Icy Worlds of the Solar System

Edited by Pat Dasch

CAMBRIDGE UNIVERSITY PRESS
## Contents

*List of contributors*  page viii  
*Preface*  xiii  
*Acknowledgements*  xiv  

**Introduction**  1  
*Jonathan I. Lunine*

1  The history and significance of ice on Earth  6  
*Robert Bindschadler*
- The water planet  7  
- Early glaciations  8  
- Ice sheets, sea level, and climate  9  
- Ice sheet response  13  
- Snow and sea ice  15  
- Ice sheets and weather  17  
- Metamorphism of snow into ice  20  
- Climate tape recorder  21  
- Ice sheet facies  23  
- Ice sheet motion  24  
- Ice shelves  28  
- Ice landscaping  29  
- Meteorite catchers  30  
- Summary  32

2  Ice on Mercury and the Moon  33  
*Bryan Butler*
- Mercury  33  
- The Moon  50  
- Future missions  58

3  How the Earth got its atmosphere  60  
*Tobias Owen*
- How planets keep their atmospheres  60  
- Why small planets have different atmospheres  62
### Contents

Frigid worlds, atmospheric evolution, and cosmic time travel 63
The sources of atmospheres: problems with meteorites 65
The sources of atmospheres: icy planetesimals? 67
Solar Composition Icy Planetesimals (SCIPs): a new type of icy planetesimal 69
The sources of atmospheres: a rocky component? 72
The importance of impact erosion 74
Tests of the model 75

4 The frozen landscape of Mars 79

MICHAEL T. MELLON
Mars: yesterday and today 79
Polar deposits 81
Seasons bring change 85
Shapes in the polar landscape 86
Deep in the ice cap 88
The sky above 89
The permafrost below 92
Buried ice from the past 94
Running water from frozen ground 95
Moving ice 98
At the limits of vision 99
Impact craters in the permafrost? 101
Climate change 103
An elusive resource 105
Hazards of living on ice 107
Life? 108
The future 109

5 The ice moons of Sol 110

PAUL M. SCHENK
Moon madness 112
Water! Water! 113
Organic stews? 114
Energy to spare 118
Ice worlds – Oceanus Amokium? 121
Triton

It’s a not-so small world after all

6 Triton, Pluto, and beyond

JOHN A. STANSBERRY

Pluto’s story

Triton and the Trans-Neptunian objects (TNOs)

Triton and Pluto: twin siblings of a distant Sun

Geology recorded in water ice “rock”

Tidal evolution and giant impacts

Kuiper Belt objects: cousins to Triton and Pluto

Triton and Pluto today

Nitrogen, methane, and atmospheres

Ice transport and seasons

The fate of Pluto’s atmosphere

Not yet explored

7 Comets: ices from the beginning of time

DALE P. CRUIKSHANK

What are comets?

The interstellar medium, and the death of stars

Comets are formed

The composition of comets

Special properties of water ice

What comets are made of

Comet dust

Where do comets come from?

Space missions to comets

Conclusion

Index