Viruses and microbes

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Abstract. This is an introduction to viruses, microbes and epidemiology, by insisting on mathematical aspects. We first discuss the basics of unicellular life, with a look at bacteria, and other types of microbes. Then we discuss the viruses, their size, geometry and functioning, with a look at genomes and mutations too. Then, we present the basics of epidemiology, with some history, mathematical models and computations, and with some more advanced theory too, taking into account antibiotics and vaccines. Finally, as main illustrations, we discuss the case of the plague, and of Ebola.

Preface

Viruses and microbes, this is certainly a scary theme of discussion, for us modern humans. In more ancient times, like the Middle Ages, the knowledge of these beasts was very poor, and even their very existence was unclear, but with this not adding in fact any serenity to the debate, with scary stories and discussions about various diseases caused by them, such as smallpox or plague, abounding. It is probably to the Stone Age that we have to go back in time, to find humans really in love and harmony with nature, with no questions asked about viruses and microbes, and death by disease in general.

But life goes on, and as you can see, viruses and microbes are something that everyone talks about, nowadays. Especially scientists, from the branches of science related to medicine. What goes on, and since a few centuries already, is some sort of holy crusade, coming with a certain religious aura, against all these viruses and microbes.

Interestingly, the foundations of modern biology and medicine are provided by Darwin's theory of evolution, with diseases playing a key role there, in the evolution of humans, and of other species. So, it is these very foundations that modern biology and medicine are trying to fight, disagree with, and in a certain sense, even negate.

But are we here for talking philosophy. Thanking life that I am not a biologist or a doctor myself, and nor are you I guess, if interested in such an amateurish book on the subject, as the present one, let us leave to biologists and doctors the task of getting okay with foundations, philosophy and ethics, and learn instead a bit from what they found. The present book will be an introduction to viruses, microbes and epidemiology, by insisting on mathematical aspects, with the plan, in 4 parts, being as follows:

(I) We will first discuss the basics of unicellular life, which is something truly fascinating, notably with a look at bacteria, and other types of microbes.

(II) Then we will discuss the viruses, which are technically not really alive, their size, geometry and functioning, and with a look at genomes and mutations too.

(III) Then, we will discuss basic epidemiology, with history, models and computations, and more advanced theory too, taking into account antibiotics and vaccines.

(IV) Finally, as main illustrations for the viruses and microbes, and the diseases caused by them, we will discuss the case of the plague, and of Ebola.

In the hope that you will find this book useful. Perhaps as a disclaimer, please don't treat patients with knowledge learned from here, personally I'm a quantum physicist, as daytime job, and this book stands for what it is worth, namely something rather philosophical and mathematical, half-way between astrology, and modern science.

It is a pleasure to thank my various scientific friends, including a number of biology and medicine researchers, the discussions with them having always been very interesting, and refreshing. Thanks as well to the internet, for the so many things that can be learned from there. Finally, many thanks to my cats. They are so proud and fearless, when facing illness and death, and it is hard not to be in awe, to such a display of wisdom.

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Part I

Unicellular life

Exit light
Enter night
Take my hand
Off to never-never land

CHAPTER 1

Self-replication

1a.

1b.

1c.

1d.

1e. Exercises

Exercises:

Exercise 1.1.

Exercise 1.2.

Exercise 1.3.

Exercise 1.4.

Exercise 1.5.

Exercise 1.6.

Exercise 1.7.

Exercise 1.8.

Bonus exercise.

CHAPTER 2

Life, cells

2a.

2b.

2c.

2d.

2e. Exercises

Exercises:

Exercise 2.1.

Exercise 2.2.

Exercise 2.3.

Exercise 2.4.

Exercise 2.5.

Exercise 2.6.

Exercise 2.7.

Exercise 2.8.

Bonus exercise.

CHAPTER 3

Microbes

3a.

3b.

3c.

3d.

3e. Exercises

Exercises:

Exercise 3.1.

Exercise 3.2.

Exercise 3.3.

Exercise 3.4.

Exercise 3.5.

Exercise 3.6.

Exercise 3.7.

Exercise 3.8.

Bonus exercise.

CHAPTER 4

Bacteria

4a.

4b.

4c.

4d.

4e. Exercises

Exercises:

Exercise 4.1.

Exercise 4.2.

Exercise 4.3.

Exercise 4.4.

Exercise 4.5.

Exercise 4.6.

Exercise 4.7.

Exercise 4.8.

Bonus exercise.

Part II

Viruses, mutations

But her ghost wheels her barrow
Through streets broad and narrow
Crying, cockles and mussels
Alive, alive, oh

CHAPTER 5

Viruses

5a.

5b.

5c.

5d.

5e. Exercises

Exercises:

Exercise 5.1.

Exercise 5.2.

Exercise 5.3.

Exercise 5.4.

Exercise 5.5.

Exercise 5.6.

Exercise 5.7.

Exercise 5.8.

Bonus exercise.

CHAPTER 6

Size, geometry

6a.

6b.

6c.

6d.

6e. Exercises

Exercises:

Exercise 6.1.

Exercise 6.2.

Exercise 6.3.

Exercise 6.4.

Exercise 6.5.

Exercise 6.6.

Exercise 6.7.

Exercise 6.8.

Bonus exercise.

CHAPTER 7

Genome, mutations

7a.

7b.

7c.

7d.

7e. Exercises

Exercises:

EXERCISE 7.1.

EXERCISE 7.2.

EXERCISE 7.3.

EXERCISE 7.4.

EXERCISE 7.5.

EXERCISE 7.6.

EXERCISE 7.7.

EXERCISE 7.8.

Bonus exercise.

CHAPTER 8

Immune system

8a.

8b.

8c.

8d.

8e. Exercises

Exercises:

Exercise 8.1.

Exercise 8.2.

Exercise 8.3.

Exercise 8.4.

Exercise 8.5.

Exercise 8.6.

Exercise 8.7.

Exercise 8.8.

Bonus exercise.

Part III

Epidemiology

If I were asleep, I could dream
If I were afraid, I could hide
If I go insane
Please don't put your wires in my brain

CHAPTER 9

Some history

9a.

9b.

9c.

9d.

9e. Exercises

Exercises:

Exercise 9.1.

Exercise 9.2.

Exercise 9.3.

Exercise 9.4.

Exercise 9.5.

Exercise 9.6.

Exercise 9.7.

Exercise 9.8.

Bonus exercise.

CHAPTER 10

Basic models

10a.

10b.

10c.

10d.

10e. Exercises

Exercises:

Exercise 10.1.

Exercise 10.2.

Exercise 10.3.

Exercise 10.4.

Exercise 10.5.

Exercise 10.6.

Exercise 10.7.

Exercise 10.8.

Bonus exercise.

CHAPTER 11

Antibiotics

11a.

11b.

11c.

11d.

11e. Exercises

Exercises:

Exercise 11.1.

Exercise 11.2.

Exercise 11.3.

Exercise 11.4.

Exercise 11.5.

Exercise 11.6.

Exercise 11.7.

Exercise 11.8.

Bonus exercise.

CHAPTER 12

Vaccines

12a.

12b.

12c.

12d.

12e. Exercises

Exercises:

Exercise 12.1.

Exercise 12.2.

Exercise 12.3.

Exercise 12.4.

Exercise 12.5.

Exercise 12.6.

Exercise 12.7.

Exercise 12.8.

Bonus exercise.

Part IV

Plague, Ebola

Regrets, I've had a few
But then again, too few to mention
I did what I had to do
And saw it through without exemption

CHAPTER 13

The plague

13a.

13b.

13c.

13d.

13e. Exercises

Exercises:

Exercise 13.1.

Exercise 13.2.

Exercise 13.3.

Exercise 13.4.

Exercise 13.5.

Exercise 13.6.

Exercise 13.7.

Exercise 13.8.

Bonus exercise.

CHAPTER 14

Black Death

14a.

14b.

14c.

14d.

14e. Exercises

Exercises:

Exercise 14.1.

Exercise 14.2.

Exercise 14.3.

Exercise 14.4.

Exercise 14.5.

Exercise 14.6.

Exercise 14.7.

Exercise 14.8.

Bonus exercise.

CHAPTER 15

Ebola

15a.

15b.

15c.

15d.

15e. Exercises

Exercises:

Exercise 15.1.

Exercise 15.2.

Exercise 15.3.

Exercise 15.4.

Exercise 15.5.

Exercise 15.6.

Exercise 15.7.

Exercise 15.8.

Bonus exercise.

CHAPTER 16

Lab viruses

16a.

16b.

16c.

16d.

16e. Exercises

Congratulations for having read this book, and no exercises for this final chapter.

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