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Science: How does it happen and where does it lead?

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Science, as I explained in my earlier Post entitled *Science explained*, is the discovery and explanation of observed patterns, followed by communication of all of this to others. But defining it thus does not make it happen. And, though it happens somewhat automatically for those of us who are involved, this may be far from obvious for many, and it is apparent that there is much general misunderstanding about the processes by which science 'happens' . So, I shall here attempt to explain, providing examples from my own scientific research.

For science to happen, there are three basic requirements. It is firstly necessary to have a ***venue***, that includes location and facilities. Secondly, it requires ***people***, including those who carry out the science, as well as those who provide administrative and logistical support. And, of course, it thirdly requires ***resources***, those things additional to the people and their venue, such as certain equipment, travel, miscellaneous supplies and person-time. In general, the resources necessary for science can be expressed in terms of funding, though sometimes person-time and other resources may be contributed without charge. In other words, science is really a 'business', just like any other, but where assessment depends on various scientific outcomes and outputs. I shall return later to the issues surrounding evaluation of science and scientists.

Venues are diverse. They may include office and/or desk space, areas occupied and utilised by people, locations with natural vegetation, and so on. These are all places where science can and does occur. And yes they can include laboratories, inhabited by people in white lab coats, but such venues would no doubt be in the minority.

The people who make science happen may take on a variety of roles. A few will be ***science leaders***, who may design science programs, sometimes with more than one distinct project and sometimes providing instruction, guidance or supervision for others. Some will be ***science support staff***, involved in doing much of the actual work through data collection, computerisation of data, maintaining facilities and equipment, and so on. It is also common to find ***science volunteers***, people who donate their time, and sometimes other resources, to help progress science. And I am sure you will be pleased to hear that there will also generally be ***science admin staff***, a group oft-maligned by science leaders and support staff, but necessary none-the-less as they create and maintain essential organisation structure.

Resources are the most varied of all, as what it takes to carry out science varies enormously from one kind of science to another. Person-time (and energy) are always important as no task gets completed, including something to do with science, unless time and effort are invested. Additional resources may be small and simple things, like just a notepad and pen, as might be necessary if one were investigating patterns of car-use at different times and places (e.g., type of vehicle; # passengers etc.); . The cost of such science, excluding person-time, might be similarly small. Toward the other end of the spectrum might be science involving experiments carried out on-board rockets and the like as they hurtle through outer space. I imagine the cost of such science would be astronomical (literally!). My own science requires low to moderate levels of equipment and hence financial resources.

So where does all of this lead? What are the outputs and outcomes?

Science outputs are generally presentations of the two basic ingredients of science, discovery and explanation, though the form in which these are presented varies greatly. Of course, there are published articles in scholarly settings like refereed journals, books and conference proceedings, the standard outlets for scientists in academia. However, there are also reports of a myriad of different kinds, that may not be considered published in academic sense and are often referred to as the 'grey literature'. For a science output to be considered 'published' it must generally appear in a recognised outlet and be available, at least in principle, to anyone. Combined, the published and unpublished grey literature are huge, with 10's of thousands of journals and perhaps even more kinds of reports.

Outcomes, which are not the same thing as outputs are also important and, arguably more important, than mere outputs, as it is the outcomes that really represent the results of science. In this context outcomes are impacts in terms of changes to what people think, say and do. When someone finds a cure for a major disease, that's an obvious scientific outcome, and a significant one at that! That would lead on to the topic of assessing science quality, but I shall leave that for later.

In summary, science is like most, if not all, human endeavours, requiring adequately resourced and managed people, working in appropriate settings, towards certain outputs

and outcomes. It is not inherently mysterious, but that does not mean that anyone can easily do it. Just how one becomes a research scientist will soon be another topic.

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