

## Mechanics of the Cell – second edition

Detailed outline  
(15 April, 2009)

Contents

Preface

List of symbols

Chapter 1 – Introduction to the cell

1.1 Designs for a cell

1.2 Cell shapes, sizes and structures

1.3 Biomaterials: soft strings and sheets

1.4 Forces inside and outside the cell

1.5 Summary

Chapter 2 – **Soft materials and fluids**

**2.1 Fluctuations at the cellular level**

**2.2 Movement in a viscous fluid**

**2.3 Random walks**

**2.4 Diffusion**

**2.5 Correlation functions**

**2.6 Summary**

**2.7 Problems**

Part I – Rods and ropes

Chapter 3 – Polymers

3.1 Catalogue of biofilaments

**3.2 Mathematical description of flexible rods**

3.3 Sizes of polymer chains

3.4 Entropic elasticity

3.5 Buckling (**formerly 10.1**)

3.6 Measurements of cellular filaments

3.7 Summary

3.8 Problems

**Chapter 4 – Complex filaments**

**4.1 The structure of complex filaments**

**4.2 Protein and RNA folding**

**4.3 Stretching of folded polymers**

**4.4 Torsion**

#### 4.5 Tubes and coils

#### 4.6 Multi-stranded filaments

#### 4.7 Summary

#### 4.8 Problems

### Chapter 5 – Two-dimensional networks

#### 5.1 Soft networks in the cell

#### **5.2 Elasticity in two dimensions**

#### 5.3 Isotropic networks

#### 5.4 Networks with low coordination number

#### 5.5 Membrane-associated networks

#### 5.6 Summary

#### 5.7 Problems

### Chapter 6 – Three-dimensional networks

#### 6.1 Networks of biological rods and ropes

#### **6.2 Elasticity in three dimensions**

#### 6.3 Entropic networks

#### 6.4 Semiflexible polymers in solution

#### 6.5 Rheology of cytoskeletal components

#### 6.6 Summary

#### 6.7 Problems

## Part II – Membranes

### Chapter 7 – Biomembranes

#### 7.1 Biomembranes and cell walls

#### 7.2 Self-assembly of amphiphiles

#### 7.3 Bilayer compression resistance

#### 7.4 Bilayer bending resistance

#### 7.5 Edge energy

#### **7.6 Cell walls and sheaths**

#### 7.7 Summary

#### 7.8 Problems

### Chapter 8 – Membrane undulations

#### 8.1 Thermal fluctuations in membrane shape

#### 8.2 Mathematics of curvature

#### 8.3 Membrane bending and persistence length

#### 8.4 Scaling of polymers and membranes

#### 8.5 Measurement of membrane undulations

#### 8.6 Summary

#### 8.7 Problems

## Chapter 9 – Intermembrane and electrostatic forces

9.1 Interactions between membranes

9.2 Charged plate in an electrolyte

9.3 van der Waals and electrostatic interactions

9.4 Entropic repulsion of sheets and polymers

9.5 Adhesion

**9.6 Signal propagation**

9.7 Summary

9.8 Problems

## Part III – The whole cell

### Chapter 10 – Structure of the simplest cells

10.1 Cell shapes

10.2 Energetics of thin shells

10.3 Pure bilayer systems

10.4 Vesicles and red blood cells

**10.5 Bacteria**

**10.6 Simple eukaryotes**

**10.7 Vesicles as a means of drug delivery**

10.8 Summary

10.9 Problems

### Chapter 11 – Dynamic filaments

11.1 Movement in the cell

11.2 Polymerization of actin and tubulin

11.3 Molecular motors

11.4 Forces from filaments (**add DNA**)

**11.5 Cell propulsion**

11.6 Summary

11.7 Problems

### Chapter 12 – Growth and division

**12.1 The division cycle**

**12.2 Time evolution of cell shape**

**12.3 What drives the shape changes?**

**12.4 Division cycle of filamentous algae**

**12.5 Replicating the blueprint**

**12.6 Forces in mitosis**

**12.7 Summary**

**12.8 Problems**

## **Chapter 13 – Control and organization**

**13.1 Mechanisms of transcription control**

**13.2 Rate equations: stability and switching**

**13.3 Case study: bacteria**

**13.4 Case study: eukaryotic checkpoints**

**13.5 Organization of organelles**

**13.6 Summary**

**13.7 Problems**

Appendix A Animal cells and tissues

Appendix B The cell's molecular building blocks

Appendix C Elementary statistical mechanics

Appendix D Elasticity

**Appendix E Micromanipulation techniques**

Glossary

References

Index