A critical appraisal of the statement “So much of the work done in science now requires input from multiple disciplines, that the separation of the disciplines is irrelevant and unnecessary”

Curiosity of the world around us and the desire to ask “why” and “how” is a defining characteristic of humanity is itself. If this is loosely labelled as science, it can be demonstrated that in history, science is an all-encompassing subject and a metamorphosis of disciplines that change based on a multitude of influences. Looking into the past and assessing the historical separation of science, religion and magic allows us to piece together a clear picture of how to maximise scientific progress in future. This requires critical evaluation of the costs and benefits of discipline isolation to elucidate a clear, evidence-based path forward in research and education. Although I agree interdisciplinary research is becoming a central part of modern science, the separation of disciplines is essential for collaboration between them. I will argue that the optimal way forward is not to abolish disciplines, but to promote communication and collaboration between them while retaining specialisation.

The first thing to consider is what is meant by science? Science can be defined as “the pursuit and application of knowledge and understanding of the natural and social world following a systematic methodology based on evidence” - this applies to a wide variety of modern subjects[1]. Looking further back, the word meant collective knowledge in 14th century English, originating from the Latin scientia which meant knowledge[2]. Moreover, the word scientist was first used in the 19th century by William Whewell and the segregated disciplines as we know them only emerged in the 18/19th centuries with increasingly specialist journals and societies established in the 20th century with diversification of disciplines continuing to this day[2,3]. It is evident that science has not been separated in the same strict way it is today for most of history, with fluid boundaries that promoted communication and allowed growth. There is evidence of humans practicing what can be considered science, since written language was established[4,5].

An obvious indication of early science is treatment of illness, as it is a prominent and visible issue in human societies. The Edwin Smith papyrus dating from the 17th century BC is a medical document that organizes 48 injuries with symptoms, treatments and prognosis given in a consistent and systematic way[5]. Fascinatingly, it is the first recorded reporting of the cause of a spinal injury; “Case 33: it is his fall head-downward which caused a vertebra to crush into its counterpart”[5]. This is clear evidence of rationality and evidence-based deduction. Further evidence of rationality is shown in “The Diagnostic Handbook” created in Babylonia in the 11th century BC which demonstrated that the observation of a patient can be used to predict future disease progression and outcome[4]. However, the cause of the disease is clearly attributed to the gods. Interestingly, the prevalent left/right and colour symbolism in Babylonian society wasn’t always applied to this handbook which demonstrates some separation from magic[4]. The development of science and its organisation into disciplines has been seen in many historical societies around the world, from the āšipu (exorcist) who used the diagnostic handbook in Babylonia, combining many aspects of modern biology, to the natural philosophers of the renaissance such as Galileo, who contributed to astrophysics, maths and philosophy[4,6]. Science is an ancient subject, not always going by the same name, that has naturally been sorted into disciplines throughout history. However, these disciplines have been fluid and covered a broad range of overlapping knowledge.

In recent history there has been a marked increase in organisation and specialisation within science. The definition of a discipline is transient and contextual; they organise scientific activity and allow interactions between groups of scientists where they can develop standards that allow them to share their research[7]. They are used to link researchers and institutions, and some such as Robert Silliman, argue that for a discipline to exist as a separate entity it must be professionalised by the development of journals, fellowships and societies[7]. The origin of disciplines can generally be attributed to fusion of smaller groups or fission of larger ones[7,8]. For example, when Hooke published the first evidence of microorganisms using a microscope there was the necessity for microbiology to develop from biology – a fission event[9]. Within this, the fission/fusion model demonstrates that new techniques and instrumentation can advance subjects to the point where specialisation is required to become well versed in the subject[7,8]. Other social, political and economic factors influence the development of science; scientists are influenced by the culture they live in and what that society requires from science[7,8]. For example, the birth of computer science was a direct consequence of World War Two which required rapid development of code breakers[10]. Increased specialisation leads to the formation of disciplines and is an indication of the expanding complexity of the broader subject, driven by progress in knowledge that may be influenced by a variety of factors.

The way in which science advances has been modelled in a few different ways such as the accumulation theory, where facts are slowly built up over time and models increase in accuracy, including the correction of errors[11]. This theory assumes that progress is steady and guaranteed using the scientific method. Kuhn proposed another theory that periods of steady growth are interrupted by revolutions that may leave problems unexplained that were previously thought to be accounted for and may require the development of multiple theories under different conditions[11]. These different conditions present a chance for the development of multiple disciplines as each set of conditions becomes more complex.

Although the separation of the sciences into modern disciplines as we know them has been a consequence of increased complexity, recently there has been an increased desire for interdisciplinary research[12]. In the influential paper “The Chemical Basis of Morphogenesis” Alan Turing states “The full understanding of the paper requires a good knowledge of mathematics, some biology and some elementary chemistry. Since readers cannot be expected to be experts in all of these subjects, a number of elementary facts are explained[13].” Specialisation is required for increasing depth of understanding, increasing efficiency, establishing of basic standards and increasing experimental rigor[14]. Although this is intuitive, specialisation of disciplines has its disadvantages such as that raised by Konrad Lorenz “the specialist knows more and more about less and less and finally knows everything about nothing[14].” This eludes to the idea that specialists cannot judge other disciplines as well as generalists and hence leads to the problem that highly specialised disciplines risk isolation, stifling innovation by surrounding themselves with a standard level of assumed knowledge, homogenous perspectives and similar skillsets[14]. For example, Pasteur’s contributions to microbiology have been credited to his outsider perspective[14]. Furthermore, monopoly of a discipline over a set of resources or facilities may harm progress of other disciplines that could potentially benefit from them[14]. Monotony can be another disadvantage of the isolation of disciplines; transfer between disciplines is made more difficult as the degree of knowledge required and the lack of support from contacts in the community increases[14]. This monotony risks a decrease in progress as researchers lose motivation and innovation. There is a trade between isolating the disciplines and interdisciplinarity. Interdisciplinary research has been shown to have higher impact than that of isolated-disciplines[15,16]. Unsurprisingly, there are higher levels of collaborations between geographically close universities, particularly within countries[15]. This indicates that the cost of increased research impact and complexity is that increasingly specialised disciplines require better coordination between them in order to maintain and maximise progress between researchers across the globe.

Throughout most of history, science has developed with flexible separation into disciplines which allowed extensive communication between them. In modern science a higher level of organisation is a necessity that reflects the extent of current subject knowledge. There is a requirement for highly specialised researchers to understand the full complexity of disciplines and to keep up to date with research across the world. However, as disciplines become more specialist there is a risk of reducing progress through isolation, monotony and monopoly[14]. Much of the work done in science now is high impact interdisciplinary research and to promote continued progress across disciplines more support is required to facilitate communication and collaboration between them. There are many ways this can be implemented for example, as indicated by Alan Turing, making papers accessible and readable to non-specialists[13]. Other possibilities could include offering cross-field fellowships and creating opportunities for interactions with other disciplines[14]. The title statement is correct in its assertion that today's ease of communication makes it possible to nurture collaboration and hence progress across and between disciplines as never before, allowing unique perspectives and distinct skillsets to come together. However, it is incorrect to label the separation of disciplines as unnecessary and irrelevant, since a degree of specialisation is prerequisite to any meaningful form of collaboration and also because the risks of isolation can be counteracted by encouraging communication and collaboration.

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