It may have escaped the notice of the casual observer and user of carbon fibre products such as the tennis racket or golf club that carbon fibre has been around now for 50 years from those ‘heady days’ of the 1960s when, as a matchbox curiosity, the short black ‘prickly’ fibre was worth more than its ‘weight in gold’. Within a year, the fibre was being produced as continuous fibre in bundles or tows of 10,000 individual filaments wound onto spools that could be thrown like an American football to the back of college lecture theatres, the fibre unravelling as it sped from the speaker’s hand over the heads of excited engineering students.

The discovery of this high-strength, high-stiffness, lightweight material that could be woven into fabric had returned us to those factories of northern British towns of the eighteenth and nineteenth century. Fibre in and product out through the factory front door, we have now arrived where material processing and manufacture, design and fabrication of the final product can now take place under one roof. We have arrived back to the factory of the future.

It is fitting on the occasion of 50 years of carbon fibre to place on record the historical stages of the development of structural carbon fibre composites (and other fibre composites), as well as premonitory things that happened on the way. An impressionistic map, if you like, of the present state of the art for readers coming new to the field as well as those ensconced in research and development of composite materials and large composite structures, from the emergence of the science of composites and the evolution of a number of neighbouring disciplines.

In the ‘blink of an eye’, we have in composite materials discovered a clearly defined and distinct discipline, which in practice doubles up as a multidiscipline with a substantial number of independent ‘branches’, each one with its multifarious journals and textbooks, read by practicing materials scientists and engineers alike who communicate with each other on that basis. The discipline of the materials science and engineering of contemporary composite materials has emerged from those small beginnings one half century ago.

But this book is in no sense a textbook of carbon fibre composite materials alone. In this single volume, the authors have produced an impressionistic map of the present state of the science and mechanics of composite materials, seen as
a pointillistic portrait of the discipline of composites, to be viewed from a slight
distance. But what defines composite materials science and links it to traditional
engineering disciplines? Perhaps the way to address this question is by means of
what philosophers call an *ostensive definition*, relying on analogical or case-based
reasoning. In other words, the chapters presented here are an essay in ostensive
definition albeit a comprehensive one.

Throughout these chapters, we observe the materials scientist and engineer
working at several levels of organisation, each of which is underpinned by the next
level. This feature is central to the subject of composite materials—the concept
of ‘architecture’ as the defining theme that connects composite materials science
and engineering across orders of magnitude of size. At some point on this scale
can be defined the concept of meso-structure, a term frequently used by modellers
and simulators of composites that level between the microscopic level and the
macroscopic appearance from the viewpoint of the engineer.

The author of each chapter starts from their own personal viewpoint, delving
into the natural characteristics and behaviour of a particular class of engineering
material reinforced in some way by carbon fibre or another fibre of those high-
performance fabrics, probing and examining such concepts and relationships as
structural architecture and design from the very small to the very large. What
emerges is the evolution of a number of neighbouring disciplines in mechanical
design and processing: experimentation and analysis, mathematical and continuum
modelling, constitutive and physical modelling (or micromechanics or damage
mechanics), computational mechanics and virtual simulation aided by computer
power.

Fine-scale phenomena become embedded in calculations representing larger-
scale behaviour, arriving at intelligent mechanical design based upon the application
of the principles of integrated multi-scale mechanics and hierarchical models and
analyses. They all share certain characteristics in terms of hierarchy in which
material constitutive properties are passed on from one model to the next via
inheritance throughout the complete manufacture and design process.

Throughout the book, major themes range from descriptions and analyses of
nano- and micro-scale phenomena that affect composite material behaviour at the
metre level of size and above. They include the nature of cracks that nucleate and
grow to threaten the safety of large engineering composite structures, fundamental
material issues that affect composite weakness and compromise composite strength
and solutions to challenging material problems that hinder the safe exploitation of
large composite structures. This requires an in-depth knowledge and understanding
of the deformation and cracking processes in composites best detected and moni-
tored directly, tracing damaging mechanisms and structural changes over time.

But that which draws the threads of chapters together is an understanding of
the structural integrity of the composite. By means of careful experimentation
and sound analysis, this ultimately leads to successful forecasting of the limits of
material performance on the one hand and defines the conditions for safe operation
of composite structure on the other from ‘cradle to grave’.
Robert Hooke writes, in his book *Micrographia (1665)*, an imprint of the Royal Society of London:

And I have often thought that probably there might be a way found out to make an artificial glutinous composition much resembling if not full as good, nay better than that excrement or whatever substance it might be out of which the silk worm draws his clew. If such a composition were found it were certainly an easy matter to find very quick ways of drawing it into small wires’ for use. I do not mention the use of such an invention nor the benefit that is likely to accrue to the finder, they being fully obvious. This hint may I therefore hope to give some inquisitive person an occasion of making some trials which if successful I have my aim and I suppose he will have no occasion to be displeased.

- Old English *wîr*; Germanic origin, probably the base of Latin *viere* ‘plait, weave’

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