

July 1, 2003

Biological Process Engineering  
Errata

Special thanks to M. Jason Brooke, Karen Coyne, Daren Fife, Linda Moran, Stephen Reiling and Linda Rinko

These can be reached at web site

<http://www.bioe.umd.edu/artjohnson/books/bioproceng.html>.

p. 2 Table 1.1.1:

1 volt = 1 N m/coulomb

Add to Table 1.1.1:

1 pound = 4.448 N

p. 32 Example 1.6.3-1

$C_{TOT}$  should be  $2.88 \times 10^{-7}$  coulomb<sup>2</sup>/N m

p. 39 Example 1.6.5-2, last line above Remark, should read:

$$C = (1/0.000768 \text{ kg}) (6.28 \times 10^6 \text{ rad/sec})^2 \\ = 3.30 \times 10^{-11} \text{ sec}^2/\text{kg}$$

p. 42 Second paragraph from the bottom, line 1:

"behaviour" should be "behavior"

p. 43 sixth line from top

"modfies" should be "modifies"

p. 44 equation 1.7.13 should read:

$$2\pi r \ddot{a} r \tau = \pi r^2 \rho$$

Labelling on Figure 1.7.1:

"Dr" should be " $\Delta r$ "

"u" should be " $\theta$ "

"pcos" should be " $p \cos \phi$ "

the angle between the vertical vector and the resultant vector in the little diagram at the upper right should

be labelled " $\phi$ ."

p. 46 Figure 1.7.2

$\theta_1$  and  $\theta_2$  should be  $\Phi_1$  and  $\Phi_2$

p. 47 Example 1.7.3-1, line 3:

$4.1 \times 10^{-5} \text{ m}^3 \text{ O}_2/\text{sec}$  should be  $4.2 \times 10^{-5} \text{ m}^3 \text{ O}_2/\text{sec}$

p. 49 Fourth line from the top:

" $F_{\text{ACO}_2}$ " should be " $F_{\text{AcCO}_2}$ "

Second equation should be:

$$V_{\text{De}} = V_e [(F_{\text{AcCO}_2} - F_{\text{eCO}_2}) / F_{\text{AcCO}_2}]$$

p. 50 Second line from top

The parenthesis after  $e^{-30/67}$  should be larger

p. 51 Fourth line from top:

"flaw" should be "flow"

p. 51 Equation 1.7.21

$K_y$  should be  $k_y$

p. 55 Equation 1.7.40

Term on the right should be  $\frac{1}{\kappa} \frac{\partial \ddot{O}}{\partial t}$

p. 59 Equation 1.7.56, should be:

$$\phi = \phi_0 + \frac{\dot{\omega}_i}{4\pi k r_0}$$

p. 70 Example 1.7.5-3, second equation

Second term on the left should be  $\frac{P_{\text{lt}}}{R_{\text{lt}}}$

p. 72 Third paragraph, line 3

"expressioins" should be "expressions"

- p. 74 Equation 1.7.83, top equation  
Left term should be  $-kA\phi$
- p. 77 Line after Eq. 1.8.3:  
The units should be  $[m^4/(N \cdot sec)]$  instead of  $[(N \ sec)^{-1}]$ .
- p. 82 Equation 1.8.20  
Should read  $R = L/kA$   
Equation 1.8.22 should be:  
$$R = \frac{1/r_i - 1/r_o}{4\delta k}$$
- p. 85 Two lines below equation 1.8.34,  $D_{AB}$ , and  $D_{AC}$  should be:  
"the mass diffusivities of substance A in shell B and of substance A in another shell C ( $m^2/sec$ )."
- p. 97 Problem 1.4-20, third line  
"contain" should be "contains"
- p. 98 Problem 1.6-3, figure below  
rightmost  $I_{AW}$  should be labeled  $I_{LT}$
- p. 100 Problem 1.6-6, seventh line from top of page  
"88.6 coul<sup>2</sup> (Nm<sup>2</sup>)" should read "88.6 x 10<sup>-12</sup> coul<sup>2</sup> / (Nm<sup>2</sup>)"
- p. 100 Problem 1.6-8, fourth line from the bottom should read:  
"stops, a seiche of up to 6m in height..."
- p. 105 Problem 1.9-1, line 9  
"prompty" should be "promptly"
- p. 107 Problem 1.9-9, eighth line should read  
"... a capacity element in parallel with a"
- p. 110 Line 3:  
"conduct" should be "conduit"

p. 111 Line 3

"frictioin" should be "friction"

p. 122 Table 2.4.3

The equation that appears as:

$$10^7 \ln \square = A \ln T + BT^{-1} + CT^{-2} + D$$

should be:

$$\ln(10^7 \square) = A \ln T + BT^{-1} + CT^{-2} + D$$

This equation appears incorrectly in three places in the table. The numerical example at the bottom of Table 2.4.3 is correct.

p. 130 Table 2.4.1, "Lubricating Oil":

There should be a blank between "S.A.E. 10" and "S.A.E. 30".  
"S.A.E. 30" should be on the same level as "16°C".

p. 131 Table 2.4.2

Temp	H <sub>2</sub> O
-20	0.81
-10	0.84
0	0.88
10	0.93
20	0.96
30	0.99
40	1.02
50	1.05
60	1.08
70	1.12
80	1.16
90	1.20
100	1.24

p. 132 Second part of Table 2.4.3.

The equation above the line with A, B, C, D should be:

$$\ln(10^7 \square) = A \ln T + BT^{-1} + CT^{-2} + D$$

p. 133 The equation above the line with A, B, C, D should be:

$$\ln(10^7 \square) = A \ln T + BT^{-1} + CT^{-2} + D$$

The footnote at the bottom of Table 2.4.3 should be:

<sup>a</sup>For example, the viscosity of CO at 300K is  $\ln(10^7)$  = ..."

p. 137 Equation 2.4.8, right hand side of first line:

Add right parenthesis to the first term:

$$(\tau_{r+\Delta r,x} A_{r+\Delta r})$$

p. 140 Example 2.4.2-1, second equation

Third term from left should be " $\frac{v_2^2 - v_1^2}{\alpha g}$ "

Second term from left should be " $\frac{(p_2 - p_1)}{\gamma}$ "

p. 141 Section 2.4.4

Last word of first line should be "extremely."

p. 143 Equation 2.4.26, Leftmost term

Should be:  $\rho \left( \frac{\partial v_z}{\partial t} + v_x \frac{\partial v_z}{\partial x} + v_y \frac{\partial v_z}{\partial y} + v_z \frac{\partial v_z}{\partial z} \right)$

Equation 2.4.29, right hand side should be:

$$\mu \left( \frac{\delta^2 v_z}{\delta x^2} + \frac{\delta^2 v_z}{\delta y^2} + \frac{\delta^2 v_z}{\delta z^2} \right)$$

p. 154 line 2

"appication" should be "application"

p. 165 First full paragraph, line 1, second word should be "number."

p. 169 Line below equation 2.5.36, should be:

"where  $I_f$  is the fluid inertance ( $N \text{ sec}^2/\text{m}^5$ )."

p. 171 Equation 2.5.39, second line:

All  $v$ 's in numerator should be  $v^2$ .

p. 175 Last paragraph, line 1:

"modelled" should be "modeled"

p. 178 Second paragraph, line 3

"2.5.4b" should be "2.5.42b"

p. 192 Replace all text after the first line of the last paragraph with:

Xylem radii range from 10  $\mu\text{m}$  to 700  $\mu\text{m}$ . A xylem radius of 20  $\mu\text{m}$  causes a capillary rise of 75 cm, not enough to draw water to the top of most plants. However, the lumena of xylem vessels are not open to the air at the upper end; rather, they branch to form a meshwork of small, tortuous interstitial spaces that act like capillaries with 5 nm radius. Calculated capillary pressures for these small spaces are about  $2.9 \times 10^7 \text{ N/m}^2$ , or enough to draw water to a height of nearly 3000 m. As long as these small capillaries are water filled, they can maintain the integrity of the water column in even the tallest trees.

p. 193 The last line of the first paragraph should be:

"hydrostatic pressure, gravitational potential, and cell net osmotic potential."

p. 201 Example 2.5.9-1

The standard deviation should be 95 :m, not 95 :g.

p. 201 Example 2.5.9-1, line 4

Density of manure should be  $1050 \text{ kg/m}^3$

p. 203 Last paragraph, line 1:

"were" should be "was"

p. 206 line 11

"They particles" should be "The particles"

p. 248 Problem 2.4-10

is in the wrong place. It should be renumbered as 2.6-9 because it involves nonNewtonian fluids.

p. 249 Rightmost figure

Diameter should be 1.4 cm, not 14 cm.

Problem 2.5-2, line 2

"waer" should be "water"

Problem 2.5-3

The dimension for the trachea during normal breathing should be 14 mm instead of 14 cm.

Problem 2.5-5

Should read "Example 2.5.2-1"

p. 250 Problem 2.5-7 should read:

"A fluid with viscosity of 1.0 kg/(m sec) and density of 1304 kg/m<sup>3</sup> . . . what is the pressure loss in the pipe in terms of fluid height?"

p. 251 Problem 2.5-18, fifth line

"discharger" should read "discharge"

Also add at the end:

"Assume the volume flow rate is 0.01 m<sup>3</sup>/sec."

p. 252 Problem 2.5-18, line 1

"2.5 x 10<sup>5</sup> N/m<sup>5</sup>" should be "2.5 x 10<sup>5</sup> N sec/m<sup>5</sup> "

p. 257 Problem 2.8-1, Table

Units of Volume Flow Rate should be (m<sup>3</sup>/sec)  
Units of Static Pressure should be (N/m<sup>2</sup>)

p. 258 Problem 2.8-4.

Add: "The pump characteristic for Problem 2.8-4 is found at the top of page 259."

The diagram at the top of page 258 refers to Problem 2.8-2.

p. 261 Second line, reference pages should be

"p 3-1 to p 3-30."

p. 264 Table 3.1.1, entry "Time"

"stead state" should be "steady state"



- p. 278 Example 3.2.2.1-1, first equation  
Term on right should be "0.07673(707)<sup>0.425</sup> (1.85)<sup>0.725</sup> "  
Example 3.2.2.1-1, line 16  
Should read "Skin temperature... Eq. 3.2.12 to be"  
Example 3.2.2.1-1, line 17  
Should read " $\theta_{sk} = 25.8 + 0.267(22^\circ\text{C}) = 31.7^\circ\text{C}$ "  
Example 3.2.2.1-1, line 19  
Should read: " $\dot{q} = (\theta_{sk} - \theta_\infty) / R_{tot} = \dots$ "
- p. 285 Third line:  
"From Eq. 3.2.30" should read "From Eq. 3.2.31"
- p. 288 Table 3.3.1, bottom line under "Natural"  
Should read:  
"number and Prandtl number . . . "
- p. 289 Insert in line 7, after "... (Figure 3.3.2).":  
"Dimensionless numbers for fluid flowing inside a long duct or tube are almost always based upon the hydraulic diameter of the tube rather than upon its length."
- p. 302 Example 3.3.1.2-1, Sixth line under "Solution"  
Should read: "From Eq. 3.2.11"
- p. 304 Example 3.3.1.2-1, second line under "Remarks"  
"hot tubes" should be "hot tubs"
- p. 321 Example 3.3.1.4-1, below second equation, add:  
"Although the Prandtl number appears in Eq. 3.3.61, it has not been included in the above equation because both Eqs. 3.3.32b and 3.3.41b were developed for Prandtl numbers of about 1.0. Thus, omitting the Prandtl number here will have no effect."
- p. 345 Third line below "Radiation Exchange"  
"Figure 3.4.12" should be "Figure 3.4.13"



- p. 350 Second line from bottom, should be:  
 "Stefan-Boltzmann constant [ = 5.676 x 10<sup>-8</sup> N m/(sec m<sup>2</sup> K<sup>4</sup>) ]  
 ;..."
- p. 359 Equation 3.4.22  
 The rightmost symbol should be t<sub>sr</sub> instead of t<sub>r</sub>.
- p. 372 Table 3.5.4, entry for Cross-country running should be:  
 "732-746"
- p. 378 Example 3.5.3.4-1, equation for coefficient b should read:

$$b = \frac{n \sum xy - \sum x \sum y}{n \sum x^2 - (\sum x)^2}$$

$$= \frac{(4)(50.238) - (30)(5.797)}{4(350) - (30)^2}$$

- p. 388 Equation 3.6.9 should read:  
 "C<sub>v</sub> = 711.3 + 0.0249T + 0.0000448T<sup>2</sup> "
- p. 392 Table 3.6.1, The entry for "water" under "Ecological  
 Materials" should be:  
 "water (0°C) 4190"
- p. 393 Table 3.6.1, The entry for "water" under "Liquids" should  
 be:  
 "water (22°C) 4197"
- p. 397 The first word on the page should be "from" instead of "to"  
 In the calculation of □<sub>s</sub>, the denominator should also  
 include the *mc<sub>p</sub>* term, 0.140 x 10<sup>-3</sup> N m/(sec °C). The value  
 for □<sub>s</sub> is correct at 39.99°C.
- p. 421 last equation should be  

$$LMTD = \frac{(37^\circ C - 0^\circ C) - (25^\circ C - 15^\circ C)}{\ln[(37-0)/(25-15)]}$$
- p. 423 last line

" $6.25 \times 10^{-5} \text{ m}^2/\text{sec}$ " should be " $6.25 \times 10^{-5} \text{ m}^3/\text{sec}$ "

p. 430 Heisler chart for the slab is incorrect and is identical to the Heisler chart for the cylinder. The correct chart appears here on the next page.

p. 465 Example 3.8.1.1-2:

Area of the sides of the stack (middle of the page) should be:

$$A = \pi dL = \pi (0.10 + 2(0.0005\text{m})) (1.5\text{m}) = 0.476 \text{ m}^2$$

Total thermal resistance is:

$$\begin{aligned} R_{\text{tot}} &= \frac{1}{h_c A} + \frac{\ln(r_o/r_i)}{2\pi kL} \\ &= \frac{1}{20 \frac{\text{N}}{(\text{msec}^\circ\text{C})} (0.476\text{m}^2)} + \frac{\ln(0.0505\text{m}/0.0500\text{m})}{2\pi [0.10\text{N}/(\text{C sec})] (1.5\text{m})} \\ &= 0.1050 + 0.0106 = 0.1156 \frac{\text{sec}^\circ\text{C}}{\text{Nm}} \end{aligned}$$

The equivalent convection coefficient is:

$$h_{\text{equiv}} = \frac{1}{R_{\text{tot}} A} = \frac{1}{[0.1156\text{sec}^\circ\text{C}/(\text{Nm})][0.476\text{m}^2]} = 18.2 \frac{\text{Nm}}{\text{m}^2 \text{C sec}}$$

p. 481 Problem 3.4-10, last sentence:

"tranferred" should be "transferred"

p. 483 Problem 3.6-4

The average temperature of the surface of the pipe is  $-10^\circ\text{C}$ .

p. 487 Problem 3.7-12, line 3

should read "... Assume that the feet..."

p. 489 Problem 3.9-3

$\dot{M}$ , the net metabolic heat production of the entire body (N m/sec);

p. 500 Equation 4.3.7

$m_B$  should be  $\dot{m}_B$

p. 504 Equation 4.3.15 should read:

$$D_{AB} = \frac{0.01013T^{1.75} (1 / M_A + 1 / M_B)^{1/2}}{P[(V_A)^{1/3} + (V_B)^{1/3}]}$$

p. 508 Example 4.3.2.1-4, first equation has a number of errors.  
It should read:

$$D_{O_2 - O_2} = \frac{0.01013 (310 \text{ K})^{1.75} (2 \text{ kg mol} / 32 \text{ kg})^{1/2}}{(101300 \text{ N/m}^2) [2 (16.6 \text{ m}^3)^{1/3}]}$$
$$= 0.220 \times 10^{-4} \text{ m}^2/\text{sec}$$

Next line should read:

"Similarly,  $D_{H_2O - H_2O} = 0.351 \times 10^{-4} \text{ m}^2 / \text{sec}$  and

$D_{\text{air} - \text{air}} = 0.203 \times 10^{-4} \text{ m}^2/\text{sec}$ "

p. 511 Add to the end of the list of parameter definitions just below the table.

"Remember when using this equation to correct for temperature effects on liquid diffusivities that viscosity values are also very temperature dependent."

p. 515 Last equation

lowercase "c" subscript should be uppercase "C"

p. 517 Table 4.3.6, entry 10

H<sub>2</sub> through Cellophane should be H<sub>2</sub>O through Cellophane

p. 520 Last paragraph, line 2

The word "tortuoisity" should be "tortuosity"

p. 525 Section 4.3.2.6, line 5

The word "moisutre" should be "moisture"

p. 529      Second line  
              "intereface" should be "interface"

p. 531      Second line underneath Table 4.3.8  
              (m<sup>3</sup>) should be (m<sup>2</sup>)

p. 533 Table 4.3.9 at top  
Should read: "Permeability [ $10^{-16} \text{ m}^4/(\text{sec N})$ ]"

Entry 11 should be:

"Rubber hydrochloride"

Second line at bottom of table should be:

"...pressure-flow system."

p. 534 Line below equation 4.3.37. Insert after  $R_i$  ,:  
"the individual film resistance ( $(\text{sec N})/\text{m}^5$ );  $L_i$ , the individual "

p. 537 Example 4.3.3.2-1, last equation should be

$$L_{\text{CO}_2} = R_{\text{CO}_2} A P_{\text{CO}_2} = (2.25 \times 10^{12} \text{ N sec} / \text{m}^5) (0.04 \text{ m}^2) [5.0 \times 10^{-16} \text{ m}^4 / (\text{sec N})]$$
$$= 0.000045 \text{ m} = 0.04 \text{ m}$$

p. 538 Fifth line above Table 4.3.10

The word should be "retentate"

p. 544 The molar volume of water should be:

$$V_w = 0.018016 \text{ m}^3/\text{kg mol}$$

Second equation should be numbered (4.3.42).

p. 545 Table 4.3.12, "Sucrose" entry, should be:

"Sucrose 5% wt/wt -410

p. 546 Table 4.3.13, title, should read:

"Conversions among Different Concentration Designations..."

Entry for  $\mu$  from  $\psi$  should be:

$$\mu = \frac{\psi M_{sv}}{\rho M_{si} + \psi (M_{sv} - M_{si})}$$

Entry for  $v\%$  from  $\psi$  should be:

$$v \% = \frac{10^2 \psi}{\rho_{si}}$$

p. 548 eighth and ninth lines should read:

"...solvent moves through the membrane from the pure solvent side to the solution side . . . "

next to last line

"physcial" should be "physical"

p. 550 Equation at top of page should be numbered (4.3.44)

Line 18 of paragraph starting with "Some membranes . . . " should read:

"solute. When in doubt about the value of the transmission coefficient, it can be"

Last paragraph, line 7

The word "reponsible" should be "responsible"

p. 553 Example 4.3.3.3-1. Statement of the problem should be:

"Determine the molecular weight of fructose from its osmotic pressure."

p. 557 Middle of page:

"Using Eq. 4.3.38," should be "Using Eq. 4.3.39,"

$\pi_{salt}$  calculation should yield:

$$\pi_{salt} = - 32,300 \text{ kN} / \text{m}^2$$

Next equation should be:

$$\begin{aligned} \pi_{body} - \pi_{salt} &= - 800 \text{ kN} / \text{m}^2 + 32,300 \text{ kN} / \text{m}^2 \\ &= 31,500 \text{ kN} / \text{m}^2 \end{aligned}$$

Membrane resistance should be:

$$R = \frac{\Delta p}{\dot{V}} = \frac{31.5 \times 10^6 \text{ N} / \text{m}^2}{2.89 \times 10^{-15} \text{ m}^3 / \text{sec}} = 1.09 \times 10^{22} \text{ Nsec} / \text{m}^5$$



p. 558 Top equation should be:

$$A = \frac{40 \times 10^{10} \text{ Nsec/m}^3}{1.09 \times 10^{22} \text{ Nsec/m}^5} = 3.67 \times 10^{-11} \text{ m}^2$$

Next equation should be:

$$d = \sqrt{\frac{4A}{\pi}} = \sqrt{\frac{(4)(3.67 \times 10^{-11})}{\pi}}$$
$$= 6.84 \times 10^{-6} \text{ m}$$

Remarks, line 5, should be:

"a resistance of  $(1.09 \times 10^{22} \text{ N sec/m}^5)(0.125 \times 10^{-4} \text{ m}^2) = 1.36 \times 10^{17} \text{ N sec/m}^3$ , or  $1.36 \times 10^{17} \text{ N sec/m}^5$  per  $1 \text{ m}^2$  area."

Line 8 under "Remarks"

"thorough" should be "through"

p. 560 Table 4.3.14:

The Calculated Equilibrium Potential for  $\text{Na}^+$  should be  $+61.5 \times 10^{-3}$  instead of  $+60 \times 10^{-3}$ .

p. 564 line 3

"adminster" should be "administer"

p. 565 Figure caption, fig 4.3.28

"devlier" should be "deliver"

p. 566 Example 4.3.3.6-1.

The answer for  $\dot{m}$  should be:  $3.33 \times 10^{-8} \text{ kg/sec}$

p. 569 Last paragraph before "4.4 Convection", line 3

"from" should be "form"

Add to the end of the sentence after Eq. 1.8.2:

Comparing Eq. 1.8.2 to Ea. 4.3.35 shows that membrane permeability (P) in  $[\text{m}^4/\text{N sec}]$  is equivalent to the permeability (k) in  $(\text{m}^2)$  divided by the viscosity ( $\eta$ ) in  $(\text{N sec/m}^2)$ . The quantity  $k/\eta$  has been called the permeability coefficient in Eq. 1.8.3.

p. 573 The sentence just before equation 4.4.14 should be:

The ratio of the square of the heat transfer (see Section 3.3.1.1) and mass transfer boundary layer thicknesses is given by the nondimensional Lewis number, defined as:

$$Le = \frac{Sc}{Pr} = \frac{k}{c_p \rho D} \quad (4.4.14)$$

Add this sentence at the end of the paragraph containing equation 4.4.14:

"All properties referring to 'fluid' should be those for the bulk fluid or for the solvent; thus, for water vapor evaporating into air, the properties sought are the properties of air."

p. 574 Third line below equation 4.4.18 should read:

"the thermal conductivity of the fluid [N m/m sec °C)]"

p. 580 Equation 4.4.31 should be:

$$\dot{m} = \dot{V}(c_{A2} - c_{A1})$$

p. 583 Three lines above eqn 4.5.1:

The word "objedct" should be "object"

p. 583 Line 5 beneath section 4.5.1

The word "objedct" should be "object"

p. 588 First paragraph, line 7;

"surrace" should be "surface"

Title at 4.5.1.3

"Bionsensors" should be "Biosensors"

p. 602 Example 4.6.1-2, line 6.

$V_{TOT}$  should be  $7.12 \times 10^{-5} \text{ m}^3$

p. 603 Last paragraph, line 4 should read:

"....since the effort variable is"

p. 605 Figure 4.7.1, bottom half

"The "c" on the right should be "c<sub>∞</sub>".

p. 608 Equation 4.7.10:

The upper limit for the rightmost integral should be:

$$c_{N2}$$

Equation 4.7.11 should be:

$$\dot{m}_N = \frac{D_{MN} A c_{tot}}{(z_2 - z_1)} \ln \left( \frac{c_{tot} - c_{N1}}{c_{tot} - c_{N2}} \right)$$

Equation 4.7.12 should be:

$$R_m = \frac{(c_{N2} - c_{N1})}{\dot{m}_N} = \frac{(c_{N2} - c_{N1})(z_2 - z_1)}{D_{MN} A c_{tot}} \left[ \ln \left( \frac{c_{tot} - c_{N1}}{c_{tot} - c_{N2}} \right) \right]$$

p. 609 The first equation on the page should be:

$$c = \frac{m}{V} = \frac{pM}{RT}$$

Figure 4.7.3:

The diagram at the top of the page should be labeled with  $Z_2$  at the level of the water surface and  $Z_1$  at the top of the opening.  $c_{w2}$  corresponds to  $Z_2$ .

Line four beneath the diagram caption:

saturated water vapor pressure at 20°C from Table 4.8.2 should be 2337 N/m<sup>2</sup>.

p. 610 The equation for  $c_{w2}$  should be:

$$c_{w2} = \frac{(2337 \text{ N/m}^2)(18 \text{ kg/kg mole})}{[8314.34 \text{ N m/(kg mol K)}](293 \text{ K})}$$

$$= 0.01727 \text{ kg/m}^3$$

The first equation for bare earth  $R_m$  should be:

$$R_m = \frac{(0.01727 \text{ kg/m}^3 - 0 \text{ kg/m}^3)(0.01 \text{ m})}{(0.250 \times 10^{-4} \text{ m}^2/\text{sec})(1 \text{ m}^2)(1.21 \text{ kg/m}^3)} \times \left[ \ln \left( \frac{1.21 - 0 \text{ kg/m}^3}{1.21 - 0.01727 \text{ kg/m}^3} \right) \right]$$

$$= 0.0821 \text{ sec/m}^3$$

The equation for mulch  $R_m$  is:

$$R_m = \frac{(0.01282 - 0 \text{ kg/m}^3)(0.1 \text{ m})}{(0.246 \times 10^{-4} \text{ m}^2/\text{sec})(0.001 \text{ m}^2)(1.22 \text{ kg/m}^3)} \times \left[ \ln \left( \frac{1.22 - 0 \text{ kg/m}^3}{1.22 - 0.01282 \text{ kg/m}^3} \right) \right]$$

$$= 451 \text{ sec/m}^3$$

The entries for the bottom table, "No Mulch" column should be:

$c_{w2}$	$0.01727 \text{ kg/m}^3$
$R_m$	$0.0821 \text{ sec/m}^3$

p. 614 Equation 4.7.17 should be:

$$c_{\text{avg}} = \frac{m/\pi r^2}{\sqrt{4\pi Dt}} e^{-(x-vt)^2/4Dt}$$

p. 616 Figure 4.7.6, caption.

The Péclet number should be " $dv/D$ "

p. 621 Table 4.7.2, "Red Blood Cell" entry size should be 7.5 x 2.2 (nonspherical)

p. 626 Title 4.7.4

should be "Non-Steady State Mass Transfer"

- p. 639 Line 6 should be:  
 "...the wetter the incoming air, the warmer will be the exiting air,"  
 Last paragraph, line 1  
 "psychometrics" should be "psychrometrics"
- p. 641 The line above equation 4.8.16 should read:  
 total mass, heat added to a psychrometric mixture comprises the difference of total enthalpy of the mixture
- $$q = m(h_{en_2} - h_{en_1}) \quad (4.8.16)$$
- p. 656 equation 4.8.27 should be:
- $$\dot{m}_i = \frac{\dot{m}_{H_2O}}{(\omega_o - \omega_i)}$$
- p. 674 Example 4.8.2-1, line below first equation.  
 "0.156% db" should be "15.6% db"
- p. 676 equation at the top of the page. There should be a closed parenthesis after °C:  
 . . . = 1029 N m / (kg °C)
- p. 680 Problem 4.3-1, line 2  
 "respiratory mechnics" should be "respiratory mechanics"  
 Problem 4.3-1, line 5  
 should be "compare the diffusivity of oxygen in SF<sub>6</sub> to oxygen in air under the same conditions."  
 Problem 4.2-3, line 1  
 "concentrated" should be "constructed"
- p. 681 Problem 4.3-14, line 5  
 should be: "... lasagna piece. What is the initial rate of moisture removal from the lasagna, assuming that the ambient air is perfectly dry and at 22°C?"

- p. 682      Problem 4.3-15, line 7  
should be: "...exist at the interface, what is the initial rate of sugar diffusion into the less concentrated portion?"
- p. 683      Problem 4.3-30, line 1  
"osmotic concentration" should be "osmotic pressure"
- p. 684      Problem 4.3-33, line 10  
permeate flow rate should be 0.4 L/min  
Problem 4.4-3, line 9.  
"3.7 x 10<sup>-7</sup> m/sec" should be "3.7 x 10<sup>-7</sup> m<sup>2</sup>/sec"  
Problem 4.4-5, line 4  
delete the second "transferred from the air bubble to the water"
- p. 685      Problem 4.4-8  
The units on water vapor pressure should be N/m<sup>2</sup>, not kN/m<sup>2</sup>.  
Problem 4.4-10 line 3:  
"biofileter" should be "biofilter"
- p. 687      Problem 4.6-6  
Resistance of the outer bag should be  
$$9 \times 10^7 \text{ sec/m}^3$$
- p. 691      Problem 4.7-21, line 3  
The last word should be spelled "concentration."
- p. 692      Problem 4.8-6, line 4  
"biomedial" should be "biomedical"
- p. 704      Add to the index entry for Area, surface:  
$$\text{sphere, see Sphere, area}$$
- p. 706      The entry for "Bulk fluid temperature" should refer to pages 292 and 295.

p. 707      Insert after the entry for Chronic obstructive pulmonary disease:

        Circle segment, area    601

        Entry for carbohydrate:    oxidation should be:

        Oxidation 41, 660

p. 721      "Nernst equation" entry

        "914" should be "560"

p. 727      Add to index entry for Sphere:

        Sphere

            Area            399, 576, 578

            Volume        399, 576, 578

p. 730      "Universal gas constant" entry

        "914, 571, 634" should be "560, 571, 634"

