Many of the most fundamental advances in theoretical physics and the most far-reaching developments in technology have at their origins Maxwell’s equations [1] unifying electricity and magnetism, which were formulated and published just over 150 years ago. It therefore seemed appropriate to synthesize an overview of current developments building upon Maxwell’s legacy, as well as review the current status of progress since his time.

At the most fundamental level, the insights provided by Maxwell’s equations have inspired even more ambitious attempts to unify other aspects of the interactions of elementary particles. An important obstacle to progress in this endeavour was the weakness of the weak interactions, which could be understood only if the quanta that mediated them were very heavy, unlike the massless photon quantum of the electromagnetic interactions. A key advance in overcoming this obstacle was the introduction into particle physics of the concept of spontaneous symmetry breaking, which was to be reviewed at this meeting by one of its progenitors, Tom Kibble. He was unfortunately unable to present his review in person, nor contribute an article to this issue. Indeed, while we were in the final stages of preparing for this issue, we received the sad news that he had passed away. Tom Kibble was a giant of theoretical physics, a scientist of the highest calibre, yet modest and unassuming. We dedicate this issue to his memory.

The ideas of spontaneous symmetry breaking proposed by Tom Kibble and others were incorporated into the standard model of particle physics, which unifies electromagnetic and weak interactions and also describes the strong nuclear interactions using an approach built upon Maxwell’s ideas. The current experimental status of the standard model is reviewed in this issue in the article by Butterworth [2].

The standard model is widely considered to provide only incomplete unification of the fundamental interactions, and there are many theoretical speculations about what may lie beyond it. The status of experimental
searches for physics beyond the standard model, principally at the Large Hadron Collider (LHC) at CERN, is reviewed in this issue by Virdee [3]. To date, there is no confirmed experimental evidence for any physics beyond the standard model, but hopes are high that this may appear in experiments at the LHC at higher energies.

Unification of all the fundamental interactions and a unified description of forces and matter are the dreams of many theoretical physicists. In this issue, Wilczek [4] reviews ideas about how these objectives may be attained, and describes some circumstantial evidence that such a ‘grand unification’ might lie within reach.

Maxwell’s equations were originally proposed to describe interactions at their most fundamental level. However, one of the most striking developments in recent years has been the realization that similar equations may emerge in other systems, as reviewed in two articles in this issue. Sachdev [5] discusses the role of emergent gauge fields in efforts to understand high-temperature superconductors, and Moessner and Rehn [6] describes the emergence of Maxwell electromagnetism in condensed-matter systems.

These contributions serve as inspirations and as warnings. On the one hand, they exemplify the richness of the phenomena that may emerge in solid-state physics, providing laboratories for testing novel ideas in theoretical physics, whose applicability at a more fundamental level remains elusive. On the other hand, they raise the question of whether phenomena we currently regard as fundamental may actually emerge from some underlying dynamics that still lies beyond our reach.

Further examples of the richness of electromagnetic phenomena in condensed-matter systems are provided by photonic crystals. As described in this issue by Lang et al. [7], these may exhibit novel properties that are not apparent at the fundamental level.

A common theme of all the articles in this issue is the vastness of the horizons opened up by Maxwell’s insights. His equations provide an almost universal language for describing developments in physics over an enormous range of scales, from the large-scale structure of the Universe through the dynamics of matter to the most intimate structure of the fundamental interactions.

In the words of Albert Einstein: ‘One scientific epoch ended and another began with James Clerk Maxwell’. To this might be added a similar observation about an epoch of technology. Moreover, both the scientific and the technological epochs are continuing to evolve at a fast pace. The ramifications of Maxwell’s equations seemed destined to dominate physics and technology for the foreseeable future.

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