



# Biochemistry

**T . A . B R O W N**

Manchester Institute of Biotechnology  
Faculty of Life Sciences, University of Manchester, UK



Scion

---

© **Scion Publishing Limited, 2016**

First published 2016

All rights reserved. No part of this book may be reproduced or transmitted, in any form or by any means, without permission.

A CIP catalogue record for this book is available from the British Library.

ISBN 978 1 907904 28 8

---

### **Scion Publishing Limited**

The Old Hayloft, Vantage Business Park, Bloxham Road, Banbury OX16 9UX, UK  
[www.scionpublishing.com](http://www.scionpublishing.com)

### **Important Note from the Publisher**

The information contained within this book was obtained by Scion Publishing Ltd from sources believed by us to be reliable. However, while every effort has been made to ensure its accuracy, no responsibility for loss or injury whatsoever occasioned to any person acting or refraining from action as a result of information contained herein can be accepted by the authors or publishers.

Readers are reminded that medicine is a constantly evolving science and while the authors and publishers have ensured that all dosages, applications and practices are based on current indications, there may be specific practices which differ between communities. You should always follow the guidelines laid down by the manufacturers of specific products and the relevant authorities in the country in which you are practising.

Although every effort has been made to ensure that all owners of copyright material have been acknowledged in this publication, we would be pleased to acknowledge in subsequent reprints or editions any omissions brought to our attention.

Registered names, trademarks, etc. used in this book, even when not marked as such, are not to be considered unprotected by law.

# Detailed contents

---

Preface.....	12
Abbreviations.....	12
How to use this book.....	12
<b>CHAPTER 1 Biochemistry in the modern world.....</b>	<b>1</b>
<b>1.1 What is biochemistry?.....</b>	<b>1</b>
1.1.1 Biochemistry is a central part of biology.....	2
1.1.2 Chemistry is also important in biochemistry.....	3
<b>Box 1.1 The origins of biochemistry.....</b>	<b>5</b>
<b>Box 1.2 Schrödinger and biology.....</b>	<b>5</b>
1.1.3 Biochemistry involves the study of very large biomolecules.....	6
<b>Box 1.3 Atoms, isotopes and molecular masses.....</b>	<b>6</b>
1.1.4 Biochemistry is also the study of metabolism.....	7
1.1.5 The storage and utilization of biological information is an important part of biochemistry.....	10
1.1.6 Biochemistry is an experimental science.....	11
<b>Box 1.4 'Omics are collections of biomolecules.....</b>	<b>11</b>
Further reading.....	12

## **PART 1 Cells, organisms and biomolecules**

<b>CHAPTER 2 Cells and organisms.....</b>	<b>13</b>
<b>2.1 Cells - the building blocks of life.....</b>	<b>13</b>
<b>Box 2.1 Units of measurement.....</b>	<b>14</b>
2.1.1 There are two different types of cell structure.....	14
<b>Box 2.2 Species names.....</b>	<b>15</b>
2.1.2 Prokaryotes.....	15
<b>Box 2.3 Bacteria communicate with one another in a biofilm.....</b>	<b>18</b>
<b>Box 2.4 The microbiome.....</b>	<b>19</b>
2.1.3 Eukaryotes.....	19
2.1.4 What about viruses?.....	25
<b>Box 2.5 Unusual types of infectious particles.....</b>	<b>25</b>
<b>2.2 Evolution and the unity of life.....</b>	<b>26</b>
2.2.1 Life originated four billion years ago.....	26

2.2.2	Three and a half billion years of evolution	28
<b>Box 2.6</b>	Mass extinction events	30
	Further reading	31
	Self-assessment questions	31
<b>CHAPTER 3</b>	<b>Proteins</b>	35
<b>3.1</b>	<b>Proteins are made of amino acids</b>	36
3.1.1	Twenty different amino acids are used to make proteins	36
3.1.2	The biochemical features of amino acids	36
<b>Box 3.1</b>	Are there two versions of every amino acid?	39
<b>Box 3.2</b>	The ionization of water and the pH scale	40
3.1.3	Some amino acids are modified after protein synthesis	43
<b>Box 3.3</b>	Types of chemical bond	44
<b>3.2</b>	<b>The primary and secondary levels of protein structure</b>	45
3.2.1	Polypeptides are polymers of amino acids	45
3.2.2	Polypeptides can take up regular conformations	47
<b>Box 3.4</b>	The unusual characteristics of the peptide bond	47
<b>Box 3.5</b>	What is the difference between a left-handed and a right-handed helix?	49
<b>Box 3.6</b>	Predicting the secondary structure of polypeptide from its amino acid sequence	49
<b>3.3</b>	<b>Fibrous and globular proteins</b>	50
3.3.1	Fibrous proteins: keratin, collagen and silk	50
3.3.2	Globular proteins have tertiary and possibly quaternary structures	52
<b>Box 3.7</b>	Using collagen structure to identify extinct animals	53
<b>Box 3.8</b>	An example of a protein with a mixture of domains	56
<b>3.4</b>	<b>Protein folding</b>	56
3.4.1	Small proteins fold spontaneously into their correct tertiary structures	56
3.4.2	Protein folding pathways	56
<b>Box 3.9</b>	Studying protein folding	58
3.4.3	Protein folding is one of the fundamental principles of biology	59
	Further reading	61
	Self-assessment questions	61
<b>CHAPTER 4</b>	<b>Nucleic acids</b>	00
<b>4.1</b>	<b>The structures of DNA and RNA</b>	00
4.1.1	Polynucleotide structure	00

4.1.2	DNA and RNA secondary structures	00
<b>Box 4.1</b>	Base stacking	00
<b>Box 4.2</b>	The discovery of the double helix	00
<b>Box 4.3</b>	Sugar pucker	00
<b>Box 4.4</b>	Units of length for nucleic acid molecules	00
4.1.3	RNAs display a diverse range of chemical modifications	00
<b>4.2</b>	<b>Packaging of DNA</b>	00
4.2.1	Nucleosomes and chromatin fibers	00
<b>Box 4.5</b>	DNA packaging in bacteria	00
	Further reading	00
	Self-assessment questions	00
<b>CHAPTER 5</b>	<b>Lipids and biological membranes</b>	00
<b>5.1</b>	<b>Lipid structures</b>	00
5.1.1	Fatty acids and their derivatives	00
<b>Box 5.1</b>	Structural notation for fatty acids	00
<b>Box 5.2</b>	Essential fatty acids	00
5.1.2	Diverse lipids with diverse functions	00
<b>Box 5.3</b>	Polyterpenes	00
<b>Box 5.4</b>	Prostaglandins	00
<b>5.2</b>	<b>Biological membranes</b>	00
5.2.1	Membrane structure	00
<b>Box 5.5</b>	The carbohydrate component of a membrane	00
5.2.2	Membranes as selective barriers	00
<b>Box 5.6</b>	Voltage-gated ion channels and nerve impulses	00
<b>Box 5.7</b>	The biochemistry of cystic fibrosis	00
	Further reading	00
	Self-assessment questions	00
<b>CHAPTER 6</b>	<b>Carbohydrates</b>	00
<b>6.1</b>	<b>Monosaccharides, disaccharides and oligosaccharides</b>	00
6.1.1	Monosaccharides are the building blocks of carbohydrates	00
<b>Box 6.1</b>	Representations of monosaccharide structures	00
<b>Box 6.2</b>	The different types of isomers relevant to carbohydrate structure	00
6.1.2	Disaccharides are made by linking together pairs of monosaccharides	00
<b>Box 6.3</b>	Some humans have recently evolved the ability to digest milk	00
6.1.3	Oligosaccharides are short monosaccharide polymers	00

<b>6.2 Polysaccharides</b> .....	00
6.2.1 Starch, glycogen, cellulose and chitin are homopolysaccharides.....	00
<b>Box 6.4 The reducing and non-reducing ends of a starch molecule</b> ....	00
6.2.2 Heteropolysaccharides are found in the extracellular matrix and in bacterial cell walls.....	00
Further reading .....	00
Self-assessment questions .....	00

## PART 2 Energy generation and metabolism

<b>CHAPTER 7 Enzymes</b> .....	00
<b>7.1 What is an enzyme?</b> .....	00
7.1.1 Most enzymes are proteins.....	00
7.1.2 Some enzymes require cofactors .....	00
<b>Box 7.1 Metalloproteins and metalloenzymes</b> .....	00
7.1.3 Enzymes are classified according to their function.....	00
<b>Box 7.2 Oxidation and reduction reactions</b> .....	00
<b>7.2 How enzymes work</b> .....	00
7.2.1 Enzymes are biological catalysts.....	00
<b>Box 7.3 Reversible reactions</b> .....	00
<b>Box 7.4 The specificity of substrate binding</b> .....	00
7.2.2 Factors influencing the rate of an enzyme-catalyzed reaction .....	00
<b>Box 7.5 Exploiting thermostable enzymes in biofuel production</b> .....	00
<b>Box 7.6 The Michaelis–Menten equation</b> .....	00
7.2.3 Inhibitors and their effects on enzymes.....	00
<b>Box 7.7 Allosteric enzymes</b> .....	00
Further reading.....	00
Self-assessment questions.....	00
<b>CHAPTER 8 Energy generation: glycolysis</b> .....	00
<b>8.1 An overview of energy generation</b> .....	00
<b>Box 8.1 Units of energy</b> .....	00
8.1.1 Activated carrier molecules store energy for use in biochemical reactions .....	00
8.1.2 Biochemical energy generation is a two-stage process.....	00
<b>8.2 Glycolysis</b> .....	00
8.2.1 The glycolytic pathway.....	00
<b>Box 8.2 Biochemical synthesis of ATP</b> .....	00

8.2.2	Glycolysis in the absence of oxygen.....	00
<b>Box 8.3</b>	<b>Aerobes and anaerobes</b> .....	00
8.2.3	Glycolysis starting with sugars other than glucose .....	00
8.2.4	Regulation of glycolysis.....	00
<b>Box 8.4</b>	<b>Why is phosphofructokinase regulated by AMP and not ADP?</b> ..	00
<b>Box 8.5</b>	<b>Control of fructose 6-phosphate levels by glucagon</b> .....	00
	Further reading.....	00
	Self-assessment questions.....	00
<b>CHAPTER 9</b>	<b>Energy generation: the TCA cycle and electron transport chain</b> .....	00
<b>9.1</b>	<b>The TCA cycle</b> .....	00
9.1.1	The entry of pyruvate into the TCA cycle .....	00
<b>Box 9.1</b>	<b>Identification of the mitochondrial pyruvate carrier protein</b> ..	00
9.1.2	The steps of the TCA cycle.....	00
<b>Box 9.2</b>	<b>Succinyl CoA synthetases</b> .....	00
9.1.3	Regulation of the TCA cycle .....	00
<b>9.2</b>	<b>The electron transport chain and the synthesis of ATP</b> .....	00
9.2.1	Energy is released as electrons are passed along the electron transport chain.....	00
<b>Box 9.3</b>	<b>Redox potential</b> .....	00
9.2.2	The structure and function of the electron transport chain .....	00
<b>Box 9.4</b>	<b>The location of the electron transport chain</b> .....	00
9.2.3	Synthesis of ATP .....	00
<b>Box 9.5</b>	<b>Why is a protein that makes ATP called an ATPase?</b> .....	00
<b>Box 9.6</b>	<b>The rotation of the F<sub>0</sub>F<sub>1</sub> ATPase</b> .....	00
9.2.4	Inhibitors and uncouplers of the electron transport chain .....	00
9.2.5	Cytoplasmic NADH cannot gain access to the electron transport chain .....	00
<b>Box 9.7</b>	<b>The smell of skunk cabbage</b> .....	00
	Further reading.....	00
	Self-assessment questions.....	00
<b>CHAPTER 10</b>	<b>Photosynthesis</b> .....	00
<b>10.1</b>	<b>An overview of photosynthesis</b> .....	00
10.1.1	Photosynthesis is the light-driven production of carbohydrates.....	00
10.1.2	Photosynthesis occurs in specialized organelles .....	00
<b>10.2</b>	<b>The light reactions</b> .....	00
10.2.1	Sunlight is harvested by photosynthetic pigments .....	00
<b>Box 10.1</b>	<b>Fall colors</b> .....	00

	<b>Box 10.2</b> Atomic orbitals.....	00
	<b>Box 10.3</b> The role of carotenoid pigments in photoprotection .....	00
	10.2.2 Electron transport and photophosphorylation .....	00
	<b>Box 10.4</b> The Z scheme.....	00
	<b>Box 10.5</b> Photosynthesis in bacteria .....	00
<b>10.3</b>	<b>The dark reactions</b> .....	00
	10.3.1 The Calvin cycle.....	00
	10.3.2 Synthesis of sucrose and starch.....	00
	10.3.3 Carbon fixation by C4 and CAM plants .....	00
	<b>Box 10.6</b> Increasing the photosynthetic capability of crop plants.....	00
	Further reading.....	00
	Self-assessment questions.....	00
	<b>CHAPTER 11 Carbohydrate metabolism</b> .....	00
<b>11.1</b>	<b>Glycogen metabolism</b> .....	00
	11.1.1 Synthesis and degradation of glycogen .....	00
	11.1.2 Control of glycogen metabolism.....	00
	<b>Box 11.1</b> Blood sugar.....	00
	<b>Box 11.2</b> Avoiding a futile cycle.....	00
	<b>Box 11.3</b> Control of glycogen metabolism by calcium.....	00
	<b>Box 11.4</b> Allosteric control of glycogen metabolism in liver cells.....	00
<b>11.2</b>	<b>Gluconeogenesis</b> .....	00
	11.2.1 The gluconeogenesis pathway .....	00
	<b>Box 11.5</b> The energy budget for gluconeogenesis.....	00
	11.2.2 Regulation of gluconeogenesis .....	00
<b>11.3</b>	<b>The pentose phosphate pathway</b> .....	00
	11.3.1 The oxidative and non-oxidative phases of the pentose phosphate pathway.....	00
	<b>Box 11.6</b> Did Pythagoras ban the broad bean because of the pentose phosphate pathway?.....	00
	Further reading.....	00
	Self-assessment questions.....	00
	<b>CHAPTER 12 Lipid metabolism</b> .....	00
<b>12.1</b>	<b>Synthesis of fatty acids and triacylglycerols</b> .....	00
	12.1.1 Fatty acid synthesis.....	00
	<b>Box 12.1</b> The energy requirement for fatty acid synthesis .....	00
	12.1.2 Triacylglycerol synthesis.....	00
	<b>Box 12.2</b> Lipoproteins .....	00



<b>12.2</b>	<b>Breakdown of triacylglycerols and fatty acids</b>	00
12.2.1	Breakdown of triacylglycerols into fatty acids and glycerol	00
12.2.2	Breakdown of fatty acids	00
	<b>Box 12.3</b> The Greek notation for fatty acid structure	00
	<b>Box 12.4</b> The glyoxylate cycle	00
	<b>Box 12.5</b> The biochemistry of <i>Lorenzo's Oil</i>	00
<b>12.3</b>	<b>Synthesis of cholesterol and its derivatives</b>	00
12.3.1	Synthesis and degradation of cholesterol	00
12.3.2	Synthesis of cholesterol derivatives	00
	Further reading	00
	Self-assessment questions	00
<b>CHAPTER 13 Nitrogen metabolism</b>		00
<b>13.1</b>	<b>Synthesis of ammonia from inorganic nitrogen</b>	00
13.1.1	Nitrogen fixation	00
	<b>Box 13.1</b> Nitrogen fixation by symbiotic cyanobacteria	00
13.1.2	Nitrate reduction	00
<b>13.2</b>	<b>Synthesis of nitrogen containing biochemicals</b>	00
13.2.1	Synthesis of amino acids	00
	<b>Box 13.2</b> Synthesis of the correct enantiomer of glutamate	00
	<b>Box 13.3</b> Genetically modified crops that are resistant to a herbicide that disrupts aromatic amino acid synthesis	00
13.2.2	Synthesis of nucleotides	00
	<b>Box 13.4</b> Nucleotide synthesis is a target for cancer chemotherapy	00
13.2.3	Tetrapyrrole synthesis	00
<b>13.3</b>	<b>Degradation of nitrogen-containing compounds</b>	00
13.3.1	Degradation of amino acids	00
13.3.2	The urea cycle	00
	<b>Box 13.5</b> Diseases associated with defects in nitrogen metabolism	00
	Further reading	00
	Self-assessment questions	00

**PART 3 Storage of biological information and synthesis of proteins**

<b>CHAPTER 14 DNA replication and repair</b>		00
<b>14.1</b>	<b>DNA replication</b>	00
14.1.1	Initiation of DNA replication	00
14.1.2	The elongation phase of DNA replication	00
	<b>Box 14.1</b> Supercoiled DNA	00

	<b>Box 14.2</b>	DNA polymerases .....	00
	<b>Box 14.3</b>	Why does a DNA polymerase require a primer? .....	00
	14.1.3	Termination of replication .....	00
	<b>Box 14.4</b>	The interaction between Tus proteins and the replisome .....	00
	<b>Box 14.5</b>	Telomerase and cancer .....	00
<b>14.2</b>	<b>DNA repair</b> .....		00
	14.2.1	Correcting errors in DNA replication .....	00
	<b>Box 14.6</b>	Base tautomerism can result in replication errors.....	00
	14.2.2	Repair of damaged nucleotides .....	
	<b>Box 14.7</b>	Photoreactivation repair of cyclobutyl dimers.....	00
	<b>Box 14.8</b>	Defects in DNA repair underlie a number of important human diseases .....	00
	14.2.3	Repair of DNA breaks .....	00
		Further reading.....	00
		Self-assessment questions.....	00
	<b>CHAPTER 15</b>	<b>RNA synthesis</b> .....	00
<b>15.1</b>	<b>Transcription of DNA into RNA</b> .....		00
	15.1.1	Coding and noncoding RNAs .....	00
	15.1.2	Initiation of transcription .....	00
	<b>Box 15.1</b>	Promoters for RNA polymerase I and RNA polymerase III.....	00
	15.1.3	The RNA synthesis phase of transcription .....	00
	<b>Box 15.2</b>	Rifamycins are important antibiotics that block bacterial RNA synthesis .....	00
	15.1.4	Termination of transcription.....	00
<b>15.2</b>	<b>RNA processing</b> .....		00
	15.2.1	Processing of noncoding RNA by cutting and end-trimming ..	00
	<b>Box 15.3</b>	Density gradient centrifugation.....	00
	15.2.2	Removal of introns from eukaryotic pre-mRNA .....	00
	<b>Box 15.4</b>	Transesterification .....	00
	<b>Box 15.5</b>	The 'minor spliceosome' .....	00
	<b>Box 15.6</b>	Alternative splicing.....	00
	15.2.3	Chemical modification of noncoding RNA.....	00
		Further reading.....	00
		Self-assessment questions.....	00
	<b>CHAPTER 16</b>	<b>Protein synthesis</b> .....	00
<b>16.1</b>	<b>The genetic code</b> .....		00
	16.1.1	The features of the genetic code .....	00
	16.1.2	How the genetic code is enforced during protein synthesis ...	00

	<b>Box 16.1</b>	The notation for distinguishing between different tRNAs.....	00
	<b>Box 16.2</b>	Wobble and alternative initiation codons .....	00
<b>16.2</b>	<b>The mechanics of protein synthesis .....</b>		<b>00</b>
	16.2.1	Ribosomes.....	00
	16.2.2	Translation of an mRNA into a polypeptide .....	00
	<b>Box 16.3</b>	Internal ribosome entry sites – initiation of eukaryotic translation without scanning.....	00
	<b>Box 16.4</b>	Antibiotics that target the bacterial ribosome.....	00
<b>16.3</b>	<b>Post-translational processing of proteins.....</b>		<b>00</b>
	16.3.1	Processing by proteolytic cleavage .....	00
	<b>Box 16.5</b>	Synthesis of the Gag and Gag–Pol polyproteins .....	00
	16.3.2	Chemical modification of proteins.....	00
<b>16.4</b>	<b>Protein targeting .....</b>		<b>00</b>
	16.4.1	The role of sorting sequences in protein targeting.....	00
	<b>Box 16.6</b>	Protein targeting in bacteria.....	00
		Further reading.....	00
		Self-assessment questions.....	00
<b>CHAPTER 17 Control of gene expression .....</b>			<b>00</b>
<b>17.1</b>	<b>Regulation of the gene expression pathway.....</b>		<b>00</b>
	17.1.1	Regulation of the initiation of transcription in bacteria .....	00
	<b>Box 17.1</b>	Transcriptomics – studying changes in gene expression patterns .....	00
	<b>Box 17.2</b>	The allolactose paradox.....	00
	<b>Box 17.3</b>	Repressible operons .....	00
	17.1.2	Regulation of the initiation of transcription in eukaryotes .....	00
	<b>Box 17.4</b>	Zinc fingers .....	00
	17.1.3	Gene regulation after transcript initiation .....	00
<b>17.2</b>	<b>Degradation of mRNA and protein .....</b>		<b>00</b>
	17.2.1	RNA degradation.....	00
	17.2.2	Degradation of proteins.....	00
	<b>Box 17.5</b>	Protein and mRNA half-lives .....	00
		Further reading.....	00
		Self-assessment questions.....	00

**PART 4 Studying biomolecules**

<b>CHAPTER 18 Studying proteins, lipids and carbohydrates.....</b>			<b>00</b>
<b>18.1</b>	<b>Methods for studying proteins.....</b>		<b>00</b>
	18.1.1	Methods for identifying the presence of an individual protein...	00

<b>Box 18.1</b>	Immunoglobulins and antibody diversity .....	00
<b>Box 18.2</b>	Electrophoresis .....	00
18.1.2	Studying a proteome .....	00
<b>Box 18.3</b>	Chromatography.....	00
18.1.3	Studying the structure of a protein .....	00
<b>Box 18.4</b>	Circularly polarized light.....	00
<b>Box 18.5</b>	Interpreting an NMR spectrum .....	00
<b>18.2</b>	<b>Studying lipids and carbohydrates</b> .....	00
<b>Box 18.6</b>	Metabolomics .....	00
18.2.1	Methods for studying lipids .....	00
18.2.2	Studying carbohydrates .....	00
	Further reading.....	00
	Self-assessment questions.....	00
<b>CHAPTER 19</b>		
	<b>Studying DNA and RNA</b> .....	00
<b>19.1</b>	<b>Manipulation of DNA and RNA by purified enzymes</b> .....	00
19.1.1	Types of enzyme used to study DNA and RNA.....	00
<b>Box 19.1</b>	What is 'restriction'?.....	00
19.1.2	The polymerase chain reaction.....	00
<b>Box 19.2</b>	Using PCR to alter the codons in a gene.....	00
<b>19.2</b>	<b>DNA sequencing</b> .....	00
19.2.1	Methodology for DNA sequencing.....	00
19.2.2	Next generation sequencing.....	00
<b>Box 19.3</b>	Did Neanderthals and modern humans meet and interbreed? ..	00
<b>19.3</b>	<b>DNA cloning</b> .....	00
19.3.1	Methods for DNA cloning .....	00
<b>Box 19.4</b>	Integration of a yeast plasmid into a chromosome .....	00
19.3.2	Using DNA cloning to obtain recombinant protein .....	00
<b>Box 19.5</b>	Synthesis of recombinant factor VIII protein .....	00
	Further reading.....	00
	Self-assessment questions.....	00

# Abbreviations

---

<b>ACP</b>	acyl carrier protein	<b>PADP</b>	polyadenylate-binding protein
<b>AIDS</b>	acquired immunodeficiency syndrome	<b>PCNA</b>	proliferating cell nuclear antigen
<b>ALA</b>	$\delta$ -aminolevulinat	<b>PCR</b>	polymerase chain reaction
<b>ATP</b>	adenosine 5'-triphosphate	<b>PNPase</b>	polynucleotide phosphorylase
<b>CAP</b>	catabolite activator protein	<b>PRPP</b>	phosphoribosyl pyrophosphate
<b>CD</b>	circular dichroism	<b>PSE</b>	proximal sequence element
<b>cDNA</b>	complementary DNA	<b>qPCR</b>	quantitative PCR
<b>CF</b>	cystic fibrosis	<b>RISC</b>	RNA-induced silencing complex
<b>CFTR</b>	cystic fibrosis transmembrane regulator	<b>RNA</b>	ribonucleic acid
<b>CIEP</b>	crossover immunoelectrophoresis	<b>RRF</b>	ribosome recycling factor
<b>CPSF</b>	cleavage and polyadenylation specifying factor	<b>rRNA</b>	ribosomal RNA
<b>CRE</b>	cAMP response element	<b>scRNA</b>	small cytoplasmic RNA
<b>CREB</b>	cAMP response element binding	<b>SDS</b>	sodium dodecyl sulfate
<b>CstF</b>	cleavage stimulation factor	<b>SDS-PAGE</b>	sodium dodecyl sulfate polyacrylamide gel electrophoresis
<b>CTD</b>	C-terminal domain	<b>siRNA</b>	small interfering RNA
<b>ddNTPs</b>	dideoxynucleotides	<b>snoRNA</b>	small nucleolar RNA
<b>DNA</b>	deoxyribonucleic acid	<b>snRNA</b>	small nuclear RNA
<b>DNase I</b>	deoxyribonuclease I	<b>snRNP</b>	small nuclear ribonucleoprotein
<b>EGFR</b>	epidermal growth factor receptor	<b>SRP</b>	signal recognition particle
<b>ELISA</b>	enzyme-linked immunosorbent assay	<b>SSB</b>	single strand binding protein
<b>HAT</b>	histone acetyltransferase	<b>STATs</b>	signal transducers and activators of transcription
<b>HDAC</b>	histone deacetylase	<b>TAF</b>	TBP-associated factor
<b>HIV</b>	human immunodeficiency virus	<b>TBP</b>	TATA-binding protein
<b>HPLC</b>	high performance liquid chromatography	<b>TFIID</b>	transcription factor IID
<b>HRP</b>	horseradish peroxidase	<b>TIM</b>	translocator inner membrane
<b>ICATs</b>	isotope-coded affinity tags	<b>TOM</b>	translocator outer membrane
<b>IPTG</b>	isopropyl- $\beta$ -D-thiogalactoside	<b>tRNA</b>	transfer RNA
<b>IRES</b>	internal ribose entry site	<b>UBF</b>	upstream binding factor
<b>ITAF</b>	IRES trans-acting factor	<b>UCE</b>	upstream control element
<b>JAKs</b>	Janus kinases	<b>UTR</b>	untranslated region
<b>MALDI-TOF</b>	matrix-assisted laser desorption ionization time of flight		
<b>MAP</b>	mitogen activated protein		
<b>miRNA</b>	microRNA		
<b>mRNA</b>	messenger RNA		
<b>NHEJ</b>	nonhomologous end-joining		
<b>NMR</b>	nuclear magnetic resonance		
<b>ORF</b>	open reading frame		