

**Table 3.2 Osmolar solutes found in the extracellular and intracellular fluids**

| Solute  | Plasma<br>(mOsm/L) | Interstitial<br>(mOsm/L) | Intracellular<br>(mOsm/L) |
|---|--------------------|--------------------------|---------------------------|
| Na <sup>+</sup>   | 143                | 140                      | 14                        |
| K <sup>+</sup>  | 4.2                | 4.0                      | 140                       |
| Ca <sup>++</sup>  | 1.3                | 1.2                      | 0                         |
| Mg <sup>++</sup>  | 0.8                | 0.7                      | 20                        |
| Cl <sup>-</sup>   | 108                | 108                      | 10                        |
| HCO <sub>3</sub> <sup>-</sup>   | 24                 | 28.3                     | 10                        |
| HPO <sub>4</sub> <sup>-</sup> , H <sub>2</sub> PO <sub>4</sub> <sup>-</sup> | 2                  | 2                        | 11                        |
| SO <sub>4</sub> <sup>-</sup>  | 0.5                | 0.5                      | 1                         |
| Phosphocreatine   |                    |                          | 45                        |
| Carnosine   |                    |                          | 14                        |
| Amino acids   | 2                  | 2                        | 8                         |
| Creatine  | 0.2                | 0.2                      | 9                         |
| Lactate   | 1.2                | 1.2                      | 1.5                       |
| Adenosine Triphosphate  |                    |                          | 5                         |
| Hexose Monophosphate  |                    |                          | 3.7                       |
| Glucose   | 5.6                | 5.6                      |                           |
| Protein   | 1.2                | 0.2                      | 4                         |
| Urea  | 4                  | 4                        | 4                         |
| Others  | 4.8                | 3.9                      | 11                        |
| <b>Total (mOsmoles/liter)</b>   | <b>302.8</b>       | <b>301.8</b>             | <b>302.2</b>              |
| <b>Corrected Osmolar Activity (mOsmoles/liter)</b>                          | <b>282.5</b>       | <b>281.3</b>             | <b>281.3</b>              |
| <b>Total Osmotic Pressure at 37°C (mm Hg)</b>                               | <b>5450</b>        | <b>5430</b>              | <b>5430</b>               |

Source: Data from A.C. Guyton, *Textbook of Medical Physiology*, 8th ed. (Philadelphia: W.B. Saunders Co., 1991), 277.

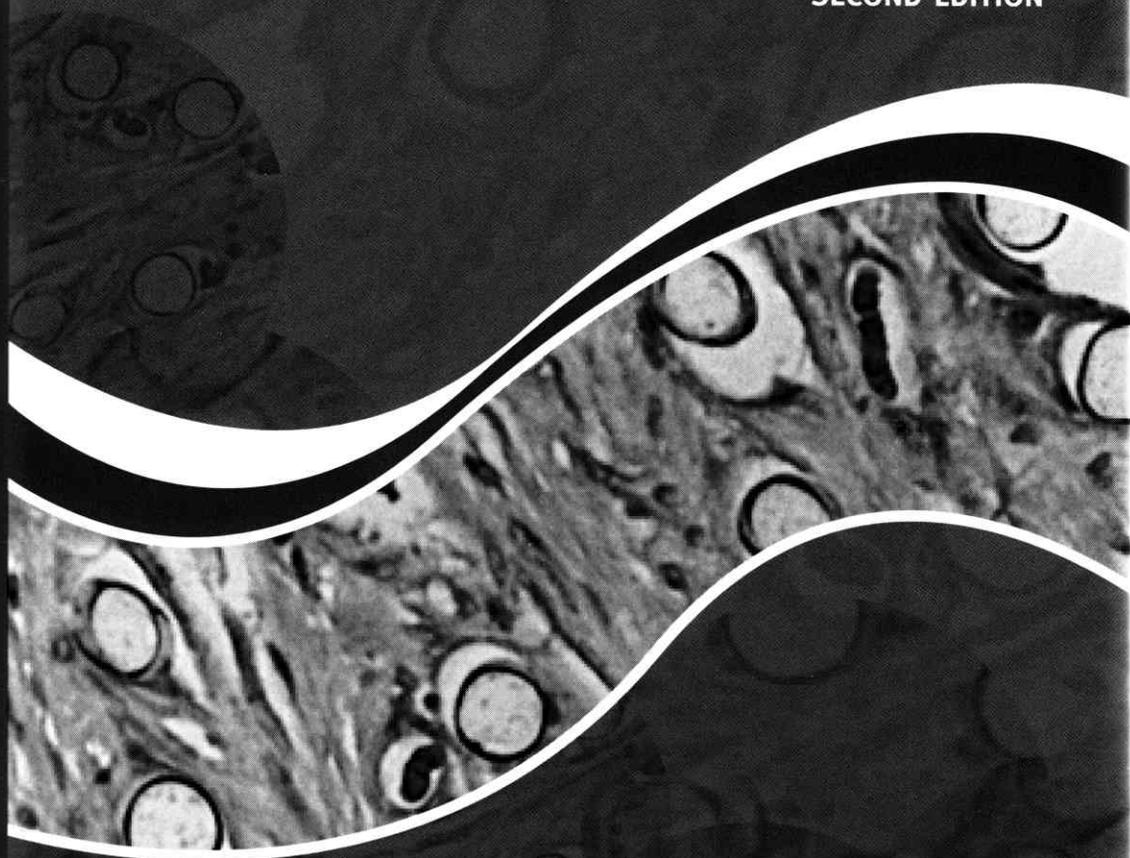
for the following discussion. Of particular interest is the fact that nearly 80% of the total osmolarity of the interstitial fluid and plasma is produced by sodium and chloride ions. As we discussed earlier, the interstitial fluid arises from filtration of plasma through the capillaries. We would therefore expect the composition of these two fluids to be very similar. This is shown in Table 3.2. We find this to be true with the exception that the protein concentration in the interstitial fluid is significantly smaller in comparison to its value in the plasma.

### 3.3 CAPILLARY PLASMA PROTEIN RETENTION

The retention of proteins by the walls of the capillary during filtration of the plasma is readily explained by comparing the molecular sizes of typical plasma protein molecules to the size of the pores within the capillary wall. Figure 3.1 illustrates the relative size of various solutes as a function of their molecular weight. The wall of a capillary, illustrated in Figure 3.2, consists of a single layer of *endothelial cells* that are surrounded on their outside by a *basement membrane*. The basement membrane is a mat-like cellular support structure, or extracellular matrix, that consists primarily of a protein called *type IV collagen*, and is joined to the cells by the glycoprotein called

# **Basic Transport Phenomena in Biomedical Engineering**

SECOND EDITION



**Ronald L. Fournier**

|                   |                                     |
|-------------------|-------------------------------------|
| Vice President    | Denise Schanck                      |
| Senior Editor     | Robert L. Rogers                    |
| Associate Editor  | Summers Scholl                      |
| Senior Publisher  | Jackie Harbor                       |
| Production Editor | Karin Henderson                     |
| Copyeditor        | Annette Musker                      |
| Cover Designer    | Aktiv                               |
| Indexer           | Ronald Fournier                     |
| Typesetter        | Phoenix Photosetting, Chatham, Kent |
| Printer           | Sheridan Books, Inc., Ann Arbor     |

© 2007 by Taylor & Francis Group, LLC

This book contains information obtained from authentic and highly regarded sources. Reprinted material is quoted with permission, and sources are indicated. A wide variety of references are listed. Reasonable efforts have been made to publish reliable data and information, but the author and the publisher cannot assume responsibility for the validity of all materials or for the consequences of their use.

No part of this book may be reprinted, reproduced, transmitted, or utilized in any form by any electronic, mechanical, or other means, now known or hereafter invented, including photocopying, microfilming, and recording, or in any information storage or retrieval system, without written permission from the publishers.

**Trademark Notice:** Product or corporate names may be trademarks or registered trademarks, and are used only for identification and explanation without intent to infringe.

ISBN 1 591 69026 9

#### Library of Congress Cataloging-in-Publication Data

Fournier, Ronald L.

Basic transport phenomena in biomedical engineering / Ronald L. Fournier.—2nd ed.  
p. ; cm.

Includes bibliographical references and index.

ISBN 1-59169-026-9 (alk. paper)

1. Biological transport. 2. Biomedical engineering. 3. Biotechnology.  
[DNLN: 1. Biological Transport. 2. Biomedical Engineering. 3. Blood—metabolism.
4. Cell Membrane—metabolism. QU 120 F778b 2006] I. Title.

R857.B52F68 2006

571.6'4—dc22

2006004326

Published in 2007 by Taylor & Francis Group, LLC,  
270 Madison Avenue, New York, NY 10016, USA and  
2 Park Square, Milton Park, Abingdon, Oxon, OX14 4RN, UK.

Printed in the United States of America on acid-free paper.

10 9 8 7 6 5 4 3 2

**T&F** informa

Taylor & Francis Group, an informa business

Visit our web site at <http://www.garlandscience.com>

To my wife Lynn, and our sons