COMETS!

Join David J. Eicher in this fast-paced and entertaining journey through the history, present, and future of these important yet mysterious cosmic bodies. From ancient times, humans have been fascinated by "broom stars" and "blazing scimitars" lighting up the sky and moving against the fixed background of stars. The Great Comets of our time still receive in-depth attention – ISON, Hale-Bopp, Hyakutake, West, and others – while recent spacecraft encounters offer amazing insight into the earliest days of the solar system.

In this guide you will discover the cutting-edge science of what comets are, how they behave, where they reside, how groups of comets are related, and much more. The author carefully explores the ideas relating comets and life on Earth – and the danger posed by impacts. He finishes with practical how-to techniques, tips, and tricks of observing comets and even capturing your own images of them successfully.

David J. Eicher is editor in chief of *Astronomy* magazine, the world's largest publication on the subject. He is president of the Astronomy Foundation, the telescope industry's first-ever trade association. He is author of 17 books on science and history, and at age 15 he founded a magazine on observing galaxies, clusters, and nebulae, *Deep Sky Monthly*. An avid observer of astronomical objects for more than 35 years, he was honored in 1990 by the International Astronomical Union with the naming of minor planet 3617 Eicher.

COMETS!

Visitors from Deep Space

DAVID J. EICHER
Astronomy magazine

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This work is dedicated to several astronomers I had the privilege of interacting with in my youth and who left a great impression on me. I will always be grateful.

Bart Bok
Brian Marsden
Carl Sagan
Carolyn Shoemaker
Gene Shoemaker
Clyde Tombaugh
Gérard de Vaucouleurs

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Foreword

With the appearance of two bright comets in the year 2013, sky watchers around the world are preparing to train their telescopes on this pair of wonders in the night. The starlike central portions surrounded by soft haze, and followed by gossamer tails, appear rarely enough in our lives that they surely deserve our full attention and our passion.

David J. Eicher's book brings the magical world of comets to life. It is not an arcane mathematical textbook but a celebration of these slowly wandering objects. It delves into Tycho's Comet of 1577, the comet that led to the great Danish astronomer's discovery that comets pass through the sky well beyond the orbit of the Moon. The book devotes considerable space to Halley, the most famous of comets and the first comet shown to be periodic.

Comets are famous not just for what they are, but also for what they can do. In 1994 Comet Shoemaker-Levy 9 performed the first major cosmic collision witnessed by humanity when it collided with Jupiter. My role in the discovery of that comet is a story that dates back to 1965, while I was a teenage camper at the Adirondack Science Camp near Lewis, New York. Our camp director asked that each participant display a project at the camp's annual science fair. He also insisted these projects need not be completed by the date of the fair; he wanted us to stretch our limits, to conceive and conduct a project that could last a lifetime, and one that could also fail. "Failure," he told us, "is the great teacher. If everything you do in science is a great success, then you probably haven't learned anything."

Although I completed a project that summer, I left camp dissatisfied. Two months later, while walking down to my high school French oral examinations, an idea suddenly hit me from out of the blue: I could begin a program of hunting for comets with a telescope. Inspired by the discovery of the Great Comet Ikeya-Seki of 1965, by the time I reached school I had already begun my plans. "Qu-est-ce que vous envisagez de faire une carrière?" (What do you want to do for a career?), asked Mr. Hutchinson, my examiner. Sitting up proudly in my chair, I replied, "Je veux

découvrir une comète." (I wish to discover a comet.) Hutchinson sat up in his chair, stared at me, and asked in English, "How the hell do you expect to earn any money doing that?" We had a good laugh, and then he said, again in English, "Alright, but if you do not find a comet within the next 25 years, I will come back and lower your grade!" His timing was about right; I began my program on December 17, 1965, 62 years after the Wright brothers' flight, and discovered my first comet 19 years later, on November 13, 1984.

In 1989 I joined Gene and Carolyn Shoemaker's Palomar Asteroid and Comet Survey. Within the next few years we discovered 13 new comets, including 8 periodic comets, then numbered Shoemaker-Levy 1 through 8. On the night of March 23, 1993, I exposed two films that happened to contain the planet Jupiter. Two days later Carolyn, while exploring those films with her stereomicroscope, suddenly looked up. "I think I have found a squashed comet," she said. Gene looked at the films, then glared at me with a look of absolute puzzlement I had never seen before. When I got my turn, I noticed that each image showed two bars of fuzzy light with several tails pointing toward the top of the film, and each one surrounded on both sides by a thin trailed line.

Our discovery was just the beginning of the story. Over the next two years the comet figuratively whisked us off into space with it, and our fortunes were necessarily tied in with its headlong crash into Jupiter. During the week of the great impacts, July 16–23, 1994, we lived in Washington, D.C., and visited the Space Telescope Science Institute in nearby Baltimore each day. This comet taught us much about the splendid beauty of the night sky and the uncountable events featured within it.

Perhaps more importantly, as rare as this event was in our time, comet collisions were common in the early stages of the solar system. They may have accounted for much of the accumulation of water on Earth. In their many impacts with the early Earth, comets likely provided one additional thing. The materials they contain often sport particles of carbon, hydrogen, oxygen, and nitrogen. These CHON particles represent the simple alphabet of life. As CHON particles filter to the ground from direct impacts or close approaches, they can – over time – evolve into proteins, RNA, and DNA. When we look at a comet in the night, we may actually be looking at our own birthright.

These are the ideas that comets can engender. As you read this marvelous book, you may be learning about your own distant past.

David H. Levy

(David H. Levy is a Canadian astronomer, science writer, and comet hunter who is celebrated for his 22 comet and 41 asteroid discoveries. In 2010 he earned his Ph.D. from Hebrew University in Jerusalem.)

Preface

When I was 14, I fell in love with the universe. The discovery occurred with a one-time view of Saturn through a telescope at a local "star party." There was something so calm and comforting about gazing skyward at the twinkling dots spread across an inky black cosmos. Somewhere amid all the apparent serenity out in the universe things must be incredibly more complicated than they were for an earthbound kid. So in the cool spring of America's Bicentennial year, I found a new habit: taking my family's pair of 7×50 binoculars, grabbing a sleeping bag, and, with my dog in tow, wandering out from the edge of our neighborhood into a cornfield and lying down, taking long stares at the star fields and glows of the Milky Way above the southern Ohio landscape.

The sessions went from a few minutes at first, to hours after a couple of weeks. I might as well have been on the Moon; civilization was shielded, the neighborhood tucked away behind a low screen of trees, the sky fortunately dark, and my only companions Oscar the border collie, the occasional rustle of a squirrel or raccoon, and the deep beauty of the sky above. As Earth slowly rotated, I saw the universe's whole show – as far as we can see it from our place in the cosmos. Gradually, I learned constellations, recognized bright stars as my friends, and squinted toward the positions of fuzzy objects I couldn't quite make out – clusters of stars and glowing gas clouds in the Milky Way Galaxy – as seen through the old binoculars. Before I knew it, I had been taken into another world. I didn't know exactly why I'd gone, except that this world was alluring for the mystery and the grandeur of the vastness of space.

Soon I was heading out to the cornfield observatory on virtually every clear night. Warm clothes protected against the chill of a late-night dew; ultimately, an extension cord allowed a radio to carry soft music to the scene. Star atlases and the gentle glow of a red-filtered flashlight added ambience to what was becoming a junior science project. Each night I got to know my new friends better and better. There were Vega, Deneb, Altair, the North America Nebula, Coma Berenices. Lots of features presented themselves night after night. Once in a while a bright meteor streaked

overhead. One particular meteor that spring was an absolute monster – a magnitude –4 fireball that lit up the ground in the early morning hours and, just as I was getting sleepy, jacked up my heart rate in an instant and perked up my dog.

Backyard astronomy became a way of life, an antidote to the uncertainty of the teenage years in high school. Before I knew it, I had joined an astronomy club, volunteered to write their observing column, and bought a telescope. It was an 8-inch Celestron Schmidt-Cassegrain scope, and after a year of observing with the binoculars, the scope added a whole new dimension to viewing distant objects. Now the fuzzy things scattered across the sky were resolved into sharp, impressive detail, as star clusters, nebulae, and galaxies far away from our own came into view. They too became well-known friends. There were so many of these so-called deep-sky objects, things beyond the solar system, that the astronomy club newsletter lacked room to write about them all. So by age 15 I began planning and publishing a little magazine called *Deep Sky Monthly*. It eventually attracted a following of about 1,000 subscribers and, before I knew it, I was publishing it throughout the rest of high school and into my college years.

Throughout my early years of observing the sky, I specialized in observing deep-sky objects, joining the staff of *Astronomy* magazine in 1982 and taking with me the retitled and quarterly magazine *Deep Sky*, which we published in Milwaukee for another decade. (Eventually it became clear that to move forward with *Astronomy*, the big title, I had to give up the smaller one.) But although my specialties were galaxies, planetary nebulae, and other fuzzy objects, I always kept an affinity for galaxy lookalikes – comets.

Comets very much resemble deep-sky objects as seen in a telescope's eyepiece. They move relative to the background stars, of course, whereas galaxies don't. But the visual similarities between comets and deep-sky objects drove the 18th-century French observer Charles Messier to produce the most famous catalog of sky objects in history, to separate the "nuisances" from the comets he cherished.

And comets loomed large in my early observing experiences. During my first big spring of observing the sky, Comet West (C/1975 V1) lit up the morning sky and became an instant classic, a brilliant spectacle. Soon after I arrived at *Astronomy*, the quirky comet IRAS-Araki-Alcock (C/1983 H1) appeared like a giant, luminous cotton ball as it quickly swept across the sky, passing close to Earth. I was fortunate enough to write most of the observing stories in *Astronomy* about Comet 1P/Halley, the most famous comet of all, during its 1985/6 apparition. And more recently, we all enjoyed big events like Comet Shoemaker-Levy 9 (D/1993 F2) slamming into Jupiter in 1994, and the Great Comets Hyakutake (C/1996 B2) and Hale-Bopp (C/1995 O1).

In late 2013, Comet ISON (C/2012 S1) is poised to be a Great Comet, putting on a brilliant show as it visits the inner solar system, pulled by the Sun. The universe has so much to offer and really changes lives with an understanding of the immensity and grandeur of all that awaits us "out there." I hope this book can play some small part in your discovery or appreciation of comets and the cosmos at large.

Acknowledgments

Many people's help goes into the making of any book, and such is the case with this work. It's particularly true when the timescale is so short: Spurred on by the discovery of Comet ISON, having waited for a bright comet for more than 15 years, I thought of doing a book on comets on the New Year 2013. After I received interest from the folks at Cambridge University Press, we all realized that we had just three months to put a book together, and the good folks at the Press wanted the better part of 100,000 words. This is my 17th book, and it has been far more of a scramble than any previous project. That I finished on time is due as much to many others who helped me as it is to hours of solitary writing.

First and foremost, I want to thank my wife, Lynda, and son, Chris, both great supporters and involved in their own worlds of discovery, Lynda as a teacher, helping to inspire young minds, and Chris as a chemistry student in college who will go on to help science move forward. And I thank my father, John, who at age 92 is still going strong and delights in discussing the philosophy of science at length once or twice a week. Thanks also to my sister, Nancy, for taking such good care of him.

I want to thank my friend David H. Levy, one of the great figures in the world of comets, for contributing his Foreword. I've known David since I was 17 years old, since the days he started contributing writings to my little publication *Deep Sky Monthly*. What a pleasure it has always been to know David.

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And a special thank you to Michael Bakich, *Astronomy* magazine's photo editor, for helping me to select some images.

At the tag end of the 1980s I wrote a book for Cambridge, a compilation of deep-sky observing stories called *The Universe from Your Backyard*. It's been 24 years since the publication of that book. I hope my next book for Cambridge will come a little sooner than that.