The Thread of Life

The Story of Genes & Genetic Engineering

Susan Aldridge

生命之源

——基因与基因工程的故事

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我社从英国剑桥大学出版社引进的《生命之源：基因与基因工程的故事》（*The Thread of Life : Gene and Genetic Engineering*）就是这样一部优秀的科普作品，所涉及的生物技术、生物工程和基因工程虽然是深奥的前沿学科，但是在作者笔下有关内容变得生动、形象、引人入胜。不仅如此，本书还提供了精心绘制的插图，以提高读者的兴趣，帮助读者加深理解。

本书可作为大专院校生物、医学专业学生的专业英语教材或课外读物，也可供广大英语爱好者用作提高科普英语水平的读物。

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Preface

The human genome project, DNA testing, gene therapy, and genetic engineering ... there is no shortage of news about the gene revolution. This book aims to take you behind the headlines and explore the fast-moving and fascinating world of molecular biology.

In the first part of the book, I have tried to convey the power and uniqueness of the DNA molecule: how it was discovered, what it does, and where it came from. This leads into genetic engineering and its potential. In a very real sense, there is nothing special about gene transfer — it has been going on for billions of years. Its potential comes from humans, rather than the blind forces of evolution, being at the controls. The applications of genetic engineering and related technology that have attracted the most publicity — gene testing and therapy, and transgenic animals — are considered next.

But genetic engineering is just one aspect of biotechnology (although the two terms are often used synonymously); in the third part of the book I try to look at the wider world of biotechnology, as well as that of genetic engineering — as applied to plants and the environment.

Critics say that there is an overemphasis on DNA in biology, leading to a kind of reductionism, which has alienated the public, and some scientists, from its benefits. In the last part, I have tried to put DNA in context by looking at some other new ideas that have emerged in biology over the last 20 years or so.

Susan Aldridge
London

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Figs. 1.2(a) and (b) and 1.3(a) and (b) are modified from *Biological Science 1 & 2*, 2nd edition, by N. P. O. Green, G. W. Stout and D. J. Taylor, edited by R. Soper. Cambridge University Press, 1993.
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Fig. 3.1 is from *Gray's Anatomy*, 35th edition, edited by R. Warwick and P. Williams. Longman (London), 1973.

Contents

PART I

What is DNA?

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1

DNA is life's blueprint

Take a large onion and chop finely①. Place the pieces in a medium-sized casserole② dish. Now mix ten tablespoons of washing-up liquid with a tablespoon of salt, and make up to two pints③ with water. Add about a quarter of this mixture to the onion and cook in a bain-marie in a very cool oven for five minutes, stirring frequently, and liquidise at high speed for just five seconds.

Now strain④ the mixture and add a few drops of fresh pineapple juice to the strained liquid, mixing well. Pour into a long chilled glass and finish off by dribbling ice-cold alcohol (vodka will do) down the side so that it floats on top of the mixture. Wait a few minutes and watch cloudiness form where the two layers meet. Now lower a swizzle stick into the cocktail and carefully hook up the cloudy material. It should collapse into a web of fibres that you can pull out of the glass. This is DNA (short for deoxyribonucleic acid⑤).

DNA is the stuff that genes are made of. Genes carry biological information, which is translated into the characteristics of living things and is passed on down the generations. So genes determine the colour of a butterfly's wings, the scent of a rose, and the sex of a baby. DNA is just a chemical — not a more complex entity like a chromosome⑥ or a cell — and it is only in a biological context that it acquires its status as the molecular signature of an organism.

Discovering DNA

The chopping, cooking, grinding and mixing processes described above re-

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① chop finely: cut carefully into small pieces
② casserole: 勺皿
③ pint: 品脱(英美干量或液量名)
④ strain: filter 过滤
⑤ deoxyribonucleic acid: 脱氧核糖核酸
⑥ chromosome: 染色体

semble those carried out every day in laboratories all around the world to extract DNA from living tissue. DNA dominates modern biology — yet many decades passed between its discovery and the realisation of its significance.

DNA was first isolated from human pus① — a mixture of bacteria, blood plasma② and white blood cells that exudes from infected wounds and abscesses③ — by the Swiss biochemist Friedrich Miescher in 1869. Miescher's life and work were greatly influenced by his uncle, the anatomist Wilhelm His, who was one of the founding fathers of molecular biology. After studying medicine, Miescher moved to Tübingen to work with the great chemist Felix Hoppe-Seyler in the first laboratory in the world devoted exclusively to the study of biochemistry.

The late nineteenth century was an exciting time. Although English physicist Robert Hooke had described cells as long ago as 1665 in his classic work *Micrographia*, it was only in the nineteenth century that their significance as the fundamental building blocks of all organisms was realised. Cells are tiny compartments, full of a fluid called cytoplasm④ and separated from their outer environment by a thin membrane⑤ of a fatty material. Organisms may consist of a single cell — like bacteria, amoebae and yeast — or they may exist as a community of different types of cell working together. These multicellular⑥ organisms range from sponges, jellyfish and tiny pond animals, which get by⑦ with just a few cell types, to humans who boast over 200 different types of cell.

In the 1860s the idea that life somehow arose spontaneously was finally overturned. Rudolf Virchow, the father of clinical pathology⑧, developed the idea that cells — life's building blocks — could only come from other cells. Experiments carried out by the great French scientist Louis Pasteur supported this view. Pasteur showed that vessels containing broth went mouldy

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① pus：脓液
② plasma：血浆
③ abscess：脓肿
④ cytoplasm：细胞质
⑤ membrane：（动、植物的）膜、薄膜
⑥ multicellular：多细胞的
⑦ get by：keep alive/maintain their lives
⑧ pathology：病理学

only when contaminated by airborne microbes[①]. If they were heated and sealed they remained sterile — no microbial life appeared spontaneously under such conditions.

Bacteria come from other bacteria, by a simple cell division process called binary fission[②]. This might happen as often as every 20 minutes. Given unlimited food and energy — and an idealised predator-free environment — a single bacterium would give rise to numbers greater than the human population (5 billion) in under[③] 11 hours.

Binary fission is an example of asexual reproduction[④], in which a new organism comes from a single 'parent'. More complex creatures, such as ourselves, come from the union of a cell from each of two parents. This is sexual reproduction. The cell formed by this union grows into a complete organism (containing, in a human, at least 1 000 000 000 000 or 10^{12} cells) by a cell division process called mitosis[⑤]. In multicellular organisms, cells multiply rapidly only during development and in response to tissue damage[⑥]. The rest of the time there is a balance between cell death and cell renewal.

Each time a cell divides it produces two cells of the same type. A human skin cell has to make another human skin cell, for example, and leaf cells must make more leaf cells, while bacteria produce more bacteria of the same species. The problem facing Virchow, Pasteur and their contemporaries was how to build on[⑦] the proof that cells come from other cells and show how the particular characteristics of each cell type were transmitted when the cells multiplied.

Most cells are too small to be seen with the naked eye, so much laboratory time was spent peering at them through microscopes. The new biochemists seized upon the intensely coloured dyes, such as Perkin's Mauve[⑧], which were being turned out by the fledgling[⑨] German chemical industry. These

① microbe：微生物
② binary fission：二分裂
③ under：less than
④ asexual reproduction：无性繁殖
⑤ mitosis：(细胞)有丝分裂
⑥ in response to tissue damage：when tissue damage occurs/in case of tissue damage
⑦ build on：find
⑧ Mauve：苯胺紫染料
⑨ fledgling：newly developed

stains helped to reveal the inner structure of cells. This, together with improvements in the optics of the microscope, showed that many cells have a central core known as the nucleus① (first observed in 1831). Just prior to Miescher's discovery of DNA, the German scientist Ernst Haeckel had suggested that the nucleus was of key importance in passing on characteristics from one generation to the next.

Miescher had a particular interest in the chemical contents of cells. Every morning he would call at the local clinic to pick up used bandages. In the days before antiseptics②, these would be soaked in pus and Miescher had discovered that the large nuclei of the white blood cells it contained were ideal for his studies.

It was in these nuclei that Miescher discovered a new substance in 1869. It appeared only when he added an alkaline③ solution to his cells. Looking under the microscope he saw that this treatment made the nuclei burst open, releasing their contents. So he called the new substance nuclein④, on the assumption that⑤ it came from the nucleus.

Analysis of nuclein showed that it was an acid, and that it contained phosphorus⑥. These findings suggested that nuclein did not fit into any of the known groups of chemicals that are found in cells, such as proteins, carbohydrates and lipids⑦. Miescher went on to show that nuclein was present in many other cells. Later, nuclein was renamed nucleic acid, and we now know it as DNA.

Miescher became particularly interested in sperm⑧ cells from Rhine salmon⑨, because nuclei account for more than 90% of the cell mass in that type of cell (in later life Miescher's attention shifted back to the whole organism and he became interested in the conservation of Rhine salmon). In these experiments, Miescher also extracted a simple protein, protamine⑩, from the

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① nucleus：细胞核，(复) nuclei
② antiseptic：防腐剂
③ alkaline：碱性的
④ nuclein：核素、核质
⑤ on the assumption that：assuming that/on the supposition that/on the basis of
⑥ phosphorus：磷
⑦ lipid：脂类
⑧ sperm：精子
⑨ salmon：(莱茵河的)一种鲑鱼
⑩ protamine：鱼精蛋白

nucleus. Protamine is unique to sperm nuclei. In all other nuclei, a similar protein is found called histone①, first identified by the German chemist, Albrecht Kossel. It was therefore established that the nucleus contained both DNA and protein — but which of them was involved in the process of inheritance?

Picking up the threads② of inheritance

Meanwhile, the microscope was revealing more and more about the secret life of cells. In 1879, the German chemist Walther Flemming discovered tiny thread-like structures within the nucleus, made of a material that he called chromatin③ because it readily absorbed colour from the dyes used to stain cells and tissues. (Later these threads were named chromosomes.)

The stained chromosomes revealed the intimate details of mitosis to Flemming and others. They saw how the chromosomes double up, as if a copy of each has been provided by the cell. And then, just before the cell divides, the paired chromosomes split up, like a divorcing couple, with each eventually taking up residence in one of the two new cells produced by the cell division. So mitosis is accompanied by the delivery of a fresh set of chromosomes to each new cell.

Then sex was put under the microscope. Oskar Hertwig, working in the French Riviera in 1875, placed tiny drops of sea water containing eggs and sperm from the Mediterranean sea horse on a glass slide, focussed the lens on his microscope, and then sat back to watch the action. He missed the moment of fertilisation — when sperm and egg cells meet — but saw their two nuclei fuse together and then begin to divide.

Eight years later Edouard van Beneden, at the University of Liège, saw that chromosomes from sperm and egg mingled④ during the fertilisation of

① histone：组蛋白
② threads：(referring to) thread-like structures
③ chromatin：染色质
④ mingled：mixed/merged

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