Scientific Uncertainty in a Nutshell

A guide for journalists prepared by the Science Media Centre of Canada

This is part of the Science in a Nutshell series produced by the SMCC. It offers a simple explanation of scientific uncertainty.

Where does scientific uncertainty come from?

The public often wants an absolute yes-or-no black-or-white answer to science questions. But uncertainty is an inherent part of science.

The process of science is slow—most "discoveries" come from persistent and methodical research. Scientific advancement relies on researchers constantly pushing the boundaries of what is known. In order to do so, they follow the scientific method, which has four key steps:

1. Observations;
2. Formulating a (testable) hypothesis that explains the observations;
3. Making predictions based on the hypothesis;
4. Testing the predictions, which in turn test the hypothesis.

Researchers adjust or confirm the hypothesis based on the test results, repeating the process many times over. Once a hypothesis has withstood rigorous testing, it becomes a scientific theory, gains more acceptance and will be considered "true" as long as it isn't falsified. The experiment must also be reproducible by other independent researchers.

A theory is never actually proven to be correct, rather it is strengthened by repeated unsuccessful attempts to prove it wrong. So, there is always some level of uncertainty associated with scientific conclusions, even the ones that make it into textbooks

But at the leading edge of science hypotheses can be short lived. They are often based on incomplete observations and cannot be upheld as more pieces of the puzzle emerge. They remain important to scientific progress and may lead to new insights. If a scientist's hypothesis is proven wrong it does not undermine her credibility, it merely shows that she is pushing the frontiers of knowledge.

Uncertainty in action: climate models

In order to predict the climate of the future, scientists rely on computer models that simulate processes in the atmosphere, ocean and on land. In a system as complex as our planet, it is impossible to represent every process with its own mathematical equation, so climate modellers bundle some processes together based on empirical estimates, a practice called *parameterization*.

A number of climate models currently in use differ in their parameterizations. Each has its strengths and weaknesses. All do a reasonably good job at "predicting" the climate of the past century or so, but they diverge in their predictions of future climate and offer some degree of uncertainty.

There are many reasons for the differences among the models, including our understanding of important processes, such as the role of clouds in climate forcing or the way the biosphere stores and recycles carbon. Neither can scientists predict how human societies will alter their use of fossil fuels in the future, making it difficult to predict what the climate will be like in 50 or 100 years. (*For more information on uncertainty in climate models please Climate Models in a Nutshell.*)

Uncertainty in action: medical reporting

Writing about medical advances, a journalist is mainly faced with three kinds of uncertainty.

1. Uncertainty that arises from variations in a sample, such as the people enrolled in a clinical trial to test the effectiveness of a drug. Not everyone will respond to a drug in the same way, therefore the more people enrolled in the trial the greater confidence in the result.
2. Uncertainty associated with study design, for example, whether the questions asked and outcomes measured were appropriate, and whether a representative population was sampled. For example, a recent U.S. study that questioned the safety of home births included old data and women who had not planned to give birth at home.
3. Uncertainty that stems from divergent and sometimes contradictory results from a number of studies on the same topic, a discrepancy often caused by differences in study design and how the research questions were asked.

Dealing with uncertainty

Uncertainty is likely to play a role in media coverage of most scientific issues. It is the journalist's responsibility to put the uncertainty into context and help their audience understand its sources and meaning. Providing examples is an important tool for illustrating how numbers are to be interpreted.

In climate models:

- Treat uncertainty as a normal aspect of pushing the boundaries of knowledge.
- Explain the sources of uncertainty.
- Emphasize the aspects that different models agree on rather than their discrepancies, as these are the predictions that scientists have the most confidence in.
- Determine the general scientific consensus on the question under investigation.

In medical reporting:

- Put any single study in the context of related studies and trials.
- Point out the limitations of the study, e.g. randomized placebo-controlled trial vs. observational study, the duration of the study, number of individuals enrolled and funding.

For more information:

Open letter on climate change and the integrity of science:
http://www.sciencemag.org/cgi/reprint/328/5979/689.pdf

Digital RoundTable on the uncertainty in climate modelling: www.thebulletin.org/web-edition/roundtables/the-uncertainty-climate-modeling

IPCC uncertainty assessments: http://www.ipcc.ch/publications_and_data/ar4/wg1/en/ch1s1-6.html

Climate model uncertainty explained:
http://wikiadapt.org/index.php?title=Climate_model_uncertainty

The Clinical Evidence glossary of the British Medical Journal:
http://clinicalevidence.bmj.com/ceweb/resources/glossary.jsp

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