**Guess and Check in Science**

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One can view the science as a back and forth process:

Guess and Check.

Metaphor and Computation.

Metaphors are the essence of guessing and I think of the greatest importance in all of human thinking including science. The choice of the right metaphor and the right guess is of great importance. Indeed, if the guess is too far from the mark, and the metaphor wrong, the scientific process may not converge. Scientists looking under a bright light cannot see what remains in darkness.

Science needs clever metaphors as its guesses, as scientists decide what to do tomorrow. But scientists check their guesses and in that way science is quite different from other kinds of human thought.

Checking does not work if different people get different results when they do computations and checking. If results are not consistent, confusion occurs. Metaphors have no place in checking!

Inconsistent models are dangerous because the results of calculations can depend on how the inconsistency is resolved. Different scientists may choose to resolve the inconsistency differently. The choice may be made without conscious thought—since scientists and mathematicians are human beings, not abstract logical machines—and the choice is often presented *sotto voce*, for the same reason. Different results will then be produced by what seems to be the same model and confusion will occur, often degenerating into personal conflict. The scientific social process will not converge.

Checking must be done carefully, as carefully in theories and simulations as in experiments.

The plain fact is that it is very hard to get reproducible results in experiments. You can’t do something new until you have actually shown you can reproduce the old. Many variables have to be exactly right (say 100 in a typical physiological or biophysical experiment) before you can begin to do something new.

I believe simulations and theory have to be similarly precise in the checking of our guesses. Theory must be consistent and analyzed without errors if everyone is to get the same results. Simulations have to be checked again and again because simulations are not mathematics. They are not buttressed by theorems. Simulations need to be checked as much as experiments.

If metaphors are used instead of calculations in the interpretation of experiments or simulations, only confusion can occur. An x-ray structure is a set of numbers. It is not a description of ions moving through that structure. The Nobelist is entitled to his metaphors of ionic motion but metaphors they are, not scientific results. They must be checked by computation and simulations. A simulation is a calculation dependent on all sorts of assumptions and approximations, physical, chemical and mathematical. If structures or simulations are viewed as true, and not calibrated against other ‘truths’, only confusion can result.

So both guessing with metaphor, and checking with compulsion are needed to do good science.

The problem here is that human beings do science and humans are not logical beings at all (thank heaven!). We all have motivations and complex histories etc that govern our behaviors. And we have different ‘inherent’ capabilities (i.e., very hard to change after the age of eight or so). People who are good at guessing love metaphors and (usually) hate checking. People who are good at checking love detail and (usually) hate metaphors or guessing.

The problem is that science (in my opinion) **requires** both behaviors and thus both types of people. That is very hard, but that is what we have to try to do if we want to be make our science efficiently reliable.