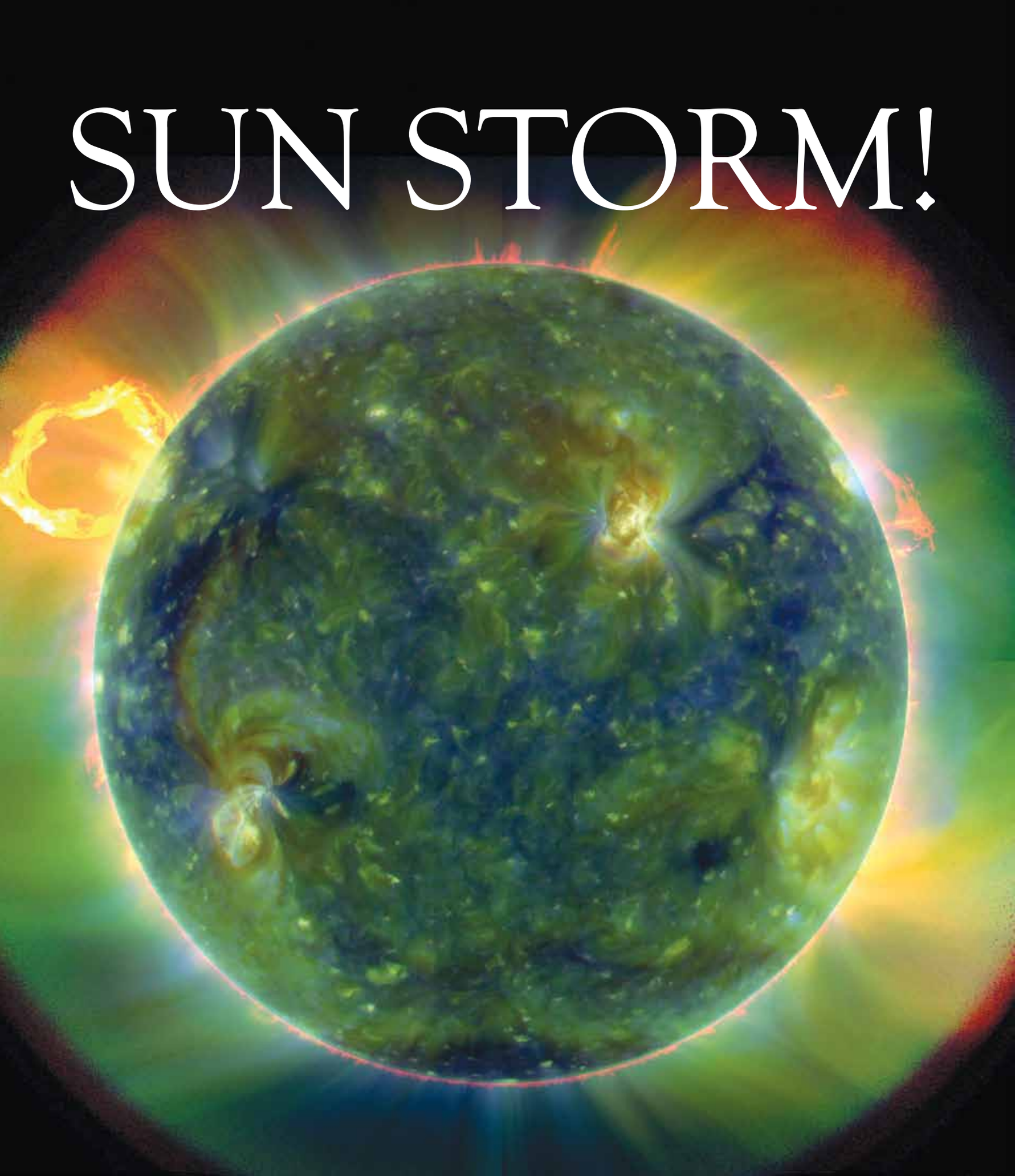
SUN STORM!



Richard Fisher '61 hasn't exactly predicted an apocalypse.

But if his worst fears come to pass, it might be the closest thing to one most of us will experience — and it could be coming to your electrical grid soon.

by Doug McInnis

Richard Fisher '61 took his first photo of the sun in November 1960, standing on MacEachron Field and looking through an antique telescope loaned to him by physics professor **Grant O. Gale**. Fisher happened to capture a powerful solar storm in progress and was fascinated. "I've got to know more about this," he wrote in his journal.

It wasn't an idle wish. That snapshot "unfolded a path that, for me, ranged over mountaintop observatories, solar eclipse expeditions, Apollo-Skylab missions, space shuttle scientific payloads, and a score of scientific space flight missions," Fisher says.

His first stop after Grinnell was at the University of Colorado for a Ph.D. in astrophysics, then to a long NASA career capped by the directorship of that organization's heliophysics division. On Sept. 29, 2011, in a ceremony at NASA headquarters, he was awarded the NASA Distinguished Service Medal — the organization's highest honor — for contributions "representing substantial progress to the NASA mission in the interest of the United States." He also has won NASA's Exceptional Achievement Medal, and — twice — its Exceptional Service Medal. Fisher's greatest contributions are to heliophysics, which he describes as "the study of a magnetic variable star — our sun — and how it drives the planets of our solar system, including the Earth, and organizes interplanetary space."

This wide view of the sun encompasses space sciences, computer modeling, and mathematics. Fisher's work included developing the fleet of orbiting spacecraft that have both furthered solar science and provided Earth with advanced warning of solar storms. Now he holds the position of scientist emeritus at Goddard Space Flight Center in Maryland, and remains one of the world's foremost authorities on the study of the sun.

Today Fisher — and anyone else, via NASA's website — can see the object that centers our galaxy through the high-tech eyes of 27 satellites designed to study the star and help Earthlings understand when solar storms threaten. These are storms that could severely cripple large parts of the industrial world by causing huge, long-lasting power blackouts, knocking out satellites we depend on for communications and navigation, and potentially reducing life in developed nations to chaos that could last for years.

> "A loss of power could lead to a cascade of operational failures that could leave society and the global economy severely disabled."
>
> **— Lloyd's of London**

Such solar storms aren't new, Fisher says. In 1859, telegraph operators were amazed when their telegraph papers burst into flames and they got an electric shock from their telegraph keys. In 1989, 6 million people in Quebec lost electric power for nine hours. In both cases, massive solar storms sent protons blasting to Earth, raising havoc with just about everything electrical.

Solar storms can happen "anytime, like earthquakes," Fisher says, but tend to reach peak intensity at the end of a cycle. "The fall of 2011 has seen the onset of increasing frequency of solar activity as the 22-year solar magnetic cycle proceeds toward a new sun-spot maximum," he says. And sunspot maximum is where the danger is.

By and large, the Earth's magnetic field diffuses the worst of these storms. But for reasons that aren't well understood, the protective force of the magnetic field doesn't always work, and the storms strike Earth with devastating power. This happened in 1859 and again in 1921, periods during which we lived in a largely low-tech world.

This time, electric power could go off and stay off — perhaps for months — over large portions of the industrialized world, Fisher says. Everything that depends on electricity would shut down, instantly crippling a world more reliant than ever on the electric grid and a plethora of high-tech gadgets.

"If you wake up and your power is down, you can cope for a day," Fisher says. "And I suspect you could get along for a week. But if it goes on for 100 days, it would be like Hurricane Katrina."

Facing page: An extreme ultraviolet image of the sun taken by NASA's Solar Dynamics Observatory satellite. Reds show relatively cool areas, blues and greens are hotter. Images such as this help scientists predict solar storms. Credit: NASA/GSFC/AIA

Or worse, because the damage could be almost global in scope. The impact of a complete power loss would ripple throughout the national and global economic system. Without power, factories and offices would shutter. Paychecks would stop. For example, "As people in the United States lose their jobs, they wouldn't be spending money, and that would impact other countries where the things we buy are made," says **Heidi Shierholz '94**, a labor-market economist at the Economic Policy Institute in Washington, D.C.

As businesses closed and workers were furloughed, the problems would multiply. "A one-percent decline in gross domestic product translates into an almost one-percent rise in unemployment," Shierholz says. "Declines in the labor market would put downward pressure on prices, so housing prices might drop further."

But a declining GDP and rising unemployment would likely be dwarfed by more immediate problems, such as lack of such basics as heat, light, fuel, water, refrigeration, and sewage treatment. The toll on humanity could be enormous. Furnaces wouldn't run. Electric-powered sewage systems would back up. Food would rot in homes and supermarkets. GPS navigation wouldn't work, which is a big deal if you're trying to land a GPS-guided aircraft in low visibility.

So why aren't we all panicking?

That's a good question, and one with no good answer. Partly, perhaps, because the potential danger is unknown to much of the public, although last year the chief science advisers to U.S. President Barack Obama and British Prime Minister David Cameron took the issue to the op-ed page of *The New York Times*. They warned that damages in the United States could hit $2 trillion in the first year — and that it could take four to 10 years to recover from a storm.

In a way, the situation parallels New Orleans before Hurricane Katrina drowned the city. The city fathers and the Army Corps of Engineers knew the flood control system *could* catastrophically fail, but it never had, so we as a nation didn't fix it.

Richard Fisher '61

The man behind the forecast

Richard Fisher arrived at Grinnell as a precocious teenager who had done so well on his National Merit exams that Grinnell admitted him after his junior year of high school. Fisher repeated the performance, speeding through Grinnell in three years. He left with a Phi Beta Kappa key and an education that would shape his career.

He received superb training in science, learning not only theory but how to build basic scientific instruments and operate the power tools needed to make them. These skills paid rich dividends at NASA, where theory and practicality conjoin daily.

Fisher benefited from the humanities as well — in particular from a course on Greek history taught by **Richard Westfall**, a science historian who went on to write a celebrated biography of Sir Isaac Newton. The course focused in part on Homer's *Iliad*, which Westfall used as a vehicle to help students understand human motivation and behavior. That knowledge was invaluable when Fisher became a NASA administrator trying to convince key legislators to fund his projects. "I learned how to work the system," Fisher says.

Outside the classroom, he ran on Grinnell's varsity cross country team under coach **Dick Young**, a taskmaster who won championships. "Dick taught me that in the big time, life is an indoor-outdoor, 365-days-a-year, all-body contact sport," Fisher says. "If you don't like that, you shouldn't be in it." That advice also proved invaluable in Washington, where toughness is a key to success.

During his first year at Grinnell, **William C. Oelke '28** loaned Fisher a concave grating spectrograph and encouraged him to develop photographic and spectroscopic diagnostic skills that were vital to astrophysical practice at that time. This experience propelled Fisher into later experimental activities.

But the pivotal point in Fisher's education occurred when physics professor **Grant O. Gale** loaned him that telescope he used to take his first photo of a solar active region.

Richard Fisher 61

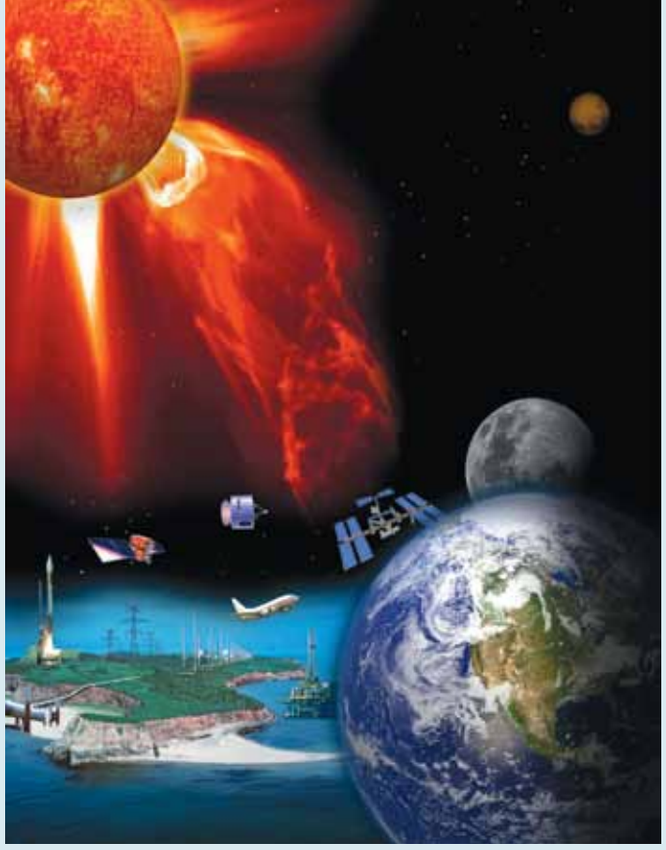
In some ways, it launched a curiosity that had as much power as another one of Gale's early acts: giving one of the world's first transistors to **Robert Noyce '49**, who became the co-founder of Intel Corp. and co-inventor of the silicon chip.

Noyce is better known — at present. But Fisher's pioneering work in heliophysics and the elaborate solar-weather detection system he's helped develop may soon prove to have a greater import than most of us would ever have imagined.

Fisher wants to be sure we don't repeat that disaster scenario on a worldwide scale. The first thing we need, he believes, is accurate information about the sun that can help us understand solar storms and plan for their occurrences.

That depends on good information of the kind provided by the advanced-warning system Fisher helped design. With notice, operators of electric grids, satellite networks, and other systems can take evasive action, although how much they can do to prevent catastrophic damage isn't known for certain.

Fisher wants us to prepare now by planning and funding a replacement fleet of sun-studying satellites. "I'd say we have about 10 years left," he says. "Now is the time to think about this. The size of the national investment in solar-storm detection is pretty big — and you don't order new spacecraft like you order pizza. It takes years and some fraction of a billion dollars to send one up. We're essentially living off aging assets." ■



NOT Just the Facts, Ma'am

Science education at Grinnell

More than 50 years ago, **Richard Fisher '61** learned to be a scientist by practicing his craft as a Grinnell undergraduate. With the help of his teachers, he built basic scientific instruments and used them to study the sun.

Grinnell still believes in the hands-on approach, and has begun to make it an even bigger part of its curriculum. Biology 150, the redesigned introductory biology course, is a case in point. Legions of college and university graduates recall intro biology as a course in which teachers talked and students took notes, often in a packed lecture hall.

Grinnell's Biology 150 curriculum has turned that approach on its head. It requires each student to design his or her own scientific investigations, much as Fisher did when he photographed the sun. "Instead of expecting all students to learn exactly the same list of biological facts, we expect all students to practice the same skills while investigating interesting biological questions," biology faculty members wrote. "It's not that facts are unimportant. [But] research shows that people are more likely to remember facts, understand concepts, and apply them to new situations when they use them."

Brace Yourself!

Lloyd's assesses the potential damage

In a worst-case scenario, solar storms would inflict a long-term shutdown of the electric grid, disrupt GPS signals, and bombard Earth with potentially damaging particles and radiation. And from those three things would flow a host of ills. Here's a breakdown on what to expect, based on assessments from NASA and Lloyd's of London, the famed insurance syndicate:

- Disruption of GPS systems needed for air and sea navigation.
- Rising high-altitude radiation levels that could affect airline flight crews and frequent fliers.
- Shutdowns of electric-powered systems, including water and sewer.
- Failure of refrigeration systems in homes, supermarkets, and food warehouses.
- Hospital power failures as backup power units run out of fuel.
- Disruption of cell phone and wireless Internet networks.
- Disruption of global stock exchanges from damage to GPS systems, which generate precise time-stamping for stock trades.
- Disruption of electronic cash transfers.
- Pipeline damage from the corrosive effects of space weather.
- Disruption of railroad signal settings.