"How? A physicist's reality check on the physician's expectations"

New applications and potentially meaningful breakthroughs in Magnetic Resonance are countless, now and then. And undoubtedly, this will stay that way. MR technology went through several cycles in which it reinvented itself, from the transition from continuous wave to pulse Fourier transform NMR, by the introduction of superconducting magnets, multidimensional and hetero-nuclear experiments to the use of magnetic resonance for clinical diagnosis and, more recently, its introduction towards the real time control of new therapeutic applications. Although its evolutionary path seems endless, the process may sometimes be far from linear and quite often the technology developed to meet the physician's expectations may lead to completely unanticipated breakthroughs. Both technology push and physicians pull play an important role. Already in the late eighties of the last century, MR spectroscopy was the driving force towards higher sensitivity and field strength. And indeed, in vivo spectroscopy gradually produced better data and introduced important scientific insights in several metabolic pathways. But ultimately functional brain imaging based on the field dependent BOLD effects was the dominant "pull" factor that caused a wide spread use of 3T systems for research purposes. This resulted in a huge paradigm shift in how cognitive brain research is conducted. From there it was an expeditious evolutionary path to the introduction of 3T in regular patient care. In spite of the fact that hardly any large, randomized controlled trials to assess the efficacy of 1.5 as compared to 3.0T for any type of disease, the clinical adoptation for 3T took little time. Subsequently cognitive sciences drove the magnetic field strengths even further, to 7T, 9.4T and more recently 10.5 and 11.7T for human applications. Besides further improvements in the applications of MRI to study brain function and connectivity, these high field strengths have opened new areas of research. Some applications could directly leverage the effects that are magnified by high field strengths, e.g. quantitative susceptibility imaging. Other emerged due to the technical challenges that high fields introduce, such as understanding and overcoming the inherent B_1^+ field inhomogeneity's at higher Larmor frequencies. These latter studies resulted images that display conductivity and permittivity (Electrical Property Tomography), a new contrast mechanism for which most applications still have to be explored. Even increased spatial resolution in structural brain MRI based on conventional contrast has resulted in new, unexpected findings. Whereas the increased conspicuity of micro-bleeds at high field strength doesn't come as a surprise, the detection of micro-infarcts, cortical lesions in MS patients and intracranial plaque loads produces new biomarkers. These markers can be used for both early diagnosis and therapy planning and monitoring. The same trend is visible in body applications. Improved high field structural MRI in oncology may fulfil new requests to better align tumor genotyping with the phenotype of neoplasm to increase prognostic and predictive diagnostic value in cancer. The exploding field of regenerative medicine needs longitudinal non-disruptive imaging at the sub-millimeter scale. Not only to track stem-cells, but also to monitor tissue regeneration and function repair. High field will offer new opportunities to meet the requirements that these new therapeutic approaches will introduce. Diagnosis and therapy will merge further. It can be expected that besides the tendency to use higher field strengths, different magnet concepts may be needed. For MR guided High Intensity Focused Ultrasound this may not be the case yet. This technique is already being used in many different applications, ranging from uterine fibroid and tumor ablations to applications in the brain. But to fully merge external beam radiotherapy with MRI, magnet designs will have to be adapted. Initially this will be done at lower (1.5T) field strengths, using a complete new magnet design (as well as gradient and RF coils) that is transparent for photon beams and allows a defined pathway for treatment. This will become even more a challenge for image guided proton therapy. And coming full circle, ultra high field combined with multi-transmit applications that will allow us to focus and control B_1^+ fields may end up in the ultimate therapeutic-diagnostic MRI device where radiofrequency interaction with tissue may result in diagnostic and therapeutic applications at the same time. Rather than being an obstacle for some MRI applications, RF heat deposition may be rendered in a useful therapeutic device. These and other trends in the use of MRI technology in conjunction with higher (and other) magnet designs will be discussed.