# Doomsday Fears at RHIC

*This year, the Relativistic Heavy Ion Collider (RHIC) is poised to begin a program of cutting-edge nuclear science. Recently, alarmist journalism unnecessarily raised public fears about implausible doomsday scenarios associated with the machine.*

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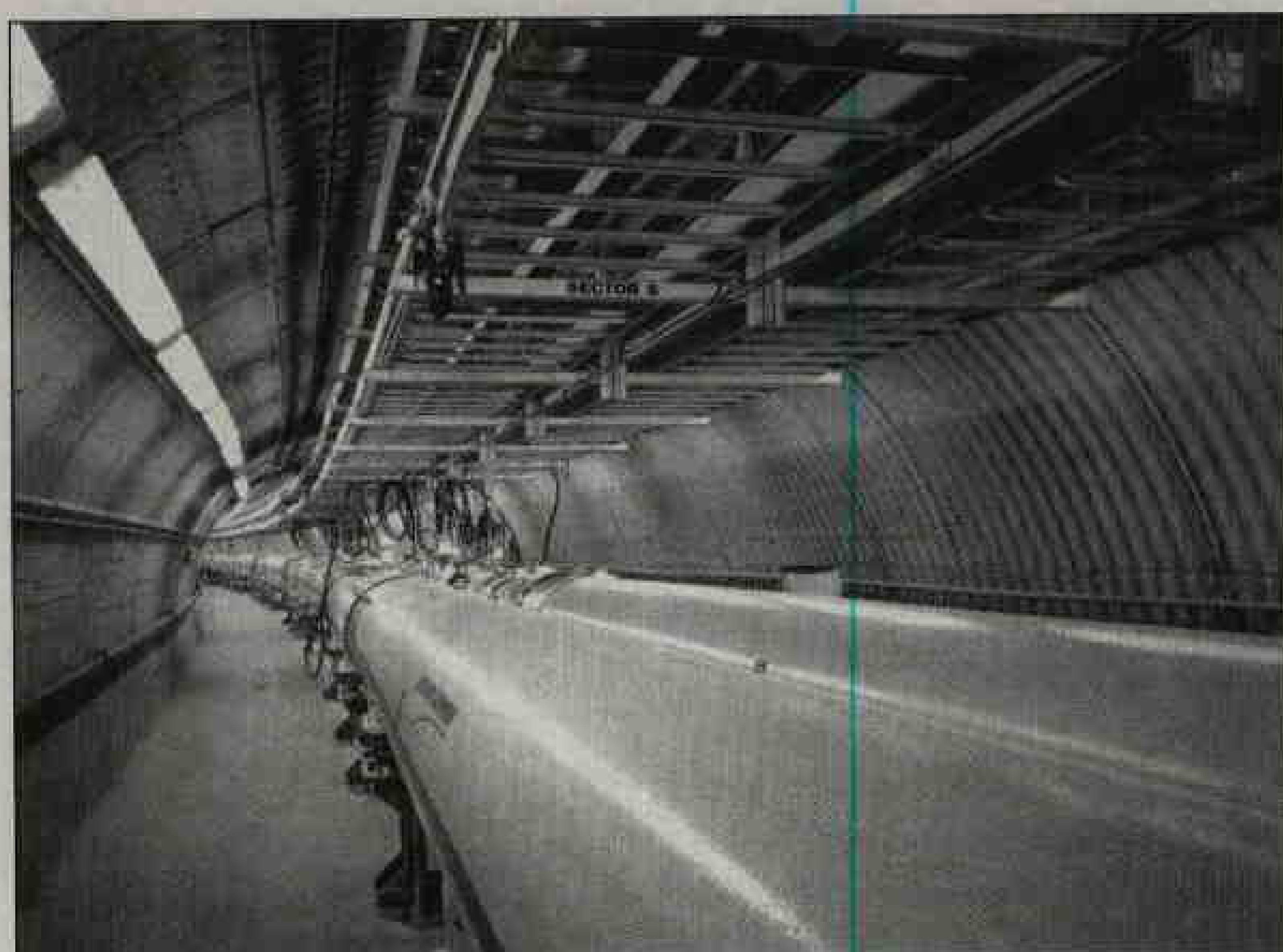
The Relativistic Heavy Ion Collider (RHIC; pronounced "rick") is a 2.4-mile circumference collider at Brookhaven National Laboratory (BNL) on Long Island. The machine is scheduled to go online in May 2000 and is designed to, among other things, collide two gold nuclei, each with 197 nucleons (protons and neutrons), head-on at 99.995 percent the speed of light. This will allow physicists to study the quark-gluon plasma, along with a wide variety of nuclear properties. Such words can certainly spark the imagination, but what exactly are these scientists doing?

At just over $10^{-15}$ meters, fifty thousand times smaller than a typical atom, a gold nucleus is made of a soup of hundreds of nucleons which together act very much like a glob of liquid. Each nucleon is an individually wrapped "bag" containing three objects known as quarks. In the bag, the quarks are bathed in a seething sea of energy fluctuations. The primary denizens of this sea, gluons, are responsible for mediating the strong nuclear force—the force holding the bag of quarks together.

Oddly, no free quark or gluon has ever been directly observed. Indeed, based on quantum chromodynamics (QCD), the theory governing the forces between quarks and gluons, we may *never* expect to see such objects. On everyday human scales, gluons and quarks interact so strongly and in such a peculiar way that they are forever hidden from direct observation through a process called confinement. However, vast and reliable *indirect* evidence for quarks and gluons has accumulated since the 1960s (Halzen 1984; Carrigan 1990; Close 1993; Icke 1995).

When RHIC slams together two nuclei at such fantastic speeds, one goal is to raise the temperature of the colliding nuclei to about a trillion degrees Celsius. At this temperature, nuclear matter undergoes a phase transition analogous to liquid water becoming a gas. The individual bags of nucleons within the nucleus boil away, unleashing the quarks and gluons trapped inside, creating a new state of nuclear matter known as a quark-gluon plasma (QGP).[1] The QGP acts as a single "giant" bag of confined quarks and gluons just a little bigger than the whole nucleus. Within $10^{-24}$ seconds the QGP will expand in a fireball, cool, then precipitate into a fantastic flurry of subatomic particles racing off to highly sophisticated detectors.



RHIC magnets, a view inside the RHIC ring tunnel. Photos courtesy of Brookhaven National Laboratory.

The Collider will give scientists insight into, among other things, the early moments of the universe. A millionth of a second or so after the Big Bang, our own universe began cooling not unlike the QGP fireball. However, at the beginning of time, the *whole universe* was steeped in a QGP. At RHIC, experimentalists are struggling to get a glimpse of just *two* nuclei undergoing a phase transition. In other words, the amount of matter and energy involved at the RHIC experiment is tiny by universal standards. The RHIC Web site notes that the total energy of the two colliding gold nuclei is only equal to about the energy of a mosquito hitting a screen door! Understanding the "smallness" of this experiment is important in addressing doomsday claims. Although the experiment is quite grand on a human scale, it is a far cry from "playing God."

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## The Doomsday Claims

In 1999, some segments of the media and the public fixated on several speculative doomsday scenarios at RHIC. How such claims began can be traced to a few articles in the popular press. However, there may have been latent confusion in the public regarding the science at RHIC that allowed the doomsday claims to easily take hold. One common doomsday scenario claimed that the violently colliding nuclei would create a mini-black hole which would swallow Earth and everything on it. Another scenario involved the creation of "strange matter" which, through a chain reaction, may go on to precipitate all "regular matter" into "strange matter," also destroying the world. These concerns have been directly and rationally addressed officially by the lab itself and unofficially by individual experts.

The mini-black hole scenario can be dismissed with simple physics arguments. There isn't enough matter or energy at RHIC to create a black hole. A back-of-the-envelope calculation demonstrates that RHIC lacks about thirty-six orders of magnitude in mass and energy to create a nucleus-sized black hole! With this heavy constraint, it is just about as likely that a black hole will randomly appear next to your head as you read this article. If a black hole were to be created with RHIC energies (using very generous assumptions), it would have to be around $10^{-38}$ meters in radius. Gravity expert Steven Carlip of the University of California at Davis has estimated that such a small black hole would harmlessly evaporate in about $10^{-90}$ seconds in a puff of Hawking radiation (Carlip 1999). Creating black holes at RHIC is not a realistic possibility.

Strange matter is a hypothesized form of matter that theoretical physicists have been pondering for a number of years. Nucleon bags contain three quarks in combinations of the two lightest varieties (out of six) known dryly as "up" and "down." The next heaviest quark is called "strange." Strange matter simply has more quarks of a wider variety per bag. A "strangelet" typically has six quarks in various combinations of up, down, and strange. The catch is that, although QCD doesn't eliminate strangelets as a possible configuration of quarks, no one has ever seen such objects in the lab.

According to some theorists there is a remote possibility that strangelets have a lower energy than conventional nuclear matter. After a string of highly unlikely possibilities, if lodged in a nucleus, not only could this object be stable, but the rest of the nucleus would reconfigure itself to be a strangelet too as it falls to the lowest possible energy configuration. In a chain reaction, these voracious strangelets could wander around converting every nucleus they touched into strange matter. Although the chain of events required is unlikely, the production of a hungry strangelet could create an unimaginable catastrophe. Scientists claim that such a situation is "highly unlikely." But how unlikely?

To put all doomsday notions to rest, we turn to cosmic rays. Cosmic rays include ubiquitous particles ranging in size from individual protons to large nuclei. There is a wide spectrum of energies associated with cosmic rays. Indeed, there are many cosmic ray collisions which are far more energetic than can be achieved in any laboratory, including RHIC. There are billions of RHIC-like events *per second* pounding into the Moon alone. This has been occurring over billions of years and each one is, in principle, capable of producing a strangelet or other catastrophe. With these natural statistics, no evidence of a voracious reaction has ever been observed on the Moon or elsewhere. This should be a convincing argument that experiments at RHIC won't herald doomsday.

In other words, RHIC isn't doing anything nature itself hasn't done repeatedly and more vigorously since nearly the beginning of time; scientists are just being more systematic on a very small scale. Indeed, if such things are possible at RHIC, we would have already seen evidence for black holes, strangelets, or other wild catastrophes from cosmic rays.

Broadly addressing the above concerns, physicist John Marburger, director of Brookhaven National Laboratory, has stated: "Possible dangerous consequences of RHIC collisions have been explored, analyzed, and laid to rest long ago by men and women who also have families and hopes for the future. No scientific experiment is worth risking the life of even one person, or the health of our environment. No one who is knowledgeable about the RHIC experiments believes such risks are present" (Marburger 1999a). Marburger asked Robert Jaffe of MIT to chair a scientific committee to officially investigate the doomsday issue. By the end of September, the committee published their scientific report "Review of Speculative 'Disaster Scenarios' at RHIC" (Jaffe 1999) which rigorously addressed the doomsday claims. The report concluded that RHIC operations are safe.

## Generating Irrational Fear

The media's approach to RHIC has been quite varied. Most coverage of RHIC by the media has been positive. Many very objective and well-written articles have been published in preceding months (Boyle 1999; Browne 1999; Lane 1999; Rogers 1999; Matthews 1999; Mukerjee 1999; Suplee 1999). However, a few bad apples have spoiled things for everyone, sparking unnecessary fear and concern in the public regarding the safety of RHIC (Leake 1999; Moody 1999a). This has put BNL sharply on the defensive. Alarmist writers have done the journalistic equivalent of wantonly shouting "fire" in a crowded theater. These writers, often operating from nothing better than rumors and the words of crackpots, sparked a blizzard of panicked letters by concerned citizens as the word of "pending doomsday" spread.

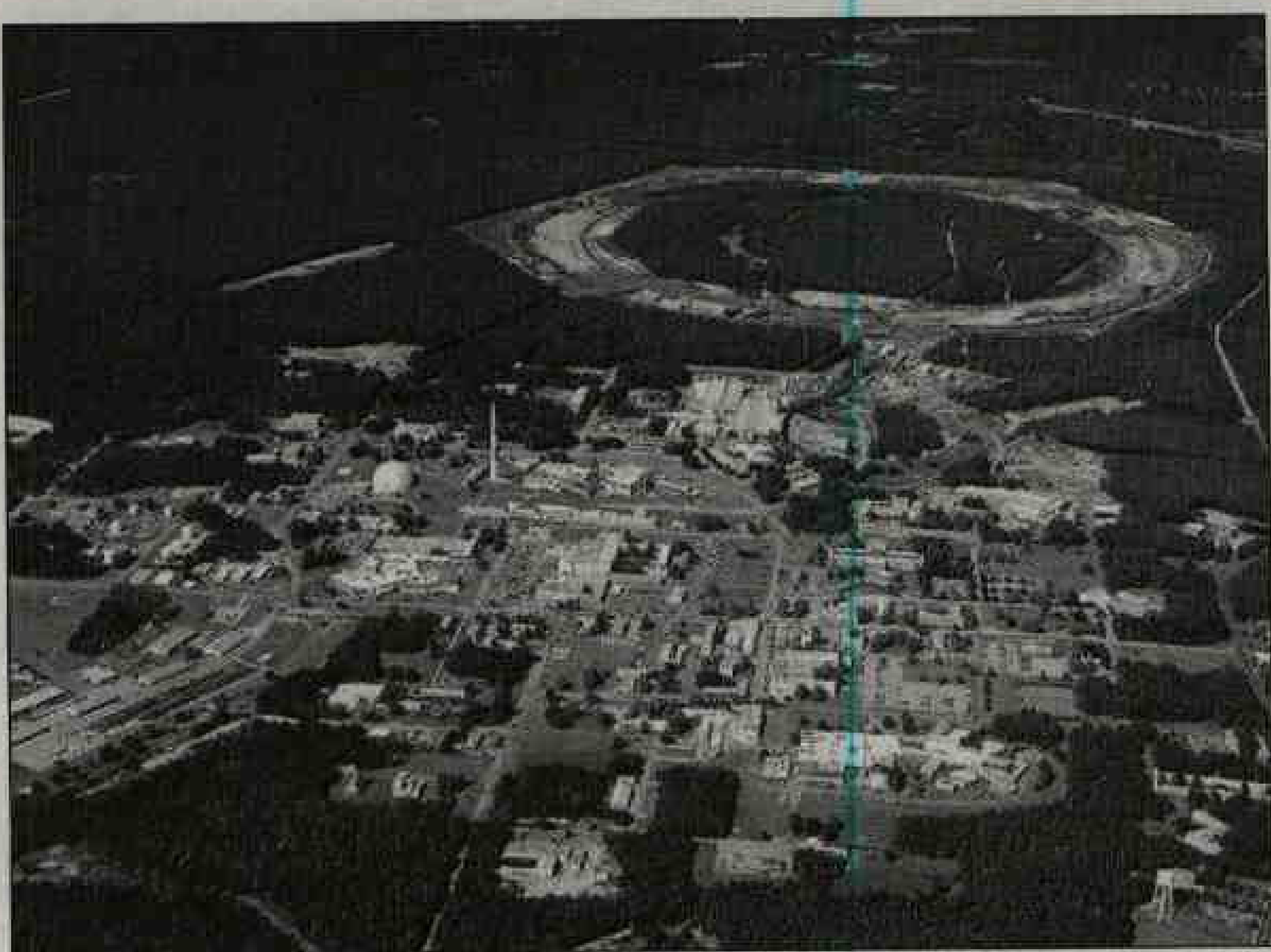
In July 1999, *Scientific American* reported that a March article on RHIC by Madhusree Mukerjee entitled "A Little Big Bang" (Mukerjee 1999) "alarmed several readers" (Letters 1999). True to *Scientific American* style, the article itself provided a readable account of the activities at RHIC. Yet it prompted readers to openly speculate on the possibility of RHIC somehow altering "the underlying nature of things such that it cannot be restored" and creating miniature black holes. Another reader waxes that he is "concerned that physicists are boldly going where it may be unsafe to go." How such fears were spawned before this article is unclear.

Also in July, Jonathan Leake of the *Sunday Times* of London wrote an article simply entitled "Big Bang Machine Could Destroy Earth" (Leake 1999). The article goes on to rationally describe the goals of the experiment and outlines some of the details of the science involved. On the whole, the short article is rather informative. However, interspersed amongst the fairly calm and rational text are spikes of unqualified alarmist rhetoric. The sensationalist title of Leake's piece betrays his underlying premise: the machine is dangerous. The "could" in the title, from a journalistic point of view, is essentially superfluous. The piece ends by quoting a leading British scientist: "The big question is whether the planet will disappear in the twinkling of an eye. It is astonishingly unlikely that there is any risk—but I could not prove it."

In September, Fred Moody wrote a short online opinion piece for ABCNEWS.com entitled "Atlas Shrugs" (Moody 1999a). Moody's past articles demonstrate that he is quite educated in a whole host of technology subcultures. However, the article is the most incendiary and blatantly irresponsible piece of journalism yet published on RHIC safety issues. A few weeks after his original article, Moody published an apologetic follow-up piece that chided scientists for not having a sense of humor (Moody 1999b). However, the damage had already been done.

Moody's piece starts with a quote: "If scientists can be counted on for anything, it's for creating unintended consequences." The article's summary box glibly states, "The hubris of trying to replicate the universe just after the Big Bang could have catastrophic consequences." From here the piece introduces us to Moody's friend, David Melville, "an eccentric physicist and thinker" who writes Moody a "panicky e-mail" admitting that he is "preoccupied" with the RHIC experiments, "the most dangerous event in human history." At one point (it was later removed), in the margins, there was an informal online poll asking the loaded question, "Should potentially dangerous experiments, like the one at Brookhaven, be allowed to proceed [yes or no]?" Melville claims, "It has been theorized by Steven Hawking that from this quark-gluon plasma other forms of matter are also produced. The most dangerous being a black hole." Hawking's honest, but comically wry, response: "I never said that. Long Island is quite safe" (BNL 1999).

Moody elaborates on the various doomsday scenarios already discussed, liberally adding his friend's personal scientific theories and viewpoints. Moody then goes on to speculate that "Sagan considered nuclear war the likeliest cause of destruction [of an advanced civilization], but the creation of an annihilating black hole is more plausible. Not only does it explain the apparent absence of life anywhere else in the universe, it also explains the absence of any past civilizations." Creating a black hole in the lab is more likely than nuclear holocaust? This is just a small sampling of Moody's irresponsible journalism. Keep in mind this is coming from the technology section of ABCNEWS.com, a major online news source! It is not surprising that, after the Moody article, public fears began to rise above the apparently preexisting din of quacks and alarmists. Within several weeks of the article's publication, President Clinton asked to be briefed on the safety issues at RHIC. In a matter of a few months, the system cascaded from a few random alarmist letters in *Scientific American* to scientists briefing the President of the United States on science fiction doomsday scenarios.



Aerial view of Brookhaven National Laboratory with the RHIC ring in the background.

## Discussion

The two articles mentioned above, along with the alarmist public letters, play off of a number of fairly devious misinformation techniques and argumentative fallacies. They are designed to highlight the "reality" of the doomsday scenarios: appealing to authority, playing off of public mistrust of science, misrepresenting complicated scientific ideas, masking irrationality in a package of rationality—the list goes on. Alas, for every ounce of misinformation, it seems to take a pound of clarity to undo the damage. So what can be done?

On one level, the answer is obvious: scientists, members of the media, and the public, using open lines of communication, need to work together to combat ignorance. However, the tension between the three sectors is clear. One can't help but wonder if the public and the media perceive scientists to be so righteous and arrogant that, out of spite, they simply *want* them to be wrong. And let's face it, some scientists clearly enjoy the wall of mystique and complexity surrounding their fields of expertise.

Personality conflicts aside, if a member of the public reads an article from a major news source that quotes experts who claim doomsday is nigh, this *should* be a cause for rational alarm. Public safety is clearly important. However, individuals should act responsibly on such concerns. People have a right to demand accurate media reporting, but they also have a right to demand clear and unpretentious explanations directly from experts—especially when safety is a concern. Physicist Daniel Cebra, director of the Nuclear Group at the University of California at Davis, and active member in the RHIC project at BNL, personally phoned a number of openly worried members of his small community to calm fears after seeing their letters in the local paper. These individuals demanded a response from an expert and got it. This kind of outreach can only improve the relationship between the public and the scientific community.

However, if a scientist generates a media event by using phrases that are flippant, "brutally frank," or unintentionally alarmist, they probably need to rephrase themselves to match the language of their listeners. Mismatches between colloquial and technical language are at the source of much turmoil between science and the media. For example, scientists often speak differently from nonscientists when it comes to assessing degrees of probability. When expressing a "scientific opinion," without the direct benefit of experiment, most scientists are open to possibilities and enjoy using their imaginations as much as anyone else. A priori, truly unquestionably impossible things are indeed rare. If one discovers something that is really absolutely impossible, that's important and you remember it. Everything else can be categorized in varying degrees of possibility ranging over many orders of magnitude between probability equals zero and one. Considerable room for smallness exists between those two numbers. There is an art to assessing such probabilities responsibly and appreciating "effective impossibility" when you see it. But there is also an art, which many scientists seem to lack, to expressing impossibility to nonscientists; scientists feel guilty saying something is unquestioningly impossible. Consequently, ask a scientist if something is "possible" you may be asking for trouble. Be prepared to have all of your fears and fantasies confirmed with a heavily qualified "yes, but. . . ."

In turn, scientists should expect the public and the media to be able to apply basic critical thinking skills in order to process important information. Complex and heavily qualified answers from scientists are usually not the forte of the public nor the media. Shades of possibility are generally ignored. Depending on the audience, events tend to be divided sharply between two choices: "possible" and impossible. In our cynical culture, raised on Murphy's Law, many interpret the word "possible" to mean "if the outcome is bad, it will happen; if the outcome is good, it won't." Many responsible attempts of scientists to explain themselves are usually met with—ironically—skepticism. However, this is often not skepticism fueled by rationality, healthy curiosity, or wizened expertise. It is reactionary, jaded skepticism applied too broadly and too haphazardly. Often, in the eyes of the media and, by proxy, the public, explanations or "rationalizations" are interpreted as signs that someone is avoiding the truth. One should not ignore stated facts simply because someone is explaining herself! If a listener has questions and an expert is giving a point-by-point response, it is probably in the listener's best interest to pay close attention.

Over the past several months, Jack Marburger, Daniel Cebra, and many other scientists have done an excellent job in clarifying and calming the brewing fears surrounding RHIC. Indeed, the scientific community has learned some valuable and humbling lessons in public relations from this experience. In turn, the media have largely responded responsibly, often rallying to the defense of RHIC and calling for rationality in the thick of what seemed like thundering public irrationality. Finally, the public, other than a few extremists, have demonstrated that they still trust science but want to hold it accountable; on the whole, people *are* paying attention and *do* care about what scientists are doing.

Rationality seems to have prevailed for now; it has withstood the onslaught of a modern mania. Although we must all be ever-vigilant to stem the growth of irrationality, this exercise alludes to a rather encouraging future where science, the media, and the public ultimately work together for a more intellectually responsible society.

## Note

1. Scientists at CERN in Geneva, Switzerland, have recently announced the exciting discovery of a new state of nuclear matter (CERN 2000). Technically, they are claiming evidence for what is called "quark-gluon matter." Most regard quark-gluon matter to be a state whereby only a portion of the collision region between the two nuclei shows evidence of quark deconfinement. This is not quite the same as a quark-gluon plasma.

The term *quark-gluon plasma* is usually reserved for a similar, but more specialized, thermodynamic condition whereby most or all of the quarks and gluons amongst the two nuclei are deconfined. In other words, a quark-gluon plasma is a special type of quark-gluon matter and has yet to be discovered. RHIC, with energies about ten times those currently available at CERN, is positioned for further study of quark-gluon matter and the discovery of the quark-gluon plasma.

Also, it should be noted that although quarks and gluons become deconfined in a small region around the reaction, this in no way implies that free quarks are directly seen in the laboratory. Evidence for quarks and gluons is, and possibly shall forever remain, only accessible through indirect measurement. This appears to be a fundamental consequence of the very non-intuitive and complex forces which operate between these objects.

Professor Luciano Maiani, CERN Director General, said: "The combined data coming from the seven experiments on CERN's Heavy Ion program have given a clear picture of a new state of matter. This result verifies an important prediction of the present theory of fundamental forces between quarks. It is also an important step forward in the understanding of the early evolution of the universe. We now have evidence of a new state of matter where quarks and gluons are not confined. There is still an entirely new territory to be explored concerning the physical properties of quark-gluon matter. The challenge now passes to the Relativistic Heavy Ion Collider at the Brookhaven National Laboratory and later to CERN's Large Hadron Collider."

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## Web sites

**altair.ucdavis.edu/rhic.html**—This Web site was compiled by Jennifer Klay, a graduate student in the Nuclear Group at the University of California, Davis. The site outlines the ongoing debate regarding the safety of RHIC operations. It also provides many useful links to the major articles mentioned in this piece.

**www.rhic.bnl.gov**—This is the official RHIC Web site.

**www.bnl.gov**—This is the official Brookhaven National Laboratory Web site. □