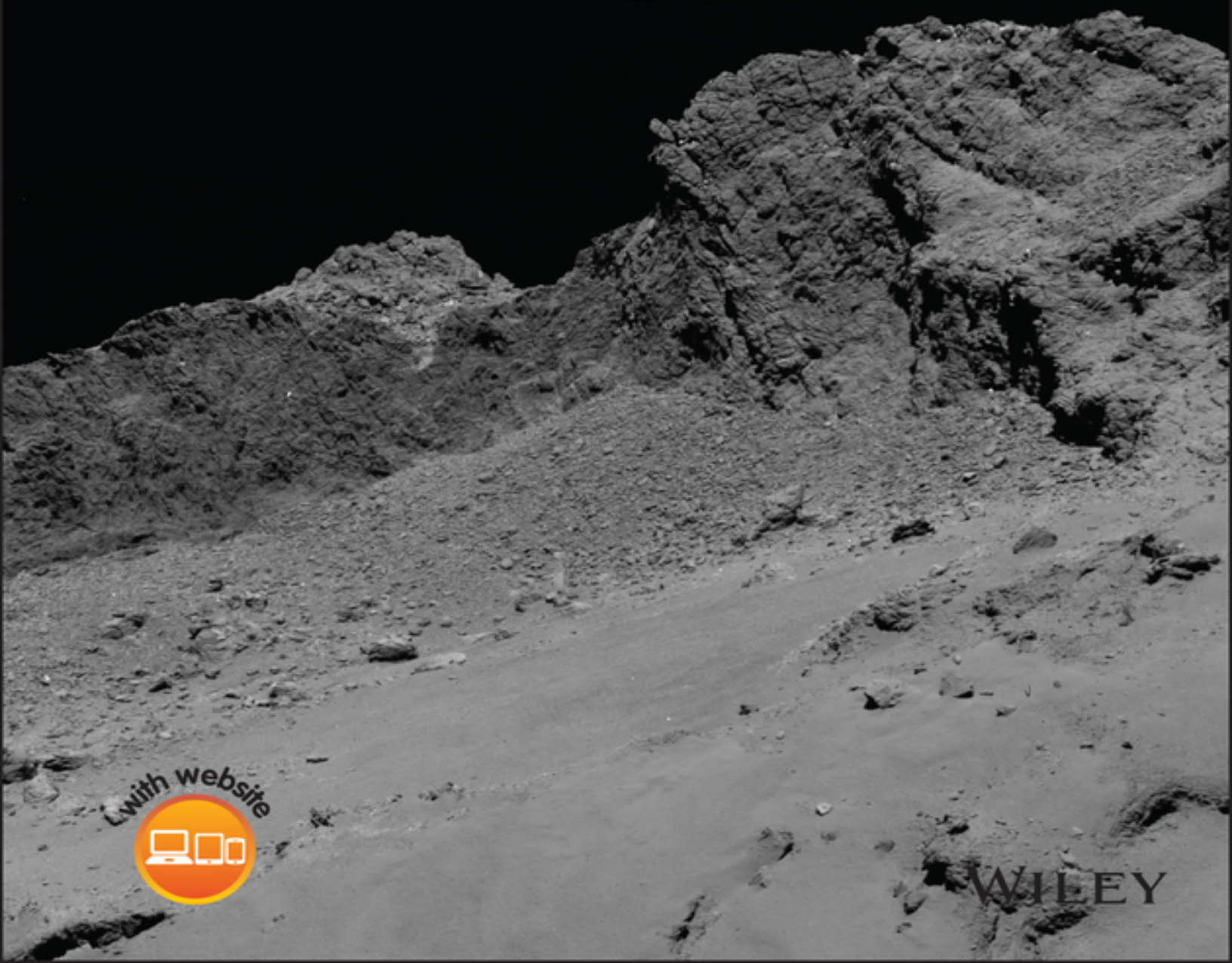
ANDREW M. SHAW

ASTROCHEMISTRY

THE PHYSICAL CHEMISTRY OF THE UNIVERSE

SECOND 2 EDITION



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Dedicated to My Family

Astrochemistry

The Physical Chemistry of the Universe

SECOND EDITION

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WILEY

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Preface to the First Edition

Astrochemistry draws its inspiration, language, fascination, beauty, elegance, and confusion from many different disciplines: starting with astronomy, passing through physical chemistry, and ending with the new ideas of astrobiology. It is this breadth of fascination that I have attempted to capture in *Astrochemistry: From Astronomy to Astrobiology*. Choosing such a broad subject comes with the serious problem of how to limit the discussion of the details to allow an appreciation of the whole. I could have written an entire book on molecular astrophysics, looking at what molecules are doing in the various environments of space. I could have looked simply at the wonders of planetary chemistry, concentrating on the solar system or even just one planet such as Jupiter. Why does it have a giant red spot? Instead, I have chosen to apply a more general boundary condition for the book taking in all of the subjects but focused on the theme of 'The Origin of Life'.

Astrochemistry starts with the origins of the Universe and the theory of the Big Bang, resulting in the formation of hydrogen, helium, and a little lithium. Gravity pulls the matter together to form stars, galaxies, and clusters of galaxies, all of which give off light in some form. The light tells the molecular story with information on the formation and evolution of stars and the role of atoms. At times these interesting subjects are buried in the disciplines of astronomy and astrophysics and I have tried to bring the pieces of the story together, concentrating on astrochemistry. The cycle of star formation ends with a supernova blowing huge quantities of material into the interstellar medium, now laden with all of the elements of the Periodic Table. Chemistry in the interstellar medium,

with rather cold and tenuous conditions, is now possible and this controls the starting molecular inventory. To understand this fully, the subjects of quantum mechanics and kinetics need to be applied, through spectroscopy and chemical reaction networks, to the giant molecular clouds of the interstellar medium – the birthplace of stars and life?

Giant molecular clouds collapse to form stars and solar systems, with planets and debris left over such as comets and meteorites. Are comets and meteorites the delivery vehicles that enable life to start on many planets and move between the planets as the solar system forms, providing water and molecules to seed life? The planets have to be hospitable, however, and that seems to mean wet and warm. Carbon-based life forms and liquid water seem to be the successful life-experiment on Earth from which we can draw some more general conclusions about the requirements for life in a view towards astrobiology. A look at prebiotic chemistry and primitive life forms on Earth poses interesting questions such as what is a cell and how big does it have to be? The guiding principles for prebiotic chemistry are the laws of thermodynamics that keep the origins of life and its understanding on the straight and narrow.

Finally, and tantalizingly for this book and astrochemistry, there is Titan. The Cassini–Huygens mission is now in orbit in the Saturnian system as the book is published. The Huygens probe has already made the descent to the surface of Titan and the data have been transmitted back successfully. Scientists, astronomers, astrochemists, and astrobiologists are trying to understand it. I have taken a brief look at Titan as a case study to apply all that has been learnt and to review the possibilities for astrochemistry in what is surely to be a very exciting revelation of the structure and chemistry of Titan.