Preface

The related subjects of Astrochemistry and Astrobiology are in an era of explosive growth. Both are strongly multidisciplinary: thus, contributions to, and discussions of, these subjects involve scientists who might primarily describe themselves as astronomers, chemists, physicists, astrophysicists, molecular biologists, evolutionary biologists, etc. Proposed phenomena in both areas must be consistent with universal physico-chemical principles. A major purpose of this volume is to outline these physico-chemical principles and describe how they underpin our efforts to understand astrochemistry and to make predictions in astrobiology.

Our book comprises ten chapters, each written by an expert, or experts, in the subject matter of their chapter. Because the backgrounds of those entering the fields of astrochemistry and astrobiology can be very diverse, authors have all been asked to pitch their chapters at a level that should be understandable by this wide range of readership. Chapter 1 seeks to introduce those aspects of physical chemistry which are relevant to the discussions of various topics in astrochemistry and astrobiology to be found in the subsequent eight chapters. These later chapters can be roughly sub-divided into three (Chaps. 2, 3, and 4) that deal with topics within astrochemistry and five (Chaps. 5, 6, 7, 8, and 9) that examine aspects of astrobiology – interpreted broadly.

Major concerns in astrochemistry are (1) the identification of the molecules that exist in the cosmos and the characterisation of the physical conditions in those regions of the universe where the observed molecules are found; (2) laboratory measurements on the spectroscopy of potential molecules and on the rates and products of homogeneous and heterogeneous processes that may contribute to the formation and destruction of molecules, under the generally extreme interstellar conditions where molecules are found; (3) the creation of computer models that use laboratory data and seek both to reproduce what is found in the 'molecular universe', and to suggest what other molecules may be present and which processes appear to be especially important, so as to focus the efforts of laboratory scientists. These topics are dealt with, in turn in chapters by Maryvonne Gerin (in Chap. 2), Michael Pilling (in Chap. 3), and by Valentine Wakelam, Herma Cuppen and Eric Herbst (in Chap. 4).

In any search for life elsewhere in the universe, we only have one exemplar: life here on the Earth. Consequently, it makes sense to search for astronomical bodies which appear to offer living systems a similar environment. For planets outside the solar system, that is, exoplanets, this idea leads to the notion of a Habitable Zone – or more colloquially a 'Goldilocks Zone' – generally defined as the range of radii around a star where the temperature at a planet's surface will not be too high or too low for liquid water to exist. In addition, there may be other bodies, such as the Jovian moon, Europa, where liquid water might be stable. In Chap. 5, Lisa Kaltenegger describes the methods by which planets are detected and characterised, and how, in the future, it may be possible, using sensitive spectroscopic methods to search for biosignatures – signatures of life – in their atmospheres. The importance of water for life as we know it – and may know it – is the subject of Philip Ball's Chap. 6. He emphasises that water does not simply play a passive role in biochemistry, and considers the possibility that other solvents might support and encourage life. Of course, even in thinking about life here on Earth, we must be careful not to adopt too anthropogenic a view. Charles S. Cockell, in Chap. 7, considers the range of physical conditions – temperature, pressure, aridity, pH, etc. – which different life forms on our planet can tolerate.

In searching for – even contemplating – life on exoplanets, we may have the existence of life here on Earth to guide us, but we are severely handicapped by our ignorance about how earthly life came into being. In Chap. 8, Robert Pascal under the title 'Life, Metabolism and Energy', considers how any proposals for the emergence of life must be consistent with thermodynamic and kinetic constraints. Then, in Chap. 9, Irene Chen and her colleagues reflect on the possibility that our present biological world was preceded by one in which RNA, rather than DNA, played an important evolutionary role, and they also discuss the importance of the creation of cells and their linkage to lipids.

Sydney Leach's final chapter is different in kind from those that precede it. He writes a contemplative essay on each of the previous chapters in turn. In some places, he expands on the matters dealt with in earlier chapters, in others he inserts his own view of various topics, and in yet others he adds some extra material that might have been included earlier if space had allowed.

As the outline in the previous paragraphs indicates, the topics that are covered in the individual chapters proceed from those that might be classed as belonging to astrochemistry to those dealing with aspects of astrobiology. Nevertheless, every effort is made to bring together concepts in astrochemistry and astrobiology, which have traditionally been dealt with as separate areas of science.

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