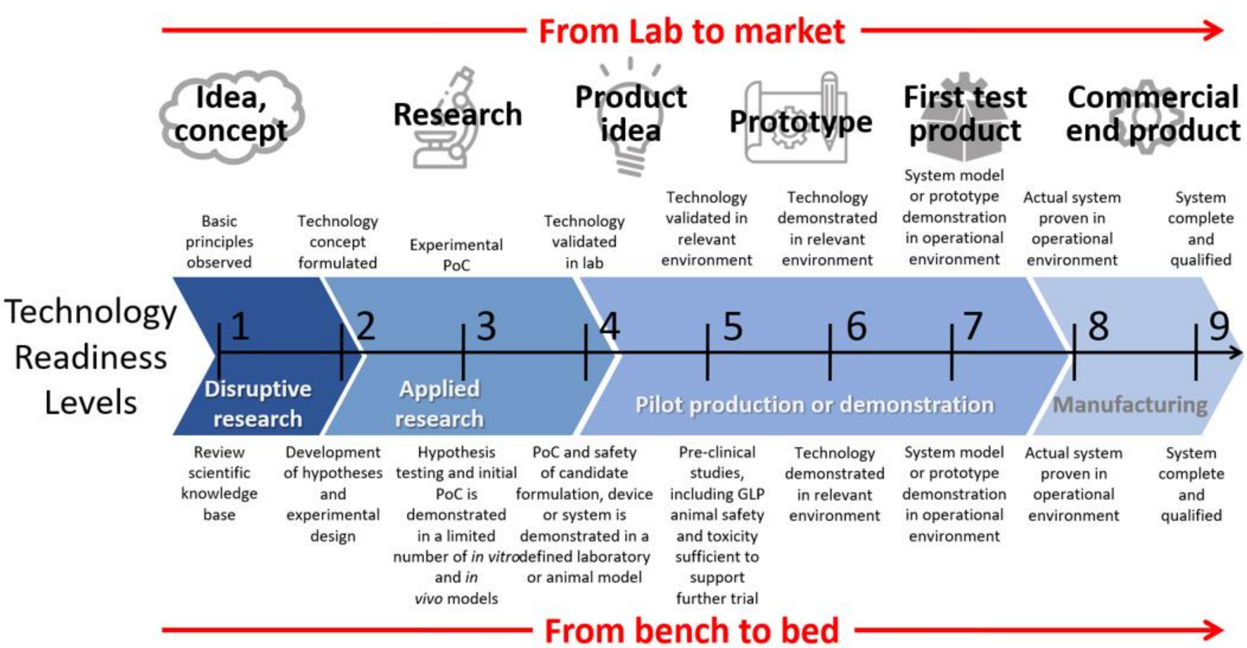
Crossing the "valley of death"[1]

Panagiotis Kavouras
School of Chemical Engineering, National Technical University of Athens

The transformation of an idea into a technology, a process that falls under the broader term *innovation*, lacks the glamour a scientific theory – that tries to explain fascinating topics such as the history of the universe or the structure of matter – has for lay people. This is perhaps in contrast to the fact that societies come into contact - and are therefore directly affected - by the products of technology rather than by science *per se*. At the same time, society's trust in science does not seem to be as easily shaken as its trust in technological marvels such as the mobile phone or the coronavirus vaccine. In other words, although technology is the “child” of scientific research, the former seems to be treated with less admiration or more suspicion than the latter.

But is it right to treat science and technology as two processes only loosely connected or as processes involving different types of institutions? The answer is both yes and no. But let us look at the way in which the transformation of a scientific discovery into a technological application is described. The diagram below shows this transformation as it passes through successive “Technology Readiness Levels” (TRLs). Note that there are two descriptions for each TRL: one for the biomedical research field (below the axis) and one for the other research fields (above the axis).



A diagram outlining of the Technology Readiness Levels.

[1] This is a translation in English of an article originally published in Greek at PRISMA Science Magazine, originally authored and subsequently translated by Panagiotis Kavouras, on the 24th of June 2023. Its online freely available version can be found here: https://www.avgi.gr/entheta/prisma/453079_diashizontas-tin-koilada-toy-thanatoy.

TRL1 is where the initial scientific hypothesis or the concept under consideration is located, i.e., we are at the "dawn" of the scientific search or what is called "basic research". Between TRL2 and TRL4 we achieve (or fail to achieve) the confirmation of the initial scientific hypothesis under laboratory conditions, i.e., on a small scale and under conditions that simulate, to some extent, the actual operating conditions of the potential final product.

Between TRL4 and TRL7 the development of the relevant technology and demonstration of the operation of the prototype, whether it is a device or a drug, is achieved on a large scale or in a real-world application. This "periodisation" of the technological development steps is completed in TRL8 and TRL9, within which the final marketable product is manufactured and made available for commercial purposes.

The most critical period in transforming a scientific idea into a product is between TRL4 and TRL6, which has the eerie name “valley of death”. This is the period during which the chances of failure of a particular technology are highest. The main reason for this is that between TRL4 and TRL6 there is a funding gap. Specifically, the technology under development is at such a point in its development that (a) it requires sufficient resources for further development that are not available to universities or research centres, and (b) it has not demonstrated its seamless operation or safety as a marketable product to attract funding from industry.

It is precisely at this point that there is a need for a "conversation" between the research communities of universities, public research centres and industry or entities that carry out research funded by non-public funds. This conversation is not always entirely efficient due to a lack of trust between these two research communities, which are not always clearly delineated. The concern on the part of the research community of universities and public research centres is that public money is being provided to develop a technology that will be bought by industry to be turned into a profit machine for the interests of a private company. On the other hand, the research community active in industry criticises the “other side” for using insufficiently reliable, partially opaque and non-standardised research practices.

We believe that Research Integrity can play a useful role here. Having established a framework of good practice for producing reliable research results, mainly in the areas of basic and applied research, it can provide a *lingua franca* between the two aforementioned research communities. What remains to be seen is whether and how the framework of existing Research Integrity principles and good practices can be adapted to the way industry works, i.e., in the areas of pilot and mass production.

This provides the rationale of a research effort that the organisers of the 8th World Congress Conference on Research Integrity have launched. They hoped that this research will result in a text, a declaration, that will provide a framework for credible technology development or the “evolution” of Research Integrity into *Innovation Integrity*. In other words, a framework of principles and good practices that will reduce, if only slightly, the depth and width of the valley of death.

Certainly, Research Integrity cannot solve all the challenges that plague the transformation of scientific research into innovation. Therefore, the research effort outlined has specific limitations. It cannot resolve issues related to the exponential acceleration of technological development, i.e., in the context of the so-called fourth industrial revolution, nor can it resolve issues related to conflicts of interest of multinational giants or to current intense geopolitical upheavals. However, what Research Integrity can do is to enhance trust between researchers working in academic and industrial environments by developing harmonised *modus operandi* and by promoting transparent research processes from both sides of the valley of death.

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