Some Observations About Science

George W. Benthien

December 25, 2023

I have been involved in science for over 40 years, and I have great respect for what has been accomplished through science. However, like most scientists, I have a healthy skepticism of reported scientific results until I have examined them and found them to be credible. Today, science has such an exalted position in our society and many non-scientists tend to accept statements made by scientists in the media as fact without examination. I have provided the following observations to help non-scientist evaluate the many scientific claims reported in the media.

1. Not all statements by scientists are scientific, especially when they deal with morally or politically or philosophically charged topics like climate change, artificial intelligence, and evolution. We need to ask "What is the evidence for what is being claimed?" It is helpful to remember that most scientists are generally not experts when it comes to arguments involving morality, philosophy, and politics.

2. The reason that many scientists get involved in politically charged topics is that most scientific research is funded by the government which is inherently political. Scientists soon learn that their projects will not get funded if they stray too far from what the government sponsors want. This does not mean that the research is invalid, but it does bring in to question the scientist's objectivity. I find that the Scientists who can speak most freely about politically charged topics are often those that have job security because of their status such as Nobel prize recipients or ones who are retired and no longer depend on government funding.

3. Unanimity is rare in science. When you hear general statements such as "scientists say", it is helpful to replace this by "some scientists say". I would also be wary of consensus arguments such as 97% of scientists support some conclusion. First of all, the percentage is generally not the result of a rigorous survey of scientists. Moreover, you don't see consensus arguments used for well established conclusions such as the earth revolves around the sun. Consensus arguments are often used to support a conclusion when the available evidence is inconclusive

4. It is important to understand the definition of key terms used in a scientific argument. For example, "climate change" is a common term in contemporary discourse. It is generally accepted that the climate has been changing throughout the history of the world. Thus,

"climate change" used in this sense is not controversial. However, the term "climate change" as it is used today refers specifically to human induced changes. Not everyone agrees on which changes in climate are human induced.Sometimes there is more than one definition of a term that are commonly used. For example, the term "evolution" is sometimes used to merely denote change over time. At other times it is used to specifically denote Darwinian evolution. It is important to understand which definition is being used. Sometimes different definitions are used in different parts of an argument.

5. We often fail to ask such common sense questions as "Are the reported results reasonable?" and "How could they possibly know that?". Of course, results can appear to be unreasonable and still be true. However, in such cases much more support is needed.

6. Science today has become very specialized. Most scientists only have expertise in a very small subset of science as a whole. Outside of their area they may not be any more of an expert than you or I.

7. We usually think of science in terms of the so-called "scientific method" that involves making hypotheses and experimentally evaluating these hypotheses. However, sciences that deal with the past use a fundamentally different approach than sciences aimed at making future predictions such as physics and chemistry. Some of the sciences that deal with the past are geology, cosmology, archeology, and evolutionary biology. It is difficult to define exactly what constitutes science, but certainly observational and experimental data is a key component. The problem faced by sciences dealing with the past is that we can't directly observe past events or perform experiments in the past. In addition, there is usually limited information on the surrounding conditions when these events occurred, particularly if the events occurred in the distant past. The usual approach used by these sciences is to postulate a cause in the past and to observe how well this cause explains observations we make in the present. However, given any number of observations in the present it is possible that more than one assumed cause could produce similar observed results. Scientists seek to make enough observations so that there is one explanation that best explains what we observe.

   This approach is similar to the approach taken in the investigation of a crime. Evidence is collected in the present and various causes are examined to determine what is the most likely cause of the crime. As we know, the decisions made in criminal courts are sometimes not unanimous. Even when they are unanimous, they are sometimes overturned later. Therefore, I believe that sciences attempting to explain the past don't provide the same degree of certainty as sciences such as physics and chemistry that can more directly experimentally evaluate their assumptions. Investigations dealing with the past are important and should be taken seriously. However, we need to keep in mind the limitations of such investigations. When we hear a scientific explanation of events in the past, we must keep in mind that this is just a story of what scientists think happened and is not based on direct observation.

8. The factual nature of observed data is not always as clear as we might think. Often, hidden assumptions we make about the natural world influence how we interpret what we see or observe. In addition, data that doesn't agree with our worldview is often ignored. A good example is the currently accepted fact that the earth revolves around the sun. Prior to the introduction of an improved view of motion and inertia by Galileo, Newton, and Kepler, a

common sense interpretation of astronomical observations seemed to support the view that the earth is the fixed center of our solar system. For a more complete discussion of this example see my paper *Galileo and Changing Views of the Universe* that can be viewed in the web site gbenthien.net.

9. It is important to ask if the results of an investigation have been confirmed by other similar investigations. The possibility of errors in measurement and interpretation are much less if similar investigations by other investigators have produced similar results. One problem that is seen more today than in the past is that some experiments involve very sophisticated experimental systems that are very difficult or impossible to duplicate. For example, they might involve complicated computer controls and components that are expensive and difficult to build. Some examples are the large Hadron Collider (atomic particle accelerator) in Switzerland and the $465-million Large Synoptic Survey Telescope in Chile. This sophistication makes reliability assessment of experiments much more difficult.

10. In evaluating reported scientific results It is important to see if there are other scientists that have objected to the reported findings, and to examine their arguments. You might disagree with their objections, but it is important to know what they are.

Hopefully these observations will help you to be better examiners of scientific statements in the media. We need to recognize that scientists are usually honest, but like everybody else they can sometimes go down the wrong path.