

# Wheat Science and Trade



Brett F. Carver

**Wheat**  
**Science and Trade**



# Wheat Science and Trade

Edited by

**Brett F. Carver**

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# Dedication

to  
Paul Jackson, Jr., and Henry Jo Von Tungeln,  
for their lifetime and relentless dedication  
to furthering the science and trade of wheat,  
so all might prosper.



# Contents

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<b>Foreword</b>	<b>xvii</b>	The potential of wild emmer in wheat improvement	21
<b>Preface</b>	<b>xix</b>	Concluding remarks on the process of wheat evolution	22
<b>Acknowledgements</b>	<b>xxi</b>	Future perspectives	23
<b>Contributors</b>	<b>xxiii</b>	References	23
<b>Section I: Making of a Wheat Plant</b>	<b>3</b>	<b>2 Development of the wheat plant</b>	<b>31</b>
<b>1 Wheat evolution, domestication, and improvement</b>	<b>5</b>	Summary	31
Summary	5	Introduction	31
Introduction	5	Scales of plant development	32
Wheat domestication and human civilization	6	Canopies	32
Wheat cultivation	7	Shoots or tillers	33
Origin, domestication, and evolution of wheat	8	Phytomers	33
Polyploidy, a form of plant evolution	8	Morphological naming schemes	34
Origin of the A genome	10	Leaves	34
Origin of the B genome	10	Tillers	34
Emmer and durum wheat	11	Inflorescence parts	35
Origin of <i>Triticum turgidum</i>	11	Roots	35
Origin of <i>Triticum dicoccoides</i> (wild emmer)	11	Shoot development	35
Origin of hexaploid wheat	14	Phenology	36
Genome evolution and modification	16	Shoot apex	39
Mechanisms for chromosome evolution	18	Integrating phenology, the shoot apex, and phytomers	42
Chromosomal rearrangements and repetitive DNA	18	Environmental factors influencing shoot development	42
Heterochromatin	18	Temperature	43
Repetitive DNA	19	Nontemperature environmental factors	45
Repatterning of rDNA arrays in the wheat genome	20	Digital technologies for wheat development	47
Repetitive DNA and mobile elements as perpetual generators of diversity and evolution	21	Linking molecular biology and functional genomics to development	49
		Future perspectives	50
		References	50

<b>3 The flowering pathway in wheat</b>	<b>57</b>	<b>Section II: Making of a Wheat Crop</b>	<b>73</b>
Summary	57	<b>4 Systems-based wheat management strategies</b>	<b>75</b>
Overview of flowering induction in wheat	57	Summary	75
Genetic locations of flowering time genes	58	Introduction	75
Genetic loci regulating vernalization response	58	Advances in wheat management	75
<i>VRN-1</i> on the long arm of homoeologous chromosomes 5	58	Yield building versus yield protecting factors	75
<i>VRN-A<sup>m</sup>2</i> on chromosome 5A <sup>m</sup> in a genomic region translocated from chromosome 4A <sup>m</sup>	59	Intensive wheat management	76
<i>VRN-B3</i> on the short arm of chromosome 7B	59	Matching cultivar to environment	76
Other vernalization genes in wheat	60	Fertility and pest management	77
Genetic loci regulating photoperiod sensitivity	60	Timeliness and precision	78
Genetic loci regulating plant development processes	60	Previous crop management	78
Quantitative trait loci affecting flowering time	61	Limitations of the system	79
Epistatic interactions	61	Dual-purpose wheat	79
Positional cloning of flowering time genes in wheat	61	Description of the system and area of adaptation	79
<i>VRN-A<sup>m</sup>1</i> , an orthologue of <i>API</i> , promotes flowering	61	Characterizing a suitable dual-purpose cultivar	80
<i>VRN-A<sup>m</sup>2</i> , a CCT-domain-containing gene, represses flowering	62	Fertility management	80
<i>VRN-B3</i> , an orthologue of <i>FT</i> , promotes flowering	63	Grazing termination and impact on grain yield	81
Successes in positional cloning of vernalization genes	63	No-till wheat production	82
Orthologues of other known flowering time genes	64	Why no-till has increased	82
Concomitant transcriptional profiles of flowering time genes	64	Long-term experiments	84
Comparative studies on flowering pathways in plants	65	Future perspectives	84
Flowering pathways in model species	65	References	86
A model for the wheat flowering pathway	66	<b>5 Diseases which challenge global wheat production—the wheat rusts</b>	<b>89</b>
Future perspectives	67	Summary	89
References	68	Introduction	90
		Wheat leaf rust	90
		Distribution and epidemiology	90
		Origin and historical importance	91
		Effects on grain and flour quality	92
		Taxonomy, life cycle, and host range	93
		Genetic variation in <i>P. triticina</i>	94
		Virulence variation	94
		Molecular variation	95
		Leaf rust resistance in wheat	96
		Race-specific resistance	96
		Durable leaf rust resistance in wheat	98
		Association with other disease resistance genes	100

Leaf rust resistance in durum wheat	101	Symptoms and epidemiology	137
Wheat stripe rust	102	Causal organism	137
Distribution and epidemiology	102	Disease management	138
Origin and historical importance	103	Cephalosporium stripe	139
Taxonomy, life cycle, and host range	104	Symptoms and epidemiology	139
Genetic variation in <i>Puccinia striiformis</i> f. sp. <i>tritici</i>	105	Causal organism	140
Virulence variation	105	Disease management	140
Molecular variation	106	Eyespot	141
Stripe rust resistance in wheat	107	Symptoms and epidemiology	141
Race-specific resistance	107	Causal organisms	141
High-temperature adult-plant resistance	108	Disease management	142
Slow-rusting resistance	109	Future perspectives	142
Wheat stem rust	109	References	144
Distribution and epidemiology	109		
Origin and historical importance	110		
Taxonomy, life cycle, and host range	112		
Genetic variation in <i>Puccinia graminis</i> f. sp. <i>tritici</i>	112		
Stem rust resistance in wheat	114		
Future perspectives	116		
References	117		
<b>6 Diseases which challenge global wheat production—root, crown, and culm rots</b>	<b>125</b>	<b>7 Diseases which challenge global wheat production—powdery mildew and leaf and head blights</b>	<b>155</b>
Summary	125	Summary	155
Introduction	125	Introduction	155
Common root rot	126	Powdery mildew	156
Symptoms and epidemiology	126	Taxonomy and life history	156
Causal organism	128	Identification and symptomology	156
Disease management	129	Distribution and losses	157
Fusarium crown rot	129	Pathogen variability	157
Symptoms and epidemiology	129	Stagonospora nodorum blotch	157
Causal organisms	130	Taxonomy and life history	157
Disease management	130	Identification and symptomology	157
Pythium root rot	131	Distribution and losses	158
Symptoms and epidemiology	132	Pathogen variability	158
Causal organisms	133	Septoria tritici blotch	158
Disease management	133	Taxonomy and life history	158
Rhizoctonia root rot and bare patch	134	Identification and symptomology	158
Symptoms and epidemiology	134	Distribution and losses	158
Causal organisms	135	Pathogen variability	159
Disease management	136	Tan spot	159
Take-all	136	Taxonomy and life history	159
		Identification and symptomology	159
		Distribution and losses	159
		Pathogen variability	160
		Fusarium head blight	160
		Taxonomy and life history	160
		Identification and symptomology	160
		Distribution and losses	161
		Pathogen variability	161
		Management of residue-borne diseases	161
		Crop diversity	161
		Host-plant resistance	161

Powdery mildew	161	<b>10 Temporally and spatially dependent nitrogen management for diverse environments</b>	<b>203</b>
Stagonospora nodorum blotch	162	Summary	203
Septoria tritici blotch	162	Introduction	203
Tan spot	163	Nitrogen-use efficiency as a driver of new technology	204
Fusarium head blight	163	Case study: What defines diverse environments	205
Future perspectives	163	Is nitrogen needed	206
References	164	Importance of spatial variability on N requirement	206
<b>8 Nematodes which challenge global wheat production</b>	<b>171</b>	Importance of temporal and spatial variability combined	207
Summary	171	Nutrient deficiencies other than N	209
Introduction	171	Prediction of yield potential	209
Cereal cyst nematode	172	Prediction of N responsiveness independent of yield potential	210
Symptoms and epidemiology	172	Midseason N applications can result in maximum yields	210
Causal organisms	173	Determination of midseason N rate	211
Management	174	“Ramp” method of determining midseason N rate	212
Root-lesion nematode	177	Future perspectives	213
Symptoms and epidemiology	177	References	213
Causal organisms	178	<b>11 Grain yield improvement in water-limited environments</b>	<b>215</b>
Management	179	Summary	215
Future perspectives	182	Introduction	215
References	183	Climate and crop growth	216
<b>9 Insects which challenge global wheat production</b>	<b>189</b>	Water-limited yield potential	218
Summary	189	Characterizing target environments	219
Hessian fly	189	Breeding for improved performance under drought	221
Economic impact and distribution	189	Yield potential and genetic gain in water-limited environments	221
Biology, plant damage, and control methods	190	Physiological breeding	223
Utilization of host-plant resistance	191	Breeding tools	224
Bird cherry–oat aphid	192	Indirect selection via correlated traits	224
Biology, plant damage, and control methods	192	High-throughput phenotyping	225
Utilization of host-plant resistance	193	Quantitative trait loci	227
Greenbug	194	Functional genomics and beyond	229
Economic impact and distribution	194	Defining the breeding target	231
Biology, plant damage, and control methods	194	Increasing water uptake	232
Utilization of host-plant resistance	195	Stem carbohydrate production	234
Russian wheat aphid	196	Tiller production	236
Economic impact and distribution	196	Early leaf area development	238
Biology, plant damage, and control methods	196		
Utilization of host-plant resistance	197		
Future perspectives	198		
References	199		

Transpiration efficiency	240	Variation from in vitro tissue culture	282
Maintenance of leaf area	242	Transgenic wheat and its impact on wheat breeding	282
Future perspectives	243	Methods to assess genetic variation	284
References	243	Methods of selecting while inbreeding to develop a cultivar	285
<b>12 Cutting down on weeds to cut a cleaner wheat crop</b>	<b>251</b>	Pedigree selection	286
Summary	251	Bulk selection	287
Impact of weeds on wheat	252	Single-seed descent	289
Competition	252	Doubled haploid breeding	291
Nutrients	252	Backcrossing	292
Light (shading)	252	Major issues all wheat breeders face	293
Water	253	Early- vs late-generation selection	293
Wheat grain yield	253	Impact of molecular markers on wheat breeding	294
Wheat grain quality and marketability	254	The practice of wheat breeding	296
Controlling weeds with integrated weed management systems	256	Extension of the theory	296
Preventative control	256	Cultivar release	299
Cultural control	257	Understanding the phenotype	299
Mechanical control by tillage	260	Breeding hybrid wheat	300
Chemical control	261	Importance of technology	301
Biological control	263	Future perspectives	301
Weed spatial variation and precision farming	263	Webliography	303
Putting it all together: Examples of effective systems	264	References	304
Winter wheat in North America: Winter wheat–summer crop–fallow	264	<b>14 State of QTL detection and marker-assisted selection in wheat improvement</b>	<b>309</b>
Spring wheat in North America	265	Summary	309
Spring wheat in Australia	266	Introduction	309
Future perspectives	268	Breeding by visual selection	310
References	268	Complex traits and gene pyramiding	311
<i>Section III: Making of a Wheat Cultivar</i>	<b>273</b>	Genetic mapping	311
<b>13 Wheat breeding: Procedures and strategies</b>	<b>275</b>	Early progress and developments	313
Summary	275	Genetic maps	313
Brief history of wheat breeding	276	Consensus map	314
The context of applied wheat breeding	277	Progress in marker technology	314
Accessing genetic resources	277	Current progress in QTL analysis and deployment of MAS	316
Methods to generate genetic variation	279	Single-gene traits and complex traits	316
Hybridization	279	Recurrent selection	316
Mutations	280	Replicated field analysis	317
		Haplotype analysis	318
		Gene cloning and perfect markers	318
		Complex traits	319
		Future developments and uses of QTL analysis and mapping	320

Association mapping	320	Sequencing the gene space using gene-enrichment methodologies	355
Gene expression analysis	321	New-generation sequencing technologies	357
Future perspectives	321	Future perspectives	357
References	322	References	359
<b>15 Genome organization and comparative genomics</b>	<b>327</b>	<b>16 Synthetic wheat—an emerging genetic resource</b>	<b>369</b>
Summary	327	Summary	369
Mapping	328	Introduction	369
Genetic mapping	328	Primary synthetic hexaploid wheat	371
Deletion mapping	329	New genetic variability for tolerance to biotic stress	371
Comparative genetics	330	Rust diseases	371
Comparative mapping	330	<i>Septoria</i> diseases and tan spot	372
Triticeae tribe	330	Karnal bunt	372
Pooideae subfamily	332	Fusarium and powdery mildew diseases	373
Poaceae family	332	Insect pests	373
Colinearity at the DNA sequence level	333	Soilborne nematodes	373
Map-based cloning	335	New genetic variability for tolerance to abiotic stress	374
Disease resistance genes	336	Drought	374
<i>Lr21</i>	337	Salinity and waterlogging	374
<i>Lr10</i>	337	Micronutrient imbalance	375
<i>Lr1</i>	338	Temperature stress	375
<i>Pm3</i>	338	Preharvest sprouting	376
Genes involved in adaptation	339	Grain quality attributes	376
<i>VRN-1</i> , <i>VRN-2</i> , and <i>VRN-3</i>	339	Strategies for using primary synthetics in applied wheat breeding	377
<i>Q</i>	341	Performance of derived synthetics	378
<i>Ph1</i>	341	Resistance to biotic stress	378
Physical mapping in hexaploid wheat	342	Tolerance to abiotic stress	378
Constructing subgenomic BAC resources	343	Future perspectives	380
Advantages of subgenomic BAC resources	346	References	381
Chromosome-based approach offers more than subgenomic BAC libraries	347	<b>17 Success in wheat improvement</b>	<b>387</b>
Physical map of chromosome 3B—a case study	348	Summary	387
Organization and evolution of the wheat genome	349	World yield gains	387
Organization of genes and repeats	350	Genetic component of grain yield improvement	388
Evolution of the wheat genome	352	Empirical estimation of genetic gain	389
Toward sequencing the wheat genome	353	Grain yield	389
Sanger sequencing	354	Yield components	391
Hierarchical genome sequencing	354	Wheat yield gains in light of other crops	392
Whole-genome shotgun sequencing	354	Future perspectives	393
Sequencing of gene-rich BAC clones	354	References	394

<b>18 Transgenic applications in wheat improvement</b>	<b>397</b>	Fundamental wheat classification criteria	444
Summary	397	US system of wheat classification	444
Introduction	398	Grade factors	444
Wheat transformation: Methods and results	398	Nongrade factors	446
Targets for wheat transformation	398	Moisture content	446
DNA delivery methods and integration	399	Protein content	446
Identification of transformants	401	Wheat ash content	446
Regeneration of fertile plants	404	Kernel weight	446
Efficiency of wheat transformation	404	Grain hardness	447
Applications of wheat transformation	404	Falling number	447
Promoters	405	Starch viscosity	447
Applications for functional genomics	406	Wet gluten content	447
Applications to understand or modify seed properties	408	Dough performance	448
Applications to improve pathogen and pest resistance	412	Product performance	449
Applications to improve tolerance of abiotic stress	414	Canadian system of classification and marketing	449
Other applications	415	Australian system of classification and marketing	450
Impacts on production agriculture	416	Purchasing decision making	450
Limitations of wheat transformation technology	418	Grain exchanges	451
Genotype	418	Open outcry system	452
Structures of integrated transgenes	418	Farmer to elevator	452
Integration location	421	Elevator to world	452
Inheritance anomalies	421	Future perspectives	453
Transgene expression levels and stability	422	References	454
Unintended effects of transformation, transgene insertion, or expression	423		
Practical considerations	424	<b>20 Passing the test on wheat end-use quality</b>	<b>455</b>
Future perspectives	424	Summary	455
References	426	Introduction	455
		Characteristics of major wheat-based foods	457
<i>Section IV: Making of a Wheat Industry</i>	<b>437</b>	Essential bread requirements	457
<b>19 Overview of wheat classification and trade</b>	<b>439</b>	Straight-dough processes	457
Summary	439	Sponge and dough and other pre-ferment processes	458
Introduction	439	High-volume bread types	458
World production	439	Steamed breads	459
Global wheat trade	440	Low-volume bread types	460
		Two-layered bread	460
		Single-layered bread	461
		Asian noodles	461
		Soft-bite noodles	462
		Hard-bite noodles	462
		Soft wheat products	462
		Cookies and crackers	462
		Cakes and batters	463
		Durum pasta	464

Compositional analysis and grain testing	465	Flat bread	499
Moisture	465	Yellow alkaline noodles	500
Protein content	466	White salted noodles	500
Kernel texture	466	Cookies (biscuits) and cakes	500
Grain soundness and $\alpha$ -amylase	468	Chinese steamed bread	500
Polyphenol oxidase	469	Starch-gluten manufacture	500
Test milling	470	Pasta	500
Grain and flour ash	470	Protein composition and wheat quality	500
Flour color	471	Dough quality and functional proteins	501
Speckiness	472	Dough quality and polypeptide composition	502
Starch and flour properties	472	Grain hardness	505
Total starch content	472	Starch pasting properties	505
Starch damage	472	Protein composition and genotype identification	505
Starch and flour paste viscosity and swelling power	472	Application of principles: Defects explained	505
Solvent retention capacity	475	Lipid composition and wheat quality	506
Dough testing and prediction of dough properties	476	Lipid composition and distribution	506
SDS sedimentation volume	476	Interaction with gluten proteins	508
Recording dough mixers	477	The role of flour lipids in baking	508
Measuring extensional properties of developed doughs	479	Dough structure and gas cell stabilization	509
Uniaxial extension	479	Starch composition and wheat quality	509
Biaxial extension	479	Amylose content	510
Other dough rheology tests	482	Starch granules	510
End-product testing	482	Gelatinization temperature	511
Emerging opportunities	483	Viscosity of starch	511
Spectroscopy	483	Swelling power	512
Cultivar identification	485	Nonstarch polysaccharide composition and wheat quality	512
Future perspectives	485	Flour color and wheat quality	513
References	486	Enzymes and wheat quality	514
<b>21 The biochemical and molecular basis of wheat quality</b>	<b>495</b>	Lipase and lipoxygenase	514
Summary	495	Polyphenol oxidase	515
Introduction	496	Peroxidase	515
Diversity of wheat utilization	496	Enzymes in sprouted or LMA-affected grain	515
The range of uses of wheat—western foods	496	Proteases	516
The range of uses of wheat—“exotic” foods	497	Selection for wheat quality in breeding	516
Industrial uses of wheat	497	Future perspectives	516
Processing specifications for wheat utilization	499	References	517
Pan bread	499		

<b>22 New uses for wheat and modified wheat products</b>	<b>521</b>	New market for wheat in ethanol industry	539
Summary	521	Soft and waxy wheat for ethanol production	541
Introduction	521	Feedstock criteria for ethanol production	541
White wheat	523	Evaluation techniques for feedstock and co-product quality	542
White wheat breeding	523	Recent advances in technology	542
Hard white wheat—consumer markets	525	Fermentation technology	542
Low polyphenol oxidase wheat	526	Processing technology	543
Altered starch	527	Future perspectives	543
Altered starch breeding	527	References	544
Waxy (amylose-free) wheat	527		
High-amylose wheat	527		
Sweet wheat	528		
Altered starch characteristics	528		
Unique waxy wheat flour properties	528		
Waxy wheat starch structure and properties	529		
High-amylose wheat	531		
Wheat phytochemicals	532	<b>23 US wheat marketing system and price discovery</b>	<b>551</b>
Phenolics	532	Summary	551
Carotenoids	533	Introduction	551
Vitamin E	534	Marketing system	551
Lignans	534	Price discovery and determination	552
$\beta$ -Glucan	535	Commodity futures exchanges	553
Phytosterols	535	Hedges	554
Dietary fiber, inulin, and resistant starch	536	Cash price relationships	555
Betaine	537	Physical flow of wheat	555
Industrial wheat	538	Cash prices	555
Breeding wheat for nonfood uses	538	Quality discounts and premiums	556
Wheat conversion to ethanol	539	Future perspectives	556
		Reference	556
		<b>Index</b>	<b>557</b>



# Foreword

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“No one can be a statesman who is entirely ignorant of the problems of wheat.” This statement from Socrates carries as much impact now, as when it was first uttered over two thousand years ago. Indeed just as the system of government of ancient Greece has become globalized, so too has their staple cereal. At around 680 million tonnes from 224 million hectares in 2008–2009, wheat is the world’s greatest source of food calories from the biggest crop area; it is the most widely consumed grain across all its diverse products, and the agricultural commodity most traded internationally (124 million tonnes).

When wheat price more than doubled in the year up to March 2008, alarm bells were ringing for politicians; eight months later it has fallen back to where it was, which although an alarming fall for farmers, marks a return to around the smoothed long-term trend price. This price in real terms is as low as wheat has ever been, resulting from the steady decline in the real price over the last 60 years, a huge bonus for consumers and world development, and a reflection of productivity growth based on science and technology. Reasonable wheat prices are vital for poor consumers; only productivity gains can deliver this and at the same time allow wheat farming to remain economically viable. Whether researchers can continue to achieve these gains—while doing so sustainably, including avoiding expansion of the world’s wheat area, and delivering better wheat products—is the subject of this book.

While cost reductions through input efficiencies per ton of grain are important, wheat productivity gains over the last 60 years largely reflect yield increase: world wheat yield has risen from 1.0 to 3.0 t ha<sup>-1</sup> in this period, and continues to

advance at about 1% per annum. Wheat occupies a very broad range of agroecologies, from favorable irrigated and high-rainfall environments to unfavorable, semiarid environments, yet generally similar relative progress, beginning in the developed world, has now been seen under almost all these circumstances. Underpinning this is a huge international research effort, spanning all aspects of genetic improvement and crop management.

At the beginning, this was based entirely in the public sector: the last 30 years has seen a significant shift to private-sector research, not just in agricultural chemicals and machinery, but also in variety delivery. For many obvious reasons yield must continue to grow, and to do so at better than the current 1%. While rural extension and yield gap closing are important in achieving this, vital will be wheat research investments at an intensity (research costs per value of product) at least as high as in the past, along with gains in research efficiency. Close communication and sharing of ideas and materials among wheat researchers, as is so evident in the chapters of this book, should engender efficiency gains, since the challenges are daunting for individual research teams and are often common around the world; achieving efficient private–public complementation remains another important goal.

Also evident is the fact that environmental issues and the industrial and nutritional quality of grain have become increasingly important for researchers and farmers alike. In the former area, progress has been made through yield increase itself, and through the gradual adoption of conservation tillage and more efficient input delivery to the crop. It is not helped by misguided notions

of low-input farming nor, at the other extreme, input subsidies and excessive price support. Driven by intense market competition, wheat industrial quality in major wheat exporting nations has probably been improved in the last 30 years as significantly as has yield itself. In developing countries, nutritional quality could assume greater importance as consumers have less opportunity to favorably supplement high-wheat diets. Many quality improvements are foreshadowed herein.

It is not clear how much yield could increase with better pest, nematode, disease, and weed control because modern agriculture invests heavily to keep these losses low (probably <10%); but losses could be higher in neglected parts of the developing world. Either way, the whole world needs less costly control methods, especially easy-to-incorporate and more durable host-plant resistance, which is probably the most fruitful field for transgene deployment. Although modern wheat fields are often deplored because of their apparent uniformity, the researcher knows that it is the underlying hidden genetic diversity, in the face of biotic and abiotic stresses, and the diversity of the management and cropping system,

which is the diversity that really counts. At the same time, the researcher must remain always vigilant against evolving biotic stress organisms. Over 25% of the book is devoted to biotic stresses of wheat.

Wheat is currently the premier food grain of the world, because of its versatility in production and use, and because of the huge body of research knowledge underpinning modern wheat production and marketing which can be seen here. Wheat is the grain crop *par excellence* of the vast temperate semiarid and subhumid regions of the world, regions which will grow in importance as water and land competition elsewhere intensifies. Because of these advantages, wheat should remain the premier food grain through to peak world population and beyond. The world needs this to be the case, but continuing research across all of the diverse fields affecting wheat productivity and utilization that are described herein will be essential.

R.A. (Tony) Fischer, CSIRO Plant  
Industry, Canberra, Australia  
December 2008

# Preface

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Wheat is the cosmopolite of edible plants. It can be used in worldly ways and grown in worldly places. Its sphere of influence is global. Scientists marvel at its genetic complexity, but its complexity is perfectly fitting for such a versatile and planetary crop plant.

Much of what the world's agricultural society produces in food derives from wheat and other cereal crops. Hence to no surprise, a critical and nutritious part of the human diet comes from wheat—indeed no other grain crop can produce as many types of food. Calling it a staple may be a bland understatement, when wheat can dominate the ingredient list of appetizer to dessert, with versatility beyond what the mill can generate. Wheat farmers do not simply produce a wheat crop; they produce a food ingredient, and it is this distinction on which *Wheat: Science and Trade* is based.

In a specialized and highly focused era of scientific discovery, our literary base can easily become highly fragmented. This tendency applies no less to the literature for wheat. Whether the subject addresses soil management, epidemiology of a various array of pathogens, or genetic approaches to improving wheat productivity, one can find a significant piece of literature devoted entirely to that subject area within the past 30 years. This book represents a concerted attempt to swing the literary pendulum back to center. This is a book about *wheat* and the products derived from it—not strictly about bread wheat, not about wheat breeding, and not only about wheat quality, but all of that, and more. Consider it a drill-to-mill treatise of the current knowledge base and futuristic visions for wheat to flourish in a global environment and in a world market.

*Wheat: Science and Trade* was designed as a hub for directing students, practitioners, and scientists into four knowledge centers, or sections. The primary intended audience includes a wide spectrum of agricultural scientists working in the general research areas of crop science and soil science, and more specifically in weed science, plant pathology, entomology, genetics, cultivar development, physiology, taxonomy, cereal chemistry, food processing, and agribusiness. Another principal use of this book should include the classroom for advanced undergraduate students and graduate students studying crop production and utilization. Vocational agricultural teachers and practitioners, and the clientele they serve, will also find this book to be a critical resource. No matter the audience, the reader will likely reach equilibrium with the information provided herein and that which is extensively cited in a multitude of references.

The four sections approach wheat science and trade from the making of a wheat plant, to the making of a wheat crop, to the making of a wheat cultivar, and finally to the making of a wheat industry. The various sections provide the following: (i) fresh perspectives on classic tenets that define the evolutionary and phenological development of wheat (Section I, Chapters 1–3); (ii) a comprehensive view of some of the primary pathogens, pests, and abiotic stress factors that must be overcome to ensure a viable and marketable product, and the practices that can be adopted to maximize profitability (Section II, Chapters 4–12); (iii) the genetic components that define wheat improvement and cultivar development, from dissection of a myriad of traits critical to the total wheat industry to the development of novel

genetic resources critical to its continued worldwide production (Section III, Chapters 13–18); and (iv) a contemporary look at the functional properties that allow wheat products to appear from one end of the grocery store to the other, and the forces that drive wheat from family farm to river barge (Section IV, Chapters 19–23).

Chapters 20 to 22 provide a three-dimensional perspective on what determines wheat quality and how wheat quality can be manipulated to benefit humankind, even beyond the natural power of wheat's flour. Each of these chapters begins from a common base to which most might consider the one and only product of wheat—milled flour. Each chapter extends from that base to take the subject of wheat quality to very different levels, whether to describe the techniques used to predict quality from an end-use perspective, or to reveal

the basic biochemical components which may lay the foundation for end use, or to consider areas which newly define wheat quality. Finally, we are reminded that certain uses of wheat demand different pricing structures, but more determines wheat price than the wheat itself.

Excellence reflected in this book emanates from the talented panel of authoritative contributors with whom I have had the honor to work. My sincerest appreciation is extended to all of them. I trust you will be equally rewarded by their insight as I.

Brett F. Carver, PhD  
Editor, Regents Professor  
Department of Plant and Soil Sciences  
Oklahoma State University  
Stillwater, OK  
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Brett F. Carver



# Contributors

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Kim B. Anderson, PhD  
Professor and Crop Marketing Specialist  
Charles A. Breedlove Professor in Agribusiness  
Department of Agricultural Economics  
Oklahoma State University  
Stillwater, OK  
USA

Robert Asenstorfer, PhD  
Research Fellow  
University of Adelaide  
School of Agriculture Food and Wine  
Waite Campus  
Glen Osmond  
Australia

David Backhouse, PhD  
Senior Lecturer in Plant Pathology  
University of New England  
Armidale, New South Wales  
Australia

P. Stephen Baenziger  
Eugene W. Price Distinguished Professor  
Department of Agronomy and Horticulture  
University of Nebraska  
Lincoln, NE  
USA

Ian Batey, PhD, MRACI  
Honorary Research Fellow  
Food Science Australia and Wheat CRC  
North Ryde (Sydney)  
Australia

Arthur D. Bettge  
USDA-ARS  
Western Wheat Quality Lab  
Pullman, WA  
USA

Robert E. Blackshaw, PhD  
Weed Scientist  
Agriculture and Agri-Food Canada Research  
Center  
Lethbridge, Alberta  
Canada

Ann E. Blechl, PhD  
Research Geneticist  
USDA-ARS  
Western Regional Research Center  
Albany, CA  
USA

B. Wade Brorsen, PhD  
Regents Professor and Jean & Patsy Neustadt Chair  
Department of Agricultural Economics  
Oklahoma State University  
Stillwater, OK  
USA

Scott C. Chapman, PhD  
Crop Adaptation Scientist  
CSIRO Plant Industry  
Brisbane  
Australia

Xianming Chen, PhD  
Research Plant Pathologist  
USDA-ARS  
Wheat Genetics, Quality, Physiology and  
Disease Research Unit  
Pullman, WA  
USA

Anthony G. Condon, PhD  
Crop Physiologist  
CSIRO Plant Industry  
Canberra  
Australia

Geoffrey Cornish, BSc, Grad Dip Teaching,  
Assoc Dip Appl Chem, MRACI  
Leader Wheat Quality Research  
Grain Quality Research Laboratory  
South Australian Research and Development  
Institute  
Adelaide  
Australia

Li Day, PhD  
Senior Research Scientist  
Food Science Australia  
Werribee  
Australia

Ronald M. DePauw, CM, SOM, FAIC, FCSCA,  
BA, Msc, PhD  
Senior Principal Wheat Breeder  
SemiArid Prairie Agricultural Research Centre  
Agriculture and Agri-Food Canada  
Swift Current, Saskatchewan  
Canada

Katrien M. Devos, PhD  
Professor  
Department of Crop and Soil Sciences, and  
Department of Plant Biology  
University of Georgia  
Athens, GA  
USA

Jaroslav Doležal, PhD  
Principal Investigator and Research Group  
Leader  
Laboratory of Molecular Cytogenetics and  
Cytometry  
Institute of Experimental Botany  
Olomouc  
Czech Republic

Jeffrey T. Edwards, PhD  
Small Grains Extension Specialist  
Oklahoma State University  
Stillwater, OK  
USA

Catherine Feuillet, PhD  
Research Director  
Structure, Function and Evolution of the Wheat  
Genomes Laboratory  
INRA—Genetics, Diversity and Ecophysiology  
of Cereals Unit  
Clermont-Ferrand  
France

Mark E. Fowler  
Director of Technical Services  
International Grains Program  
Kansas State University  
Manhattan, KS  
USA

Gurjeet S. Gill, PhD  
Associate Professor  
School of Agriculture, Food and Wine  
University of Adelaide  
South Australia  
Australia

Robert A. Graybosch, PhD  
Research Geneticist  
USDA-ARS-GFBU  
University of Nebraska  
Lincoln, NE  
USA

Perry Gustafson, PhD  
Research Geneticist  
USDA-ARS  
University of Missouri  
Columbia, MO  
USA

Marion O. Harris, PhD  
Department of Entomology  
North Dakota State University  
Fargo, ND  
USA

Louis S. Hesler, PhD  
Research Entomologist  
North Central Agricultural Research  
Laboratory  
USDA-ARS  
Brookings, SD  
USA

Gavin Humphreys, PhD  
Research Scientist  
Agriculture and Agri-Food Canada  
Cereal Research Centre  
Winnipeg  
Canada

Yue Jin, PhD  
Research Plant Pathologist  
USDA-ARS  
Cereal Disease Laboratory  
St. Paul, MN  
USA

Huw D. Jones, PhD, FIBiol  
Principal Investigator and Research Group  
Leader  
Cereal Transformation Laboratory  
Plant Science Department  
Rothamsted Research Harpenden  
United Kingdom

James Kolmer, PhD  
Research Plant Pathologist  
USDA-ARS  
Cereal Disease Laboratory  
St. Paul, MN  
USA

Rui Hai Liu, MD, PhD  
Associate Professor  
Department of Food Science  
Cornell University  
Ithaca, NY  
USA

Philippe Lucas  
Directeur de Recherche  
Institut National de la Recherche  
Agronomique  
Le Rheu  
France

Drew J. Lyon, PhD  
Dryland Cropping Systems Specialist  
University of Nebraska-Lincoln  
Panhandle Research and Extension  
Center  
Scottsbluff, NE  
USA

XueFeng Ma, PhD  
Senior Scientist  
Ceres, Inc.  
Thousand Oaks, CA  
USA

Ronald L. Madl, PhD  
Director, Bioprocessing and Industrial Value  
Added Program  
Co-director, Center for Sustainable Energy  
Grain Science Department, Kansas State University  
Manhattan, KS  
USA

Daryl Mares, PhD  
Senior Research Fellow  
University of Adelaide  
School of Agriculture Food and Wine  
Waite Campus  
Glen Osmond  
Australia

David Marshall, PhD  
Research Leader and Professor  
USDA-ARS  
Department of Plant Pathology  
North Carolina State University  
Raleigh, NC  
USA

Kendall L. McFall  
Senior Vice President and  
Chief Operating Officer  
Engrain, LLC  
Adjunct Instructor  
Department of Grain Science  
Kansas State University  
Manhattan, Kansas  
USA

C. Lynne McIntyre, PhD  
Research Geneticist  
CSIRO Plant Industry  
Brisbane  
Australia

Gregory S. McMaster, PhD  
USDA-ARS, Agricultural Systems Research  
Unit  
Fort Collins, CO  
USA

Kolumbina Mrva, PhD  
Senior Research Fellow  
University of Adelaide  
School of Agriculture Food and Wine  
Waite Campus  
Glen Osmond  
Australia

Eviatar Nevo, PhD  
Professor of Evolutionary Biology  
Director International Graduate Center of  
Evolution  
Institute of Evolution  
University of Haifa  
Mount Carmel, Haifa  
Israel

Julie M. Nicol, PhD  
Senior Soil Borne Wheat Pathologist  
ICARDA-CIMMYT Wheat Improvement  
Program  
CIMMYT Global Wheat Program  
Ankara  
Turkey

Ivan Ortiz-Monasterio, PhD  
Agronomist and Wheat Harvest Coordinator  
CIMMYT Global Wheat Program  
Mexico, D.F.  
Mexico

Timothy C. Paulitz, PhD  
Research Plant Pathologist  
USDA-ARS  
Root Disease and Biological Control Research  
Unit  
Washington State University  
Pullman, WA  
USA

David R. Porter, PhD  
Professor and Head  
Plant and Soil Sciences  
Oklahoma State University  
Stillwater, OK  
USA

Gary J. Puterka, PhD  
USDA-ARS  
Plant Science Research Laboratory  
Stillwater, OK  
USA

Olga Raskina, PhD  
Senior Scientist  
Institute of Evolution  
University of Haifa  
Mount Carmel, Haifa  
Israel

William R. Raun, PhD  
Regents Professor  
Plant and Soil Sciences  
Oklahoma State University  
Stillwater, OK  
USA

Greg J. Rebetzke, PhD  
Research Geneticist  
CSIRO Plant Industry  
Canberra  
Australia

Richard A. Richards, PhD  
Research Program Leader  
CSIRO Plant Industry  
Canberra  
Australia

Andrew S. Ross, PhD  
Associate Professor  
Department of Crop and Soil Science  
Oregon State University  
Corvallis, OR  
USA

Jackie C. Rudd, PhD  
Texas AgriLife Research  
Texas A&M System  
Amarillo, TX  
USA

Yong-Cheng Shi, PhD  
Professor  
Department of Grain Science and Industry  
Kansas State University  
Manhattan, KS  
USA

Richard W. Smiley, PhD  
Professor of Plant Pathology  
Oregon State University  
Pendleton, OR  
USA

John B. Solie, PhD  
Biosystems and Agricultural Engineering  
Oklahoma State University  
Stillwater, OK  
USA

Daryl J. Somers, PhD  
Research Chair  
Molecular Breeding and Biotechnology  
Vineland Research and Innovation Centre  
Vineland Station, Ontario  
Canada

Richard M. Trethowan, PhD  
Professor of Plant Breeding  
University of Sydney  
Plant Breeding Institute  
Camden, New South Wales  
Australia

Maarten van Ginkel, PhD, Ir  
Deputy Director General—Research  
ICARDA  
Aleppo  
Syria

Anthony F. van Herwaarden, PhD  
Crop Agronomist  
CSIRO Plant Industry  
Brisbane  
Australia

Donghai Wang, PhD  
Associate Professor  
Department of Biological and Agricultural  
Engineering  
Kansas State University  
Manhattan, KS  
USA

Michelle Watt, PhD  
Research Scientist  
CSIRO Plant Industry  
Canberra  
Australia

Colin Wrigley, MSc, PhD, FRACI  
Honorary Research Fellow  
Food Science Australia and Wheat CRC  
North Ryde (Sydney)  
Australia

Xiaorong Wu, PhD  
Research Associate  
Department of Biological and Agricultural  
Engineering  
Kansas State University  
Manhattan, KS  
USA

Liuling Yan, PhD  
Assistant Professor  
Plant and Soil Sciences  
Oklahoma State University  
Stillwater, OK  
USA



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