UPPINGHAM SCHOOL
BIOLOGY DEPARTMENT

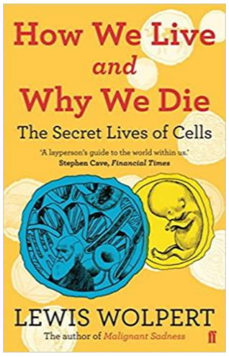
Pre- Lower Sixth Preparation Material

This booklet has been designed to help reduce the jump between IGCSE Biology and the A-level course. Please work through it during the Summer Holidays. Your teacher will expect you to have completed it and to hand it in when you return to school in September. The material is focused around the two topics that are covered at the start of the Lower Sixth course – Cells and Biological Molecules. There are also small maths and practical skills sections. You may need to look up the answers to some areas of this booklet. In some sections, resources for this have been suggested. The idea is that you are building on your knowledge from GCSE and preparing for the A-level style of working.

We would also like you to ensure that you have read the following books. You will be expected to be able to discuss these in your lessons when you return in September.

How We Live and Why We Die: The Secret Lives of Cells

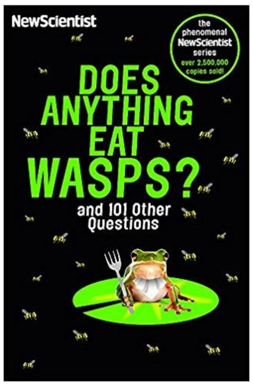
by Lewis Wolpert



This will provide you with a good introductory knowledge of the material that you will cover in the Lower Sixth course. It is needed to answer some of the sections of this booklet.

Does Anything Eat Wasps?

by New Scientist



If you are serious about studying Biology you should be asking questions – both about how everyday things work and also about the information that you are given. Don't just accept that something is correct without challenging it further.

This book will help you look at how problems in Biology can be approached. It highlights how important it is to ask questions about how things work and also that people can have conflicting views on the answers to such questions. It will also show you the many different factors have to be taken into consideration when answering questions in Biology and that there is often not one single correct answer.

There are some additional suggestions for material to read at the end of the booklet. These are optional.

Cells

Draw labelled diagrams of an animal cell, a plant cell, a bacterial cell and a virus in the spaces below.

Use the website Cells Alive as your source material (http://www.cellsalive.com/cells/cell_model.htm). This page contains the plant and animal cell models (start the animation). A bacterial cell can be found at http://www.cellsalive.com/cells/bactcell.htm. Use the internet to find a general structure for a virus or use a specific example of a virus.

Animal cell

Plant cell

Bacterial cell

Virus

List the functions of the following structures of a cell:

Structure	**Function**
Nucleus	
Cell membrane	
Cell wall	
Cytoplasm	
Mitochondrion	
Chloroplast	
Vacuole	
Smooth endoplasmic reticulum	

Rough endoplasmic reticulum	
Golgi apparatus / Golgi body	
Centrioles	
Ribosome	
Lysosome	

Respiration and Photosynthesis

Complete the table.

	Photosynthesis	Aerobic respiration
Which organisms carry out this process?		
Where in the organisms does the process take place?		
Energy store at the beginning of the process	Sun	
Energy store at the end of the process		In cells
Reactants needed for the process		
Products of the process		
Overall word equation		
Balanced symbol equation for the overall process		

Which of the answers for aerobic respiration would be different for anaerobic respiration? Add these answers to the table in a different colour.

Transport of substances

There are several different ways in which molecules can cross a cell membrane. List the key features of diffusion, osmosis and active transport below.

Method of transport across cell membrane	**Key features**
Diffusion	
Osmosis	
Active transport	

What are the features that affect the rate of diffusion? Explain why they have that effect.

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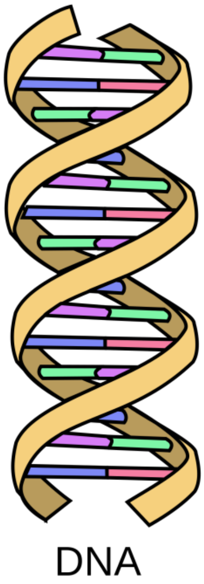
DNA

Describe the key features of the structure of a DNA molecule



How does DNA control the function of our cells?

What is a chromosome and how many do we have in our cells?

Mitosis and meiosis are two types of cell division. What are the differences between them? Draw a table to compare them below.

Biological molecules

Complete the table showing the key properties of the listed biological molecules.

Biological molecule	What elements does it contain?	What smaller units is it made from?	What enzyme is used to digest it?	What role does it play in the body?
Carbohydrates (sugars) e.g. glucose, starch, cellulose, glycogen				
Lipids				
Proteins				

What is an enzyme?

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What factors affect the rate of enzyme-catalysed reactions? How do they produce these effects?

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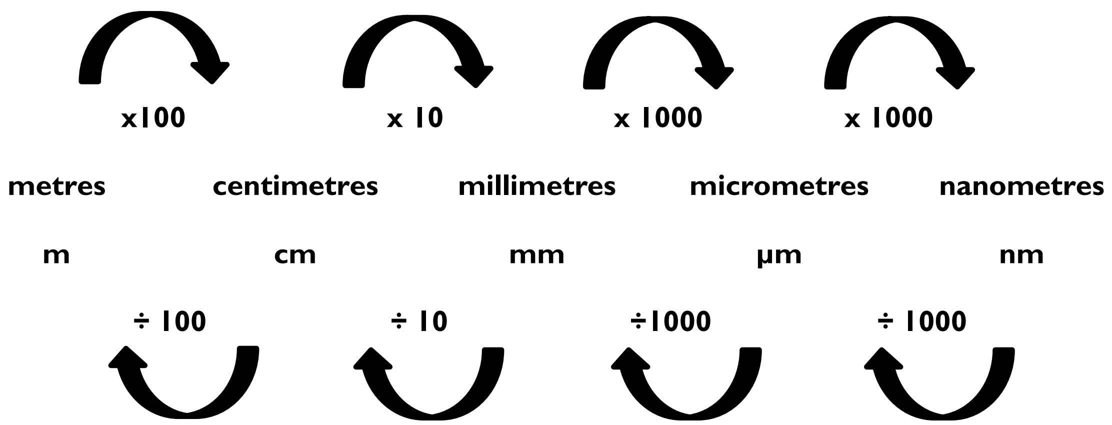
Maths skills

1. Converting units

In Biology you need to be able to convert between different units.

You need to be able to convert between units, square units and cubed units.



Convert the following units and complete the table.

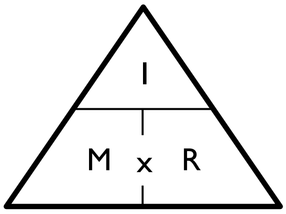
m	cm	mm	µm	nm
3				
	8.3			
		55		
			7200	
				200 000

2. Magnification

You should be able to use the formula to calculate magnification and size.

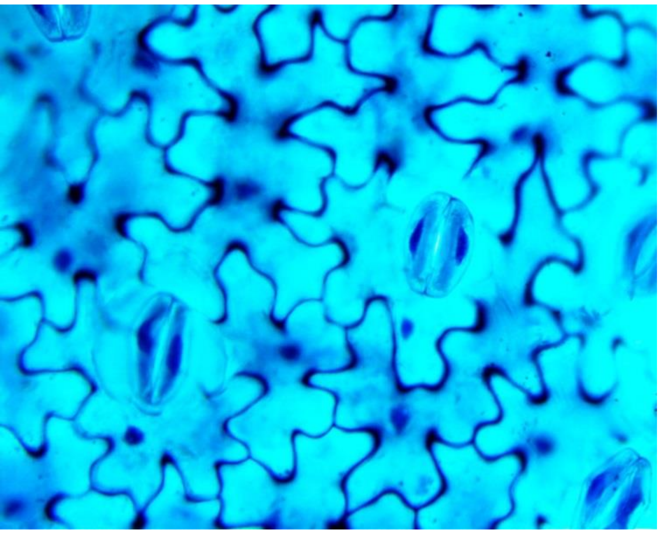
$$\text{Magnification (M)} = \frac{\text{Size of image (I)}}{\text{Real size of object (R)}}$$

To help rearrange this formula you can use the triangle



Remember to put all sizes into the same units before you start. Magnification has no units.

The magnification of this image is x 1500 what is its size in real life?



The length of each guard cell in this diagram is 18 μm. What is the magnification of the image?

If the diameter of a red blood cell in real life is 8 µm. What is the magnification of this image?

3. Percentage change

To calculate percentage changes (including increases and decreases) use the following formula:

$$\% \text{ change} = \frac{\text{change in values}}{\text{original value}} \times 100$$

Remember – if it is a % decrease then the larger of the two numbers goes on the bottom of the equation. If it is a % increase then the smaller of the two numbers goes on the bottom of the equation.

Calculate the following percentage changes using the formula above.

a) A heart rate increases from 75 beats per minute to 97 beats per minute. What is the percentage increase?

b) A population of bacteria decreases from 1364 cells to 389 cells. What is the percentage decrease?

c) A rate of reaction starts at 4.5 AU per second and increases to 12.5 AU per second. What is the percentage increase?

d) The number of cases of heart disease in a population starts at 856 and decreases to 691. What is the percentage decrease?

4. Rounding numbers

If a value is below 5 you should round it down. If it is above 5 then round up.

Round the following numbers to the number of decimal places shown in brackets.

123.56 (1 decimal place)

658.254 (2 decimal places)

151.11 (1 decimal place)

25.5 (no decimal places)

98.65 (1 decimal place)

5. Standard Form

Standard form is used to represent very big or very small numbers.

Numbers are written as $A \times 10^n$ where A is a value between 1 and 9 and n is the number of places that you have to move the decimal point.

If n is negative, the number is very small and the decimal point must be moved to the left. If n is positive, the number is large and the decimal point should be moved right.

e.g. 150 000 = 1.5×10^5
0.00042 = 4.2×10^{-4}

Express the following in ordinary form.

a) 1.23×10^2

b) 5.2×10^4

c) 8.65×10^{-1}

d) 5.4×10^{-6}

Express the following in standard form.

a) 152000

b) 4800

c) 0.0003

d) 0.0000045

6. Significant Figures

The number of significant figures gives a measure of the uncertainty of a measurement. Whether a number is significant or not is determined by what the number is and where it is within the order of digits.

- Any non-zero digit is significant
- Any zeros between other numbers are significant
- Any leading zeros are NOT significant
- Trailing zeros are only significant if there is a decimal point included in the number

For example:
0.00250 has 3 significant figures
37040 has 4 significant figures
25.0 has 3 significant figures

How many significant figures in the following?

a) 325

b) 2510.0

c) 0.003

d) 256.01

e) 89760

Express the following to the number of significant figures shown in brackets.

a) 2584 (3 significant figures)

b) 279.40 (4 significant figures)

c) 68579 (2 significant figures)

7. Graphs and Tables in Biology

a) Tables

There are a number of rules to follow when you draw a table in Biology:

- The independent variable (what was varied in the experiment) must go in the first column of your table
- Headings for columns must be detailed
- All numbers in the table should be to the same number of decimal places (or at least the same number of dp in each column)
- No units should appear in the main table – these must remain in the headings

Draw a table for the following data:

An experiment with the enzyme catalase was performed. The concentration of catalase was varied and the resulting rate of oxygen formation measured. The following data were obtained:

1% catalase – 7 $cm^3.min^{-1}$ oxygen production

5% catalase – 16 $cm^3.min^{-1}$ oxygen production

8% catalase – 28 $cm^3.min^{-1}$ oxygen production

10% catalase – 49 $cm^3.min^{-1}$ oxygen production

12% catalase – 54 $cm^3.min^{-1}$ oxygen production

b) Line graphs

- These are used when you have a dependent and an independent variable. The independent variable must be on a continuous scale, like temperature.

  The independent variable (what you are varying) is plotted on the x (horizontal) axis.
  The dependent variable (what you are measuring) is plotted on the y (vertical) axis.

- Points are plotted in pencil using a cross.

- Axes must be labelled with a title and units

- The scale on each axis must go up in equal units, e.g. 2, 4, 6, 8 not 2, 5, 10, 14.

- If you are not certain of the overall trend or do not have sufficient intermediate points you should join the points using ruled lines. Lines or curves of best fit should only be used when you have lots of data.

Draw a line graph for the data in your table.

Lung cancer, chronic bronchitis and coronary heart disease (CHD) are associated with smoking. Tables 1 and 2 give the total numbers of deaths from these diseases in the UK in 1974.

Table 1 Men

Age/years	Number of deaths (in thousands)		
	lung cancer	chronic bronchitis	coronary heart disease
35-64	11.5	4.2	31.7
65-74	12.6	8.5	33.3
75+	5.8	8.1	29.1
Total (35-75+)	29.9	20.8	94.1

Table 2 Women

Age/years	Number of deaths (in thousands)		
	lung cancer	chronic bronchitis	coronary heart disease
35–64	3.2	1.3	8.4
65–74	2.6	1.9	18.2
75+	1.8	3.5	42.3
Total (35–75+)	7.6	6.7	68.9

1. Of the men who died aged 35-64 from one of these three causes, what percentage of them died of lung cancer?

2. What percentage of deaths from chronic bronchitis in women happened to women aged 65-74?

3. Deaths from lung cancer drop as people get older. Is there a bigger percentage difference for men or women from 35-64 to 75+?

4. What fraction of coronary heart disease deaths of men over 34 are in the 75+ bracket? What about for women?

Practical work

Join the boxes to link the word to its definition.

Accurate	A statement suggesting what may happen in the future.
Data	An experiment that gives the same results when a different person carries it out, or a different set of equipment or technique is used.
Precise	A measurement that is close to the true value.
Prediction	An experiment that gives the same results when the same experimenter uses the same method and equipment.
Range	Physical, chemical or biological quantities or characteristics.
Repeatable	A variable that is kept constant during an experiment.
Reproducible	A variable that is measured as the outcome of an experiment.
Resolution	This is the smallest change in the quantity being measured (input) of a measuring instrument that gives a perceptible change in the reading.
Uncertainty	The interval within the true value can be expected to lie.
Variable	The spread of data, showing the maximum and minimum values of the data.
Control variable	Measurements where repeated measurements show very little spread.
Dependent variable	Information, in any form, that has been collected.

Design an experiment to investigate the effect of changing temperature on an enzyme-catalysed reaction. The enzyme converts substance X from a colourless solution to a blue solid and water.

Consider how you would set up your experiment, what equipment you might need, how you would measure your results, which variables you would need to control and how you might do this.

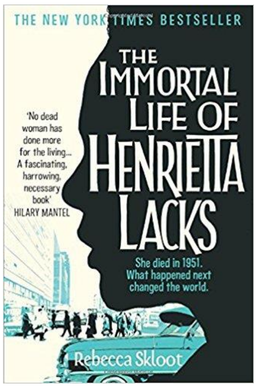
Optional reading list

Here are some other books that might be of interest to you. They will give you a better overall understanding of different areas of Biology.

Life at the Extremes: The Science of Survival – Frances Ashcroft

How do people survive extremes of heat, cold, depth, speed and altitude? This book explores the limits of human survival and the physiological adaptations which enable us to exist under extreme conditions. In man's battle for survival in the harshest of environments, the knowledge imparted by physiology, the 'logic of life', is crucial. What causes mountain sickness? Why is it possible to reach the top of Everest without supplementary oxygen, yet be killed if a plane depressurises suddenly at the same altitude. Why are astronauts unable to stand without fainting when they return to Earth? Why do human divers get the bends but sperm whales don't? Will men always be able to run faster than women? Why don't penguins get frostbite?

The Immortal Life of Henrietta Lacks – Rebecca Skloot



Her name was Henrietta Lacks, but scientists know her as HeLa. Born a poor black tobacco farmer, her cancer cells – taken without her knowledge – became a multimillion-dollar industry and one of the most important tools in medicine. Yet Henrietta's family did not learn of her 'immortality' until more than twenty years after her death, with devastating consequences . . .

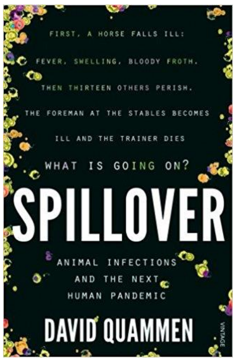
Rebecca Skloot's fascinating account is the story of the life, and afterlife, of one woman who changed the medical world forever. Balancing the beauty and drama of scientific discovery with dark questions about who owns the stuff our bodies are made of, *The Immortal Life of Henrietta Lacks* is an extraordinary journey in search of the soul and story of a real woman, whose cells live on today in all four corners of the world.

Bring Back the King: The New Science of De-extinction – Helen Pilcher

If you could bring back just one animal from the past, what would you choose? It can be anyone or anything from history, from the King of the Dinosaurs, *T. rex*, to the King of Rock 'n' Roll, Elvis Presley, and beyond.

De-extinction - the ability to bring extinct species back to life - is fast becoming reality. Around the globe, scientists are trying to de-extinct all manner of animals, including the woolly mammoth, the passenger pigeon and a bizarre species of flatulent frog. But de-extinction is more than just bringing back the dead. It's a science that can be used to save species, shape evolution and sculpt the future of life on our planet. In *Bring Back the King*, scientist and comedy writer Helen Pilcher goes on a quest to identify the perfect de-extinction candidate. Along the way, she asks if Elvis could be recreated from the DNA inside a pickled wart, investigates whether it's possible to raise a pet dodo, and considers the odds of a 21st century Neanderthal turning heads on public transport.

Spillover: Animal Infections and the Next Human Pandemic – David Quammen

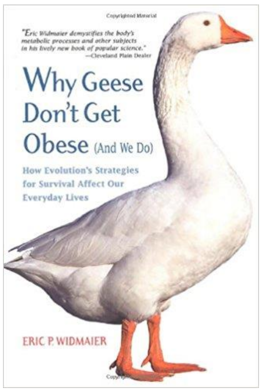


First, a horse in Brisbane falls ill: fever, swelling, bloody froth. Then thirteen others drop dead. The foreman at the stables becomes ill and the trainer dies. What is going on?

As globalization spreads and as we destroy the ancient ecosystems, we encounter strange and dangerous infections that originate in animals but that can be transmitted to humans. Diseases that were contained are being set free and the results are potentially catastrophic.

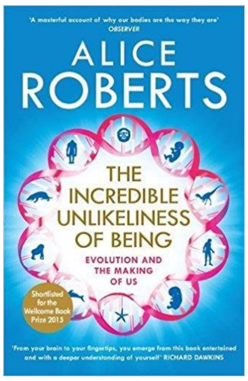
In a journey that takes him from southern China to the Congo, from Bangladesh to Australia, David Quammen tracks these infections to their source and asks what we can do to prevent some new pandemic spreading across the face of the earth.

Why Geese Don't Get Obese (And We Do) – Eric P. Widmaier



Why are elephants' ears so big? Why do humans get the bends when dolphins don't? Imagine being able to consume 250,000 calories (50 Christmas dinners) daily without gaining weight! If we had the metabolism of a shrew, we could, and we would have to. In this text, Eric Widmaier offers a physiologist's view of the features and abilities humans and other creatures have evolved to meet the seemingly impossible challenges of survival.

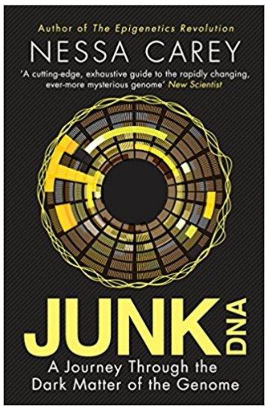
The Incredible Unlikeliness of Being – Alice Roberts



Alice Roberts takes you on the most incredible journey, revealing your path from a single cell to a complex embryo to a living, breathing, thinking person. It's a story that connects us with our distant ancestors and an extraordinary, unlikely chain of events that shaped human development and left a mark on all of us. Alice Roberts uses the latest research to uncover the evolutionary history hidden in all of us, from the secrets found only in our embryos and genes - including why as embryos we have what look like gills - to those visible in your anatomy.

This is a tale of discovery, exploring why and how we have developed as we have. This is your story, told as never before.

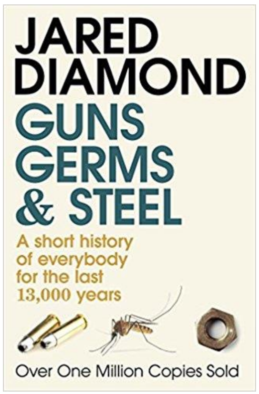
Junk DNA: A journey through the dark matter of the genome – Nessa Carey



For decades after the identification of the structure of DNA, scientists focused only on genes, the regions of the genome that contain codes for the production of proteins. Other regions that make up 98 percent of the human genome were dismissed as "junk," sequences that serve no purpose. But researchers have recently discovered variations in this junk DNA that are involved with a number of diseases. Our increasing knowledge of junk DNA has led to innovative research and treatment approaches that may finally ameliorate some of these conditions.

Junk DNA can play vital and unanticipated roles in the control of gene expression, from fine-tuning individual genes to switching off entire chromosomes. These functions have forced scientists to revisit the very meaning of the word "gene" and have engendered a spirited scientific battle over whether or not this genomic "nonsense" is the source of human biological complexity

Guns, germs and steel – Jared Diamond

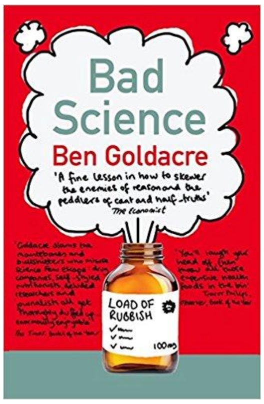


Why has human history unfolded so differently across the globe?

In his Pulitzer Prize-winning book, Jared Diamond puts the case that geography and biogeography, not race, moulded the contrasting fates of Europeans, Asians, Native Americans, sub-Saharan Africans, and aboriginal Australians.

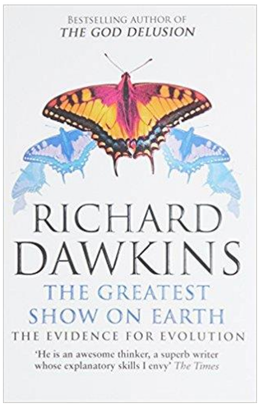
An ambitious synthesis of history, biology, ecology and linguistics, *Guns, Germs and Steel* remains a ground-breaking and humane work of popular science.

Bad Science (also Bad Pharma) – Ben Goldacre



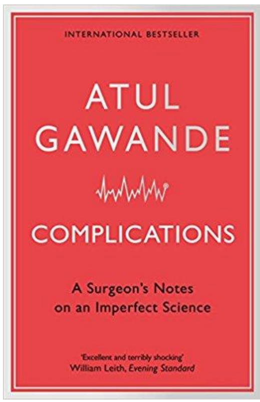
Since 2003 Dr Ben Goldacre has been exposing dodgy medical data in his popular *Guardian* column. In this eye-opening book he takes on the MMR hoax and misleading cosmetics ads, acupuncture and homeopathy, vitamins and mankind's vexed relationship with all manner of 'toxins'. Along the way, the self-confessed 'Johnny Ball cum Witchfinder General' performs a successful detox on a Barbie doll, sees his dead cat become a certified nutritionist and probes the supposed medical qualifications of 'Dr' Gillian McKeith. Full spleen and satire, Ben Goldacre takes us on a hilarious, invigorating and ultimately alarming journey through the bad science we are fed daily by hacks and quacks.

The Greatest Show on Earth – Richard Dawkins



In *The Greatest Show on Earth* Richard Dawkins takes on creationists, including followers of 'Intelligent Design' and all those who question the fact of evolution through natural selection. Like a detective arriving on the scene of a crime, he sifts through fascinating layers of scientific facts and disciplines to build a cast-iron case: from the living examples of natural selection in birds and insects; the 'time clocks' of trees and radioactive dating that calibrate a timescale for evolution; the fossil record and the traces of our earliest ancestors; to confirmation from molecular biology and genetics. All of this, and much more, bears witness to the truth of evolution.

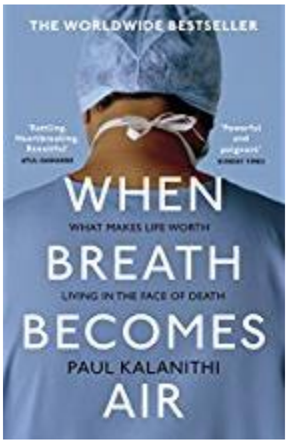
Complications (and other titles) – Atul Gawande



In these gripping accounts of true cases, bestselling author Atul Gawande performs exploratory surgery on medicine itself, laying bare a science not in its idealised form, but as it actually is - complicated, perplexing and profoundly human.

This is a stunningly well-written account of the life of a surgeon: what it is like to cut into people's bodies and the terrifying - literally life and death - decisions that have to be made: operations that go wrong; of doctors who go to the bad; why autopsies are necessary; what it feels like to insert your knife into someone. This is a very good read for anyone interested in medicine or healthcare.

When Breath Becomes Air – Paul Kalanithi



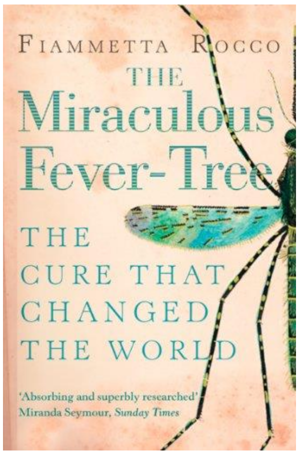
At the age of thirty-six, on the verge of completing a decade's training as a neurosurgeon, Paul Kalanithi was diagnosed with inoperable lung cancer. One day he was a doctor treating the dying, the next he was a patient struggling to live.

When Breath Becomes Air chronicles Kalanithi's transformation from a medical student asking what makes a virtuous and meaningful life into a neurosurgeon working in the core of human identity – the brain – and finally into a patient and a new father.

What makes life worth living in the face of death? What do you do when when life is catastrophically interrupted? What does it mean to have a child as your own life fades away?

Paul Kalanithi died while working on this profoundly moving book, yet his words live on as a guide to us all. *When Breath Becomes Air* is a life-affirming reflection on facing our mortality and on the relationship between doctor and patient, from a gifted writer who became both.

The Miraculous Fever Tree – Fiammetta Rocco



A rich and wonderful history of quinine – the cure for malaria.

In the summer of 1623, ten cardinals and hundreds of their attendants, engaged in electing a new Pope, died from the 'mal'aria' or 'bad air' of the Roman marshes. Their choice, Pope Urban VIII, determined that a cure should be found for the fever that was the scourge of the Mediterranean, northern Europe and America, and in 1631 a young Jesuit apothecarist in Peru sent to the Old World a cure that had been found in the New – where the disease was unknown.

The cure was quinine, an alkaloid made of the bitter red bark of the cinchona tree, which grows in the Andes. Both disease and cure have an extraordinary history. Malaria badly weakened the Roman Empire. It killed thousands of British troops fighting Napoleon during the Walcheren raid on Holland in 1809 and many soldiers on both sides of the American Civil War. It turned back many of the travellers who explored west Africa and brought the building of the Panama Canal to a standstill. When, after a thousand years, a cure was finally found, Europe's Protestants, among them Oliver Cromwell, who suffered badly from malaria, feared it was nothing more than a Popish poison. More than any previous medicine, though, quinine forced physicians to change their ideas about treating illness. Before long, it would change the face of Western medicine.