a point with infinite mass appearing outside the shell of a black hole.) Although no singularity, either naked or clothed, has ever been spotted in space, Hawking reluctantly conceded to Thorne in 1997 when Matthew Choptuik proved mathematically that the phenomenon was theoretically possible. Ever game, in December 2000, Hawking bet Gordon Kane \$100 that the Higgs Boson – labeled by headline writers as "the God particle" because it apparently gives matter its mass – will be discovered at the Fermilab Tevatron, the most powerful accelerator.

This kind of informal accounting of scientific forecasts often has subtexts. In the early 1980s, theorist Frank Shu bet observational cosmologist George Djorgovski 100 gallons of gasoline (at the tail end of the oil crisis, gas was precious) that, by January 1, 2001, theorists would have determined several cosmological constants (such as the density of the mass of the universe) to such high precision that the job of observers (like Djorgovski) would be simply to confirm the predicted value. Nearly 10 years later when things were looking especially good for the theorists, stubbornly optimistic Djorgovski made a parallel bet with David Spergel at Princeton. On the appointed day, the theorists had not prevailed. In a triumph for observation and empirical research, both Shu and Spergel conceded to Djorgovski. Shu paid up in wine of equal value to 100 gallons of gasoline.

Physics and cosmology are such quantitative fields that they readily lend themselves to wagers. And since it can take decades to build the high-priced gear needed to prove a theory, long-term betting is a way of dispensing credit for early insight. But other avenues of research have their share of bets. Early last year, two scientists studying

the process of aging agreed to a \$500 million bet on the world record for a human lifespan, now at 122 years old. University of Illinois at Chicago biologist Jay Olshansky bet that at least one person now alive will live to be 130, but no older. Steven Austad at the University of Idaho countered that the longest-lived person born in 2000 will make it to 150. If any 2-year-old today lasts till January 1, 2150, then Austad wins. Since neither Olshansky nor Austad expects to be around that long, a panel will adjudicate the contest and bequeath the prize to the bettors' heirs. And since neither scientist had \$500 million on hand, each started a trust fund with \$300, which according to their calculations should top \$500 million in 150 years if the compounding is left undisturbed.

The value of responsible wagers on the future is so ingrained in some large research institutions that simple systems were created to track them. For several decades at the venerable Bell Labs in New Jersey, employees kept a book in which they recorded their gambles. It was sort of an office pool for geeks. Challenges ranged from bets on research findings to prognostications on the future of politics, public affairs, and the economy. Pierre Hohenberg, now at Yale, worked at the lab and added a bet or two to the book. "The stakes were always primarily symbolic – prestige among your peers – though since we were pitting our brains against those of our colleagues, it was not frivolous," he says. The book disappeared in 1990, without a backup copy, so earlier bets have vanished. Purloined by a sore loser? No one knows.

But at the Stanford Linear Accelerator Center, a similar accountability book lives on. The Official SLAC Theory Group Record of Wagers holds 33 pages with about 60 bets, the earliest dating back to 1985. It's an ordinary lab notebook, filled with scribbles and an occasional pasted-in email, documenting Ed Witten's bet against Michael Peskin, for instance, that the cosmological constant is, well, constant. At stake: "One dinner in an Indian restaurant better than the one in which the bet was made." Other bets, too good to pass up, draw additional players. Fifteen bettors signed up for this one: "By 1990, it will be well accepted that an elementary Higgs scalar particle does not exist." Five names for, nine against.

Biologists keep records of their speculations as well. David Stewart, a biochemist at Cold Spring Harbor Laboratory, oversees an old blue notebook that records the

largest technical wager pool going. In this betting book, more than 400 scientists have put their money on what they believe will be the total number of genes in the human genome. The grand prize is called Genesweep. The winner will take the total pool (currently less than \$500) and an autographed copy of the classic book *The Double Helix*. Guesses range from a low of 27,000 genes to a high of 312,000. DNA codiscoverer James Watson bet on 73,210 genes, while Francis Collins, head of the Human Genome Project, predicted 48,011. The first peer-reviewed tally in 2001 estimated the total to be around 30,000, cutting out both Watson and Collins as contenders. As the research is honed, scientists can make further wagers of \$20. The final total is expected to be determined in 2003.

Betting on the future is more than just entertainment. It's also an engine for study, rigor, and planning. With each handshake since Kepler's, some bit of scientific thinking has been further refined. And remembered. The injection of real money into debates has weeded out brainless bragging, insincere speculation, and a tendency – particularly among losers – to forget. Captured in lab books and witnessed by colleagues, real long bets endure enough to instruct us.

TRANSPORTATION

The Stake: \$1,000

Background

Although the United States military has used "drones" since World War I, commercial pilots scoff at the notion of Mom and Suzie boarding pilotless DC-10s. A joke in the industry says that folks might be happy enough with the innovation until they settle into their seats and hear, "This is your pilot speaking, speaking, speaking, speakingä" But the comfort test – not only is it safe, but does it feel safe? – evolves as technology does. Mundie is betting that airplanes, traffic control, and communications technology will improve enough to eliminate fatal glitches and offer fliers adequate reassurance. Schmidt, a pilot himself, begs to differ.

YES

Craig Mundie

CTO, Microsoft

Lee Hartwell Innovation Fund at the Fred Hutchinson Cancer Research Center

"My logic goes like this: First, we have planes today that can take off, fly, and land without a pilot. Pilots are there only in case something untoward happens. Second, we already have remotely controlled aircraft, which we've seen, for example, in the Afghanistan war. Third, computers themselves, over the next 18 years – if we stay on this Moore's law kick – will be about 4,000 times more powerful than they are today.

The next step in this logic is that with computers increasingly a part of critical infrastructure, the industry is going to have to focus a lot more on making machines that just don't fail. If we go at that hot and heavy for five or 10 years, I imagine arriving at a methodology for system design that yields as much dependability, on an everyday basis, as the triple-redundant computer that flew guys to the moon. Finally, air traffic control will no longer be based on staticky communications with people staring at radar screens; it'll be completely computerized."

NO

Eric Schmidt

CEO, Google

Chalk (Communities in Harmony Advocating for Learning and Kids)

"Even though the technology to take off, cruise, and land automatically already exists, no licensed air carrier (commercial or private) by 2030 will be able to fly without at least one pilot – in the pilot seat – supervising the whole process. On takeoff, the

training and timing for handling emergencies such as engine failure are not going to be transferable to autopilots and machines. On landing, automated airplanes would have to sequence in with many older airplanes piloted by humans. Towers and air-traffic controllers love to change everything at the last minute, and adding the ability to make changes by computer while simultaneously using voice is not realistic. Finally, the FAA changes so slowly that if pilotless travel like this were at all possible, the adoption and certification would take at least 50 years."

PUBLISHING

The Stake: \$1,000

Background

It's only a matter of time before the entrenched book publishing industry undergoes fundamental change. Amazon successfully overhauled book ordering, marking the first giant leap away from business as usual. Since then, wholesaler Ingram has begun filling custom orders as small as one unit, and online publishers such as Xlibris and 1stBooks now provide thorough services intended to sidestep the big-name publishers. And more upheaval is coming: Book business expert Epstein believes it'll take the form of wireless, Web-based bookstores at airports and corner markets worldwide; equipped with trimmers and binding devices, these kiosks will dispense texts much like ATMs spit out money. But Net pioneer Cerf thinks otherwise. It'll be ebooks, he says, that will truly overturn the staid old industry. If downloadable files are reader friendly on a computer screen, why waste paper?

YES

Jason Epstein

Former editorial director, Random House; author,
Book Business: Publishing: Past, Present, and Future

DESIGNATED NONPROFIT:

New York Public Library

"I'm confident that print on demand is the future of the book business. Used at the point of sale, new POD technology – like a prototype developed by Marsh Technologies – will have fully integrated components and a cost of about \$100,000

per unit.

"Nothing is as inexpensive, easy to carry around, and indestructible as a physical book. And readers don't want to have texts augmented with sound and pictures and all sorts of other things; you're supposed to imagine all that when you read – that's what the writer's there for. Plus, habits don't change that quickly. If you're in business, you have to approach the market as it is, rather than as it might be, or should be, or will be someday."

NO

Vint Cerf

Vice president, WorldCom

DESIGNATED NONPROFIT:

Internet Society

"Carrying around a bunch of paper is unnecessary. Despite the argument that a traditional book doesn't need a battery or a recharge, I believe that it will be very common for people to read for work and for pleasure with the same electronic devices they use daily.

"Books aren't going away, of course. But at some point laptops, or smaller devices with high-quality displays and suitable access controls for intellectual property, will make the sale and consumption of books, sound, and movies practical. Apple's iPod offers an example. I'm betting that by 2010, 50 percent of books will be delivered electronically."

ARTIFICIAL INTELLIGENCE

The Stake: \$10,000

Background

In 1950, mathematician Alan Turing conceived of a test that would determine whether a machine had demonstrated human-level intelligence. The players: a computer, a human foil, and a judge. Conversing via text on matters of art, science, nature, and personal experience, the judge attempts to discern which is the living person and which the machine. To fool the judge is to pass the test.

But imagine this experiment conducted in 2029, and you run into a few problems – Kurzweil and Kapor, for the purposes of their bet, have carefully addressed these. First, they've agreed, the human decoy must be all human – no neural implants, no genetic enhancements. Second, the computer has to be a computer – no biological neurons allowed. The machine is permitted, however, to invent its own life story.

YES

Ray Kurzweil

Author, entrepreneur, technologist

DESIGNATED NONPROFIT:

Kurzweil Foundation

"Scientists have already reverse-engineered two dozen of the several hundred regions of the human brain; we'll understand its principles of operation and be in a position to re-create its powers in synthetic substrates well within 30 years. But we won't program human intelligence link by link in some massive expert system. Nor will we simply set up a single genetic algorithm and have intelligence at human levels automatically evolve itself. Rather, we will set up an intricate hierarchy of self-organizing systems, based largely on the reverse-engineering of the human brain, and then provide the computer entity with an education, which, given the increasing power of machines, can proceed hundreds if not thousands of times faster than the comparable process for humans."

NO

Mitchell Kapor

Founder, Lotus; angel investor

DESIGNATED NONPROFIT:

Electronic Frontier Foundation

"Each of us knows what it is like to be in a physical environment; we know what things look, sound, smell, taste, and feel like. Such experiences form the basis of agency, memory, and identity. Without human experiences, a computer cannot fool a smart judge probing its ability to communicate about the quintessentially human. In the past, scientists have employed metaphors to characterize mysteries of human functioning – the heart as pump, the brain as telephone switchboard. My prediction is that contemporary metaphors of brain-as-computer and mental activity-as-information processing will in time also be superseded and will not prove to be a basis on which to build human-level intelligent machines – if indeed any such basis ever exists."

ASTRONOMY

The Stake: \$1,000

Background

In the 1920s, Edwin Hubble discovered that the universe was expanding, galaxies and stars moving away from one another like spots on an inflating balloon. Whether this expansion would go on forever or at some point reverse itself became a point of debate among physicists. Initially, the dispute hinged on two factors: the rate of expansion (astronomers measure this by looking at the redshift of distant galaxies), and the total mass of the universe, including the large, invisible component dubbed "dark matter." If the total mass were great enough, gravity would slow and eventually reverse the growth, collapsing the cosmos back in on itself. Then, in 1998, new measurements revealed that the universe was not only expanding but accelerating; a mysterious force, which scientists called "dark energy," seemed to be pushing it apart faster and faster. Myhrvold believes that this discovery, among others, guarantees that the universe will expand forever – and most of today's astrophysicists would agree. Hillis, on the other hand, notes that dark energy is an enigma – no one knows what it is or what its properties are – and might be an early sign of trouble with cosmology theory as a whole.

YES

Danny Hillis

Cochair and CTO, Applied Minds

DESIGNATED NONPROFIT:

Long Now Foundation

"I don't believe the measurements that show the universal expansion is accelerating. There's a long chain of evidence leading up to that conclusion, and I suspect a mistake somewhere in that chain. We have to do an awful lot of extrapolating when we measure things like the redshift of supernovas at the edge of the universe, and I don't think we have things so neatly figured out. What if light actually loses energy as it propagates over long distances? That would throw off redshift measurements entirely. There's a lot of room for surprises. We already know there are all kinds of dark matter, and there may be varieties of dark energy out there, too – maybe one that's pushing in the other direction. What I'm really betting on is that the universe will turn out to be complicated in directions we have not even figured out yet. Not only is the world more interesting than we expect, it's more interesting than we can expect. Also, cosmology is subject to fads: If I'd bet at any point that the current scientific consensus was wrong, I'd have been right."

NO

Nathan Myhrvold

Copresident and cofounder, Intellectual Ventures

DESIGNATED NONPROFIT:

Institute for Advanced Study

"I think the evidence is pretty consistent that we're going to end up in a cold, dark universe. The reason to believe in a closed universe is either because you want to be contrary or because you subscribe to an aesthetic notion of cosmology. It's kind of

cool to think of the whole thing expanding and contracting, throbbing there for all time. But appealing or not, most estimates about the pressure and critical mass of the universe right now have me winning. First, empirically, we have the fact that the universe is expanding. Also, over the past 20 years, astronomers have developed very clever, indirect ways of finding dark matter, and they've discovered that there isn't nearly enough to collapse the universe – not by a factor of 10. Finally, there are theories in cosmology that embrace the idea that the universe is a random accident, like a bubble in a bottle of fizzy water. In that scenario, bubbles like our universe form, and they expand, and they go away. Take the evidence together and I think I've got the upper hand."

SOFTWARE

The Stake: \$5,000

Background

In the world of software development, a handful of hot spots have been glowing over the last decade. India, which sold \$6.2 billion worth of software in 2001, is catching up with Japan, which drew revenues of \$14.9 billion. With heft like that, these powerhouses – chasing the US, whose sales hit \$96.6 billion – look like long-term contenders. But nothing is permanent, right? Israel (\$607 million in 2001 sales), Russia (\$431 million), and Ireland (\$405 million) are throwing off sparks, and Dyson believes this is just the beginning.

YES

Esther Dyson

Chair, EDventure Holdings; investor whose portfolio includes several Russian startups

DESIGNATED NONPROFIT:

Eurasia Foundation

"Russia right now is a world leader in unexploited mathematical/logical talent and creativity. Its programmers are beginning to recognize their own capabilities, and they will no doubt figure out how to organize their marketplace better, putting in place not just software firms but training centers, educational loans, and the like. I

expect them to be recognized as leaders not so much for financial muscle, but as the community to go to when you want creative solutions to tough programming problems. The Russian talent for algorithms will shine."

NO

Bill Campbell

Chair, Intuit

DESIGNATED NONPROFIT:

Computer Museum History Center

"As long as there is business opportunity – and I am confident there will be – the US will provide world leadership in software development."

NEWS

The Stake: \$1,000

Background

Over nearly two centuries, the bastions of traditional news journalism have built an imposing standard of reporting and presentation. About a decade ago, these news outlets began posting their work online. In the meantime, the advent of weblogs allowed individuals to, in effect, publish their own journalism. The first such sites – essentially electronic diaries to which readers could add their comments – appeared in the mid-'90s; the current tally may well be in the hundreds of thousands. While they don't always hew to traditional news values of accuracy and objectivity, blogs do at their best convey an authenticity and immediacy the big outlets can't summon.

For this bet, five searches on Google (which ranks a page's relevance by the number of other URLs that link to it) will determine the outcome. If a blog outranks nytimes.com in three or more searches, Winer prevails. If not, the victory goes to Nisenholtz. And what happens if news organizations appropriate the emergent format to bolster their own authority? If [The New York Times](http://TheNewYorkTimes.com) runs a blog that tops a Google search by 2007, Nisenholtz claims the triumph.

YES

Dave Winer

CEO, Userland.com

DESIGNATED NONPROFIT:

World Wide Web Consortium

"We're returning to what I call amateur journalism: created for the love of writing, without expectation of financial compensation. This process is fed by the changing economics of the publishing industry, which is employing fewer writers and editors. The Web has taught us to expect more information, not less, and that's the sea change the Times faces: how to remain relevant to a population that can do for themselves what the big publications won't. The "dumb it down" philosophy forces all stories through too narrow a channel to serve the diverse world we live in. When the Times covers my industry, for instance, it seems to know three stories – Microsoft is evil, Java (or whatever the topic du jour) is the future, and Apple is dead. All other stories are cast as one of those three. Bored readers are looking for alternatives, but because the paper is limited in its number of writers, it can't branch out to cover other angles. My bet says the tide has turned: Informed people will look to amateurs

they trust for information they want."

NO

Martin Nisenholtz

CEO, New York Times Digital

DESIGNATED NONPROFIT:

Neediest Cases Fund

"Readers need a source of information that is unbiased, accurate, and coherent. News organizations like the Times can provide that far more consistently than private parties can. Besides, the weblog phenomenon does not represent anything fundamentally new in the news media: The New York Times has been publishing individual points of view on the Op Ed page for 100 years. In any case, nytimes.com and weblogs are not mutually exclusive. We would like to extend our ability to act as a host for all sorts of opinions, and weblog technology might well be useful in doing so. After all, in countries whose citizens don't enjoy First Amendment protection, weblogs are run by people who'd be considered professional journalists in the US. In its six years online, nytimes.com has been a center of innovation, and it'll continue to be, incorporating weblogs and whatever else will enable our reporters and editors to present authoritative coverage of the most important events of the day, immediately and accurately."

SPORTS

The Stake: \$1,000

YES

Mike Elliott

Editor at large, Time

DESIGNATED NONPROFIT:

Vaccine Fund of the Global Alliance for Vaccines and Immunization

"As immigration and technology continue to make the US a more international nation, so the quality of its soccer team will continue to rise. Already, American teenagers can hold their own with players from more established countries, while players like Claudio Reyna and Kasey Keller have become acknowledged

international stars. The Curse of the Bambino, on the other hand, is one of those mystical truths beyond the reach of human intervention. Cheers, Ted."

Background

As the one-world culture of the 21st century reaches into every corner of our lives, sports is no exception. And for a country as economically, intellectually, and culturally global as the United States, international "football" mania is nothing less than inevitable. FIFA, the foremost international soccer authority, estimates that today there are 18 million soccer players in the US – giving the nation one of the highest proportions of players worldwide. Nevertheless, the US men's team has yet to advance beyond the second round in the World Cup. If the United States dominates the shrinking globe in finance, defense, film, computing – why not soccer? Perhaps because popularity doesn't actually score you points on the field. Ask a diehard Red Sox fan – the beloved but beleaguered BoSox haven't won a World Series since 1918.

NO

Ted Danson

Actor

DESIGNATED NONPROFIT:

American Oceans Campaign

"The Red Sox have had such bad luck in the 20th century, I have to believe that in the new millennium it can only get better. Besides, statistically, scoring goals is harder than hitting a home run, and in the World Cup, you have the whole world against you. The Red Sox only have to beat the Yankees."

There's no end to the number of predictions we might make about the future, but bets are a different story. A bet requires an opponent. Of course, if no one chooses to contest a forecast (Internet security breaches will increase over the next three years – any takers?), you've learned how much certainty a proposition inspires. On the other hand, you might find a rash of challengers (Al Gore will win the presidency in 2004), in which case, you've learned something else. These three bets are among those awaiting their matches at www.longbets.org. Will anyone risk \$1,000?

THE END OF "EVERYTHING"

Neither superstring theory, membrane theory, nor any other unified theory describing all the forces of nature will have won a Nobel Prize by 2020.

The Stake: \$1,000

John Horgan

Author, *The End of Science* and *The Undiscovered Mind*

DESIGNATED NONPROFIT:

Nature Conservancy

"The dream of a unified theory, a theory of everything, will never be entirely abandoned. But I predict that, over the next 20 years, fewer smart young physicists will be attracted to an endeavor that has vanishingly little hope of an empirical payoff. Most physicists will come to accept that nature might not share our passion for unity. Physicists have already produced theories – Newtonian mechanics, quantum mechanics, general relativity, nonlinear dynamics – that work extraordinarily well in certain domains, and there is no reason why there should be a single theory that applies to everything. The quest for a unified theory will come to be seen not as a branch of science, which tells us about the real world, but as a kind of mathematical theology."

Background

There were two great insights in the 20th century about how our universe works. One was Einstein's theory of relativity and the other was quantum physics. Both of these breakthroughs can successfully predict events in their own respective realms (gravitational fields versus electromagnetism and subatomic interactions), but their findings cannot be reconciled with each other. Scientists have struggled to develop a unified theory that can accommodate the seeming contradictions between the two.

Stephen Hawking famously termed it the Grand Unification Theory and suggested that its discovery is tantamount to "reading the mind of God." Many feel that promising advances have been made along the lines of superstring theory, which posits a 10-dimensional universe in which the presence of vibrating strings or membranes account for the inexplicable behavior of subatomic particles. Noted contrarian John Horgan is characteristically skeptical of this research, chalking it up to nothing more than a desperate need for order among scientists.

TERROR

Bioterror, or bioerror, will lead to 1 million casualties in a single event by 2020.
The Stake: \$1,000

Martin Rees

Astrophysicist, Institute for Advanced Study, Princeton

DESIGNATED NONPROFIT:

King's College Chapel Foundation

"Biotechnology is advancing rapidly, and by 2020 there will be thousands – even millions – of people with the capability to cause a catastrophic biological disaster. My concern is not only organized terrorist groups but individual weirdos with the mindset of people who now design computer viruses. Even if all nations impose effective regulations on potentially dangerous technologies, the chance of active enforcement seems to me as small as in the case of the drug laws."

Background

Biological warfare dates back to at least 1763, when British general Jeffery Amherst ordered that the blankets of smallpox patients be given to Delaware Indians. Such practices were outlawed – along with chemical weapons – by the 1925 Geneva Convention, after chlorine and mustard gas attacks caused 1.2 million casualties in World War I. Even research into biowarfare was prohibited by the 1972 Biological Weapons Convention. Since then, we've suffered practically no incidents involving either chemical or biological weaponry in conventional warfare. At the dawn of the 21st century, however, conventional war is hardly the only threat. The 1995 sarin gas attack on the Tokyo subway (total fatalities: 15) and last year's anthrax mail attack

(total fatalities: 5) prove that even a small-scale disaster by a few fringe figures can provoke worldwide fear. And these events only hint at the potential nightmare of a large-scale bioterrorist assault. Justifiably, the UN classifies chemical and biological weapons as "weapons of mass destruction" alongside nuclear warheads, and while existing toxins like anthrax, botulism, pneumonic plague, cholera, diphtheria, and Ebola are terrifying enough, our advancing understanding of biology could yield still more horrors. Rees is willing to bet that an unprecedented biological disaster will occur within two decades.

LONGEVITY

At least one human born in the year 2000 will still be alive in 2150.

The Stake: \$1,000

Peter Schwartz

Cofounder and chair, Global Business Network; author, *The Art of the Long View*

DESIGNATED NONPROFIT:

Chabot Space & Science Center

"Science and medicine will not only extend more people's lives to their full Hayflick span, 120 years, but advances in biology will lengthen human life even beyond that. If we look at the current work on stem cells and phenomena like telomerase, an enzyme in DNA, we find we're learning a great deal about the control mechanisms for aging. It's very likely that over the next 25 years, society will see serious and effective medical intervention in the aging process – people undergoing such therapy will keep looking and feeling and acting younger than their calendar age. The prospect of individuals living significantly longer than the current norm will begin to open up. In fact, looking at historical trends, one finds that over the past century, we nearly doubled our lifespan, the average having gone from about 45 to 85. There's no reason to imagine that we won't do at least as much in the next century. If you double 85, you're at 170 – so my bet is actually conservative."

Background

On August 4, 1997, Jeanne Louise Calment of Arles, France, died at the age of 122 years and 164 days. Hers was the longest human life on record, and it added ballast to

a proposition, labeled the "Hayflick limit," posited by biologist Leonard Hayflick in 1961. By growing human embryonic lines in a lab, Hayflick demonstrated that cells divide only about 50 times before entering senescence, at which point they become inert and begin degenerating, making their human hosts prone to ailments like liver disease and arteriosclerosis. The Hayflick limit ordains that even if you avoid serious injury and illness, your "molecular clock" will wind down and your cells cease dividing. But don't stop feeding your 401(k). Schwartz says the Hayflick limit is reaching a limit.