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Commentary

Scientific Consensus as a Foundation for Extension Programming

Abstract

Given the commitment of Cooperative Extension to science-based programming, it is important to be able to ascertain whether, and to what degree, consensus exists among expert scientists on issues relating Extension programming. This Commentary provides insights into what scientific consensus means, how it develops, and how to recognize when it exists. An example—anthropogenic climate change—is presented. However, the importance of distinguishing scientific consensus from conjecture cuts across many areas of Extension programming agriculture and natural resources, including GMOs, pesticides, environmental protection, and others.

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We Extension professionals take pride in providing science-based information to the public. Scientific consensus is central to our work. Yet only through decades of my work as an Extension specialist, a researcher, and a teacher, have I come to understand what this really means.

What Is a Scientific Consensus?

The Oxford Dictionary defines *consensus* as "a general agreement." Applied to scientific issues, "consensus" means that a general agreement exists among publishing scientists. The phrase "publishing scientist" refers to those experts who regularly publish original research papers in peer-reviewed journals. "Peer review" means that papers are rigorously vetted by publishing experts before they are accepted for publication in the journal. While the system is not perfect, it provides substantial quality control.

Consensus does not mean that all scientists agree. For example, some scientists still question the scientific consensus that smoking causes cancer.

Scientific consensus is not created through some formal process. It is not the result of a vote by scientists. Rather, it is an organic outcome of the scientific process itself. Consensus emerges on a given question when, after years of research and the publication of hundreds or even thousands of research papers, so much published evidence exists that the majority of scientists independently conclude that the question is no longer interesting.

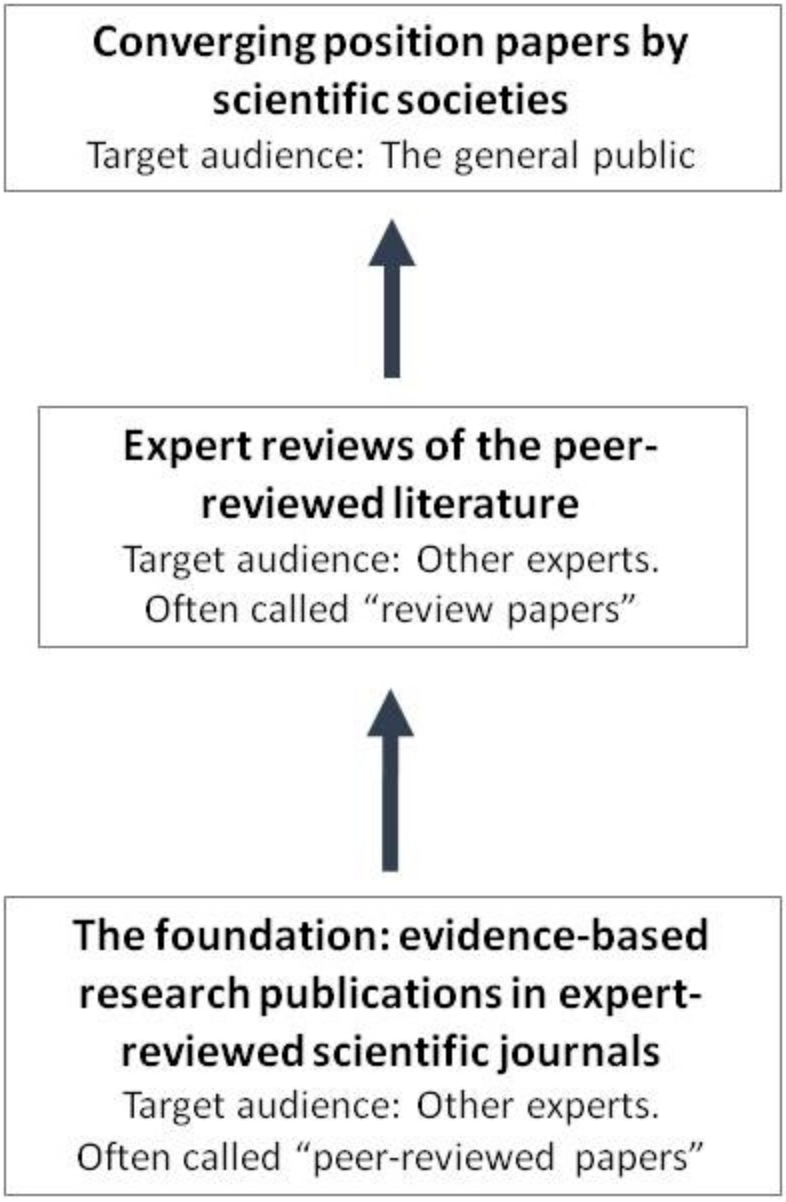
"Consensus" also does not mean "set in stone." All scientific knowledge is considered "conditional." This means that all scientific knowledge is subject to change as new information becomes available. However, this does not give us license to ignore a scientific consensus based on substantial, carefully evaluated evidence.

How Can We Tell That a Scientific Consensus Exists?

There is only one primary source of modern scientific information: papers reporting original research in peer-reviewed scientific journals (Figure 1). All other sources of scientific information—college textbooks, government publications, news releases, blogs, magazines, radio talk shows, etc.—are secondary sources. These secondary sources may—or may not—accurately reflect the peer-reviewed literature. Furthermore, they almost never present the key evidence reported in research papers. For that, one has to go to the peer-reviewed literature.

Figure 1.

Phases Observed as Scientific Consensus Emerges in Published Literature



In topics of active research, one often finds peer-reviewed papers reporting competing findings. However, after hundreds or even thousands of research papers are published on a topic, researchers often can draw conclusions that are well supported by evidence. These experts describe these conclusions—and the supporting evidence—in peer-reviewed review papers (Figure 1). Such review papers can be considered expert summaries of the peer-reviewed scientific literature.

The target audience for original, peer-reviewed research papers, as well as the review papers that follow, is other experts in the field. These papers are written with technical jargon and standards of writing that are outside the normal day-to-day realm of most Americans. For problems of great interest to society, these results are sometimes translated to more accessible formats through position papers from scientific societies or formal assessments processes from governmental or

intergovernmental organizations (Figure 1).

Scientific societies are long-standing organizations dedicated to advancing research, holding conferences for the exchange of the latest research, and communicating research findings to the general public (Bahr, 2007). Legitimate scientific societies must be distinguished from organizations that exist for the purposes of activism, public relations, or lobbying. Such organizations may attempt to create a façade of scientific credibility, but publishing experts know the difference and usually distance themselves from the latter.

When prestigious scientific societies produce converging position statements and none publish positions to the contrary, that is powerful evidence of scientific consensus that even the general public can recognize and comprehend. Some individuals within these organizations may disagree with aspects of their society's position statement—remember, consensus is not unanimity—but the position represents the overall consensus of members of the society.

Expert scientists who regularly publish peer-reviewed research papers learn to be highly cautious in our public statements. It is called "the error of least drama" (Bryssea, Oreskes, O'Reilly, & Oppenheimer, 2013). Thus, when scientific organizations publish position statements, you can be assured these have been highly edited by experts with the goal that every statement in the document can be defended with peer-reviewed, published evidence.

Some people mistakenly claim that acknowledging a scientific consensus is an "appeal to authority." This is usually because they object to the findings of the community of experts. One reason such criticism is misguided is that because none of us can possibly read the hundreds or thousands of peer-reviewed, original research papers that relate to each and every topic of importance to society, we depend on the communities of experts to carefully craft accurate summaries of the state of the science in language the public can understand. We are always free to verify that consensus for ourselves, but most critics of scientific consensus greatly underestimate the expertise and time needed to properly evaluate the massive database that underlies an existing consensus.

All scientific knowledge is conditional. However, as scientific findings begin to accumulate, they get "shaken out" in the community of experts and not in the "blogosphere." Some publishing experts will be the first to recognize an emerging finding. Other publishing experts (not bloggers) will be the ones who vigorously challenge that finding with valid evidence, and indeed, they may be successful in changing the minds of their colleagues—based on expert evidence. Or they may be unsuccessful, depending on the quality and strength of their evidence. This process may last for years, but eventually, if an idea is well supported by data from many sources, experts recognize this and cease debating what is now obvious to them.

That is consensus. There is no group decision among experts to agree. They simply move on to study and debate other questions. In fact, if a researcher continues to study questions that have already been answered, it is not only boring to the researcher and her/his staff, it is an abuse of taxpayer dollars. Furthermore, one risks the loss of respect in the scientific community. As an extreme example, a researcher who studies whether the Moon truly orbits the Earth would have a difficult time competing for scarce research funds.

Although I have focused on scientific societies, certain other organizations produce highly respected, carefully constructed position statements. Examples include regulatory agencies that consistently use a science-based approach, government research institutions, and universities.

Example

The following statements reflect a very broad scientific consensus (Anderegg, Prall, Harold, & Schneider 2010; Cook et al. 2013; Doran & Zimmerman 2009; Gleick et al. 2010; Oreskes, 2004), readily fitting the standards described above. This consensus can be verified if one takes the time to read hundreds of peer-reviewed research papers and one attends legitimate scientific conferences, as I have done.

- Certain gases, such as CO_2, trap heat. These are called "greenhouse gases."

- Atmospheric concentrations of greenhouse gases are increasing rapidly (as measured in geological time), largely as a result of human activities. Basic physics, as well as paleontological evidence, indicate that this is expected to cause measurable global warming.

- Earth is experiencing rapid warming (in geological terms), as determined by many measures, including: rising near-surface air temperatures; rising sea levels; and melting of sea ice, ice sheets, and glaciers.

- While some aspects of this warming may be beneficial, the rapid global warming we are experiencing is resulting in increasing risks.

- The pace, magnitude, and timing of these risks are not fully known and are actively being investigated. However, many researchers are concerned—some are even alarmed—about the long-term changes we humans are causing.

Over 12,000 refereed papers have been published on global warming and climate change (Cook et al. 2013). Well over 100 scientific organizations have published position papers in essential agreement on key points listed above, with no legitimate scientific societies holding positions contrary to any of these points (Figure 2). The latest report of the Intergovernmental Panel on Climate Change, Working Group I https://www.ipcc.ch/report/ar5/wg1/ written by over 250 expert scientists from 39 countries and reviewed by many other expert scientists before publication, provides additional evidence of consensus on the points stated above.

Figure 2..

A Partial List of Scientific Societies That Have Published Statements Endorsing Scientific Consensus on the Fundamentals of Global Warming

Academy of Sciences, France
Accademia Nazionale dei Lincei, Italy
Academy of Science of South Africa
American Academy of Pediatrics

American Association for the Advancement of Science
American Association of Wildlife Veterinarians
American Astronomical Society
American Chemical Society
American College of Preventive Medicine
American Geophysical Union
American Institute of Biological Sciences
American Institute of Physics
American Meteorological Society
American Physical Society
American Public Health Association
American Society of Agronomy
American Society of Plant Biologists
American Statistical Association
Association of Ecosystem Research Centers, USA
Australian Coral Reef Society
Australian Institute of Physics
Australian Meteorological and Oceanographic Society
Australian Medical Association
Botanical Society of America
Brazilian Academy of Science
British Antarctic Survey
Canadian Meteorological and Oceanographic Society
Chinese Academy of Science
Crop Science Society of America
Deutsche Akademie der Naturforscher Leopoldina, Germany
Ecological Society of America
European Academy of Sciences and Arts
European Federation of Geologists
European Geosciences Union

European Science Foundation
Federation of Australian Scientific and Technological Societies
Geological Society of America
Geological Society of London
Indian National Science Academy
InterAmerican Network of Academies of Sciences, representing 14 merit-based science academies in the Americas
International Association for Great Lakes Research
International Council of Academies of Engineering and Technological Sciences
International Union for Quaternary Research
International Union of Geodesy and Geophysics
Mexican Academy of Sciences
National Academy of Sciences, USA
National Research Council, USA
Natural Science Collections Alliance, USA
Network of African Science Academies, representing 13 African science academies
Organization of Biological Field Stations, USA
Polish Academy of Sciences
Royal Meteorological Society, United Kingdom
Royal Society of Canada
Royal Society of New Zealand
Royal Society of the United Kingdom
Russian Academy of Sciences
Science Council of Asia, representing 19 scientific organizations in Asia
Science Council of Japan
Society of American Foresters
Society for Industrial and Applied Mathematics
Society of Systematic Biologists
Soil Science Society of America

University Corporation for Atmospheric Research
The Wildlife Society, USA
World Federation of Public Health Associations
Note: This list includes the most prestigious scientific societies in the world. To my knowledge, no scientific society has a position statement refuting the scientific consensus described in this article.

Extension has moved slowly in providing programming on this well-established scientific consensus. Sadly, this issue has become so politicized in the U.S. that there are serious risks to even broaching the topic with some stakeholders. Although I believe we are failing to serve the public when we avoid the topic, I respect the decision many Extension professionals have made to avoid alienating stakeholders. We can provide programming only as quickly as our stakeholders wish to receive it. Fortunately, Extension educators are discovering ways to provide programming on climate change that are appropriate to audiences holding diverse viewpoints on the subject (Jemison, Hall, Welcomer, & Haskell 2014; Jones & Lenart 2014; Morris, Megalos, Vuola, Adams, & Monroe 2014).

Conclusion

Social-psychological dynamics can cloud our personal perception of scientific information (Kahan, Jenkins-Smith, & Braman 2010; Kahan et al. 2012; Johnson, 2001; Vincelli & Humble, 2013). As humans, we are all subject to this, and it creates challenges to developing sound Extension programming. However, on controversial questions, we science-based educators must challenge ourselves to objectively assess whether scientific consensus exists, and—when it does—to look past our wishes, desires, and other social-psychological forces in our own thinking, so that we can continue to serve the public with science-based information.

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