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SPACE—WHERE NOW, AND WHY?

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Planetary science holds my interest and my passion. I was trained in the field of history, where I learned that what happened in the past has a direct influence on the present and future. Over the years I have endeavored to understand two more fields, geology and astronomy, both bearing directly on planetary science. These fields are basically historical sciences—astronomy is like a time machine that tells us about the creation of our solar system and our universe, geology reveals the nature of our world in the past and helps us to understand Earth and its neighboring planets today.

I have concentrated my work on a search for comets and for planet-crossing asteroids capable of impacting Earth as a means to understand the effects of such impacts on all the solid bodies in our solar system. Impact cratering is a process that affects all life, which to me means that science and society cannot help but be intertwined. In 1993 I was fortunate to be part of the team—with Eugene Shoemaker and David Levy—that discovered comet Shoemaker-Levy 9 (S-L 9). Many scientific discoveries today are done as a team effort, and while I was the first to see this comet on our films, this was possible only because other members of the team had taken the photographs. Observing at the telescope was among the hardest, most demanding work that any of us did and we were all in it together. While finding this comet was a fantastic discovery, the events that followed were not only exciting, but humbling. S-L 9 was the first comet to be seen in an orbit around a planet, Jupiter—rather than in an orbit around the sun—the first comet to be observed so completely disrupted that there seemed to be a steady-state number of 21 fragments, and the first large object to be seen impacting another body. S-L 9 became everyone's comet, as professional scientists and amateur astronomers sought to learn more about it and to find the best ways to observe its inevitable impact on Jupiter. The Internet made possible the exchange of huge quantities of information and beautiful images to the general public, as well. For 15 months there was enthusiastic cooperation between scientists, amateur astronomers, educators, and the media, who were witnessing an event that had never before been described in the historical record. Not since the days of Apollo and lunar exploration had science, technology, and the rest of society had such an affinity for each other. Occasionally we are lucky to have a meeting of minds and events that makes the discoveries of science meaningful to all.

From the days when humans first emerged as thinking beings, they have cultivated a curiosity about the unknown and a desire to explore it. Where did we come from? Why are we here? Where does our future lie? These are age-old questions that we are still exploring. Are they only philosophical in nature? Do we know the answers to some of them? Can anyone predict the future? No doubt the first concerns and questions of humanity were of a physical nature. Where does the next meal come from? How can we stay warm, or cool? Where can we find shelter and safety? These were matters of creature comfort and basic survival, and too many are still chiefly concerned with those questions. Even so, as people sought answers and migrated throughout the world, they observed the skies above and wondered at the marvels that they saw there. How many people have wished that they had wings to fly, to soar like birds, with no earthly constraints? How many have wondered what it would be like to touch the clouds, to wander on the moon, or to see beyond the stars? In the night sky, before cities developed artificial lighting, people were able to see the constellations above, to marvel at meteors, comets, and all the unknown phenomena of the heavens, and to imagine that there could be other worlds with life like ours. It was thus that the space sciences (astronomy and planetary science) began to develop. But knowledge of the heavens was acquired only gradually because, on the whole, understanding astronomical phenomena was to their way of thinking not paramount since it had little to do with human survival.

Over time, however, the development of technology, coupled with space sciences, brought more answers to our curious questions, and we began to see how Earth was part of a larger system. Telescopes designed to view night skies revealed new wonders, and society's egocentric beliefs were gradually forced to yield to the realization that Earth was not the center of the solar system, that there was more—a whole universe beyond. It is my conviction that this realization unlocked the door to our future. New and better instruments for examining the skies have been developed almost yearly, enabling astronomers to move beyond the solar system in their research. New and improved technology has allowed human beings to leave the confines of Earth and venture into near space. Better technology coupled with improved astronomical knowledge made it possible for us to observe comet Shoemaker-Levy 9, and to follow it through its impact on Jupiter and its aftermath.

A newly emerging subfield of planetary science which integrates the geology of solid bodies throughout the solar system with the biological search for life, now complements astronomy. Much of what we have learned about the planets and their moons, about asteroids and comets, depended on the development of new and improved films and cameras and, at the same time, on ever more capable computers and

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software. Engineers provided the technical expertise and imagination not only to take man to the moon, but to provide the rockets, the probes, the instruments, and the improved methods of communication that enable us to explore our solar system and learn many of the secrets underlying its formation and evolution. Different branches of science have become more integrated with each other.

In today's world, as nations and peoples grow closer through computer technology, the Internet, and faster communication and transportation, people have become aware of new and changing challenges to their way of life. Still, to many, space exploration by telescope and by manned and unmanned missions seems frivolous and unnecessary. We are more concerned with the effects of changing economies and governments, with the disappearance and birth of nations, with old hatreds re-emerging and warfare used as a solution, with dangers to our health from new viral and bacterial infections that spread very quickly in unforeseen ways as people cross boundaries and oceans, with hunger and poverty that remain prevalent as populations burgeon, with acid rain and an ozone hole that grows larger, and with storms, earthquakes, floods, and droughts that we cannot always predict or warn against, and over which we have no control. Solutions to these problems are difficult to come by, yet societies must not be negligent. Maintaining a close partnership with science and its counterpart, technology, holds many advantages. For example, technological developments resulting from space programs have become part of society's everyday life, affecting many different areas as new applications are found for them. Among these are the uses to which computers and computer imaging have been put as they revolutionize the way business, medicine, education, transportation, communication, and science, are done.

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While there remains much to be discovered beyond Earth, and it is clear that the scientific and technological advances that are driven by our curiosity also have advantages for society, there are other astronomical phenomena closer to Earth that pose a threat to society. The effort to discover new asteroids and comets has revealed primitive bodies of great beauty that pose a danger to Earth. The science of impact, accretion, destruction of planets, and the extinction and regeneration of life forms carries with it an awareness of the awesome interrelationships of bodies throughout our universe and the possibilities for life and its disappearance, once again. We have learned that comet and asteroid impacts are part of the history of all solid bodies in our solar system and that impact is an ongoing natural process. Images taken by the Hubble space telescope and other very large telescopes that can look deep into space portray the birth and death of stars, inform us that there is a natural, sometimes violent, process of evolution of worlds throughout the universe on an unimaginably long time scale. On Earth we worry because species become extinct on a short time scale. Yet that, too, is part of a natural, perhaps universal, process.

Although extinction and impact events are natural phenomena, we must find a way to prevent an impact on Earth by small and large objects such as asteroids and comets. If a car approached as you crossed the street, would you rush ahead, return to the sidewalk, or stand in front of it and wait for the collision? Are we going to wait for an impact from space, or are we going to take steps to avoid such a disaster? If the future of Earth is to involve the future of society, we should not wait.

Most people do not like too much change, nor do they like to consider altering natural processes. While society has gradually shown a willingness to manipulate human biology to prevent disease, most people are reluctant to consider the possibilities offered by the controversial subject of cloning. In a similar vein, society has been willing, and has even demanded, flood control, but it has been reluctant to consider changing weather patterns either to increase or decrease rainfall. People find it difficult to envision having the ability to control hurricanes and tornadoes, but science may someday have the ability to do just that. Society seems to believe that it must accept earthquakes as natural and unavoidable, but there are already methods under consideration to avoid catastrophic earthquakes. As difficult as natural phenomena are to deal with, society must not maintain a parochial attitude toward preventing catastrophes that science may help avoid. Now is the time to change our philosophical approach to our world, to realize that while bad things can and do happen, we may be able to prevent them or at least ameliorate their effects without harming society or our environment. The threat of an impact from space—which could be the worst catastrophe of all because a large impact could bring the human race to extinction—has been considered, and methods to deal with this threat are being discussed. At the same time, we need to be aware that venturing into space may provide the ultimate answer to whether or not humans can survive another threat, the evolution of our sun. I hope that we are able to develop a willingness to consider new approaches to our environmental and biological problems.

Clearly, science and society are intricately entwined, and as one progresses, so does the other. Pure science, the search for knowledge without knowing where it will lead, is part and parcel of what will make the world a better place for all mankind. The more we learn, the more questions we can ask and the more answers we can obtain. Society may not always look favorably on science, thinking it too difficult, too technical, or too abstruse to apply to most people. But as society struggles to find answers to its problems, it would do well to remember that science has touched upon and improved almost every aspect of our lives. We must therefore conquer our fears so that we can continue to progress on all fronts, and explore space as a new frontier that belongs to all of us. Science will likely provide the answers for our future and, indeed, whether we as a species have a future at all. The challenge awaits us.

ILLUSTRATION: TERESE WINSLOW; SHOEMAKER-LEVY 9 CONCEPTUAL ILLUSTRATION: DAVE SEAL AND PAUL CHODAS/JPL/NASA