Preface

The original volume of *Comets and the Origin and Evolution of Life* was published in 1997 as the product of a conference held on those topics in Eau Claire, WI. The timing of the conference seemed particularly opportune in light of the recent (1986) encounter of the *Giotto* and VEGA spacecraft with Comet Halley, recent improvements in the chemical analysis of interplanetary dust particles (IDPs) and chemical models of organic synthesis in meteorites and comets. In addition, the prospect of new data from spacecraft such as NASA's Comet Rendezvous/Asteroid Flyby mission (CRAF) and the joint ESA/NASA *Rosetta* mission promised exciting progress in our understanding of the nature of comets and their organic materials.

In the 9 years since the publication of the original volume, great progress has been made in this dynamic field. Signature events include the detailed observations of Comet Hyakutake in 1996 and Comet Hale-Bopp in 1997, and new spacecraft encounters with comets: Deep Space 1 with Comet Borrelly in 2001, *Stardust* with Comet Wild 2 in 2004 (with coma samples to be returned to Earth in 2006), and *Deep Impact* with Comet Tempel 1 in 2005. There have also been disappointments: the CRAF mission was canceled, NASA's CONTOUR mission was lost shortly after launch in 2002, and the much-delayed *Rosetta* mission (with mission capabilities now descoped from sample return to Earth to in situ analysis of Comet Churyumov–Gerasimenko in 2014). But the editors agreed with the urging of our publishers that it was now an opportune time to update and rework the original 1997 volume.

As in the original volume, we review the history of our study of comets and the origin of life while describing the current state of the field. Oró, Lazcano, and Ehrenfreund review the historical development of the key idea of this book and its predecessor that comets have played an important role in the origins of life by introducing vital prebiotic organic materials at a very early stage in Earth's history. It seems very likely now that the accumulation of the organic inventory of the Earth was likely a mix of exogenic organics with those endogenically synthesized in the early atmosphere or, perhaps, in other terrestrial or deep-sea locations. Delsemme (in an updated version of an earlier chapter) estimates the volatile inventory brought to the early Earth during its formation by cometary impact.

An important fraction of cometary material has been delivered to the Earth in the form of dust; perhaps the majority of the organic cometary material has been delivered in this way. The analysis of Antarctic Micrometeorites (AMMs), described in detail by Maurette, may provide important information on this cometary material. At the time of publication, however, a conclusive link between AMMs and comets remains to be made.

While less dramatic than spacecraft missions, the continuing progress in discovering complex organic macromolecules in comets, protostars, and interstellar clouds has been spectacular since the publication of the first book. Huebner and Snyder review this active field, in particular, focusing on the discovery of many different organic molecules in the active chemical environments of the hot molecular cores of star forming regions (HMCs). Because synthesis can occur in HMCs at much faster rates than in cold interstellar clouds, they are of particular importance for the study of the organic molecules inside comets.

The inevitable increase in computational power in the last decade has allowed numerical simulations of comet impacts to have increased spatial and temporal resolution. Pierazzo and Chyba present the results of recent simulations that model organic delivery to Mars, Europa, and the Moon, in addition to the Earth. As reported in the previous volume impact shocks, although high, do allow approximately 10% of the incoming organic material to survive the impact process – although many uncertainties in such modeling remain, especially with the applicability of high-temperature pyrolysis data. This survivability is particularly high in the case of oblique impacts. On Mars, with its lower escape speed, higher survivability fractions are possible.

The chapter by Chyba and Hand substantially updates its predecessor chapter in the 1997 volume, coauthored by Chyba and the late Carl Sagan. This chapter places the issue of impact delivery of organics by comets in the broad context of the history of the Heavy Bombardment and the very early history of the Earth. If both exogenous and endogenous sources of organics were present on the early Earth, it is of importance to attempt to compare the amounts of organics produced from either source. (Note that exogenous sources also include the synthesis of organics by impact shock and dust delivery as well as impact delivery.) Although such attempts are necessarily incomplete and limited by necessary assumptions, it seems as though atmospheric UV photolysis and delivery of IDPs probably dominated the origins of organics on the early Earth in roughly equal proportion, with other sources (e.g., hydrothermal vents and impact shocks) playing a smaller quantitative role.

The original volume of *Comets and the Origin and Evolution of Life* also considered the role that comets and asteroids played in the destruction, or frustration, of life on Earth. In the first of three chapters linked by this theme, Zahnle and Sleep analyze the conditions under which life appeared on the Earth. These conditions were shaped by the end of the Heavy Bombardment, and the accompanying shocks and heating events, leading to rock vapor atmospheres with ocean-vaporizing consequences that would have persisted for months to millenia after each large impact. In a companion to the impact delivery analyses of Pierazzo and Chyba, Zahnle and Sleep consider the sterilizing aspect of such events on early Mars as well as on the Earth.

The geological history of the early Earth is preserved only in a few locations on the Earth. Two of them are the Pilbara craton in Western Australia and the Kaapvaal craton in southern Africa. Glikson presents the current results of detailed explorations of both features with a focus on the identification of signatures of events from the early Precambrian. Among the exciting discoveries from this process are the apparent intermittent (perhaps because of impact sterilization events) appearance of stromatolites and possible connections between early impacts and hydrothermal vent activity and iron-rich sediments that may be associated with postimpact volcanism.

In the final chapter liked with the theme of impact destruction of life, Morrison reviews the contemporary hazard of comet impacts. While a significant effort has been made to identify near-Earth asteroids that may pose an impact threat to our civilization, identifying such threats from the comet population (which mostly resides in the outer solar system) is much more difficult. A perpetual survey will be required for such objects. If a comet is identified on an orbit that will likely result in an impact, we have to consider the possibility that a poorly determined orbit may produce a "false alarm." Finally, the orbital velocities of comets, which are much higher than near-Earth asteroids, present significant problems with interception and orbit change.

If comet nuclei have a significant organic component, how likely is it that, in addition, they may have once contained liquid water? Podolak and Prialnik examine the role that intense internal heating from radioactive ^{26}Al may have played in creating temporary ($\sim 10^5$ y) liquid water environments inside comets of >10 km radius.

Kissel and Krueger, in two concluding chapters, review the history and future of spacecraft missions to comets and the chemistry of interstellar and cometary dust. There are much exciting spacecraft data still to be gathered. The year 2006 will see the recovery of comet dust from the *Stardust* spacecraft and in 2014 *Philae*, the lander portion of *Rosetta*, will make the first soft-landing on a comet nucleus.

In the final chapter, Krueger and Kissel present the results of the analysis of dust from Comet Wild 2, using the CIDA instrument on the *Stardust* spacecraft. The results are compared with a scenario for the synthesis of organic material in cometary dust.

This new volume has taken a long time to compile. The editors decided early in the process of preparation that, given the dynamic nature of this field, a limited rewrite of the previous edition would not suffice. The reader will notice a diversity of views and approaches in the chapters of the book. The editors felt that such a rapidly developing field is best served by conveying differences in ideas, and chose not to impose consensus on the authors. We hope that this book encapsulates the excitement of the study of comets and the origins of life and gives some picture of the great developments in knowledge that surely lie ahead.

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P.J. Thomas
R.D. Hicks
C.F. Chyba
C.P. Mckay

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