‘Science’ is a concept and practice that has evolved since the pre-modern era. Derived from the Latin word ‘scientia’ meaning ‘knowledge’, many definitions have been proposed throughout the ages, from the all-encompassing ‘knowledge attained through study or practice’¹ to the more specific ‘the pursuit and application of knowledge and understanding of the natural and social world following a systematic methodology based on evidence’².
Dr Corinne Schuster-Wallace (The United Nations University, Canada):

While overly simplistic – as what doesn’t work in one place may well work in another, and vice versa – there is an important lesson to be learnt by revisiting this definition of science. However, before rejection of what doesn’t work, I would argue that we need to understand why, as well as recognise the many different types of evidence that should be considered prior to rejection. Today’s research and international development is predicated on, and largely measured against, business metrics of success. Rarely, if ever, does anyone have the courage to admit failure, yet failure is where learning occurs. In order to advance applied research, particularly in water-health, it is important to share what didn’t work, where and why, as much as the success stories. This is how we have moved into research on social capital, why we have targeted water, sanitation and hygiene (WaSH) in maternity wards, and why we believe that there is a need for a different approach to WaSH and wellbeing; the status quo is not working, so we continue to seek different solutions.

Dr Patricia Rousselle (French National Centre for Scientific Research, France):

I agree with that statement as I experience it every day. We are always hoping that our experiments or our hypotheses ‘will work’ so we can elucidate new mechanisms and see our data accepted and discussed by the scientific community. We are indeed disappointed when things ‘don’t work’ as we know that all the committed efforts won’t be valued or even discussed. However, I believe that exploring various approaches and opportunities is inevitable to obtain significant results. In biology, negative results are often instructive and may guide the next experiment. Thanks to their valuable meaning, they are often considered as important steps toward success; but they are not prized on their own. This allows the scientific community to focus on major and reproducible results, which is to me, a way to progress within a high level of complexity. Therefore, courage is definitely necessary to handle this reality, as is perseverance and rigour. This is especially true in cell biology, as many experiments that ‘work’ have to be repeated before convincing results can be gathered within a compelling hypothesis.

Professor Paul Avan (University of Auvergne, France):

Our attempts to design new methods to diagnose and monitor patients have typically been lengthy processes, from bench to bedside then back, and from animal models to different clinical settings in which different cohorts of patients could be explored on different time scales. Along the way, a substantial part of the work has been ‘the prediction of what should work’, and its logical follow-up: ‘the explanation of why it actually does not work’.

Our work has certainly required more stubbornness than we initially thought, as well as the strength of will not to become discouraged by repeated failure. In a domain as complex as biology, life teaches even the most experienced researchers that evidence is seldom comprehensive and may support different frameworks of explanation; therefore, acceptance is often temporary, heuristic or beyond our grasp.

Professor Anna-Liisa Brownell (Harvard Medical School, USA):

Science is an investigation of nature. I learnt this in an experimental way. At the early age of 14, I was interested in plants and wanted to identify them. A Swedish botanist who lived in the 17th Century, Carl Linnaeus, had created the principles to determine the natural genera and species of organisms, and he formed a uniform system for naming them known as binominal nomenclature. His method was published as a book that enabled people to stepwise investigate plants to find their family and Latin name. While investigating a plant, there were several choices in each step that followed to the next criteria. If you had selected a wrong choice at some phase, the following choices might become impossible and you had to return to some previous choices to reconsider. This is a form of experimental investigation. The study of nature can also be theoretical, but we know that the theories have to be proven to be valid and this often requires experimental approaches.

Dr Jacob Bronowski, renowned mathematician, biologist and science historian, defined science simply as: ‘the acceptance of what works and the rejection of what does not’, adding, ‘that needs more courage than we might think’. To what extent has your experience of scientific research led you to relate to Bronowski’s definition and facilitated progress in your field of study?
Significant impact in clinical medicine. The role of DNA repair pathways is crucial: critical observation. A good scientist notices things that others did not see before; moreover, this person needs to see it several times before believing it. I agree with Bronowski that it can be easy to ignore warnings and focus on signs confirming prior belief. It takes courage to acknowledge flaws and reconsider what one previously thought was true. In my view, the use of systematic and evidence-based methodology is not a prerequisite in science, but it follows naturally from the process of critical questioning.

For me, the most important aspect of science is asking questions. I always tell students to never believe what they are told; they should go and see for themselves. Just as in interviewing people, it is important to remember that it is not only what you ask, but how you pose a question that largely determines the answer you will receive. When interpreting answers, a second important aspect of science is crucial: critical observation. A good scientist notices things that others did not see before; moreover, this person needs to see it several times before believing it. I agree with Bronowski that it can be easy to ignore warnings and focus on signs confirming prior belief. It takes courage to acknowledge flaws and reconsider what one previously thought was true. In my view, the use of systematic and evidence-based methodology is not a prerequisite in science, but it follows naturally from the process of critical questioning.

I would agree that accepting what works and rejecting what does not work takes courage. I would add that it also takes courage to conduct the experiments that are necessary to show what works and publish the results. This has been particularly true regarding the DNA repair and recombination field, where often particular pathways have been relegated to insignificant roles in maintaining DNA (genetic) stability. For example, it was widely accepted that the most significant pathway for repair of DNA double-strand breaks was by non-homologous end joining (NHEJ), akin to bashing the broken ends of DNA together. This pathway was accepted, in part, due to observations that NHEJ plays a critical role in immunoglobulin gene rearrangements; moreover, many radiation-associated chromosomal rearrangements occur thanks to NHEJ. Homologous recombination pathways were well established to function in meiotic recombination, but at one time, they were thought to play a minor role in double-strand break repair in somatic cells. With the discovery that the breast cancer genes BRCA1 and BRCA2 function in homologous recombination, scientists had to take a step back and realise that ‘minor’ pathways still play a significant role in maintaining genetic stability and preventing cancer. While arguing about DNA repair pathways may seem pedantic, the acceptance of these observations has now led to the discovery of new pharmaceuticals to treat cancers defective in BRCA1 and BRCA2 genes and is thus having a significant impact in clinical medicine.

Sources: 1 Websters New Dictionary; 2 UK Science Council

As I read Bronowski’s definition of science, I am reminded of the compelling argument for an empirical perspective towards scientific research. It is through this tradition that much research has occurred and science has advanced. The question being studied should determine whether a positivist or constructionist methodology is employed. Not all questions about the human experience require an empirical approach. The human condition living in an ever-changing environment is blunted in complexity. Due to the fact that I tend to research complex social phenomena, such as the experience of returning to work after depression, I prefer to use a more constructivist approach. For this reason, a methodology that gives voice to the study participants is required. People are the experts in their lived experiences. They are skilled at telling their stories and passing on their truths when they are guided by the right questions. Bronowski’s empiricism does not reach such complex social phenomenon in which each participant’s story is unique and situation specific.

In the past two decades, the concept of ‘evidence-based medicine’ has emerged in clinical practice. The philosophy behind it is to practice medicine on the basis of scientific evidence, preferably obtained in randomised clinical trials. There appears to be a double standard when introducing new scientific insights into medical practice. New diagnostic and therapeutic methods that show some degree of benefit are embraced and introduced relatively quickly, supported by medical and patient forums, whereas a different level of evidence may be required to abandon a procedure that has not shown benefits. Perceived population benefit drives introduction of new scientific developments whereas individual cases, although sometimes considered exemptions, may prevent rejection of what does not work in general practice. It is not uncommon for ‘best practice’ to change based on new research findings illustrating the dynamic nature of practicing evidence-based medicine. In the end, integration of the best available scientific information with the doctor’s clinical experience would provide for optimal, tailor-made medicine.