SPACE SHUTTLE ARE THE SPAWN OF GODDAR'S PIONEERING RESEARCHES

ROCKET SCIENTIST

ROBERT GODDARD

He launched the space age with a 10-ft. rocket in a New England cabbage field

By JEFFERY KLUGER

Robert Goddard was R not a happy man when he read his copy of the New York Times on Jan. 13, 1920.

For some time, he had feared he might be in for a pasting in the a press, but when he picked up the paper that day, he was stunned.

Not long before, Goddard, a physics professor at Clark University in Worcester, Mass., had published an arid little paper on an outrageous topic, rocket travel. Unlike most of his col- leag ues, Goddard be- lieved rocketry was a viable technology, and his paper, primly ti- tled "A Method of Reaching Extreme Alti- tudes," was designed to prove it. For the lay reader, there wasn't much in the writing to excite interest, but at the end, the buttoned-up profes- sor unbuttoned a bit.

If you used his technology to build a rocket big enough, he argued, and if you primed it with fuel that was powerful enough, you just might be able to reach the moon with it. Goddard meant his moon musings to be innocent enough, but when the Times saw them, it pounced. As anyone knew, the paper explained with an editorial eye roll, space travel was impossible, since without atmosphere to push against, a rocket could not move so much as an inch. Professor Goddard, it was clear, lacked "the knowledge ladled out daily in high schools."

Goddard seethed. It wasn't just that the editors got the science all wrong. It wasn't just that they didn't care for his work. It was that they had made him out a fool. Say what

MANY OF GODDARD'S ROCKETS, LIKE THIS CLUMSY 1927 MODEL, SIMPLY FIZZLED ON THE PAD

BORN Oct. 5, 1882, in Worcester, Mass. 1908 Begins studying physics at Clark University 1915 Proves that rocket engines can produce thrust in a vacuum 1926 Launches the first liquid-fueled rocket to an altitude of 41 ft. 1930 Begins working in Roswell N.Mex; develops supersonic and multi-stage rockets and fin-guided steering 1945 Dies at age 62, holding 214 patents

you will about a scientist's research, but take care when you defame the scientist. On that day, Goddard-who would ultimately be hailed as the father of modern rock- etry- sank into a quarter- century sulk from which he never fully emerged. And from that sulk came some of the most incandescent achievements of his age.

Born in 1882, Goddard was a rocket man before he was a man at all. From child- hood, he had an instinctive feel for all things pyrotechnic; he was intrigued by the infernal powders that fuel firecrackers and sticks of TNT. Figure out how to manage that chemical violence, he knew, and you could do some ripping-good flying. As a student and professor

> "Why don't you ask your own Dr. Goddard? He knows better than any of us"
>
> A CAPTURED V-2 SCIENTIST, asked how Germany learned to build rockets

at Worcester Polytechnic In- stitute and later at Clark, God- dard tried to figure out just how. Fooling around with the arithmetic of propulsion, he calculated the energy-to-weight ratio of various fuels. Fooling around with airtight chambers, he found that a rocket could indeed fly in a vacuum, thanks to Newton's laws of action and reaction. Fooling around with basic chemistry, he learned, most important, that if he hoped to launch a missile very far, he could never do it with the poor black powder that had long been the stuff of rocketry. Instead, he would need something with real propulsive oomph-a liquid like kerosene or liq- uid hydrogen, mixed with liquid oxygen to allow combustion to take place in the airless environment of space. Fill a missile with that kind of fuel, and you could re- tire black powder for good.

For nearly 20 years. God- dard's theories were just theo- ries. When he'd build a rocket and carry it out to a field, it never flew anywhere at all. When he'd return to Clark, fizzled missile in hand, he'd be greeted by a colleague ask- ing, as was his habit, "Well, Robert, how goes your moon- going rocket?" When he steeled himself to publish his work, the Times made him wish he hadn't.

Finally, all that changed. On March 16, 1926, Goddard finished building a spindly, 10-ft. rocket he dubbed Nell, loaded it into an open car and trundled it out to his aunt Effie's nearby farm. He set up the missile in a field, then

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summoned an assistant, who lit its fuse with a blowtorch attached to a long stick. For an instant the rocket did nothing at all, then suddenly it leaped from the ground and screamed into the sky at 60 m.p.h. Climbing to an altitude of 41 ft., it arced over, plummeted earthward and

ripping-good flying. As a student and professor

GODDARD, LEFT, MADE GREAT ADVANCES IN NEW MEXICO IN THE '30S

slammed into a frozen cabbage patch 184 ft. away. The entire flight lasted just 2% sec.-but that was 2% sec. longer than any liquid-fueled rocket had ever managed to fly before.

Goddard was thrilled with his triumph but resolved to say little about it. If people thought him daft when he was merely designing rockets, who knew what they'd say when the things actually started to fly? When word nonetheless leaked out about the launch and inquiries poured into Clark, Goddard answered each with a pinched, "Work is in progress; there is nothing to report." When he finished each new round of research, he'd file it under a deliberately misleading title- "Formulae for Silvering Mirrors," for ex- ample-lest it fall into the wrong hands.

But rockets are hard to hide, and as Goddard's Nells grew steadily bigger, the town of Worcester caught on. In 1929, an 11-ft. missile caused such a stir the police were

orn in 1882, Goddard was a rocket man before he was a man at all. From child- hood, he had an instinctive feel for all things pyrotechnic; he was intrigued by the infernal .

called. Where there are police there is inevitably the press. and next day the local paper ran the horse-laughing head- line: MOON ROCKET MISSES TARGET BY 238.799% MILES. For Goddard, the East Coast was clearly becoming a cramped place to be. In 1930. with the promise of a $100,000 grant from financier Harry Guggenheim, Goddard and his wife Esther headed west to Roswell, N.Mex., where the land was vast and the launch weather good, and where the locals, they were told, minded their business.

In the open, roasted stretches of the Western scrub, the fiercely private ely Goddard thrived. Over the next nine years, his Nells grew from 12 ft. to 16 ft. to 18 ft., and their altitude climbed from 2,000 ft. to 7,500 ft. to 9,000 ft. He built a rocket that exceeded the speed of sound and another with fin- stabilized steering, and he filed dozens of patents for everything from gyroscopic guidance systems to multistage rockets. By the late 1930s, how gto ever, Goddard grew troubled.

He had noticed long before that of all the countries that showed an interest in rocketry, Ger- many showed the most. Now and then, German engineers would contact Goddard with a technical question or two, and he would casually re- spond. But in 1939 the

BY 1932, GODDARD, SECOND FROM RIGHT, WAS BUILDING ROCKETS FITTED WITH GYROSCOPES. THREE YEARS LATER HE WENT SUPERSONIC

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GODDARD,LEFT ,AND HIS BROTHER-IN-LAW SALVAGE A SMASHED ROCKET IN 1927

at Worcester Polytechnic In- stitute and later at Clark, God- dard tried to figure out just how. Fooling around with the arithmetic of propulsion, he calculated the energy-to-weight ratio of various fuels. Fooling around with airtight chambers, he found that a rocket could indeed fly in a vacuum, thanks to Newton's laws of action and reaction. Fooling around with basic chemistry, he learned, most important, that if he hoped to launch a missile very far, he could never do it with the poor black powder that had long been the stuff of rocketry. Instead, he would need something with real propulsive oomph-a liquid like kerosene or liq- uid hydrogen, mixed with liquid oxygen to allow combustion to take place in the airless environment of

responded, "Why don't you ask your own Dr. Goddard? He knows better than any of us." When some V-2s finally made their way to the U.S. and Goddard had a chance to au- topsy one, he instantly recog- nized his own handiwork. "Isn't this your rocket?" an assistant asked as they poked around its innards. "It seems to be," Goddard replied flatly.

oddard accepted G paternity of his bastard V-2, and that, as it turned out, was the last rocket he fathered while alive. In 1945 he was found to have throat cancer, and before the year was out, he was dead. His technological spawn, however, did not stop. American scien- tists worked alongside émigré German scientists to incorpo- rate Goddard's innovations into the V-2, turning the killer missile into the Redstone, which put the first Americans into space. The Redstone led directly to the Saturn moon rockets, and indirectly to virtu- ally every other rocket the U.S.

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Though Goddard never saw a bit of it, credit would be given him, and-more impor- tant to a man who so dis- dained the press-amends would be made. After Apollo 11 lifted off en route to human- ity's first moon landing, the New York Times took a be- mused backward glance at a tart little editorial it had pub- lished 49 years before. "Fur- ther investigation and experi- mentation," said the paper in 1969, "have confirmed the findings of Isaac Newton in the 17th century, and it is now definitely established that a rocket can function in a vacuum as well as in an atmo- sphere. The Times regrets the error." The grim Professor Goddard might not have appreciated the humor, but he would almost certainly have accepted the apology.

TIME senior writer Jeffrey Kluger is the co-author, along with Jim Lovell, of Apollo 13

A HUNDRED-YEAR COUNTDOWN

Goddard was not the first to conceive of liquid-fueled rockets, but he was the first to make one fly. The descendants of his invention put machines into space and humans on the moon

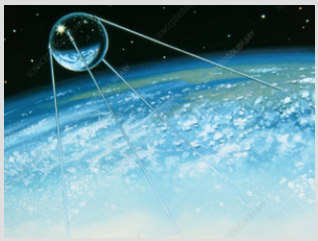
►**1903** Russia's Konstantin Tsiolkovsky publishes "Exploring Space with Reactive Devices," the first great rocketry study

1920 Goddard publishes the first of only two rocketry papers he will ever write

1926-39 Goddard launches the first liquid-fueled rockets, eventually building models that climb past 9,000 ft. and break the speed of sound

1944 Germany, inspired in part by homegrown rocketeer Hermann Oberth and in part by Goddard, launches the first V-2 rockets against London and Paris

1945 German rocketeers, led by Wernher von Braun, are brought to America to design rockets for the U.S



A **1957** The U.S.S.R. launches Sputnik 1, the first satellite
1958 The U.S. answers with the smaller Explorer 1

A **1961** The U.S.S.R.'s Yuri Gagarin becomes the first human being in space: America's Alan Shepard follows the next month.

1967 NASA launches the 36-story Saturn V, then-and still-America's largest rocket

1969 Apollo 11, launched by a Saturn V, lands the first men on the moon

1981 The U.S. launches the first space shuttle

1986 Shuttle Challenger explodes, killing seven astronauts; the next month, the U.S.S.R. launches the first component of the Mir space station

1995 First American astronaut flies aboard Mir

▼**1998** Assembly begins of International Space Station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TIME, MARCH 29, 1999

ASTRONOMER

EDWIN HUBBLE

He saw a vast universe beyond the Milky Way, then found the first hints that it began with a Big Bang

By MICHAEL D. LEMONICK

During the past 100 years, astronomers have discovered quasars, pulsars, But all these pale next to thblack holes and planets orbiting dis- tant suns.e discover- ies Edwin Hubble made in a few remarkable years in the 1920s. At the time, most of his colleagues believed the Milky Way galaxy, a swirling collec- tion of stars a few hundred thousand light-years across made up the entire cosmos. But peering deep into space from the chilly summit of Mount Wil son, in Southern California, Hubble realized that the Milky Way is just one of millions of galaxies that dot an incompara- bly larger setting.

Hubble went on to trump even that achievement by showing that this galaxy-studded cosmos is expand- ing-inflating majestically like an unimaginably gigantic bal- loon-a finding that prompted Albert Einstein to acknowl- edge and retract what he called "the greatest blunder of my life.

" Hubble did nothing less, in short, than invent the idea of the universe and then provide the first evidence for the Big Bang theory, which describes the birth and evolu- tion of the universe. He dis- covered the cosmos, and in doing so founded the science of cosmology.

Hubble's astronomical tri- umphs earned him worldwide scientific honors and made him the toast of Hollywood during the 1930s and 1940s- the confidant of Aldous Hux- ley and a friend to Charlie Chaplin, Helen Hayes and William Randolph Hearst. Yet nobody (except perhaps Hubble) could have imagined

BORN November 1889 in Marshfield, Mo.
1910 Enters Oxford as a Rhodes scholar
1919 Joins the staff of the prestigious Mount Wilson Observatory after serving in World War I
1923 Proves that the universe extends far beyond the edges of the Milky Way galaxy
1925 Creates the first useful scheme for classifying galaxies
1929 Proves that the universe is expanding
1936 Publishes The Realm of the Nebulae, a huge popular success
1943 Becomes temporary head of Army ballistics research
DIES Sept. 28, 1953

HUBBLE NAVIGATED THE HEAVENS FROM HIS PERCH AT MOUNT WILSON

such a future when the 23-year-old Oxford graduate began his first job, in New Albany, Ind., in 1913.

Hubble majored in sci- ence as an undergraduate at the University of Chicago. A tall, powerfully built young man, he excelled at basketball and boxing (fight promoters reportedly tried to talk him into turning pro), and his combination of academic and athletic prowess earned him a Rhodes scholarship to Oxford. In England, Hubble kept up his muscular pursuits: he fought, ran track and played on one of the first baseball teams ever organized in the British Isles.

Though he was popular with students-especially, according to Hubble biographer Gale Christianson, with the girls, who were evidently charmed by his affected British diction and "Oxford mannerisms"- Hubble longed to return to science.

His official academic focus shifted, thanks to a promise made to his dying father that he would study law rather than science (he also took up literature and Spanish). On his return to America, he took a position as a high school Spanish teacher.

After a year, he signed on as a graduate student at Yerkes Observatory in Wis- consin and embarked on the work that would one day make him famous: studying faint, hazy blobs of light called nebulae (from the Latin word for cloud) that are visible through even a modest telescope.

Hubble's skills as an as- tronomer were impressive enough to earn him an offer from the prestigious Mount Wilson Observatory. World War I kept him from accepting right away, but in 1919 the newly discharged Major Hubble-as he invariably intro- duced himself-arrived at ob- servatory headquarters, still in uniform but ready to start ob- serving with the just completed 100-in. Hooker Telescope, the most powerful on earth.

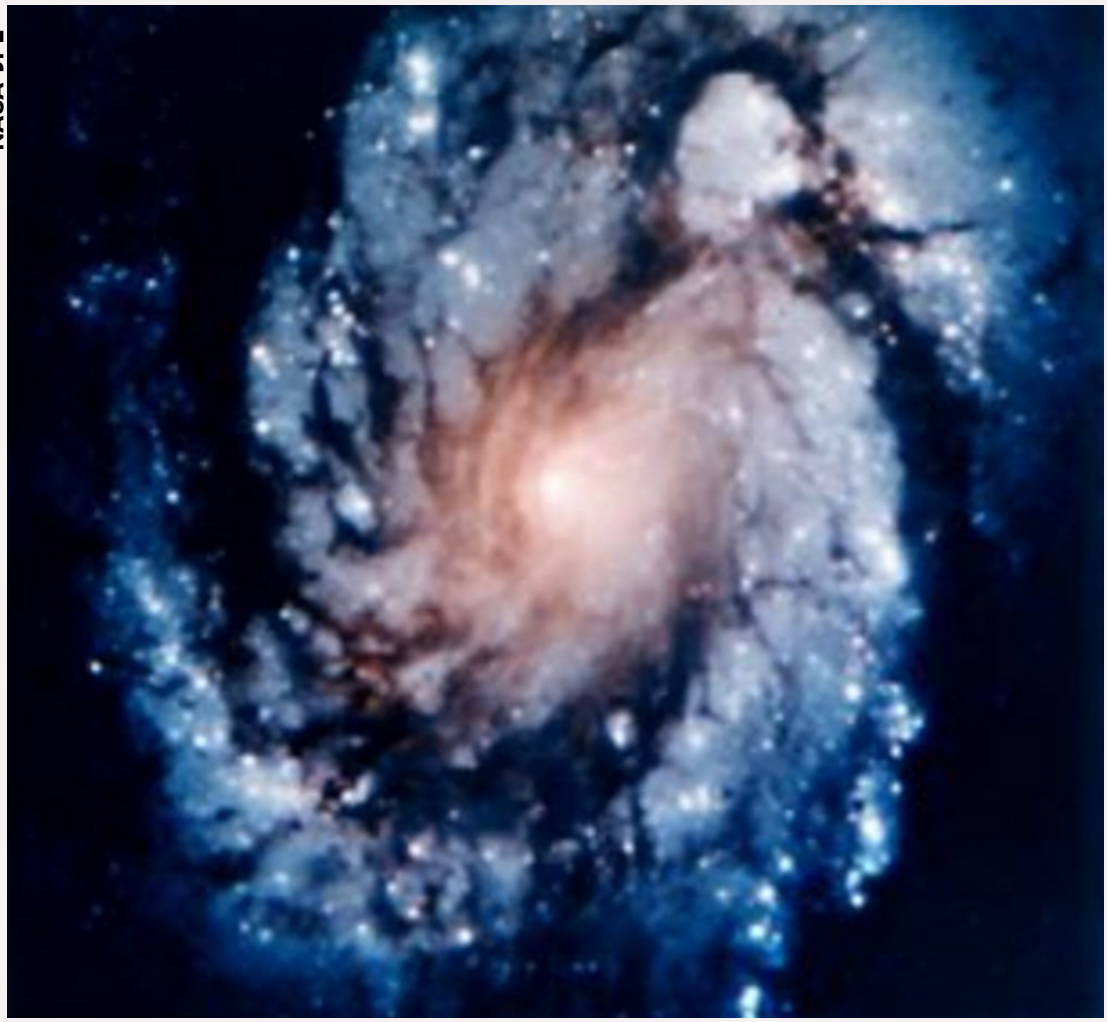
Up on the mountain, Hub- ble encountered his greatest scientific rival, Harlow Shapley, who had already made his reputation by measuring the size of the Milky Way. Using bright stars called Cepheid variables as standardized light sources, he had gauged the galaxy as being an astounding 300,000 light-years across- 10 times as big as anyone had thought. Yet Shapley claimed that the Milky Way was the whole cosmic ball of wax. The luminous nebulae were, he insisted, just what they looked like: clouds of glowing gas that were relatively nearby.

> [Hubble's] discovery that the universe is expanding was one of the great intellectual revolutions of the 20th century.
>
> **STEPHEN HAWKING, A Brief History of Time**

OXFORD MADE HIM A RABID ANGLOPHILE; HIS FAVORITE EXPRESSION WAS "BY JOVE"

Hubble wasn't so sure. And in 1924, three years after Shapley departed to take over the Harvard Observatory, Hubble found proof to the contrary. Spotting a Cepheid variable star in the Andromeda nebula, Hubble used Shapley's technique to show that the nebula was nearly a million light-years away, far beyond the bounds of the Milky Way. It's now known to be the full-fledged galaxy closest to our own in a universe that contains tens of billions of galaxies. "I do not know," Shapley wrote Hubble in a letter quoted by biographer Christianson, "whether I am sorry or glad to see this break in the nebular problem. Perhaps romeda both." (Hubble was not entire- mapley's ly magnanimous in victory. To the end he insisted on using the term nebulae instead of Shapley's preferred galaxies.) Hubble's scientific reputa- tion was made almost overnight by his discovery that the universe is vast and the Milky Way insignificant. But he had already moved on to a new problem. For years, astronomers had noted that light from the nebulae was .

Tredder than it should be.he most likely cause of this so-called red shifting was motion away from the observer. (The same sort of thing happens with sound: a police car's siren seems to drop in pitch abruptly as the car races past a listener.) Hubble Milton Humason, began measuring the distances to these receding nebulae and found what is now known as Hubble's Law: the farther away a galaxy is from Earth, the faster it's racing away. Could it be that the universe as a whole is rapidly expanding? That conclusion was extraordinary, almost mind-blowing, yet seemed inescapable.



NASA-JPL

When Einstein heard of Hubble's discovery, he was elated. More than a decade earlier, his general theory new of relativity had told him that the universe must either be expanding or contracting, yet astronomers had told him it was doing neither. Against his better judgment, Einstein had uglied up his elegant equations with an extra factor he called the cosmological term- a sort of antigravity force that kept the universe from collapsing in on itself.

ut suddenly, the B cosmological term was unnecessary. Einstein's instincts had been right, after all. His great blun- der had been to doubt himself, and in 1931, during a visit to Caltech, the great and grateful physicist traveled to the top of Mount Wilson to see the telescope and thank Hubble personally

for delivering him from folly. With the greatest scientif ic superstar of the age paying him homage, Hubble

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Gold and glory than its other big rival, professional corporate futurology Corporate trend spotting, after all, is limited to gizmos that might conceivably make someone money.

Science fiction, in its sleep and entirely by accident, makes absurd amounts of money: SF films,

comic books, action figures, CD-ROMs, computer games, chrome cards, costumes-there's no end to i

Science fiction is a fun-house mirror for a society warped by raging technological advance.

Science fiction doesn't want or need to make much sense. It seeks astonishment, terror, wonder, ecstasy and dread. It is spectacular and mythic, an oxygen tent for society's daydreams.

Science fiction cordially ignores many vital technologies, such as, say, garbage recycling. Recycling is hugely important, but it has zero science-fictional thrift SF's saga of the techno-sublime is about power, speed and transcendence of human limits.

Ray guns, starships, arti- ficial intelligence, virtual reality, nanotechnology-all beloved of SF, and every last one of them a big Techni- color disruption of the mundane.

When science fiction gets over its trite romance with the parts catalog, it can achieve unnerving power. Aldous Huxley and George Orwell are the classic exemplars of that small, élite class of science-fiction writers who frighten and annoy science- fiction devotees.

Huxley's Brave New World (1932) bursts with prescient speculation: "feelie" multimedia, Prozac-like "soma" tranquilizers, test-tube babies. Late in life Huxley became a psy- chedelics guru,

seduced by the potent allure of brain chemistry.

rwell holds the world record for scaring us away from a fu- ture that seemed perfectly plausible. People like to claim that Orvell "got it wrong" as if it were Orwell's fault that we don't dwell in some ghastly dystopia. Orwell's 1984 (published in 1949) is the bitter work of a dying man. Granted, political correctness and language theory haven't become "Newspeak" just yet. But Orwell's portrait of a debased Britain, singing machine-made pop songs and obsessed with vast public lotteries, has a certain uneasy resonance even now.

On the grim subject of networked surveillance, maybe Orwell was just a big, mean, bring-down pessimist. On the other hand, we haven't yet seen an Internet society in the grip of a genocidal land war. Security video- cams are already ubiquitous, they've become far too common- place for fiction to notice. Huxley and Orwell, of course, didn't think of themselves as sci- ence-fiction writers. The true artists of the genre are a tribe apart. Many created "future histo- ries" that are worked out in ex- quisite detail. Robert A. Heinlein, for instance, was a hugely popular SF writer, but of a surprisingly gloomy and gothic cast. His forecast for the late 20th century was summed up briskly: "Considerable technical advance during this period, accompa- nied by a gradual deterioration.

BEFORE IT HIT THE MAINSTREAM, SCIENCE FICTION FLOURISHED IN PULP MAGAZINES

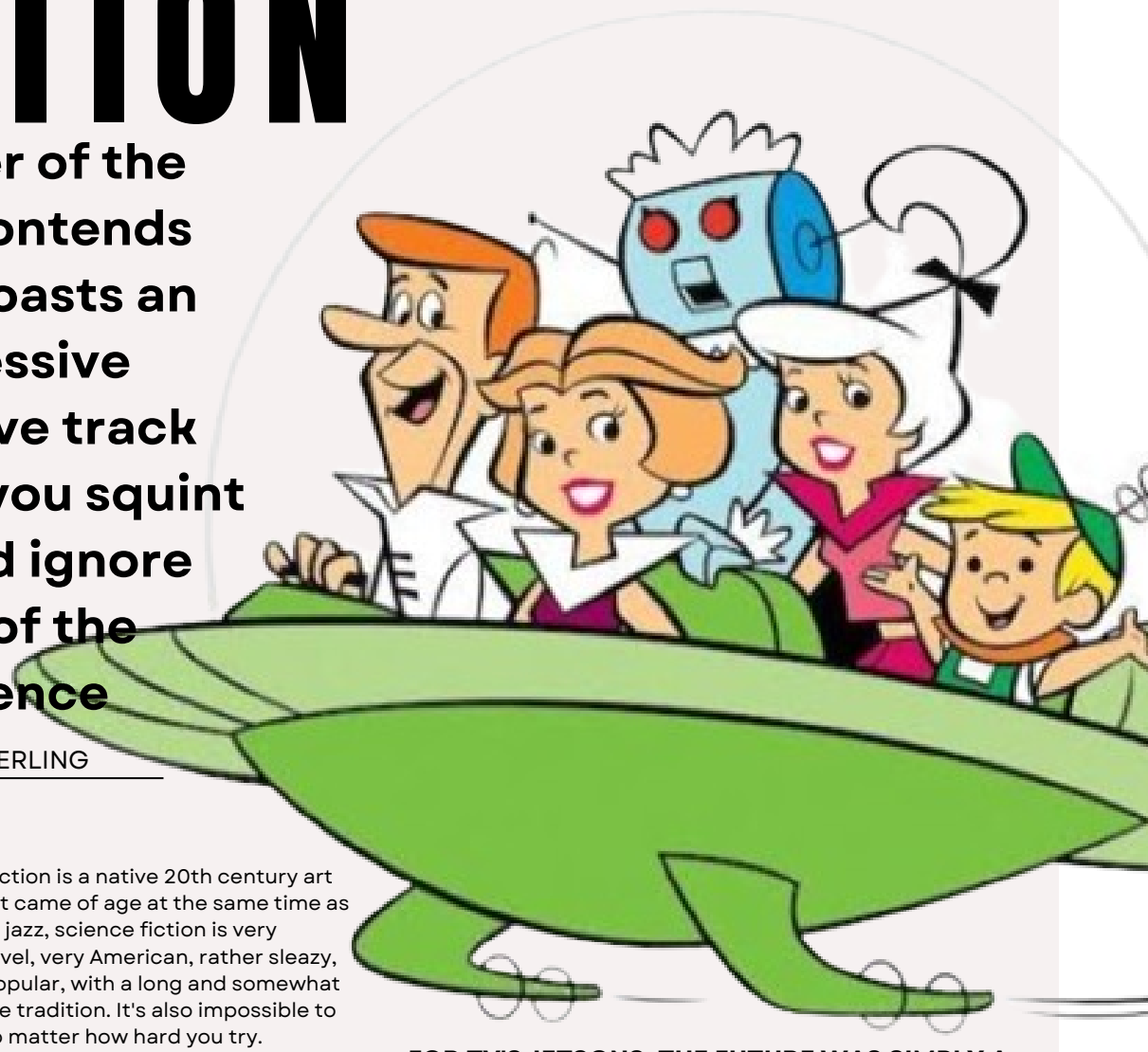
THE MAIDEN IN PERIL IS A STAPLE OF SCI-FI B MOVIES

LAIL FINLAY-HERNANDEZ, 1936 BY STREET & SMITH PUBLICATIONS: BY ARRANGEMENT WITH FORREST J ACKERMAN

A CENTURY OF SCIENCE FICTION

A master of the genre contends that it boasts an impressive predictive track record-if you squint hard and ignore most of the evidence

By BRUCE STERLING



Science fiction is a native 20th century art form that came of age at the same time as jazz. Like jazz, science fiction is very street-level, very American, rather sleazy, rather popular, with a long and somewhat recondite tradition. It's also impossible to avoid, no matter how hard you try.

Science fiction boasts an impressive predictive track record-if you squint hard and ignore most of the evidence. Atom bombs, spacecraft, comsats, credit cards, jukeboxes, wa- terbeds, gene splicing-they all appeared in science fiction first, well before showing up at the mall or the military base. But science fiction is visionary by design and prophetic only by accident. You'll have a hard time finding androids, aliens. time travelers or psychic powers at the K Mart, even though science-fiction writers have obsessed about them for 70 years.

The U.S. Congress' Office of Technology Assessment had all the virtues sometimes claimed for science fiction. The OTA Was concerned with genuine, hard-core technological prediction. It paid close scholarly attention to technical trends and their social implications with facts, figures and footnotes-and Congress abolished it in the mid-1990s. The OTA didn't work out; science fiction suits us better. American society prefers to have supergizmos dropped on its head out of nowhere, with no time to prepare and no real thought of the consequences. We love it that way. It's livelier, funnier, freer and just more American.

FOR TV'S JETSONS, THE FUTURE WAS SIMPLY A SITCOM WITH GADGETS

"Leap, and the net will appear!" If science fiction outlived the OTA, it also gets more girls

fundamentalists plugged into cunning propaganda networks. These way-out notions of Heinlein's were composed in the 1940s; he probably thought he was being very provocative, out- there and outrageous. Time has been less kind to other works of SF, despite hard work and serious intent. Harry Harrison's novel Make Room! Make Room! (the source of the movie Soylent Green) predicted a New York City crammed with 35 million people, each allotted a meager three square meters of living space. That novel is set to- day-in 1999. It was published in 1966. The scenario made sense back then, before the advent of widespread birth control. All you had to do was follow the exponential curves. If the tag end of the century resembles the work of any sin-gle SF writer, it must surely be J.G. Ballard. One might make an argument for the prescience of William Burroughs (if you're a junkie), or the uncanny knack of William Gibson (if you're a ca- reer computer criminal). But Ballard is surely the most insightful artist the genre ever produced. While most SF writers of his gen- eration were down at the Jet Propulsion Laboratory cheering on the moon landings.

THE IQ MERITOCRACY

Our test-obsessed society has Binet and Terman to thank-or to blame

U.S. SIGNAL COMPS

By NICHOLAS LEMANN

A Frenchman, the psychologist Alfred Binet, published A the first standardized test of human intelligence in 1905. But it was an American, Lewis Terman, a psychology professor at Stanford, who thought to divide a test taker's "mental age," as revealed by that score, by his or her chronological age to derive a number that he called the "intelligence or IQ. It would be to think of a pop-scientific coinage that has had a greater im- hard pact on the way people think about themselves and others.No country embraced the IQ-and the application of IQ test- ing to restructure society-more thoroughly than the U.S.Every year millions of Americans have their IQ measured, many with a direct descendant of Binet's original test,the Stanford-Binet, although not necessarily for the purpose Binet intended. He developed his test as a way of identifying public school stu- dents who needed extra help in learning, and that is still one of its leading uses.

But the broader and more controversial use of IQ testing has its roots in a theory of intelligence-part science, part sociology- that developed in the late 19th century, be- fore Binet's work and entirely separate from it Championed first by Charles Darwin's cousin Francis Galton,intelligence was the most valuable human attribute, and that if people who had a lot of it could be iden- tified and put in leadership positions, all of society would benefit. - Terman believed IQ tests should be used to conduct a great sorting out of the population, so that young people would be as- signed on the basis of their scores to particular levels in the school system, which would lead to corresponding socioeconomic desti- nations in adult life. The beginning of the IQ-testing movement overlapped with the eugenics movement-hugely popular in America and Europe among the "better sort" before Hitler gave it a bad name-which held that intelligence was mostly inherited and that people deficient in it should be discouraged from repro- ducing. The state sterilization that Justice Oliver Wendell Holmes

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