

# **MATHEMATICS AND BIOLOGY**

## **MATH-UA 255 and BIOL-UA 255**

### **Syllabus**

Professors Daniel Tranchina

Fall 2018

## **Required Textbook**

Hoppensteadt, F. and Peskin, C.S. (2002), Modeling and Simulation in the Life Sciences, 2nd ed., Springer. Available online (pdf) through NYU Library Springer Link

## **Prerequisites**

Calculus I and Introductory Biology

## **Week 1**

### **The Heart and Circulation**

1.1 Plan of the Circulation . . . . .	5
1.2 Volume, Flow, and Pressure . . . .	7
1.3 Resistance and Compliance Vessels . . .	8
1.4 The Heart as a Pair of Pumps . . .	10
1.5 Mathematical Model of the Uncontrolled Circulation . . .	14

## **Week 2**

### **The Heart and Circulation**

1.5 Mathematical Model of the Uncontrolled Circulation . . .	14
1.6 Balancing the Two Sides of the Heart and the Two Circulations . . . .	18
1.7 The Need for External Circulatory Control Mechanisms . . . .	20
1.8 Neural Control: The Baroreceptor Loop. . . .	21

## Week 3

### The Heart and Circulation

1.9 Autoregulation . . . . .	25
1.10 Changes in the Circulation Occurring at Birth . . . . .	28
1.11 Dynamics of the Arterial Pulse . . . . .	33

## Week 4

### Gas Exchange in the Lungs

2.1 The Ideal Gas Law and the Solubility of Gases . . . . .	76
2.2 The Equations of Gas Transport in One Alveolus . . . . .	78
2.3 Gas Transport in the Lung . . . . .	82
2.4 Optimal Gas Transport . . . . .	83

## Week 5

### Gas Exchange in the Lungs

2.4 Optimal Gas Transport . . . . .	83
2.5 Mean Alveolar and Arterial Partial Pressures . . . .	85
2.6 Transport of O <sub>2</sub> . . . . .	87

## Week 6

### Control of Cell Volume and Electrical Properties of Cell Membranes

3.1 Osmotic Pressure and the Work of Concentration . . . 109

3.2 A Simple Model of Cell Volume Control . . . . 113

3.3 The Movement of Ions Across Cell Membranes . . 115

## Week 7

### Control of Cell Volume and Electrical Properties of Cell Membranes

3.4 The Interaction of Electrical and Osmotic Effects . . . . .	118
3.5 The Hodgkin-Huxley Equations for the Nerve Action Potential . . . . .	124

## Week 8

### Control of Cell Volume and Electrical Properties of Cell Membranes

3.5 The Hodgkin-Huxley Equations for the Nerve Action Potential . . . . .	124
---	-----

**MIDTERM**, Tuesday, October 25.

## Week 9

### The Renal Countercurrent Mechanism

4.1 The Nephron. . . . .	147
4.2 Dynamics of $\text{Na}^+$ and $\text{H}_2\text{O}$ : Transport along the Renal Tubules . . . . .	150
4.3 The Loop of Henle . . . . .	152

## **Week 10**

### **The Renal Countercurrent Mechanism**

4.3 The Loop of Henle . . . . .	152
4.4 The Juxtaglomerular Apparatus and the Renin-Angiotensin System . . . .	155
4.5 The Distal Tubule and Collecting Duct: Concentrating and Diluting Modes . . .	157

## **Week 11**

### **The Renal Countercurrent Mechanism**

4.5 The Distal Tubule and Collecting Duct: Concentrating and Diluting Modes . .	157
4.6 Remarks on the Significance of the Juxtaglomerular Apparatus . . . . .	158

## **Week 12**

### **Muscle Mechanics**

5.1 The Force-Velocity Curve . . . . .	171
5.2 Crossbridge Dynamics . . . . .	173

### **Thanksgiving**

## **Week 13**

### **Muscle Mechanics**

5.2 Crossbridge Dynamics . . . . .	173
------------------------------------	-----

## **Week 14**

### **Epidemiology**

Epidemics (Lecture notes to be distributed)

Endemics (Lecture notes to be distributed)

## **Week 15**

### **Epidemiology**

Endemics (continued)

### **Discussion of final exam questions**

### **Closing remarks**

## **Course Grades**

Course grades are based on graded homework assignments, midterm and final examinations.

Each accounts for one-third of the overall grade.

## **Office Hours**

Tuesdays 10:30 am – 12:30 pm, room 918 Courant Warren Weaver Hall

Appointments outside formally scheduled office hour are welcome.