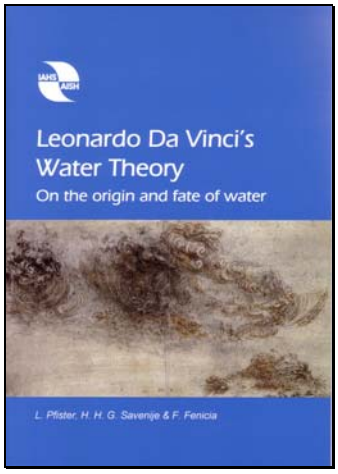
Leonardo Da Vinci's Water Theory:

On the origin and fate of water



Laurent Pfister
Centre de Recherche Public – Gabriel Lippmann, Grand-Duchy of Luxembourg

Hubert H. G. Savenije
Delft University of Technology, The Netherlands

Fabrizio Fenicia
Delft University of Technology, The Netherlands

Illustrated with Da Vinci's drawings and sketches

Foreword by Jeff McDonnell

Leonardo Da Vinci (1452–1519) was not only one of the greatest artists of his time, he was also a great engineer and scientist. A large part of his scientific work was dedicated to understanding the movement, circulation and physical characteristics of water in its different forms. This book aims to make Leonardo Da Vinci's contributions to the science of water accessible to a wider public and to compare his ideas with our present knowledge.

Fascinating, revealing and inspiring, Leonardo Da Vinci's Water Theory opens up a new history to the study of water. Two hundred years before Newton, Perrault and Halley, Leonardo Da Vinci was doing hypothesis-driven science and describing and classifying hydrological processes. For example, he came close to the modern definition of the hydrological cycle, recognising that water passes through the major river systems countless times, summing up to volumes much greater than those contained in the world's oceans. Pfister, Savenije and Fenicia carefully report Da Vinci's seminal work and provide a modern hydrological backdrop.

IAHS Special Publication 9

2009 ISBN 978-1-901502-34-3
92 + xx pages (paperback);
Price £25.00

Sponsored by:

Fonds National de la Recherche Luxembourg

UNESCO's Hydrological Processes and Climate Section Division of Water Sciences, as a contribution to the International Hydrological Programme.

Please send book orders and enquiries to:

Mrs Jill Gash ***jilly@iahs.demon.co.uk***
IAHS Press, Centre for Ecology and Hydrology
Wallingford, Oxfordshire OX10 8BB, UK
tel.: + 44 1491 692442 fax: + 44 1491 692448

Contents

Foreword

We know more about celestial bodies than soils underfoot.
Water is the driving force of all nature. Leonardo Da Vinci (1452–1519)

The International Association of Hydrological Sciences (IAHS) is the oldest international hydrological society (now almost 90 years old), with national representatives in 98 countries, and more than 5000 individual members. While the Association has been active in many areas of the science for many decades (through conferences and symposia, coordination with the UNESCO International Hydrological Programme, etc.), the role of IAHS as the key international water organization has grown enormously as the role of water in earth system science has grown in recognition. IAHS currently leads the Decade on Prediction in Ungauged Basins, an effort to fundamentally change the field of hydrological science from calibration-based modelling to new approaches focused on fundamental understanding of hydrological systems. IAHS is also expanding its publishing model, from strictly one of Proceedings and Reports (Red Books) publishing to one that includes new book series, like the Benchmark Papers in Hydrology. It is in this context of new publishing models that the IAHS volume on *Leonardo Da Vinci's Water Theory* by Pfister, Savenije and Fenicia, is introduced—a volume brimming with new insights into the basic origins of hydrology and a timely counterpoint for the many new initiatives and discoveries within IAHS.

Pfister, Savenije and Fenicia present a dazzling array of insights into hydrological processes by hydrology's first, and perhaps most, significant figure. It is amazing to consider that as a scientist 200 years before Newton and 300 years before Linnaeus, Leonardo Da Vinci was doing hypothesis-driven science and describing and classifying myriad hydrological processes and basic properties of water. As perhaps the world's first experimental hydrologist (among his many other possible titles), Da Vinci was working on the hydrological cycle 200 years before Pierre Perrault's field studies of the hydrological cycle and Edmund Halley's experiments on evaporation. Pfister, Savenije and Fenicia note that Da Vinci came very close to the modern definition of the hydrological cycle when he explained that water passes through the major river systems countless times, summing up to volumes much greater than those contained in the world's oceans. Da Vinci's work, and in particular his contributions of a hydrological nature—summarized here for the first time—forms the hydrological bedrock of our science.

The team of Pfister, Savenije and Fenicia is a perfect trio for the Da Vinci hydrological historical narrative. Laurent Pfister is a research hydrologist at the Public Research Center–Gabriel Lippmann Institute in Luxembourg and a long-time Da Vinci-phile and avid water history buff. Huub Savenije is Professor of Hydrology at TU Delft and recent recipient of the European Geophysical Union Darcy Medal, based on his considerable contributions to international hydrology. Fabrizio Fenicia is a native Roman and a hydrological modeller at TU Delft with a gift for translation and interpretation of the many Da Vinci Codices and other obscure materials. Together, this trio of hydrological sleuths has uncovered a vast array of hitherto unassembled material and provided an impressive foundational document for hydrology. Fascinating, inspiring, revealing and amazing, *Leonardo Da Vinci's Water Theory* opens up a new history to the study of water. Pfister, Savenije and Fenicia's obvious passion for the material, the interesting modern hydrological backdrop for the materials, and accurate and careful reporting of the facts—many unearthed for the first time in this volume—make this a benchmark work.

Jeffrey J. McDonnell
Richardson Chair in Watershed Science
Oregon State University, USA

Preface

Leonardo Da Vinci (1452–1519) was not only one of the greatest artists of his time, he was also a great engineer and scientist. Only relatively recently, at the beginning of the 19th century, did we recover fragments of his many scientific writings. A large part of his scientific work was dedicated to understanding the movement, circulation and physical characteristics of water in its different forms: as a gas (water vapour), as mist, as drops, as stagnant or flowing water, as ice, hail and snow. This book aims to make Leonardo Da Vinci's contributions to the science of water accessible to a wider public and to compare his ideas with our present state of knowledge.

With the benefit of hindsight, we now know that many of the things that Leonardo Da Vinci wrote were incorrect, while in some cases he built on the false premises of classical authors who preceded him. But what makes Leonardo Da Vinci unique is his scientific approach. He can be regarded as the first hydrologist who formulated hypotheses on the basis of empirical evidence, which he subsequently tried to falsify or test under different conditions (Pfister & Savenije, 2006). Being an artist, a philosopher, an engineer and a scientist, he was capable of combining his talents for observation, for capturing images in drawings, for designing instruments to test his hypotheses, and for translating these into causal relationships. On top of that, he tried to translate his theories into quantitative relationships, difficult though this may have been in his time, given the limited means available for hydrological observation. He was probably the first hydrological experimentalist to design and build his own instruments to test his hypotheses.

Although his writings were never formally published, his work, like that of the classical Greek philosophers before him, should be considered as a benchmark in the science of hydrology. With this book, we hope that this knowledge will be brought to the community of hydrological scientists, and to all who have an interest in this great artist, scientist and engineer.

Many people have written about Leonardo Da Vinci, and recently, probably as a reaction to the novel by Dan Brown (*The Da Vinci Code*), he has received a lot of attention from the public and the media. However, little has been written about Leonardo's pioneering work on water. Hydrology being a relatively young science, the hydrological community has not spent much time looking back at how the ancient philosophers and scientists regarded water, or putting hydrology into an historical perspective.

This book aims to fill that gap, and to give Leonardo Da Vinci the credit for being one of the first hydrologists, if not the first, who used experiment and deduction as powerful tools for the development of theory. He was a real *Homo universalis* who

not make a distinction between the different disciplines, science, engineering, philosophy and art. He considered "*painting as a science*", and maybe that was his great strength, both as an artist and a scientist.

The citations taken from Leonardo Da Vinci's notebooks and used throughout this volume mainly stem from earlier publications in English by Jean-Paul Richter (1888) and by Edward McCurdy (1942, re-edited in French in 1987 and 1989). Jean-Paul Richter's compilation of Leonardo's manuscripts was originally translated from Italian into English by R. C. Bell and E. J. Poynter, while Edward McCurdy's work was translated from Italian and English into French by Louise Servicen for the re-editions of 1987 and 1989. Given the fact that these translators may well have included their own successive interpretations into Leonardo's writings, the authors have preferred to rely to a certain extent on their own verifications by referring to the original Italian text (Majer, 2006).

Creating this book has been a truly international collaborative effort between researchers of the Public Research Center – Gabriel Lippmann and the Delft University of Technology, with support coming from UNESCO, IAHS and the National Research Fund of Luxembourg. The authors are most grateful to these organisations for their support and they express their thanks to Penny Perrins and Cate Gardner for their continuous assistance and truly dedicated work throughout the production process of this book.

The authors would like to conclude with a personal note. The idea for writing this book was born in late summer 2004 in the mind of Christelle Poirier during a visit to a Da Vinci exhibition at the Foundation Pierre Giannada in Martigny, Switzerland. She suggested that we should jointly write a book in which we would compare Leonardo's ideas with modern insights in the hydrological sciences. At that time she was fighting a tough battle against a terrible disease. She lost that battle only a couple of months later. As a tribute to her, we have done our utmost to stay close to her ideas.

Laurent Pfister
Head of the research unit 'Geohydrosystems and Landuse Management'
Department Environment & Agro-biotechnologies,
Centre de Recherche Public – Gabriel Lippmann, Belvaux,
Grand-Duchy of Luxembourg

Hubert H. G. Savenije
Chair of Hydrology at the Water Resources Section
Department of Water Management
Delft University of Technology, The Netherlands